VTA's BART Silicon Valley—Phase II Extension Project

Noise and Vibration Technical Report

Prepared for:

Santa Clara Valley Transportation Authority
Federal Transit Administration

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Summary

This report summarizes the evaluation of the potential noise and vibration impacts caused by both construction and operation of the Santa Clara Valley Transportation Authority's (VTA's) BART Silicon Valley—Phase II Extension Project (Project). This technical report also addresses VTA's transit-oriented joint development (TOJD) at four stations and two ventilation structure locations. Mitigation measures are proposed to address both noise and vibration impacts caused by construction and operation of the TOJD.

Groundborne noise and vibration levels for the tunnel portion of the alignment have been projected for the interiors of occupied buildings that are noise and vibration sensitive and adjacent to the tunnel alignment. Airborne noise projections were also made for the aboveground portion of the alignment north of Interstate (I-) 880.

Noise and vibration predictions contained herein are based on empirical models developed for the U.S. Department of Transportation and adopted by the Federal Transit Administration (FTA). The environmental noise and vibration criteria used in this analysis are contained in the FTA publication *Transit Noise and Vibration Impact Assessment* (Ref. 1), which is sometimes referred to as the *FTA Guidance Manual*. The resulting groundborne noise and vibration predictions and potential mitigation, as determined by the vibration prediction model and applicable criteria, form the basis of the groundborne noise and vibration impact assessment for the BART Extension.

This report discusses the field testing and measurements conducted for the alignment, airborne noise impact analysis, groundborne noise and vibration impact analysis, and preliminary indications of feasible mitigation measures, where necessary, to reduce noise and/or vibration levels to achieve the FTA criteria. Because the project presents several options for stations and two for tunnel boring, and the Twin-Bore Option tunnel would have greater impacts than the Single-Bore Option tunnel, the report primarily addresses the Twin-Bore Option while highlighting differences with the Single-Bore Option.

Construction Noise and Vibration

Construction Noise

Construction of the Project is anticipated to exceed FTA construction noise thresholds for L_{eq} (equivalent sound level) during daytime and nighttime construction work. With incorporation of construction noise mitigation measures, development of comprehensive construction noise specifications, and a noise mitigation and monitoring plan, construction noise impacts would be reduced; however, not to a less-than-significant level at all locations. Because of the proximity of sensitive noise receptors, the construction of the Project would result in significant and unavoidable noise impacts at the Downtown San Jose and Diridon Stations for all options even after all feasible mitigation measures have been implemented.

Construction Vibration

Construction of the Project is anticipated to exceed FTA construction vibration thresholds. With incorporation of construction vibration mitigation measures, development of comprehensive construction vibration specifications, and a vibration mitigation and monitoring plan, construction vibration impacts can be reduced to below FTA vibration thresholds for all options.

Operational Airborne Noise

This report analyzed the potential for the Project to generate airborne noise impacts from train operations, which can occur where trains are running on track aboveground, at ventilation facilities where train noise is transmitted to the surface from the tunnel below, from storage yard tracks, and from maintenance facility activities. Where the alignment is in a tunnel configuration, FTA airborne noise thresholds are not exceeded and noise mitigation is not required, except at ventilation shafts. Operational airborne noise caused by the operation of the two ventilation facilities would exceed the FTA threshold. However, mitigation measures have been identified to reduce this noise impact to a less-than-significant level.

The aboveground alignment, storage yard tracks, and maintenance facility, all located north of I-880, are near noise-sensitive residential and hotel land uses to the west. The residential uses would not be impacted by operational airborne noise because they are approximately 400 feet away from the Project, and sound walls exist between the residences and the Project; therefore, no mitigation is required for operational airborne noise impacts on residential land uses. Noise levels at the hotel (also approximately 400 feet away) would be considered a moderate noise impact according to the FTA criteria. Noise mitigation was considered for this potential moderate impact but determined not reasonable because the increase in noise level was only 2 dBA (A-weighted sound levels), and this increase would not be readily perceptible in the interior living spaces of the hotel. Therefore, no mitigation is required for operational airborne noise impacts on hotel land uses. The above conclusions apply to all options.

Operational Vibration

The analysis of operational vibration impacts concluded that levels were less than the FTA criteria. Therefore, no mitigation is required.

Operational Groundborne Noise

Groundborne noise impacts are projected to exceed the FTA criteria at a number of locations for the Twin-Bore Option. Isolated Slab Track (IST) is recommended as mitigation for 20,600 to 22,700 linear feet of the tunnel portion of the alignment, depending on which design options are selected. This mitigation would reduce groundborne noise impacts to less than the FTA criteria.

Groundborne noise impacts for the Single-Bore Option would be less than for the Twin-Bore Option due to the increased depth of the Single-Bore Option and the beneficial effect of the upper track supported on a suspended slab structure rather than on a tunnel invert. Consequently, the amount of mitigation would be less for the Single-Bore Option and would range from 13,525 to 16,150 linear feet of IST. This mitigation would reduce groundborne noise impacts to less than the FTA criteria.

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Acronyms and Abbreviations

AF	Adjustment Factor
BART	Bay Area Rapid Transit
BART SFO	BART South San Francisco
BVR	Building Vibration Response
CEQA	California Environmental Quality Act
dB	decibels
dBA	A-weighted decibels
DF	direct fixation
FDL	Force Density Level
FST	floating slab track
FTA	Federal Transit Administration
GBN	groundborne noise
GBV	groundborne vibration
HRDF	highly resilient direct fixation fasteners
Hz	Hertz
I-	Interstate
IL	Insertion Loss
IST	Isolated slab track
kV	kilovolt
L_{dn}	day-night equivalent sound level
L_{eq}	equivalent sound level
LSR	Line Source Response
L_v	vibration velocity level
MF	Modeling Factor
MFR	multi-family residence
MI	Moderate Impact
mph	miles per hour
NB	northbound
NI	No Impact
Phase I Project	BART Silicon Valley—Phase I Berryessa Extension Project
Phase II Project	BART Silicon Valley—Phase II Extension Project
PPV	peak particle velocity
RMS	root mean square
ROW	right-of-way
RSF	rail suspension fastener
RT	resiliently supported ties
SB	southbound
SEL	Sound Exposure Level
SFR	single-family residence
SI	Severe Impact

TBM	tunnel boring machine
TVF	tunnel ventilation fan
TOJD	transit-oriented joint development
U.S. 101	U.S. Highway 101
UPRR	Union Pacific Railroad
VdB	vibration velocity decibels
VTA	Santa Clara Valley Transportation Authority

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Chapter 1
Project Description

1.1 Introduction

The Santa Clara Valley Transportation Authority's (VTA) Bay Area Rapid Transit (BART) Silicon Valley—Phase II Extension Project (Phase II Project, or Project) would consist of an approximately 6-mile extension of the BART system from the terminus of VTA's BART Silicon Valley—Phase I Berryessa Extension Project (Phase I Project) in San Jose to Santa Clara (Figure 1-1). The Phase I Project is currently under construction and scheduled to be operational in late 2017. The Phase II BART Extension would descend into an approximately 5-mile-long tunnel, continue through downtown San Jose, and terminate at grade near the Santa Clara Caltrain Station (Figure 1-2). Four passenger stations are proposed, and service for the BART Extension would start in 2025, assuming funding is available. The Phase II Project also includes VTA's transit-oriented joint development (TOJD) at the four stations and two ventilation structures as described below. VTA's TOJD has independent utility and no federal nexus and is being environmentally cleared as part of the VTA's compliance with the California Environmental Quality Act (CEQA).

1.2 BART Extension

The BART Extension alignment would begin with a reconfiguration of the Phase I BART tail tracks. The at-grade Phase I tail tracks located east of U.S. Highway 101 (U.S. 101) and between Mabury Road and Las Plumas Avenue in San Jose would be partially removed to allow for construction of the East Tunnel Portal, bored tunnels, and supporting facilities. The Phase I tracks would be connected at the Phase I/Phase II interface to allow for BART operation along the entire 16-mile Silicon Valley Rapid Transit Corridor from Fremont to Santa Clara. The alignment would transition from a retained fill configuration south of Mabury Road near the end of the Phase I alignment to an at-grade configuration, then descend into to a retained-cut configuration, and enter the East Tunnel Portal just north of Las Plumas Avenue.

South of the East Tunnel Portal, the alignment would pass beneath Lower Silver Creek and under Marburg Way directly east of U.S. 101, curve under U.S. 101 south of the McKee Road overpass, and enter Rock Station.

Alum Rock/28th Street Station would be located between U.S. 101 and North 28th Street and between McKee Road and Santa Clara Street. The station would be underground, with aboveground facilities such as street-level entrances, a parking structure of up to seven levels, kiss-and-ride (passenger drop-off) facilities, and other transit facilities. Improvements to North 28th Street would include new or modified traffic signals at intersections near the station, and a pedestrian/bicycle/transit gateway along the south side of the station area at North 28th Street from Santa Clara Street.

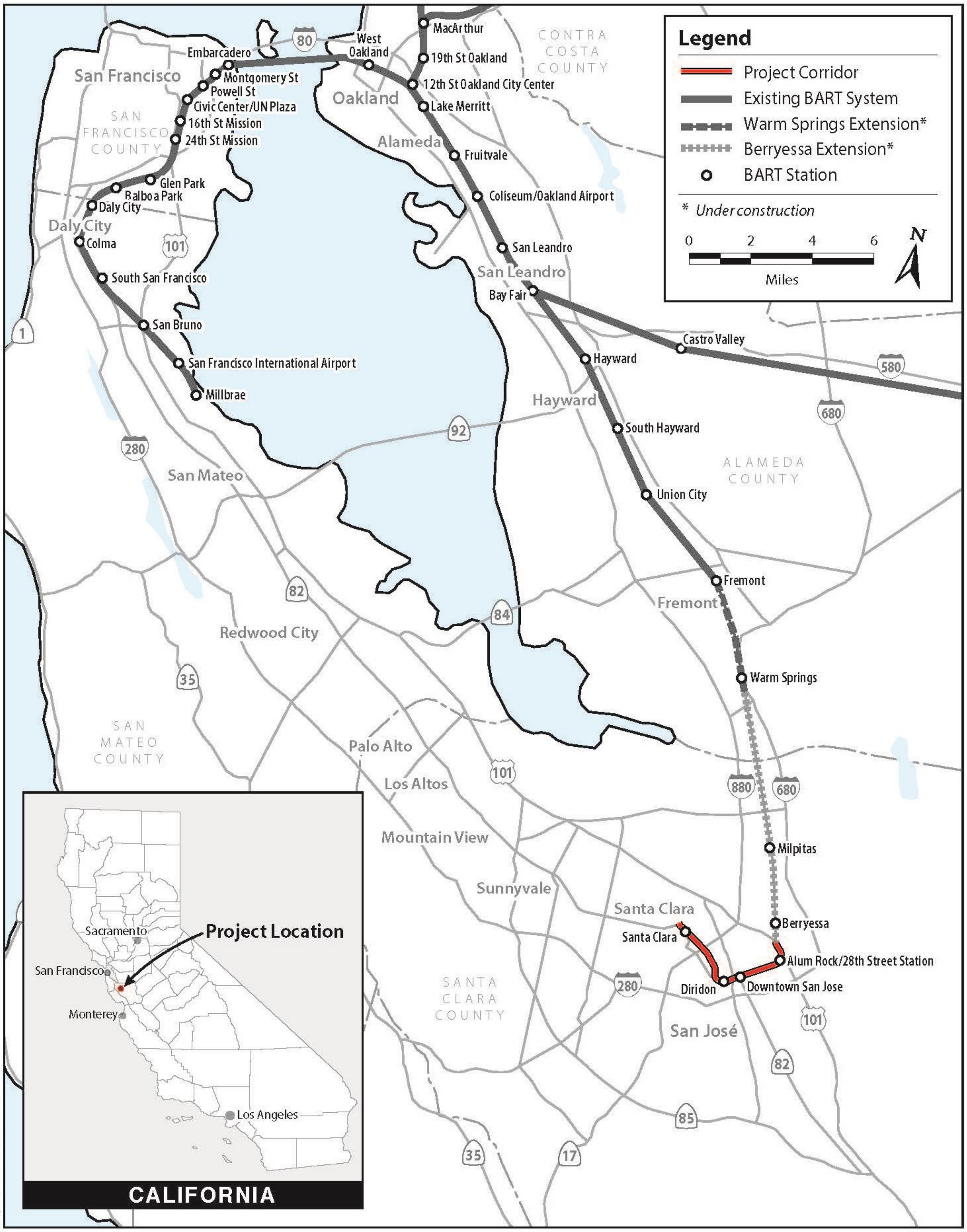

Figure 1-1: Regional Location

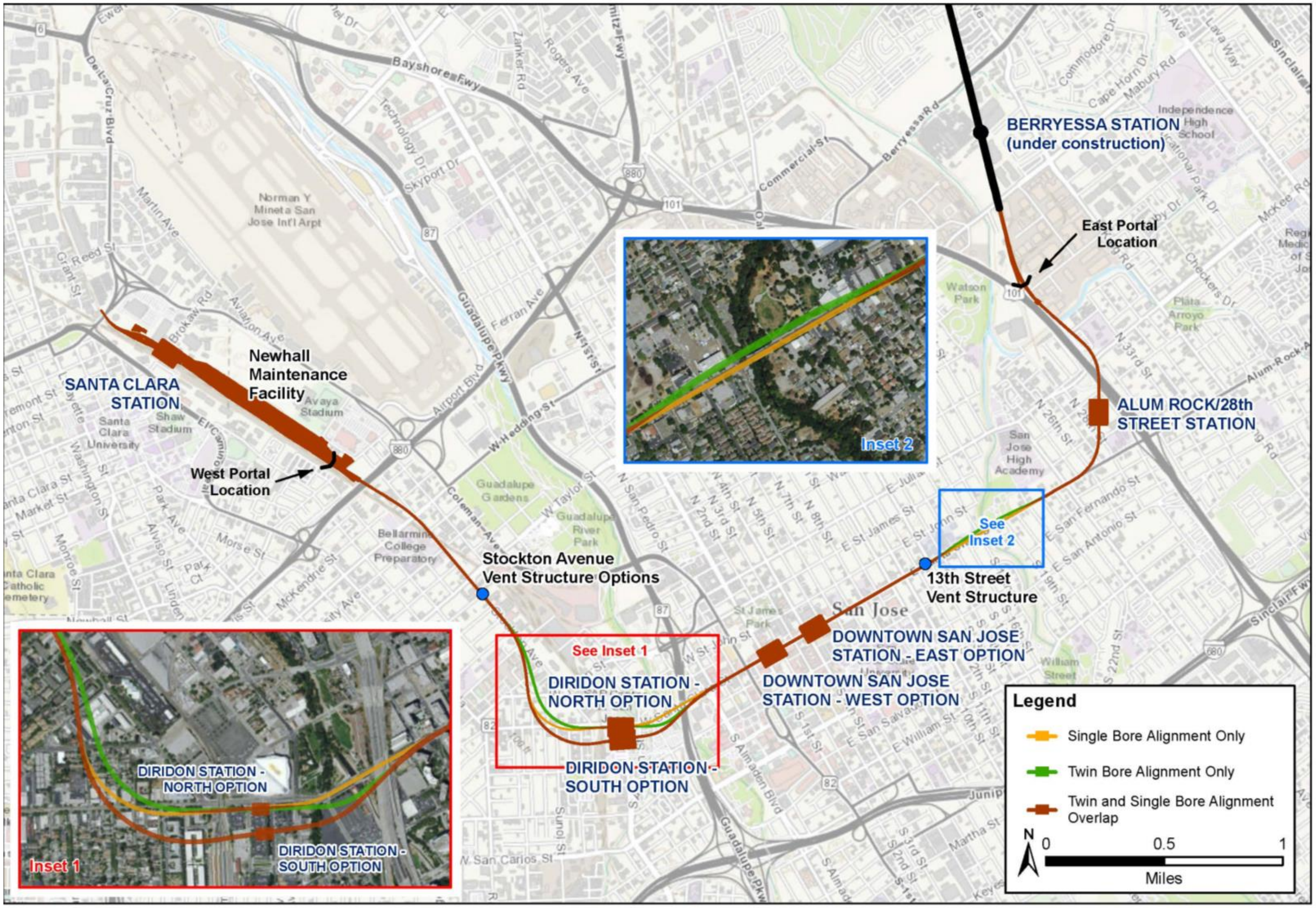

Figure 1-2: Project Map (with Options)

The station also would have system facilities such as electrical, ventilation, and communication equipment. Detention basins would be located in landscaped and unpaved areas of the station.

