Appendix C

Noise and Vibration Technical Report

WILSON IHRIG & ASSOCIATES
ACOUSTICAL AND VIBRATION CONSULTANTS
CALIFORNIA NEW YORK WASHINGTON

6001 SHELLMOUND STREET
SUITE 400
EMERYVILLE, CA 94608
Tel: 510-658-6719
Fax: 510-652-4441
www.wiai.com

Caltrain Peninsula Corridor Electrification Project

Noise and Vibration Technical Report

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Prepared by
Wilson, Ihrig & Associates

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1 Introduction

Wilson, Ihrig and Associates prepared a noise and vibration analysis for the Peninsula Corridor Joint Power's Board for the Peninsula Corridor Electrification Project (PCEP or Proposed Project).

The Caltrain Modernization Program would electrify and upgrade the performance, operating efficiency, capacity, safety and reliability of Caltrain's commuter rail service. The entire Caltrain Modernization Program, which includes installation of an advanced signal/positive train control system and electrification, is planned to be completed by 2019. The PCEP is a component of the Caltrain Modernization program and consists of converting Caltrain from diesel-hauled to Electric Multiple Unit (EMU) trains for 75 percent of the service[1] within the Study Area bound by the San Francisco station at 4th and King Streets and the Tamien Station in San Jose. As part of the project, new electrical infrastructure would be installed in the Study Area, and electrified vehicles would be procured and purchased. Caltrain currently operates five trains per peak hour at a maximum speed of 79 miles per hour (mph) with 92 trains per day between San Jose and San Francisco. The Proposed Project would increase service up to six Caltrain trains per peak hour, per direction at operating speeds of up to 79 mph with 114 trains per day between San Jose and San Francisco. Project construction is schedule between 2015 and 2019 with revenue service expected in 2019 with the first full year of revenue service likely to occur in 2020.

The existing ambient noise in the Caltrain corridor is primarily dominated by noise from the existing Caltrain rail service, tenant passenger and freight rail service on the Caltrain corridor, traffic on main highways and major arterials nearby, and aircraft flyover noise from nearby airports including San Francisco and San Jose International. The Day-Night noise level (Ldn) typically ranged from 67 to 73 Ldn and extended up to 82 Ldn at one area in San Jose. The existing ambient vibration in the corridor is dominated by vibration from the Caltrain rail service and tenant passenger and freight rail service, and to a much lesser extent traffic on nearby streets. The typical vibration level from Caltrain was 70 to 76 VdB at a distance of 50 ft from the track centerline, and the vibration approached 79 VdB at 50 ft distance at one location in Santa Clara.

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

[1] The Proposed Project has funding for rolling stock to cover replacement of 75 percent of the rolling stock for the San Jose to San Francisco service. Caltrain will replace the remaining 25 percent over time as existing diesel stock reaches the end of its design life.

crossing. Freight trains operating on the existing rail alignment are another source of ambient noise and vibration. Currently, freight trains nominally operate between 8 p.m. and 5 a.m.

Based on the analysis summarized herein, the following impacts were identified for Proposed Project construction:

- Temporary noise impacts for noise sensitive uses within
  - 25 ft of overhead contact system installation
  - 60 ft of overbridge barrier installation
  - 55 ft of ancillary facility installation
- Temporary vibration impacts for occupied residential buildings within 45 ft
- Potential building damage impacts for structures within 15 ft of vibratory compactor or 25 ft of vibratory hammer activities

Construction mitigation measures such as a noise control plan and a vibration control plan would help to reduce these impacts. These plans should incorporate best practices to reduce noise and vibration and site specific measures to protect buildings from potential building damage from construction damage; these measures would not necessarily guarantee noise and vibration exposure to less than the criterion limits, particularly where night construction is necessary.

Based on the analysis summarized herein, the following impacts were identified for Proposed Project operations:

- Year 2020 and 2040
  - Moderate noise impact from Ancillary Facilities
    - TPS1 Option 3 (1 hotel)
  - No significant new noise impacts from railroad operations
  - No significant new vibration impacts from railroad operations

Mitigation to address operational noise impacts are as follows:

- Ancillary facilities siting, design (perimeter barriers) and equipment placement and selection to conform to a performance criterion that limits substation noise to 60 dBA at 50 feet.

Based on the analysis summarized herein, the following cumulative impacts were identified for operational noise:

- Year 2020
  - Cumulative, No Project: 15 Moderate Impacts
  - Cumulative with Project: 11 Moderate Impacts
- Year 2040
  - Cumulative No Project: 39 Moderate Impacts, 9 Severe Impacts
  - Cumulative with Caltrain Full Electrification: 37 Moderate Impacts, 7 Severe Impacts

- Cumulative with Blended Service, 79 mph scenario: 23 Moderate Impacts, 24 Severe Impacts
- Cumulative with Blended Service, 110 mph scenario: 6 Moderate Impacts, 42 Severe Impacts

Potential mitigation to address cumulative operational train noise impacts are as follows:

- Wayside horns, building sound insulation, quiet zones, and grade separations, depending on funding availability and specific site constraints.

Based on the analysis summarized herein, the following cumulative impacts were identified for operational vibration:

- Year 2020
  - Cumulative, No Project: no significant impacts
  - Cumulative with Project: no significant impacts
- Year 2040
  - Cumulative No Project: no significant impacts
  - Cumulative with Caltrain Full Electrification: No significant impacts
  - Cumulative with Blended Service, 79 mph scenario: Potentially significant impact where a doubling of train vibration effects would occur
  - Cumulative with Blended Service, 110 mph scenario: Potentially significant impact where a doubling of train vibration effects would occur and possibly due to 110 mph speeds.

Potential mitigation to address cumulative operational vibration impacts are as follows:

- Location and design of special trackwork, vehicle suspension, special track support systems, building modification, trenches and buffer zones.

Based on the analysis of a Diesel Multiple Unit Alternative summarized herein, the following findings are made:

- Year 2020 and 2040
  - No new moderate or severe impacts

2 Project Description

2.1 Location and Limits

The Peninsula Corridor Joint Powers Board (JPB) owns and operates approximately 51 miles of primarily two-track mainline railroad right-of-way (ROW) between the 4th and King Street Station in San Francisco and south of the Tamien Station in San Jose, Santa Clara County. The JPB purchased this ROW from the Southern Pacific Transportation Company in 1992. Between Tamien Station and Gilroy, the mainly single-track ROW is owned by the Union Pacific Rail Road (UPRR). Caltrain has trackage rights with UPRR to provide commuter service in this approximately 25-mile segment between Tamien Station and Gilroy. This project is limited to the Caltrain ROW only.

2.2 Background

Caltrain trains presently consist of diesel locomotive-hauled, bi-level passenger cars. As of mid-2013, Caltrain operates 46 northbound and 46 southbound (for a total of 92) trains per day between San Jose and San Francisco during the week. Three of these trains start in Gilroy during the morning commute period, and three terminate in Gilroy during the evening commute period. Eleven trains in each direction are “Baby Bullet” express service trains that make the trip between San Francisco and San Jose in less than 1 hour. Service is frequent during the peak periods (5 trains per peak hour per direction [pphpd]) and is provided every hour in both directions during the midday. Caltrain provides hourly service in both directions on Saturdays and Sundays (36 trains on Saturdays and 32 trains on Sundays) between San Jose Diridon and San Francisco 4th and King Stations only. Weekend service includes two “Baby Bullet” express service trains per day in each direction. Caltrain also provides extra service for special events such as San Jose Sharks and San Francisco Giants games.

In addition to Caltrain commuter rail service, UPRR operates approximately six daily freight trains between Santa Clara and San Francisco under a “Trackage Rights Agreement” with Caltrain. From Santa Clara to San Jose, on a joint use corridor, UPRR operates approximately 9 daily freight trains. Three passenger train services also operate on the Santa Clara to San Jose segment: the Capitol Corridor (14 daily trains), the Altamont Commuter Express (ACE, 8 daily trains during weekdays only), and the Amtrak Coast Starlight (2 daily trains).

The Proposed Project is part of a program to modernize operation of the Caltrain rail corridor between San Jose and San Francisco.[2] There is a lengthy history of planning for modernization of the Caltrain Peninsula Corridor. Modernization projects include the installation of an advanced signal system and the electrification of the rail line. The advanced signal project (Caltrain Communications Based Overlay Signal System (CBOSS)/Positive Train Control (PTC) commonly referred to as CBOSS/PTC or CBOSS), and corridor electrification are discussed below. The JPB previously evaluated corridor electrification in a prior EIR, for which a draft was completed in 2004 and a final was completed in 2009. The JPB did not certify the Final EIR due to the need for resolution of issues regarding joint planning for shared use of the Caltrain corridor for Caltrain service and for future high-speed rail (HSR) service. The Federal Transit Administration (FTA) completed the final EA and adopted a Finding of No Significant Impact in 2009.

[2] JPB is currently updating its Strategic Plan to account for recent policy commitments (Caltrain Modernization [CalMod], blended service, and High-Speed Rail).

Since 2009, the JPB, the California High-Speed Rail Authority (CHSRA), the California Legislature, the Metropolitan Transportation Commission (MTC) and other parties have worked together to develop a vision of a “blended system” whereby both Caltrain and HSR would utilize the existing Caltrain Peninsula Corridor. This vision for implementing blended service was included in the *Revised 2012 Business Plan* that the CHSRA Board adopted in April 2012 for the California High-Speed Rail System (CHSRA 2012).

The JPB and CHSRA are committed to advancing a blended system concept. In 2013, the JPB and CHSRA signed a Memorandum of Understanding (MOU) to this effect. This local vision was developed with stakeholders interested in the corridor. The blended system would remain substantially within the existing Caltrain ROW and accommodate future high-speed rail and modernized Caltrain service by primarily utilizing the existing track configuration.

Based on the blended system vision, the Caltrain Peninsula Corridor has been designated to receive an initial investment of Proposition 1A bond funds that would benefit Caltrain and its modernization program in the short term and HSR in the long run. The JPB, CHSRA and seven other San Francisco Bay Area agencies (City and County of San Francisco, San Francisco County Transportation Authority, Transbay Joint Powers Authority, San Mateo County Transportation Authority, Santa Clara Valley Transportation Authority, City of San Jose, and MTC) have approved an MOU (*High Speed Rail Early Investment Strategy for a Blended System in the San Francisco to San Jose Segment known as the Peninsula Corridor of the Statewide High-Speed Rail System*) to pursue shared use of the corridor between San Jose and San Francisco to provide blended service of both Caltrain commuter rail service and HSR intercity service (JPB 2012). The MOU includes agency and funding commitments toward making an initial investment of $1.5 billion in the corridor for purchasing and installing an advanced signal system, electrifying the rail line from San Francisco to San Jose, and purchasing electrified rolling stock for Caltrain. The MOU also conceptually outlines potential additional improvements (i.e., “Core Capacity” projects[3]) needed beyond the first incremental investment of $1.5 billion to accommodate future high-speed rail service in the corridor.

Corridor improvements identified in the MOU include the following:

- **Advanced Signal System (commonly referred to as CBOSS PTC or CBOSS):** CBOSS stands for Communications Based Overlay Signal System and PTC stands for Positive Train Control. This project (currently being installed, including a new fiber optic backbone) will increase the operating performance of the current signal system, improve the efficiency of grade crossing warning functions, and automatically stop a train when there is violation of speed or route. This project, which includes implementation of safety improvements mandated by federal law, is scheduled to be operational by 2015 as mandated by the Federal Railroad Administration (FRA).

[3] “Core capacity” projects (as defined in the nine-party MOU) including needed upgrades to stations, tunnel, bridges, potential passing tracks, other track modifications, and rail crossing improvements including selected grade separations will be required to accommodate the mixed traffic capacity requirements of high-speed rail service and commuter services on the Caltrain corridor. The specific core capacity projects have not been identified or defined at this time. These projects would be identified in future discussions and evaluations between CHSRA and the JPB. Core capacity projects would be subject to separate, project-level NEPA and, if applicable, CEQA evaluation by the implementing agency.

- **Corridor Electrification:** The JPB decided to prepare this new EIR for the corridor electrification due to the changes in existing conditions[4] that have occurred along the corridor since the prior EIR analyses was conducted, to update the environmental analysis, and to update the cumulative analysis of blended service and other cumulative developments along the corridor. Completion of a new EIR will also allow public agencies, stakeholders, the public and decision-makers the opportunity to review and comment on the project's environmental effects in light of current information and analyses. This project will provide for operation of up to 6 Caltrain trains per peak hour per direction (an increase from 5 trains per peak hour per direction at present). Electrification can be analyzed as a separate project under the California Environmental Quality Act (CEQA) because it has independent utility (providing Caltrain electrified service) and logical termini (station end points). Electrification of the rail line is scheduled to be operational by 2019. The Proposed Project includes 114 trains per day between San Jose and San Francisco and 6 trains per day between Gilroy and San Jose. Future proposed actions to expand service beyond 114 trains per day may require additional environmental review.
- **Blended Service:** The JPB, CHSRA, and the MOU partners have agreed on shared use of the Caltrain corridor for use of up to 6 Caltrain trains per peak hour per direction and up to 4 HSR trains per peak hour per direction. The operational feasibility of blended service has been studied, but this project is presently only at the conceptual planning phase. The potential addition of HSR service to this corridor will be the subject of a separate environmental review process that will be undertaken subsequent to the environmental process for the Peninsula Corridor Electrification Project (PCEP). Based on the current CHSRA *Revised 2012 Business Plan*, blended service along the Corridor is scheduled to commence by 2029.

2.3 Project Description

The Proposed Project consists of converting Caltrain from diesel-hauled to Electric Multiple Unit (EMU) trains for service between the 4th and King Street Station in San Francisco and the Tamien Station in San Jose. Operating speed would be up to 79 miles per hour (mph), which is what it is today.

In 2019, service between San Jose and San Francisco would use a mixed fleet of EMUs and diesel locomotives, with approximately 75% of the service being electric and 25% being diesel in 2019.[5] After 2019, diesel locomotives would be replaced with EMUs over time as they reach the end of their service

[4] For example, there have been changes in existing development adjacent to the Caltrain ROW and stations, in levels of traffic, and in adopted land use plans around stations.

[5] This project only includes funding for EMUs representing approximately 75 percent of the operational fleet between San Jose and San Francisco. In 2019, some peak period service (e.g., bullet/Gilroy-SF trains) would be diesel on weekdays. All other service, including off-peak, would be EMU-based in 2019. Funding for replacement of the remainder of the diesel fleet between San Jose and San Francisco would have to come from future funding sources. It is expected that 100 percent of the San Jose to San Francisco fleet would be EMUs by 2029, because the fleet would need to be fully electrified to operate in a blended service environment with HSR. Fully electrified service between San Jose and San Francisco is included in the cumulative impact analysis contained in Chapter 4 but is not part of the Proposed Project.

life. Caltrain's diesel-powered locomotive service would continue to be used to provide service between the San Jose Diridon Station and Gilroy.[6] Fleet requirements under the Proposed Project are presented in Table 2-1.

Table 2-1. Fleet Requirements of the Electrification Program

Year	Diesel Locomotives	Diesel-Hauled Coaches/Cabs	Electric Multiple Units	Total Passenger Vehicles
2019[a] (six trains per peak hour/direction)	9	45	96	150
2040[b] (six trains per peak hour/direction)	6	31	138 to 150	175 to 187

[a] The majority of vehicles will be replaced in 2019 as they reach the end of their design life. Additional vehicles would be replaced after 2019 as they reach the end of their design life.

[b] Diesel operation limited to San Jose – Gilroy shuttle service in 2040. 2040 operations assume fully electrified operations between San Jose and San Francisco and that the San Francisco Downtown Extension (DTX) has been completed. However, the Proposed Project only includes funding for 75 percent of the rolling stock for this service at this time. The fleet estimates for 2040 are only conceptual at this time.

Source: EIR, Chapter 2, Project Description

The level of Caltrain operations and, therefore, fleet requirements under the Proposed Project are based on six trains per peak hour per direction (pphpd) along most of the alignment, with a mixed EMU and diesel locomotive fleet. Caltrain service would also include six diesel-powered trains per day in the San Jose to Gilroy segment in 2019.

The project would require the installation of 130 to 140 single-track miles of overhead contact system (OCS) for the distribution of electrical power to the electric rolling stock. The OCS would be powered from a 25 kilovolt (kV), 60 Hertz (Hz), single-phase, alternating current (AC) supply system consisting of traction power substations (TPSs), one switching station (SWS), and paralleling stations (PSs). These traction power facilities (TPFs) are described in more detail in the following pages, and TPF noise levels shall comply with IEEE national standards and guidelines for electrical power facilities.

2.3.1 Overhead Contact System

To permit electric vehicles to run along a railroad track, two types of electrical power distribution system are in general use. The first type is a low-voltage direct current (DC) third rail system, as employed in the 1,000-volt DC BART system. The second type is an overhead contact wire system, used for both light and heavy rail transit. Light rail applications typically use low-voltage OCS, such as the Muni in San Francisco at 600 volts, or the Santa Clara Valley Transportation Authority light rail service at 750 volts. For high-speed, intercity passenger or commuter rail lines, the OCS is usually a high-voltage AC system, as used by Amtrak, Maryland Regional Commute trains (MARC), Southeastern Pennsylvania Transportation Authority (SEPTA), New Jersey Transit (NJT), and Metro-North Railroad (MNRR) at 11.5 to 12.5 kV, and at 25 kV on Amtrak's Northeast Corridor and portions of the NJT. This project would have an AC OCS. The

[6] The Proposed Project only includes electrification to a point approximately 2 miles south of Tamien Station (the JPB-owned ROW). The Union Pacific Corridor south of this point would not be electrified by this Project.

typical voltage used for regional and intercity rail throughout Europe and the rest of the world is 25 kV at commercial frequencies (50 to 60 Hz). As noted above, this project would have a 25 kV AC OCS at 60 Hz.

This power supply and distribution system and voltage are compatible with the requirements of HSR and would accommodate future development of HSR in the Caltrain Peninsula Corridor. The OCS conductors and traction power equipment will be sized and located based on a computerized analysis of traction power load flow requirements using the probable maximum capacity of the Peninsula Corridor alignment of Caltrain.

A mainline OCS typically consists of two conductors above each track in what is known as a catenary configuration: a messenger wire (much like a utility transmission line) sags between support points, below which a near-level contact wire is suspended. Both main wires are energized and are part of the same circuit. The pantograph, mounted on top of the electric vehicles, slides along the underside of the contact wire and collects the traction current from it.

The messenger wire is typically supported by means of cantilevered, hinged bracket arms that extend horizontally over the track from vertical steel poles mounted clear of the dynamic envelope (i.e., the range of motion of the train on the track) of the vehicles. The OCS for also includes negative feeder and static wires. The autotransformer system is described further below. These are also supported on the OCS poles. These poles are placed approximately 10 to 12 feet of the centerline of the tracks they serve. In areas where there is limited clearance between tracks, multi-track support structures, such as multi-wire headspans attached to taller steel poles, are employed. The poles themselves are supported by cast-in-place concrete foundations or driven pile footings, which are typically set back approximately 10 to 12 feet from the track centerline. Depending upon the clearance requirements of particular sections of the route, the contact wire height would vary from approximately 16.0 feet to 23.0 feet. Pole heights range from 30 to 50 feet. Also, depending on along-track span length and other requirements, the messenger wire would typically be positioned between 2 feet and 5 feet directly above the contact wire.

Clearances for maintenance and operation of the OCS would be designed to allow for existing freight railroad and tenant passenger rail clearances and operations. Normal design clearances up to 23 feet would be provided in all open, unconstrained areas. Special designs could be employed in close clearance tunnels or under bridges in order to provide sufficient clearances to existing freight and diesel passenger trains.

On tangent, or straight, sections of track, the OCS supports can be spaced up to 230 feet apart, though they would typically be about 180 to 200 feet apart. On curved track sections, the span lengths between supports must be reduced. The Caltrain ROW has two small radius curves, one just south of the San Francisco terminus and one north of the San Jose Diridon Station, where the support spacing would be reduced to approximately 75 feet. For the larger radius curves along the route, pole spacing would range from 120 to 150 feet.

The particular type of OCS support on a given segment is dependent upon the track segment's exact configuration (e.g., number of tracks) and other site-specific requirements and constraints. Power would be supplied to the OCS at each of the TPFs, either by means of non-insulated aerial connections or by insulated underground connections. Power would generally be delivered to the OCS through a pole-mounted disconnect switch, which permits energization or de-energization of a particular section of the OCS conductors. The overhead electrical system would include an integrated bonding and grounding system to protect the public during all system operations.

As noted above, the OCS poles nominally need to be approximately 10 to 12 feet from the centerline of the railway tracks. In addition, there needs to be clearance of vegetation within approximately 10 feet of the OCS poles and catenary system for electrical safety. Trimming or removal of trees would be required along the tracks and electrical facilities where they would otherwise pose a maintenance or safety concern. The distance from the railway outside track centerlines to the outer edge of the vegetation clearance zone (called the electrical safety zone or ESZ) would be up to 24 feet (up to 12 feet to the OCS pole alignment + 2 feet for the width of the pole + 10 feet for the vegetation clearance). In addition, structures cannot be closer than 6 feet to the OCS pole alignment (the 6 feet is within the 24-foot ESZ).

At tunnel locations, all within San Francisco, the project includes potential tunnel and track modifications necessary to provide adequate vertical clearances for the OCS for both passenger and existing freight operations. These improvements could include potential “notching” (i.e., minor excavation of the tunnel wall) of the tunnel, horizontal realignment of tracks to maximize vertical clearance, and potential lowering of the track grade. If lowering of the track grade is necessary, construction would involve temporary removal of the track and track ballast, excavation, and then replacement of track ballast and tracks. At certain bridge overcrossings where vertical height is constrained, the project also would include minor track lowering to provide adequate vertical clearance for existing passenger and freight vehicles.

2.3.2 Auto-Transformer Power Feed Arrangement

The auto-transformer power feed system arrangement reduces the need for substations and would require the installation of only two TPSs spaced 36 miles apart. There are three options for the site of each of the TPSs. In addition, there would be one switching station (SWS1) and seven paralleling stations (PS1 through PS7) at a spacing of approximately 5 miles. Two options have been identified for the PS4, PS5, and PS6 sites.

The paralleling stations provide additional power support to the power distribution system and permit increased spacing of the primary substations. In addition to reducing the number of substations—and thereby minimizing the introduction of new, large equipment installations into the corridor—the auto-transformer feed arrangement for implementation along the Caltrain corridor would help reduce electromagnetic fields (EMF) and electromagnetic interference (EMI) because the arrangement includes two parallel aerial feeders, one on each side of the alignment. The currents in the parallel feeders flow in the opposite direction to that in the main catenary conductors, reducing the EMF/EMI effects created by current flow in the OCS.

Final site selection will be coordinated with local authorities.

2.3.3 Traction Power Substations, Switching Stations, and Paralleling Stations

The two traction power substations would each include two 60MVA (million Volt-amperes) oil-filled transformers that would step down the power utility supplied voltage of 115 kV to the 2 by 25 kV distribution voltage needed for the OCS. The source power utility would be requested to provide two incoming feeds, which would tap two phases of each three-phase transmission line. The traction power substation compound would include circuit breakers and switching equipment that would feed power from the high-voltage lines to each line section of track. The line-side equipment would be designed to provide alternate switching arrangements in the event of a substation equipment outage. A substation compound would typically be approximately 150 feet by 200 feet in size.

At approximately the midpoint between substations, a switching station would be installed. At the switching station a phase break would be required to ensure the power supplies from each substation is isolated from each other in order to avoid a fault condition. In addition, switching would be installed to provide operating flexibility during equipment outages. Between the substations and the switching station, paralleling stations would be installed to maintain the autotransformer system and system operating voltages. The switching station would be equipped with two 10-MVA oil-filled auto-transformer units and the paralleling stations with either one or two 10-MVA oil-filled auto-transformer units. These facilities would contain a variety of circuit breakers and switching equipment but would be typically as shown in the proposed location drawings above. Switching station compound dimensions are typically 80 feet wide by 160 feet long; paralleling station compound dimensions are typically 40 feet wide by 80 feet long.

2.3.4 Overbridge Protection Structures

Electrification of the corridor would require the construction or enhancement of overbridge protection barriers on 47 roadway or pedestrian bridges across the Caltrain alignment. These barriers are necessary to prohibit access to the rail corridor and prevent objects from being thrown off the bridges in a manner that would damage or interfere with the electrical facilities. Fifteen of the existing bridges already have such barriers on both the north and south bridge face, six bridges have a barrier on only one bridge face, and 26 have no overbridge protection barriers. Overbridge protection barriers would be 6.5 feet high above sidewalk or pavement level, and placed along the parapet of the bridge at least 10 feet from the closest energized conductors crossing underneath. The existing barriers would be enhanced to meet these requirements. The overbridge protection barriers would have black, red, and white signage that says, “Danger, Live Wire.”

For two-track segments, the length of the overbridge protection barrier would be about 35 to 40 feet long. For three- and four-track segments, the overbridge protection barrier would be from 65 to 80 feet long. Overbridge protection barriers may be constructed from a variety of materials, including timber, sheet metal, small mesh wire fabric, plastic, concrete, or other solid material.

The Proposed Project proposes to use a fine mesh wire fabric; this provides safety protection and maintainability, but affords a measure of transparency for both pedestrians and motorists.

2.3.5 Grade Crossing Warning Devices

The Proposed Project would also require a change in the warning devices for at-grade crossings. At present, grade crossings are operating with Harmon Crossing Predictors and Grade Crossing Predictors as warning devices. As part of the Proposed Project, those warning devices would be removed because they operate on a DC circuit and the proposed EMUs would operate on an AC circuit.

Caltrain trains equipped with onboard CBOSS PTC equipment will communicate with the grade crossings wirelessly, allowing the grade crossing gates to function safely. CBOSS PTC will be in place by 2015.

For non-Caltrain trains (which will not have onboard CBOSS PTC equipment), Audio Frequency Overlays (AFOs), also known as track circuits, will be installed at fixed locations along the Caltrain ROW, allowing the grade crossing gates to function safely. An AFO is a sensor that activates the grade crossings when the train is approaching. New cables and wires are required for the AFOs. Cable and wire installation will be within the Caltrain ROW and construction activities will include:

- Trenching and excavating
- Installation of conduits
- Installation of cables and wires
- Installation of AFO equipment
- Connections at grade crossings

In the next phase of design, additional engineering will be conducted on the performance of AFOs and alternative design options.

2.3.6 Rolling Stock

New EMUs are the preferred rolling stock option for the Proposed Project. New EMUs would replace the portion of Caltrain's existing diesel locomotives and passenger cars that will reach the end of its useful life by 2019. Caltrain would operate electric service between San Francisco and San Jose with EMUs. With EMUs, each car, or set of cars (unit), can have its own pantograph mounted on the roof and separate electric motor drives to each axle of the trucks, using four motors (one per axle) or two motors (one per truck). EMUs can be operated in a variety of train consists, dependent upon the requirements of the rail system operator. Options include single motor cars (where each car is fitted with a driving cab at both ends) and paired cars (where there is a driving cab at only one end of each car). A pair can comprise two motor-cab cars, or a motor-cab plus a non-motored trailer-cab car. Another option would be two motorized cab cars with multiple non-motored trailer cab-cars in between.

EMUs currently in use include the 1,500-volt DC gallery cars now being operated by Metra in Chicago. These cars closely resemble the Caltrain double-level gallery cars. Northern Indiana Commuter Transportation District also operates the new 1,500-volt DC multi-level Nippon Sharyo cars in northern Indiana and Illinois. Twenty-five kV AC single-level EMUs are in service on the Deux Montagnes Commuter Railroad in Montreal. In addition, Metro-North Railroad, NJT, and SEPTA operate single-level EMUs powered from an 11.5- to 12.5-kV and 25-kV AC OCS. There is currently no United States-based prototype for the EMU proposed for the Proposed Project. The EMU vehicle that is proposed for the Proposed Project would be a multi-level car of comparable dimensions to the existing Caltrain gallery car. Caltrain has received a waiver from the FRA that would allow modern European EMU equipment to operate on the Caltrain Peninsula Corridor provided that temporal separation is provided between the light-weight EMUs and heavy freight trains (this is referred to as the FRA "waiver").

Power for the electric vehicles would be drawn from the OCS through a roof-mounted pantograph on the power car(s) or locomotive. The pantograph is a hinged, mechanical device that can extend vertically to follow variations in the OCS contact wire height, with a typical extension from as low as 14 feet up to 24 or 25 feet.

2.3.7 Caltrain Operating Scenario(s) Under Electrification

The proposed level of Caltrain operations includes 6 trains per peak hour during the a.m. and p.m. peaks, as well as mid-day services for a total of 114 trains per day. In addition to regular service (stopping at every station), existing weekday Caltrain service includes six a.m. northbound and p.m. southbound baby bullet trains and five a.m. southbound and p.m. northbound baby bullet trains. There is approximately one train per hour per direction from 10 a.m. until 2 p.m. and after 7 p.m. With project implementation, there would be approximately six a.m. and p.m. baby bullet trains per direction. There would be approximately two trains per hour per direction from 9 a.m. until 4 p.m. and after 7 p.m. An example prototypical schedule of proposed Caltrain service is provided in The EIR Appendix I, *PCEP System Ridership Technical Memorandum*. This prototypical schedule was developed to derive ridership estimates and for use in the analysis in this EIR. The actual schedule may vary.

2.3.8 Construction

Construction activities for PECP would consist of the installation of OCS poles and wires; the construction of TPFs; the installation of pantograph inspection platforms; and the erection of overbridge protection barriers on roadway bridges that cross the Caltrain alignment. Installation of wiring and storage tracks within the Central Equipment Maintenance Operations Facility (CEMOF) and at the Lenzen Yard in San Jose are also included. Construction of the electrification infrastructure from San Francisco to San Jose would take approximately 3 to 4 years, including commissioning and testing.

2.3.8.1 Construction Methods

Under normal conditions, pole foundations would be excavated by means of 3-foot-diameter augers, and the soil would be removed to a depth of approximately 15 feet. In areas that are close to drainages paralleling the rail corridor or in areas where there is potential for encountering contaminated soils or groundwater, an alternate process would be used. In order to reduce impacts to the drainage banks and vegetation, a steel casing would be vibrated into place by ultrasonic vibrators. The casing would be sunk to the full 15-foot depth, and soil would be excavated to a depth of only 5 to 7 feet to place the pole foundation.

Spoils resulting from the excavations for OCS pole foundations would be relatively small in quantity. These spoils would be disposed of by spreading them along the railroad ROW in the vicinity of the excavation. Any spoils found to be contaminated with hazardous waste would not be spread within the ROW; the disposal of such material is addressed in EIR Section 3.8, *Hazards and Hazardous Materials*.

Construction would typically occur along 1- to 2-mile sections of the corridor and would involve several “passes” per track. One pass would install the foundations, a second would place the poles, and another would install the feeder wires and support arms; these would then be followed by additional passes for installation of the messenger and contact wires. The final pass would involve a system check to ensure proper installation. This sequence is consecutive; however, construction could occur in several segments simultaneously, with different activities occurring at any or all of those locations.

The construction equipment required for these operations may include flatbed trucks, on which various items of construction equipment would be mounted. These may include auger drill rigs, directional bore machines, cranes, and telescoping boom bucket trucks. There would be other support vehicles, many of which would be fitted with hi-rail equipment, because the primary access to the construction sites for the catenary system would be from the tracks.

The track windows required for the installation of the OCS poles and foundations would be different from those required for other tasks, depending upon whether there is access for the contractor to perform the construction adjacent to the tracks, or whether there are constraints to access due to natural resources or the potential for archaeological resources in the immediate vicinity. Work adjacent to the tracks is best for minimizing impacts on train operations, but work on the tracks may be preferable where feasible to avoid impacts on sensitive resources.

Based upon the current and planned track alignment, there would be approximately 3,200 poles and 3,800 foundations. Approximately 20 to 30 percent of the poles and foundations could be installed with off-track equipment and with minimal impact on train operations. Nominal timeframes for installing OCS pole foundations and poles with off-track access would be between 10:00 a.m. and 3:00 p.m., but installations may be outside these hours if needed to meet the overall construction schedule. The remaining 70 to 80 percent of the poles and foundations would be installed with on-track equipment, requiring single-track access work windows. This work would need to be performed during off-peak operations, with single-tracking, such as:

- 8:00 p.m. to 6:00 a.m., Monday through Thursday
- 8:00 p.m. Friday to 6:00 a.m. Monday

The windows for the installation of the OCS conductors, such as static wires, parallel feeders, and messenger and contact wires, would use on-track equipment and require nighttime and weekend track occupancies, including weekend outages that would require total suspension of passenger revenue service. These track windows would primarily use single-tracking but would require some multiple track shutdowns to install the OCS conductors at the complex interlockings. The majority of such OCS wirework would need to be accomplished during the nighttime using single-track windows, but some portions of the work could only be installed by using complete weekend outages, requiring suspension of passenger service to increase working efficiency and reduce public safety risks. Typical work windows for on-track equipment would be:

- 8:00 p.m. to 6:00 a.m., Monday through Friday (night and multiple tracking)
- 8:00 p.m. Friday to 6:00 a.m. Monday (with single-tracking)

Bridge barrier installation would consist generally of installing prefabricated components onto the existing parapets of the overhead bridges that traverse the project corridor. Work crews would install anchor bolts into the existing bridge structure and then mount the bridge barrier. Equipment used would typically be pneumatic drills, flatbed trucks, utility trucks, boom trucks, generators, and light towers. The JPB would coordinate with Caltrans or city departments of public works to obtain the required permit approvals for barriers on state or city roadways, respectively.

The installation of overbridge protection barriers would occur almost entirely with the use of off-track equipment. Installation of overbridge protection barriers would occur from 7:00 a.m. to 7:00 p.m. Monday through Sunday. Any work requiring the use of on-track equipment would be minimal and would be coordinated with the on-track window requirements for OCS wire installation.

The sites proposed for the location of the traction power substations, switching stations, and paralleling stations are mostly in industrial or open space areas, transportation use, or proximate to existing high-voltage facilities. Site preparation would include clearing, grubbing, and grading with bulldozers and dump trucks. Site access would be prepared concurrently with the site operations.

A ground grid composed of copper wire and driven ground rods, which is necessary for the protection of personnel and equipment during operation of the electrical systems, would be placed below each TPF at a depth of approximately 3 feet and then covered by fill.

Interconnections between electrical equipment would be accomplished in part by raceways contained in concrete encased conduits (duct banks). These duct banks would be installed as explained below.

- Dig a 4-foot-deep trench with backhoe.
- Construct forms as necessary (plywood and 2x4s).
- Arrange conduits per design plans.
- Place encasement concrete.
- Remove forms and backfill with soil.

Concrete foundations would be required for the mounting of freestanding electrical transformers, circuit breakers, and disconnect switches, as well as for the prefabricated control and medium voltage switchgear building. Foundations would generally be constructed as explained below.

- With bulldozer and backhoe, dig to bottom grade per design plan.
- Construct forms as necessary (plywood and 2x4s).
- Arrange reinforcing steel, anchor bolts, grounding connections, and conduits (extensions of duct banks) as required per design plans.
- Place concrete.
- Strip forms and backfill.

Electrical equipment to be installed would include outdoor high-voltage switches, transformers, and cables, as well as the prefabricated control and switchgear room. Some of the equipment would be mounted on small steel structures. Equipment weights range from several hundred pounds to 100,000 pounds; therefore, the installation rigs would range from small truck-mounted cranes to larger track-mounted units. The equipment would be electrically connected together by cable or by buss (open air copper or aluminum tubes). Small truck-mounted cranes would be used to move and arrange the reels of cable and to support buss work during installation.

The primary service from the local utility network would be via either underground or overhead transmission lines. The installation would be either through duct banks or via direct connections to the transmission lines. Station sites would typically be finished with fencing along the entire periphery. Ground surfaces would be covered with clean crushed rock.

The electrical system would be tested prior to initiation of electrified train operations. Testing would be in two main phases. The first phase would involve testing with no power to verify that the installation complies with the design. In the second phase, the system would be energized to verify performance and to adjust system protective devices.

The installation of the substation, switching, and paralleling stations would be done with off-track equipment. The work window requirements for constructing the interface facilities to the OCS conductors would be coordinated with the installation of the OCS wires.

2.3.8.2 Construction Schedule/Durations

The preliminary project schedule (subject to change) is provided below.

- Environmental review/design/permitting: 1–2 years.

- Construction: 3–4 years.
- Testing: 1–2 years.

The goal is to commence electric revenue service is 2019. The construction activities described above are not sequential; construction could occur simultaneously at several locations.

3 Noise and Vibration Descriptors

3.1 Noise

Noise is typically described as unwanted sound. Sound is caused by transmission of mechanical energy that propagates as waves of alternating pressure through a medium (fluids, solids, or gases such as the air). Sound is commonly discussed in terms of a source, path, and receiver. Figure 3-1 illustrates a typical source-path-receiver scenario for airborne sound from rail transit. Several factors affect the quality of sound as perceived by the human ear. Sound can be further described in terms of intensity, pitch, and time variation.

The intensity of a sound is determined by the fluctuation in air pressure above and below the atmospheric pressure at equilibrium by sound waves. Sound intensity is usually expressed in terms of the sound pressure level (L_p) in decibel (dB) units. Decibels are logarithmic values of the ratio of the pressure produced by the sound wave to a reference pressure[7], calculated as:

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

Where "p" is the RMS pressure and "p_{ref}" is the reference pressure.

Decibels are used instead of actual pressure units to account for the extremely large range of sound pressure values that the human ear is capable of perceiving. For example, a train horn noise of 100 dB has about 5,600 times greater pressure than a very low sound of 35 dB typically found in a rural environment.

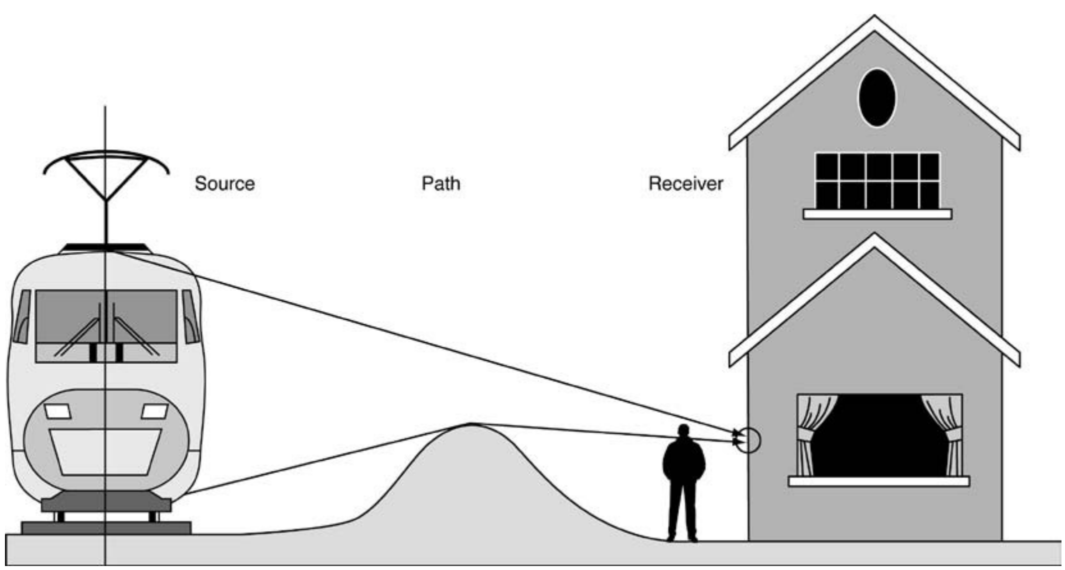
Sound attenuates as a function of the distance between the source and the receiver due to geometric spreading. Geometric spreading loss is due to energy dissipation into three dimensions as sound travels through the air and the wave energy is spread out over an increasingly large area. For point sources,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

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

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

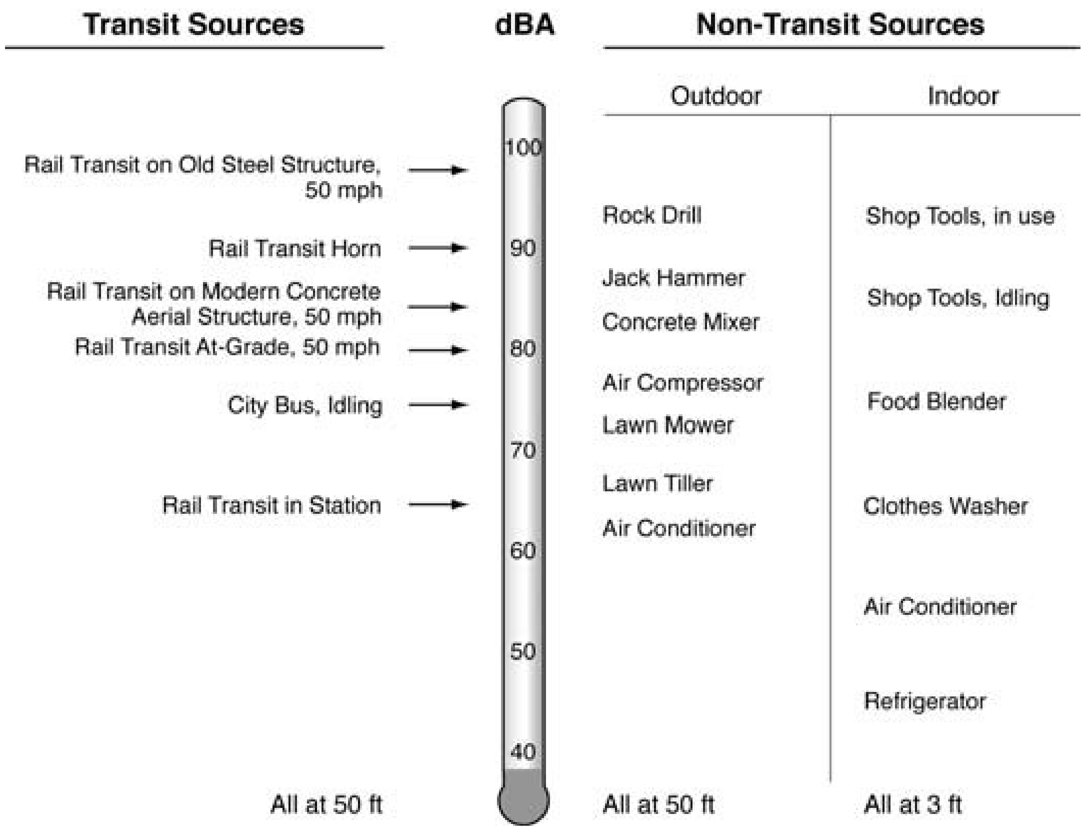
The pitch describes the character and frequency content of noise. It is expressed in terms of the rate of fluctuation of the air pressure in cycles per second or Hertz (Hz). The average human ear is sensitive to noise frequencies between 20 Hz and 20,000 Hz. However, the human hearing system does not respond equally to all frequencies, and it is more sensitive to mid-band frequencies (e.g., 500 to 2,000 Hz). Thus, the A-weighting system de-emphasizes the low and very high frequency components of the sound in a manner similar to the response of the average human ear. The A-weighted sound level (dBA) is commonly used to quantify environmental noise because it correlates well with human response and is expressed in terms of a single number. Figure 3-2 provides a comparison of noise levels of transportation and non-transportation related sources. This figure also provides typical noise levels found at different environmental settings (e.g., urban, rural).

Environmental noise commonly varies with time. There are several descriptors to characterize environmental noise according to their duration. The equivalent noise level (L_{eq}) is the logarithmic (or energy) summation over a period of interest, and it is widely used as a single-number descriptor of environmental noise. One common usage of the L_{eq} is the Day-Night Sound Level (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 between 10 p.m. and 7 a.m. Many studies have shown that the L_{dn} is well-correlated with human annoyance for community noise. Finally, the community noise equivalent level (CNEL) is the A-weighted L_{eq} for a 24-hour period similar to the L_{dn} except that the 24-hour period is broken into three periods for day, evening, and night with a 5 dB penalty applied to the evening period (7 p.m. to 10 p.m.) and a 10 dB penalty applied to the nighttime period (10 p.m. to 7 a.m.). The noise metrics CNEL and L_{dn} are typically equal or differ by no more than 1 decibel. The L_{dn} descriptor will be used in this report to assess 24-hour noise, except where CNEL is used in local ordinances.



Source: FRA, 2012.

Figure 3-1 Source-Path-Receiver Framework for Airborne Wayside Noise



Source: FTA, 2006.

Figure 3-2 Typical A-weighted Sound Levels

3.2 Groundborne Noise and Vibration

Ground vibration is an oscillatory motion of the soil with respect to the equilibrium position and can be quantified in terms of displacement, velocity, or acceleration. Vibration can be described by its peak or 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. Construction vibration is assessed in terms of peak velocity, or peak particle velocity (PPV).

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

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

Where "v" is the RMS velocity amplitude and "v_{ref}" is the reference velocity amplitude[8].

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

Thus, the descriptor used in this report to assess groundborne vibration for human annoyance is the L_v in decibels or VdB[9]. Vibration is a function of the frequency of motion measured in cycles/second or Hz. Ground vibration of concern for transportation sources generally spans from 4 Hz to 60 Hz. The overall vibration is the combined energy of ground motion at all frequencies, and this overall vibration level is used in this analysis.

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

Vibration caused by the transit structure, such as at-grade ballast and tie track, radiates energy into the adjacent soil in the form of different types of waves[10] 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 in Figure 3-3.

Figure 3-4 illustrates the typical levels of human response and, at much higher levels, the structural response to groundborne vibration. The figure shows that the threshold of human perception is about 65 VdB, while the threshold for “cosmetic” structural damage is about 100 VdB (re: 1 micro-in/sec). However, the latter threshold, building damage is directly related to the condition of the structure. It is very rare that transportation-generated ground vibration approaches building damage levels.

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

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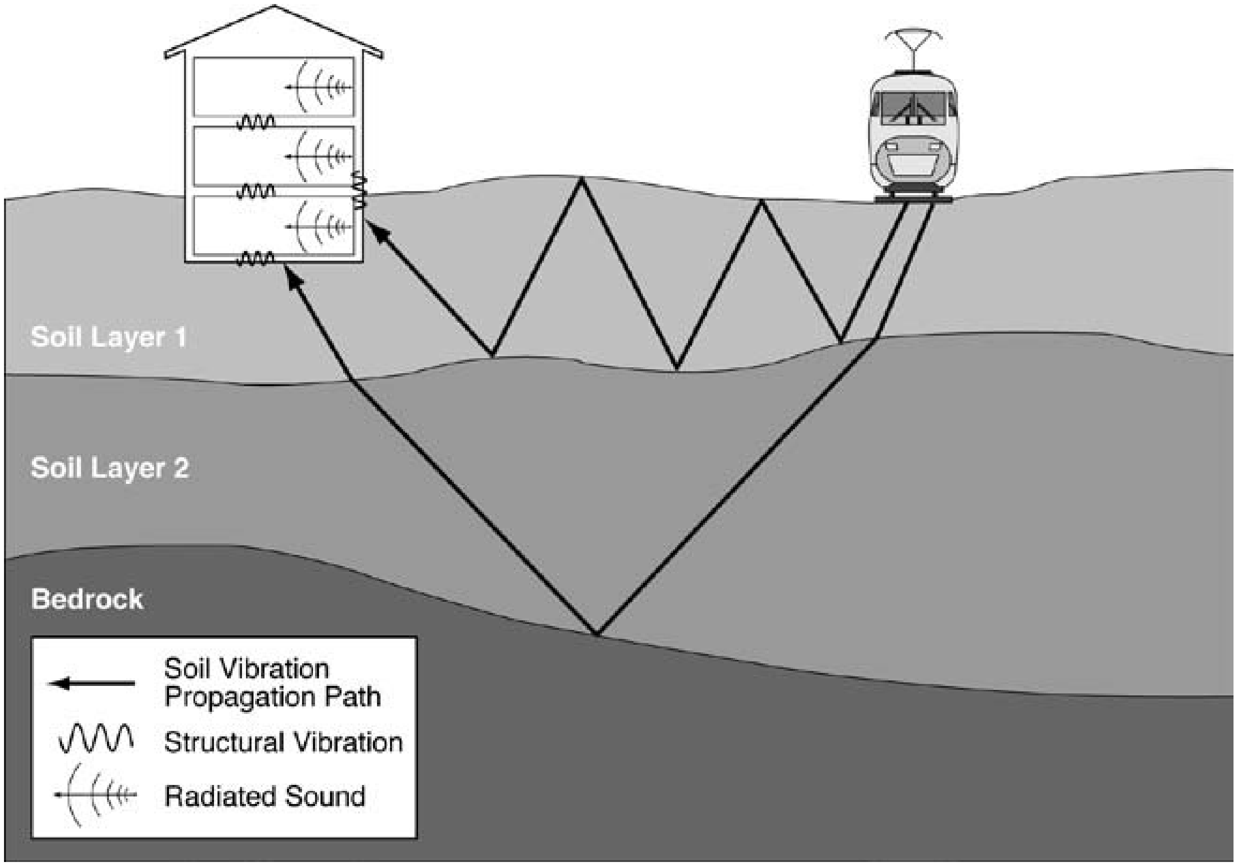
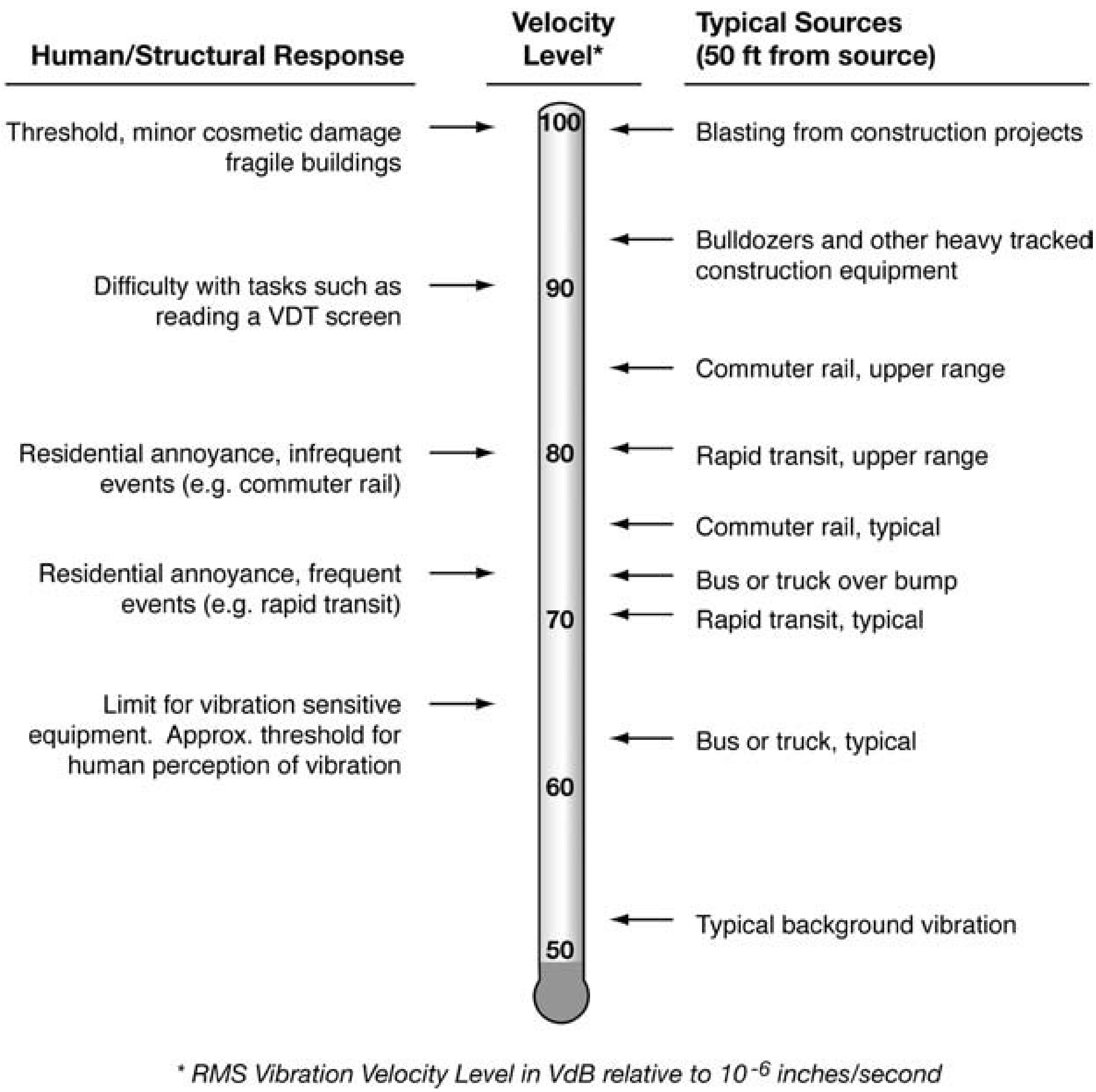
[9] The abbreviation VdB is used in this document for vibration levels to reduce the potential for confusion with sound decibels (dB).

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



Source: FRA, 2012.

Figure 3-3 Propagation of Groundborne Vibration into Buildings



Source: FTA, 2006.

Figure 3-4 Typical Levels of Groundborne Vibration

4 Noise and Vibration Impact Criteria

4.1 Noise Impact Criteria

Several federal laws and guidelines are relevant to the assessment of ground transportation noise and vibration impacts. The National Environmental Policy Act of 1969 (NEPA) requires preparation of an Environmental Impact Statement (EIS) or an Environmental Assessment (EA) for federal or federally supported projects that will affect environmental quality, including noise impacts. The Noise Control Act of 1972 (42 USC 4910) 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.” The California Environmental Quality act (CEQA) requires preparation of an Environmental Impact Report, Mitigated Negative Declaration, or Negative Declaration for discretionary projects requiring public approvals that do not qualify for a statutory or categorical exemption.

The U.S. Department of Transportation, Federal Transportation Administration (FTA) has implemented these mandates and has published impact assessment procedures and criteria for noise (FTA, 2006). The impact criteria are based on maintaining a noise environment considered acceptable for land uses where noise may have an effect. Land use also factors into the determination of impact; while industrial uses are not considered, places where people sleep or where quiet is an integral component of the land use get an additional 5 dB protection. Descriptions of the three land use categories that are subject to noise criteria are shown in Table 4-1. 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 as defined in Table 4-1.

Table 4-1
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 nighttime sensitivity to noise is assumed to be the utmost importance.
3	Outdoor $L_{eq}(h)^b$	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, museums, campgrounds and recreational facilities can also be considered to be in this category. Certain historical sites and parks are also included.

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

The FTA noise impact criteria are based on comparing the existing outdoor noise levels and the future outdoor noise levels from the proposed project in combination with the existing noise. The impact criteria for increases in project noise exposure increase are presented in Figure 4-1 and Figure 4-2. Noise level increases are categorized as *No Impact*, *Moderate Impact*, or *Severe Impact*, where the two levels of noise impact are characterized by:

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

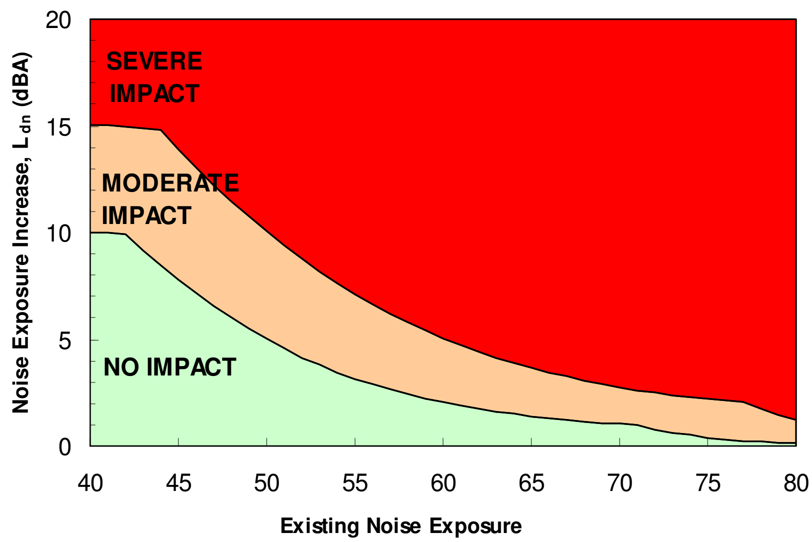
> ***Severe Impact:*** Project-generated noise in the Severe Impact range can be expected to cause a significant percentage of the people to be highly annoyed by the new noise levels and represents the most compelling need for mitigation. Noise mitigation will normally be specified for sensitive receptors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

The thresholds for these three levels of impact, as indicated in Figure 4-1 and Figure 4-2 are based on the increase of the existing ambient noise level associated with operation of the Project and they can also be used to evaluate the Project in combination with other new planned projects (i.e., cumulative impact).

The process of determining impact severity begins with a determination of land use with reference to the land use categories defined in Table 4-1. Once the land use category has been determined, the appropriate noise metric 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 the total noise exposure associated with the proposed project combined with the existing ambient and, in the case of a cumulative noise analysis, other projects. Using the data in Figure 4-1 or Figure 4-2, the severity of impact is determined.

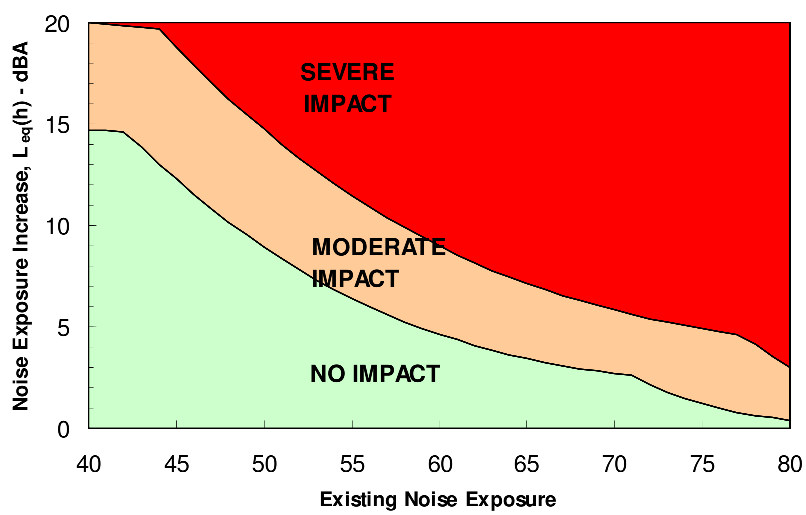
A hypothetical example would be a residential property that has an existing noise exposure of L_{dn} 60 dBA. The noise exposure resulting from the proposed project, regional growth, and other planned projects could result in a noise level exposure of L_{dn} 65 dBA. Adding (on a logarithmic basis) L_{dn} 65 dBA to the existing noise level would result in a total noise exposure of L_{dn} 66 dBA. This represents a potential increase of 6 dBA over the existing noise level. Using Figure 4-1 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* to the residential property

The FTA criteria can also be presented in terms of absolute levels for evaluating noise from the transit project alone. However, the absolute criteria is only applicable to new transit sources where the existing noise levels generated by existing transit systems, roadway, and other sources will not change as a result of the project. The absolute criteria assume the project noise can be added to the existing noise to come up with a new total noise level. If the existing noise was dominated by a source that changed due to the project it would be incorrect to add the project noise to the existing noise. Therefore, the relative form of the noise criteria must be used for projects involving proposed changes to an existing transit system.



Source: FTA, 2006.

Figure 4-1 Allowable Increase in Total Noise Levels Allowed for FTA Category 1 and 2



Source: FTA, 2006.

Figure 4-2 Allowable Increase in Total Noise Levels Allowed for FTA Category 3

4.2 Operation Vibration Criteria

4.2.1 Human Annoyance Criteria

Vibration impact levels are affected by the receptor land-use category and how frequent the vibration events occur, and are stated as the maximum root-mean-square (RMS) vibration level. The impact level also depends on the type of analysis being conducted (i.e., groundborne vibration or groundborne noise).

The FTA provides guidelines to assess the human response to different levels of groundborne noise and vibration from a new project shown in Table 4-2. These levels represent the RMS vibration level of an event (i.e., the vibration during a train passby). In addition, the guideline provides criteria for special buildings that are very sensitive to groundborne noise and vibration. The impact criteria for these special buildings are shown in Table 4-3. There are two recording studios along the existing alignment[11]. Documentation of the existing ambient conditions within those facilities has not been done as part of this study.[12]

The criteria in Table 4-2 and Table 4-3 apply only to occupied spaces within potentially impacted building (i.e., receptor). As indicated in Table 4-2 and Table 4-3 the frequency of train events must be considered.

Groundborne noise impacts are only evaluated for subway projects or in the cases where a special use building has been isolated for noise but not vibration. Since the existing conditions include vibration from surface commuter and freight railroad activities, no further discussion of groundborne noise will be considered in this analysis.

However, additional considerations are given for existing vibration when the project will be located in an existing rail corridor. For a heavily-used rail corridor, defined as more than 12 trains per day, if the existing train vibration exceeds the impact criteria given in Table 4-2 and Table 4-3, the project will cause additional impact if the project significantly increases the number of vibration events. Approximately doubling the number of events is required for a significant increase in number of events.

If there is not a significant increase in vibration events, there will be additional impact only if the project vibration estimated using FTA guidance manual procedures will be 3 VdB or more higher than the existing vibration. These two criteria will be used to evaluate the vibration from the Project.

[11] Trieste Recording Studios at 1465 25th St, San Francisco, CA 94107; and HIT Wall Recording at 120 S Linden Avenue, South San Francisco, CA 94080
[12] If the Project should introduce a new noise or vibration impact, then measurements to document the existing conditions would be included as part of the mitigation.

Table 4-2
Groundborne Vibration (GBV) and Groundborne Noise (GBN) Impact Criteria

Land Use Category	GBV Impact Levels (VdB re 1 micro inch/sec)			GBN Impact Levels (dB re 20 micro Pascals)		
	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

Notes:
1. Frequent Events is defined as more than 70 vibration events of the same source per day.
2. Occasional Events is defined as between 30 and 70 vibration events of the same source 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. Ensuring lower vibration levels in a building often requires special design of the HVAC systems and stiffened floors.
5. Vibration-sensitive equipment is generally not sensitive to groundborne noise.

Source: FTA, 2006

Table 4-3
Groundborne Vibration and Groundborne Noise Impact Criteria for Special Buildings

Type of Building or Room	Groundborne Vibration Impact Levels (VdB re 1 micro-inch/sec)		Groundborne Noise Impact Levels (dB re 20 micro-Pascals)	
	Frequent[1] Events	Occasional or Infrequent[2] Events	Frequent[1] Events	Occasional or Infrequent[2] Events
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

Notes:
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.

Source: FTA, 2006

4.2.2 Building Damage Criteria

Normally, vibration resulting from a train passby would not cause building damage. However, damage to fragile historic buildings located near the right-of-way can be a concern if the vibration approaches or exceeds 90 VdB. As documented in Section 5.1.2, the existing train vibration does not reach this level and the Proposed Project, which could potentially generate lower vibration levels than the existing trains with the use of lighter-weight EMUs, would also not reach this level. Further discussion on vibration criteria for construction is included in the next section.

4.3 Construction Noise and Vibration Criteria

The FTA construction criteria were used for identifying construction noise and vibration impacts. The FTA assessment criteria for construction noise are presented in Table 4-4. The criteria are based on the equivalent sound level (Leq) from all equipment operating during a given 8-hour period. Noise impacts for long-term construction projects, with daily variations in construction activities, are based on a 30-day average Ldn or Leq.

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

The local noise ordinances for all the cities/municipalities along Caltrain corridor generally limit construction noise to particular time periods during weekday, weekend, and holiday daylight hours. Nighttime construction work is generally prohibited, but some jurisdictions allow for a variance. Some of the municipal codes provide more detailed comments regarding construction noise by listing the maximum noise levels allowable at property lines or at a specified distance from construction equipment.

For the municipal codes that include construction noise level limits, the allowable maximum noise levels at property lines differ by jurisdiction, ranging from 86 to 110 dBA. Since the local municipal codes specify construction noise limits in terms of maximum levels, and are not assessed using an energy-averaged sound level, it is difficult to compare them directly to the FTA criteria. If one assumes that the all the construction equipment generates 86 dBA continuously over an 8-hour period, the corresponding Leq value would also be 86 dBA Leq. Typically, the actual level will be less, because each piece of equipment generates its maximum noise for only a portion of every hour and portion of every 8-hour work day. For example, construction equipment that would exceed the municipal codes’ maximum noise limits during a given activity, could potentially comply with the FTA criteria when energy-average over 8 hours with non-continuous operation.

Table 4-4
FTA Construction Noise Assessments Criteria

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

Notes:
a In urban areas with very high ambient noise levels (L_{dn} > 65 dB), L_{dn} from construction operations should not exceed existing ambient + 10 dB.
b 24-hour L_{eq}, not L_{dn}.
Source: FTA, 2006.

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

Vibrations generated by surface transportation and construction activities are mainly in the form of surface or Raleigh waves. Studies have shown that the vertical component of transportation generated vibrations is the strongest, and that peak particle velocity (PPV) correlates best with building damage and complaints. Table 4-5 summarizes the construction vibration limits shown in FTA guidelines for structures located near the right-of-way of a transit project.

Table 4-5
Construction Vibration Damage Criteria

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

* RMS velocity in decibels (VdB) re: 1 micro-inch per second
Source: FTA, 2006.

4.4 Stationary Source Criteria

The noise criteria for stationary sources, such as electrical substations and support facilities, were established by the FTA methods described in Section 4.1. Thus, the noise from these facilities is evaluated as part of the entire project noise, and the impact is based on comparing the project noise with the existing conditions. Most of the local codes limit continuous noise to be the same as the existing ambient, in some cases up to 5 to 10 dBA above the existing ambient background. The net result being an increase of 3 to 6 dBA over the existing ambient condition. For existing noise environments on the order of 65 to 70 Ldn, the FTA noise criteria discussed above in Section 4.14.1 typically defines a moderate noise impact as a noise increase around 1 to 2 dBA and a severe impact for noise increase above 3 dBA, which is consistent with or more restrictive than local codes.

4.5 Local Regulations

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

4.5.1 Local Regulations - General Plan Noise Elements

The Noise Elements in the General Plans for all the cities/municipalities along Caltrain corridor identify the average noise standard for the Community Noise Equivalent Level (CNEL) to be 65 dB. This is usually illustrated by 65 dB CNEL noise contours overlaid over a map of the city/municipality. These contours consistently follow the railroad tracks, freeways and major connectors that intersect the cities/municipalities, indicating that these are the major sources of existing noise exposure in the communities. Brisbane, South San Francisco, San Bruno, Millbrae, Burlingame, San Carlos, Menlo Park, Palo Alto, Sunnyvale, Santa Clara and San Jose also indicate noise from adjacent airports as contributing factors to the existing noise levels.

4.5.2 Local Regulations - Municipal Codes

The property line noise level restrictions in the municipal codes for the various cities along the Caltrain corridor can be grouped into four general methods. (1) The municipal codes for San Francisco, Brisbane, San Bruno, San Carlos, Redwood City and Palo Alto regulate the property line noise levels based on the dBA level above local ambient, with the local ambient defined in each City's code. (2) South San Francisco, San Mateo, Belmont, North Fair Oaks/ San Mateo County, Menlo Park, Atherton, Sunnyvale and Santa Clara all provide maximum allowable noise levels for day time and night time hours. Some of these cities further delineate the maximum allowable noise level per land use type, while others include additional regulations regarding tonal noises. (3) The San Jose municipal code specifies maximum allowable noise levels at residential and commercial property lines but does not provide further detail with regard to time periods or local ambient noise levels. (4) The cities of Millbrae and Burlingame do not include any quantitative noise limits in their municipal codes.

Most of the cities along this corridor limit construction noise to particular time periods during weekday, weekend and holiday daylight hours. Nighttime construction is prohibited. Some of the municipal codes provide more detailed comments regarding construction noise by listing the maximum noise levels allowable at property lines or at a specified distance from construction equipment.

Of all the cities along the Caltrain corridor, only Sunnyvale, Santa Clara, and San Jose specify limits on groundborne vibration. Santa Clara's municipal code sets the vibration perception threshold at a motion velocity of 0.01 inch/second over the range of one to 100 Hz which cannot be exceeded at the adjoining property lines for all land use types. Construction activities are exempt from both noise and vibration limits during allowed hours per the Santa Clara municipal code. Sunnyvale and San Jose limit ground vibration to activity which is imperceptible without instrumentation at the property line.

Table 4-6 summarizes the local ordinances for the cities along the Caltrain corridor.

Table 4-6
Summary of Local Noise and Vibration Ordinances

Jurisdiction	Noise/Vibration Source	Maximum Allowable Levels or Exemption
San Francisco	Construction	7:00 AM to 8:00 PM: 80 dBA measured at a distance of 100 feet from construction equipment. 8:00 PM to 7:00 AM: no more than 5 dBA above the ambient at any point outside of the property plane.
	Fixed	Residential Interior Noise: 45 dBA from 10:00 PM to 7:00 AM, 55 dBA from 7:00 AM to 10:00 PM with windows open except were building ventilation is achieved through mechanical means that allow windows to remain closed.
	General	Not more than 5 dBA above the ambient at any point beyond residential property plane; not more than 8 dBA above the ambient at any point beyond commercial and industrial property plane. Minimum ambient is defined as: 35 dBA for interior residential noise, and 45 dBA in all other locations.
Brisbane	Construction	83 dBA at 25 feet from individual equipment; 86 dBA at any point outside the property plane of the project. Construction permitted weekdays from 7:00 AM to 7:00 PM; weekends and holidays from 9:00 AM to 7:00 PM.
	General	Not more than 10 dB over ambient for more than 15 minutes per hour, or not more than 20 dB over ambient for more than 3 minutes per hour. Minimum ambient is defined as: 35 dBA for interior residential noise, and 45 dBA in all other locations.
South San Francisco	Construction	90 dBA at 25 feet from individual equipment; 90 dBA at any point outside the property plane of the project. Construction permitted weekdays from 8:00 AM to 8:00 PM; Saturdays from 9:00 AM to 8:00 PM; Sundays and holidays from 10:00 AM to 6:00 PM.

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

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

Jurisdiction	Noise/Vibration Source	Maximum Allowable Levels or Exemption
	General	Exterior noise: Not more than 55 dBA daytime and 50 dBA nighttime for 30 minutes per hour. Not more than 60 dBA daytime and 55 dBA nighttime for 15 minutes per hour. Not more than 65 dBA daytime and 60 dBA nighttime for 5 minutes per hour. Not more than 70 dBA daytime and 65 dBA nighttime for 1 minute per hour. Not more than 75 dBA daytime and 70 dBA nighttime for any length of time. If the measured ambient level for any area is higher than the standard, then the ambient shall be the base noise level. In such cases, the noise levels shall be increased in five dBA increments above the ambient. Interior noise: Not more than 45 dBA daytime and 40 dBA nighttime for 5 minutes per hour. Not more than 50 dBA daytime and 45 dBA nighttime for 1 minute per hour. Not more than 55 dBA daytime and 50 dBA nighttime for any length of time. If the measured ambient level for any area is higher than the standard, then the ambient shall be the base noise level. In such cases, the noise levels shall be increased in five dBA increments above the ambient. Daytime is defined as 7:00 AM to 10:00 PM; Nighttime is 10:00 PM to 7:00 AM.
Atherton	Construction	Construction permitted weekdays from 8:00 AM to 5:00 PM; prohibited on weekends and holidays.
	General	Not more than 60 dBA from 7:00 AM to 10:00 PM and 50 dBA from 10:00 PM to 7:00 AM beyond the property line. If the measured ambient equals or exceeds the noise limit, then the noise limit shall be 5 dB over the limit.
Menlo Park	Construction	85 dBA at 50 feet from equipment. Construction permitted weekdays between 8:00 AM and 6:00 PM; prohibited on weekends and holidays.
	General	Not more than 60 dBA from 7:00 AM to 10:00 PM and 50 dBA from 10:00 PM to 7:00 AM beyond the property line.
Palo Alto	Construction	110 dBA at 25 feet from individual equipment; 110 dBA at any point outside the property plane of the project. Construction permitted weekdays from 8:00 AM to 6:00 PM; Saturdays from 9:00 AM to 6:00 PM; prohibited Sundays and holidays.
	General	Not more than 6 dBA above ambient beyond residential property plane; not more than 8 dBA above ambient beyond commercial or industrial property plane. Minimum ambient is defined as: 30 dBA for interior residential noise, and 40 dBA in all other locations.
Mountain View	Construction	Construction permitted weekdays from 7:00 AM to 6:00 PM; prohibited weekends and holidays.
	Stationary	Not more than 55 dBA from 7:00 AM to 10:00 PM; not more than 50 dBA from 10:00 PM to 7:00 AM. Levels as measured at any location on any receiving residential property.
Sunnyvale	Construction	Construction permitted weekdays from 7:00 AM and 6:00 PM; Saturdays from 8:00 AM to 5:00 PM; prohibited on Sundays and national holidays

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

5 Existing Noise and Vibration Conditions

The existing ambient noise in the Caltrain corridor is primarily dominated by noise from the existing Caltrain rail service, tenant passenger and freight rail service on the Caltrain corridor, traffic on main highways and major arterials nearby, and aircraft flyover noise from nearby airports including San Francisco and San Jose International. The existing ambient vibration in the corridor is dominated by vibration from the Caltrain rail service and tenant passenger and freight rail service, and to a much lesser extent traffic on nearby streets.

In areas of the corridor that have grade crossings, the current environmental noise conditions are influenced to a large degree by warning horn noise from Caltrain and tenant passenger and freight rail service. Horn noise can be heard at great distances from the rail alignment, depending on geographical characteristics and meteorological conditions among other factors. However, the area over which train horn noise generally has an impact is normally limited to 0.25-mile in each direction from the grade crossing. The current number of grade crossings would not change as part of this Project and the number of grade crossings would be the same for both the No Project and Proposed Project conditions. However, the San Bruno Grade Separation Project, which is separate from the electrification project, will grade separate three current at-grade crossings (San Bruno, San Mateo and Angus avenues in San Bruno) by 2015, and thus horn noise would be eliminated at these crossings under both No Project and Proposed Project conditions.

Freight trains operating on the existing rail alignment are another source of ambient noise and vibration. Currently, freight trains nominally operate between 8 p.m. and 5 a.m. The noise measurement results show clear peaks in the hourly noise levels between 10 p.m. and 5 a.m., and these peaks were attributed to freight activity. Wilson, Ihrig and Associates (WIA) estimates the relative influence of freight activity on Ldn levels is on the order of 1 to 4 dBA. See discussion in Section 7-1.

Noise sensitive receptors along the Caltrain corridor include many land uses such as residential areas, schools, and hospitals. The representative sites from the Parsons 2008 study were used for the current analysis[13]. These representative sites are first-row residential areas abutting the Caltrain right-of-way, at distances that are 40 to 190 feet from the nearest Caltrain track. To address the existing environmental setting for the Caltrain corridor, WIA conducted measurements of the prevailing noise and groundborne vibration at numerous locations along the corridor as described below.

5.1 Field Measurements

A summary of all measurement locations are shown in Figure 5-1. Attachment C contains maps showing the measurement locations and receptors sites in more detail.

[13] Parsons' report indicates that "sensitive receptors were selected by their proximity to the alignment and land usage, with coverage of the length of the alignment in mind." The distances range from 40 to 190 feet distance from near track, with most typically 50 to 120 feet from near track. Ancillary facility receptors are farther from the alignment (80 to 1400 feet) but those were chosen based on screening distance from facility.

5.1.1 Existing Ambient Noise

Long-term noise measurements were conducted for a minimum of one week between May 17, 2013 and May 27, 2013 at 12 sites to characterize the existing ambient noise in areas along the Caltrain alignment and update the measurements dated from 2001 and 2002 contained in the Parsons technical study used for the 2009 Final Caltrain Electrification Project EIR/S (Parsons 2008). The results of the 2013 noise survey are contained in Table 5-1.

WIA previously conducted an extensive noise survey along the Caltrain alignment for the 2010 High Speed Rail study of the Caltrain corridor. The survey included long-term noise measurements one to three days in duration that were conducted at 35 sites between October 16, 2009 and December 2, 2009 and an additional 19 locations between March 4, 2010 and March 12, 2010. The results of this survey are summarized in a brief memo (WIA 2013) and reproduced in Table 5-2.

Specific locations for conducting the 2013 noise measurements were chosen based on review of the Parsons 2008 study data in conjunction with the HSR measurement data. The locations that were chosen are those from the Parsons 2008 study where either similar data were not available from the HSR measurement data or where the HSR measurement data differed substantially from the Parsons 2008 study data.

Long-term noise measurements were obtained by means of calibrated, precision, logging, sound level meters. All noise-measuring instruments used during the noise surveys meet 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 one hour intervals. During the monitoring period, the maximum noise level (L_{max}), minimum noise level (L_{min}), and hourly equivalent noise levels (L_{eq}) were also obtained. The L_{eq} were used to calculate the daily Day-Night Noise Level (DNL or L_{dn}) over each 24-hour period measured.

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

5.1.2 Existing Ambient Vibration

Measurements of the existing vibration levels were performed at 9 sites along the Caltrain alignment. The 9 sites chosen are roughly the same sites where vibration measurements were performed for the Parsons 2008 study. Since Caltrain trains are the dominant source of ground vibration, the vibration survey focused on obtaining ground vibration during Caltrain passbys at a typical setback distance between sensitive receptors and the nearest track. Measurements of at least twelve Caltrain train passbys were recorded at different locations. For each site, train vibration was measured at four distances from the rail alignment.

WIA previously conducted measurement of existing vibration levels along the Caltrain alignment for the High Speed Rail study of the Caltrain corridor (WIA 2013). The 2010 vibration survey included measurements at 22 sites along the Caltrain alignment between October 2009 and March 2010. At each site, measurements of at least three Caltrain train passbys were recorded at two distances from the rail alignment. The results of this survey are contained in a memo (WIA 2013) and reproduced in Table 5-4.

Results of the ambient vibration survey provide not only an indicator of the existing overall vibration levels throughout the corridor, but also indicate the degree of variability in soil vibration characteristics along the alignment, since the vibration source (Caltrain) is similar throughout the corridor.

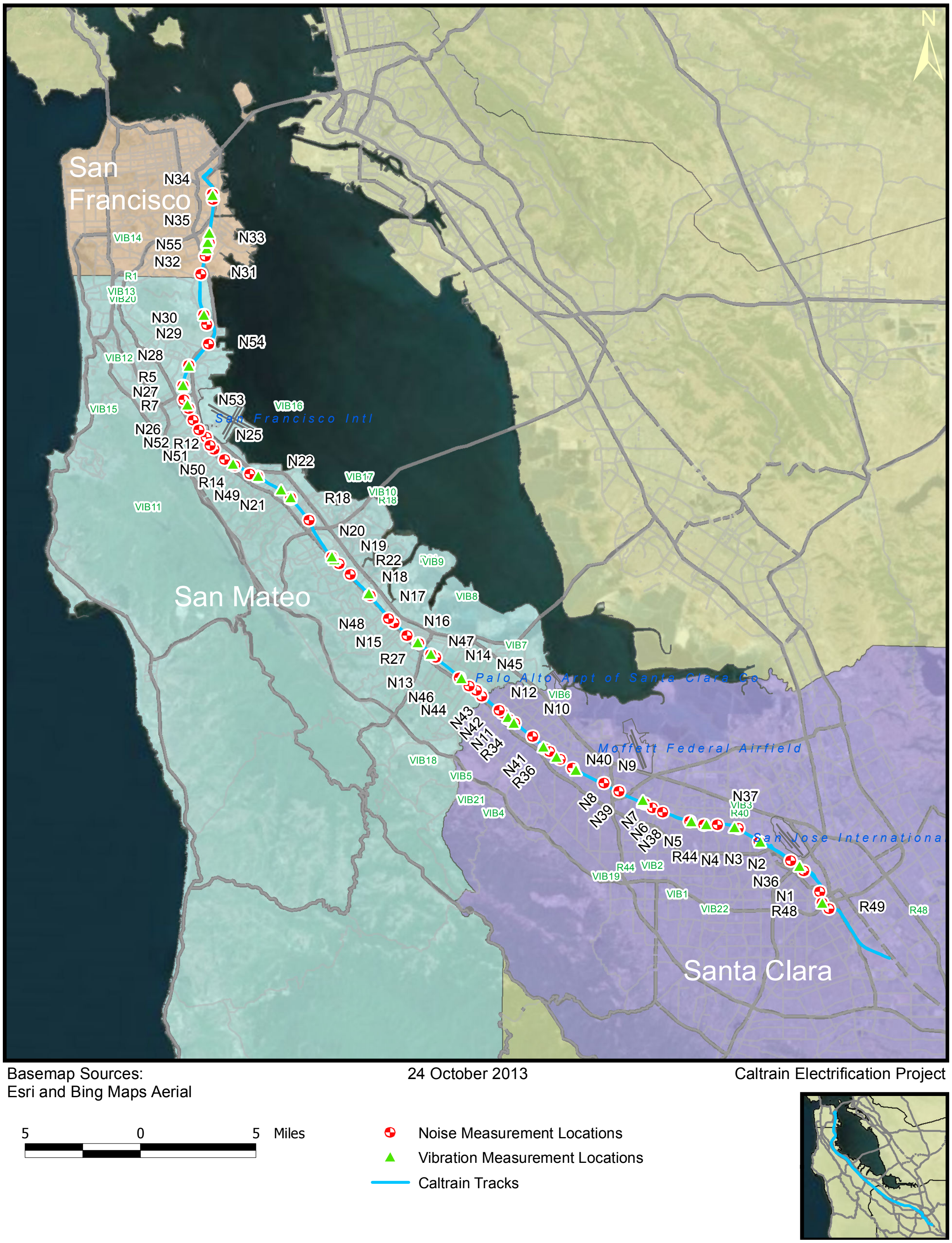


Figure 5-1 Overview Map of All Field Measurement Locations

5.2 Description of Existing Environmental Settings

5.2.1 Existing Noise Setting

The results of the existing ambient noise surveys are discussed in the following sections. Table 5-1 and Table 5-2 show the noise measurement results for the 2013 and 2009-2010 noise surveys, respectively. Figure 5-1 illustrates the approximate locations where these noise and vibration surveys were conducted. Details of the specific locations are presented in Attachment C.

5.2.1.1 San Francisco County

No new noise measurements were conducted in this section for the project.

For the HST project, existing noise levels were characterized at six locations in the vicinity of the Caltrain corridor: N34, N35, N33, N55, N32, and N31. The ambient conditions correspond to that of an Urban setting. Sources of ambient noise are Caltrain trains, freight trains, vehicles on I-280 and US 101, and local motor-vehicle traffic. The ambient L_{dn} ranged from 64 dBA to 74 dBA depending on the location. The peak hour noise level (L_{eq}) ranged between 62 dBA and 74 dBA.