From Alum Rock/28th Street Station, the alignment would curve under North 28th, North 27th, and North 26th Streets before aligning under Santa Clara Street and continuing under the Santa Clara Street right-of-way (ROW) until the alignment approaches Coyote Creek. The alignment would begin to transition north from the Santa Clara Street ROW near North 22nd Street, pass under Coyote Creek, and then transition back into the Santa Clara Street ROW near 13th Street. A systems facility site for a ventilation facility, an auxiliary power substation, and a gap breaker station would be located at the northwest corner of Santa Clara and 13th Streets.

The alignment would continue beneath Santa Clara Street to the locations of two underground station options for Downtown San Jose. The East Option would be beneath Santa Clara Street between 5th and 2nd Streets. The West Option would be beneath Santa Clara Street between 2nd and Market Streets. For the East Option, crossover tracks would be located between 5th and 7th Streets; for the West Option, crossover tracks would be located between 2nd and 4th Streets. Under either option, the station would consist of a boarding platform level, a mezzanine one level above, street-level entrances, and underground and aboveground ancillary areas for system facilities.

Under either option, streetscape improvements, guided by San Jose's Master Streetscape Plan, would be provided along Santa Clara Street to create a pedestrian corridor. For the East Option, streetscape improvements would be between 7th and 1st Streets; for the West Option, streetscape improvements would be between 4th and San Pedro Streets.

From the Downtown San Jose Station, the alignment would continue beneath Santa Clara Street and pass under Los Gatos Creek before entering the underground Diridon Station (North or South Option) between Los Gatos Creek to the east, the San Jose Diridon Caltrain Station to the west, Santa Clara Street to the north, and West San Fernando Street to the south. The station would consist of a boarding platform level, a mezzanine one level above, and street-level entrance portals at both the east and west ends of the station.

An existing VTA bus transit center would be expanded, and kiss-and-ride facilities would be located along Cahill Street. Street-level station entrance portals would provide pedestrian linkages to the Diridon Caltrain Station and SAP Center. Underground ancillary areas would be located at either end of the station box for system facilities. A systems facility site for a traction power substation, auxiliary power substation, emergency generator, and ventilation structures would be located aboveground at the east end of the station between Autumn Street and Los Gatos Creek.

West of the station, the alignment would continue beneath the Diridon Caltrain Station train tracks and White Street. The alignment would then turn north, crossing under The Alameda before aligning under Stockton Avenue. A 15,000- to 35,000-square-foot system facility site would be located east of Stockton Avenue, between Schiele Avenue and West Taylor Street. Systems facilities include a ventilation facility, an auxiliary power substation, and a gap breaker station that typically would be 12 feet high, and surrounded by a 9-foot-high wall or fence.

The alignment would continue north and cross under the Caltrain tracks, Hedding Street, and Interstate (I-) 880 before ascending and exiting the West Tunnel Portal near Newhall Street. A systems facility site would be located above the West Tunnel Portal and near PG&E’s FMC Substation. A 115-kilovolt (kV) line from PG&E’s FMC substation would serve the high-voltage substation.

Crossover tracks would be located in a retained cut trench just outside the West Tunnel Portal. The alignment would remain at grade as it enters the Newhall Maintenance Facility and Santa Clara Station to the north.

The Newhall Maintenance Facility would begin north of the West Tunnel Portal at Newhall Street in San Jose and extend to Brokaw Road near the Santa Clara Station in Santa Clara. A single tail track would extend north from Santa Clara Station and cross under the De La Cruz Boulevard overpass and terminate on the north side of the overpass. The Newhall Maintenance Facility would be constructed on the former Union Pacific Railroad (UPRR) Newhall Yard. The facility would serve two purposes: (1) general maintenance, running repairs, and storage of up to 200 BART revenue vehicles; and (2) general maintenance of non-revenue vehicles. To provide for these functions, several buildings and numerous transfer and storage tracks would be constructed. The facility would also house maintenance and engineering offices and a yard control tower. The Newhall Maintenance Facility would include service roads to all buildings and parking for employees, visitors, and delivery and service vehicles.

Santa Clara Station would be bounded by El Camino Real to the southwest, De La Cruz Boulevard to the northwest, and Coleman Avenue to the northeast near the intersection of Brokaw Road. The station would be at grade, centered at the west end of Brokaw Road, and would contain an at-grade boarding platform with a mezzanine one level below. A pedestrian tunnel would connect from the mezzanine level of the BART station to the Santa Clara Caltrain Station plaza, and to a new BART plaza on Brokaw Road. Kiss-and-ride and bus and shuttle loading areas would be provided on Brokaw Road, which would be widened and reconfigured. In addition, a three-level parking structure would be located north of Brokaw Road and east of the Caltrain tracks. System facilities would be located north of Santa Clara Station.

1.3 Transit-Oriented Joint Development

VTA is proposing to construct TOJD around the Alum Rock/28th Street, Downtown San Jose, Diridon, and Santa Clara Stations and at mid-tunnel ventilation facilities at Santa Clara and 13th Streets, and east of Stockton Avenue south of Taylor Street. VTA proposes 500,000 square feet of office space, 20,000 square feet of retail, and up to 275 dwelling units at Alum Rock/28th Street Station; 640,000 square feet of office space and 72,000 square feet of retail at Diridon Station; and 500,000 square feet of office space, 30,000 square feet of retail, and up to 220 dwelling units at Santa Clara Station.

TOJD at the Downtown San Jose Station would total 460,000 square feet of retail and office space at three locations at the East Option location, or 45,000 square feet of retail and office space at the West Option location. VTA also would develop underground or aboveground parking facilities to serve TOJD at each station location. VTA proposes 13,000 square feet of retail along Santa Clara Street at the site of the Santa Clara and 13th Streets ventilation facility, and 15,000 square feet of retail at the Stockton Avenue ventilation facility.

Chapter 2
Regulatory Setting

The environmental noise and vibration impact evaluation for the BART Extension is based on criteria defined in the FTA *Transit Noise and Vibration Impact Assessment* (Ref. 1) also referred to as the *FTA Guidance Manual*. The *FTA Guidance Manual* provides criteria to evaluate construction and operational impacts for the BART Extension. The noise and vibration criteria are based on studies that examined community reactions to noise and vibration from construction activity and transit operations. Local noise and vibration regulations do not apply to regional transit operations and are therefore not used in the impact assessment.

2.1 Airborne Noise Criteria

For transit operations aboveground, the *FTA Guidance Manual* provides noise criteria that evaluates impact based on potential changes to the existing ambient noise environment. For higher levels of existing ambient noise, less of a change is needed to cause an impact due to transit operations, which are long-term. Operational noise impacts are classified as no impact, moderate impact, or severe impact depending on the amount of change in noise level relative to the existing ambient noise level.

FTA recognizes three levels of noise analysis based on the degree of specificity of details available regarding the BART Extension and the local conditions along the transit alignment. The three levels are: Screening, General Assessment, and Detailed Analysis. Screening is intended for use in programmatic evaluation where alignments are general in nature and impacts are assessed using screening distances to quantify the number of receptors potentially impacted. A General Assessment is by nature generic, but provides an indication of impact levels beyond a Screening.

If the alignment options have been narrowed and the design has progressed sufficiently to provide specific alignment details, a more site-specific analysis called a Detailed Analysis can be conducted to obtain a more accurate projection of noise levels and assessment of potential impacts.

For both a General Assessment and Detailed Analysis, the FTA provides guidelines to assess project noise levels from mass transit system operations, as well as noise criteria to assess impacts. Table 2-1 provides the FTA noise sensitive land-use categories: Category 1, Category 2, and Category 3. The FTA guidelines specify a particular noise metric to be used depending on the specific land use (e.g., residential). Table 2-1 describes the FTA land-use categories, and specifies the noise metric to be used and the criterion for each category.

Table 2-1: FTA Land Use Category and Noise Metric for Transit Impact Criteria

Land Use Category	Noise Metric (dBA)	Description of 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.
2	Outdoor L_{dn}	Residences and buildings where people normally sleep. This category includes homes, hospitals, and hotels where a nighttime sensitivity to noise is assumed to be of utmost importance.
3	Outdoor L_{eq}(h)	Institutional land uses with primarily daytime and evening use. This category includes schools, libraries, and churches where it is important to avoid interference with activities such as speech, meditation, and concentration on reading material. Buildings with interior spaces where quiet is important, such as medical offices, conference rooms, recording studios, and concert halls fall into this category. Places for meditation or study associated with cemeteries, monuments, museums, campgrounds and recreational facilities can also be considered to be in this category. Certain historical sites and parks are also included.
dBA = A-weighted decibel; L_{eq} = equivalent sound level; L_{dn} = day=night equivalent sound level; (h) = hour		

The three levels of noise impact defined by the FTA guidelines—*no impact*, *moderate impact*, and *severe impact*—are shown graphically in Figure 2-1 (Land Use Categories 1 and 2) and Figure 2-2 (Land Use Category 3).

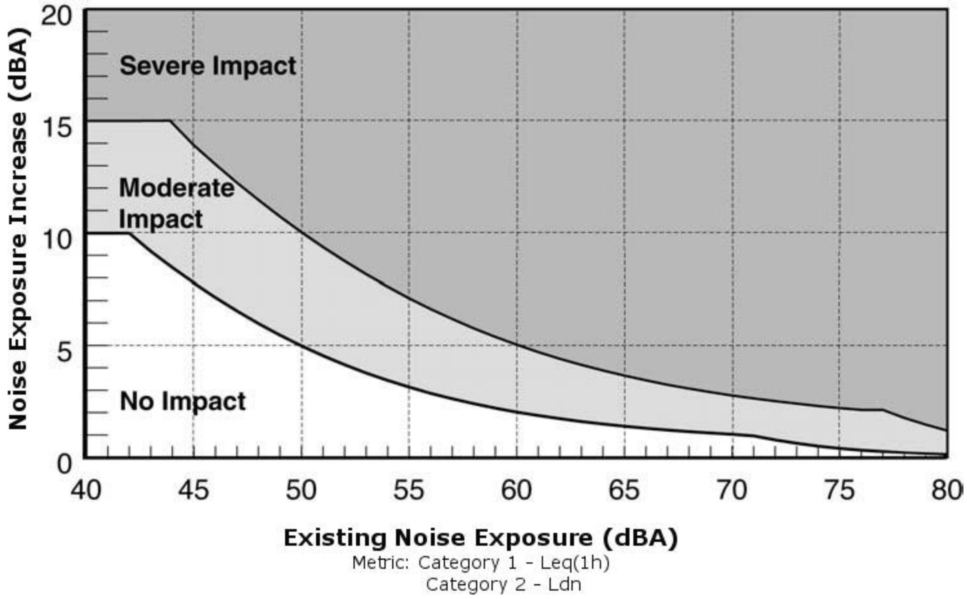

Figure 2-1: Increase in Cumulative Noise Levels Allowed by Criteria (Land Use Categories 1 and 2)

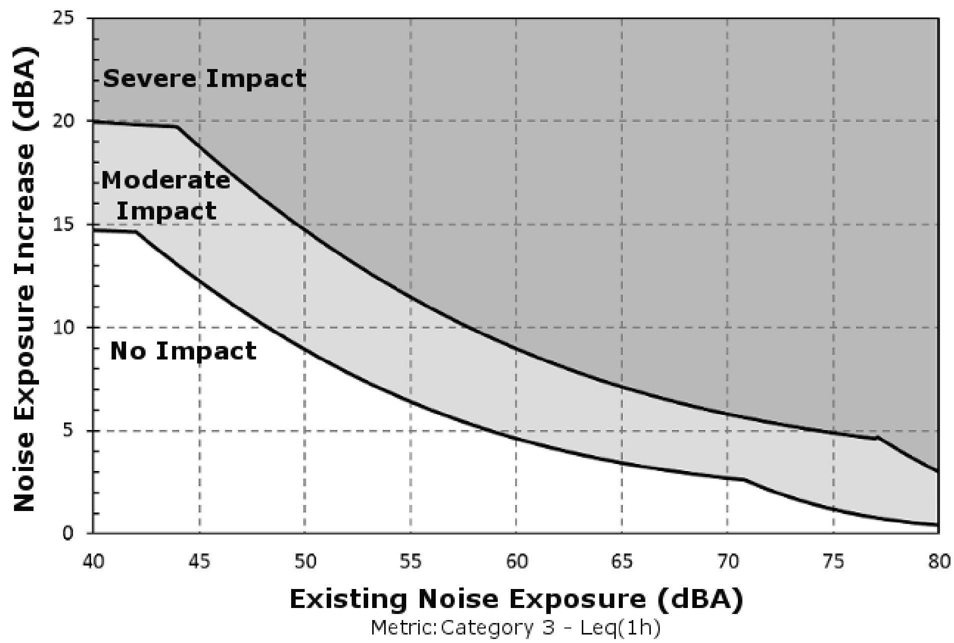

Figure 2-2: Increase in Cumulative Noise Levels Allowed by Criteria (Land Use Category 3)

The FTA noise impact thresholds are presented in Table 2-2. They are based on the existing ambient noise exposure level and the projected increase in noise level created by the project or combination of new projects. The noise thresholds in Table 2-2 reflect the graphic data presented in Figure 2-1 and Figure 2-2.

Table 2-2: Cumulative Increase Thresholds for Transit Noise Impact

Existing Noise Exposure, L_{eq} or L_{dn}	Impact Threshold for Increase in Cumulative Noise Exposures (dBA)			
	Category 1 or 2 Sites		Category 3 Sites	
	Impact	Severe Impact	Impact	Severe Impact
45	8	14	12	19
46	7	13	12	18
47	7	12	11	17
48	6	11	10	16
49	5	11	10	15
50	5	10	9	15
51	5	9	8	14
52	4	9	8	13
53	4	8	7	13
54	3	8	7	12
55	3	7	6	11
56	3	7	6	11
57	3	6	6	10
58	2	6	5	10
59	2	5	5	9
60	2	5	5	9
61	1.9	5	4	9
62	1.7	4	4	8
63	1.6	4	4	8
64	1.5	4	4	7
65	1.4	4	3	7
66	1.3	3	3	7
67	1.2	3	3	7
68	1.2	3	3	6
69	1.1	3	3	6
70	1.0	3	3	6
71	1.0	3	3	6
72	0.8	3	2	5
73	0.6	2	1.8	5
74	0.5	2	1.5	5
75	0.4	2	1.2	5

Note: Maximum 1-hour L_{eq} is used for land use involving only daytime activities; L_{dn} is used for land uses where nighttime sensitivity is a factor.

Source: *FTA Transit Noise and Vibration Impact Assessment,* May 2006.

BART Extension-generated noise in the No Impact range is not likely to be found annoying. Noise projections in this range are considered acceptable by FTA, and mitigation is not required. At the other extreme, noise projections in the Severe Impact range represent the most compelling need for mitigation unless there are means to avoid this by changing the location of the project. There is a presumption by the FTA that mitigation will be incorporated in the project unless there are truly extenuating circumstances to prevent it. The goal in mitigating noise impacts is not simply to reduce predicted levels to just below the Severe Impact threshold, but to gain substantial noise reduction through the use of mitigation measures. BART Extension-generated noise in the moderate impact range will also require consideration and adoption of mitigation measures where considered reasonable.

The *FTA Guidance Manual* does not directly address ancillary facilities that do not operate continuously. The tunnel ventilation fans (TVFs) are the main example of this. TVFs are used primarily in emergencies. They also need to be tested occasionally and will from time to time be used to ventilate tunnel sections during nighttime maintenance work. An applicable criterion for this infrequent, operational noise source is provided by a City of San Jose code (Ref. 11). Although this code is intended to apply to emergency power, the operation and need for TVF are similar in that they would be infrequent and for short durations. According to the code, the noise limit for a commercial land use adjacent to a residential land use is 55 dBA (see Table 20-105 in Ref. 11).

2.2 Transit Groundborne Noise and Vibration Criteria

FTA recognizes three levels of vibration analysis based on the degree of specificity of details available regarding the BART Extension and the local conditions along the transit alignment. The three levels are: Screening, General Assessment, and Detailed Analysis. Screening is intended for use in programmatic evaluation where alignments are general in nature and impacts are assessed using screening distances to quantify the number of receptors potentially impacted. A General Assessment is by nature generic, but provides an indication of impact levels beyond a Screening.

If the alignment options have been narrowed and the design has progressed sufficiently to provide specific alignment details, a more site-specific analysis can be conducted to obtain a more accurate projection of vibration levels and assessment of potential impacts. This level of analysis is referred to as a Detailed Vibration Analysis. Where vibration impacts are indicated by the detailed analysis, further analysis can be conducted in the Final Engineering phase of the BART Extension to further refine site-specific vibration propagation characteristics in areas identified during the environmental process as impacted and needing mitigation. Such studies during later stages of engineering can also be used to refine the mitigation measures required.

Predicted levels of groundborne noise and vibration have been evaluated using the FTA criteria, according to the Land Use Categories defined in Table 2-3. The vibration criteria for the three Land Use Categories are also indicated in Table 2-3. If the overall vibration level does not exceed the relevant criterion, then neither do any of the 1/3-octave band levels. It is sufficient to evaluate just the predicted overall vibration levels, unless the criteria are exceeded, in which case an evaluation of the 1/3-octave band levels is warranted.

The FTA noise and vibration criteria are affected by the number of events, which in this case corresponds to the number of train passbys per day. The BART Extension plan for BART operations calls for more than 70 train movements a day. Hence the Frequent Events criteria would apply.

Table 2-3: Indoor Groundborne Noise and Vibration Impact Criteria

Land Use Category	GBV Impact Levels (VdB re 1 micro-inch /sec)			GBN Impact Levels (dBA 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	65	65	N/A[4,5]	N/A[4,5]	N/A[4,5]
Category 2: Residences and buildings where people normally sleep	72	75	80	35	38	43
Category 3: Institutional land uses with primarily daytime use	75	78	83	40	43	48

Notes:

[1] *Frequent Events* is defined as more than 70 vibration events of the same source per day. Most rapid transit projects fall into this category

[2] *Occasional Events* is defined as 30 to 70 vibration events of the same source per day. Most commuter trunk lines have this many operations.

[3] *Infrequent Events* is defined as fewer than 30 vibration events of the same kind per day. This category includes most commuter rail branch lines.

[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 not sensitive to groundborne noise.

GBV = groundborne vibration; GBN = groundborne noise; VdB = vibration velocity decibels; dBA = A-weighted decibels; N/A.

No buildings along the alignment have been identified that can be classified as Land Use Category 1. Such receivers would include vibration-sensitive manufacturing, research, or special medical facilities. The majority of receivers within the study area are Land Use Category 2, which include residential land uses and those where people sleep at night (e.g., hotels and hospitals). The FTA noise and vibration criteria for Category 2 receivers are 35 dBA for groundborne noise and 72 VdB (re: 10^{-6} inches per second) for vibration.

The criteria for Institutional land uses under Category 3 with daytime uses only (e.g., schools and churches) are 40 dBA for groundborne noise and 75 VdB for vibration. The criteria do not apply to most commercial or industrial uses because, in general, the activities within these buildings are compatible with higher noise levels. They do apply to business uses that depend on quiet as an important part of operations, such as sound and motion picture recording studios. If the buildings or structures are used for commercial or industrial purposes and are located in busy commercial areas, they are not considered noise sensitive, and the noise impact criteria do not apply.

FTA also provides criteria for Special Buildings, which are indicated in Table 2-4 and include buildings with performing arts facilities as well as recording studios. There no facilities in the study area have been identified that could be affected by groundborne noise or vibration that meet the definition of a Special Building.

Table 2-4: Indoor Groundborne Noise and Vibration Impact Criteria for Special Buildings

Type of Building or Room	Groundborne Vibration Impact Levels (VdB re 1 micro-inch/second)		Groundborne Noise Impact Levels (dBA re 20 micro-Pascals)	
	Frequent Events[1]	Occasional or Infrequent Events[2]	Frequent Events[1]	Occasional or Infrequent Events[2]
Concert Halls	65	65	25	25
TV Studios	65	65	25	25
Recording Studios	65	65	25	25
Auditoriums	72	80	30	38
Theaters	72	80	35	43

Notes:

[1] *Frequent Events* is defined as more than 70 vibration events of the same source per day. Most rapid transit projects fall into this category.

[2] *Occasional or Infrequent Events* is defined as fewer than 70 vibration events per day. This category includes most commuter rail systems.

If the building will rarely be occupied when trains are operating, there is no need to consider impact. For example, consider a commuter rail line next to concert hall. If no commuter trains will operate after 7 p.m., it should be rare that trains would interfere with the use of the hall.

FTA vibration criteria for detailed analysis are presented in terms of 1/3-octave bands as shown in Figure 2-3. The projected vibration levels are compared to the spectral criteria curves, and if the applicable curve is not exceeded, then no impact is projected to occur. For example, the criterion curve for residences (night) is 72 VdB above 8 Hertz (Hz). Below 8 Hz the sensitivity of humans decreases as reflected in the higher threshold, although below 8 Hz transit systems typically produce little vibration.

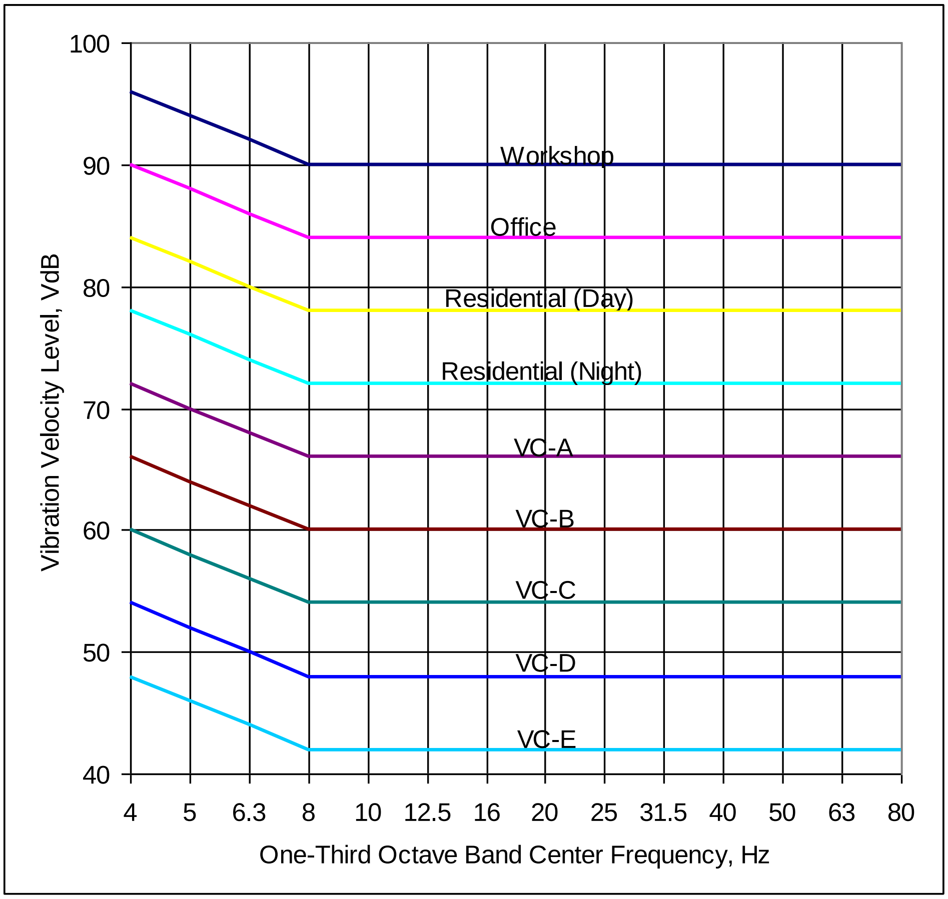

Figure 2-3: Criteria for Detailed Vibration Analysis

Interpretation of the various vibration criteria levels shown in Figure 2-3 are presented in Table 2-5. Frequency band levels that exceed a particular criterion curve indicate the need for mitigation. The frequency range(s), over which the exceedance occurs is important for determining the type and extent of mitigation. To be effective, the vibration mitigation must be able to reduce the vibration levels to achieve criteria over the frequency range of exceedance. In general, the lower the frequency at which exceedance occurs, the more difficult it is to mitigate vibration impacts, and thus more substantial measures are necessary to accomplish the reductions.

Table 2-5: Interpretation of Vibration Criteria for Detailed Analysis

Criterion Curve (See Figure 2-3)	Max L_v (VdB)[1]	Description of Use
Workshop	90	Distinctly feelable vibration. Appropriate to workshops and non-sensitive areas.
Office	84	Feelable vibration. Appropriate to offices and non-sensitive areas.
Residential Day	78	Barely feelable vibration. Adequate for computer equipment and low-power optical microscopes (up to 20X).
Residential Night, Operating Rooms	72	Vibration not feelable, but groundborne noise may be audible inside quiet rooms. Suitable for medium-power optical microscopes (100X) and other equipment of low sensitivity.
VC-A	66	Adequate for medium- to high-power optical microscopes (400X), microbalances, optical balances, and similar specialized equipment.
VC-B	60	Adequate for high-power optical microscopes (1000X), inspection and lithography equipment to 3-micron line widths.
VC-C	54	Appropriate for most lithography and inspection equipment to 1-micron detail size.
VC-D	48	Suitable in most instances for the most demanding equipment, including electron microscopes operating to the limits of their capability.
VC-E	42	The most demanding criterion for extremely vibration-sensitive equipment.

Note:
[1] As measured in 1/3-octave bands of frequency over the frequency range 8 to 80 Hz.
L_v = vibration velocity level; VdB = vibration velocity decibels

2.3 Construction Noise Thresholds

Criteria provided by FTA (Ref. 1) to assess noise impacts during project construction are indicated in Table 2-6.

Table 2-6: FTA Construction Noise Criteria[1]

Land Use	8-hour L_{eq} (dBA)		L_{dn} (dBA)
	Day	Night	30-day Average
Residential	80	70	75[2]
Commercial	85	85	80[3]
Industrial	90	90	85[3]

[1] Criteria applies at the lot line of particular noise-sensitive properties.
[2] In urban areas with very high ambient noise levels (L_{dn} > 65 dB), L_{dn} from equipment should not exceed existing ambient by more than 10 dB.
[3] Use a 24-hour L_{eq} not L_{dn}.

Table 2-7 provides the BART Facilities Standards (Ref. 18) noise criteria for construction activities. The noise criteria are shown separately for continuous noise (i.e., noise from stationary sources, or parked mobile sources, or any source or combination of sources producing repetitive or long-term noise lasting more than a few hours) and intermittent noise (i.e., noise from non-stationary mobile equipment operated by a driver or from any source of non-scheduled, intermittent, non-repetitive, short-term noise not lasting more than a few hours). The measurement period for the L_{eq} is 1 hour for both the continuous and the intermittent noise.

Table 2-7 BART Construction Noise Criteria

	Maximum Allowable Noise Level (L_{eq} dBA)			
	Continuous		Intermittent	
Land Use	**Daytime**	**Nighttime**	**Daytime**	**Nighttime**
Single- and multi-family residential areas, along major arterial	65	55	75	65
Residential structures in semi-residential/commercial areas, including hotels	70	60	80	70
Commercial areas with no nighttime occupancy	70	70	85	85
Industrial	80	80	90	90

A comparison of Table 2-6 and Table 2-7 indicates that the BART intermittent noise criteria for residences in semi-residential/commercial areas are similar to the FTA noise criteria for both daytime and nighttime construction. Either FTA 8-hour L_{eq} criteria or the BART intermittent noise criteria can be employed to assess construction noise impacts depending on the level of detail currently available for equipment and usage. The 2005 analysis employed the FTA 8-hour L_{eq} criteria because of the detail available at the time.

For the three facilities discussed in this report, the BART facilities standards criteria (1-hour L_{eq}) were employed to reflect the lack of details available at this time regarding equipment and usage. For these three facilities most of the noise would be generated by heavy construction equipment, which are mobile. Therefore, the BART facilities standards intermittent noise criteria can be used to assess impacts. This is a conservative approach in that heavy equipment would generally not be in use every hour of the construction day, whereas the FTA criteria allows the noise to be averaged over an 8-hour construction day and would permit some hours to be louder than others.

Nighttime construction would be avoided where feasible, and coordinated with the local agency. During night work, the BART nighttime noise criteria would be applicable.

If there are residences nearby, the City of San Jose has limitations on when construction can occur. Unless otherwise expressly allowed in a Development Permit or other planning approval, where there are residences within 500 feet of a construction site the City of San Jose (Ref. 13) prohibits construction from 7 p.m. to 7 a.m. It also prohibits construction on weekends unless otherwise allowed. If nighttime construction were allowed, then the nighttime noise limits in Table 2-7 would apply.

The City of Santa Clara has adopted similar construction limitations (Ref. 17). Construction within 300 feet of any residentially zoned property is prohibited between 6 p.m. and 7 a.m. weekdays and 6 p.m. to 9 a.m. weekends. In addition, construction work is prohibited on holidays. If nighttime construction were allowed, then the nighttime noise limits in Table 2-7 would apply.

2.4 Construction Vibration Thresholds

FTA provides criteria (Ref. 1) for two types of impact from construction vibration. The criteria address impacts due to annoyance and impacts due to building damage. For evaluating annoyance impacts the criteria presented in Section 2.1.2, *Transit Groundborne Noise and Vibration Criteria*, are applicable and depend on the duration of the vibration generated.

Construction vibration impacts can result in short-term annoyance and can be classified as Infrequent Events as indicated in Table 2-3. FTA guidelines (Ref. 1) for construction vibration criteria that minimize the risk of building damage (cosmetic) are presented in Table 2-8. The criteria are specified in terms of Peak Particle Velocity (PPV) in inches/second. The threshold over which a structure would sustain damage depends on the age and construction of the building and also on how well it has been maintained if it is an older building.

Table 2-8: Construction Vibration Damage Criteria

Building Category	Peak Particle Velocity (inch/second)	Approximate Vibration Level (Lv)[1]
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 building	0.2	94
IV. Buildings extremely susceptible to vibration damage	0.12	90
[1] Root mean square velocity in decibels (VdB) re 1 micro-inch/second; Lv = vibration velocity level.		