At location N33, the peak hour L_{eq} was relatively low at 64 dBA primarily due to the noise-shielding provided by first-row buildings (homes) of Caltrain trains and the distance from main arterials or freeways. A similar situation was observed for receptors near N55 because of the shielding provided by the storage buildings located next to the rail alignment.

5.2.1.2 San Mateo County

Noise levels were measured near four Receptor Sites between San Bruno and San Mateo: R5, R7, R12, and R14. The average L_{dn} noise levels ranged from 63 dBA to 78 dBA. The peak hour L_{eq} levels ranged from 65 dBA and 78 dBA.

Relatively lower levels (63 dBA L_{dn} and 65 dBA Peak Hour L_{eq}) were obtained at location R12 which was approximately 245 feet west of the southbound Caltrain track and situated behind the first row of homes along Hemlock Avenue.

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

For the HST project, noise measurements were obtained at 28 locations within San Mateo County: N30, N29, N54, N28, N27, N53, N26, N52, N25, N51, N50, N49, N22, N21, N20, N19, N18, N17, N48, N16, N15, N47, N14, N13, N46, N45, N12, and N44.

The average ambient day-night noise level (L_{dn}) varied between 66 dBA and 77 dBA depending on location, distance from the alignment, proximity to grade crossings and other noise sources. Peak Hour L_{eq} levels ranged from 64 dBA to 79 dBA.

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

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

5.2.1.3 Santa Clara County

Noise levels were measured near five Receptor Sites between Palo Alto and San Jose: R34, R36, R44, R48, and R49. The average L_{dn} noise level ranged from 69 dBA to 82 dBA and peak hour L_{eq} noise levels ranged from 69 to 83 dBA.

R36 and R48 are near at-grade rail crossings and the noise levels in excess of 80 dBA for both the L_{dn} and peak hour L_{eq} are attributed to the influence of noise from train warning horns and crossing bells.

For the HST project, noise measurements were obtained at nineteen locations within Santa Clara County: N43, N42, N11, N10, N41, N40, N9, N8, N39, N7, N6, N38, N5, N4, N37, N3, N2, N36, and N1.

The average ambient day-night noise level (L_{dn}) varied between 61 dBA and 77 dBA depending on location, distance from the alignment, proximity to grade crossings and other noise sources. Peak Hour L_{eq} levels ranged from 60 dBA to 78 dBA.

The average L_{dn} levels obtained at N11 and N41 were 61 dBA and 62 dBA, respectively. The average L_{dn} obtained at both N4 and N3 was 63 dBA. N11, N41, N4, and N3 measurement locations are representative of the existing ambient noise for single-family residences located on the western side of the Caltrain alignment. However, because noise measurements were obtained in front of the homes (whereas Caltrain noise affects the back of homes) adjustments to the measured noise level will be applied to determine the noise exposure at the back of the properties.

Table 5-1
Summary of 2013 Ambient Noise Measurement Locations and Noise Levels

County	Site No	Address	Land Use	Distance[1], feet	Date Surveyed	Average[2] L_{eq}, dBA	Average[3] L_{dn}, dBA
San Mateo County	R5	1289 Herman Street, San Bruno	Residential	85	5/17/13 – 5/24/13	78	78
	R7	847 Huntington Avenue, San Bruno	Residential	100	5/17/13 – 5/24/13	75	74
	R12	20 Hillcrest Boulevard, Millbrae	Residential	244	5/17/13 – 5/27/13	65	63
	R14	1457 California Drive, Burlingame	Residential	155	5/17/13 – 5/27/13	72	71
	R18	142 N. Railroad Avenue, San Mateo	Residential	40	5/17/13 – 5/27/13	76	74
	R22	102 Blossom Circle, San Mateo	Residential	128	5/17/13 – 5/27/13	71	70
	R27	198 Buckingham Avenue, Redwood City	Residential	50 - 70	5/17/13 – 5/25/13	72	71
Santa Clara County	R34	Peers Park, Palo Alto	Residential	40	5/17/13 – 5/25/13	73	71
	R36	4201 Park Boulevard, Palo Alto	Residential	35	5/17/13 – 5/25/13	81	80
	R44	3585 Agate Street, Santa Clara	Residential	130	5/17/13 – 5/27/13	69	69
	R48	782 Auzerais Avenue, San Jose	Residential	45	5/17/13 – 5/27/13	83	82
	R49	748 Illinois Avenue, San Jose	Residential	50	5/17/13 – 5/27/13	71	71

Notes:

1. Approximate distance from near track
2. Arithmetic average of weekday Ldn levels for Mon 5/20/13 through Fri 5/24/13 (5 days)
3. Arithmetic average of weekday Peak Hour Leq levels for Mon 5/20/13 through Fri 5/24/13 (5 days)
4. R5, R7, R36 and R48 within ¼ mile from at-grade crossings
5. R18 and R44 near stations

Source: WIA, 2013.

Table 5-2
Summary of 2009-2010 Ambient Noise Measurement Locations and Noise Levels

Sub - section	Location ID	Address	Land Use	Distance[1] feet	Date Surveyed	Average[2] L_{eq}, dBA	Average[3] L_{dn} , dBA
San Francisco County	N34	431 Pennsylvania Avenue, San Francisco	Residential	160	11/06/09 – 11/10/09	71	65
	N35	1174 22nd Street, San Francisco	Residential	75	11/30/09 – 12/02/09	74	74
	N33	48 Reddy Street, San Francisco	Residential	170	11/06/09 – 11/10/09	64	64
	N55	88 Kalmanovitz, San Francisco	Residential	165	06/14/10 – 06/15/10	62	64
	N32	48 Gould Street, San Francisco	Residential	135	06/14/10 – 06/15/10	69	68
	N31	327 Tunnel Avenue, San Francisco	Residential / Church	70	11/06/09 – 11/10/09	72	71
San Mateo County	N30	42 San Francisco Avenue, Brisbane	Residential	410	11/06/09 – 11/10/09	77	75
	N29	50 Joy Avenue, Brisbane	Residential	930	11/03/09 – 11/05/09	71	76
	N54	1300 Veterans Boulevard, South San Francisco	Hotel	100	03/09/10 – 03/10/10	72	77
	N28	242 Village Way, South San Francisco	Residential	400	11/03/09 – 11/05/09	79	77
	N27	1209 Herman Street, San Bruno	Residential	80	11/03/09 – 11/05/09	75	76
	N53	576 First Avenue, San Bruno	Residential	80	03/09/10 – 03/12/10	69	75
	N26	265 San Luis Avenue, San Bruno	Residential	180	11/03/09 – 11/05/09	68	68
	N52	1036 San Antonio Avenue, Millbrae	School	115	03/09/10 – 03/12/10	64	70
	N25	254 Monterey Street, Millbrae	Residential	150	11/03/09 – 11/05/09	71	71
	N51	150 Serra Avenue, Millbrae	Hospital	70	03/09/10 – 03/12/10	68	73
	N50	1710 California Drive, Burlingame	Hospital / Residential	140	03/09/10 – 03/12/10	63	68
	N49	966 California Drive, Burlingame	School	145	03/09/10 – 03/12/10	71	74
	N22	815 Carolan Avenue, Burlingame	Residential	145	10/30/09 – 11/02/09	74	71
	N21	396 Catalpa Street, San Mateo	Residential	50	10/30/09 – 11/02/09	71	69
	N20	1416 South Railroad Ave, San Mateo	Residential	95	10/30/09 – 11/02/09	71	67
	N19	8 Antioch Drive, San Mateo	Residential	90	10/28/09 – 10/29/09	73	73
	N18	792 Old Country Road,	Residential	120	10/28/09 –	74	73

Table 5-2
Summary of 2009-2010 Ambient Noise Measurement Locations and Noise Levels

Sub - section	Location ID	Address	Land Use	Distance[1] feet	Date Surveyed	Average[2] L_{eq}, dBA	Average[3] L_{dn}, dBA
		Belmont			10/29/09		
	N17	1088 Sylvan Drive, San Carlos	Residential	85	10/28/09 – 10/29/09	69	70
	N48	1552 West el Camino Real, San Carlos	Hotel	175	03/09/10 – 03/12/10	70	73
	N16	1840 Stafford Street, San Carlos	Residential	80	10/28/09 – 10/29/09	75	73
	N15	100-198 Winklebleck Street, Redwood City	Commercial	245	10/28/09 – 10/29/09	69	69
	N47	631 Pennsylvania Ave, Redwood City	Residential	40	03/09/10 – 03/12/10	73	77
	N14	200 Berkshire Avenue, Redwood City	Residential	40 – 55	10/23/09 – 10/27/09	70	72
	N13	1601 Stone Pine Lane, Menlo Park	Residential	35	10/23/09 – 10/27/09	76	70
	N46	1128 Merrill Street, Menlo Park	Commercial	105	03/09/10 – 03/12/10	66	72
	N45	638 Alma Street, Menlo Park	Park	130	03/05/10 – 03/08/10	65	68
	N12	248 Alma Street, Menlo Park	Residential	135	10/23/09 – 10/27/09	71	66
	N44	118 West El Camino Real, Menlo Park	Hotel	60	03/05/10 – 03/08/10	66	70
Santa Clara County	N43	Lucas Lane and Encina Avenue, Palo Alto	Hospital	35	03/05/10 – 03/08/10	67	72
	N42	Lucas Lane and Embarcadero Road, Palo Alto	School	35	03/05/10 – 03/08/10	70	74
	N11	1528 Mariposa Avenue, Palo Alto	Residential	180	10/23/09 – 10/27/09	62	61
	N10	3040 Alma Street, Palo Alto	Residential	120	10/23/09 – 10/27/09	78	77
	N41	4116 Park Boulevard, Palo Alto	Residential	190	03/05/10 – 03/08/10	57	62
	N40	4243 Alma Street, Palo Alto	Church	125	03/09/10 – 03/12/10	72	75
	N9	2358 Central Expressway, Mountain View	Residential	135	10/20/09 – 10/21/09	76	75
	N8	112 Horizon Avenue, Mountain View	Residential	285	10/20/09 – 10/21/09	71	71
	N39	Central Expressway and Whisman Station Drive, Mountain View	Residential	185	03/05/10 – 03/08/10	69	71
	N7	981 Asilomar Terrace, Sunnyvale	Residential	90	10/20/09 – 10/21/09	69	66

Table 5-2
Summary of 2009-2010 Ambient Noise Measurement Locations and Noise Levels

Sub - section	Location ID	Address	Land Use	Distance[1] feet	Date Surveyed	Average[2] L_{eq}, dBA	Average[3] L_{dn}, dBA
	N6	110 Waverly Street, Sunnyvale	Residential	100	10/20/09 – 10/21/09	71	70
	N38	111 West Evelyn Avenue, Sunnyvale	Commercial	85	03/05/10 – 03/08/10	72	76
	N5	Evelyn Terrace, Santa Clara	Residential	35 – 50	10/16/09 – 10/19/09	72	72
	N4	2790 Agate Drive, Santa Clara	Residential	160 – 175	10/16/09 – 10/19/09	64	63
	N37	2400 Walsh Avenue, Santa Clara	School	220	03/05/10 – 03/08/10	60	64
	N3	2079 Main Street, Santa Clara	Residential	140	10/16/09 – 10/19/09	64	63
	N2	1315 De Altura Commons, San Jose	Residential	95 – 115	10/16/09 – 10/19/09	67	65
	N36	726 Emory Street, San Jose	School	430 – 450	03/05/10 – 03/08/10	61	64
	N1	102 Laurel Grove Lane, San Jose.	Residential	125	10/20/09 – 10/21/09	70	72

Notes:
1. Approximate distance from near track. Range of distance shown where there are more than 2 tracks.
2. Arithmetic average of weekday Peak Hour Leq levels (2 days)
3. Arithmetic average of weekday Ldn levels (2 days)
4. N34, N33, N55, N28, N18, N11, N41, N7 (partially), N4, and N3 acoustically shielded from direct Caltrain noise exposure
5. N27, N53, N25, N49, N22, N21, N16, N15, N47, N13, N46, N45, N44, N11, N41, N9, N8, N7, and N38 within ¼ mile from at-grade crossings
6. N34, N35, N31, N26, N51, N49, N21, N18, N17, N15, N46, N40, N8, N38, N36, and N1 near stations

Source: WIA, 2013.

5.2.2 Existing Vibration Setting

The results of the existing ambient vibration surveys are discussed in the following sections. Table 5-3 and Table 5-4 show the vibration measurement results for the 2013 and 2009-2010 vibration surveys, respectively. Figure 5-1 illustrates the approximate locations where these noise and vibration surveys were conducted. Details of the specific locations are presented in Attachment C.

The results obtained in 2013 and 2009-2010 are different from those reported by Parsons in their 2008 technical study (Parsons 2008). The reasons for this are not clear; however, in our experience the values reported by Parsons are very high, and not typical for commuter rail train vibration[14].

[14] Possible causes of the discrepancy could be a misunderstanding of measurement or analysis methodology by Parsons, disagreement of methodology between Parsons and WIA methods, etc.

The highest vibration levels for each site are primarily associated with trains operating at top speeds, and this is to be expected. WIA observed top train speeds on the order of 79 mph +/- at all sites with the exception of Site R48 where speeds were up to 39 mph. There is a substantial amount of variation in the data between measurement sites which can be expected due to local soil conditions. Broadly speaking, Caltrain passbys ranged between 70 to 80 VdB for a nominal distance of 50 feet depending on measurement site. At greater distance from track centerline, for example 150 feet, vibration levels ranged from 60 to 70 VdB. Propagation characteristics for measurement sites toward the southern end of the alignment exhibited markedly higher ground vibration response than at the northern end, such as at Receptor Sites R40, R44, and R48.

The 2013 and 2010 vibration data used in this analysis are maximum passby levels defined by the RMS over the maximum period of the passby time signature. The 2008 EIR presented passby data are much higher; the cause of the difference is not known, but it could be due to the 2008 EIR consultant's use of the Lmax as the highest vibration level reached during the passby instead of the RMS over the maximum period. There is some variation in the interpretation of the correct methodology to use (Carman 2007), and in our experience, the RMS of the maximum period of the time signature is the more appropriate metric to measure and evaluate the maximum passby vibration and for use in prediction analysis. The Lmax metric can be subject to inconsistency and may lead to over-prediction of vibration. Thus, the maximum vibration levels presented herein are lower than those stated in the original 2009 EIR.

5.2.2.1 San Francisco County

Vibration levels in this section were measured near Caltrain Project Sensitive Receptor Site R1, a location near N. Portal Tunnel No. 3 between Oakdale Avenue and Palou Avenue. Ground vibration during Caltrain passbys measured up to 73 VdB at a distance of approximately 50 feet from track centerline. Vibration levels did not exhibit much attenuation with distance; a distinctive feature of the data set from R1 which may be due to effects of the tunnel structure. Passbys measured 72 VdB at a distance of 164 feet. Observed speeds were up to 79mph.

For the HSR project, Caltrain vibration levels were documented near Site R2 on the opposite side of the alignment by S. Portal Tunnel No. 3 (WIA 2013), and passby vibration measured 62 to 67 VdB at 105 to 155 feet (See HST VIB20). For the HST project, Caltrain vibration levels were documented in an open cut area between Site R2 and R3. Per the HSR measurement results (WIA 2013), passby vibration measured up to 74 VdB at 140 feet (See HST VIB13).

5.2.2.2 San Mateo County

Vibration levels were measured in San Bruno near Receptor Site R5, along Herman Street at the intersection of Tanforan Avenue. Ground vibration during near track (southbound) Caltrain passbys measured up to 75 VdB at a distance of approximately 40 feet from the near track centerline and 70 VdB at 100 feet. Far track (northbound) trains exhibited higher vibration levels comparatively presumably due to the presence of a crossover near and opposite the measurement site. Far track trains measured

74 VdB at 55 feet and 71 VdB at 115 feet. Observed speeds were up to 77mph for near track (southbound) trains and up to 65 mph for far track (northbound) trains.

For the HST project, Caltrain vibration levels were documented south of Site R5 at 228 Pine Street, San Bruno. The location is closest to Receptor Site R8 on the northbound side of the at-grade alignment near the corner of 1st Avenue and Pine Street. Per the HSR measurement results (WIA 2013), passby vibration measured 74 VdB at 100 feet and 68 VdB at 150 feet (See HST VIB16).

For the HST project, Caltrain vibration levels were documented further south at 1101 Oxford Road, Burlingame. The location is near the intersection of Oxford Road and California Drive and close to Site R14. Similar to R14 it is on the southbound side of the at-grade alignment. Per the HSR measurement results (WIA 2013), passby vibration measured 69 VdB at 100 feet and 64 VdB at 150 feet (See HST VIB11).

For the HST project, Caltrain vibration levels were documented further south at 1051 Park Avenue Burlingame. The location is near the intersection of Park Avenue and Carolan Avenue on the northbound side of the at-grade alignment. Per the HSR measurement results (WIA 2013), passby vibration measured 61 VdB at 150 feet and 58 VdB at 200 feet (See HST VIB17).

For the HST project, Caltrain vibration levels were documented at 360 – 398 Villa Terrace, San Mateo. The location abuts the tracks on the northbound side and is one block north of modeled analysis Site R17 which abuts the tracks on the southbound side. Per the HSR measurement results (WIA 2013), passby vibration measured 75 VdB at 50 feet and 67 VdB at 100 feet (See HST VIB10).

For the Caltrain study, vibration levels were measured in San Mateo near Receptor Site R18, at 140 N. Railroad Avenue, San Mateo. Ground vibration during Caltrain passbys measured up to 83 VdB at a distance of approximately 35 feet from track centerline; up to 77 VdB at 50 feet; and up to 70 VdB at 100 feet. Observed speeds were up to 77mph for these events.

Vibration levels were also measured near Receptor Site R21 at 2 Antioch Drive, San Mateo. Ground vibration during Caltrain passbys measured up to 80 VdB at 35 feet for observed speeds up to 76 mph and up to 77 VdB at 50 feet for observed speeds of 70 mph.

For the HST Project, Caltrain vibration levels were documented at 1 East 40th Avenue, San Mateo. The location is between Site R21 and R22. Per the HSR measurement results (WIA 2013), passby vibration measured 72 VdB at 80 feet and 61 VdB at 160 feet (See HST VIB9).

For the HST Project, Caltrain vibration levels were also documented at 1090 Riverton Drive, San Carlos, near analysis modeled Receptor Site R24. Per the HSR measurement results (WIA 2013), passby vibration measured 58 VdB at 100 feet and 54 VdB at 200 feet (See HST VIB8).

For the HST Project, Caltrain vibration levels were documented at 307 Beech Street, Redwood City. The location is one block north of modeled Receptor Site R26 on the northbound side of the alignment. Per the HSR measurement results (WIA 2013), passby vibration measured 75 VdB at 50 feet and 64 VdB at 150 feet (see HST VIB7).

Further south is Caltrain Receptor Site R27 where vibration levels were measured at 198 Buckingham Avenue, Redwood City. The location is on the southbound side of the alignment opposite four tracks at-grade with observed activity on more than 2 tracks. Ground vibration from Caltrain passbys measured up to 83 VdB at approximately 25 feet from track centerline; up to 77 VdB at approximately 50 feet; and up to 68 VdB at 93 feet. Observed speeds for these passbys were up to 79 mph.

For the HST Project, Caltrain vibration levels were documented at 418 Encinal Avenue, Menlo Park. The location is near and just south of Receptor Site R30 and similarly on the northbound side of the alignment. Per the HSR measurement results (WIA 2013), passby vibration measured 70 VdB at 50 feet and 66 VdB at 100 feet.

5.2.2.3 Santa Clara County

For the HST Project, Caltrain vibration levels were documented at 96 Churchill Avenue, Palo Alto. The location is about three blocks north of R34 and similarly on the southbound side of the alignment. Per the HSR measurement results (WIA 2013), passby vibration measured 74 VdB at 50 feet and 68 VdB at 100 feet (see HST VIB18).

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

For the HST Project, Caltrain vibration levels were documented at 100 – 139 West Meadow Drive, Palo Alto. The location is to the north of and relatively close to Receptor Site R36 and similarly on the southbound side of the alignment. Per the HSR measurement results (WIA 2013), passby vibration measured 69 VdB at 70 feet and 50 VdB at 140 feet (see HST VIB5).

For the HST Project, Caltrain vibration levels were documented at 240 Monroe Drive, Mountain View. The location is to the south of and relatively close to Receptor Site R36 and similarly on the southbound side of the alignment. Per the HSR measurement results (WIA 2013) passby vibration measured 70 VdB at 100 feet (see HST VIB21).

For the HST Project, Caltrain vibration levels were documented at 40 South Rengstorff Avenue, Mountain View. The location is near Receptor Site R34 though on the southbound side of the alignment. Per the HSR measurement results (WIA 2013), passby vibration measured 77 VdB at 50 feet and 70 VdB at 100 feet (see HST VIB4).

For the HST Project, Caltrain vibration levels were documented at 200 – 216 North Mary Avenue, Sunnyvale. The location is at Receptor Site 40 and also on the northbound side of the alignment. Per the HSR measurement results (WIA 2013), passby vibration measured 78 VdB at 62 feet and 70 VdB at 132 feet (see HST VIB3).

Vibration levels were measured at Receptor Site R40 at 125 N. Mary Avenue, Sunnyvale. Ground vibration from Caltrain passbys measured up to 77 VdB at 50 feet, up to 72 VdB at 100 feet, up to 70 VdB at 150 feet, and up to 68 VdB at 200 feet. Observed speeds for these events were up to 80 mph.

For the HST Project, Caltrain vibration levels were documented at West Evelyn Terrace, Sunnyvale. The location is roughly equidistance between Receptor Site R43 and R44 and opposite four active tracks. Per the HSR measurement results (WIA 2013), passby vibration measured 80 VdB at 45 feet and 70 VdB at 100 feet (see HST VIB19).

Vibration levels were measured at Receptor Site R44 at 3529 Agate Street, Santa Clara. Ground vibration from Caltrain passbys measured up to 82 VdB at 27 feet, 79 VdB at 53 feet, 75 VdB at 85 feet, and 73 VdB at 133 feet. Observed speeds were up to 82 mph.

For the HST Project, Caltrain vibration levels were documented at 2419 – 2429 South Drive, Santa Clara. The location is between Receptor Sites R45 and R46. Per the HSR measurement results (WIA 2013), passby vibration measured 72 VdB at 140 feet and 69 VdB at 180 feet (see HST VIB2).

For the HST Project, Caltrain vibration levels were documented at 2075 Main Street, Santa Clara. The location is near and just south of Receptor Site R47. Per the HSR measurement results (WIA 2013), passby vibration measured 78 VdB at 80 feet and 73 VdB at 125 feet (see HST VIB1).

For the HST Project, Caltrain vibration levels were documented at 855 McKendrie Street, San Jose. The location is between Receptor Site R47 and R48. Per the 2010 HST draft report, passby vibration measured 77 VdB at 70 feet and 70 VdB at 195 feet (see HST VIB22).

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

Table 5-3
Summary of 2013 Vibration Measurement Locations and Groundborne Vibration Levels

County	Site No	Address	Date	Distance from track centerline[1], feet	Vibration Velocity (VdB[2])	Source[3]	Train speed, mph
San Francisco County	R1	1831 Palou Avenue, San Francisco	5/30/13	0	68	Caltrain	63-71
				14	71	Caltrain	61-79
				35	71	Caltrain	63-73
				49	73	Caltrain	61-79
				75	71	Caltrain	63-73
				89	72	Caltrain	61-79
				150	71	Caltrain	61-73
				164	72	Caltrain	61-79
San Mateo County	R5	1289 Herman Street, San Bruno	5/23/13	40	75	Caltrain	56-77
				55	74	Caltrain	57-65
				100	70	Caltrain	56-77
				115	71	Caltrain	57-65
				150	65	Caltrain	56-77
				165	68	Caltrain	57-65
				200	65	Caltrain	56-77
				215	65	Caltrain	57-65
	R18	140 N. Railroad Avenue, San Mateo	5/24/13	35	83 79	Caltrain	75-77 35-48
				50	76-77 73 67	Caltrain Caltrain BB only	75-77 25 24-25
				55	73 71	Caltrain	76 35-48
				70	70 66 62	Caltrain Caltrain BB only	75 25 24-25
				100	70 64	Caltrain	75-77 35-48
				115	67 62 58	Caltrain Caltrain BB only	75 25 24-25
				200	60-61 52	Caltrain	75-77 35-48
				215	58 50 49	Caltrain Caltrain BB only	75 25 24-25
	R21	2 Antioch Drive, San Mateo	5/28/13	35	80	Caltrain	74-76

Table 5-3
Summary of 2013 Vibration Measurement Locations and Groundborne Vibration Levels

County	Site No	Address	Date	Distance from track centerline[1], feet	Vibration Velocity (VdB[2])	Source[3]	Train speed, mph
					78	Caltrain	42-54
					72	BB only	50-55
				49	77	Caltrain	70
					74	Caltrain	40-45
					70	BB only	41-45
				75	74	Caltrain	74-76
					70	Caltrain	42-54
					67	BB only	50-55
				89	67	Caltrain	70
					66	Caltrain	40-45
					61	BB only	41-45
				150	61	Caltrain	74-76
					58	Caltrain	42-54
					57	BB only	50-55
				164	61	Caltrain	70
					56	Caltrain	40-42
					54	BB only	41-45
				200	60	Caltrain	74-76
					54	Caltrain	42-54
					54	BB only	50-55
				214	58	Caltrain	70
					52	Caltrain	40-42
					52	BB only	41-45
	R27	198 Buckingham Avenue, Redwood City	5/24/13	23	83	Caltrain	73-79
					80		60-65
				52	77	Caltrain	73-79
				53	74	Caltrain	73-79
					71		60-65
				82	71	Caltrain	73-79
				93	68	Caltrain	73-79
					65		60-65
				122	67	Caltrain	73-79
				193	60	Caltrain	73-79
					57		60-65
				222	59	Caltrain	73-79
Santa Clara County	R34	Peers Park, Palo Alto	5/30/13	28	77	Caltrain	72
					76		41-48
					73		58
				42	77	Caltrain	72

Table 5-3
Summary of 2013 Vibration Measurement Locations and Groundborne Vibration Levels

County	Site No	Address	Date	Distance from track centerline[1], feet	Vibration Velocity (VdB[2])	Source[3]	Train speed, mph
					72		32-36
				53	74 73 72	Caltrain	72 41-48 58
				67	73 66	Caltrain	72 32-36
				103	66 65 63	Caltrain	72 58 41
				117	67 60	Caltrain	72 32
				203	63 62 60	Caltrain	58 72 41
				217	56	Caltrain	32
	R40	125 N Mary Avenue, Sunnyvale	6/5/13	50	77 74 73	Caltrain Caltrain BB only	77-79 51-56 69-75
				65	74	Caltrain	65-70
				100	72 70 67	Caltrain BB only Caltrain	77-79 69-75 51-56
				115	70 69	BB only Caltrain	75 65-70
				150	70 68 63	Caltrain BB only Caltrain	77-79 69-75 51-56
				165	69 67	BB only Caltrain	75 65-70
				200	68 67 62	Caltrain BB only Caltrain	77-79 69-75 51-56
				215	68 65	BB only Caltrain	75 65-70
	R44	3529 Agate Street, Santa Clara	5/28/13	27	82	Caltrain	79
				41	79	Caltrain	74-79
				53	79	Caltrain	74-79
				63	77	Caltrain	77-79
				85	75	Caltrain	78-79

Table 5-3
Summary of 2013 Vibration Measurement Locations and Groundborne Vibration Levels

County	Site No	Address	Date	Distance from track centerline[1], feet	Vibration Velocity (VdB[2])	Source[3]	Train speed, mph
				111	73	Caltrain	74-79
				133	73	Caltrain	75-79
				185	67	Caltrain	74-79
	R48	782 Auzerais Avenue, San Jose	5/29/13	25	89	Caltrain	25-39
				39	80 68	Caltrain BB only	15-25 14-20
				50	76	Caltrain	25-39
				64	71 62	Caltrain BB only	15-25 14-20
				100	69	Caltrain	25-39
				114	65 58	Caltrain BB only	15-25 14-20
				200	61	Caltrain	25-39
				214	58	Caltrain	15-25

Notes:
1. Approximate horizontal distance to the respective track for each group of passbys.
2. Vibration levels with respect to 1 µ-inch/sec.
3. "Caltrain" is non-Baby Bullet and Baby Bullet trains; "BB only" is only Baby Bullet trains

Source: WIA, 2013.

Table 5-4
Summary of 2009-2010 Vibration Measurement Locations and Groundborne Vibration Levels

County	Location ID	Address	Date	Distance from track centerline[1], feet	Vibration Velocity (VdB[2])	Source
San Francisco County	VIB14	391 Pennsylvania Avenue, San Francisco	11/24/09	120	52	Caltrain
				220	48	Caltrain
	VIB20	Diana Street, San Francisco	2/24/10	105 to 155	62 to 67	Caltrain
	VIB13	1700 Egbert Avenue, San Francisco	11/03/09	140	74	Caltrain
				240	63	Caltrain
San Mateo County	VIB12	29 San Francisco Avenue, Brisbane	11/03/09	300	43	Caltrain
				400	38	Caltrain
	VIB15	257 Village Way, South San Francisco	11/24/09	275	41	Caltrain
				325	40	Caltrain
	VIB16	228 Pine Street, San Bruno	11/24/09	100	74	Caltrain
				150	68	Caltrain
	VIB11	1101 Oxford Road, Burlingame	10/30/09	100	69	Caltrain
				150	64	Caltrain
	VIB17	1051 Park Avenue, Burlingame	11/24/09	150	61	Caltrain
				200	58	Caltrain
	VIB10	360 – 398 Villa Terrace, San Mateo	10/02/09	50	75	Caltrain
				100	67	Caltrain
	VIB9	1 East 40th Avenue, San Mateo	10/27/09	80	72	Caltrain
				160	61	Caltrain
	VIB8	1090 Riverton Drive, San Carlos	10/27/09	100	58	Caltrain
				200	54	Caltrain
	VIB7	307 Beech Street, Redwood City	10/27/09	50	75	Caltrain
				150	64	Caltrain
	VIB6	418 Encinal Avenue, Menlo Park	10/23/09	50	70	Caltrain
				100	66	Caltrain
Santa Clara County	VIB18	96 Churchill Avenue, Palo Alto	11/25/09	50	74	Caltrain
				100	68	Caltrain
	VIB5	100 – 139 West Meadow Drive, Palo Alto	10/23/09	70	69	Caltrain
				140	50	Caltrain
	VIB21	240 Monroe Drive, Mountain View	3/08/10	100 to 115	70	Caltrain
				100	75 to 81	Freight
	VIB4	40 South Rengstorff Avenue, Mountain View	10/23/09	50	77	Caltrain
				100	70	Caltrain
	VIB3	200 – 216 North Mary Avenue, Sunnyvale	10/20/09	62	78	Caltrain
				132	70	Caltrain
	VIB19	West Evelyn Terrace, Sunnyvale	12/02/09	45	80	Caltrain

Table 5-4
Summary of 2009-2010 Vibration Measurement Locations and Groundborne Vibration Levels

County	Location ID	Address	Date	Distance from track centerline[1], feet	Vibration Velocity (VdB[2])	Source
				110	70	Caltrain
	VIB2	2419 – 2429 South Drive, Santa Clara	10/20/09	140	72	Caltrain
				180	69	Caltrain
	VIB1	2075 Main Street, Santa Clara	10/20/09	80	78	Caltrain
				125	73	Caltrain
	VIB22	855 McKendrie Street, San Jose	3/10/10	70 to 195	70 to 77	Caltrain
				83 to 258	68 to 77	Amtrak
				100 to 270	64 to 73	Freight

Notes:
1. Approximate horizontal distance to the existing Caltrain alignment.
2. Vibration levels with respect to 1 μ-inch/sec.

Source: WIA, 2013.

5.3 Adjustments to the Measured Ambient Noise Levels

In rail transportation projects that extend over long distances, it is not feasible to measure ambient noise at all or even a majority of noise receptors that could be potentially impacted. The FTA recommended approach is to characterize the noise environment for "cluster" of sites based on measurements or estimates at representative locations.

The representative sites from the Parsons 2008 study were used for the current analysis. Existing ambient noise levels were established for each representative site using the nearest representative measurement either from Table 5-1 or Table 5-2 and adjusting for distance to the receptor position. At locations where noise measurements were obtained in front of the homes and Caltrain is directly exposed to the back of homes, the data were adjusted to determine the noise exposure at the back of the properties.

6 Noise and Vibration Prediction Methodology

6.1 Noise

6.1.1 Train Operations

The FTA detailed noise analysis procedure was used to calculate train noise levels for representative sites. Specific input parameters for the FTA noise model are presented in Table 6-1.

Existing Diesel Train Operations

Existing Caltrain diesel trains were modeled using sound exposure level (SEL) references for diesel locomotives and commuter rail cars provided in the FTA guidelines. The calculations assume each Caltrain train consists of one locomotive and five passenger cars at the existing service level of 92 trains per day (and 5 trips per peak hour) and maximum train speeds up to 79 mph.

Figure 6-1 shows the projected day-night noise exposure levels (L_{dn}) versus distance calculated for existing operations at 79 mph. The FTA model levels were compared to measurements conducted in 2013, and the results confirmed the FTA model values. Attachment A contains a discussion of the passby measurement data and comparison with FTA model.

No Project Scenario

The No Project scenario calculations use the same input parameters as existing operations.

Electrification Project (Year 2019 and 2040)

The Proposed Project would replace approximately 75% of the locomotive and passenger car fleet with EMU technology with a catenary system by 2019. After 2019, diesel locomotives would be replaced with EMUs over time as they reach the end of their service life. It is expected that 100% of the fleet would be EMU by 2029, and thus 100% EMUs were assumed for the year 2040.

The EMU train consists were assumed to be six cars long, with three motor cars (powered cars) and three non-powered trailer cars. The Proposed Project assumes maximum train speeds would not change; however there will be a higher number of total trains per day (114 between San Jose and San Francisco vs. 92 today). The analysis also assumes EMU cars would be roughly the same length as the existing Caltrain rail cars, but potentially up to 90 ft long.

The FTA guidelines give no specific reference sound exposure level (SEL) for EMU trains, thus reference SEL values were adapted from the Federal Railroad Administration (FRA) Guidance Manual[15]. The analysis assumes a reference SEL of 77.5 dBA for the propulsion noise component of a single EMU power unit. The three power units were modeled as "locomotives" with speed coefficient K = 0. Wheel-rail noise, due to all six EMU cars, was modeled using a reference SEL of 80 dBA with speed coefficient K = 20.

Figure 6-1 shows the projected L_{dn} levels versus distance calculated for the year 2040 EMU operations (114 daily trains) at 79 mph. EMU L_{dn} projections are 2.2 dBA lower than the No Project operations at this speed.

Figure 6-2 shows the L_{dn} levels versus train speed. This demonstrates how total noise levels are expected to vary with train speeds, which depends on the train type/consist and corresponding K factors used in the FTA noise model. Wheel-rail noise decreases at slower speeds, which is more evident in the EMU trains. The effect of engine noise from the diesel locomotive combined with a longer passby time causes a slight increase in the L_{dn} levels for No Project operations. At 35 mph EMU operations are 7.3 dBA lower than the No Project operations.

Diesel Multiple Unit (DMU) Alternatives (Year 2019 and 2040)

An alternative DMU train scenario was analyzed for an 8-car train consisting of single-level DMU vehicles. The DMU analysis assumed four cars would be powered and four would be non-powered trailer cars. The DMU alternative assumes the same schedule and maximum train speeds as the Proposed Project.

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[15] The FRA Guidance Manual includes more recent data on train systems including data on high-speed and very high-speed steel-wheeled EMU trains. The high-speed category refers to trains less than 150 mph where aerodynamic noise sources are not a significant factor. The reference noise exposure levels at 50 feet as specified in the FRA guidelines for the high-speed EMU train category are 86 dBA SEL for propulsion noise and 91 dBA SEL for wheel-rail noise. The propulsion SEL corresponds to a length of 634 feet as defined by the total length of power cars. The wheel-rail SEL corresponds to a length of 634 feet as defined by the total train length and a speed of 90 mph. Thus, the SEL values have been adjusted for the length of cars and trains proposed for the Project.

Length and speed adjustments were applied to the above FRA guidelines reference values to normalize to the FTA guidelines reference SEL conditions (i.e., 1 car at 50 mph). The propulsion SEL was adjusted to a length of 270 feet based on length of three powered Caltrain EMU cars at 90 feet each. The wheel-rail SEL was adjusted to a length of 540 feet based on the total six Caltrain EMU cars at 90 feet each. The wheel-rail SEL was adjusted to a speed of 50 mph based on the formula $K*\log_{10}(\text{speed/reference speed})$ where the reference speed in this case is 90 mph and K = 20. No speed adjustment was made to the propulsion SEL. The total train propulsion SEL was distributed among the three Caltrain EMU power cars and the total train wheel-rail SEL was distributed among the six Caltrain EMU cars (both powered and non-powered). The equivalent reference SELs were 77.5 dBA at 50 feet for a single power unit (propulsion noise) and 77.4 dBA at 50 feet for a single car running at 50 mph (wheel-rail noise). Since FRA values are not intended for projects with conventional train speeds below 90 mph, the wheel-rail noise SEL is too low when adjusted down to 50 mph. Thus a higher, and therefore more conservative for environmental analysis SEL of 80 dBA was used based on the expectation that a steel wheel system would be no less than 80 dBA at 50 mph.

DMU trains were modeled using a reference SEL of 85 dBA and speed coefficient K = 0 for powered DMU vehicles, and 82 dBA SEL and K = 20 for non-powered vehicles.

As represented by the respective reference SELs, DMU vehicles are typically quieter than diesel locomotives and louder than EMU vehicles. However, the number of vehicles per train determines the total sound exposure for each train. Figure 6-1 shows the projected L_{dn} versus distance calculated for the year 2040 DMU operations (114 daily trains) at 79 mph. The 8-car DMU noise projections are 0.1 dBA higher than No Project operations and 2.3 dBA higher than EMU operations at 79 mph. At 35 mph, as shown in Figure 6-2, DMU operations are 2.0 dBA lower than No Project operations and 5.3 dBA higher than EMU operations.