Historic buildings were identified within the study area. They are close enough to the source of construction-related vibration to warrant analysis. FTA recommends a PPV criterion of 0.12 inch/second for buildings that are extremely susceptible to vibration, which might include fragile historic buildings depending on their construction type, age, and level of maintenance. At and above this level of PPV, a historic building that is fragile may suffer cosmetic damage, characterized by fine cracking (in plaster or masonry) or the re-opening or widening of old cracks. At this level of vibration there is no risk of structural damage.

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Chapter 3
Methodology

3.1 Construction

Construction noise and vibration impacts for the tunnel segment were analyzed in previous environmental studies for the BART Extension (Ref. 14). Reference 14 presents a detailed evaluation of construction noise impacts for the BART Extension using assumptions provided at the time of the study. The construction phasing, anticipated construction equipment and their duration of use have not materially changed for the current BART Extension. The results of the 2005 construction impact study are summarized herein. The 2005 construction impact analysis evaluated seven areas of construction:

1. Downtown San Jose Station
2. Alum Rock/28th Street Station
3. Diridon Station
4. Portals
5. 15th Street ventilation shaft
6. Stockton Avenue ventilation shaft
7. Gap breaker station (5)

There have been changes to the BART Extension since 2005. Currently there are two options for the Downtown San Jose Station and two options for Diridon Station. Otherwise the locations of the construction sites are very similar or the same as those in 2005. The ventilation shaft facility at 15th Street is now proposed at 13th Street. The ventilation shaft at Schiele Avenue is actually four alternative locations along Stockton Avenue and is now labeled Stockton Avenue ventilation shaft. The Santa Clara Station was not included in the referenced 2005 study. The only noise receptor near the Santa Clara Station construction site would be the Candlewood Suites, which would be approximately 300 feet away at the closest point of the station.

3.1.1 Construction Equipment

Typical construction equipment would include backhoes, bulldozers, end-loaders, cranes, wrecking balls, forklifts, haul trucks, jackhammers, excavators, boom drill rigs, crawler cranes, crawler bulldozers/loaders, pavement breakers, loader/bobcats, trucks, excavators, generator/compressors, water trucks for dust control, and concrete and materials/equipment trucks. Significant oversized equipment would be used extensively on the BART Extension such as crane, bulldozers, loaders, pavement breakers, excavators, and backhoes. A soil mix wall batch plant for cement slurry preparation would be required for cut-and-cover excavation.

3.1.2 Tunnel Construction

The tunnels would be constructed using one or more tunnel boring machines (TBM). The TBM is anticipated to progress at a rate of 30 to 75 feet per day depending on soil conditions encountered. The TBM would be a source of groundborne noise and/or vibration, the impact of which depends on the proximity of the tunnel to sensitive receptors and soil conditions encountered.

The soil excavated by the TBM would be removed from the tunnel by either by a muck train or a conveyor system. Typically muck trains operate on small jointed rails supported on wood crossties laid on the tunnel floor. This type of soil removal can be source of groundborne noise depending on the proximity of the tunnel to sensitive receptors and soil conditions encountered. Generally, a soil conveyor system generates no perceptible noise or vibration for receptors on the surface above.

3.1.3 Portal, Station Box, Ventilation Structure, and Underground Crossover Construction

The portals, the three underground station boxes, one underground crossover, and two mid-tunnel ventilation structures would be constructed by a cut-and-cover construction method for the Twin-Bore Option. The Single-Bore Option would not require the three underground station boxes to be constructed by a cut-and-cover construction method as they would be contained within the tunnel structure. Demolition of existing structures would be required at various locations where cut-and-cover occurs. Cut-and-cover construction involves excavation from the street or ground level. Temporary shoring walls would be required to support the earthen walls during excavation, typically by using a soil-cement mix wall or slurry diaphragm wall. A soil mix wall construction involves either drilling many holes with an auger or digging a trench, both of which generate airborne noise and ground vibration.

3.1.4 Truck Haul Routes

Trucks hauling equipment, materials, and soil can be a source of noise depending on the routes selected.

3.2 Construction Noise

Noise emission levels for the various anticipated construction equipment, the number of pieces of equipment, and the anticipated percentage of time the equipment will be used each hour and during each construction shift are provided multiple tables in Reference 14 for each of the construction phases. Based on these data, hourly L_{eq} noise levels were projected at the nearest noise-sensitive receptors for each phase of construction. The analysis concluded that

L_{eq} levels for an 8-hour period would be similar to the hourly L_{eq} levels. The noise emission levels used in the 2005 analysis for the anticipated construction equipment are provided in Table 3-1.

Table 3-1: Construction Equipment and Noise Emission Levels

Equipment Type	Usage Factor (Percentage of Time Used During Each Hour and During Each Shift)	Typical Sound Level at 50 feet (dBA)
Excavators (Cat 245; Cat 235; Cat 225)	75	82; 70; 82
Dump trucks	10	81
Front end loaders (Cat 966; Cat 988)	75	81; 81
Dozers (Cat D-6; Cat D-8)	75	82; 85
Concrete trucks	25	77
Small construction vehicles (pickup trucks)	25	68
Cranes (Manitowoc 4100, Grove 20T RT)	50	81 (Manitowoc); 74 (Grove)
Large diameter drill-rig (Casagrande C800)	75	81
Small diameter drill-rig (Soilmec 825)	25	80
Diesel generators (150 kW)	100	69[1]
Flat-bed semi-trucks	10	81
Diesel pumping equipment	100	77
Compressed-air construction tools	25	81
Tie-back installation drilling equipment	75	75
Concrete pumping truck	25	77
Rail welding plant (Holland Welder)	75	77
Air compressors (125 cfm, 250 cfm)	75	70[1]
Earth pressure balance tunnel boring machine	60	70
Muck conveyor	75	65
Grout batch plant	75	80
Supply train, including locomotive (25–35 ton)	50	70 at 5 mph near portal
Welding equipment (400 amp)	50	73
Grout silos	100	70
Grout mixers	100	71
Grout pumps	100	77

[1] Assumed to be acoustically treated with proper noise control
kW = kilowatt; cfm = cubic foot per minute; mph = miles per hour

The L_{eq} for a single piece of equipment is obtained from the following formula:

$$L_{eq}(\text{equip}) = E.L. + 10 \times \log_{10}(U.F.) - 20 \times \log_{10}(D/50) - 10 \times G \times \log_{10}(D/50)$$

where L_{eq}(equip) is the L_{eq} at a receiver resulting for operation of a single piece of equipment over a specified time period, E.L. is the noise emission level (i.e., typical sound level) of the particular piece of equipment at the reference distance of 50 feet as obtained in Table 3-1, G is a constant to account for topography and ground effects, D is the distance from the receiver to the piece of equipment, and U.F. is the usage factor that accounts for the fraction of time that the equipment is in use over the specified time period.

The factor G is obtained from Chapter 6 of the *FTA Guidance Manual*. For most situations G can conservatively be taken to be equal to zero (0), which it is for hard ground.

The combination of noise "L_{eq}(combined)" from more than one piece of equipment operating during the same time period is obtained from the decibel addition of the L_{eq} of each single piece of equipment as given by:

$$L_{eq}(\text{combined}) = 10 \times \log 10(10^{Leq1/10} + 10^{Leq2/10} + 10^{Leq3/10} + \cdots + 10^{LeqN/10})$$

where $L_{eq}1$, $L_{eq}2$, $L_{eq}3$, $L_{eq}N$ are the individual L_{eq}'s for 1 through N pieces of equipment.

For the three facilities analyzed for this report, the various types of equipment, the number of pieces of equipment, and the usage factors were based on the type of equipment and usage details contained in the 2005 report (Ref. 14) for similar kinds of construction. As with the 2005 analysis, three phases of construction were assumed. For each phase, the two loudest types of equipment and the number of equipment pieces were assumed to produce noise for 1 hour based on their usage factor. The noise data used in the analysis are provided in Table 3-1. The combined noise projected to the nearest noise sensitive receptors was calculated using the two equations presented above. The specific noise receptors potentially impacted by the construction of these three facilities and the projected noise levels compared to the applicable noise criteria are provided in Section 4.1.1, *Construction Impacts*.

3.3 Construction Vibration

The TBM creates vibration as the cutting head rotates and removes soil at the tunnel face. With an anticipated rate of 30 to 75 feet per day advancement of the tunnel face vibration may be perceptible as either groundborne noise or vibration for 3–4 days. If the soil excavated by the TBM is removed from the tunnel by a muck train operating on jointed rails supported on wood crossties laid on the tunnel floor, there could be significant groundborne noise depending on the proximity of sensitive receptors.

The cut-and-cover construction for the portals, the underground station boxes, underground crossover, and mid-tunnel ventilation structures could be a source of vibration depending on the proximity of nearby receptors. Demolition of existing structures could also be a vibration source. Table 3-2 provides typical vibration levels for equipment generally used in the type of construction anticipated. This analysis assumes that piles driven with either impact or sonic hammers would not be used unless vibration levels are restricted to levels below the acceptable criteria.

Table 3-2: Typical Vibration Levels for Construction Equipment

Equipment		PPV at 25 feet (inch/second)	Approximate Lv[1] at 25 feet
Clam shovel drop (slurry wall)		0.202	94
Hydromill (slurry wall)	in soil	0.008	66
	in rock	0.017	75
Vibratory roller		0.210	94
Hoe ram		0.089	87
Large bulldozer		0.089	87
Caisson drilling		0.089	87
Loaded trucks		0.076	86
Jackhammer		0.035	79
Small bulldozer		0.003	58

Source: *FTA Guidance Manual*
[1] Root mean square (RMS) velocity in decibels (VdB) re 1 micro-inch/second

For the purpose of assessing the potential for damage to buildings due to construction activity for the equipment listed in Table 3-2, the peak particle velocity vibration at distances other than 25 feet can obtained using the following formula:

$$PPV_{equip} = PPV_{ref} \times (25/D)^{1.5}$$

where PPV_{equip} is the peak particle velocity in inches per second of the equipment adjusted for distance, PPV_{ref} is the reference vibration level in inches per second at 25 feet obtained from Table 3-2, and D is the distance in feet between the equipment and receiver.

For the purpose of assessing the potential for annoyance or interference with vibration-sensitive activities, the vibration level at any distance D can be obtained from the following equation:

$$L_V(D) = L_V(25ft) - 30 \times \log_{10}(D/25)$$

To assess the potential for annoyance, this level of vibration is compared to the infrequent events criteria in Table 2-3 and Table 2-4 depending on the type of receiver.

For vibration generated by TBM operation, Dowding (Ref. 8) provides data for soil and rock. The data for TBM in rock was used to project vibration levels at the ground surface due to TBM operation.

3.4 Transit Operations

Transit vehicle operations produce airborne noise that is projected to the wayside when tracks are above grade and can produce groundborne noise and/or vibration inside adjacent buildings for alignment segments that are in a tunnel, if the buildings are close enough and other conditions are conducive to these phenomena. The *FTA Guidance Manual* provides methodologies for predicting levels of noise and vibration for both configurations. Table 3-3 provides the parameters used in the noise analysis (wayside train noise) for above-grade operations.

Table 3-3: Summary of Key Parameters for BART Train Wayside Noise Analysis

Parameter	**Year 2035**
Reference Sound Exposure Level (SEL_{ref}) at 50 feet[1]	82 dBA
Number of cars per train (N_{pk}) during peak hours	10
Average number of cars per train (N_d) during the daytime (between 7 a.m. and 10 p.m.)	10
Average number of cars per train (N_n) during the nighttime (between 10 p.m. and 7 a.m.)	10
Peak hour volume of trains (V_{pk}) – one direction	10
Off-peak hour volume of trains (V_{opk}) – one direction	3
Peak hours service	6 a.m.–7:30 p.m.
Off-peak hours of service	4 a.m.–6 a.m. and 7:30 p.m.–1 a.m.
Average hourly daytime volume of trains (V_d) (between 7 a.m. and 10 p.m.) – one direction	8.83
Average hourly nighttime volume of trains (V_n) (between 10 p.m. and 7 a.m.) – one direction	2.78
Maximum train speed	70 mph
Track type (e.g., welded, jointed)	Welded

[1] The *FTA Guidance Manual* provides a reference Sound Exposure Level (SEL) of 82 dBA for a single transit car traveling at 50 mph on ballast-and-tie track at a distance of 50 feet from the receptor. Specific wayside noise data have been measured for the BART system over the past years and have been used for previous BART extensions and have been found to be consistent with this noise emission level.

3.4.1 Prediction Model for Transit Vehicle Wayside Noise

The *FTA Guidance Manual* provides a detailed methodology for modeling airborne train noise, which is often referred to as wayside noise. Depending on the adjoining land use, projections of wayside noise are either based on an exposure over 1 hour (L_{eq}) or a daily exposure (L_{dn}) as discussed in Section 2.1.1, *Airborne Noise Criteria*. When evaluating noise impacts on institutional land uses, the "peak hour" L_{eq} (hour with the greatest number of trains) is compared to the FTA criteria. When evaluating residential land uses, the L_{dn} is compared to the FTA criteria.

The FTA wayside noise model accounts for the length of each train, the speed of the train, the number of trains per hour (which varies over the course of a day), and the distance from both tracks to buildings on either side of the alignment. The projected wayside noise levels also account for the noise shielding effects of topography and existing property line sound walls, where such walls are constructed from an adequate acoustical material (e.g., Concrete Masonry Units wall). Train speed was assumed to be 67 miles per hour (mph) except close to a station where the train was assumed to travel at 35 to 50 mph. The wayside noise analysis for the BART Extension where it is above grade is based on 10-car BART trains traveling on ballasted track. The existing topographical conditions and the existing sound walls were evaluated and incorporated into the prediction model.

The *FTA Guidance Manual* provides a reference Sound Exposure Level (SEL) of 82 dBA for a single transit car traveling at 50 mph at a distance of 50 feet from the receptor. Specific wayside noise data have been obtained for the BART system over the past years and have been used for previous BART extensions. It is noted that the noise emission level for a BART trains is consistent with the emission level suggested in the *FTA Guidance Manual.*

The reference SEL is a measure of the total sound energy of an event. In effect, the total sound energy is compressed to a 1-second period. SEL is a useful intermediate measure of acoustic energy when calculating L_{eq} type measures such as L_{dn}. For example, the following equation is used to calculate L_{eq} over a period of "T" seconds (3,600 seconds for 1 hour) assuming that "N" trains pass in that period and that the "average" SEL for all trains (SEL_{avg}) is

$$L_{eq}(T) = 10 \times \log_{10} (N/T) + SEL_{avg}$$

where: N = number of trains over period T and SEL_{avg} takes into account number of cars per train. The L_{dn} is the day-night level, which is the average hourly L_{eq} over a 24-hour period with nighttime hourly L_{eq} weighted by adding 10 dBA to the hourly L_{eq} between 10 p.m. and 7 a.m. to account for increased sensitivity to noise during these hours.

Figure 3-1 presents the L_{dn} for BART trains operating at 67 mph on ballast-and-tie track for the operating schedule presented in Table 3-3.

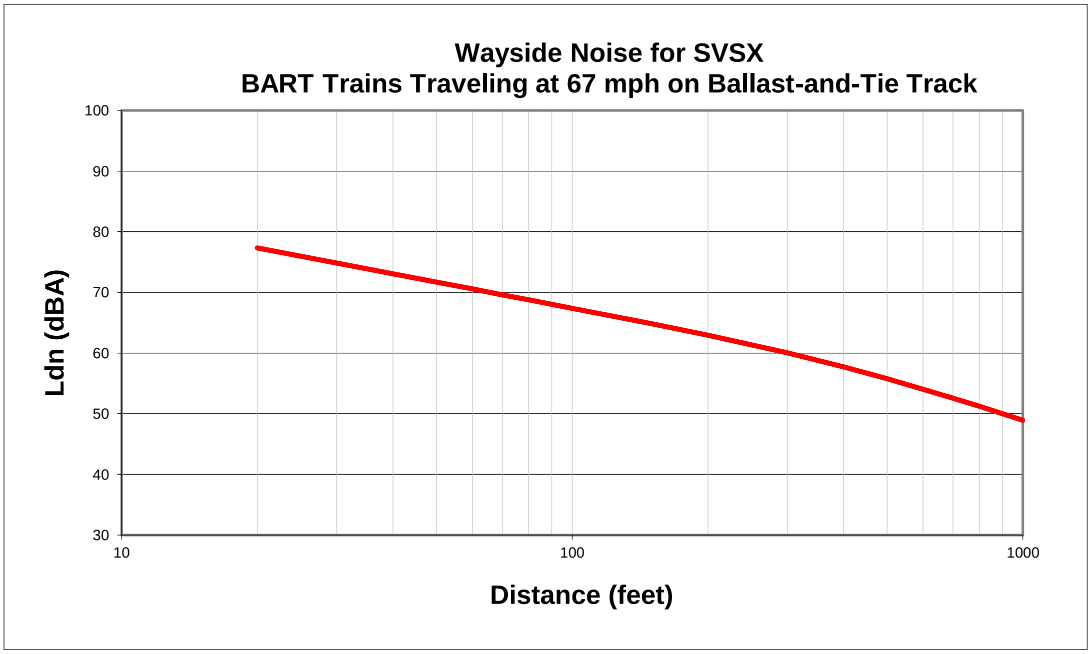

Figure 3-1: BART Noise Exposure Level (L_{dn})

Where a residential building with a second story would be impacted by wayside noise, the potential for improving the building's noise insulation is considered as a mitigation alternative to a project sound wall, which would otherwise need to be much higher. In the case of a noise impact on a second- or third-story residence, and where there is an existing property-line sound wall, the noise insulation mitigation measure for the second story and higher may suffice.

3.4.2 Prediction Model for Transit Vehicle Groundborne Vibration

The methodology used for predicting interior groundborne vibration and noise levels from future transit train operations was developed during an extensive research project conducted for the United States Department of Transportation. The methodology is discussed in detail in the paper, *A Prediction Procedure for Transportation Groundborne Noise and Vibration* (Ref. 2). The methodology has been used successfully in the United States for over 30 years to evaluate the environmental effects of groundborne noise and vibration for numerous transit projects. This prediction procedure is the basis for the methodology recommended in the *FTA Guidance Manual*. Project-specific data related to vibration and used in the groundborne noise and vibration model are contained in Reference 6.

The prediction methodology is based on the fact that vibration is generated by a train's wheels rolling on steel rails. The resulting vibration is caused by the inherent roughness and irregularities in the rail, which forces the wheels to move up and down, thus imparting a force in the rail. The vibration generated by the resulting forces propagates through the underlying structure of the transit system that supports the track and subsequently into the surrounding soil until it encounters nearby buildings, at which point the vibration is transmitted into the building through its foundation.

This physical process of vibration generation and propagation can be divided into independent elements that make up the prediction model. Each of these elements can be quantified independently by physical measurement. The individual vibration model elements are combined to predict groundborne noise and vibration.

The prediction model for groundborne vibration employs the following equation:

$$L_v = FDL + LSR + BVR + AF + MF$$

where:

where:	L_v	=	Projected vibration velocity level in a specific building – VdB
	FDL	=	Force Density Level – dB Re: 1 lb/ft$^{1/2}$
	LSR	=	Line Source Response – dB Re: 10^{-6} (inch/sec)/(lb/ft$^{1/2}$)
	BVR	=	Building Vibration Response – dB (relative level)
	AF	=	Adjustment Factor for track and structure – dB (relative level)
	MF	=	Modeling Factor

The frequency spectrum of groundborne vibration and noise is divided up into 1/3-octave bands, and field measurements and analysis are conducted accordingly. The overall vibration level at a location inside a building is the combination of the individual 1/3-octave band spectrum levels determined by an energy sum over all the bands. The energy sum results in a single-number vibration level (also in decibels – VdB). The FTA General Assessment vibration criteria are based on the overall vibration level, whereas in the FTA Detailed Assessment, the evaluation is based on a comparison of the individual 1/3-octave band levels to the criterion.

Each projection of groundborne vibration begins with the FDL, which represents the line source of vibration forces generated by the dynamic interaction of the transit vehicle and track and the track support system (rail fasteners). The LSR represents the vibration velocity level at a receiver location relative to the FDL. The LSR reflects the response of the local soil strata to vibration at the source and the attenuation of vibration energy due to propagation through the surrounding soil from the track to the ground surface at a point removed from the track. The LSR is added to the FDL to provide the ground surface vibration velocity level in the absence of a building.

The BVR represents the response of a particular building or type of building structure relative to ground vibration. The response of the building includes the foundation coupling loss, floor-to-floor attenuation, and resonant amplification of vibrating room surfaces (floors/ceilings and walls) that may apply to a specific receiving area within the building.

To predict groundborne noise and vibration levels for conditions other than a track with continuously welded rail, an AF is applied to account for the effects on the level of vibration generated at the source due to special trackwork, such as crossovers and turnouts, and the specific alignment structures, such as retained cuts, embankments, tunnel geometry, and construction type (bored vs. cut-and-cover; single- vs. double-box).

The empirical model has various uncertainties inherent in the derivation of the FDL, LSR, and BVR parameters from field measurement data. There are also uncertainties associated with the application of the various LSR for locations along the alignment away from the locations used to measure the various LSR for the corridor, and there are uncertainties in application of the BVR, which have been measured for buildings similar to those in the corridor. Consequently, an MF is added to the vibration levels projected by the FTA model to account for these various uncertainties. This results in a somewhat conservative projection of the expected level of vibration.

When a projected vibration level exceeds the applicable FTA criterion, it is necessary to consider vibration mitigation. Potential mitigation measures are evaluated to determine their effectiveness in reducing the projected vibration. The vibration reduction performance of specific measures (e.g., special track fastener) have been quantified previously through controlled, in-situ measurements.

A mitigation measure's performance is referred to as its Insertion Loss (IL) in dB, where the performance of the mitigation measure is relative to a standard or more commonly used means of rail support. The IL factor is representative of the vibration with mitigation relative to the vibration without mitigation (i.e., the basic track design proposed for a project).

When evaluating the effectiveness of various mitigation measures to reduce vibration that is projected to exceed the FTA criterion, the IL for a specific mitigation measure is added to the projected vibration level before mitigation. The following equation indicates how the IL is applied to obtain the mitigated level of vibration:

$$L_{v\ (\text{with mitigation})} = L_{v\ (\text{before mitigation})} + IL$$

where IL = insertion loss for specific vibration mitigation – dB (relative level).

The IL is measured and expressed in 1/3-octave band levels. An IL with a negative value represents a reduction in vibration and a positive IL represents an increase in vibration.

3.4.3 Prediction Model for Transit Vehicle Operational Groundborne Noise

Groundborne noise is the noise generated inside a building due to vibration of the building's interior surfaces such as floors, walls, and ceilings. This vibration causes sound to be radiated inside rooms within the buildings. In the case of the BART Extension, the source of groundborne vibration is the transit system operating in a tunnel. Because groundborne noise is generally characterized by low frequency sound, it is commonly described as a rumble such as one might hear from a subway train in a large city. The level of groundborne noise in a particular room is affected by the level of vibration of the room's surfaces and the amount of acoustic absorption in the room.

The following relation has been used for converting 1/3-octave band vibration velocity levels to 1/3-octave noise levels:

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

where:

L_A = sound pressure level (dB re: 20 micro-Pascals)

L_v = vibration velocity level (VdB re: 1 micro-inch/second)

K_{rad} = adjustment to account for conversion from vibration to sound pressure level and acoustical absorption

$K_{A\text{-}wt}$ = A-weighting adjustment at the 1/3-octave band frequency.

The calculation of K_{rad} can be determined from the following:

$$K_{rad} = -(10 \operatorname{Log}_{10}(\alpha) + 1)$$

where: α = average absorption coefficient for the room in each 1/3-octave band.

For residential receptors and other receptors where there is nighttime occupancy, an absorption coefficient of 0.5 has been assumed. This results in a K_{rad} of +2 dB. Reference 2 includes details and measured data relating to the conversion of groundborne vibration to noise levels, and +2 dB is a reasonable and realistic value to use. To account for the typical acoustical absorption found in schoolrooms and churches, an absorption coefficient of 0.3 has been assumed for institutional receptors. This results in a K_{rad} of +4 dB for institutional receptors.

3.4.4 Derivation of Groundborne Noise and Vibration Prediction Model Parameters

The FTA model is an empirical model, which means that all of the elements are obtained from conducting field measurements. The following describes the various components of the FTA model.

BART Force Density Level

The FDL defines the amount of dynamic force transmitted by the wheels of a transit train through the rail and its fastening system to the tunnel structure below. A representative FDL is obtained by field measurements performed for the same or similar vehicles and rail systems to those proposed for the BART Extension being analyzed. The FDL spectrum used in this analysis was obtained by field measurements at several locations with revenue trains operating on the existing BART system.

Several track fastening and support systems have been measured for, including traditional direct fixation (DF) fasteners, resiliently supported ties (RT), highly resilient direct fixation fasteners (HRDF), and discrete and continuous floating slab systems. FDL spectra were determined for several different train speeds within single- and double-box, cut-and-cover tunnel sections in Berkeley (original BART system) and South San Francisco (BART SFO). A section of special track fasteners was tested near Balboa Park in San Francisco, and a discrete floating slab track system was tested in Concord. Measurement results from the locations in the BART SFO tunnel, near Balboa Park, and in Concord are discussed in Reference 4.

The value of the FDL is a function of train speed and has been applied in the vibration prediction model accordingly. BART train operating speeds used in the analysis are shown in Table 3-4. Actual operating speeds are slightly less (e.g., 67 mph for a set speed of 70 mph) than these nominal maximum speeds.

Table 3-4: BART Train Speeds Used in Analysis

Start Civil Station	End Civil Station	Start Street	End Street	Train Speed (mph)
580	641	US-101	17th Street	50
641	678	17th Street	8th Street	70
678	705	8th Street	1st Street	50
705	737	1st Street	Autumn Street	35
737	803	Autumn Street	Santa Clara Maintenance Facility	50

Line Source Response

The LSR characterizes the vibration velocity response at a single location to incoherent forces distributed over the length of a train or transit vehicle (i.e., a finite line source). LSR as used herein refers to the response of a free ground surface, not to the response of a built surface, such as a floor. In practice, the LSR for a soil region is determined by field measurements. The measurement consists of imparting a vertical force to the ground surface or at the bottom of a borehole in the case of a tunnel alignment using a large hammer, measuring that force with a load cell or strain gauge, and simultaneously measuring the vertical vibration velocity of the ground surface at several distances away from the location of the impacts. This measurement procedure provides what is referred to as a “point source response” (as the hammer acts at one point) also called a “transfer mobility.” The measured point source responses are used to construct the LSR by numerical integration over the length of a train.

The normal procedure for collecting transfer mobility data is to impact the ground and measure the ground surface velocity at six or seven distances. For surface alignments, a pneumatic, force-instrumented hammer is used for the impacts. For subway alignments, a force-instrumented tool is attached to the end of a drill string and the impacts delivered by a standard, 130-pound driller’s slide hammer. A graphic representation of the borehole test is presented in Figure 3-2.

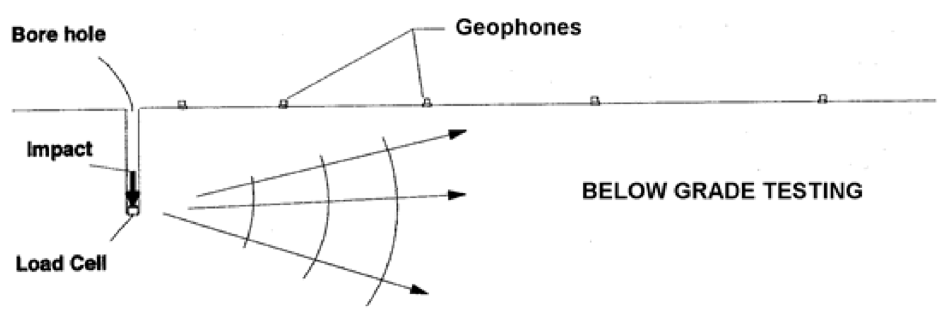

Figure 3-2: Borehole Vibration Propagation Test (Cross Section)

Before constructing LSRs from the transfer mobility data, the data were checked for typical relationships between depths and locations, for responses similar to those determined previously for similar soil strata, and for repeatability and coherence in the measured responses. Transfer mobility data collected by the borehole vibration testing were then fit with polynomial functions of distance using least squares regression. The point source responses that are derived from the curve fitting were then numerically integrated over the length of a four-car BART train to obtain the following mathematical function for the line source response with distance:

$$LSR(d) = A + B \cdot Log(d) + C \cdot Log2(d) + D \cdot Log3(d)$$

where: A, B, C, D = polynomial coefficients

d = perpendicular and horizontal distance from the track centerline

Because groundborne noise and vibration are typically not significant more than 150 feet from subway tracks, integration over a length equal to four BART cars provides a reasonable approximation for train lengths of four cars and greater. It is noted that BART operates trains up to ten cars.

During the previous Preliminary Engineering phase for the Silicon Valley Rapid Transit BART Extension, of which the tunnel alignment for the current BART Extension was a part, vibration propagation tests were conducted in the corridor study area. Figure 3-3 shows a map of the test locations.

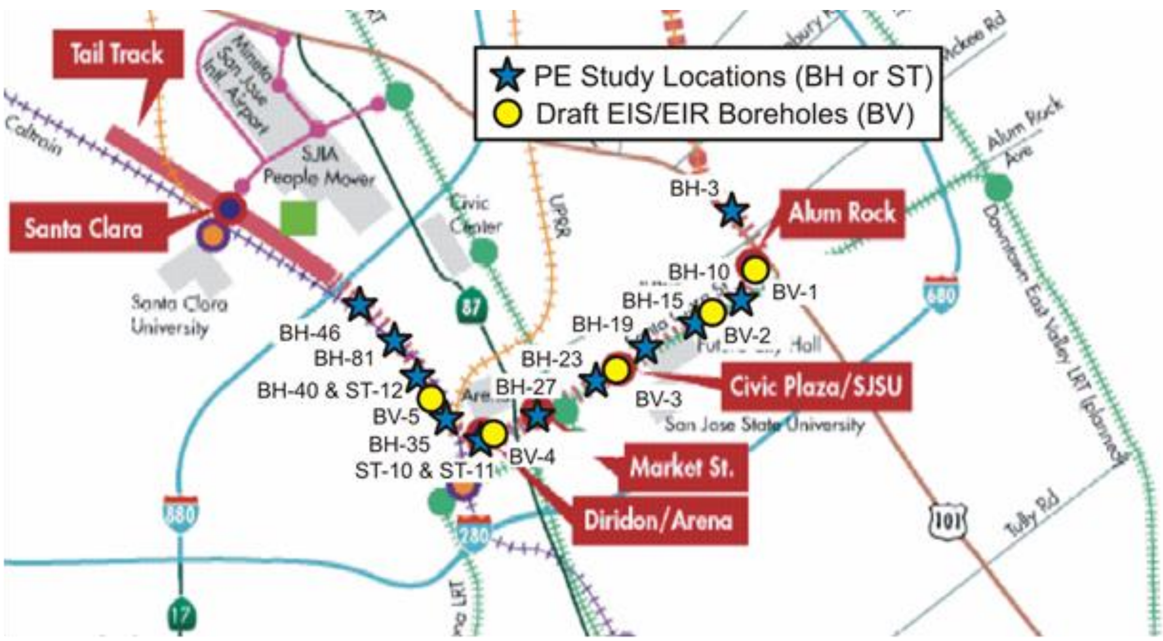

Figure 3-3: Silicon Valley Santa Clara Extension Borehole Test Locations

Table 3-5: Silicon Valley Santa Clara Extension Tunnel Segment Vibration Test Site Details

Borehole	Civil Station	Top of Rail[1] (feet)	Measurement Depths Below Grade (feet)	Test Date
BH-3	582+00	57	50, 60, 70	Jan 3-4, 2005
BH-10	625+00	57	55, 62.5, 70	Jan 7-8, 2005
BH-15	646+00	65	92, 97	Dec 13, 2004
BH-19	667+00	55	47.5, 59, 69	Jan 28 & Feb 1, 2005
BH-23	690+00	50	52.5, 60, 67.5	Oct 31, 2004
BH-27	715+00	62	51, 60, 70	Nov 11, 2004
BH-35	750+00	55	42.5, 55, 67.5	Dec 17 & 20, 2004
BH-40	776+00	65	32.5, 42.5, 52.5	Dec 15 & 16, 2004
BH-46	809+00	59	32.5, 41.5, 51.5	Dec 5, 2004
ST-10	739+00	50	30, 40, 50, 60, 70	Jul 1, 2005
ST-11	742+00	53	30, 40, 50, 60, 70, 80	Jun 30, 2005
ST-12	776+00	65	36.5, 46.5, 56.5, 66.5	Jul 27, 2005
BH-81	790+00	69	53, 60, 70, 80, 90, 100	Jul 20, 2005

Note:
[1] Top of Rail refers to the depth of the rail below grade obtained from the *Silicon Valley Santa Clara Extension Plan and Profile Drawings*, Conceptual Plans, August 3, 2015.