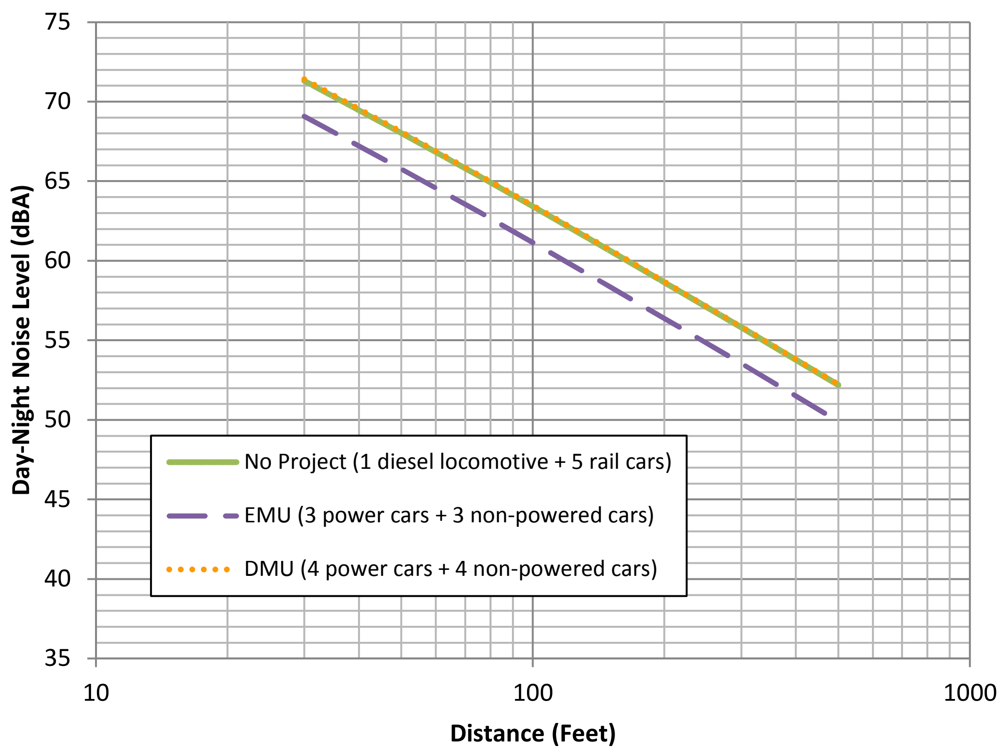

Figure 6-1 Day-night Noise Level for Caltrain Trains at 79 mph

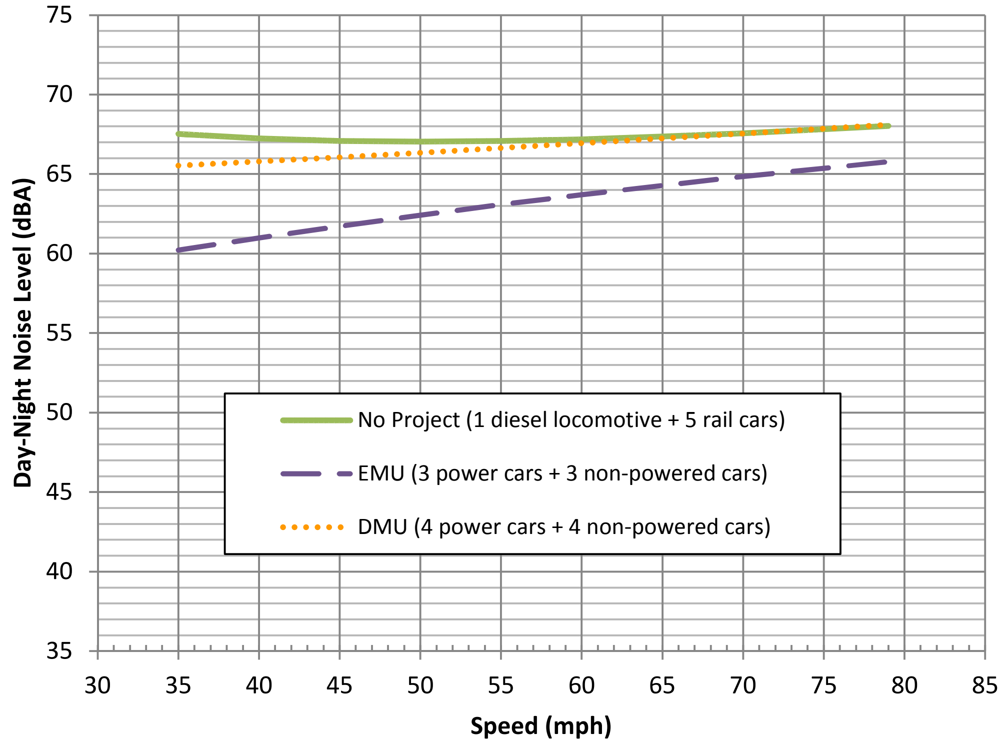

Figure 6-2 Speed Dependence of Day-night Noise Level for Caltrain Trains at 50 Feet

Table 6-1
Input Values Used in FTA Rail Noise Model

Detail	No Project	Electrification[2] by 2019		Electrification[2] by 2040	DMU Alternative[3]
Train Type: Power Unit Reference SEL[1] Non-powered Passenger Car Reference SEL[1]	Diesel-Electric Locomotive 92 Rail Car 82	Diesel-Electric Locomotive 92 Rail Car 82	Electric Multiple Unit Propulsion 77.5 Wheel-rail 80	Electric Multiple Unit Propulsion 77.5 Wheel-rail 80	Diesel Multiple Unit Power Unit Car 85 Non-Powered Rail Car 82
Distance to Track Centerline	40 to 190 feet	40 to 190 feet	40 to 190 feet	40 to 190 feet	[same as EMU]
Train Speed	35 to 79 mph	35 to 79 mph	35 to 79 mph	35 to 79 mph	[same as EMU]
Speed Coefficient, K for Power Units	-10	-10	0	0	0
Speed Coefficient, K for Rail Cars	20	20	20	20	20
Average Number of Power Units	1	1	3	3	4
Average Number of Rail Cars Per Train	5	5	6	6	4
San Jose Diridon Station to San Francisco					
Trains/Day (24-hour period)	92 (100%)	28 (25%)	86 (75%)	114 (100%)	[same as EMU]
Northbound Trains/hr (Peak Hours)	5	2	4	6	[same as EMU]
Southbound Trains/hr (Peak Hours)	5	2	4	6	[same as EMU]
Northbound Trains/Daytime (7 AM to10 PM)	38	12	37	50	[same as EMU]
Northbound Trains/Nighttime (10 PM to 7 AM)	8	2	6	7	[same as EMU]
Southbound Trains/Daytime (7 AM to 10 PM)	39	12	37	50	[same as EMU]
Southbound Trains/ Nighttime (10 PM to 7 AM)	7	2	6	7	[same as EMU]
Tamien Station to San Jose Diridon Station					
Trains/Day (24-hour period)	40	0	48	46	[same as EMU]
Northbound Trains/Daytime (7 AM to10 PM)	15	0	21	19	[same as EMU]
Northbound Trains/Nighttime (10 PM to 7 AM)	5	0	3	3	[same as EMU]
Southbound Trains/Daytime (7 AM to 10 PM)	18	0	21	22	[same as EMU]
Southbound Trains/ Nighttime (10 PM to 7 AM)	2	0	3	2	[same as EMU]

Notes:

1. Reference SEL at distance of 50 feet and 50 mph on continuously welded rail, dBA
2. EMU 6-car train with 3 powered cars and 3 non-powered cars; propulsion and wheel-rail components modeled separately.
3. DMU 8-car train with 4 powered cars and 4 non-powered cars

Train Horns and Crossing Bells

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

The horn noise prediction model is based on a reference level of 96 dBA Lmax at 100 feet. The model takes into account the receptor distance from the grade crossing and the track and adjusts the SEL to account for horn usage (non-continuous horn blowing). Horn noise modeling for existing Caltrain trains is further discussed in Section 7.1 . Future horn noise modeling uses the same input assumptions as existing Caltrain trains, except as discussed in San Bruno where grade separation projects will be complete.

Special Trackwork

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

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

Curving Noise (Wheel Squeal)

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

It is assumed track curves and any resulting wheel squeal noise would not be changed as a result of the proposed Electrification Program and therefore is not included in this analysis.

Cumulative Scenarios (Year 2020 and 2040)

Table 6-1 presents the existing and future train operation assumptions used for the cumulative scenarios. Specific input parameters for the cumulative noise model are presented in Table 6-3.

In year 2020, it is assumed that 75 percent of the Caltrain trains running from San Jose to San Francisco would use EMU technology with a catenary system. From Gilroy to San Jose the same diesel train configuration would continue as it does today with six trains per day, three trains per direction per day. It is assumed that would total freight trips per days would increase by 32 percent from existing 2013 freight activity. Some ACE and Capital Corridor would be added. No increase in Coast Starlight service is assumed. Non-railroad ambient noise is assumed to increase by 3 percent annual growth or approximately 1 dB over seven years.

In year 2040, it is assumed that 100 percent of the trains running from San Jose to San Francisco would use EMU technology with a catenary system, with the same configuration and parameters discussed above. From Gilroy to San Jose the same diesel train configuration would continue as it does today with six trains per day; three trains per direction per day. It is assumed that would total freight trips per days would increase by 108 percent from existing freight activity. Some ACE and Capital Corridor would be added. No increase in Coast Starlight service is assumed. Non-railroad ambient noise is assumed to increase by 3 percent annual growth, which is approximately 3 dB over 27 years. New rail noise sources assumed to be operating by 2040 include High-Speed Rail and Dumbarton Rail Corridor.

Table 6-2
Passenger and Freight Train Operations for Cumulative Scenarios

Existing (2013) Train Service					
	Total Daily Number of Trains				
System	**Tamien - Diridon**	**Diridon - Santa Clara**	**Santa Clara - Redwood City**	**Redwood City - San Francisco**	**Source/Comment**
Caltrain	40	92	92	92	Existing Caltrain Schedule
ACE	8	8	--	--	ACE Schedule
Capitol Corridor	--	14	--	--	CCJPA Schedule
Coast Starlight	2	2	--	--	AMTRAK schedule
Freight	4	9	2	6	Caltrain dispatch data
Total	54	125	94	98	
Assumed 2020 Train Service					
	Total Daily Number of Trains				
System	**Tamien - Diridon**	**Diridon - Santa Clara**	**Santa Clara - Redwood City**	**Redwood City - San Francisco**	**Source/Comment**
Caltrain	48	114	114	114	PCEP NOP
High-Speed Rail	--	--	--	--	Assumed by 2029
ACE	12	12	--	--	ACE forward NOP
Capitol Corridor	--	22	--	--	CCJPA Draft 2013 Vision Plan
Coast Daylight	4	4	4	4	Assumed in 2020
Dumbarton Rail Corridor	--	--	--	--	Assumed > 2020

Coast Starlight	2	2	--	--	No change
Freight	5	12	3	8	32% increase assumed; based on assumed 4% per annum (from UPRR) increase from 2013 - 2020.
Total	71	166	121	126	
Change from 2013	*17*	*41*	*27*	*28*	
Assumed 2040 Train Service					
System	**Total Daily Number of Trains**				**Source/Comment**
	Tamien - Diridon	**Diridon - Santa Clara**	**Santa Clara - Redwood City**	**Redwood City - San Francisco**	
Caltrain	46	114	114	114	PCEP NOP
High-Speed Rail	--	--	80	80	CHSRA Business Plan
ACE	20	20	--	--	ACE forward NOP
Capitol Corridor	--	30	--	--	CCJPA Draft 2013 Vision Plan
Coast Daylight	4	4	4	4	2013 California Rail Plan
Dumbarton Rail Corridor	--	--	--	6	2013 California Rail Plan
Coast Starlight	2	2	--	--	No change
Freight	8	19	4	12	108% increase assumed; based on assumed 4% per annum (from UPRR) increase from 2013 - 2040.
Total	80	195	208	216	
Change from 2013	*26*	*70*	*114*	*118*	
Source: ICF					

Table 6-3
Input Values Used in FTA Rail Noise Model for New Rail Sources in Cumulative Scenarios

Detail	CHSRA[2]	Dumbarton Rail Corridor	Coast Daylight
Train Type: Power Unit Reference SEL[1] Non-powered Passenger Car Reference SEL[1]	Electric Multiple Unit Propulsion 77.2 Wheel-rail 80	Diesel-Electric Locomotive 92 Rail Car 82	Diesel-Electric Locomotive 92 Rail Car 82
Train Speed	79 mph and 110 mph	75 mph	79 mph
Speed Coefficient, K for Power Units	0	-10	-10
Speed Coefficient, K for Rail Cars	20	20	20
Average Number of Power Units	8	1	1
Average Number of Rail Cars Per Train	8	4	6
Trains/Day (24-hour period)	80	6	4
Northbound Trains/Daytime (7 AM to10 PM)	34	2	2
Northbound Trains/Nighttime (10 PM to 7 AM)	6	1	0
Southbound Trains/Daytime (7 AM to 10 PM)	34	2	2
Southbound Trains/ Nighttime (10 PM to 7 AM)	6	1	0
Service Area Overlap with Caltrain	Santa Clara – San Francisco[3]	Redwood City – San Francisco	Tamien – San Jose Diridon

Notes:
1. Reference SEL at distance of 50 feet and 50 mph on continuously welded rail, dBA
2. EMU 8-car train with all powered cars. Reference SELs adapted from FRA as adapted for Caltrain EMU (discussed in footnote 15) except that HSR assumes train length of 660 feet with 8 power (propulsion) units.
3. South of Santa Clara, CHSRA is assumed in separate dedicated alignment from Caltrain which will be subgrade or aerial.

6.1.2 Ancillary Facilities

The noise impact assessment for ancillary facilities was conducted following the FTA guidelines. Noise levels from substations, switching stations, and paralleling stations were projected to the location of sensitive receptors and the increase in noise levels from the existing ambient condition compared to the maximum increase allowed by the FTA criteria shown in Figure 4-1 and Figure 4-2.

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

Track Power Substations, Switching Stations, and Paralleling Stations

The traction power supply system proposed for the Project will be a 2 x 25 kV auto-transformer system utilizing two supply stations (substations) spaced 36 miles apart, one switching station located approximately midpoint between substations, and seven paralleling stations spaced approximately 5 miles apart.

The substations would have two 60 MVA (million Volt-amperes) oil-filled transformers that will step down the utility supplied voltage of 115 kV to the 2 x 25 KV distribution voltage for the OCS (Overhead Contact System). The switching station would be equipped with two 10 MVA oil-filled auto-transformer units and the paralleling station would be either one or two 10 MVA oil-filled autotransformer units.

The typical substation site dimensions are 150 feet by 200 feet; switching station site dimension are typically 80 feet by 160 feet; paralleling station site dimensions are typically 40 feet by 80 feet.

The Parsons 2008 study included noise levels for equipment associated with a typical electrical substation[16]; however, the analysis is being done using FTA reference levels for substations, because the levels are typical of transformers used for rail transit projects. The FTA reference sound exposure level (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).

6.1.3 Noise from Train Station

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

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

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

The traffic analysis indicates that on roads in the vicinity of stations, the typical change in traffic volumes with the Project would range from -4% to 10%, with a maximum change of up to 31%. During the peak traffic hours, the typical changes in the traffic volumes would correspond to a relative change of less than 0.5 dBA, up to a 1.1 dBA increase where the peak hour changes by 31%. However, over a 24-hour period, the effect of the changed traffic on the road noise component would be less, 0.8 dBA or less. In the noise model, the sensitivity of noise impact evaluation to the non-railroad ambient indicates that the non-railroad ambient would have to increase by more than 1.0 dBA in order for the total Project noise to generate a Moderate Impact, thus the changes in traffic noise are not significant

[16] The values provided in the Parsons 2008 analysis require additional knowledge of the size and exposed surface area of the transformers, which does not appear to be included in their calculations.

6.1.4 Construction

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

Joint use of the corridor for construction and operation of trains would place major logistical constraints on both. On the construction side, this would restrict working room and working hours, and reduce efficiencies due to constant interruption from passing trains. On the train operation side, the joint use of the corridor would require single-tracking, service interruptions, speed restrictions and worker safety flag controls.

The FTA method was used to determine construction noise exposure for each piece of equipment, which is based on the following equation:

$$L_{eq}(\text{equip}) = E.L. + 10\ \text{Log}(UF) - 20\ \text{Log}(D/50) - 10\ G\ \text{Log}(D/50)$$

where:

L_{eq}(equip) is the L_{eq} in A-weighted decibels (dBA) at a receiver resulting from the operation of a single piece of equipment over a specified time period.
E.L. is the emission level, derived from the maximum noise level of the particular piece of equipment at 50 feet in A-weighted decibels (dBA).
UF is the usage factor of the construction equipment that accounts for the fraction of time that the equipment is operating at full power over the specified time period.
D is the distance in feet to the affected noise sensitive receiver; and
G is the ground effects constant (zero for acoustically hard ground surface conditions).

Based on the Parsons 2008 report, a total of three construction activities have been identified for the Proposed Project for the purpose of determining construction noise exposure. These activities include: 1) Overhead Contact System Installation; 2) Overbridge Protection Barrier Installation; and 3) Substations, Switching, and Paralleling Station Construction. Each stage has several activities that could create high noise levels. The noise levels for major pieces of construction equipment within a given stage have been identified.

Table 6-4 (reproduced from the Parsons 2008 study) summarizes typical maximum noise emission levels (L_{max}) of the construction equipment operating at full power at a reference distance of 50 feet and the corresponding 8-hour L_{eq} levels at 50 and 100 feet based on respective usage factors. The usage factors account for the total time during an eight-hour day in which a piece of equipment is producing noise under full power and were estimated by Parsons based on experience with other similar construction projects. The usage factors have not been changed from the 2008 analysis. Note that the noise levels in Table 6-4 are typical values, and thus there can be wide fluctuations in the noise emissions of similar equipment based on factors such as the operating condition of the equipment and the technique used by the equipment operator.

A ground factor (G) of 0 was used. This represents an acoustically hard ground cover and is representative of the majority of the areas along the project alignment. Thus, in areas of open field or similar environments where the ground provides some acoustical absorption, the analysis estimates in this report are slightly conservative.

Table 6-4
Typical Construction Equipment Noise Emission Levels

Equipment	Maximum Noise Level, dBA, 50 feet from Source	8-Hour Equipment Usage Factor	Total 8-Hour Leq Exposure, dBA[1]		
			50 feet		100 feet
Overhead Contact System Installation					
Foundation Installation Without Casing			**76**		**70**
Auger/drill rigs	85	0.063	73		67
Concrete truck	82	0.063	70		64
Telescoping boom bucket trucks	81	0.013	62		56
Front loader	80	0.038	66		60
Dump truck	71	0.019	54		48
Generator to vibrate the concrete	82	0.019	65		59
Foundation Installation With Casing			**77**		**70**
Auger/drill rings	85	0.031	70		64
Concrete truck	82	0.031	67		61
Telescoping boom bucket trucks	81	0.025	65		59
Front loader	80	0.038	66		60
Vibratory hammer	85	0.063	73		67
Dump truck	71	0.019	54		48
Generator to vibrate the concrete	82	0.019	65		59
OCS Pole Installation			**73**		**67**
Diesel construction train (stationary)	70	0.063	58		52
Diesel construction train (in transit)	77	0.0007	45		39
Telescoping boom bucket trucks	81	0.063	69		63
Generator (nighttime lighting)	82	0.063	70		64
OCS Wiring			**74**		**68**
Diesel construction train (stationary)	70	0.094	60		54
Diesel construction train (in transit)	77	0.008	56		50
Telescoping boom bucket trucks	81	0.094	71		65
Generator (nighttime lighting)	82	0.094	72		66
Overbridge Protection Barriers					
Installation of Barriers to Roadway Bridges			81		75
Pneumatic drill (in concrete)	85	0.30	80		74

Table 6-4
Typical Construction Equipment Noise Emission Levels

Equipment	Maximum Noise Level, dBA, 50 feet from Source	8-Hour Equipment Usage Factor	Total 8-Hour Leq Exposure, dBA[1]		
			50 feet		100 feet
Utility truck (with crane)	81	0.30	76		70
Flatbed truck	78	0.10	68		62
Substation, Switching, and Paralleling Stations					
Ground Clearing Stage - one site only			**83**		**77**
Dozer	85	0.50	82		76
Front loader	80	0.30	75		69
Dump truck	71	0.25	65		59
Compactor	81	0.25	75		69
Ground Grade			**81**		**75**
Backhoe	80	0.30	75		69
Hammer to drive rods (small vibrator)	86	0.25	80		74
Concrete Foundations			**84**		**78**
Flatbed truck	78	0.10	68		62
Wood saw to construct forms	88	0.25	82		76
Concrete truck	82	0.25	76		70
Utility truck (with crane)	81	0.30	76		70
Generator to vibrate the concrete	82	0.15	74		68
Electrical Equipment Installation			**83**		**77**
Flatbed truck	78	0.15	70		64
Forklift	80	0.27	74		69
Large crane	85	0.50	82		76

Notes:
1. Distances are measured from the center of the noise producing activities associated with the construction phase.

Source: Parsons, 2008.

6.2 Groundborne Vibration

6.2.1 Train Operations

Since the Project entails changing out the existing diesel locomotives and passenger cars with a new set of vehicles, the analysis approach has been to document the vibration propagation trend with distance to develop site specific vibration curves to use instead of the FTA general vibration assessment curves. For the future case, there are several variables which could affect the ground vibration, and those are discussed below.

Per the FTA guidance manual, the Caltrain corridor is considered a 'heavily-used rail corridor' since there are more than 12 trains per day. As such the focus of the impact assessment is the potential for the project to cause additional vibration impact by comparing existing and future conditions.

The analysis procedure entails documenting vibration from existing rail operations. WIA conducted measurements to document existing levels of vibration in the study area and assess vibration propagation characteristics as a function of distance from the Caltrain tracks.

To assess the potential for vibration impact with the future (Electrification) condition, WIA reviewed factors that would have the potential to increase vibration levels.

No Project Scenario

Vibration predictions associated with the No Project Scenario are determined from the existing vibration data obtained along the corridor. Vibration data measured as a function of distance for existing Caltrain operations at top speeds form the basis for predicting the vibration levels associated with the No Project Scenario.

WIA developed site-specific ground vibration propagation characteristics from the vibration measurements conducted in 2013. The measurements consisted of recording passby vibration at four distances simultaneously in order to obtain ground vibration propagation characteristics specific to each measurement site. Passbys were typically recorded for trains operating on both the near and far tracks which provided up to eight unique data points of vibration as a function of distance for each passby measurement. Multiple passby samples were recorded at each distance and samples of similar characteristics (e.g., track, speed, etc.) were energy averaged.

The compiled data are contained in Attachment B and represent the range of passby levels measured for the existing diesel locomotive train operations at each of the Receptor Sites: R01, R05, R18, R21, R27, R34, R40, R44, and R48. The measurement sites are consistent with the measurement sites contained in the 2008 EIR as described above in Section 5.0.

The Attachment B charts show the overall vibration level (VdB) plotted on the vertical axis versus distance (feet) from track centerline on the horizontal axis. The overall vibration level is the energy summation of the 1/3-octave band (spectral) data measured at each field position. The charts also show the FTA generalized base curves for locomotive powered trains and rapid transit trains for comparison with the 2013 vibration data. The Category 2 vibration threshold of 72 VdB for frequent passby events is also plotted for context.

For the No Project Scenario, the 2008 EIR used the FTA generalized curve for locomotive powered passenger operations and adjusted up or down based on the EIR vibration measurement data. However, based on the 2013 data and 2010 data from the HSR study (CHSR 2010), the existing Caltrain vibration levels more closely resemble the lower FTA base curve for rapid transit trains (with some exceptions where data varied higher or lower). Furthermore, adjusting the 2013 data for speed differences (e.g., normalizing to the 50 mph of the FTA base curves) results in an even closer fit between the 2013 vibration data and the FTA base curve for rapid transit. This result is expected, based on the vehicle characteristics and WIA experience on similar projects over the years.

Proposed Project

Factors that would potentially cause changes to the wayside vibration levels include:

- Vehicle source vibration characteristics
- Train speed
- Distance between receptor and track centerline
- Track structure type

For the Proposed Project, the model parameters above are understood to remain the same with the one exception that the EMU vehicle may have different source vibration characteristics than the existing locomotive powered trains. Therefore, for any given receptor, all parameters remain the same with the exception of the vehicle.

The future Caltrain rolling stock (vehicles) will be electric multiple unit (EMU) vehicles (i.e., no locomotive). The vibration characteristics attributable to the change in vehicle will be a function of truck (bogie) design, unsprung mass of the vehicle, type of primary suspension, and wheel type among other factors. These details should be reviewed during final design for comparison to the existing Caltrain vehicles to confirm the vibration analysis assumptions.

The existing Caltrain Gallery Car has the following data:

- Truck weight: 19,920 lbs
- Wheel and axle assembly weight: 3,658 lbs
- Vehicle weight: Cab car – 126,700 lbs, Trailer Car – 124,300 lbs
- Primary suspension: springs

At this time, there is currently is no United States based prototype for the EMU proposed for the Caltrain Electrification Program. The EMU vehicle that would be considered would be a multi-level car of comparable dimensions to the existing Caltrain gallery car, possibly up to 90 ft length. There are European EMU vehicles that may be similar but limited information is available at this time. The Alstom Coradia is an example (maximum axle load 49,500 lbs, cab car empty weight of 144,344 lbs) as is the Siemens Desiro (maximum axle load 44,000 lbs, cab car empty weight of 132,000 lbs)(Caltrain 2009).

What is critical for vibration will be the bogie design of the future candidate vehicle and how it compares to the Caltrain gallery car with respect to total unsprung weight and primary suspension type. This should be reviewed in detail during the vehicle procurement phase such that the chosen vehicle does not have the potential to exceed the source vibration characteristics of the Caltrain Gallery car. This review should include how the motors are attached to the bogie and the effects on total unsprung weight.

A governing assumption of this analysis is that the unsprung weight of the future vehicle will not substantially exceed that of the existing Caltrain gallery car. In this context, all other factors being equal, a substantial increase in unsprung weight of the EMU vehicles compared to the existing Caltrain

Gallery Car would be on the order of 40% or more, because such an increase would cause the ground vibration to increase by 3 VdB or more as discussed above in Section 4.3.

At this time, no measurements of the proposed EMU rolling stock are available and deemed suitable for the prediction analysis. Should further data or information become available, it should be reviewed for the potential to affect the future vibration levels and the impact analysis.

6.2.2 Construction

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

The vibration produced by construction equipment was obtained from the FTA *Transit Noise and Vibration Impact Assessment* (FTA, 2006) document and from field measurements, and is shown Table 6-5. Calculations were performed to determine the distances at which vibration impacts would occur according to the criteria discussed in Section 4.2 and the FTA procedures.

Table 6-5
Vibration Source Levels for Construction Equipment

Equipment	PPV[1] at 25 feet (in/sec)	Approximate Velocity Level[2] at 25 ft (VdB)
Large bulldozer	0.089	87
Loaded trucks	0.076	86
Small bulldozer	0.003	58
Caisson Drilling	0.089	87
Vibratory hammer	0.07[3]	85[3]
Vibratory compactor/roller	0.55[4]	103[4]

Notes:
1. Peak particle ground velocity measured at 25 feet unless noted otherwise.
2. RMS ground velocity in VdB referenced to 1 micro-inch/second.
3. Measured at 88 feet by Parsons.
4. Measured at 15 feet by Parsons.

Source: FTA, 2006.

7 Noise and Vibration Impact Analysis

7.1 Operational Noise Impact Assessment

Existing Total Noise Exposure

Existing noise levels were established for each representative site using measurement data from the nearest representative noise survey location. The measured noise levels were adjusted for distance, acoustical shielding, and proximity to other noise sources where the conditions of the measurement location differed from the conditions of the receptor position for each representative site. The noise surveys ranged over multiple days. The average L_{dn} values were used, except in some cases where the minimum or maximum measured L_{dn} values were more consistent with the noise model. Table 7.1-1 lists the adjustments to the measured noise levels and indicates how each of the existing ambient noise levels were established for each representative site.

Existing Caltrain Noise Exposure

Existing diesel powered locomotive trains were modeled for existing Caltrain operations based on the assumptions and model input parameters discussed in Section 6.1.1. The noise model assumed flat terrain and acoustically "soft" (i.e. absorptive) ground conditions at locations where terrain consisted mostly of right-of-way, yards, and other non-paved surfaces. The ground factor (G) values for the distance attenuation calculations were 0.6 for noise sources located lower on the train, and 0.7 for sources located higher on the train. Where intervening terrain is mostly roadways or parking lots, then a ground factor of zero was used.

It was assumed that horn usage is less when approaching stations than grade crossings. At receptor sites within ¼ mile from grade crossings, horn usage factor of 0.3 was assumed. At locations within ¼ mile from stations, horn usage factor of 0.15 was assumed. Further, based on the existing noise measurement results, modified horn usage factors were used, ranging from 0.04 to 0.7, in order to adjust the horn noise model to the measured noise values. At a few locations, a 2 dBA adjustment was applied to account for the effect of horn noise reflecting off buildings close to the railroad right of way.

Freight Trains Noise Estimates/Modeling

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

Freight noise was estimated by using the following formula:

$L_{Freight} = 10*LOG_{10}(10^{(LTotal-\Delta Freight)/10} - 10^{LCaltrain/10})$

Where,

L_{Total} = existing noise exposure at receiver from all sources, L_{dn} dBA

$\Delta_{Freight}$ = relative increase due to freight, L_{dn} dBA; between range of 0 and 4 dB (one exception where 8 dB was used due to dominance from non-railroad ambient noise)

$L_{Caltrain}$ = modeled Caltrain noise at receiver, L_{dn} dBA

The $\Delta_{Freight}$ factor was determined based on review of the measured data and resulting non-railroad ambient noise levels. $\Delta_{Freight}$ was adjusted so that the estimated freight noise contribution fell within +/- 2 dBA of the Caltrain noise level and the resulting non-railroad ambient noise level fell within an expected range considering the site conditions and other noise sources (further discussed below).

Non-Railroad Ambient Noise Estimates/Modeling

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

$L_{Residual} = 10*LOG_{10}(10^{(LTotal/10)} - 10^{(LCaltrain/10)} - 10^{(LFreight/10)})$

Where,

L_{Total} = existing noise exposure at receiver from all sources, L_{dn} dBA

$L_{Caltrain}$ = modeled Caltrain noise at receiver, L_{dn} dBA

$L_{Freight\,=}$ Freight noise contribution computed per formula above, based on assumed relative increase due to freight, $\Delta_{Freight}$

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

Table 7-1
Existing Caltrain / Freight / Non-railroad Ambient Noise Modeling

Site No	Distance to Receptor feet	Measurement Site ID	Distance to Measurement Position feet	Minimum Measured Day-Night Level L_{dn}, dBA	Maximum Measured Day-Night Level L_{dn}, dBA	Average Measured Day-Night Level L_{dn}, dBA	Day-Night Level used for Analysis L_{dn}, dBA	Adjustment for Distance ΔdBA	Adjustment for Shielding ΔdBA	Other Adjustment ΔdBA	Total Noise Exposure at Receptor L_{dn}, dBA	Nearby Grade Crossing or Station	Track Length to Crossing or Station feet	Horn Usage	Other Adjustment to Modeled Caltrain ΔdBA	Modeled Caltrain L_{dn}, dBA	Assumed Relative Increase due to Freight $\Delta_{Freight}$	Freight L_{dn}, dBA	Non-Railroad Ambient Noise L_{dn}, dBA
1	110	N32	135	68	68	68	68	0.9	n/a	n/a	69	--	--	--	n/a	63	2	65	65
2	80	N33	170	63	64	64	64	3.3	3	n/a	70	--	--	--	n/a	65	2	65	66
3	90	N32	135	68	68	68	68	1.8	n/a	n/a	70	--	--	--	n/a	64	2	66	66
4	120	N31	70	70	72	71	71	-2.3	n/a	n/a	69	Bayshore STA	1320	0.15	n/a	66	0.6	65	60
5	110	R05	85	77	79	78	77	-1.1	n/a	n/a	76	Scott Street	100	0.30	2	71	2	73	69
6	50	R07	100	74	75	74	74	3.0	n/a	n/a	77	San Bruno Ave	970	0.30	n/a	74	0.5	73	67
7	120	R07	100	74	75	74	74.36	-0.8	n/a	n/a	74	San Bruno Ave	250	0.30	n/a	70	0.5	71	64
8	100	N53	80	74	75	75	75	-1.0	n/a	n/a	74	Angus Ave	600	0.30	n/a	71	0.5	70	64
9	150	N53	80	74	75	75	75	-2.7	n/a	n/a	72	Angus Ave	750	0.30	n/a	69	0.5	68	62
10	170	N26	180	67	68	68	67.2	0.2	n/a	n/a	67	--	--	--	n/a	60	2.7	62	64
11	160	N25	150	71	72	71	71	-0.3	n/a	n/a	71	Center St	555	0.30	n/a	66	2	66	67
12	90	R12	244	62	65	63	65	4.3	3	n/a	72	Millbrae STA	810	0.15	n/a	68	0.4	69	61
13	150	N50	140	68	68	68	68	-0.3	n/a	n/a	68	--	--	--	n/a	61	3	63	65
14	160	R14	155	70	71	71	70	-0.1	n/a	n/a	70	Broadway	2600	0.30	n/a	66	2	64	66
15	190	N22	145	71	71	71	71	-1.2	n/a	n/a	70	ped crossing	100	0.30	n/a	64	2	66	66
16	160	N22	145	71	71	71	71	-0.4	n/a	n/a	71	ped crossing	250	0.30	n/a	66	2	66	67
17	40	R18	40	71	76	74	76	0.0	n/a	n/a	76	Villa Terrace	280	0.15	n/a	73	0.1	73	60
18	70	R18	40	71	76	74	74	-2.4	n/a	n/a	72	San Mateo STA	875	0.15	n/a	69	0.1	68	56
19	110	N47	40	77	77	77	77	-4.4	n/a	n/a	73	9th Ave	480	0.30	n/a	68	2	68	69
20	85	N20	95	67	68	67	67	0.5	n/a	n/a	67	--	--	--	n/a	64	1	62	60
21	100	N19	90	72	74	73	72	-0.5	n/a	n/a	72	Hillsdale STA	1700	0.08	n/a	68	1	68	65
22	120	R22	128	70	70	70	70	0.3	n/a	n/a	70	--	--	--	n/a	65	2.7	64	67
23	120	N18	120	72	74	73	73	0.0	n/a	n/a	73	Belmont STA	1370	0.15	n/a	68	2	68	69
24	100	N17	85	70	70	70	70.3	-0.7	n/a	n/a	70	San Carlos STA	1070	0.15	n/a	67	0.5	66	60
25	90	N16	80	73	74	73	73.5	-0.5	n/a	n/a	73	Whipple Ave	1200	0.30	n/a	70	0.3	70	61
26	50	N47	40	77	77	77	77	-1.0	n/a	n/a	76	Chestnut St	300	0.30	n/a	73	0.5	72	66
27	110	R27	70	69	73	71	71	-2.0	n/a	n/a	69	--	--	--	n/a	65	1	65	62
28	50	N14	55	70	74	72	72	0.4	n/a	n/a	72	--	--	--	n/a	68	1	68	65
29	60	N13	45	68	71	70	71.1	-1.2	n/a	n/a	70	Fair Oaks	400	0.05	n/a	68	0.06	66	51
30	65	N13	45	68	71	70	71.1	-1.6	n/a	n/a	70	Watkins	775	0.05	n/a	68	0.06	66	51
31	175	N45	130	68	68	68	68	-1.3	n/a	n/a	67	--	--	--	n/a	60	4	60	65
32	100	N44	60	70	70	70	70.4	-2.2	n/a	n/a	68	Palo Alto Ave	500	0.04	n/a	65	0.7	64	60
33	120	N42	35	74	74	74	74	-5.4	n/a	n/a	69	--	--	--	n/a	65	2	63	65
34	40	R34	40	71	72	71	72	0.0	n/a	n/a	72	--	--	--	n/a	70	0.5	67	62
35	160	N10	120	77	77	77	77	-1.2	n/a	n/a	76	California Ave STA	1340	0.30	2	70	3.5	70	73
36	50	R36	35	80	81	80	80	-1.5	n/a	n/a	78	W Charleston Rd	400	0.30	n/a	74	0.5	75	68
37	150	N9	135	75	75	75	75	-0.5	n/a	n/a	75	N Rengstorff	600	0.30	2	68	2	70	71
38	110	N8	285	70	72	71	70	4.1	n/a	-1	73	Castro	400	0.30	1	69	1.5	69	66
39	150	N39	185	71	72	71	71	0.9	n/a	n/a	72	--	--	--	n/a	61	8	61	71
40	75	N7	90	66	66	66	66	0.8	3	-2	68	--	--	--	n/a	65	0.3	63	60
41	80	N7	90	66	66	66	66.3	0.5	3	n/a	70	S Mary Ave	950	0.05	n/a	66	0.6	66	61
42	80	N6	100	69	71	70	70	1.0	n/a	n/a	71	Sunnyvale STA	30	0.15	n/a	67	1.6	65	66
43	75	N6	100	69	71	70	70	1.2	n/a	n/a	71	--	--	--	n/a	65	3	65	68
44	85	R44	130	69	70	69	69	1.8	n/a	n/a	71	Lawrence STA	540	0.15	n/a	66	2	66	67
45	110	N4	160	63	64	63	63	1.6	3	n/a	68	--	--	--	n/a	62	2	63	64
46	95	N37	220	64	65	64	64	3.6	n/a	n/a	68	--	--	--	n/a	64	2	62	64
47	95	N3	140	63	64	63	63	1.7	3	n/a	68	--	--	--	n/a	64	2	62	64
48	60	R48	45	81	83	82	82	-1.2	n/a	n/a	81	Auzerais Ave	45	0.70	n/a	74	0.1	80	65
49	50	R49	50	69	73	71	71	0.0	n/a	n/a	71	--	--	--	n/a	64	0.5	69	61

Notes:

1. R38 ‘other’ adjustment due to measurement location’s proximity to VTA light rail
2. R40 ‘other’ adjustment due to measurement location’s exposure to train horns
3. R5, R35, R37, R38, PS3, and SP5-2 modeled Caltrain levels adjusted to account for horn noise reflections off buildings along right-of-way

The projected future train operations due to No Project conditions or the Proposed Project were added to existing freight train noise level and the non-railroad ambient existing noise level to develop a future total no Project and Proposed Project noise levels and determine the Proposed Project noise increase. At each receptor the applicable FTA impact thresholds, as shown in Figure 4-1 and Figure 4-2, were determined based on the total existing noise levels established for each site.

The operational train noise projections and impact results at each of the representative sites are presented in Table 7-2 for the No Project scenario. The FTA impact criteria are a comparison of future project noise with existing noise and not with projections of future “no-build” noise exposure. The No-Project scenario is included in order to be consistent with the Parsons 2008 study. Since the existing and No Project noise projections are the same, there is no noise increase and consequently no noise impacts of the No Project scenario.

Proposed Project operational train noise projections and impact results at each of the representative sites are presented in Table 7-3. Since the Proposed Project would result in quieter vehicles, the future Project noise level would be lower than existing and result in no additional impacts. As noted in the methodology section, the peak hour train frequency would increase from 5 to 6 trains, and for areas near grade crossings where the train horns dominate the noise environment, the predictions indicate some small increases under the Proposed Project. Nevertheless, at most receptors there would be no new noise impact. The exception is one site where existing noise levels are already high and the allowable noise increase is small; thus the slight increase in train events, and the corresponding increase in horn noise exposure, results in a Moderate Impact at this location.

Table 7-2
Operational Noise Levels / Impacts for No Project

					Existing				Future				FTA Impact Criteria		
Site No	Side of Alignment	Land Use[1]	Distance to Receptor[2]	Train Speed	Total Noise Exposure	Caltrain Diesel Locomotive Train Noise	Freight Train Noise	Non-Railroad Ambient Noise	Caltrain Diesel Locomotive Noise	Caltrain EMU Train Noise	Total Noise Exposure[3]	Increase	Moderate	Severe	Impact
			feet	mph	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA			
1	W	MFR	110	79	69	63	65	65	63	--	69	0.0	1.1	2.9	--
2	E	SFR	80	79	70	65	65	66	65	--	70	0.0	1.0	2.8	--
3	E	SFR	90	79	70	64	66	66	64	--	70	0.0	1.0	2.8	--
4	E	SFR	120	65	69	66	65	60	66	--	69	0.0	1.1	2.9	--
5	W	SFR	110	79	76	71	73	69	71	--	76	0.0	0.3	2.1	--
6	E	MFR	50	60	77	74	73	67	68	--	75	-2.1	0.3	2.0	--
7	W	SFR	120	60	74	70	71	64	64	--	73	-1.5	0.5	2.3	--
8	E	SFR	100	60	74	71	70	64	65	--	72	-2.1	0.5	2.3	--
9	W	SFR	150	60	72	69	68	62	63	--	70	-2.2	0.8	2.5	--
10	W	SFR	170	79	67	60	62	64	60	--	67	0.0	1.2	3.2	--
11	E	MFR	160	79	71	66	66	67	66	--	71	0.0	1.0	2.6	--
12	W	SFR	90	79	72	68	69	61	68	--	72	0.0	0.8	2.5	--
13	W	SFR	150	79	68	61	63	65	61	--	68	0.0	1.2	3.1	--
14	W	SFR	160	79	70	66	64	66	66	--	70	0.0	1.0	2.8	--
15	W	SFR	190	79	70	64	66	66	64	--	70	0.0	1.0	2.8	--
16	E	SFR	160	79	71	66	66	67	66	--	71	0.0	1.0	2.6	--
17	W	SFR	40	79	76	73	73	60	73	--	76	0.0	0.3	2.1	--
18	E	SFR	70	79	72	69	68	56	69	--	72	0.0	0.8	2.5	--
19	W	MFR	110	79	73	68	68	69	68	--	73	0.0	0.6	2.4	--
20	W	SFR	85	79	67	64	62	60	64	--	67	0.0	1.2	3.2	--
21	E	SFR	100	79	72	68	68	65	68	--	72	0.0	0.8	2.5	--
22	E	MFR	120	79	70	65	64	67	65	--	70	0.0	1.0	2.8	--
23	E	MFR	120	79	73	68	68	69	68	--	73	0.0	0.6	2.4	--
24	E	SFR	100	79	70	67	66	60	67	--	70	0.0	1.0	2.8	--
25	E	SFR	90	79	73	70	70	61	70	--	73	0.0	0.6	2.4	--
26	E	SFR	50	79	76	73	72	66	73	--	76	0.0	0.3	2.1	--
27	W	MFR	110	79	69	65	65	62	65	--	69	0.0	1.1	2.9	--
28	E	SFR	50	79	72	68	68	65	68	--	72	0.0	0.8	2.5	--
29	W	SFR	60	79	70	68	66	51	68	--	70	0.0	1.0	2.8	--
30	E	SFR	65	79	70	68	66	51	68	--	70	0.0	1.0	2.8	--
31	E	MFR	175	79	67	60	60	65	60	--	67	0.0	1.2	3.2	--
32	W	MFR	100	79	68	65	64	60	65	--	68	0.0	1.2	3.1	--
33	E	SFR	120	79	69	65	63	65	65	--	69	0.0	1.1	2.9	--
34	W	SFR	40	79	72	70	67	62	70	--	72	0.0	0.8	2.5	--
35	E	MFR	160	79	76	70	70	73	70	--	76	0.0	0.3	2.1	--
36	W	SFR	50	79	78	74	75	68	74	--	78	0.0	0.2	1.8	--
37	E	SFR	150	79	75	68	70	71	68	--	75	0.0	0.4	2.2	--
38	W	MFR	110	79	73	69	69	66	69	--	73	0.0	0.6	2.4	--

39	E	SFR	150	79	72	61	61	71	61	--	72	0.0	0.8	2.5	--
40	E	SFR	75	79	68	65	63	60	65	--	68	0.0	1.2	3.1	--
41	E	MFR	80	79	70	66	66	61	66	--	70	0.0	1.0	2.8	--
42	E	SFR	80	79	71	67	65	66	67	--	71	0.0	1.0	2.6	--
43	W	MFR	75	79	71	65	65	68	65	--	71	0.0	1.0	2.6	--
44	W	MFR	85	79	71	66	66	67	66	--	71	0.0	1.0	2.6	--
45	W	SFR	110	79	68	62	63	64	62	--	68	0.0	1.2	3.1	--
46	W	SFR	95	79	68	64	62	64	64	--	68	0.0	1.2	3.1	--
47	W	SFR	95	79	68	64	62	64	64	--	68	0.0	1.2	3.1	--
48	W	SFR	60	35	81	74	80	65	74	--	81	0.0	0.1	1.0	--
49	E	SFR	50	35	71	64	69	61	64	--	71	0.0	1.0	2.6	--

Notes:
1. SFR: Single-Family Residence; MFR: Multi-Family Residence
2. Distances for noise are from the centerline of the near tracks to the nearest sensitive land use (outdoor use area, or property/building line)
3. Future Total Noise Exposure is result of combining future Caltrain train noise with existing freight train noise and existing non-railroad ambient noise.