The LSR data obtained for the borehole measurements listed in Table 3-5 are provided in Appendix A. The application of specific borehole vibration propagation data to areas of the tunnel alignment is shown in Table 3-6.

Table 3-6: Application of Vibration Propagation Data to Tunnel Alignment

Civil Stations*		Cross Street or Feature		LSR Data Sources: Borehole (Test Depth in feet)
From	To	From	To	
581+00	595+00	Miquelita Creek	Highway 101	BH-3 (50)
610+00	635+00	28th Street	21st Street	BH-10 (59)
637+00	649+00	20th Street	16th Street	BH-10 + BH-15 (80)
649+00	661+00	16th Street	12th Street	BH-15 + BH-19 (83)
663+00	679+00	12th Street	10th Street	BH-19 (64)
680+00	698+00	7th Street	2nd Street	BH-23 (53)
706+00	710+00	Market Street	Almaden Avenue	BH-27 (50)
715+00	720+00	Almaden Boulevard	Route 87	BH-27 (60)
731+00	738+00	Los Gatos Creek	Montgomery Street	ST-10 + ST-11 (50)
746+00	759+00	White Street	Morrison Avenue	BH-35 (55)
762+00	774+00	Morrison Avenue	Lenzen Avenue	BH-40 + ST-12 (55)
781+00	803+00	Stockton Avenue	Emory Street	BH-81 (70)

Building Vibration Response

There are several factors related to a building's structure that act to either attenuate or amplify groundborne vibration. The three main components are (1) soil/foundation coupling loss, (2) floor-to-floor attenuation, and (3) floor resonance amplification due to vibration. In total, the combination of these effects is the BVR.

Many of the residential use buildings along the alignment are constructed with slab-on-grade ground floors with framed structure above where there is more than one story. This combination is particularly common for buildings with commercial uses on the ground floor and residential above. In these two- and three-story buildings, the ground floor slab generally experiences the same vibration as the surrounding ground, but the wood framed upper floors generally exhibit an amplification in vibration away from the walls.

In contrast to those residential buildings with a slab-on-grade ground floor, most of the single-family residential buildings along the alignment are constructed with a raised ground floor (wood framing). Because of the closer vertical distance to the soil, and the lighter-weight framing of these buildings compared to multi-family structures, single-family homes with a raised ground floor ultimately show somewhat higher net amplifications in their BVR spectra.

Adjustment Factor

Adjustments were made to the predictions to incorporate the effects of the way structure (bored tunnel vs. cut-and-cover) and special trackwork (e.g., switches). The track design for the BART Extension is RT. The FDL for BART on RT track is with respect to the force imparted to the tunnel invert (bottom of tunnel). Consequently, an AF was used to adjust the invert FDL to account for the force imparted to the soil surrounding the tunnel structure. One AF was used for a bored tunnel and another for a cut-and-cover structure (used in station areas). These AF are referred to as coupling loss. To determine a coupling loss for the tunnel structure, an analytical computer model was used in a study prepared in 1986. Reference 5 provides details and results for this AF to account for effects of the tunnel structure.

The BART Extension will also have special trackwork called crossovers. Where there will be crossover tracks, an AF is necessary to account for the ground vibration levels in the immediate vicinity of a track crossover, which will be higher than standard track. The higher vibration levels are generated by impacts as each wheel of the train crosses through the rail gaps at the switch frogs. This source of vibration acts like a point source acting at the switch frog and produces additional vibration.

The following adjustments were applied for receptors in the vicinity of switch frogs:

$AF_{Crossover} = +\ 10$ dB	for distances <50 feet from a frog
$AF_{Crossover} = +\ (10–15 \cdot \text{Log}[\text{distance}/50])$ dB	50 feet ≤distance ≤160 feet
$AF_{Crossover} = +\ 0$ dB	for distances >160 feet from all frogs

Insertion Loss

The baseline for design of the tunnel portion of the BART Extension is for track that would be supported on the concrete invert of the tunnel with resiliently supported ties (also known as RT). The RT system consists of a concrete block resting on an elastomeric (resilient) pad inside a rubber boot. Each rail is supported by these elements at 30-inch spacing. The support pad for reach block has a nominal, static stiffness of 140,000 pounds/inch and a dynamic to static stiffness ratio of 1.2 or less. Such a system has been implemented on the BART SFO Line in the subway box in Colma and South San Francisco. The IL represents the amount of vibration reduction in each 1/3-octave band that is achievable for a particular type of vibration mitigation compared to the BART Extension's standard track form, which is a form of RT.

The BART Facilities Standard indicates that RT is the preferred track support system. To accommodate this standard, the mitigation considered was Isolated Slab Track (IST). IST is constructed by placing a resilient mat underneath a concrete slab that is poured during construction. The specific properties of the resilient mat need to be determined on a case-by-case basis. As with a floating slab track (FST), certain frequencies of vibration may be amplified. The amount of amplification depends on several factors and can be as much as 3 VdB.

Three other mitigation approaches were also considered for their effectiveness in reducing groundborne noise and vibration:

1. Highly resilient direct fixation (HRDF) fasteners
2. Rail suspension fasteners (RSF)
3. Very highly resilient direct fixation (VHRDF) fasteners

The insertion losses for HRDF and RSF were determined from the dynamic stiffness of the respective systems. Measurement data obtained from tests conducted at an existing installation on the BART alignment has been used to verify the HRDF data. Examples of such in-situ measurements of mitigation performance are contained in Reference 4.

ILs for each mitigating option are entered into the vibration prediction model in terms of the loss for each system relative to the exact 1/3-octave band FDL values for the BART Extension baseline track support (i.e., RT). The IL for IST is theoretical based on modeling.

3.5 Cumulative Noise Thresholds

The existing ambient noise levels in the area of the BART Extension are primarily dominated by motor vehicle traffic, and cumulative noise impacts can occur due to increases in motor vehicle traffic. Changes in traffic volumes or patterns could affect the existing noise environment. The cumulative analysis addresses the potential noise increase associated with the No Project and Project Alternative.

To comply with CEQA requirements for evaluating environmental noise effects of the Phase II Project a cumulatively considerable impact is defined as:

- The cumulative increase in noise levels associated with the Project Alternative would be greater than 2 dBA, when compared to the No Project Alternative.

Otherwise, no cumulative noise impact would occur.

3.5.1 Motor Vehicle Traffic Changes

The traffic analysis of both alternatives was obtained from the study conducted by Hexagon Transportation Consultants (Ref. 15). The traffic analysis is presented in terms of peak-hour volume. Changes to the peak-hour traffic were assumed to be representative of changes throughout the day, which is a conservative assumption for the Project Alternative as most of the increase in local traffic would be associated with BART patrons driving to and from the stations, which would primarily occur during peak hours. The change in noise level associated with traffic increases is obtained from the following formula:

$$\Delta L_{eq} \text{ (peak hour)} = 10 \text{ x } \text{Log}_{10} (V_{exist}/V_{future})$$

where, ΔL_{eq} is the change in peak hour noise exposure, V_{exist} is the existing traffic volume, and V_{future} is the future traffic volume.

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Chapter 4
Impact Analysis

4.1 BART Extension

4.1.1 Construction Impacts

The construction noise and vibration analysis performed in 2005 (Ref. 14) concluded that there may be adverse noise and vibration impacts before mitigation in the vicinity of some of the construction sites. This report adds the projected noise impacts associated with the construction of the Diridon Station (South and North Options), Santa Clara Station, and Newhall Maintenance Facility. Whereas details of construction equipment, phasing, and usage were defined for the 2005 analysis, similar information is not as well defined for the construction of the three facilities added in this report. Assumptions were made for these three facilities about the type of equipment and usage for each phase based on information from the 2005 analysis, as discussed above in Section 3.1, *Construction*.

Noise

Portals

It was determined in 2005 that construction at the east and west portal sites would not cause noise impacts.

East Portal

The land use around the East Portal is primarily industrial. The closest building is 340 feet from the project site on Las Plumas Avenue. The projected 8-hour L_{eq} is 71 dBA, which is less than the daytime criterion of 90 dBA. No noise impact is projected for the East Portal construction.

West Portal

There are four single-family homes (single-story) on Stockton Avenue at a distance of 500 feet from the site. The projected 8-hour L_{eq} is 70 dBA. The L_{eq} criterion is 80 dBA for daytime and 70 dBA for nighttime. No noise impact is projected for the West Portal construction.

Alum Rock/28th Street Station

It was determined in 2005 that the construction at the Alum Rock/28th Street Station would not cause noise impacts. The location of the station has changed. The adjacent land use is primarily light industrial on both sides of North 28th Street. The Five Wounds Portuguese National Church would be at least 350 feet from the Twin-Bore Option station box cut-and-cover construction and would not be adversely impacted by construction noise. However, the church school is much closer and would require construction noise mitigation (noise wall or noise curtain to achieve the FTA criteria). The closest residences are on 27th Street. Four single-family residences would be between 400 and 750 feet away. At these distances, the 8-hour L_{eq} is projected to be from 63 to 72 dBA. This would exceed the nighttime criterion for residences, but not the daytime criterion.

A noise impact would occur if there were nighttime work. Mitigation measures for affected residences may include one or more of the following: temporary noise walls (rigid structure) or noise curtains (flexible barrier hung from frames) where feasible and practical or restrictions on hours of noise-generating construction activity. A noise wall or noise curtain would be constructed high enough at a minimum to block line-of-sight to equipment generating noise, in which case typical 5 dBA of noise reduction might be expected.

Downtown San Jose Station and Crossover

Downtown San Jose Station West Option (Market to 3rd Street)

This station option is generally same as the Downtown San Jose Station location proposed in 2005. There are several apartments on both sides of Santa Clara Street on the upper floors of buildings between 3rd and 4th Streets. The Town Park Towers, a 10-story apartment building, is on 3rd Street about 200 feet from Santa Clara Street. While the lower floors on the west side are somewhat shielded by the adjacent building, on the east side, all units have a line of sight to Santa Clara Street. All other buildings along Santa Clara Street are commercial at ground floor with offices above.

Buildings fronting Santa Clara Street would be adjacent to the station and crossover construction activity. For commercial buildings in the area, daytime construction activities are anticipated to exceed the 8-hour L_{eq} noise limit of 85 dBA by 1 to 2 dBA. For the residences in the area, nighttime construction noise levels may exceed the 8-hour L_{eq} limit of 70 dBA by as much as 15 to 18 dBA. During the daytime, construction noise is anticipated to exceed the residential construction noise limit of 80 dBA by 5 to 8 dBA. The closest units at the Town Park Towers could be exposed to an 8-hour L_{eq} of 76 dBA, which exceeds the nighttime limit but not the daytime limit.

Noise impacts are anticipated at some of the residences for the Downtown San Jose Station West Option. Mitigation measures for affected residences may include one or more of the following: new sound rated dual-glazed windows, temporary noise walls (rigid structure) or noise curtains (flexible barrier hung from frames) where feasible and practical, or restrictions on hours of noise generating construction activity. A noise wall or noise curtain would only be effective if it could be constructed high enough to block line-of-sight to equipment generating noise at a minimum, in which case typical 5 dBA of noise reduction might be expected. Greater reductions in noise would require higher noise barriers. Generally, noise barriers are only effective for one- or two-story buildings. Where buildings are farther from the construction activities, blocking line-of-sight may be possible for stories above the second floor.

Although mitigation has been identified, would be implemented to the extent practicable, and would minimize the potential construction noise to both commercial and residential land uses, construction noise may not be able to be mitigated to a less-than-significant level. Therefore, construction noise would result in a *significant and unavoidable impact* for the Downtown San Jose Station West Option.

Downtown San Jose Station East Option (3rd to 6th Street)

This option is two blocks to the east of the Downtown San Jose Station West Option. San Jose City Hall is located between 4th and 6th Streets and at its closest is 100 to 150 feet from the site. The projected noise level is an 8-hour L_{eq} of 79 dBA, which is less than the 85 dBA criterion for commercial spaces, which includes offices. The other buildings between 4th and 3rd Streets are the same as those for the Downtown San Jose Station West Option, which include residences above ground floor and commercial spaces. Noise impacts anticipated for the Downtown San Jose Station East Option are similar to those anticipated for the West Option; the same mitigation measures would also apply. Similar to the West Option, although mitigation has been identified, would be implemented to the extent practicable, and would minimize the potential construction noise to both commercial and residential land uses, construction noise may not be able to be mitigated to a less-than-significant level. Therefore, construction noise would result in a significant and unavoidable impact for the Downtown San Jose East Option.

Diridon Station (South and North Options)

The area surrounding the station sites is primarily characterized by a mix of commercial buildings, a church and residences. The impact criterion is 80 dBA for intermittent noise. There are three receptors in the area that were assessed for impact during construction: 88 Bush Street (multi-family residence at 200 feet), 56 S. Montgomery Street (church at 255 feet) and 350 W. Santa Clara Street (hotel at 140 feet to a staging area under State Route 87).

For all three phases of construction, the noise from construction at these three receptors is projected to be within the BART BFS noise criteria, which is similar to the FTA criteria. The highest level (80 dBA) is projected to occur at the hotel during the daytime. However, as the construction means and methods are not clearly defined at this point, construction noise could exceed the criteria even with mitigation.

Although mitigation has been identified, would be implemented to the extent practicable, and would minimize the potential construction noise to both commercial, church, and residential land uses, construction noise may not be able to be mitigated to a less-than-significant level. Therefore, construction noise would result in a significant and unavoidable impact for the Diridon Station South and North Options.

Santa Clara Station

The area surrounding the Santa Clara Station is characterized by a mix of commercial, light industrial, hotel, and residences. The impact criterion is 80 dBA for intermittent noise. There are two receptors in the area that were assessed for impact during construction: 611 El Camino Real (multi-family residence at 614 feet) and 481 El Camino Real (hotel at 396 feet), For all three phases of construction, the noise from construction at these two receptors is projected to be within the BART BFS noise criteria. The highest level (72 dBA) is projected to occur at the hotel during the daytime, which would not exceed the 80 dBA threshold. Therefore, no noise impacts are projected to occur during construction of this station.

Newhall Maintenance Facility North and South Options

The area surrounding the Newhall Maintenance Facility site is characterized by a mix of commercial, light industrial, and residential land uses. The impact criterion is 80 dBA for intermittent noise. There are four receptors in the area that were assessed for impact during construction: 611 El Camino Real (multi-family residence at 614 feet), 481 El Camino Real (hotel at 396 feet), 1270 De Atura Common (multi-family residences at 407 feet). and 1070 Stockton Avenue (multi-family residences at 392 feet). For all three phases of construction, the noise from construction at these four receptors is projected to be within the BART BFS noise criteria. The highest level (74 dBA) is projected to occur in Phase I at 611 El Camino Real during the daytime, which is below the 80 dBA threshold. Therefore, no impacts from noise are projected during construction of the Newhall Maintenance Facility.

Ventilation Shaft/Substation/Gap Breaker Station/Pump Station Facilities

For the Phase II Project, ventilation shafts, substations, the gap breaker station, and pump stations have been combined at two Ventilation Structure FSS sites, whereas in 2005, some of these ancillary facilities were at different locations. The 13th Street Ventilation Structure FSS replaces the 15th Street ventilation shaft site considered in 2005.

13th Street Ventilation Structure FSS

The proximity of residences to the 13th Street facility site is similar to that at the previous 15th Street ventilation shaft site proposed in 2005 for which noise impacts were projected to occur with the 80 dBA criteria. Consequently, construction of the 13th Street Ventilation Structure FSS would also result in construction noise impacts.

Mitigation measures for affected residences may include one or more of the following: new sound-rated dual-glazed windows, temporary noise walls (rigid structure) or noise curtains (flexible barrier hung from frames) where feasible and practical, or restrictions on hours of noise generating construction activity. A noise wall or noise curtain would only be effective if it could be constructed high enough to block the line-of-sight to equipment generating noise, in which case 5 dBA of noise reduction might be expected. Greater reductions in noise would require higher noise barriers. Generally, noise barriers are only effective for one- or two-story buildings. Where buildings are farther from the construction, blocking the line-of-sight may be possible for stories above the second floor. With mitigation, no noise impacts are projected.

Stockton Avenue Ventilation Structure FSS

The 2005 analysis for the alternative sites applies to the Stockton Avenue Ventilation Structure FSS. The difference is that a fourth alternative site has been added. Construction of the two southernmost alternative sites would result in construction noise impacts when the 80 dBA criteria is applied. Mitigation could consist of noise walls, restriction of working hours to daytime, and standard noise mitigation for construction equipment. With mitigation, no noise impacts are projected.

Truck Haul Routes

To minimize noise impacts, truck haul routes should be selected to avoid residential neighborhoods as much as possible, especially for trucks hauling soil from the tunnel excavation, which could be a frequent occurrence.

Vibration

Construction vibration would be generated by the following activities: TBM operation during excavation of the tunnel, operation of the muck train inside the tunnel, and construction of the stations.

Except for construction of the tunnel with a TBM, most construction vibration would occur during daytime hours.

Tunnel Construction

Operation of the TBM would be continuous with an estimated progress rate of from 30 to 75 feet per day depending on soil conditions encountered. This would involve two 10-hour shifts with 4 hours for maintenance activities.

The depth of the tunnel centerline below the ground surfaces typically ranges from approximately 40 to 60 feet. Some residences and historic structures would be located directly over the tunnels. The distance from the tunnel center to those residences and historic structures is 45 feet or more. At 45 feet, the vibration level (measured as PPV) is projected to be less than 0.02 inch/second. In terms of human perception, this vibration could vary from 75 to 83 VdB depending on soil conditions. The majority of residences within the project corridor are at least 75 feet from a tunnel centerline; therefore, vibration would be less than 75 VdB.

Impacts on Buildings (Cosmetic Building Damage)

As mentioned above, the closest residences and historic structures are approximately 45 feet from the Twin-Bore Option tunnel center and would experience a maximum PPV of 0.02 inch/second. This is substantially below the most conservative building damage criterion of 0.12 inch/second. Therefore, the potential for cosmetic damage (e.g., plaster cracks) to buildings in a fragile condition (e.g., possible older historic buildings) is extremely low.

Preconstruction surveys would be conducted of historic and other buildings to document existing conditions and thus identify any post-project construction-related damage.

The Five Wounds Portuguese National Church is approximately 300 feet from the proposed tunnel, which is much farther than the closest residences, and no impacts on this church are anticipated. This church is an historic building and is very important to the community. To ensure that no damage occurs to this historic structure, preconstruction surveys would be conducted inside and outside the church, and monitors would be installed prior to construction to monitor vibration levels during construction. Consequently, there are no projected impacts on buildings due to construction of the tunnel with a TBM.

Impacts on Occupants (Annoyance)

The FTA residential impact criterion is 80 VdB for infrequent events, 75 VdB for occasional events, and 72 VdB for frequent events. Because the perceptible vibration will last no more than 4 days, and typically only 3 days, the occasional events criterion (75 VdB) applies. This level of vibration may be perceptible to some people.

For residences that are at least 75 feet horizontally from a tunnel centerline, the vibration will be less than the criterion (72 VdB) for frequent events. For residences less than 75 feet, the vibration may be perceptible depending on the depth of the tunnel and the horizontal distance of the residence from the tunnel centerline.

It is projected that residences within a horizontal distance of 50 feet of the tunnel centerline may be impacted by TBM vibration for a period of up to 4 days. It is projected that there are approximately 36 residences (mostly west of the Diridon Station) that could experience annoyance from TBM vibration for a period of up to 4 days. This would be a short-term temporary impact and thus would not be significant.

Tunnel Construction – Muck Train

Soils excavated by the TBM can be removed by a muck train or conveyor system. Muck trains have been found to cause groundborne noise impacts in the past. To mitigate the groundborne noise to a less-than-significant level, a ballast mat would be installed underneath the tracks on which the muck train rides or a conveyor system would be used to eliminate groundborne noise from soil removal.

Alum Rock/28th Street, Downtown San Jose (East and West Options), and Diridon Station (South and North Options) Excavations

Construction-related vibration from stations and 13th Street and Stockton Avenue ventilation shaft excavations would be primarily from excavation shoring and installing tiebacks where necessary. Construction of the Alum Rock/28th Street, and Downtown San Jose Station (both options) and Twin-Bore and Single-Bore Options tunneling would require demolition of existing buildings, roadways, sidewalks, and parking lots. The Twin-Bore Option cut-and-cover station construction would result in greater surface impacts than the Alum Rock/28th

Street and Diridon Station North, Single-Bore Option. After the Twin-Bore Option station box and portals/entrances for both options are completed, the roadways would be rebuilt.

Table 4-1 indicates the various demolition and construction activities and the equipment that would produce vibration impacts for older fragile buildings. Where vibration levels are less than 0.12 inch/second PPV, impacts would be less than significant. Where a range of distance is shown, the distance depends on the actual equipment used and/or the local soil conditions.

Table 4-1: Demolition and Construction Vibration for Older Fragile Buildings

Activity	Equipment	Distance (feet)[1]
Demolition	Hoe Ram	20
	Jackhammer	10 to 15
Excavation	Trencher	20
	Caisson Drilling	20
	Hydro Mill Slurry Wall	5 to 10
	Drilling for Tiebacks	6 to 8
Roadway Subgrade Compaction	Vibratory Roller	35 to 40

[1] Distance to reach 0.12 inch/second

Structures close to cut-and-cover stations and other facilities excavations could be exposed to excessive vibration. The closest historical buildings that could be impacted are identified in Table 4-2.

Table 4-2: Impacts on Historic Buildings Along the Alignment

Historic Building	Distance from Construction to Old or Fragile Buildings	Anticipated Impact?
1375–1401 Santa Clara Street (Five Wounds Church and auxiliary buildings at the Alum Rock/28th Street Station)	Church is approximately 350 feet from the proposed cut-and-cover station box. Auxiliary buildings are much closer.	Hoe ram, jackhammer, trencher, caisson drilling, hydro mill slurry wall, drilling for tiebacks, vibratory roller
142–150 Santa Clara Street (south side of Santa Clara Street between 3rd and 4th Streets at the Downtown San Jose Station East Option)	This building is adjacent to the proposed cut-and-cover station box. The sidewalk is over 15 feet wide. There may be a basement.	Hoe ram, jackhammer, trencher, caisson drilling, hydro mill slurry wall, drilling for tiebacks, vibratory roller
138 Santa Clara Street (south side of Santa Clara Street between 3rd and 4th Streets at the Downtown San Jose Station East Option)	This building is adjacent to the proposed cut-and-cover station box. The sidewalk is over 15 feet wide. There may be a basement.	Hoe ram, jackhammer, trencher, caisson drilling, hydro mill slurry wall, drilling for tiebacks, vibratory roller

Historic Building	Distance from Construction to Old or Fragile Buildings	Anticipated Impact?
124–126 Santa Clara Street (south side of Santa Clara street between 3rd and 4th Streets at the Downtown San Jose Station East and West Options)	This building is adjacent to the proposed cut-and-cover station box. The sidewalk is over 15 feet wide. There may be a basement.	Hoe ram, jackhammer, trencher, caisson drilling, hydro mill slurry wall, drilling for tiebacks, vibratory roller
114–118 Santa Clara Street (south side of Santa Clara street between 3rd and 4th Streets at the Downtown San Jose Station East and West Options)	This building is adjacent to the proposed cut-and-cover station box. The sidewalk is over 15 feet wide. There may be a basement.	Hoe ram, jackhammer, trencher, caisson drilling, hydro mill slurry wall, drilling for tiebacks, vibratory roller
100 Santa Clara Street (south side of Santa Clara street between 3rd and 4th Streets at the Downtown San Jose Station East and West Options)	This building is adjacent to the proposed cut-and-cover station box. The sidewalk is over 15 feet wide. There may be a basement.	Hoe ram, jackhammer, trencher, caisson drilling, hydro mill slurry wall, drilling for tiebacks, vibratory roller
19 S 2nd Street (south side of Santa Clara Street, Western Dental Building at the Downtown San Jose Station West Option)	This building is adjacent to the proposed cut-and-cover station box. The sidewalk is over 15 feet wide. There may be a basement.	Hoe ram, jackhammer, trencher, caisson drilling, hydro mill slurry wall, drilling for tiebacks, vibratory roller
42–48 Santa Clara Street (south side of Santa Clara Street, Western Dental Building at the Downtown San Jose Station West Option)	This building is adjacent to the proposed cut-and-cover station box. The sidewalk is over 15 feet wide. There may be a basement.	Hoe ram, jackhammer, trencher, caisson drilling, hydro mill slurry wall, drilling for tiebacks, vibratory roller
36–40 Santa Clara Street (Downtown San Jose Station West Option)	This building is adjacent to the proposed cut-and-cover station box. The sidewalk is over 15 feet wide. There may be a basement.	Hoe ram, jackhammer, trencher, caisson drilling, hydro mill slurry wall, drilling for tiebacks, vibratory roller
22 North 1st Street (north of Santa Clara Street at the Downtown San Jose Station West Option)	This building is adjacent to the proposed cut-and-cover station box. The sidewalk is over 15 feet wide. There may be a basement.	Hoe ram, jackhammer, trencher, caisson drilling, hydro mill slurry wall, drilling for tiebacks, vibratory roller
8–14 South 1st Street (Bank of Italy/America building at the southeastern corner of Santa Clara Street and 1st Street at the Downtown San Jose Station West Option)	This building is adjacent to the proposed cut-and-cover station box. The sidewalk is over 15 feet wide. There is a basement.	Hoe ram, jackhammer, trencher, caisson drilling, hydro mill slurry wall, drilling for tiebacks, vibratory roller
34 Santa Clara Street (south side of Santa Clara Street between 1st and 2nd Streets at the Downtown San Jose Station West Option)	This building is adjacent to the proposed cut-and-cover station box. The sidewalk is over 15 feet wide. There may be a basement.	Hoe ram, jackhammer, trencher, caisson drilling, hydro mill slurry wall, drilling for tiebacks, vibratory roller

Historic Building	Distance from Construction to Old or Fragile Buildings	Anticipated Impact?
81 Santa Clara Street (north side of Santa Clara Street between 1st and 2nd Streets at the Downtown San Jose Station West Option)	This building is adjacent to the proposed cut-and-cover station box. The sidewalk is over 15 feet wide. There may be a basement.	Hoe ram, jackhammer, trencher, caisson drilling, hydro mill slurry wall, drilling for tiebacks, vibratory roller
Cahill Station and Santa Clara/Alameda Underpass (Diridon Station South and North Options)	For the Diridon Station South Option, the historic Cahill Depot is 300 feet from the tunnel and 100 feet from the closest station entrance option and reconstructed transit center. For the Diridon Station North Option, the historic Cahill Station is over 550 feet away the tunnel and 100 feet from the reconstructed transit center.	

Due to the proximity of the historic structures, vibration effects during construction are considered to be adverse. Implementation of mitigation measures would reduce this to less than significant. The contractor would be required not to exceed 0.12 inch/second construction vibration measured at historic buildings. A higher vibration level may be acceptable if it can be demonstrated by an expert that damage would not occur.

For modern buildings, including non-engineered timber and masonry buildings an appropriate criterion is 0.20 inch/second PPV, as shown in Table 2-8.

A preconstruction photo and/or video survey would be conducted of buildings potentially impacted by vibration. A Vibration Monitoring Plan would be prepared to determine which buildings will be monitored for vibration. The plan will include details of what activities are to be monitored and the limits for vibration. The plan will also develop a protocol for monitoring of existing cracks in buildings. This plan would apply to all buildings potentially impacted by vibration.

Santa Clara Station

The Santa Clara Station would require demolition of existing buildings, sidewalks, and portions of a parking lot. After the demolition is completed the new station building would be built on the surface. A pedestrian tunnel would be excavated to provide access to the Caltrain platform. Piles may be required to shore up the existing tracks. Table 4-1 provides distances based on the criterion (0.12 inch/second PPV) for older, fragile buildings. There are no buildings that fit this description in the areas surrounding the station site.

Newhall Maintenance Facility

The Newhall Maintenance Facility would require demolition of existing buildings, sidewalks, and portions of a parking lot. After the demolition is completed the new maintenance buildings would be constructed on the surface. For non-engineered timber and masonry buildings an appropriate criterion is 0.20 inch/second PPV.

4.1.2 Operational Impacts

Wayside Noise Impacts from Train Operations

Airborne noise impacts from train operations can occur where trains are running on track aboveground, at ventilation facilities where train noise is transmitted to the surface from the tunnel below, and from storage yard tracks and maintenance facility activities.

Wayside Train Noise from At-Grade Alignment

The segment of BART track that is aboveground on at-grade track north of I-880 has the potential to impact sensitive receptors. The tunnel portal is approximately 600 feet north of I-880. Beyond the portal, airborne noise from running trains would be emitted to the wayside on both sides of the alignment. The land use in this area is a mixture of residential, office, and warehouse. The noise sensitive receivers in this area are residential. The residential receivers are shielded by noise walls along the existing railroad right-of-way, or they are located a substantial distance away. The noise walls are estimated to be from 10 to 12 feet high, which provides a substantial amount of noise reduction from existing railroad operations.

Table 4-3 presents the projected wayside noise levels for ground-floor receivers. For ground-floor receivers, wayside noise is projected to result in no impact for all but one receiver (Candlewood Suites). For a graphic presentation and the determination of moderate impacts, refer to Figure 2-1. For the other ground-floor receptors, the projected increase is 0.8 dBA or less, and the threshold for a moderate impact for these receptors is 1.2 or greater based on existing ambient noise ranging from 62 to 67 dBA.