Table 7-3
Operational Noise Levels / Impacts for Electrification, by 2019

					Existing				Future				FTA Impact Criteria		
Site No	Side of Alignment	Land Use[1]	Distance to Receptor[2]	Train Speed	Total Noise Exposure	Caltrain Diesel Locomotive Train Noise	Freight Train Noise	Non-Railroad Ambient Noise	Caltrain Diesel Locomotive Noise	Caltrain EMU Train Noise	Total Noise Exposure[3]	Increase	Moderate	Severe	Impact
			feet	mph	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA			
1	W	MFR	110	79	69	63	65	65	57	60	69	-0.3	1.1	2.9	--
2	E	SFR	80	79	70	65	65	66	60	62	70	-0.4	1.0	2.8	--
3	E	SFR	90	79	70	64	66	66	59	61	70	-0.3	1.0	2.8	--
4	E	SFR	120	65	69	66	65	60	61	65	69	-0.1	1.1	2.9	--
5	W	SFR	110	79	76	71	73	69	64	68	75	-0.6	0.3	2.1	--
6	E	MFR	50	60	77	74	73	67	62	63	75	-2.4	0.3	2.0	--
7	W	SFR	120	60	74	70	71	64	59	60	72	-1.7	0.5	2.3	--
8	E	SFR	100	60	74	71	70	64	59	60	72	-2.4	0.5	2.3	--
9	W	SFR	150	60	72	69	68	62	58	59	69	-2.5	0.8	2.5	--
10	W	SFR	170	79	67	60	62	64	54	57	67	-0.2	1.2	3.2	--
11	E	MFR	160	79	71	66	66	67	60	65	71	0.0	1.0	2.6	--
12	W	SFR	90	79	72	68	69	61	62	66	72	0.0	0.8	2.5	--
13	W	SFR	150	79	68	61	63	65	55	57	68	-0.2	1.2	3.1	--
14	W	SFR	160	79	70	66	64	66	61	65	70	0.1	1.0	2.8	--
15	W	SFR	190	79	70	64	66	66	58	62	70	0.0	1.0	2.8	--
16	E	SFR	160	79	71	66	66	67	60	64	71	0.0	1.0	2.6	--
17	W	SFR	40	79	76	73	73	60	67	71	76	0.0	0.3	2.1	--
18	E	SFR	70	79	72	69	68	56	64	68	72	-0.1	0.8	2.5	--
19	W	MFR	110	79	73	68	68	69	63	67	73	0.1	0.6	2.4	--
20	W	SFR	85	79	67	64	62	60	59	61	66	-0.5	1.2	3.2	--
21	E	SFR	100	79	72	68	68	65	62	65	72	-0.2	0.8	2.5	--
22	E	MFR	120	79	70	65	64	67	59	62	70	-0.3	1.0	2.8	--
23	E	MFR	120	79	73	68	68	69	62	66	73	-0.1	0.6	2.4	--
24	E	SFR	100	79	70	67	66	60	62	65	70	-0.1	1.0	2.8	--
25	E	SFR	90	79	73	70	70	61	64	69	73	0.1	0.6	2.4	--
26	E	SFR	50	79	76	73	72	66	68	72	76	0.0	0.3	2.1	--
27	W	MFR	110	79	69	65	65	62	60	62	69	-0.5	1.1	2.9	--
28	E	SFR	50	79	72	68	68	65	63	65	72	-0.5	0.8	2.5	--
29	W	SFR	60	79	70	68	66	51	63	66	70	-0.3	1.0	2.8	--
30	E	SFR	65	79	70	68	66	51	62	65	70	-0.4	1.0	2.8	--
31	E	MFR	175	79	67	60	60	65	54	56	67	-0.2	1.2	3.2	--
32	W	MFR	100	79	68	65	64	60	59	62	68	-0.3	1.2	3.1	--
33	E	SFR	120	79	69	65	63	65	59	62	69	-0.4	1.1	2.9	--
34	W	SFR	40	79	72	70	67	62	64	66	71	-0.6	0.8	2.5	--
35	E	MFR	160	79	76	70	70	73	63	67	76	-0.5	0.3	2.1	--
36	W	SFR	50	79	78	74	75	68	68	72	78	0.1	0.2	1.8	--
37	E	SFR	150	79	75	68	70	71	61	65	75	-0.3	0.4	2.2	--

38	W	MFR	110	79	73	69	69	66	63	67	73	-0.3	0.6	2.4	--
39	E	SFR	150	79	72	61	61	71	55	57	72	-0.1	0.8	2.5	--
40	E	SFR	75	79	68	65	63	60	60	62	67	-0.6	1.2	3.1	--
41	E	MFR	80	79	70	66	66	61	61	64	70	-0.3	1.0	2.8	--
42	E	SFR	80	79	71	67	65	66	62	66	71	-0.2	1.0	2.6	--
43	W	MFR	75	79	71	65	65	68	59	62	71	-0.3	1.0	2.6	--
44	W	MFR	85	79	71	66	66	67	62	66	72	0.5	1.0	2.6	--
45	W	SFR	110	79	68	62	63	64	57	59	68	-0.3	1.2	3.1	--
46	W	SFR	95	79	68	64	62	64	58	61	68	-0.4	1.2	3.1	--
47	W	SFR	95	79	68	64	62	64	58	61	68	-0.4	1.2	3.1	--
48	W	SFR	60	35	81	74	80	65	-3	73	81	0.0	0.1	1.0	--
49	E	SFR	50	35	71	64	69	61	9	57	70	-0.9	1.0	2.6	--

Notes:

1. SFR: Single-Family Residence; MFR: Multi-Family Residence
2. Distances for noise are from the centerline of the near tracks to the nearest sensitive land use (outdoor use area, or property/building line)
3. Future Total Noise Exposure is result of combining future Caltrain train noise with existing freight train noise and existing non-railroad ambient noise.

Table 7-4
Operational Noise Levels / Impacts for Electrification, by 2040

					Existing				Future				FTA Impact Criteria		
Site No	Side of Alignment	Land Use[1]	Distance to Receptor[2]	Train Speed	Total Noise Exposure	Caltrain Diesel Locomotive Train Noise	Freight Train Noise	Non-Railroad Ambient Noise	Caltrain Diesel Locomotive Noise	Caltrain EMU Train Noise	Total Noise Exposure[3]	Increase	Moderate	Severe	Impact
			feet	mph	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA			
1	W	MFR	110	79	69	63	65	65	--	61	69	-0.5	1.1	2.9	--
2	E	SFR	80	79	70	65	65	66	--	63	69	-0.6	1.0	2.8	--
3	E	SFR	90	79	70	64	66	66	--	62	69	-0.5	1.0	2.8	--
4	E	SFR	120	65	69	66	65	60	--	65	69	-0.3	1.1	2.9	--
5	W	SFR	110	79	76	71	73	69	--	69	75	-0.7	0.3	2.1	--
6	E	MFR	50	60	77	74	73	67	--	64	74	-2.6	0.3	2.0	--
7	W	SFR	120	60	74	70	71	64	--	61	72	-1.8	0.5	2.3	--
8	E	SFR	100	60	74	71	70	64	--	61	71	-2.6	0.5	2.3	--
9	W	SFR	150	60	72	69	68	62	--	60	69	-2.7	0.8	2.5	--
10	W	SFR	170	79	67	60	62	64	--	58	67	-0.4	1.2	3.2	--
11	E	MFR	160	79	71	66	66	67	--	65	71	-0.1	1.0	2.6	--
12	W	SFR	90	79	72	68	69	61	--	67	72	-0.2	0.8	2.5	--
13	W	SFR	150	79	68	61	63	65	--	58	68	-0.3	1.2	3.1	--
14	W	SFR	160	79	70	66	64	66	--	66	70	-0.1	1.0	2.8	--
15	W	SFR	190	79	70	64	66	66	--	63	70	-0.1	1.0	2.8	--
16	E	SFR	160	79	71	66	66	67	--	65	71	-0.1	1.0	2.6	--

17	W	SFR	40	79	76	73	73	60	--	72	76	-0.3	0.3	2.1	--
18	E	SFR	70	79	72	69	68	56	--	69	72	-0.4	0.8	2.5	--
19	W	MFR	110	79	73	68	68	69	--	68	73	-0.1	0.6	2.4	--
20	W	SFR	85	79	67	64	62	60	--	62	66	-1.0	1.2	3.2	--
21	E	SFR	100	79	72	68	68	65	--	66	72	-0.4	0.8	2.5	--
22	E	MFR	120	79	70	65	64	67	--	63	69	-0.6	1.0	2.8	--
23	E	MFR	120	79	73	68	68	69	--	67	73	-0.2	0.6	2.4	--
24	E	SFR	100	79	70	67	66	60	--	66	70	-0.3	1.0	2.8	--
25	E	SFR	90	79	73	70	70	61	--	69	73	-0.2	0.6	2.4	--
26	E	SFR	50	79	76	73	72	66	--	73	76	-0.2	0.3	2.1	--
27	W	MFR	110	79	69	65	65	62	--	63	68	-0.8	1.1	2.9	--
28	E	SFR	50	79	72	68	68	65	--	66	71	-0.8	0.8	2.5	--
29	W	SFR	60	79	70	68	66	51	--	67	69	-0.8	1.0	2.8	--
30	E	SFR	65	79	70	68	66	51	--	66	69	-0.8	1.0	2.8	--
31	E	MFR	175	79	67	60	60	65	--	57	67	-0.3	1.2	3.2	--
32	W	MFR	100	79	68	65	64	60	--	63	67	-0.6	1.2	3.1	--
33	E	SFR	120	79	69	65	63	65	--	63	68	-0.8	1.1	2.9	--
34	W	SFR	40	79	72	70	67	62	--	67	71	-1.1	0.8	2.5	--
35	E	MFR	160	79	76	70	70	73	--	68	75	-0.5	0.3	2.1	--
36	W	SFR	50	79	78	74	75	68	--	73	78	-0.1	0.2	1.8	--
37	E	SFR	150	79	75	68	70	71	--	66	75	-0.4	0.4	2.2	--
38	W	MFR	110	79	73	69	69	66	--	68	72	-0.5	0.6	2.4	--
39	E	SFR	150	79	72	61	61	71	--	58	72	-0.1	0.8	2.5	--
40	E	SFR	75	79	68	65	63	60	--	63	67	-1.1	1.2	3.1	--
41	E	MFR	80	79	70	66	66	61	--	65	69	-0.6	1.0	2.8	--
42	E	SFR	80	79	71	67	65	66	--	66	71	-0.4	1.0	2.6	--
43	W	MFR	75	79	71	65	65	68	--	63	71	-0.5	1.0	2.6	--
44	W	MFR	85	79	71	66	66	67	--	67	71	0.3	1.0	2.6	--
45	W	SFR	110	79	68	62	63	64	--	60	67	-0.5	1.2	3.1	--
46	W	SFR	95	79	68	64	62	64	--	62	67	-0.7	1.2	3.1	--
47	W	SFR	95	79	68	64	62	64	--	62	67	-0.7	1.2	3.1	--
48	W	SFR	60	35	81	74	80	65	--	73	81	-0.1	0.1	1.0	--
49	E	SFR	50	35	71	64	69	61	--	56	70	-0.9	1.0	2.6	--

Notes:

4. SFR: Single-Family Residence; MFR: Multi-Family Residence
5. Distances for noise are from the centerline of the near tracks to the nearest sensitive land use (outdoor use area, or property/building line)
6. Future Total Noise Exposure is result of combining future Caltrain train noise with existing freight train noise and existing non-railroad ambient noise.

7.2 Operational Groundborne Vibration Impacts

The vibration predictions are shown below in Table 7-5. For each Receptor in the table, a representative measurement site was selected to determine the vibration attenuation characteristics and corresponding vibration level at the specified distance for the No-Project scenario.

For Receptors located between measurement sites, vibration predictions were made by interpolating between nearest 2013 measurement sites and also considering Caltrain vibration data from the nearest locations documented in the HSR measurement results (WIA 2013).

For Electrification, no adjustments were applied for train speed since the predictions represent top speeds observed in the field and it is assumed top speeds will remain unchanged with the Proposed Project. No adjustments were applied for distance since it is understood track will not be relocated.

For the Proposed Project, as discussed above in Section 6.2.1, the EMU vehicle is expected to be similar to the existing vehicle with regards to vibration, thus vibration prediction for the Project are expected to be within 3 VdB of the existing condition and thus there would be no new vibration impacts associated with Electrification based on the assumptions discussed in this report. Since there would not be a significant increase in number of trains there would be no impacts due to increase in number of trains.

The vibration predictions for the Proposed Project are expected to be somewhat conservative. It is entirely possible that the improvements to the system and conversion to EMU vehicles with the Proposed Project could reduce the vibration relative to existing Caltrain operations all other factors being equal. Further, since there are no locomotives associated with EMU trains, the effect of higher vibration otherwise caused by existing locomotives would be reduced and could potentially result in lower vibration levels. Since limited information on the future vehicle specifications is available, this remains to be seen and such a reduction has not been applied.

The vibration estimates are subject to change if more information becomes available or changes need to be made to the assumptions and parameters used in the EIR prediction analysis.

Table 7-5
Operational Vibration Level Predictions at Sensitive Receptor Sites, No-Project and Project

Site No	Alignment Segment/Receptor	Distance to Receptor Point[1], feet	Train Speed, mph	Existing and No-Project Vibration Level, VdB	Project Vibration Level, VdB	Increase in Vibration Level with Electrification	New Impact?
1	Oakdale Ave and Quint Ave	110	79	72	72-74	<3 VdB	No
2	Reddy St and Williams Ave	90	79	72	72-74	<3 VdB	No
3	Carr St and Paul Ave	80	79	75	75-77	<3 VdB	No
4	Tunnel Ave and Lathrop Ave	125	65	75	75-77	<3 VdB	No
5	Herman St and Tanforan Ave	90	79	74	74-76	<3 VdB	No
6	Huntington Ave and San Bruno Ave	40	60	81	81-83	<3 VdB	No
7	Montgomery Ave and Walnut St	120	60	73	73-75	<3 VdB	No
8	1st Ave and Pine St	100	60	75	75-77	<3 VdB	No
9	Huntington Ave and Sylvan Ave	140	60	70	70-72	<3 VdB	No
10	Can Antonio Ave and San Benito Ave	170	79	68	68-70	<3 VdB	No
11	Monterey St and Santa Paula Ave	120	79	74	74-76	<3 VdB	No
12	Hemlock Ave and Hemlock Dr	90	79	74	74-76	<3 VdB	No
13	California Dr and Dufferin Ave	150	79	71	71-73	<3 VdB	No
14	California Dr and Mills Ave	155	79	66	66-68	<3 VdB	No

15	California Dr and Palm Dr	180	79	65	65-67	<3 VdB	No
16	Park Ave and Carolan Ave	160	79	66	66-68	<3 VdB	No
17	Grand Blvd and San Mateo Blvd	30	79	84	84-86	<3 VdB	No
18	Railroad Ave and Monte Diablo	62	79	78	78-80	<3 VdB	No
19	B St and 9th Ave	100	79	72	72-74	<3 VdB	No
20	South Blvd and 16th Ave	70	79	76	76-78	<3 VdB	No
21	Pacific Blvd and Otay Ave	97	79	71	71-73	<3 VdB	No
22	Country Rd and Dale View Ave	120	79	68	68-70	<3 VdB	No
23	Country Rd and Marine View	128	79	66	66-68	<3 VdB	No
24	Country Rd and Springfield Ave	100	79	71	71-73	<3 VdB	No
25	D St and Stafford St	85	79	73	73-75	<3 VdB	No
26	Cedar St and Main St	45	79	78	78-80	<3 VdB	No
27	198 Buckingham Ave	90	79	71	71-73	<3 VdB	No
28	Arrowhead Lane and 5th Ave	50	79	77	77-79	<3 VdB	No
29	Lloyden Dr and Fair Oaks Lane	55	79	77	77-79	<3 VdB	No
30	Felton Dr and Encinal Ave	55	79	77	77-79	<3 VdB	No
31	Burgess Dr and Alma St	165	79	66	66-68	<3 VdB	No
32	Mitchell Lane and University Ave	80	79	73	73-75	<3 VdB	No
33	Alma St and Lincoln Ave	120	79	68	68-70	<3 VdB	No
34	Residences near Peers Park, Palo Alto	35	79	80	80-82	<3 VdB	No
35	Alma St and El Dorado Ave	150	79	70	70-72	<3 VdB	No
36	4237 Park Blvd, Palo Alto	55	79	76	76-78	<3 VdB	No
37	Central Exp and Thompson Ave	145	79	70	70-72	<3 VdB	No
38	Evelyn Ave and Bryant St	110	79	72	72-74	<3 VdB	No
39	Central Exp and Whisman Ave	142	79	70	70-72	<3 VdB	No
40	S. Bernardo Ave and Evelyn Ave	65	79	75	75-77	<3 VdB	No
41	Asilomar Ave and Mary Ave	75	79	76	76-78	<3 VdB	No
42	332 Angel Ave, Sunnyvale	75	79	77	77-79	<3 VdB	No
43	Fair Oaks Ave and Evelyn Ave	70	79	78	78-80	<3 VdB	No
44	Agate St and Lawrence Exp	85	79	75	75-77	<3 VdB	No
45	Agate Dr and Bowers Ave	100	79	75	75-77	<3 VdB	No
46	Alvarado Dr and San Thomas Exp	85	79	75	75-77	<3 VdB	No
47	2109 Main St, Santa Clara	95	79	76	76-78	<3 VdB	No
48	782 Auzerais Ave, San Jose	75	35	76	76-78	<3 VdB	No
49	456 Jerome St, San Jose	65	35	79	79-81	<3 VdB	No

Notes:
1. Distances for vibration analysis are from the centerline of the near tracks to the building structure.

7.3 Ancillary Facilities

In addition to the noise generated by Caltrain operations, there may be impacts caused by some of the electrical traction power substations and facilities. Potentially impacted noise sensitive receivers were identified using the screening distance of 250 feet. As explained in Section 6.1.2, FTA reference levels were used to calculate the total project noise level at the receivers identified within the screening distance.

Train operational noise levels were also calculated, per the methodology in Section 7.1, in order to predict the total Project noise levels with the ambient at the receivers, and account for both changes due to Project train operations and the new substation/facility noise source. The noise impact predictions for ancillary facilities are shown below in Table 7-6. Noise impacts would depend on facility layout. This analysis is conservative since distances were based on the closest outer footprint of facility, and the specific distance to noise sources would be greater in many cases.

PS1: Paralleling Station PS1 is located at the northeast corner of the intersection at Mariposa Street and Pennsylvania Street in San Francisco. The mixed use receiver, at the southwest corner of the intersection, is within 125 feet of the paralleling station. The increase in noise levels are projected to be 0.8 dBA resulting in No Impact.

PS2: Paralleling Station PS2 is located on property west of the alignment just south of the tunnel portal at Blanken Avenue in San Francisco. The closest residential buildings, at 110 Blanken Avenue and 233 Tunnel Avenue, are approximately 150 feet from the paralleling station. Residences located 180 feet away, at 2189 Bayshore Blvd., and 240 feet away, at 100 Lathrop Avenue, were also evaluated. None of the noise sensitive receivers within the screening distance would result in impacts.

TPS1 Option 1: Traction Power Supply Substation TPS1 Option 1 is located on commercial property along the west side of Gateway Boulevard in South San Francisco. There are no noise sensitive receivers within the screening distance. No Impact is expected to occur with this option for TPS1.

TPS1 Option 2: Traction Power Supply Substation TPS1 Option 2 is located on vacant land adjacent to commercial property on Harbor Way east of Gateway Boulevard in South San Francisco. There are no noise sensitive receivers within the screening distance. No Impact is expected to occur with this option for TPS1.

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

PS3: Paralleling Station PS3 is located to the west of the alignment near California Drive and Lincoln Avenue in Burlingame. There is a row of single family residences to the west of California Drive within 250 feet of the paralleling station. The projected noise at the closest residence would not increase due to the Project and thus No Impact would result at any of the residences.

PS4 Option 1 1: Paralleling Station PS4 Option 1 is located on the north end of the existing Hillsdale Caltrain station parking lot. No noise sensitive land uses were identified within the screening distance, thus No Impact is expected to occur with this option for PS4.

PS4 Option 2: Paralleling Station PS4 Option 2 is located on the Hillsdale Caltrain station parking lot next to E Hillsdale Blvd. No noise sensitive land uses were identified within the screening distance, thus No Impact is expected to occur with this option for PS4.

SWS1: Switching Station SWS1 is located on vacant Caltrain ROW property east of the alignment in Redwood City. There are a group of single-family residences to the west of the alignment within 250 feet of the switching station. The projected noise at the closest residence would not increase due to the Project, thus No Impact would result at any of the residences.

PS5 Option 2: Paralleling Station PS5 Option 2 is located on vacant Caltrain ROW property to the west of the alignment just south of Page Mill Road in Palo Alto. Single and multi-family residences to the east of the alignment are within 250 of the paralleling station. The projected noise associated to the Project would not increase at the closest residence, thus No Impact would result at any of the residences with this option for PS5.

PS5 Option 1: Paralleling Station PS5 Option 1 is located on vacant Caltrain ROW property to the east of the alignment at Alma Street and Greenmeadow Way in Palo Alto. The projected noise increase at the closest residence would be 0.4 dBA resulting in No Impact.

PS6 Option 2: Paralleling Station PS6 Option 2 is located on the west side of the alignment at the north end of the parking lot near the Sunnyvale Caltrain station. A group of single- family residences to the east of the alignment are located within 250 feet of the paralleling station. The projected noise increase at the closest residence would be 0.7 dBA resulting in No Impact. Thus none of the residences are identified as a Moderate Impact for this option for PS6.

PS6 Option 1: Paralleling Station PS6 Option 1 is located on vacant ROW property to the east of the alignment between the Sunnyvale Caltrain station platform area and Sunnyvale Avenue. Single-family residences and a Pet Clinic are located within 250 feet of the paralleling station along Hendy Avenue and N Murphy Avenue. The projected noise increase at the closest residence would be 0.2 dBA resulting in No Impact.

TPS2 Option 1: Traction Power Supply Substation TPS2 Option 1 is located on vacant land next to commercial property off Newhall Street in San Jose approximately 330 feet east of the alignment. The closest residential receiver is approximately 300 feet from the substation, at the corner of Newhall Street and Stockton Avenue. There are no noise sensitive receivers identified within the 250 foot screening distance and No Impact would be expected from implementing this TPS2 option.

TPS2 Option 2: Traction Power Supply Substation TPS2 Option 2 is located on commercial property off Stockton Avenue in San Jose adjacent to the Caltrain ROW. There are no sensitive receivers identified within the 250 foot screening distance. Thus, No Impact would be expected from implementing this TPS2 option.

TPS2 Option 3: Traction Power Supply Substation TPS2 Option 3 is located on the Caltrain equipment maintenance facility (CEMOF) property in San Jose. There are no noise sensitive receivers identified within the screening distance. Thus, No Impact would be expected from implementing this TPS2 option.

PS7: Paralleling Station PS7 is located on vacant Caltrain ROW property east of the alignment near the pedestrian overpass at Communications Hill Blvd in San Jose. The closest residences are over 300 feet away from the paralleling station, thus No Impact to any of the nearby residences would be expected from implementing this TPS2 option. Kurte Park is located relatively close and comes within 100 feet of the paralleling station. The park is a turfed playing field used for active recreation. Most parks used primarily for active recreation would not be considered noise sensitive.

Table 7-6
Ancillary Facility Noise Levels / Impacts for Electrification

Facility[1]	Receptor Address[2]	Land Use[3]	Receptor Distance to Ancillary Facility	Receptor Distance to Caltrain Near Track	Existing Total Noise Exposure[4]	Future: Freight + All Other Ambient Noise	Future: Project Train Noise[5]	Future: Substation Noise	Future: Total Noise Exposure[6]	Future: Increase	FTA Impact Criteria: Moderate	FTA Impact Criteria: Severe	Impact Type (number of impacts)[7]
			feet	feet	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA	Noise Exposure Increase		
PS1	211 Pennsylvania Street, San Francisco	MFR	120	255	69	69	55	62	70	0.8	1.1	2.9	--
PS2	110 Blanken Ave. / 233 Tunnel Ave., San Francisco	MFR / SFR	150	120	69	66	66	60	70	0.5	1.1	2.9	--
	2189 Bayshore Blvd., San Francisco	SFR	180	150	68	67	58	59	68	0.3	1.2	3.1	--
	100 Lathrop Avenue, San Francisco	SFR	240	120	69	66	66	56	69	0.2	1.1	2.9	--
TPS1-Opt.1	[none]	--	--	--	--	--	--	--	--	--	--	--	--
TPS1-Opt. 2	[none]	--	--	--	--	--	--	--	--	--	--	--	--
TPS1-Opt. 3	111 Mitchel Avenue, San Francisco	Hotel	70	1400	72	72	44	67	73	1.2	0.8	2.5	MI (1)
PS3	1283 California Drive, San Francisco	SFR	120	165	73	71	66	62	73	-0.1	0.6	2.4	--
PS4-Opt. 1	[none]	--	--	--	--	--	--	--	--	--	--	--	--
PS4-Opt. 2	[none]	--	--	--	--	--	--	--	--	--	--	--	--

SWS1	2690 Westmoreland Ave., Redwood City	SFR	180	110	69	67	62	59	68	-0.7	1.1	2.9	--
PS5-Opt. 2	2617 Alma Street, Palo Alto	MFR	180	160	76	75	66	59	75	-0.7	0.3	2.1	--
PS5-Opt. 1	102 Greenmeadow Way, Palo Alto	SFR	100	140	74	73	67	64	74	0.4	0.5	2.3	--
	256 Monroe Dr., Palo Alto	SFR	130	100	75	74	69	62	75	0.2	0.4	2.2	--
PS6-Opt. 2	105 N Taaffe Street, Sunnyvale	SFR	100	80	71	68	67	64	72	0.6	1.0	2.6	--
PS6-Opt. 1	100 N Murphy Ave, Sunnyvale	SFR	70	110	75	73	68	67	75	0.1	0.4	2.2	--
TPS2-Opt. 1	[none]	--	--	--	--	--	--	--	--	--	--	--	--
TPS2-Opt. 2	[none]	--	--	--	--	--	--	--	--	--	--	--	--
TPS2-Opt. 3	[none]	--	--	--	--	--	--	--	--	--	--	--	--
PS7	[none]	--	--	--	--	--	--	--	--	--	--	--	--

Notes:
1. PS: Paralleling Station; TPS: Traction Power Supply Substation; SWS: Switching Station
2. [none] indicates no noise sensitive receivers within 250 feet of the facility.
3. SFR: Single-Family Residence; MFR: Multi-Family Residence
4. Existing Total Noise Exposure is based on representative noise measurement data as discussed in Section 7.1.
5. Project Train Noise levels shown are for year 2020 schedule.
6. Future Total Noise Exposure is result of combining substation noise with future total noise levels (i.e., ambient + Project train noise + Freight train noise) calculated for the receptor based on methodology discuss in Section 7.1.
7. SI: Severe Impact; MI: Moderate Impact; Indicated in parentheses is the total number of similarly exposed land uses within the screening distance that are impacted.
8. Year 2040 noise impacts from ancillary facilities would be the same as 2020. Year 2040 total noise levels would be slightly lower by 0.1 to 0.3 dBA, or the same depending on how far from the Caltrain alignment the ancillary receptor is located.

7.4 Construction

7.4.1 Construction Noise

Noise exposure for all equipment being used in each construction stage (outlined in Table 6-4) were combined together to determine the total noise impact. The results of these calculations are shown in Table 7-7. To assess the extent of impact, a calculation was performed to determine the distance from the construction activities where an 80 dBA exposure would occur over an 8-hour period. The exposure level of 80 dBA represents the 8-hour L_{eq} limit for daytime construction noise at residential land uses.

Another area where construction noise impacts may occur would be sensitive land uses that are adjacent to construction lay-down or staging areas. These are areas where construction equipment and materials are stored and accessed during the construction period. At the time of this study, specific locations and details of the lay-down areas were undecided. If a lay-down area is selected that is within 90 feet of a residential area, it is possible that noise impacts could occur, and mitigation would be required.

Table 7-7
Distance to Noise Impact During Construction Stages

Construction Stage	Distance to Leq of 80 dBA based on 8-Hour/Day of Exposure to Construction Noise[1], feet
Overhead Contact System Installation	
Foundation installation without casing	30
Foundation installation with casing	35
OCS pole installation	25
OCS wiring	30
Overbridge Protection Barriers	
Installation of barriers to roadway bridges	60
Substation, Switching, and Paralleling Stations	
Ground Clearing Stage -- one site only	75
Ground grade	55
Concrete foundations	80
Electrical equipment installation	70

Notes:
1. Based on the construction noise limit criteria of 80 dBA for daytime hours at residential land uses. Distances are measured from the center of the noise producing activities associated with the construction phase.

Source: Parsons, 2008.

7.4.2 Construction Vibration

Table 7-8 shows the results of the vibration calculations. The distances shown in Table 7-8 are the maximum distances at which short-term construction vibration impacts may occur. Mitigation would be required if construction equipment were to operate within the distances shown in Table 7-8 from wood-framed buildings located along the project alignment.

Table 7-8
Construction Equipment Vibration Impact Distances

Equipment	Distance to Vibration Annoyance[1] feet	Distance to Vibration Building Damage[2] feet
Large bulldozer	45	--
Loaded trucks	40	--
Small bulldozer	--	--
Caisson Drilling	45	--
Vibratory hammer	130	25
Vibratory compactor/roller	85	15

Notes:
1. This is the distance at which the RMS velocity level is 80 VdB or less at the inside of the building structure. When propagating from the ground surface to the building structure foundation, there is a vibratory coupling loss of approximately 5 dB; however, this loss is offset by the building amplification in light-frame construction. Thus, no additional adjustments are applied.
2. This is the distance at which the peak particle velocity is 0.50 inch/sec or less
-- Distance is less than 10 feet.

Source: Parsons, 2008.

8 Cumulative Noise Analysis

Taking into account the future noise contributions from all noise sources for the Year 2020 and year 2040 conditions, the expected noise increase over the existing condition was determined and the noise increase was compared to the FTA noise impact criteria. Table 8-1 summarizes the number of noise impacts for the various cumulative scenarios.

For the year 2020 condition, the cumulative scenario with the Project results in four fewer Moderate Impacts as compared with the same cumulative scenario without the Project (No Project).

For the year 2040 condition, the cumulative scenario with Caltrain Full Electrification results two fewer Moderate Impacts and two fewer Severe Impact as compared with the same 2040 cumulative scenario without the project (No Project).

Table 8-1
Summary of Impacts for Cumulative Noise Analyses

Cumulative Year	Caltrain Scenario	Maximum Caltrain Speeds	High-Speed Rail (HSR) Speeds	No Impact	Moderate Impact	Severe Impact
2020	No Project	79 mph	--	34	15	0
	Project	79 mph	--	38	11	0
2040	No Project	79 mph	--	1	39	9
	Full Electrification	79 mph	--	5	37	7
		Blended Service 79 mph		2	23	24
		Blended Service 110 mph		1	6	42

Table 8-2
Impacts for 2020 Cumulative Condition with No Project

				Existing	FTA Impact Criteria		Future Year 2020				
Site No	Side of Alignment	Land Use[1]	Distance to Receptor[2]	Total Noise Exposure[3]	Moderate	Severe	Total Noise Exposure[4]	Noise Increase with No Project + Cumulative	Moderate Impact	Severe Impact	Primary Noise Source(s) Influencing Cumulative Noise[5]
			feet	L_{dn}, dBA			L_{dn}, dBA	L_{dn}, dBA			
1	W	MFR	110	69	1.1	2.9	70	0.9	--	--	F A
2	E	SFR	80	70	1.1	2.8	71	0.8	--	--	F A
3	E	SFR	90	70	1.1	2.8	71	0.8	--	--	F A
4	E	SFR	120	69	1.1	2.9	70	0.6	--	--	C F
5	W	SFR	110	76	0.3	2.1	77	0.8	MI	--	F
6	E	MFR	50	77	0.3	2.0	76	-1.1	--	--	F
7	W	SFR	120	74	0.5	2.3	74	-0.4	--	--	F
8	E	SFR	100	74	0.5	2.3	73	-1.1	--	--	F
9	W	SFR	150	72	0.8	2.5	71	-1.2	--	--	F
10	W	SFR	170	67	1.2	3.3	68	0.9	--	--	F A
11	E	MFR	160	71	1.0	2.6	72	0.8	--	--	F A
12	W	SFR	90	72	0.8	2.5	73	0.8	MI	--	F
13	W	SFR	150	68	1.2	3.1	69	0.9	--	--	A
14	W	SFR	160	70	1.1	2.8	71	0.7	--	--	C A
15	W	SFR	190	70	1.1	2.8	71	0.9	--	--	F A
16	E	SFR	160	71	1.0	2.6	72	0.8	--	--	F A
17	W	SFR	40	76	0.3	2.1	77	0.7	MI	--	F
18	E	SFR	70	72	0.8	2.5	73	0.6	--	--	C F
19	W	MFR	110	73	0.6	2.4	74	0.8	MI	--	F A
20	W	SFR	85	67	1.2	3.3	68	0.6	--	--	C
21	E	SFR	100	72	0.8	2.5	73	0.8	MI	--	F
22	E	MFR	120	70	1.1	2.8	71	0.8	--	--	A
23	E	MFR	120	73	0.6	2.4	74	0.8	MI	--	F A
24	E	SFR	100	70	1.1	2.8	71	0.6	--	--	C F
25	E	SFR	90	73	0.6	2.4	74	0.7	MI	--	C F
26	E	SFR	50	76	0.3	2.1	77	0.6	MI	--	C F
27	W	MFR	110	69	1.1	2.9	70	0.9	--	--	F
28	E	SFR	50	72	0.8	2.5	73	1.0	MI	--	F
29	W	SFR	60	70	1.1	2.8	71	0.8	--	--	C F
30	E	SFR	65	70	1.1	2.8	71	0.9	--	--	C F
31	E	MFR	175	67	1.2	3.3	68	1.0	--	--	A
32	W	MFR	100	68	1.2	3.1	69	0.9	--	--	C F
33	E	SFR	120	69	1.1	2.9	70	0.8	--	--	C F A
34	W	SFR	40	72	0.8	2.5	73	0.8	MI	--	C F
35	E	MFR	160	76	0.3	2.1	77	1.0	MI	--	A

36	W	SFR	50	78	0.2	1.8	79	1.1	MI	--	F
37	E	SFR	150	75	0.4	2.2	76	1.1	MI	--	F A
38	W	MFR	110	73	0.6	2.4	74	0.9	MI	--	F
39	E	SFR	150	72	0.8	2.5	73	0.9	MI	--	A
40	E	SFR	75	68	1.2	3.1	69	0.8	--	--	C
41	E	MFR	80	70	1.1	2.8	71	1.0	--	--	F
42	E	SFR	80	71	1.0	2.6	72	0.8	--	--	C F A
43	W	MFR	75	71	1.0	2.6	72	1.0	--	--	A
44	W	MFR	85	71	1.0	2.6	72	0.8	--	--	F A
45	W	SFR	110	68	1.2	3.1	69	0.8	--	--	F A
46	W	SFR	95	68	1.2	3.1	69	0.7	--	--	C A
47	W	SFR	95	68	1.2	3.1	69	0.7	--	--	C A
48	W	SFR	60	81	0.1	1.0	81	-0.4	--	--	F
49	E	SFR	50	71	1.0	2.6	71	-0.4	--	--	F

Notes:

1. SFR: Single-Family Residence; MFR: Multi-Family Residence
2. Distances for noise are from the centerline of the near tracks to the nearest sensitive land use (outdoor use area, or property/building line)
3. Existing Total Noise Exposure is based on representative noise measurement data as discussed in Section 7.1.
4. Future Total Noise Exposure is result of combining future Caltrain train noise with 2020 cumulative conditions:
    a. Increased freight traffic, varies depending on location (see Table 6-2)
    b. Increased non-rail ambient
    c. New Coast Daylight service, increased ACE service, and increased Capitol Corridor service were also considered; these sources have no effect on total noise levels.
5. Primary noise sources influencing total cumulative noise levels
    a. C: Caltrain trains
    b. F: Freight trains
    c. A: Non-rail Ambient

Table 8-3
Impacts for 2020 Cumulative Condition with Project

				Existing	FTA Impact Criteria		Future Year 2020				
Site No	Side of Alignment	Land Use[1]	Distance to Receptor[2]	Total Noise Exposure[3]	Moderate	Severe	Total Noise Exposure[4]	Noise Increase with Project + Cumulative	Moderate Impact	Severe Impact	Primary Noise Source(s) Influencing Cumulative Noise[5]
			feet	L_{dn}, dBA			L_{dn}, dBA	L_{dn}, dBA			
1	W	MFR	110	69	1.1	2.9	70	0.6	--	--	F A
2	E	SFR	80	70	1.1	2.8	70	0.5	--	--	F A
3	E	SFR	90	70	1.1	2.8	71	0.6	--	--	F A
4	E	SFR	120	69	1.1	2.9	70	0.6	--	--	F
5	W	SFR	110	76	0.3	2.1	76	0.3	--	--	F
6	E	MFR	50	77	0.3	2.0	76	-1.3	--	--	F
7	W	SFR	120	74	0.5	2.3	73	-0.6	--	--	F
8	E	SFR	100	74	0.5	2.3	73	-1.4	--	--	F

9	W	SFR	150	72	0.8	2.5	71	-1.5	--	--	F
10	W	SFR	170	67	1.2	3.3	68	0.7	--	--	F A
11	E	MFR	160	71	1.0	2.6	72	0.8	--	--	F A
12	W	SFR	90	72	0.8	2.5	73	0.8	MI	--	F
13	W	SFR	150	68	1.2	3.1	69	0.7	--	--	A
14	W	SFR	160	70	1.1	2.8	71	0.7	--	--	A
15	W	SFR	190	70	1.1	2.8	71	0.9	--	--	F A
16	E	SFR	160	71	1.0	2.6	72	0.8	--	--	F A
17	W	SFR	40	76	0.3	2.1	77	0.7	MI	--	F
18	E	SFR	70	72	0.8	2.5	73	0.6	--	--	F
19	W	MFR	110	73	0.6	2.4	74	0.8	MI	--	F A
20	W	SFR	85	67	1.2	3.3	67	0.2	--	--	F
21	E	SFR	100	72	0.8	2.5	73	0.6	--	--	F
22	E	MFR	120	70	1.1	2.8	70	0.5	--	--	A
23	E	MFR	120	73	0.6	2.4	74	0.7	MI	--	F A
24	E	SFR	100	70	1.1	2.8	71	0.6	--	--	F
25	E	SFR	90	73	0.6	2.4	74	0.7	MI	--	F
26	E	SFR	50	76	0.3	2.1	77	0.6	MI	--	F
27	W	MFR	110	69	1.1	2.9	70	0.6	--	--	F
28	E	SFR	50	72	0.8	2.5	73	0.6	--	--	F
29	W	SFR	60	70	1.1	2.8	70	0.5	--	--	F
30	E	SFR	65	70	1.1	2.8	71	0.6	--	--	F
31	E	MFR	175	67	1.2	3.3	68	0.8	--	--	A
32	W	MFR	100	68	1.2	3.1	69	0.7	--	--	F
33	E	SFR	120	69	1.1	2.9	69	0.5	--	--	F A
34	W	SFR	40	72	0.8	2.5	72	0.3	--	--	F
35	E	MFR	160	76	0.3	2.1	77	0.6	MI	--	A
36	W	SFR	50	78	0.2	1.8	79	1.2	MI	--	F
37	E	SFR	150	75	0.4	2.2	76	0.8	MI	--	F A
38	W	MFR	110	73	0.6	2.4	74	0.6	--	--	F
39	E	SFR	150	72	0.8	2.5	73	0.9	MI	--	A
40	E	SFR	75	68	1.2	3.1	68	0.2	--	--	F
41	E	MFR	80	70	1.1	2.8	71	0.8	--	--	F
42	E	SFR	80	71	1.0	2.6	72	0.7	--	--	F A
43	W	MFR	75	71	1.0	2.6	72	0.8	--	--	A
44	W	MFR	85	71	1.0	2.6	72	1.2	MI	--	F A
45	W	SFR	110	68	1.2	3.1	69	0.6	--	--	F A
46	W	SFR	95	68	1.2	3.1	68	0.3	--	--	A
47	W	SFR	95	68	1.2	3.1	68	0.3	--	--	A
48	W	SFR	60	81	0.1	1.0	81	-0.4	--	--	F
49	E	SFR	50	71	1.0	2.6	70	-1.4	--	--	F

Notes:
1. SFR: Single-Family Residence; MFR: Multi-Family Residence
2. Distances for noise are from the centerline of the near tracks to the nearest sensitive land use (outdoor use area, or property/building line)
3. Existing Total Noise Exposure is based on representative noise measurement data as discussed in Section 7.1.
4. Future Total Noise Exposure is result of combining future Caltrain train noise with 2020 cumulative conditions:
    a. Increased freight traffic, varies depending on location (see Table 6-2)
    b. Increased non-rail ambient
    c. New Coast Daylight service, increased ACE service, and increased Capitol Corridor service were also considered; these sources have no effect on total noise levels.
5. Primary noise sources influencing total cumulative noise levels
    a. C: Caltrain trains

b. F: Freight trains
c. A: Non-rail Ambient

Table 8-4
Impacts for 2040 Cumulative Condition with No Project

				Existing	FTA Impact Criteria		Future Year 2040				
Site No	Side of Alignment	Land Use[1]	Distance to Receptor[2]	Total Noise Exposure[3]	Moderate	Severe	Total Noise Exposure[4]	Noise Increase with No Project + Cumulative	Moderate Impact	Severe Impact	Primary Noise Source(s) Influencing Cumulative Noise[5]
			feet	L_{dn}, dBA			L_{dn}, dBA	L_{dn}, dBA			
1	W	MFR	110	69	1.1	2.9	72	2.7	MI	--	F A
2	E	SFR	80	70	1.1	2.8	73	2.5	MI	--	A
3	E	SFR	90	70	1.1	2.8	73	2.7	MI	--	F A
4	E	SFR	120	69	1.1	2.9	71	2.0	MI	--	F
5	W	SFR	110	76	0.3	2.1	78	2.4	--	SI	F
6	E	MFR	50	77	0.3	2.0	78	0.7	MI	--	F
7	W	SFR	120	74	0.5	2.3	75	1.4	MI	--	F
8	E	SFR	100	74	0.5	2.3	75	0.6	MI	--	F
9	W	SFR	150	72	0.8	2.5	73	0.5	--	--	F
10	W	SFR	170	67	1.2	3.3	70	2.9	MI	--	A
11	E	MFR	160	71	1.0	2.6	74	2.6	MI	--	F A
12	W	SFR	90	72	0.8	2.5	74	2.3	MI	--	F
13	W	SFR	150	68	1.2	3.1	71	2.9	MI	--	A
14	W	SFR	160	70	1.1	2.8	72	2.4	MI	--	A
15	W	SFR	190	70	1.1	2.8	73	2.7	MI	--	F A
16	E	SFR	160	71	1.0	2.6	74	2.6	MI	--	F A
17	W	SFR	40	76	0.3	2.1	78	2.0	MI	--	F
18	E	SFR	70	72	0.8	2.5	74	1.8	MI	--	F
19	W	MFR	110	73	0.6	2.4	76	2.5	--	SI	A
20	W	SFR	85	67	1.2	3.3	69	2.0	MI	--	C F
21	E	SFR	100	72	0.8	2.5	74	2.4	MI	--	F
22	E	MFR	120	70	1.1	2.8	73	2.6	MI	--	A
23	E	MFR	120	73	0.6	2.4	76	2.6	--	SI	A
24	E	SFR	100	70	1.1	2.8	72	2.0	MI	--	F
25	E	SFR	90	73	0.6	2.4	75	2.0	MI	--	F
26	E	SFR	50	76	0.3	2.1	78	1.9	MI	--	F
27	W	MFR	110	69	1.1	2.9	71	2.1	MI	--	F
28	E	SFR	50	72	0.8	2.5	74	2.2	MI	--	F
29	W	SFR	60	70	1.1	2.8	71	1.4	MI	--	C F

30	E	SFR	65	70	1.1	2.8	72	1.6	MI	--	F
31	E	MFR	175	67	1.2	3.3	70	2.9	MI	--	A
32	W	MFR	100	68	1.2	3.1	70	1.9	MI	--	F
33	E	SFR	120	69	1.1	2.9	71	2.3	MI	--	A
34	W	SFR	40	72	0.8	2.5	74	1.7	MI	--	C F
35	E	MFR	160	76	0.3	2.1	79	2.6	--	SI	A
36	W	SFR	50	78	0.2	1.8	80	2.2	--	SI	F
37	E	SFR	150	75	0.4	2.2	78	2.7	--	SI	A
38	W	MFR	110	73	0.6	2.4	75	2.1	MI	--	F
39	E	SFR	150	72	0.8	2.5	75	3.3	--	SI	A
40	E	SFR	75	68	1.2	3.1	70	1.7	MI	--	C F
41	E	MFR	80	70	1.1	2.8	72	2.0	MI	--	F
42	E	SFR	80	71	1.0	2.6	73	2.1	MI	--	A
43	W	MFR	75	71	1.0	2.6	74	2.7	--	SI	A
44	W	MFR	85	71	1.0	2.6	74	2.5	MI	--	A
45	W	SFR	110	68	1.2	3.1	71	2.7	MI	--	F A
46	W	SFR	95	68	1.2	3.1	70	2.4	MI	--	A
47	W	SFR	95	68	1.2	3.1	70	2.4	MI	--	A
48	W	SFR	60	81	0.1	1.0	82	1.3	--	SI	F
49	E	SFR	50	71	1.0	2.6	72	1.2	MI	--	F

Notes:

1. SFR: Single-Family Residence; MFR: Multi-Family Residence
2. Distances for noise are from the centerline of the near tracks to the nearest sensitive land use (outdoor use area, or property/building line)
3. Existing Total Noise Exposure is based on representative noise measurement data as discussed in Section 7.1.
4. Future Total Noise Exposure is result of combining future Caltrain train noise with 2040 cumulative conditions:
    a. New Dumbarton Rail service between San Francisco and Redwood City (sites 1 – 26)
    b. Increased freight traffic, varies depending on location (see Table 6-2)
    c. Increased non-rail ambient
    d. New Coast Daylight service, increased ACE service, and increased Capitol Corridor service were also considered; these sources have no effect on total noise levels.
5. Primary noise sources influencing total cumulative noise levels
    a. C: Caltrain trains
    b. F: Freight trains
    c. A: Non-rail Ambient

Table 8-5
Impacts for 2040 Cumulative Condition with Caltrain Full Electrification

				Existing	FTA Impact Criteria		Future Year 2040				
Site No	Side of Alignment	Land Use[1]	Distance to Receptor[2]	Total Noise Exposure[3]	Moderate	Severe	Total Noise Exposure[4]	Noise Increase with Full Electrification + Cumulative	Moderate Impact	Severe Impact	Primary Noise Source(s) Influencing Cumulative Noise[5]
			feet	L_{dn}, dBA			L_{dn}, dBA	L_{dn}, dBA			
1	W	MFR	110	69	1.1	2.9	71	2.5	MI	--	F A
2	E	SFR	80	70	1.1	2.8	72	2.2	MI	--	A
3	E	SFR	90	70	1.1	2.8	72	2.4	MI	--	F A
4	E	SFR	120	69	1.1	2.9	71	1.7	MI	--	F
5	W	SFR	110	76	0.3	2.1	78	2.0	MI	--	F
6	E	MFR	50	77	0.3	2.0	77	0.4	MI	--	F
7	W	SFR	120	74	0.5	2.3	75	1.2	MI	--	F
8	E	SFR	100	74	0.5	2.3	74	0.4	--	--	F
9	W	SFR	150	72	0.8	2.5	72	0.2	--	--	F
10	W	SFR	170	67	1.2	3.3	70	2.7	MI	--	A
11	E	MFR	160	71	1.0	2.6	74	2.5	MI	--	F A
12	W	SFR	90	72	0.8	2.5	74	2.2	MI	--	F
13	W	SFR	150	68	1.2	3.1	71	2.7	MI	--	A
14	W	SFR	160	70	1.1	2.8	72	2.3	MI	--	A
15	W	SFR	190	70	1.1	2.8	73	2.7	MI	--	F A
16	E	SFR	160	71	1.0	2.6	74	2.6	MI	--	F A
17	W	SFR	40	76	0.3	2.1	78	1.8	MI	--	F
18	E	SFR	70	72	0.8	2.5	74	1.5	MI	--	F
19	W	MFR	110	73	0.6	2.4	75	2.5	--	SI	A
20	W	SFR	85	67	1.2	3.3	68	1.4	MI	--	F
21	E	SFR	100	72	0.8	2.5	74	2.2	MI	--	F
22	E	MFR	120	70	1.1	2.8	72	2.3	MI	--	A
23	E	MFR	120	73	0.6	2.4	75	2.4	MI	--	A
24	E	SFR	100	70	1.1	2.8	72	1.7	MI	--	F
25	E	SFR	90	73	0.6	2.4	75	1.9	MI	--	F
26	E	SFR	50	76	0.3	2.1	78	1.8	MI	--	F
27	W	MFR	110	69	1.1	2.9	71	1.7	MI	--	F
28	E	SFR	50	72	0.8	2.5	74	1.7	MI	--	F
29	W	SFR	60	70	1.1	2.8	71	0.9	--	--	F
30	E	SFR	65	70	1.1	2.8	71	1.1	MI	--	F
31	E	MFR	175	67	1.2	3.3	70	2.7	MI	--	A
32	W	MFR	100	68	1.2	3.1	70	1.5	MI	--	F
33	E	SFR	120	69	1.1	2.9	71	1.9	MI	--	A
34	W	SFR	40	72	0.8	2.5	73	0.9	MI	--	F
35	E	MFR	160	76	0.3	2.1	78	2.3	--	SI	A

36	W	SFR	50	78	0.2	1.8	80	2.2	--	SI	F
37	E	SFR	150	75	0.4	2.2	78	2.5	--	SI	A
38	W	MFR	110	73	0.6	2.4	75	1.8	MI	--	F
39	E	SFR	150	72	0.8	2.5	75	3.2	--	SI	A
40	E	SFR	75	68	1.2	3.1	69	1.0	--	--	F
41	E	MFR	80	70	1.1	2.8	72	1.7	MI	--	F
42	E	SFR	80	71	1.0	2.6	73	1.9	MI	--	A
43	W	MFR	75	71	1.0	2.6	73	2.5	MI	--	A
44	W	MFR	85	71	1.0	2.6	74	2.7	--	SI	A
45	W	SFR	110	68	1.2	3.1	70	2.4	MI	--	F A
46	W	SFR	95	68	1.2	3.1	70	2.0	MI	--	A
47	W	SFR	95	68	1.2	3.1	70	2.0	MI	--	A
48	W	SFR	60	81	0.1	1.0	82	1.2	--	SI	F
49	E	SFR	50	71	1.0	2.6	72	0.6	--	--	F

Notes:

1. SFR: Single-Family Residence; MFR: Multi-Family Residence
2. Distances for noise are from the centerline of the near tracks to the nearest sensitive land use (outdoor use area, or property/building line)
3. Existing Total Noise Exposure is based on representative noise measurement data as discussed in Section 7.1.
4. Future Total Noise Exposure is result of combining future Caltrain train noise with 2040 cumulative conditions:
    a. New Dumbarton Rail service between San Francisco and Redwood City (sites 1 – 26)
    b. Increased freight traffic, varies depending on location (see Table 6-2)
    c. Increased non-rail ambient
    d. New Coast Daylight service, increased ACE service, and increased Capitol Corridor service were also considered; these sources have no effect on total noise levels.
5. Primary noise sources influencing total cumulative noise levels
    a. C: Caltrain trains
    b. F: Freight trains
    c. A: Non-rail Ambient

Table 8-6
Impacts for 2040 Cumulative Condition with Blended Service (79 mph scenario)

				Existing	FTA Impact Criteria		Future Year 2040				
Site No	Side of Alignment	Land Use[1]	Distance to Receptor[2]	Total Noise Exposure[3]	Moderate	Severe	Total Noise Exposure[4]	Noise Increase with Blended Service + Cumulative	Moderate Impact	Severe Impact	Primary Noise Source(s) Influencing Cumulative Noise[5]
			feet	L_{dn}, dBA			L_{dn}, dBA	L_{dn}, dBA			
1	W	MFR	110	69	1.1	2.9	72	2.9	MI	--	F A
2	E	SFR	80	70	1.1	2.8	73	2.7	MI	--	A
3	E	SFR	90	70	1.1	2.8	73	2.8	--	SI	F A
4	E	SFR	120	69	1.1	2.9	72	2.7	MI	--	F
5	W	SFR	110	76	0.3	2.1	78	2.4	--	SI	F
6	E	MFR	50	77	0.3	2.0	78	0.8	MI	--	F
7	W	SFR	120	74	0.5	2.3	75	1.4	MI	--	F
8	E	SFR	100	74	0.5	2.3	75	0.7	MI	--	F
9	W	SFR	150	72	0.8	2.5	73	0.6	--	--	F
10	W	SFR	170	67	1.2	3.3	70	3.0	MI	--	A
11	E	MFR	160	71	1.0	2.6	74	2.7	--	SI	F A
12	W	SFR	90	72	0.8	2.5	75	2.8	--	SI	F
13	W	SFR	150	68	1.2	3.1	71	3.0	MI	--	A
14	W	SFR	160	70	1.1	2.8	73	3.1	--	SI	A
15	W	SFR	190	70	1.1	2.8	73	3.1	--	SI	F A
16	E	SFR	160	71	1.0	2.6	74	3.1	--	SI	F A
17	W	SFR	40	76	0.3	2.1	79	2.7	--	SI	F
18	E	SFR	70	72	0.8	2.5	75	2.7	--	SI	F
19	W	MFR	110	73	0.6	2.4	76	3.1	--	SI	A
20	W	SFR	85	67	1.2	3.3	69	2.4	MI	--	F
21	E	SFR	100	72	0.8	2.5	75	2.8	--	SI	F
22	E	MFR	120	70	1.1	2.8	73	2.8	--	SI	A
23	E	MFR	120	73	0.6	2.4	76	3.0	--	SI	A
24	E	SFR	100	70	1.1	2.8	73	2.7	MI	--	F
25	E	SFR	90	73	0.6	2.4	76	2.9	--	SI	F
26	E	SFR	50	76	0.3	2.1	79	2.8	--	SI	F
27	W	MFR	110	69	1.1	2.9	71	2.4	MI	--	F
28	E	SFR	50	72	0.8	2.5	74	2.4	MI	--	F
29	W	SFR	60	70	1.1	2.8	72	2.2	MI	--	F
30	E	SFR	65	70	1.1	2.8	72	2.3	MI	--	F
31	E	MFR	175	67	1.2	3.3	70	3.0	MI	--	A
32	W	MFR	100	68	1.2	3.1	70	2.5	MI	--	F
33	E	SFR	120	69	1.1	2.9	72	2.6	MI	--	A
34	W	SFR	40	72	0.8	2.5	74	2.1	MI	--	F
35	E	MFR	160	76	0.3	2.1	79	2.7	--	SI	A

36	W	SFR	50	78	0.2	1.8	81	2.9	--	SI	F
37	E	SFR	150	75	0.4	2.2	78	2.8	--	SI	A
38	W	MFR	110	73	0.6	2.4	76	2.5	--	SI	F
39	E	SFR	150	72	0.8	2.5	75	3.3	--	SI	A
40	E	SFR	75	68	1.2	3.1	70	2.1	MI	--	F
41	E	MFR	80	70	1.1	2.8	73	2.5	MI	--	F
42	E	SFR	80	71	1.0	2.6	74	2.7	--	SI	A
43	W	MFR	75	71	1.0	2.6	74	2.9	--	SI	A
44	W	MFR	85	71	1.0	2.6	74	3.5	--	SI	A
45	W	SFR	110	68	1.2	3.1	71	2.8	MI	--	F A
46	W	SFR	95	68	1.2	3.1	71	2.6	MI	--	A
47	W	SFR	95	68	1.2	3.1	71	2.6	MI	--	A
48	W	SFR	60	81	0.1	1.0	82	1.2	--	SI	F
49	E	SFR	50	71	1.0	2.6	72	0.6	--	--	F

Notes:

1. SFR: Single-Family Residence; MFR: Multi-Family Residence
2. Distances for noise are from the centerline of the near tracks to the nearest sensitive land use (outdoor use area, or property/building line)
3. Existing Total Noise Exposure is based on representative noise measurement data as discussed in Section 7.1.
4. Future Total Noise Exposure is result of these 2040 cumulative conditions:
    a. Blended service up to 79 mph train speed
    b. New Dumbarton Rail service between San Francisco and Redwood City (sites 1 – 26)
    c. Increased freight traffic, varies depending on location (see Table 6-2)
    d. Increased non-rail ambient
    e. New Coast Daylight service, increased ACE service, and increased Capitol Corridor service were also considered; these sources have no effect on total noise levels.
5. Primary noise sources influencing total cumulative noise levels
    a. C: Caltrain trains
    b. F: Freight trains
    c. H: High-Speed trains
    d. A: Non-rail Ambient

Table 8-7
Impacts for 2040 Cumulative Condition with Blended Service (110 mph scenario)

				Existing	FTA Impact Criteria		Future Year 2040				
Site No	Side of Alignment	Land Use[1]	Distance to Receptor[2]	Total Noise Exposure[3]	Moderate	Severe	Total Noise Exposure[4]	Noise Increase with Blended Service+ Cumulative	Moderate Impact	Severe Impact	Primary Noise Source(s) Influencing Cumulative Noise[5]
			feet	L_{dn}, dBA			L_{dn}, dBA	L_{dn}, dBA			
1	W	MFR	110	69	1.1	2.9	72	3.4	--	SI	F A
2	E	SFR	80	70	1.1	2.8	73	3.4	--	SI	A
3	E	SFR	90	70	1.1	2.8	73	3.4	--	SI	F A
4	E	SFR	120	69	1.1	2.9	72	2.8	MI	--	F
5	W	SFR	110	76	0.3	2.1	78	2.5	--	SI	F
6	E	MFR	50	77	0.3	2.0	78	1.3	MI	--	F
7	W	SFR	120	74	0.5	2.3	76	1.9	MI	--	F
8	E	SFR	100	74	0.5	2.3	75	1.3	MI	--	F
9	W	SFR	150	72	0.8	2.5	73	1.3	MI	--	F
10	W	SFR	170	67	1.2	3.3	70	3.4	--	SI	A
11	E	MFR	160	71	1.0	2.6	74	2.7	--	SI	F A
12	W	SFR	90	72	0.8	2.5	75	3.0	--	SI	F
13	W	SFR	150	68	1.2	3.1	71	3.4	--	SI	A
14	W	SFR	160	70	1.1	2.8	73	2.9	--	SI	A
15	W	SFR	190	70	1.1	2.8	73	3.1	--	SI	F A
16	E	SFR	160	71	1.0	2.6	74	3.0	--	SI	F A
17	W	SFR	40	76	0.3	2.1	79	2.9	--	SI	F
18	E	SFR	70	72	0.8	2.5	75	2.9	--	SI	F
19	W	MFR	110	73	0.6	2.4	76	3.0	--	SI	A
20	W	SFR	85	67	1.2	3.3	71	3.5	--	SI	C F H
21	E	SFR	100	72	0.8	2.5	75	3.2	--	SI	F
22	E	MFR	120	70	1.1	2.8	73	3.5	--	SI	A
23	E	MFR	120	73	0.6	2.4	76	3.1	--	SI	A
24	E	SFR	100	70	1.1	2.8	73	2.9	--	SI	F
25	E	SFR	90	73	0.6	2.4	76	2.7	--	SI	F
26	E	SFR	50	76	0.3	2.1	79	2.8	--	SI	F
27	W	MFR	110	69	1.1	2.9	72	3.4	--	SI	F
28	E	SFR	50	72	0.8	2.5	75	3.3	--	SI	F
29	W	SFR	60	70	1.1	2.8	73	3.1	--	SI	C F H
30	E	SFR	65	70	1.1	2.8	73	3.0	--	SI	F
31	E	MFR	175	67	1.2	3.3	70	3.4	--	SI	A
32	W	MFR	100	68	1.2	3.1	71	3.1	--	SI	F
33	E	SFR	120	69	1.1	2.9	72	3.4	--	SI	A
34	W	SFR	40	72	0.8	2.5	75	3.4	--	SI	C F H
35	E	MFR	160	76	0.3	2.1	79	2.7	--	SI	A

36	W	SFR	50	78	0.2	1.8	81	2.8	--	SI	F
37	E	SFR	150	75	0.4	2.2	78	2.8	--	SI	A
38	W	MFR	110	73	0.6	2.4	75	2.4	MI	--	F
39	E	SFR	150	72	0.8	2.5	75	3.4	--	SI	A
40	E	SFR	75	68	1.2	3.1	71	3.4	--	SI	C F H
41	E	MFR	80	70	1.1	2.8	73	3.1	--	SI	F
42	E	SFR	80	71	1.0	2.6	74	3.0	--	SI	A
43	W	MFR	75	71	1.0	2.6	74	3.4	--	SI	A
44	W	MFR	85	71	1.0	2.6	75	3.6	--	SI	A
45	W	SFR	110	68	1.2	3.1	71	3.4	--	SI	F A
46	W	SFR	95	68	1.2	3.1	71	3.5	--	SI	A
47	W	SFR	95	68	1.2	3.1	71	3.5	--	SI	A
48	W	SFR	60	81	0.1	1.0	82	1.2	--	SI	F
49	E	SFR	50	71	1.0	2.6	72	0.6	--	--	F

Notes:

1. SFR: Single-Family Residence; MFR: Multi-Family Residence
2. Distances for noise are from the centerline of the near tracks to the nearest sensitive land use (outdoor use area, or property/building line)
3. Existing Total Noise Exposure is based on representative noise measurement data as discussed in Section 7.1.
4. Future Total Noise Exposure is result of these 2040 cumulative conditions:
    a. Blended service up to 110 mph train speed
    b. New Dumbarton Rail service between San Francisco and Redwood City (sites 1 – 26)
    c. Increased Caltrain speeds from 79 mph up to 110 mph between San Francisco and San Jose Diridon
    d. Increased freight traffic, varies depending on location (see Table 6-2)
    e. Increased non-rail ambient
    f. New Coast Daylight service, increased ACE service, and increased Capitol Corridor service were also considered; these sources have no effect on total noise levels.
5. Primary noise sources influencing total cumulative noise levels
    a. C: Caltrain trains
    b. F: Freight trains
    c. H: High-Speed trains
    d. A: Non-rail Ambient

9 Cumulative Vibration Analysis

The thresholds used for this analysis are the FTA annoyance thresholds for residential receptors (72 VdB) and institutional buildings (75 VdB) and the structural damage threshold (90 VdB). As described by the FTA (2006), it is very rare for transportation-generated ground vibration to approach building damage levels. Thus, the primary focus of this cumulative analysis is on the annoyance thresholds.

Unlike noise, which is measured on a 24-hour day-night basis in which noise levels can increase cumulatively, vibration levels do not accumulate. Thus cumulative impacts would not result in higher vibration levels when combining multiple trains along the corridor. However, cumulative impacts can occur when multiple trains, each over the FTA vibration annoyance thresholds, pass a single sensitive receptor, resulting in an increase in the number of annoyance events.

As presented above, existing vibration levels for Caltrain's diesel service at 50 feet from the outermost track vary from 72 to 80 VdB, depending on local site conditions and speed. This range would be representative of continued diesel operations for Caltrain as well as predicted increases in cumulative diesel passenger rail operations for other tenant railroads. As presented above, existing vibration levels for freight at 100 feet from the outermost track vary from 73 to 81 VdB, which is considered representative for future freight service increases.

These existing levels exceed FTA annoyance thresholds of 72 VdB for immediately adjacent residences and of 75 VdB for immediately adjacent institutional buildings, but none approach structural damage thresholds.

Blended Service Scenario (79 mph scenario)

As described in the Final EIS/EIR for the HSR Merced-Fresno segment, HSR projects typically generate significantly fewer vibration impacts as compared with noise impacts (CHSRA 2012). Using FRA reference level of 83 VdB for 150 mph high-speed rail trains at 50 feet from track centerlines (FRA 2012) and adjusting to a 79 mph speed, potential vibration levels are generically estimated as 77 VdB which would be within the range of existing train vibration levels along the corridor today. This estimate has not been adjusted for site trackage or soil conditions or any potential track improvements that may come with Blended Service and thus may overestimate actual vibration levels for HST trains. For example, for the HSR Merced – Fresno segment, vibration levels for speeds up to 150 mph at 50 feet from the HSR track centerline were estimated as approximately 72 VdB for (CHSRA 2012). Based on the HSR Merced-Fresno vibration distance curves and adjusting downward for 79 mph speeds, vibration levels could be 66 VdB instead if similar vibration conditions (soil, trackage, etc.) were present along the Caltrain corridor as that presumed for HSR for the Merced Fresno segment.

The additional cumulative diesel traffic (ACE, DRC, Capitol Corridor, Amtrak and freight) would not increase vibration levels along the Caltrain ROW compared to existing conditions (which already includes diesel freight and passenger rail operations). Over time, these services are likely to replace their older equipment as it reaches the end of its design life and it is possible, but unknown, that new equipment may be somewhat quieter than existing equipment.

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

Based on the information presented above, cumulative train service would not change the overall range of vibration levels along the Caltrain corridor.

According to the FTA Noise and Vibration Manual (FTA 2006), in heavily used corridors, if the existing train vibration exceeds the FTA annoyance impact criteria (as noted above), the project will cause additional impact if the project significantly increases the number of vibration events defined as approximately doubling the number of events. Thus, the analysis then examined whether the increase in the number of cumulative vibration events is or is not significant.

Of all the cumulative train service increases proposed would come to full fruition, in 2040, the number of trains (including Blended Service) between Santa Clara and San Francisco would more than double. Given the more than doubling of trains along the Santa Clara to San Francisco segment of the Caltrain corridor, a potentially cumulative significant increase in the number of vibration annoyance events for residential and institutional building receptors is identified. Although HSR would operate on a separate dedicate track south of Santa Clara, if one includes 80 trains (one-way) per day and given the parallel alignment to the Caltrain ROW in some locations, there is a possible doubling of vibration events, and potential cumulative vibration impacts are also identified south of Santa Clara.

Blended Service Scenario (110 mph scenario)

In addition to train service level increases, HSR and Caltrain EMUs could operate at speeds up to 110 mph with Blended Service.

Using FRA reference level of 83 VdB for 150 mph high-speed rail trains at 50 feet from track centerlines (FRA 2012) and adjusting for 110 mph speeds, potential vibration levels for HSR trains are generically estimated as 80 VdB. As noted above, this generic vibration level estimate has not been adjusted for site trackage or soil conditions or any potential track improvements that may come with Blended Service and thus may overestimate actual vibration levels for HST trains. For example, for the HSR Merced – Fresno segment, vibration levels for speeds up to 150 mph at 50 feet from the HSR track centerline were estimated as approximately 72 VdB for (CHSRA 2012). Based on the HSR Merced-Fresno vibration distance curves and adjusting downward for 110 mph speeds, vibration levels could be 69 VdB instead if similar vibration conditions (soil, trackage, etc.) were present along the Caltrain corridor as that presumed for HSR in this segment.

Based on the FTA Reference levels for rapid transit trains at 50 mph (FRA 2006) and adjusting for 110 mph speeds, HSR EMUs could have vibration levels of 80 VdB at 50 feet from the outer track centerline which would be the same as the generic estimate for HSR trains described above and would be similarly at the top of the range of existing vibration levels along the corridor. This estimate also has not been adjusted for track improvements that will be necessary to operate at speeds up to 110 mph and thus may overestimate the actual value.

Thus, at this time, it appears likely that Blended Service would not increase overall vibration levels compared to the range of vibration levels along the Caltrain corridor today and it is distinctly possible that vibration levels for Blended Service would be lower than the generic estimates presented above when specific trackage improvements required to allow 110 mph speeds are made and when site-specific considerations are taken into account.

However, as noted above for the Blended Service 79 mph scenario, due to the substantial increase in train events, which would more than double between Santa Clara and San Francisco and the potential for more than double south of Santa Clara (if including HST service on separate dedicated trackage where along the Caltrain ROW), there is a potentially significant increase in annoyance due to cumulative vibration events for residents and institutional buildings immediately adjacent to the Caltrain ROW for the 2040 Blended Service 110 mph scenario.

Additional project-level vibration analysis is recommended as part of the subsequent HSR evaluation of Blended service in particular to assess particular Caltrain EMU and HSR train design as well as required trackage improvements needed to support Blended Service to better assess potential vibration levels along the Caltrain corridor. Potential vibration mitigation measures are listed below.

10 Diesel Multiple Unit (DMU) Alternative Analysis

Year 2020 8-car DMU operational train noise projections and impact results are presented in Table 10-1. 8-car DMU trains are expected to generate similar noise levels to the existing diesel locomotive trains. Due to the slight increase in train traffic volume, the future noise levels with the DMU Alternative are projected to increase by up 0.8 dBA depending on location and horn influence.

Year 2040 8-car DMU operation train noise projections and impact results are presented in Table 10-2. The future Project noise level result in no additional impacts,

Table 10-1
Operational Noise Levels / Impacts for 8-Car DMU Alternative, by 2020

					Existing				Future				FTA Impact Criteria		
Site No	Side of Alignment	Land Use[1]	Distance to Receptor[2]	Train Speed	Total Noise Exposure	Caltrain Diesel Locomotive Train Noise	Freight Train Noise	Non-Railroad Ambient Noise	Caltrain Diesel Locomotive Noise	Caltrain DMU Train Noise	Total Noise Exposure[3]	Increase	Moderate	Severe	Impact
			feet	mph	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA			
1	W	MFR	110	79	69	63	65	65	57	62	69	0.1	1.1	2.9	--
2	E	SFR	80	79	70	65	65	66	60	64	70	0.1	1.0	2.8	--
3	E	SFR	90	79	70	64	66	66	59	63	70	0.1	1.0	2.8	--
4	E	SFR	120	65	69	66	65	60	61	65	69	0.2	1.1	2.9	--
5	W	SFR	110	79	76	71	73	69	64	68	76	-0.4	0.3	2.1	--
6	E	MFR	50	60	77	74	73	67	62	66	75	-2.1	0.3	2.0	--
7	W	SFR	120	60	74	70	71	64	59	63	73	-1.4	0.5	2.3	--
8	E	SFR	100	60	74	71	70	64	59	64	72	-2.1	0.5	2.3	--
9	W	SFR	150	60	72	69	68	62	58	62	70	-2.1	0.8	2.5	--
10	W	SFR	170	79	67	60	62	64	54	59	67	0.1	1.2	3.2	--
11	E	MFR	160	79	71	66	66	67	60	65	71	0.2	1.0	2.6	--
12	W	SFR	90	79	72	68	69	61	62	67	72	0.2	0.8	2.5	--
13	W	SFR	150	79	68	61	63	65	55	60	68	0.1	1.2	3.1	--
14	W	SFR	160	79	70	66	64	66	61	65	70	0.2	1.0	2.8	--
15	W	SFR	190	79	70	64	66	66	58	63	70	0.1	1.0	2.8	--
16	E	SFR	160	79	71	66	66	67	60	65	71	0.1	1.0	2.6	--
17	W	SFR	40	79	76	73	73	60	67	72	76	0.3	0.3	2.1	--
18	E	SFR	70	79	72	69	68	56	64	69	72	0.3	0.8	2.5	--
19	W	MFR	110	79	73	68	68	69	63	67	73	0.2	0.6	2.4	--
20	W	SFR	85	79	67	64	62	60	59	63	67	0.2	1.2	3.2	--
21	E	SFR	100	79	72	68	68	65	62	67	72	0.2	0.8	2.5	--
22	E	MFR	120	79	70	65	64	67	59	64	70	0.1	1.0	2.8	--
23	E	MFR	120	79	73	68	68	69	62	67	73	0.2	0.6	2.4	--

24	E	SFR	100	79	70	67	66	60	62	66	70	0.2	1.0	2.8	--
25	E	SFR	90	79	73	70	70	61	64	69	73	0.2	0.6	2.4	--
26	E	SFR	50	79	76	73	72	66	68	72	76	0.3	0.3	2.1	--
27	W	MFR	110	79	69	65	65	62	60	64	69	0.2	1.1	2.9	--
28	E	SFR	50	79	72	68	68	65	63	67	72	0.2	0.8	2.5	--
29	W	SFR	60	79	70	68	66	51	63	67	70	0.3	1.0	2.8	--
30	E	SFR	65	79	70	68	66	51	62	67	70	0.2	1.0	2.8	--
31	E	MFR	175	79	67	60	60	65	54	59	67	0.1	1.2	3.2	--
32	W	MFR	100	79	68	65	64	60	59	64	68	0.2	1.2	3.1	--
33	E	SFR	120	79	69	65	63	65	59	64	69	0.2	1.1	2.9	--
34	W	SFR	40	79	72	70	67	62	64	69	72	0.3	0.8	2.5	--
35	E	MFR	160	79	76	70	70	73	63	68	76	-0.4	0.3	2.1	--
36	W	SFR	50	79	78	74	75	68	68	73	78	0.2	0.2	1.8	--
37	E	SFR	150	79	75	68	70	71	61	66	75	-0.3	0.4	2.2	--
38	W	MFR	110	79	73	69	69	66	63	68	73	-0.2	0.6	2.4	--
39	E	SFR	150	79	72	61	61	71	55	60	72	0.0	0.8	2.5	--
40	E	SFR	75	79	68	65	63	60	60	65	68	0.2	1.2	3.1	--
41	E	MFR	80	79	70	66	66	61	61	66	70	0.2	1.0	2.8	--
42	E	SFR	80	79	71	67	65	66	62	67	71	0.2	1.0	2.6	--
43	W	MFR	75	79	71	65	65	68	59	64	71	0.1	1.0	2.6	--
44	W	MFR	85	79	71	66	66	67	62	67	72	0.8	1.0	2.6	--
45	W	SFR	110	79	68	62	63	64	57	62	68	0.1	1.2	3.1	--
46	W	SFR	95	79	68	64	62	64	58	63	68	0.2	1.2	3.1	--
47	W	SFR	95	79	68	64	62	64	58	63	68	0.2	1.2	3.1	--
48	W	SFR	60	35	81	74	80	65	-3	74	81	0.0	0.1	1.0	--
49	E	SFR	50	35	71	64	69	61	9	62	71	-0.5	1.0	2.6	--

Notes:
1. SFR: Single-Family Residence; MFR: Multi-Family Residence
2. Distances for noise are from the centerline of the near tracks to the nearest sensitive land use (outdoor use area, or property/building line)
3. Future Total Noise Exposure is result of combining future Caltrain train noise with existing freight train noise and existing non-railroad ambient noise.

Table 10-2
Operational Noise Levels / Impacts for 8-Car DMU Alternative, by 2040

					Existing				Future				FTA Impact Criteria		
Site No	Side of Alignment	Land Use[1]	Distance to Receptor[2]	Train Speed	Total Noise Exposure	Caltrain Diesel Locomotive Train Noise	Freight Train Noise	Non-Railroad Ambient Noise	Caltrain Diesel Locomotive Noise	Caltrain DMU Train Noise	Total Noise Exposure[3]	Increase	Moderate	Severe	Impact
			feet	mph	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA	L_{dn}, dBA			
1	W	MFR	110	79	69	63	65	65	--	63	69	0.0	1.1	2.9	--
2	E	SFR	80	79	70	65	65	66	--	65	70	0.0	1.0	2.8	--
3	E	SFR	90	79	70	64	66	66	--	64	70	0.0	1.0	2.8	--
4	E	SFR	120	65	69	66	65	60	--	66	69	0.0	1.1	2.9	--
5	W	SFR	110	79	76	71	73	69	--	69	75	-0.5	0.3	2.1	--
6	E	MFR	50	60	77	74	73	67	--	67	75	-2.1	0.3	2.0	--
7	W	SFR	120	60	74	70	71	64	--	64	73	-1.5	0.5	2.3	--
8	E	SFR	100	60	74	71	70	64	--	65	72	-2.2	0.5	2.3	--
9	W	SFR	150	60	72	69	68	62	--	63	70	-2.2	0.8	2.5	--
10	W	SFR	170	79	67	60	62	64	--	60	67	0.0	1.2	3.2	--
11	E	MFR	160	79	71	66	66	67	0	66	71	0.0	1.0	2.6	--
12	W	SFR	90	79	72	68	69	61	0	68	72	0.1	0.8	2.5	--
13	W	SFR	150	79	68	61	63	65	0	61	68	0.0	1.2	3.1	--
14	W	SFR	160	79	70	66	64	66	0	66	70	0.1	1.0	2.8	--
15	W	SFR	190	79	70	64	66	66	0	64	70	0.0	1.0	2.8	--
16	E	SFR	160	79	71	66	66	67	0	66	71	0.0	1.0	2.6	--
17	W	SFR	40	79	76	73	73	60	0	73	76	0.1	0.3	2.1	--
18	E	SFR	70	79	72	69	68	56	0	70	72	0.1	0.8	2.5	--
19	W	MFR	110	79	73	68	68	69	0	68	73	0.1	0.6	2.4	--
20	W	SFR	85	79	67	64	62	60	0	64	67	0.0	1.2	3.2	--
21	E	SFR	100	79	72	68	68	65	0	68	72	0.0	0.8	2.5	--
22	E	MFR	120	79	70	65	64	67	0	65	70	0.0	1.0	2.8	--
23	E	MFR	120	79	73	68	68	69	0	68	73	0.0	0.6	2.4	--
24	E	SFR	100	79	70	67	66	60	0	67	70	0.1	1.0	2.8	--
25	E	SFR	90	79	73	70	70	61	0	70	73	0.1	0.6	2.4	--
26	E	SFR	50	79	76	73	72	66	0	73	76	0.1	0.3	2.1	--
27	W	MFR	110	79	69	65	65	62	0	65	69	0.0	1.1	2.9	--
28	E	SFR	50	79	72	68	68	65	0	68	72	0.0	0.8	2.5	--
29	W	SFR	60	79	70	68	66	51	0	68	70	0.1	1.0	2.8	--
30	E	SFR	65	79	70	68	66	51	0	68	70	0.0	1.0	2.8	--
31	E	MFR	175	79	67	60	60	65	0	60	67	0.0	1.2	3.2	--
32	W	MFR	100	79	68	65	64	60	0	65	68	0.0	1.2	3.1	--
33	E	SFR	120	79	69	65	63	65	0	65	69	0.0	1.1	2.9	--
34	W	SFR	40	79	72	70	67	62	0	70	72	0.1	0.8	2.5	--
35	E	MFR	160	79	76	70	70	73	0	68	76	-0.4	0.3	2.1	--
36	W	SFR	50	79	78	74	75	68	0	74	78	0.1	0.2	1.8	--
37	E	SFR	150	79	75	68	70	71	0	66	75	-0.3	0.4	2.2	--
38	W	MFR	110	79	73	69	69	66	0	68	73	-0.3	0.6	2.4	--

39	E	SFR	150	79	72	61	61	71	0	60	72	0.0	0.8	2.5	--
40	E	SFR	75	79	68	65	63	60	0	65	68	0.0	1.2	3.1	--
41	E	MFR	80	79	70	66	66	61	0	66	70	0.0	1.0	2.8	--
42	E	SFR	80	79	71	67	65	66	0	68	71	0.0	1.0	2.6	--
43	W	MFR	75	79	71	65	65	68	0	65	71	0.0	1.0	2.6	--
44	W	MFR	85	79	71	66	66	67	0	68	72	0.7	1.0	2.6	--
45	W	SFR	110	79	68	62	63	64	0	62	68	0.0	1.2	3.1	--
46	W	SFR	95	79	68	64	62	64	0	64	68	0.0	1.2	3.1	--
47	W	SFR	95	79	68	64	62	64	0	64	68	0.0	1.2	3.1	--
48	W	SFR	60	35	81	74	80	65	0	73	81	-0.1	0.1	1.0	--
49	E	SFR	50	35	71	64	69	61	0	61	70	-0.5	1.0	2.6	--

Notes:

1. SFR: Single-Family Residence; MFR: Multi-Family Residence
2. Distances for noise are from the centerline of the near tracks to the nearest sensitive land use (outdoor use area, or property/building line)
3. Future Total Noise Exposure is result of combining future Caltrain train noise with existing freight train noise and existing non-railroad ambient noise.
4. R36 is borderline and slightly below the Moderate Impact threshold.

11 Noise and Vibration Control Measures

11.1 Noise Control Measures for Proposed Project Operational Train Noise

No noise mitigation is required for the Proposed Project relative to train operations.

11.2 Noise Control Measures for Cumulative Operational Noise

The Proposed Project would contribute to cumulative operational noise impacts at multiple locations. It is recommended that Caltrain, in partnership with others implement a phased program to support incremental noise reduction measures at the locations of cumulative noise impacts over time as funding becomes available. Caltrain should work with local, state, and federal partners to establish priorities for noise reduction measure to be implemented as funding becomes available. Caltrain should also work with other rail operators to seek funding participation from multiple parties on a fair-share basis in proportion to their cumulative noise contributions. The costs for implementing the phased program should be borne by all rail operators in proportion to their contributions to cumulative train noise.

This program is expected to be implemented over a period of decades. Improvements should be phased as needed to address changes in cumulative rail service over time and cumulative rail noise. Specific measures could include the following:

Wayside horns and residential building sound insulation.
Caltrain, in cooperation with the other parties noted above, should evaluate the potential to reduce cumulative noise impacts through the installation of wayside horns and building sound insulation improvements at residences projected to have a sound increase greater than the FTA moderate impact criteria. Building sound insulation methods may include extra wall insulation, window glazing and sealing of exterior surfaces.

If this option is selected, a technical study should be completed to evaluate the effectiveness of reducing cumulative impacts to less than the FTA moderate impact threshold through these methods. If the study shows that it is feasible to reduce the impact to less than the threshold at a cumulatively affected sensitive noise receptor, then no additional mitigation at that location should be required. Building sound insulation measures need only be installed to the extent necessary to meet the impact threshold at the receptor location and should only be installed if building owners are willing to accept such measures.

Quiet Zones
The lead agency for a quiet zone designation is the local City responsible for traffic control and law enforcement on the roads at the grade crossings.

Caltrain, in cooperation with the other parties noted above and the affected local jurisdictions could consider implementation a phased program considering the potential for establishment quiet zones along the Caltrain corridor at all locations where cumulative train noise is predicted to exceed FTA moderate impact thresholds. Caltrain and other railroad operators should work closely with local jurisdictions to prepare the engineering studies and coordination agreements to design, construct, and enforce potential quiet zones.

Options for establishing quiet zones could include implementation of the following FRA pre-approved supplemental safety measures (SSM):

- Four-quadrant gate system. This measure involves the installation of at least one gate for each direction of traffic to fully block vehicles from entering the crossing.
- Gates with medians or channelization devices. This measure keeps traffic in the proper travel lanes as it approaches the crossing, thus denying the driver the option of circumventing the gates by travelling in the opposite lane.
- One-way street with gates. This measure consists of one-way streets with gates installed so that all approaching travel lanes are completely blocked. This option may not be feasible or acceptable to local jurisdictions at all locations.
- Road closure. This measure consists of closing the road to through travel at the grade crossing. This option may not be feasible or acceptable to local jurisdictions at all locations.

In addition to these pre-approved SSMs, the FRA also identifies a range of other measures that may be used to establish a quiet zone. These could be modified SSMs or non-engineering measures which might involve law enforcement or public awareness programs. Such alternative safety measures must be approved by the FRA based on the prerequisite to provide an equivalent level of safety as the sounding of horns.

The lead agency for a quiet zone designation is the local public authority. Only the local public authority can request formal approval from FRA for designation of a quiet zone. Caltrain or the other rail operators cannot on their own designate the quiet zone. Only with FRA approval of the quiet zone, could Caltrain, other tenant railroads and freight operators be relieved of the requirement to sound their horns when crossing at-grade crossings. One key aspect of local jurisdiction acceptance of a quiet zone is acceptance of potential liability in the event of accidents related to not sounding a horn at an at-grade crossing after the installation of any required SSMs. Thus, if a local city does not accept the quiet zone and the associated liability, and thus FRA does not formally designate the quiet zone, then even with the required SSMs, Caltrain, freight and other rail operators would likely continue to use train horns as a safety device in compliance with FRA requirements.

Grade Separations

Caltrain, in cooperation with other rail operators, local jurisdictions, transportation funding agencies, and state and federal agencies, could support incremental grade separations at locations of cumulative noise impacts over time as funding becomes available. Caltrain should work with local, state, and federal partners to establish priorities for grade separations to be implemented as funding becomes available. Caltrain should also work with other rail providers to seek funding participation from multiple parties on a fair-share basis in proportion to noise contributions.

11.3 Vibration Control Measures for Operations

Although significant vibration impacts are not expected due to Proposed Project, it is recommended that during final design the vibration characteristics of the EMU vehicle should be reviewed to ensure that the vibration levels would not increase beyond 3 VdB of the existing condition, as discussed in Section 6.2.1. To maintain the vibration increase below 3 VdB, the unsprung weight (truck, axles, wheels and motors) should not increase beyond 40% above the existing vehicle design.

11.4 Vibration Control Measures for Cumulative Operations

Additional vibration control measures may be necessary for impacts due to substantial increases in train vibration events along the Caltrain corridor and/or increased train speeds up to 110 mph with Blended Service. Vibration control recommendations include:

1. Complete a detailed technical evaluation when blended service is defined more clearly as part of the next environmental analysis (i.e. HSR) including any details on the actual EMUs to be used for HSR and Caltrain, if known at the time.
2. If impact is significant, then adopt vibration mitigation as feasible. To be effective, a vibration control measure must be optimized for the frequency spectrum of the vibration. The vibration measurements for the Project indicate that the dominant frequencies from the existing Caltrain tend to be below the 63 Hz 1/3-octave band. Some of the measures discussed below are amenable to optimization, whereas others are essentially a fixed design. The baseline for all projections for the Project is ballast and tie track (i.e., concrete ties on ballast). Consequently all vibration reduction performance of mitigation measures is quantified with respect to the vibration performance characteristics of ballasted track.

The California High Speed Rail Authority has identified a variety of vibration mitigation measures in prior evaluations of HSR operations including those described in Table 11-1 below:

Table 11-1: Potential Vibration Mitigation Procedures and Descriptions (CHSRA 2012)

Mitigation Procedure	Location of Mitigation	Description
Location and Design of Special Trackwork	Source	Careful review of crossover and turnout locations during the preliminary engineering stage. When feasible, relocate special trackwork to a less vibration-sensitive area. Installation of spring frogs eliminates gaps at crossovers and helps reduce vibration levels.
Vehicle Suspension	Source	Rail vehicle should have low unsprung weight, soft primary suspension, minimum metal-on-metal contact between moving parts of the truck, and smooth wheels that are perfectly round.
Special Track Support Systems	Source	Floating slabs, resiliently supported ties, high resilience fasteners and ballast mats all help reduce vibration levels from track support system (see discussion above).

Building Modifications	Receiver	For existing buildings, if vibration-sensitive equipment is affected by train vibration, the floor upon which the vibration-sensitive equipment is located could be stiffened and isolated from the remainder of the building. For new buildings, the building foundation should be supported by elastomer pads similar to bridge bearing pads.
Trenches	Along Vibration Propagation Path	A trench can be an effective vibration barrier if it changes the propagation characteristics of the soil. It can be open or solid. Open trenches can be filled with materials such as styrofoam. Solid barriers can be constructed with sheet piling, rows of drilled shafts filled with either concrete or a mixture of soil and lime, or concrete poured into a trench.
Buffer Zones	Receiver	Negotiate a vibration easement from the affected property owners or expand rail right-of-way.
Source: CHSRA 2012		

There are many factors to be considered aside from vibration reduction performance in the implementation of special track support systems, such as interaction with the vehicle's wheels and suspension. In some instances there may also be issues concerning weather where trackwork will be exposed to the elements. Based on the information below, it would be possible to determine a mitigation system that would provide 3 VdB reduction; the feasibility of such a system in a high speed train environment would have to be verified.

Following is additional discussion regarding the effectiveness of track support measures, trenches and alternatives:

- Track Support
  - Resilient Fasteners: Resilient fasteners are used to attach the rail at regular intervals to concrete track slabs. Concrete track slabs are normally used in tunnels and on elevated structures, but also sometimes used for track that is below grade in a concrete U-wall (i.e., retained cut). The softer (more resilient) the rail fastener and the further apart the fasteners are located from one another, generally the lower the vibration will be that is transmitted to the surrounding ground. Often very stiff rail fasteners are used for conventional transit. In general terms, the vibration reduction achievable from resilient fasteners depends on how much more resilient the rail fasteners are compared to ballasted track. Since resilient fasteners require a concrete slab the additional mass and stiffness of the slab provides some enhanced performance where the baseline is ballast on a soil subgrade. A class of resilient rail fasteners has been developed that are sometimes referred to as "highly resilient direct fixation" rail fasteners (HRDF). The nominal static stiffness of such fasteners is generally less than 75,000 lb/in (13 MN/m) per fastener. In some cases, HRDF have been designed with a stiffness as low as 35,000 lb/in (6 MN/m). Spacing along the rail for HRDF is typically between 20 in (51 cm) and 30 in (76 cm). With the use of HRDF it is possible to reduce vibration from 5 to 10 VdB at frequencies above 30 or 40 Hz. Consequently resilient fasteners tend to be most

effective in controlling ground-borne noise, but can also be used to reduce vibration in cases where higher frequencies are predominant.

- Ballast mats: A ballast mat consists of a rubber or other type of elastomeric (resilient) mat that is placed under the track ballast. Generally the mat is placed on a thick concrete sub-base to be effective. A ballast mat will be less effective is placed directly on the underlying soil or sub-ballast. Consequently most ballast mat applications are in tunnels or on bridges, however installations exist for ballast mats used for at-grade track. The thickness of ballast mats generally range from 1 in (2.5 cm) to 2 in (5 cm). Ballast mats when properly designed and constructed can provide reduction starting at about 20 Hz with up to 10 to 15 VdB of reduction at frequencies over 30 Hz. Consequently ballast mats tend to be most effective in controlling ground-borne noise, but can also be used to reduce vibration in cases where higher frequencies are predominant.
- Resiliently Supported Ties: A resiliently supported tie system, like the one used in the Channel Tunnel between England and France, consists of concrete half-ties (blocks) supported on rubber pads. The rails are fastened directly to the top of the concrete ties with rail clips. The stiffness of the rubber pad supporting the concrete blocks can be varied within limits to obtain greater or lesser vibration reduction. Measurement data indicates reduction starting at about 20 Hz with up to 5 to 10 VdB of reduction at frequencies over 30 Hz. Consequently resiliently supported ties tend to be more effective in controlling ground-borne noise, but can also be used to reduce vibration in cases where higher frequencies are predominant.
- Tire Derived Aggregate: Tire derived aggregate (TDA) refers to a track underlayment consisting of a sufficiently thick layer of shredded tires placed under ballasted track. The tire product employed in this design is a commercially available product that is derived from used motor vehicle tires that have been processed (shredded) to a prescribed size. TDA underlayment is constructed by excavating a trench that is approximately 2 feet deep, lining the trench with geotextile fabric, filling the trench to a depth of between 12 and 16 in (31 to 41 cm) with shredded tires (depending on the application, wrapping the shredded tires in the geotextile fabric, compacting it and then constructing the ballasted track as would normally be done with a compacted subgrade over the TDA underlayment. Measurements have been performed on three installations of TDA for transit applications. Consistent field results indicate that reductions starting at 16 Hz can be obtained with from 5 to 12 VdB of vibration reduction above 20 Hz. TDA is currently being considered for other transit applications. There are no installations for railroad, but given the promise of this measure it is being considered as a possibly viable mitigation.
- Floating Slab Trackbed: Floating slab trackbeds (FST) can be very effective at controlling groundborne noise and vibration. They have been used in many instances involving conventional rail transit system. Floating slab systems consist of a concrete slab supported on rubber pads, strips or mats. The rail is generally fastened to the concrete slab with resilient fasteners. Floating slabs are effective at reducing vibration at frequencies above the primary natural frequency of the FST in the vertical direction. The natural frequency is the main characteristic dictating FST performance. The primary natural frequency is determined by the mass of concrete and stiffness of the support resilient elements (pads, strips or mat). The heavier the slab and more resilient the support elements are the lower the natural frequency will be. Consequently FST are

typically designed to be situation-specific to optimize performance. Most all FST designs in existence today have natural frequencies that vary from 6 Hz to 16 Hz. Floating slabs employing mats will generally have higher natural frequencies such as 20 to 25 Hz. The amount of vibration reduction possible with an FST system can be as much as 25 VdB for frequencies sufficiently higher than the natural frequency of the floating slab. The highest speed transit trains running on a low natural frequency (i.e., 8 Hz) FST travel at approximately 65 mph (105 km/h). A 12 Hz FST system has been implemented for transit trains that travel at 80 mph (130 km/h). A form of FST system, the isolated slab trackbed (IST), employs a resilient layer of material underneath a concrete slab and has been used for high speed trains in places such as Japan. There are floating slabs in use for commuter rail and some shared freight railroads, but at this writing there are no known low frequency floating slabs in use for speeds greater than 100 mph (160 km/h). Consequently there may be physical restrictions that are necessary because of the higher train speed. This may limit how low a natural frequency is possible.

- Trenches or Wave Impeding Barriers: Wave Impeding Barriers (WIB) have received attention in the last several years. A WIB is constructed below grade involving either a trench or a concrete slab at some depth below the trackway. The concept is simple: just as a sound barrier blocks sound in air, a WIB blocks vibration in the ground. However, in order for the WIB to block vibration, there must be a suitable change in material properties from one side to the other – hence a trench if often considered. There are two major issues that must be overcome: a) in order to block vibration the WIB must extend fairly deep (40 to 60 ft), and b) the trench has to be structurally sound to keep it from collapsing. Experiments in Japan in recent years have evaluated a proprietary system that uses interlocking concrete tubes, and the results show promise for this approach, but this method requires several rows of tubes, potentially requiring a WIB 60 ft wide (WIA 2006). As of this writing, Wilson, Ihrig is not aware of any successful WIB installations in North America.
- Other methods to control vibration
    - Concrete Slab Supported by Piles: By supporting the concrete slab with piles, the primary vibration path from the track support system into the surrounding ground is funneled into the piles, which reduces the vibration transmitted to the track wayside. (WIA 2006)
    - Soil Modification: changing the ground vibration propagation characteristics can help to reduce the vibration transmitted to the track wayside and may also improve the performance of a resilient track support system such as TDA listed above. (WIA 2006)
    - Rail Straightness Specification: The forces transmitted to the rail fasteners, and ultimately the ground are dependent upon the roughness of both the wheels and the rails. The effect of large scale vertical undulations in the rail can combine with the smaller variations (corrugation). Rail fabricated to meet European high speed rail tolerances has a vertical tolerance of 0.015 inch/10 ft, compared to a typical freight rail which might have a vertical tolerance on the order of 0.1 inch/10 ft. This can have a substantial effect on low frequency vibration, perhaps on the order of 10 VdB. (WIA 2006)
    - Rail Profile Grinding: In some rapid transit systems, it has been shown that rail profile grinding can have a measureable and, in some cases, a significant effect on mid-frequency vibration (i.e., 50 to 160 Hz). It remains to be seen whether such improvements can be achievable and beneficial on the Caltrain system.

11.5 Noise Control Measures for Ancillary Facilities

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

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

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

11.6 Noise and Vibration Control Measures for Construction

There would be many temporary construction noise impacts along the alignment, for noise sensitive receptors that fall within the criterion distances listed above in Table 7-7. Most of the impacted areas would typically occur near substations where the criterion impact distance is larger and the construction work would focus on a specific area. For the overhead electrification work, the noise impacts would be limited in scope and duration. At substations a temporary sound wall would be beneficial, but in many cases the nature of the construction work would make such sound walls infeasible.

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

- An active community liaison program should be established. The community liaison program will keep residents informed about construction plans so residents may plan around noise or vibration impacts and will provide a conduit for residents to express any concerns or complaints.

- Contractors should be required to use newer equipment fitted with the manufacturers' recommended noise abatement measures, such as mufflers, engine covers, and engine vibration isolators intact and operational. Newer equipment will generally be quieter in operation than older equipment. All construction equipment should be inspected at periodic intervals to ensure proper maintenance and presence of noise control devices (e.g., mufflers and shrouding). Electric or "quiet" equipment should be used for generators, compressors, and other construction equipment where feasible.

- Contractors should employ construction methods or equipment that will provide the lowest level of noise and ground vibration impact near residences and consider alternative methods that are suitable for the soil condition. The contractor should be required to select construction processes and techniques that create the lowest noise levels.
- Truck loading, unloading, and hauling operations should be conducted so that noise and vibration are kept to a minimum by carefully selecting routes to avoid going through residential neighborhoods to the greatest possible extent.
- Ingress and egress to and from the staging area should be on collector streets or higher street designations (preferred), and through routes for trucks will be designed to the extent feasible to minimize the frequency of backup alarm sound.
- Idling equipment should be turned off whenever feasible.
- When practicable, temporary noise barriers will be used to protect sensitive receptors against excessive noise from construction activities. Partial enclosures around continuously operating equipment or temporary barriers along construction boundaries will be considered.
- Construction activities within residential areas will be minimized during evening, nighttime, weekend, and holiday periods to the extent feasible.
- Noise and vibration monitoring should be conducted to verify compliance with the noise limits. Independent monitoring should be performed to check compliance in particularly sensitive areas. Contractors will be required to modify and/or reschedule their construction activities if monitoring determines that maximum limits are exceeded at residential land uses.

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

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

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

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

These measures would not necessarily guarantee noise and vibration exposure within the criterion limits, but they would be helpful to reduce the impact.

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Attachment A: Passby Noise Measurements

WIA conducted short term noise measurements on Wednesday, 4 September 2013 to record individual train passby events from existing Caltrain operations and validate the FTA reference levels used in the analysis.

It is difficult to separate out the individual locomotive and passenger car components from the measured passby data. The total SEL for each train event was determined from the measurements and normalized to 50 feet and 50 mph for comparison with FTA reference levels. As presented in Table A-1 the measured train SELs ranged from 91 to 96 dBA with an average of 93 dBA.

The FTA reference values are 92 dBA SEL for a diesel locomotive and 82 dBA SEL for rail cars at 50 ft and 50 mph. A train consisting of one locomotive and five passenger cars corresponds to a total train SEL of 93.8 dBA. Thus the FTA reference values are consistent with the measurement data and no adjustments were made to the SEL for the analysis.

Table A-1

Measurement Location	Time	Source	Distance from track centerline[1], feet	Train Speed[2], mph	Measured SEL[3], dBA	Train SEL_{ref}, dBA at 50 feet, 50 mph
Keswick Ln and S. Railroad Avenue, San Mateo	2:08 PM	5-Car	82	35	90	91
	3:06 PM	5-Car	82	46	91	92
Sterling View Avenue and Old County Rd, Belmont	4:32 PM	5-Car	100	60	92	96
	4:40 PM	5-Car	100	56	89	93
	4:57 PM	5-Car	100	80	87	92
	5:07 PM	5-Car BB	100	74	89	94
	5:16 PM	5-Car BB	100	75	86	91
	5:45 PM	5-Car BB	100	70	89	93

Notes:
1. Approximate horizontal distance to the respective track for each group of passbys.
2. Approximate speed read from speed gun in field.
3. SEL = LpAeq,T + 10*LOG(T/1), where LpAeq,T is the Leq averaged over the Train event (i.e. -10dB down points) and T is the time in seconds, roughly 8 to 10 seconds long for Keswick and 4 to 6 seconds long for Sterling.

Attachment B: Caltrain Passby Vibration Data - Energy-Averaged

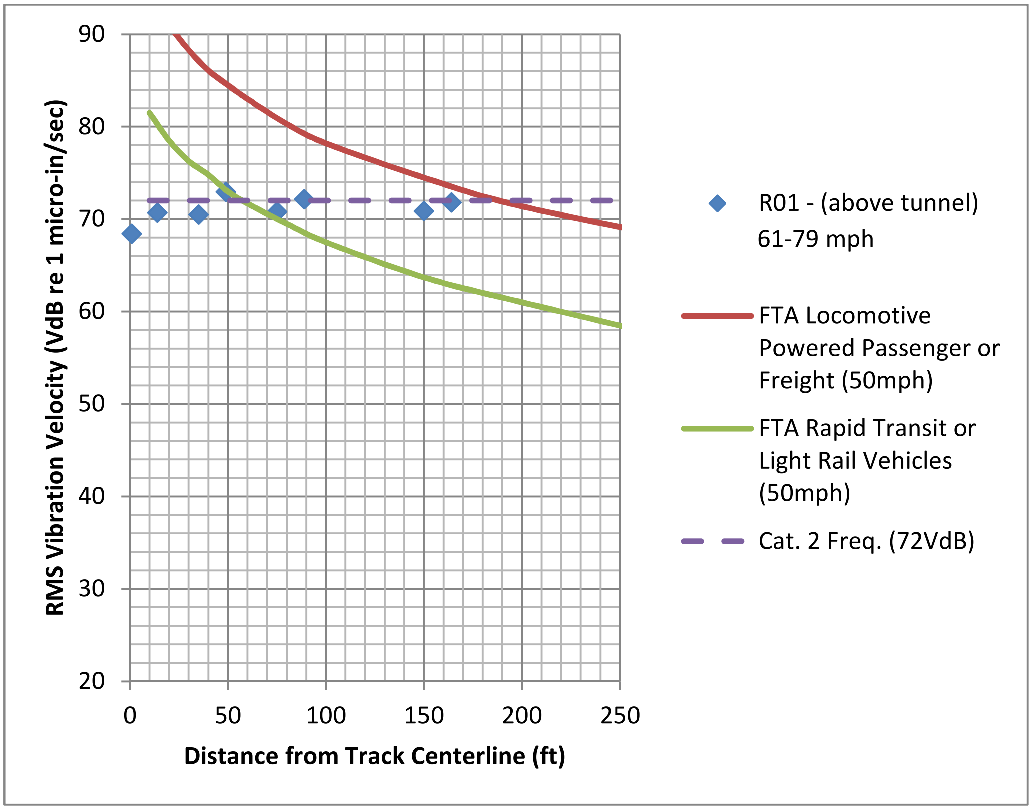

Figure B-1 Measured at Site R01 on Thursday, May 30, 2013

Vibration data shown has not been normalized to 50 mph. Since this location was above the tunnel, the distance from track centerline is not a relevant factor.

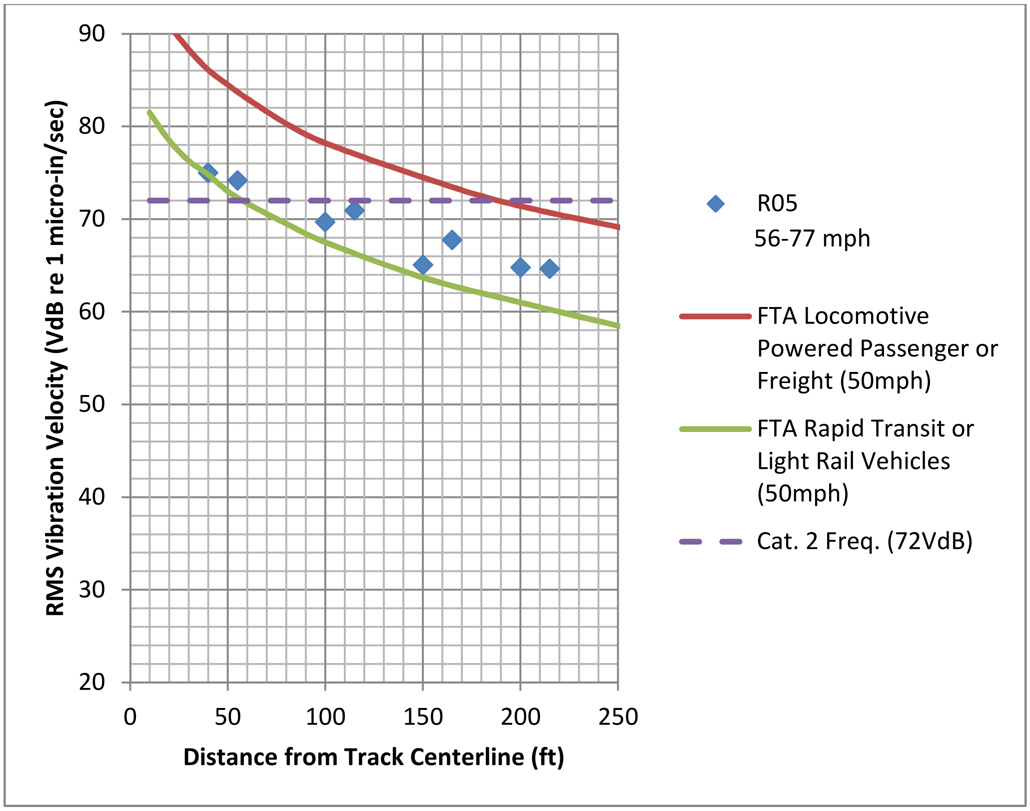

Figure B-2 Measured at Site R05 on Thursday, May 23, 2013

Vibration data shown has not been normalized to 50 mph.

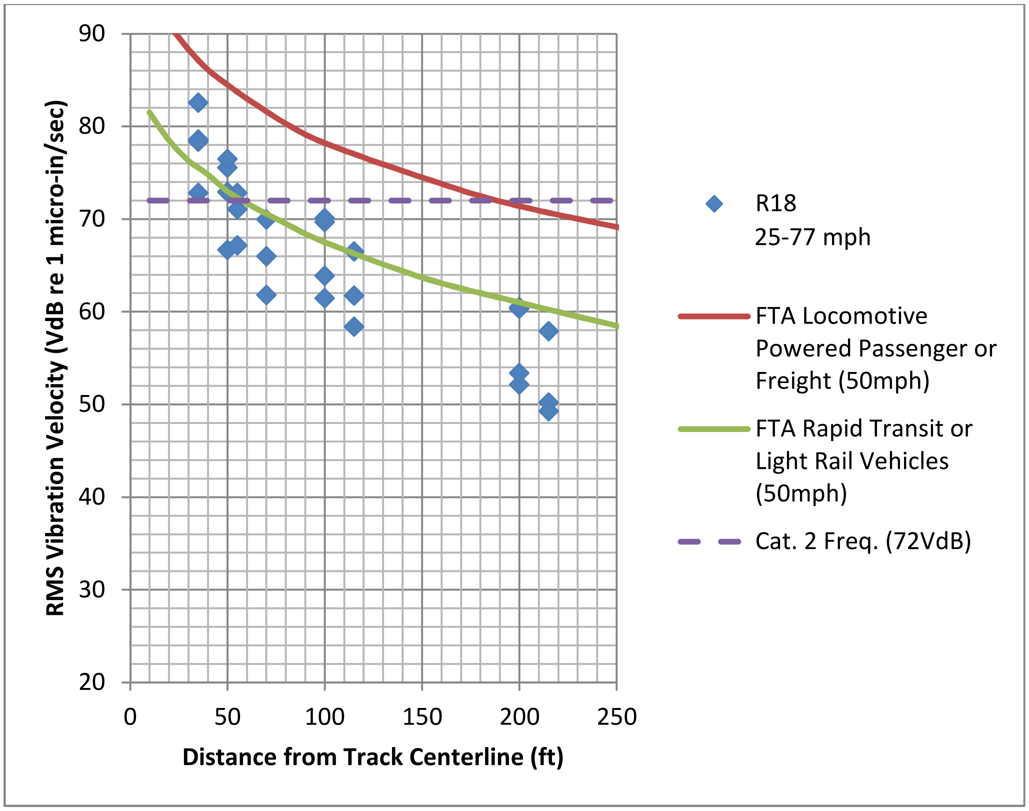

Figure B-3 Measured at Site R18 on Friday, May 24, 2013

Vibration data shown has not been normalized to 50 mph.

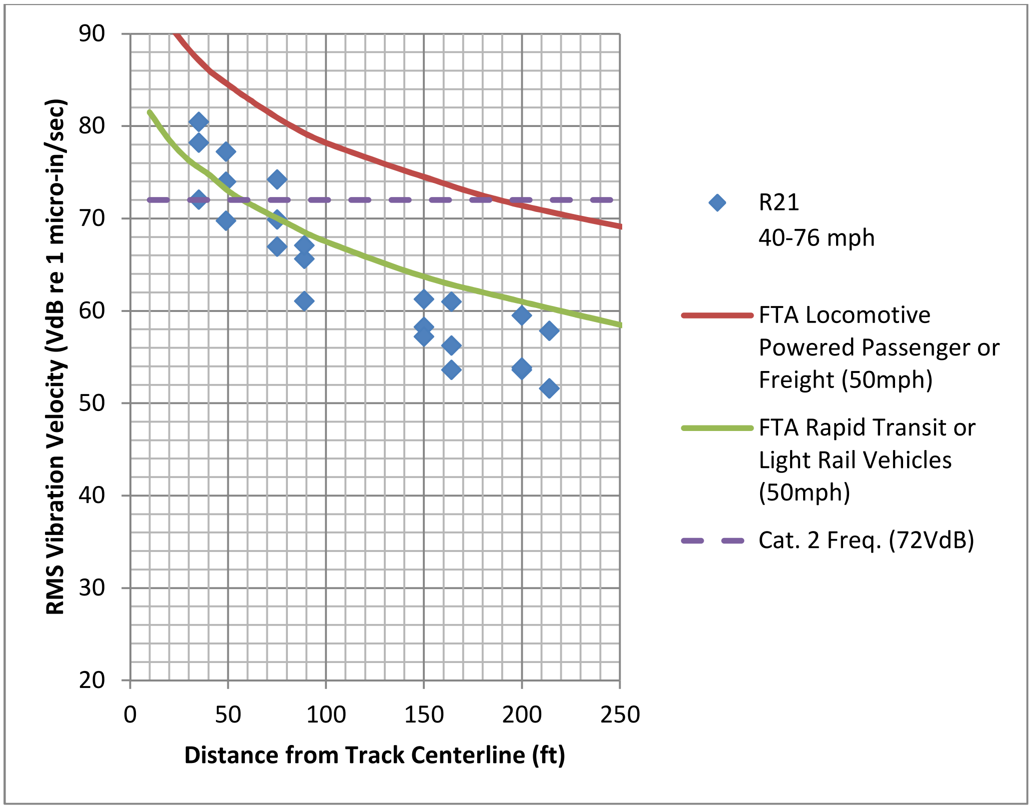

Figure B-4 Measured at Site R21 on Tuesday, May 28, 2013

Vibration data shown has not been normalized to 50 mph.

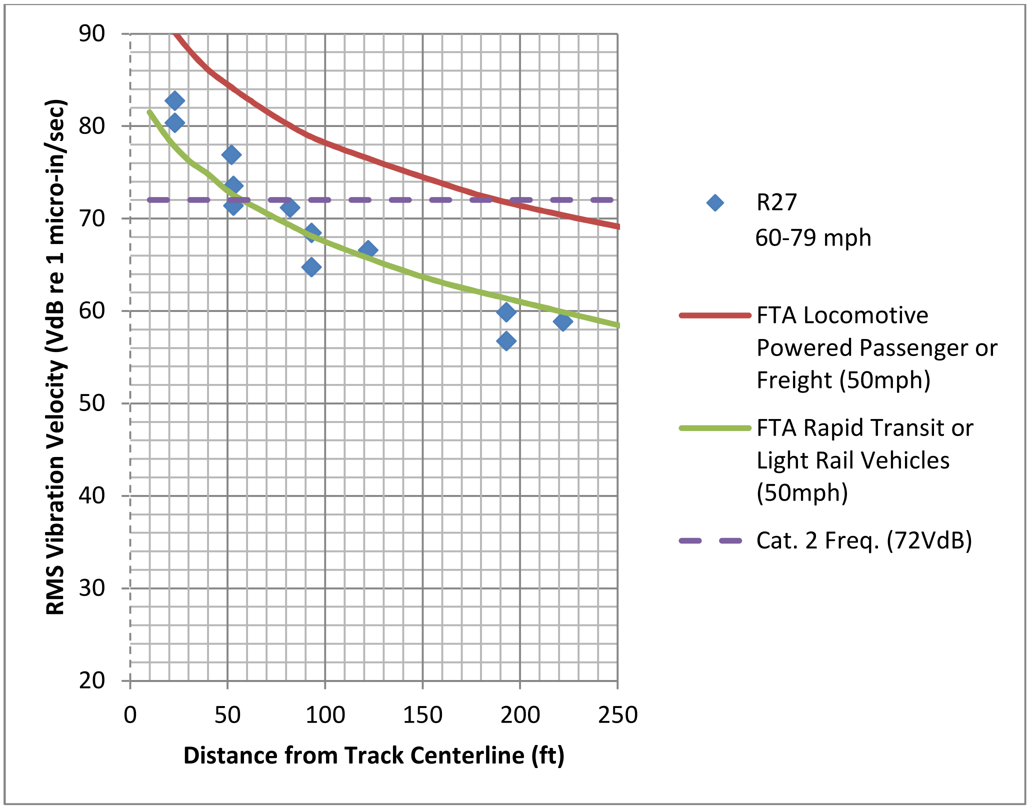

Figure B-5 Measured at Site R27 on Friday, May 24, 2013

Vibration data shown has not been normalized to 50 mph.

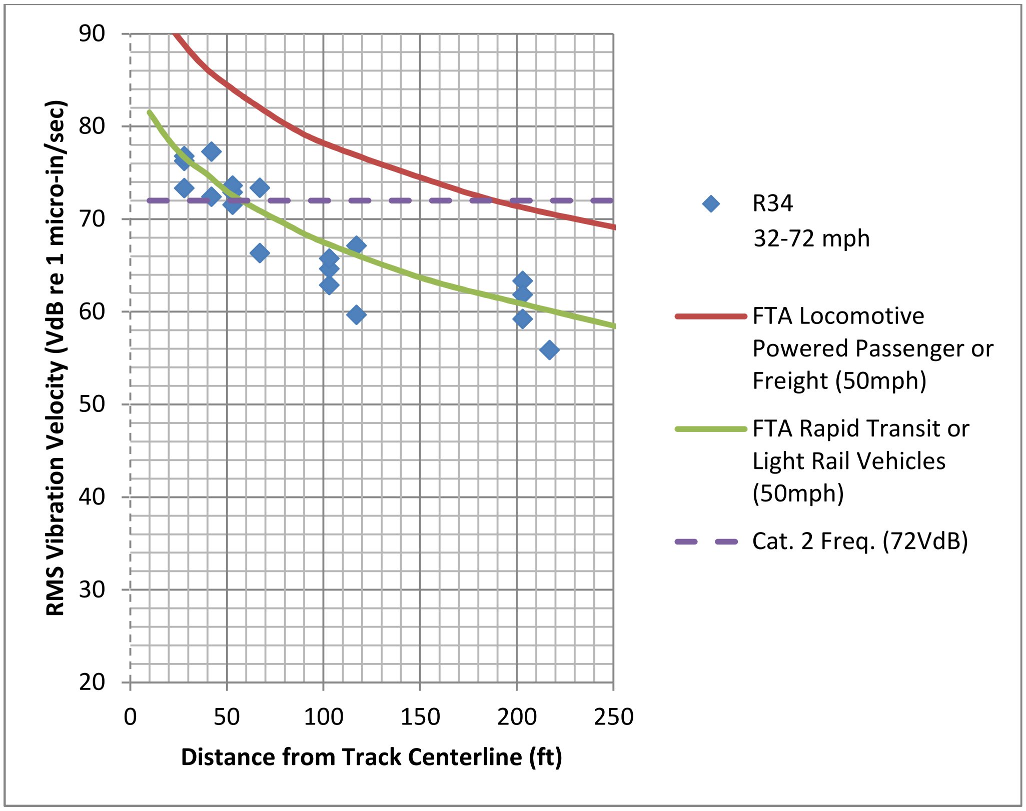

Figure B-6 Measured at Site R34 on Thursday, May 30, 2013

Vibration data shown has not been normalized to 50 mph.

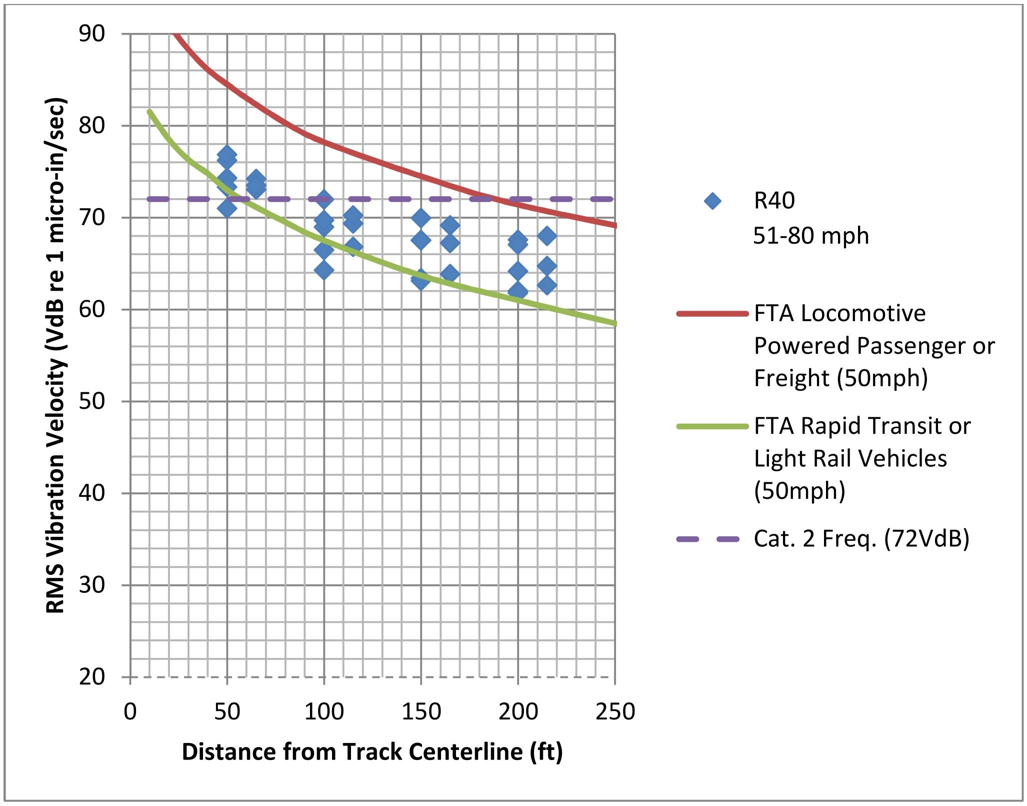

Figure B-7 Measured at Site R40 on Wednesday, June 5, 2013

Vibration data shown has not been normalized to 50 mph.

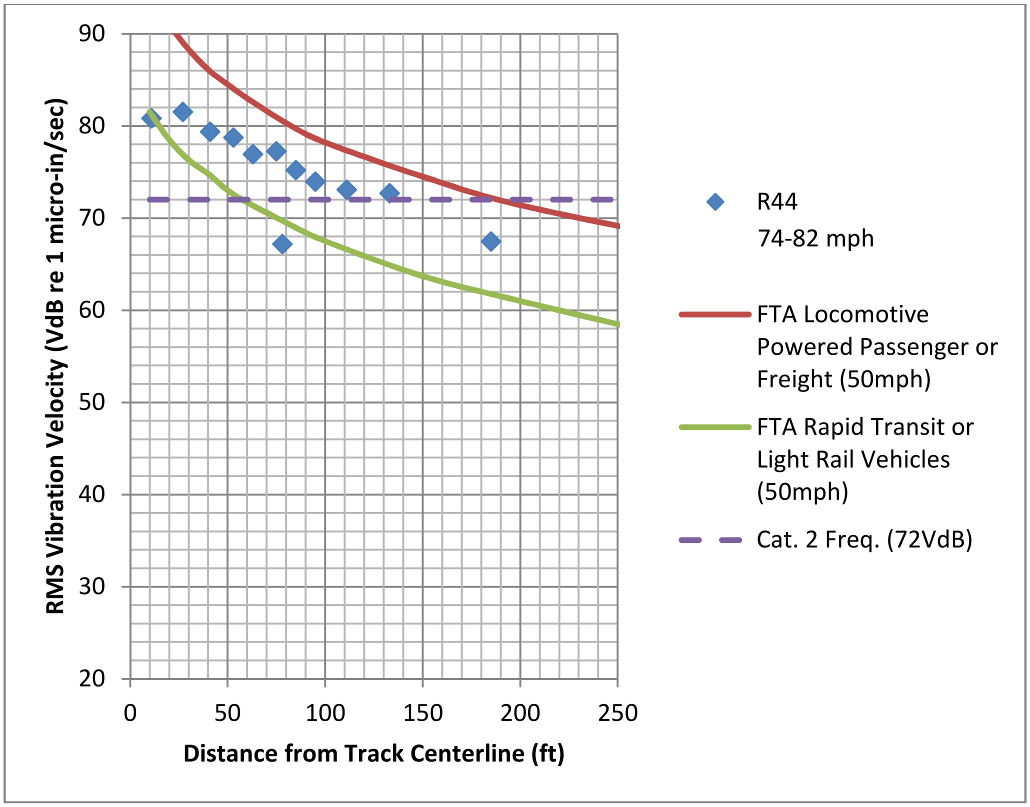

Figure B-8 Measured at Site R44 on Tuesday, May 28, 2013

Vibration data shown has not been normalized to 50 mph.

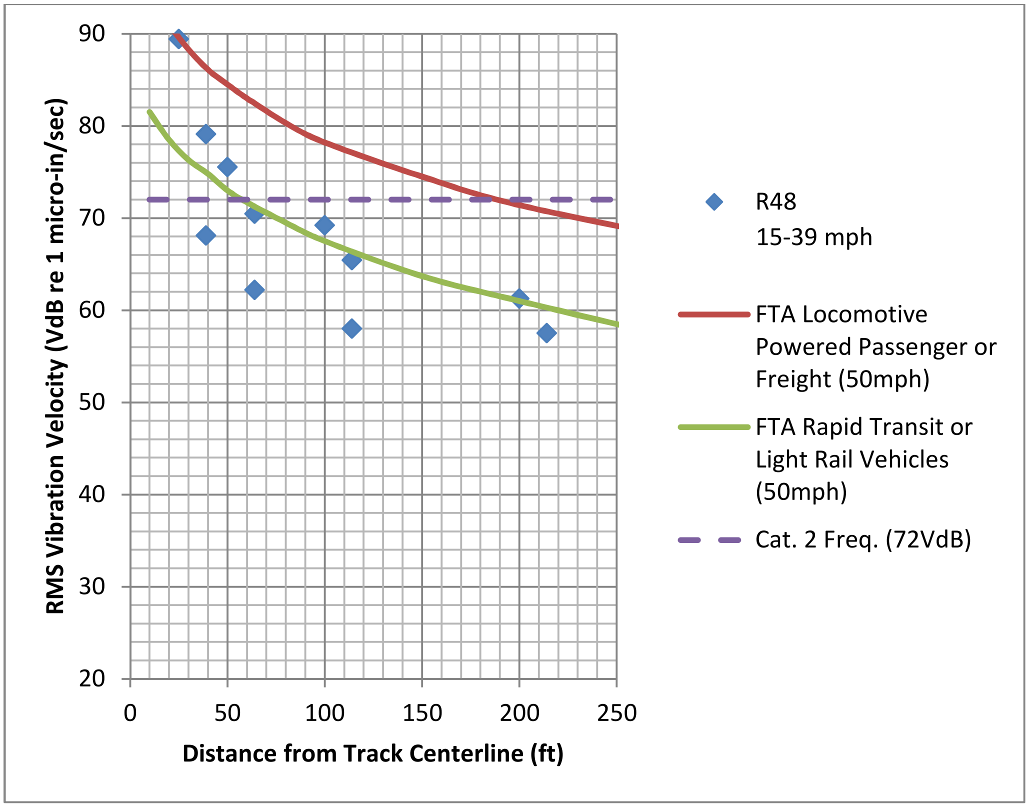

Figure B-9 Measured at Site R48 on Wednesday, May 29, 2013

Vibration data shown has not been normalized to 50 mph.

Attachment C: Measurement Locations


7th
16th
16th
Paralleling Station PS1
Mariposa
Pennsylvania
I 280
18th
I 280
N34
VIB14
San Francisco
3rd
N35
280
Quint
1
Oakdale
Silver
R1
Thornton
VIB20
N33
2
San Francisco
N55
VIB13
3rd
Us Hwy 101
Bayshore
James Lick
San Bruno
Ramp
Paul
Gilman
N32
3
N
N
Basemap Source: Esri
7 October 2013
Caltrain Electrification Project
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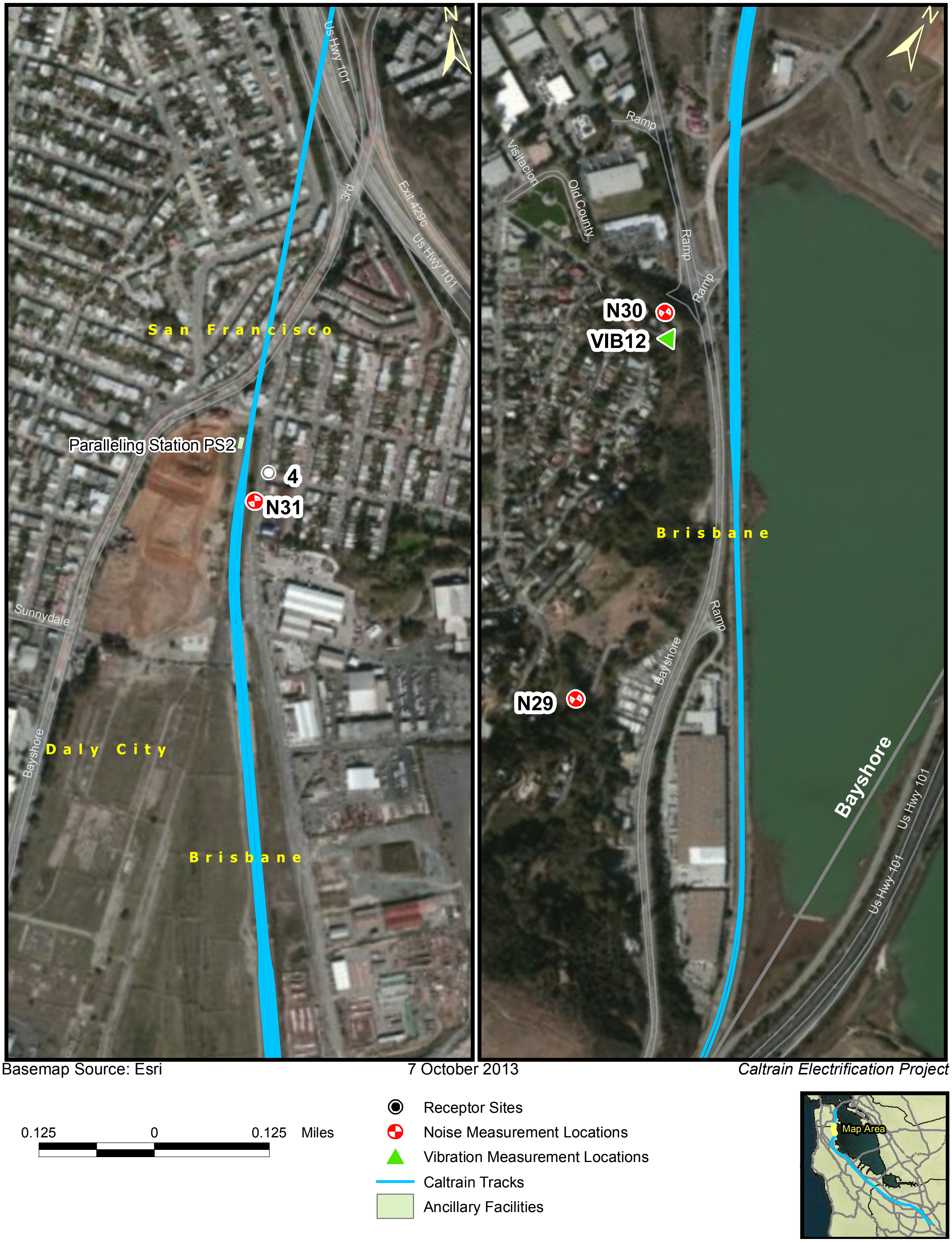
Miles
Receptor Sites
Noise Measurement Locations
Vibration Measurement Locations
Caltrain Tracks
Ancillary Facilities
Map Area


Us Hwy 101
3rd
Exit 429c
Us Hwy 101
San Francisco
Paralleling Station PS2
4
N31
Sunnydale
Bayshore
Daly City
Brisbane
N
Ramp
Visitacion
Old County
Ramp
Ramp
N30
VIB12
Brisbane
Ramp
Bayshore
N29
Bayshore
Us Hwy 101
Us Hwy 101
Basemap Source: Esri
7 October 2013
Caltrain Electrification Project
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Receptor Sites
Noise Measurement Locations
Vibration Measurement Locations
Caltrain Tracks
Ancillary Facilities
Map Area


N
Bayshore
Brisbane
Us Hwy 101
N54
South San Francisco
Oyster Point
Sisters Cities
Airport
Dubuque
Gateway
Linden
Ramp
Exit 425a
Lux
Miller
Grand
Forbes
Traction Power Supply Substation TPS1 Alternate Location
Traction Power Supply Substation TPS1 Alternate Location
Traction Power Supply Substation TPS1 Alternate Location
N28
VIB15
Airport Mitchell
Produce
San Mateo
Basemap Source: Esri
7 October 2013
Caltrain Electrification Project
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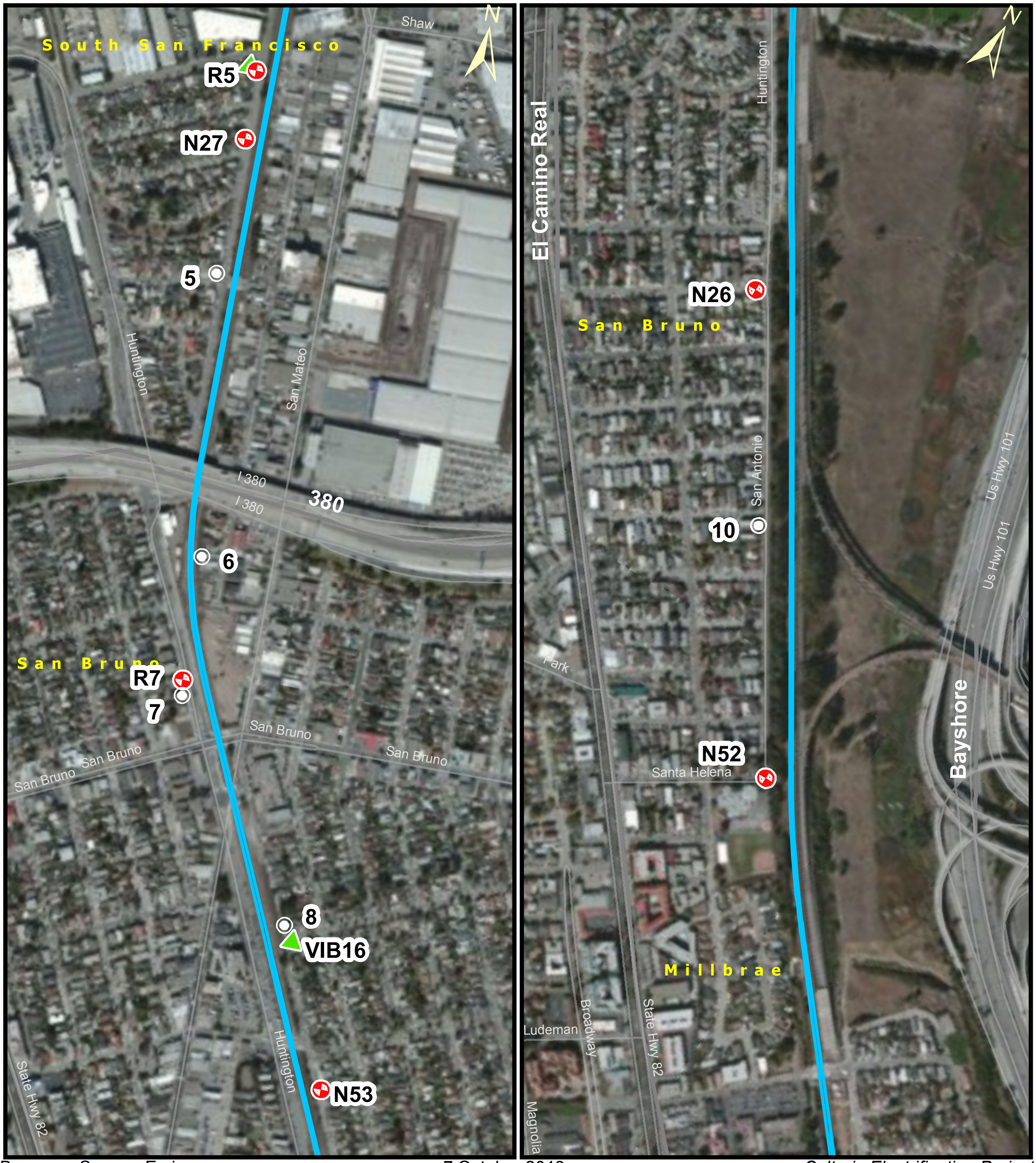
Vibration Measurement Locations
Caltrain Tracks
Ancillary Facilities
Map Area



Basemap Source: Esri

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Caltrain Electrification Project

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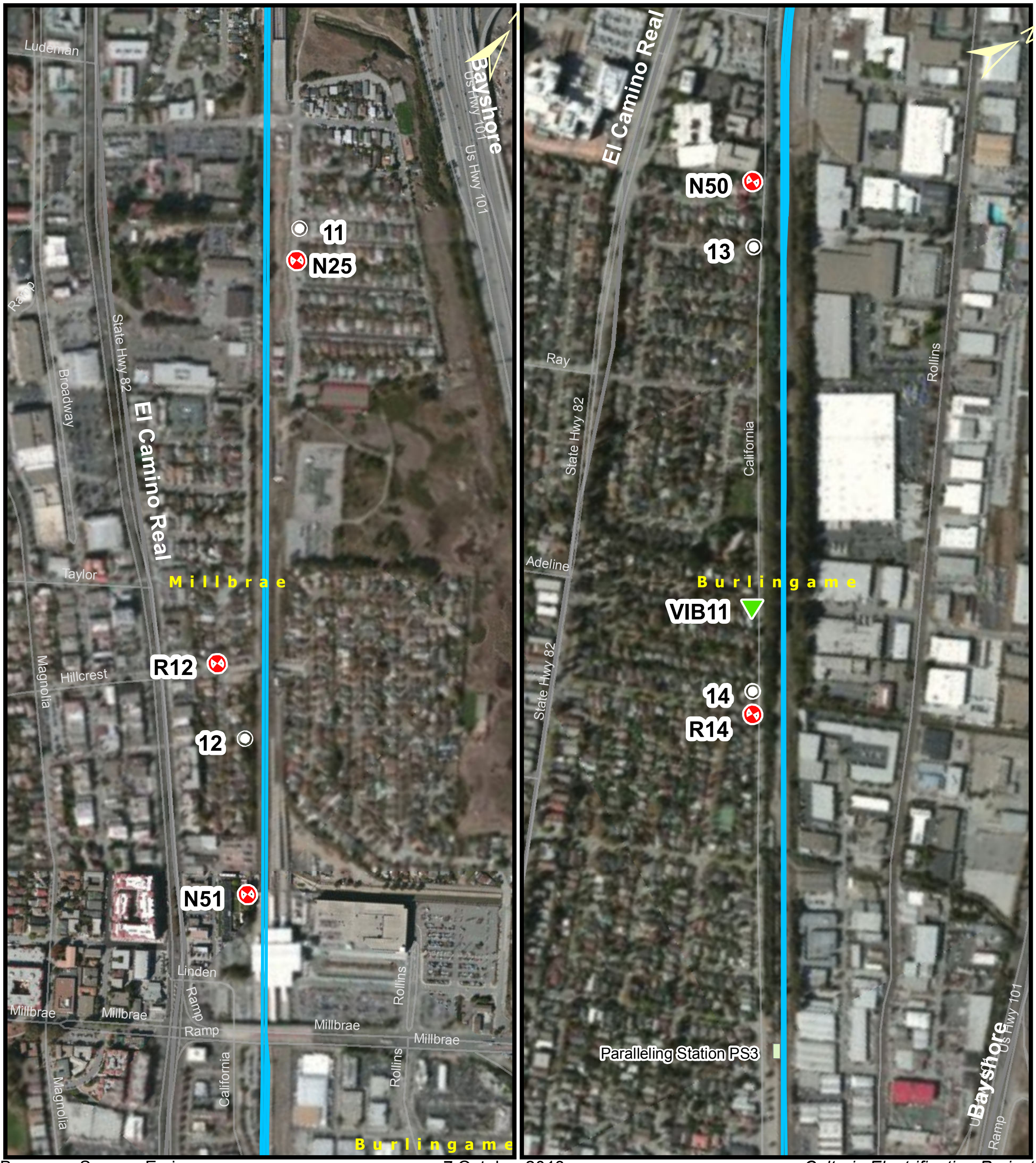
- Noise Measurement Locations
- Vibration Measurement Locations
- Caltrain Tracks
- Ancillary Facilities



Basemap Source: Esri | 7 October 2013 | *Caltrain Electrification Project*

0.125 0 0.125 Miles

- Receptor Sites
- Noise Measurement Locations
- Vibration Measurement Locations
- Caltrain Tracks
- Ancillary Facilities


Broadway
Ramp
Broadway
Ramp
Us Hwy 101
Us Hwy 101
Carmelita
Bayshore
N49
California
Burlingame
15
16
Rollins
N22
VIB17
Ramp
Oak Grove
Burlingame
Burlingame
Peninsula
Dwight
VIB10
17
Delaware
Poplar
San Mateo
San Mateo
18
R18
N21
Tilton
Delaware
Basemap Source: Esri
7 October 2013
Caltrain Electrification Project
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Receptor Sites
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Vibration Measurement Locations
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Ancillary Facilities
Map Area


9th
19
B
Delaware
Sunnybrae
San Mateo
N20
20
16th
South
Charles
Ramp
J Arthur Younger
State Hwy 92
State Hwy 92
Grant
Palm
Paralleling Station PS4 Alt 1
31st
31st
El Camino Real
Ramp
Ramp
Edison
Paralleling Station PS4 Alt 2
Ramp
Hillsdale
Hillsdale
Ramp
Ramp
Ramp
State Hwy 82
Curtiss
San Mateo
R21
21
Pacific
39th
VIB9
40th
Orinda
42nd
43rd
43rd
State Hwy 82
George
R22
22
Belmont
Ruth
Basemap Source: Esri
7 October 2013
Caltrain Electrification Project
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Caltrain Tracks
Ancillary Facilities
Map Area

Basemap Source: Esri

7 October 2013

Caltrain Electrification Project

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- Receptor Sites
- Noise Measurement Locations
- Vibration Measurement Locations
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Basemap Source: Esri
7 October 2013
Caltrain Electrification Project

0.125 0 0.125 Miles

- Receptor Sites
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- Vibration Measurement Locations
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Hazel
Middlefield
Redwood City
El Camino Real
State Hwy 82
Switching Station SWS1
R27
27
N14
North Fair Oaks
2nd
5th
Ramp
Semicircular
28
Atherton
North Fair Oaks
29
Fair Oaks
Atherton
Isabella
30
N13
Stone Pine
Menlo Park
VIB6
Atherton
Basemap Source: Esri
7 October 2013
Caltrain Electrification Project
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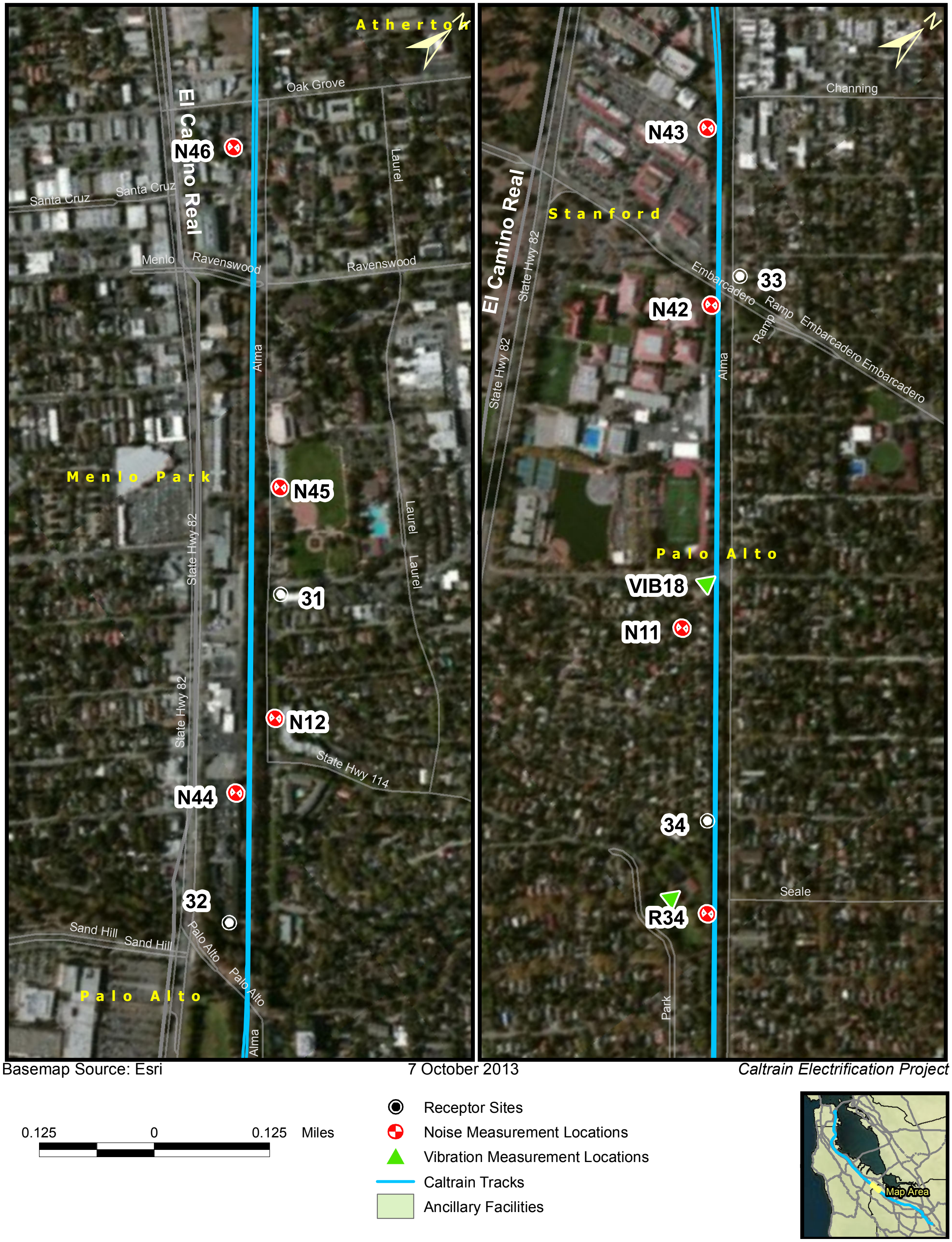
Miles
Receptor Sites
Noise Measurement Locations
Vibration Measurement Locations
Caltrain Tracks
Ancillary Facilities
Map Area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Santa Cruz
Santa Cruz
Laurel
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Ravenswood
Ravenswood
Alma
Menlo Park
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Laurel
State Hwy 82
31
State Hwy 82
N12
State Hwy 114
N44
32
Sand Hill
Sand Hill
Palo Alto
Palo Alto
Palo Alto
Alma
Channing
N43
El Camino Real
State Hwy 82
Stanford
33
Embarcadero
Ramp
Ramp
Embarcadero
Embarcadero
N42
Alma
State Hwy 82
Palo Alto
VIB18
N11
34
Seale
R34
Park
Basemap Source: Esri
7 October 2013
Caltrain Electrification Project
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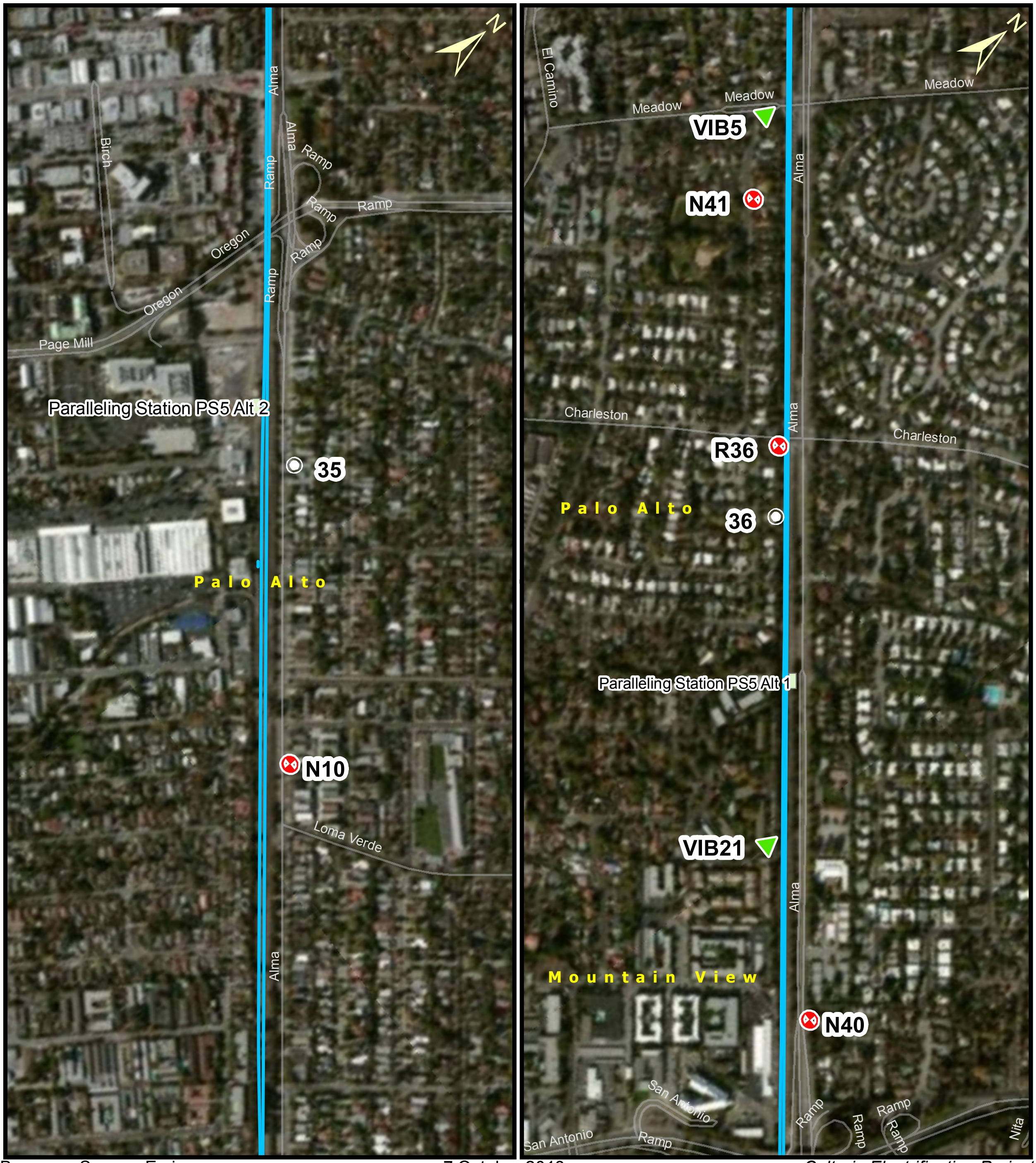
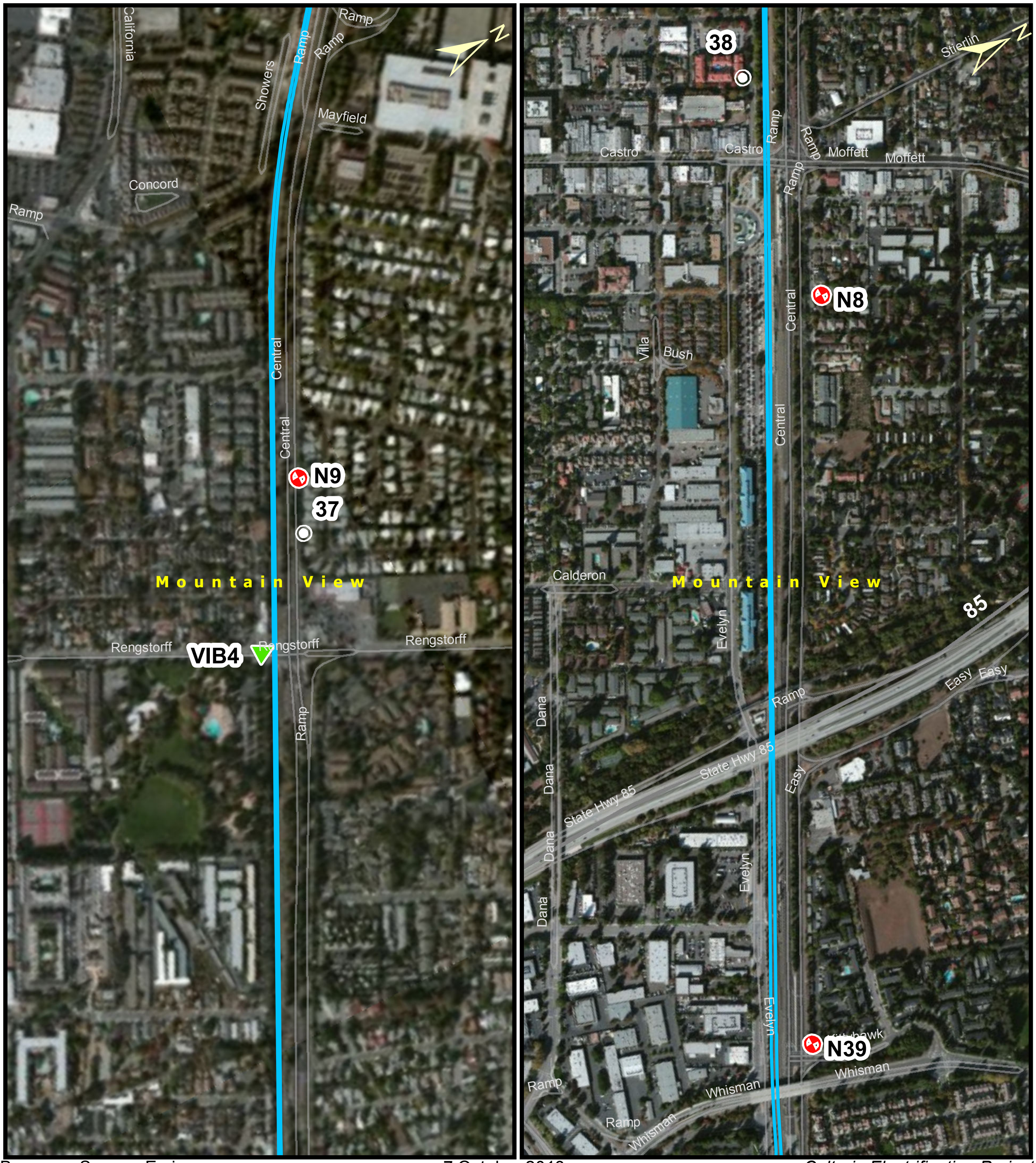
Receptor Sites
Noise Measurement Locations
Vibration Measurement Locations
Caltrain Tracks
Ancillary Facilities
Map Area



Basemap Source: Esri 7 October 2013 *Caltrain Electrification Project*

0.125 0 0.125 Miles

Receptor Sites
Noise Measurement Locations
Vibration Measurement Locations
Caltrain Tracks
Ancillary Facilities



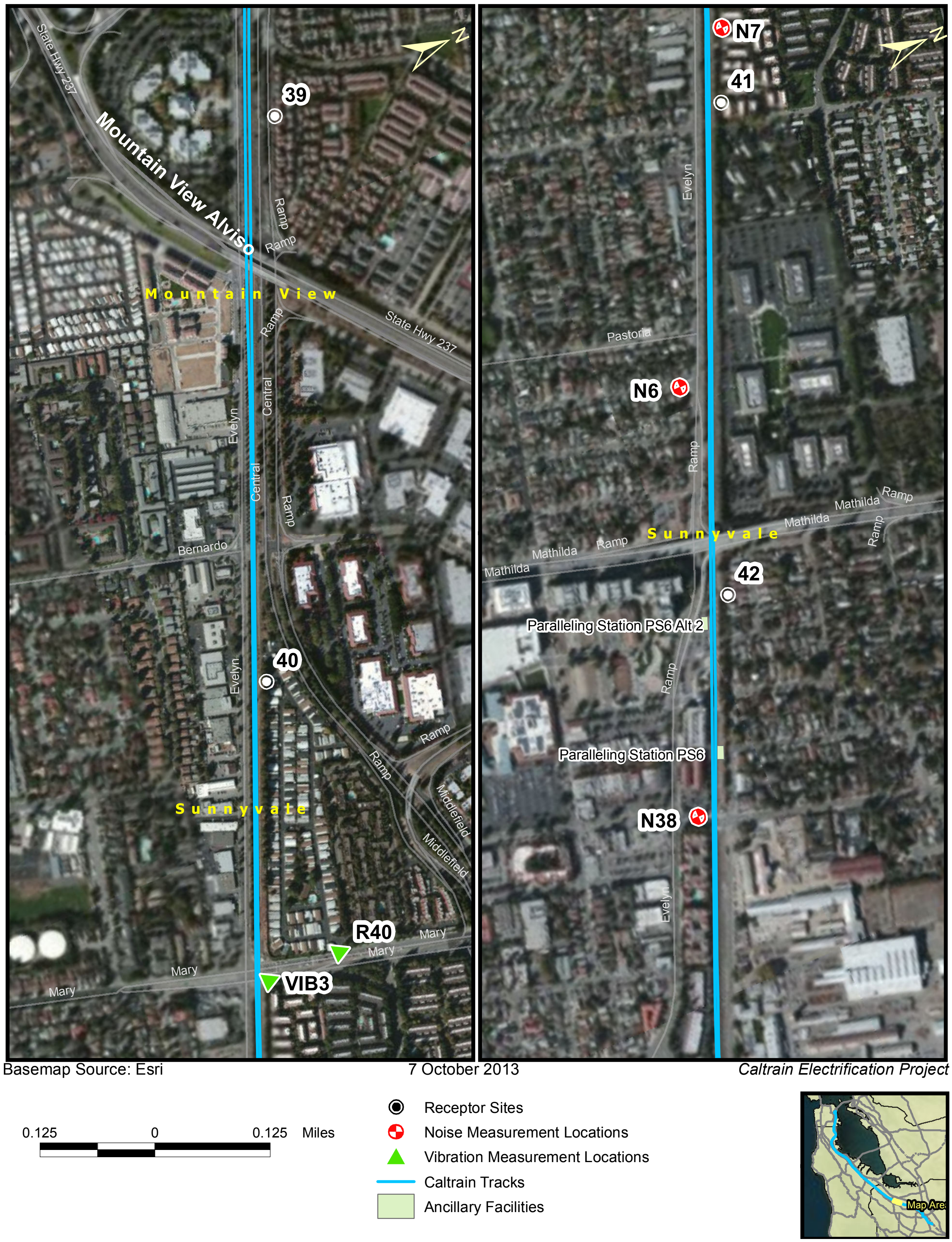
Basemap Source: Esri

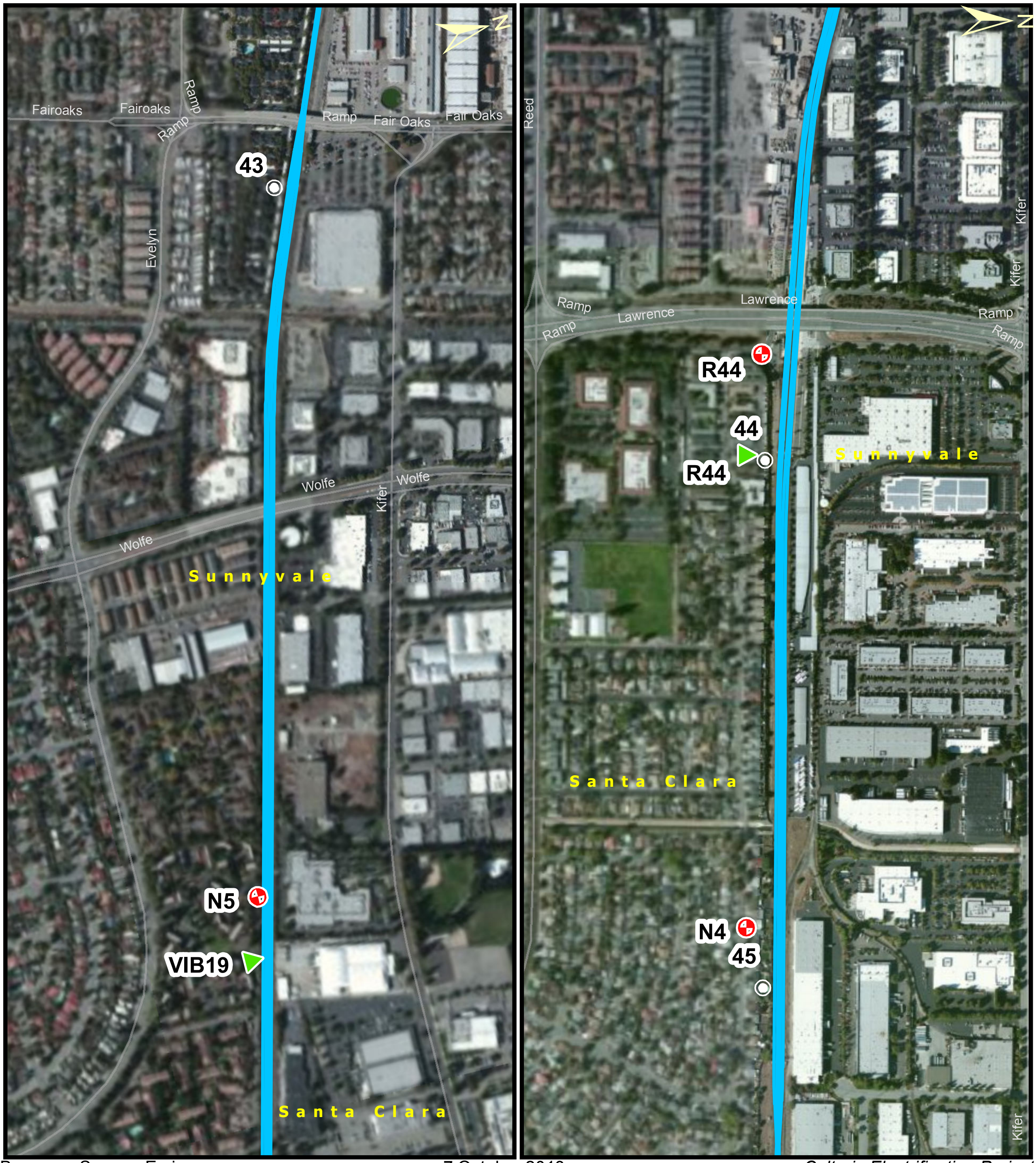
7 October 2013

Caltrain Electrification Project

0.125 0 0.125 Miles

- Receptor Sites
- Noise Measurement Locations
- Vibration Measurement Locations
- Caltrain Tracks
- Ancillary Facilities


State Hwy 237
Mountain View Alviso
39
Ramp
Mountain View
Evelyn
Central
Bernardo
40
Sunnyvale
Middlefield
Mary
R40
VIB3
N7
41
Pastoria
N6
Mathilda
42
Paralleling Station PS6 Alt 2
Paralleling Station PS6
N38
Basemap Source: Esri
7 October 2013
Caltrain Electrification Project
0.125 0 0.125 Miles
Receptor Sites
Noise Measurement Locations
Vibration Measurement Locations
Caltrain Tracks
Ancillary Facilities
Map Area



Basemap Source: Esri
7 October 2013
Caltrain Electrification Project

0.125 0 0.125 Miles

- Receptor Sites
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- Vibration Measurement Locations
- Caltrain Tracks
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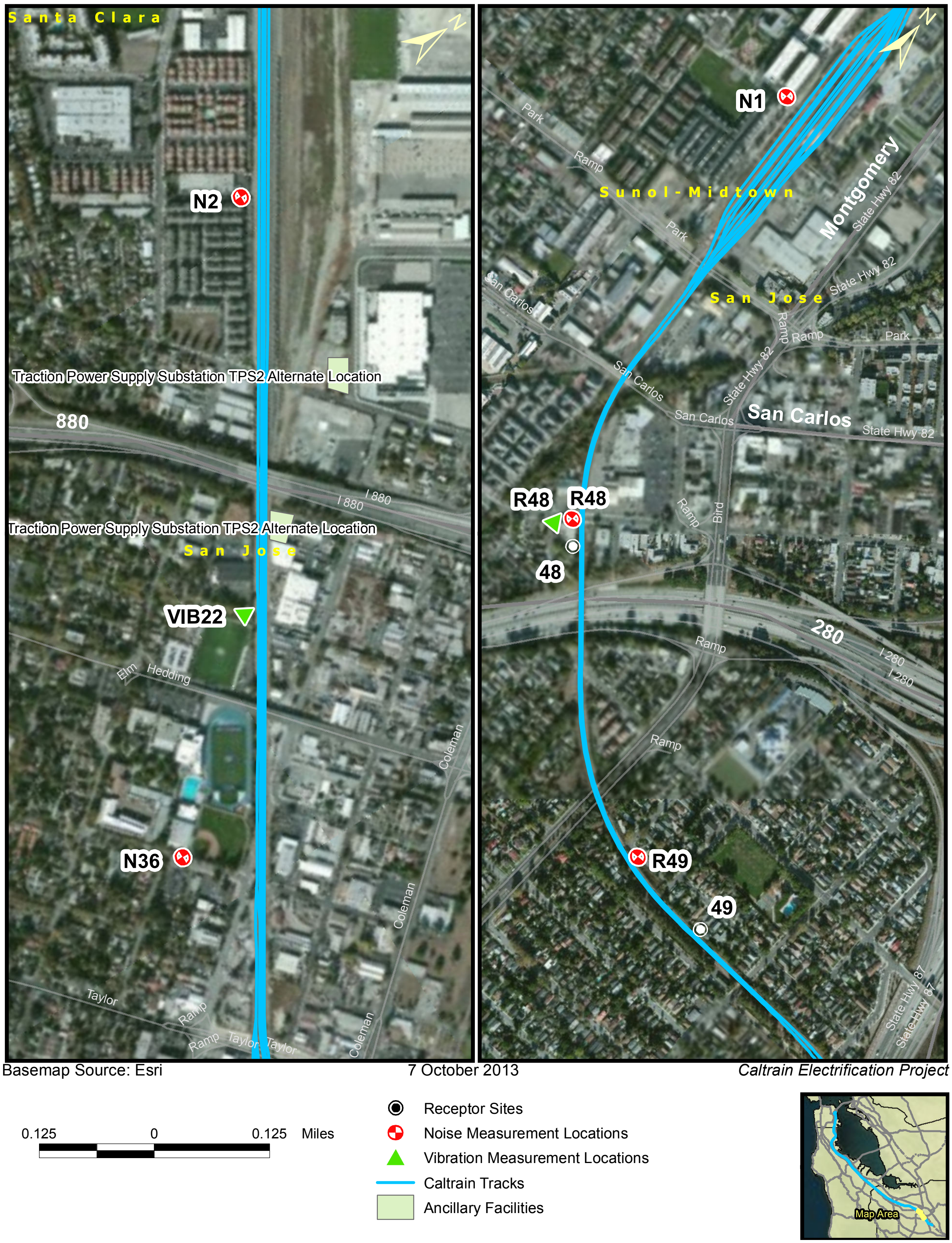
Bowers
Walsh
VIB2
N37
Santa Clara
Monroe
46
San Tomas
Ramp
Scott
Ramp
47
N3
VIB1
Memorex
Lafayette
State Hwy 82
El Camino Real
Lewis
Alviso
Cruz
De La Cruz
Coleman
Basemap Source: Esri
7 October 2013
Caltrain Electrification Project
0.125 0 0.125 Miles
Receptor Sites
Noise Measurement Locations
Vibration Measurement Locations
Caltrain Tracks
Ancillary Facilities
Map Area


Santa Clara
N2
Traction Power Supply Substation TPS2 Alternate Location
880
I 880
Traction Power Supply Substation TPS2 Alternate Location
San Jose
VIB22
Elm
Hedding
N36
Coleman
Taylor
Ramp
N1
Park
Ramp
Sunol-Midtown
Montgomery
State Hwy 82
San Jose
San Carlos
San Carlos
R48
R48
48
Bird
280
I 280
R49
49
State Hwy 87
Basemap Source: Esri
7 October 2013
Caltrain Electrification Project
0.125
0
0.125
Miles
Receptor Sites
Noise Measurement Locations
Vibration Measurement Locations
Caltrain Tracks
Ancillary Facilities
Map Area