With an existing L_{dn} of 65 dBA at Candlewood Suites, the threshold for moderate impact is 1.4 dBA. The increase in noise level for this receptor is projected to be 2 dBA. The mitigation policy adopted for the BART Extension is to mitigate moderate impacts only when the increase in noise levels is greater than 5 dBA. For the purpose of CEQA, noise increases of 5 dBA or less with a moderate impact are not significant impacts.

Table 4-4 presents the projected wayside noise levels for second-story receivers. For second-story receivers, wayside noise is projected to impact two receivers (the Dahlia Loop single-family residences complex and Candlewood Suites) with moderate impacts. The threshold for moderate impact for Dahlia Loop is 1.2 dBA. The increase in noise level at the second story of this receptor is 1.7 dBA. For Candlewood Suites, the increase in noise level is projected to be 2 dBA. Because the mitigation policy adopted for the BART Extension is to mitigate moderate impacts only when the increase in noise levels is greater than 5 dBA, these moderate impacts would not be considered significant under CEQA.

Table 4-3: First-Story, Wayside Noise Impacts from Train Operations

Civil Station	Receiver Location	Track Direction	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Estimated Sound Wall Height (feet)	Existing Ambient Ldn (dBA)	Future Ldn (dBA)	Increase Level (dBA)	Moderate Impact Increase Threshold (dBA)	Impact Type	# of Impacted Receptors
826	697 Hamline Street	S1	MFR	67	690	--	67	67.0	0.0	1.2	NI	--
829	Stockton Avenue East of Alignment	S1	SFR	67	660	--	67	67.1	0.1	1.2	NI	--
835	Campbell Avenue	S2	SFR	67	750	--	62	62.1	0.1	1.7	NI	--
835	Newhall and Elm Street Single-Family Residences	S2	SFR	67	430	--	62	62.2	0.2	1.7	NI	--
834–845	De Altura Commons	S2	SFR	67	235	10	64	64.8	0.8	1.5	NI	--
846–853	Dahlia Loop Single-Family Residences	S2	SFR	67	223	12	64	64.5	0.5	1.5	NI	--
855–860	1270 Campbell Avenue	S2	MFR	45	270	10	64	64.5	0.5	1.5	NI	--
871	Candlewood Suites Hotel	S2	Hotel	45	290	--	65	67.0	2.0	1.4	MI	1

SVSX = Silicon Valley Santa Clara Extension; CL = center line; MFR = multi-family residential; NI = no impact; MI = moderate impact; SFR = single-family residential

Table 4-4: Second Story, Wayside Noise Impacts from Train Operations

Civil Station	Receiver Location	Track Direction	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Estimated Sound Wall Height (feet)	Existing Ambient Ldn (dBA)	Future Ldn (dBA)	Increase Level (dBA)	Moderate Impact Increase Threshold (dBA)	Impact Type	# of Impacted Receptors
834–845	De Altura Commons, 2nd Floor	S2	SFR	67	235	10	67	68.3	1.3	1.2	MI	26
846–853	Dahlia Loop SFR, 2nd Floor	S2	SFR	67	223	12	67	68.7	1.7	1.2	MI	14
855–860	1270 Campbell Avenue, 2nd Floor	S2	MFR	45	270	10	67	68.2	1.2	1.2	NI	-
871	Candlewood Suites, 2nd Floor	S2	Hotel	45	290	---	65	67.0	2.0	1.4	MI	1

SVSX = Silicon Valley Santa Clara Extension; CL = center line; MFR = multi-family residential; NI = no impact; MI = moderate impact; SFR = single-family residential

4.1.3 Ancillary Facilities Impacts from Operations

BART ancillary facility noise impacts were analyzed in a 2006 memorandum (Ref. 16). The results of these analyses are summarized below. Analyses for ventilation shafts at Santa Clara Street, 13th, Street and Stockton Street were re-evaluated using more recently measured ambient noise data.

Tunnel Ventilation Shafts

Emergency Ventilation Fan Noise

Based on previous BART projects, ventilation shafts and ventilation structures that are within 200 feet of residences or other sensitive receptors would likely require noise mitigation in the form of sound attenuators for the tunnel ventilation fans depending on their operational parameters and the design of the shaft. Sound attenuators that are 7–10 feel long, installed with the fans below the ground surface, can typically provide 6 to 11 dBA noise reduction.

Therefore, to mitigate ventilation fan noise, absorptive treatment in the ventilation shaft and/or associated fan plenums would be required. The absorptive treatment could consist of spray-applied cementitious acoustical plaster, applied to the inside surfaces of the ventilation shafts and fan plenums. This treatment can provide a noise reduction of 2 to 10 dBA, depending on the configuration of the shaft and the amount and placement of this type of acoustical treatment. The mitigation should be designed to achieve a limit of 55 dBA at the residential property.

Noise reduction treatments would be implemented at ancillary facilities such as tunnel ventilation shafts, pressure relief shafts, traction power substations, and emergency backup generators such that noise levels comply with applicable Cities of San Jose and Santa Clara noise criteria at nearby developed land uses. Treatments that would be implemented, if necessary, include but are not limited to:

- Sound attenuators and acoustical absorptive treatments in ventilation shafts and facilities.
- Sound attenuators for the tunnel emergency ventilation fans.
- Perimeter noise walls (nominally an 8 feet high wall) placed around emergency generators

Train Noise

Noise from BART trains operating in the subway tunnels can be transmitted to the surface via the ventilation shafts. An evaluation was conducted to re-evaluate the ventilation shafts at the mid-tunnel structures: Santa Clara Street and 13th Street and Stockton Street (for which there are four options).

Santa Clara and 13th Streets Ventilation Facility

A ventilation facility in this neighborhood was included in the preliminary engineering design for the BART Extension. At the time, it was labeled Coyote Creek ventilation structure, and long-term ambient measurements were conducted in the neighborhood in 2008 (Ref. 12). It is now referred to as the Santa Clara and 13th Street Ventilation Facility. Ambient noise measurements were conducted in 2015 at two of the same locations studied in 2008. Table 4-5 summarizes the results of the 2008 and 2015 ambient noise measurements.

Table 4-5: Ambient Noise in the Santa Clara and 13th Street Neighborhood

Measurement Location Label	Ambient L_{dn} (dBA)				
	2008		2015		Ambient Used in Analysis
	Range	Average	Range	Average	
A	61-62	61.5	--	--	62
B	70-71	70.5	67	67	71
C	62-64	63	62-63	62.5	63
E	64-67	65.5	--	--	66
H	59-60	59.5	--	--	60
I	61-64	62.5	--	--	63

Measurements show that there has been some change in the ambient noise levels at Location B. In 2015, Location B was measured to be 3.5 dBA lower compared to 2008. Location C ambient noise levels did not change. Because higher existing ambient noise levels are more critical (more likely to require mitigation) and there is no consistent trend, the greater of the ambient readings from 2008 and 2015 was used in the impact analysis to characterize the ambient noise levels at the six locations.

There are two noise sources associated with ventilation facilities: noise from trains running in the tunnel and the testing of emergency ventilation fans. Trains run continuously during revenue hours and have the potential for impacting ambient noise over the course of a day.

Table 4-6 presents the projected levels of train noise exiting through the ventilation shaft. The train noise emitted from the Santa Clara Street/13th Street ventilation shaft is minimal, and no noise impacts are projected to occur from this source of operational noise; therefore, no mitigation is required for train noise.

Table 4-6: Airborne Train Noise from the Santa Clara/13th Street Ventilation Shaft

Civil Station	Receiver Location Address	Land Use	Vehicle Speed (mph)	Distance to Vent Structure (feet)	Existing Ambient L_{dn} / L_{eq} (dBA)	Total L_{dn} / L_{eq} (dBA)	Increase over Existing Ambient (dBA)	Moderate Impact Increase Threshold (dBA)	Impact Type
657	30 N 13th Street	MFR	67	85	67	67.1	0.1	1.2	NI
658	602 Santa Clara Street – Indian Health Center of Santa Clara Valley	Institutional	67	145	69	69.0	0.0	1.1	NI
658	28 S 13th Street	SFR	67	280	63	63.0	0.0	1.6	NI
660	29 S 13th Street – Duong Bich-Hai Thi, DDS	Institutional	67	260	63	63.0	0.0	1.6	NI
660	26 S 12th Street	SFR	67	250	63	63.0	0.0	1.6	NI
661	551 Santa Clara Street – Holistic Health Care Clinic (Chiropractic)	Institutional	67	80	69	69.1	0.1	1.1	NI
661	32 N 12th Street	MFR	67	100	66	66.1	0.1	1.3	NI
662	15 S 12th Street	SFR	67	270	64	64.0	0.0	1.5	NI
663	12 S 11th Street	MFR	67	395	64	64.0	0.0	1.5	NI
665	32 N 11th Street	MFR	67	360	66	66.0	0.0	1.3	NI

MFR = Multi-family residence
SFR = Single-family residence
NI = No Impact

Stockton Avenue Ventilation Facility

The ventilation facility in the Stockton neighborhood was studied in 2008. Long-term ambient measurements were conducted to characterize the existing conditions. In 2015, ambient noise measurements were repeated at three of the four same locations to determine changes in ambient conditions. Table 4-7 summarizes the results of the 2008 and 2015 ambient noise measurements.

Table 4-7: Ambient Noise in Stockton Avenue Neighborhood

Measurement Location Label	Ambient L_{dn} (dBA)				
	2008		2015		Ambient Used in Analysis
	Range	Average	Range	Average	
L	66–68	67	68-70	69	69
N	64–66	65	69-70	69.5	70
O	60–63	61.5	--	--	62
P	67–70	68.5	68-70	69	69

Measurements show that there has been some change in the ambient noise levels in this neighborhood. The levels appeared to have increased considerably (4.5 dBA) in the case of Location N. Because higher existing ambient noise levels are more critical (more likely to require mitigation) and there is no consistent trend, the greater of the ambient readings from 2008 and 2015 was used in the impact analysis to characterize the ambient at the four locations.

Table 4-8 presents the projected levels of train noise exiting the ventilation shaft. The train noise emitted from the Stockton ventilation shaft is minimal, and no noise impacts are projected to occur for this source of operational noise; therefore, no mitigation is required for train noise.

Table 4-8: Airborne Train Noise from Stockton Ventilation Shaft

Civil Station	Receiver Location Address	Land Use	Vehicle Speed (mph)	Distance to Vent Structure (ft)	Existing Ambient Ldn / Leq (dBA)	Total Ldn / Leq (dBA)	Increase over Existing Ambient (dBA)	Moderate Impact Increase Threshold (dBA)	Impact Type
782	701 Harding Avenue	SFR	67	345	70	70.0	0.0	1.0	NI
784	551 Stockton Avenue	SFR	67	195	70	70.0	0.0	1.0	NI
785	599 Stockton Avenue	SFR	67	115	70	70.0	0.0	1.0	NI
787	733 Schiele Avenue	SFR	67	250	63	63.0	0.0	1.6	NI
788	623 Stockton Avenue	SFR	67	165	69	69.0	0.0	1.1	NI
788	635 Stockton Avenue	SFR	67	180	69	69.0	0.0	1.1	NI
789	641 Stockton Avenue	SFR	67	140	69	69.0	0.0	1.1	NI
794	647 Stockton Avenue	SFR	67	120	69	69.0	0.0	1.1	NI
796	759 Villa Street	SFR	67	330	62	62.0	0.0	1.7	NI
796	745 W Taylor Street	SFR	67	340	63	63.0	0.0	1.6	NI
797	727 Stockton Avenue	SFR	67	400	70	70.0	0.0	1.0	NI

SFR = Single-family residence
NI = No Impact

Pressure Relief Shaft

The ventilation shafts act as pressure relief shafts as well. The ventilation shafts will have large emergency ventilation fans. Based on previous BART projects, the sound attenuators that will be required to reduce the noise from emergency ventilation fans will be more than adequate to reduce the sound of trains. Introducing two silencers in the pressure relief shaft (one to control noise within the tunnel and station, the other to control noise at the surface) would reduce the train noise by more than 15 dBA.

Traction Power Substations

Based on previous BART projects (e.g., BART SFO), traction power substations (TPSS) more than 250 feet from residences would not require noise mitigation to achieve the FTA criteria. Depending on existing ambient conditions, TPSS less than 250 feet from residences may require perimeter sound walls. For at-grade facilities, perimeter noise walls (nominally an 8-foot-high Concrete Masonry Unit wall) can be used to reduce noise at nearby noise-sensitive land uses. The level of noise reduction will depend on the specific geometry of the site, barrier, and receptors, but such a wall should provide at least 5 dBA noise reduction. Therefore, mitigation would be required if a TPSS is located less than 250 feet from a residence, unless additional noise analysis determines that the FTA criteria is not exceeded.

There are TPSS that lie within 250 feet of receptors at the Downtown San Jose West Option and Diridon Station South and North Options. The TPSS at the Downtown San Jose West Option is on the corner of Santa Clara and 3rd Streets. There are multi-family residential uses within 250 feet to the north of the TPSS location. At the Diridon Station South Option, the TPSS is on the west side of the station between Autumn Street and Los Gatos Creek. The TPSS is on the southeast corner of the station at the Diridon Station North Option on Autumn Street. There is a single-family residence within 250 feet of both the Diridon Station South and North Options' TPSS.

Older residential uses are just behind the retail uses along Santa Clara Street. The San Jose State University campus is one block south of Santa Clara Street between 4th and 10th Streets. The San Jose Civic Plaza, including San Jose City Hall, is south of Santa Clara Street, between 4th and 6th Streets. The Museum of Art, Plaza de Cesar Chavez, Street. Joseph's Cathedral, San Pedro Square, and several theaters and major hotels are near the new station locations. Low- and medium-density residential uses are to the north of Santa Clara Street, just outside of downtown San Jose.

Table 4-9, Table 4-10, and Table 4-11 summarize the noise analysis at each location. The *FTA Guidance Manual* provides a reference L_{max} noise level of 63 dBA for substations with an analysis of the closest receptor at each ventilation shaft location. Using a noise level criterion of 55 dBA, there is one projected impact each at the Downtown San Jose West and Diridon Station South and North Options. With implementation of mitigation the impact would be less than significant.

Table 4-9: Predicted TPSS Noise Levels Near the Downtown San Jose Station (West Option)

Receptor	Land Use	Distance to TPSS (feet)	Projected Maximum Noise Level (dBA)	Impact Threshold (dBA)	Impact Type
97 Santa Clara Street	MFR	20	71.0	55	Impact
101 Santa Clara Street	MFR	125	55.0	55	No Impact
60 N 3rd Street	MFR	175	52.1	55	No Impact
100 Santa Clara Street	MFR	166	52.6	55	No Impact
126 Santa Clara Street	MFR	220	50.1	55	No Impact
20 S 2nd Street	MFR	210	50.5	55	No Impact
MFR = Multi-family residence					

Table 4-10: Predicted TPSS Noise Levels Near the Diridon Station South Option

Receptor	Land Use	Distance to TPSS (feet)	Projected Maximum Noise Level (dBA)	Impact Threshold (dBA)	Impact Type
35 S Autumn Street	Single-family residence	90	57.9	55	Impact

Table 4-11: Predicted TPSS Noise Levels Near the Diridon Station North Option

Receptor	Land Use	Distance to TPSS (feet)	Projected Maximum Noise Level (dBA)	Impact Threshold (dBA)	Impact Type
35 S Autumn Street	Single-family residence	90	57.9	55	Impact

Emergency Backup Generators

Generators would be located within acoustic enclosures, which reduce the noise levels by 20 dBA. Because the generators would be enclosed within a building or station structure, the intake and exhaust openings can be acoustically louvered, or they can be ducted and lined with 1- to 2-inch-thick duct liner to reduce the generator noise by at least 10 dBA. There would be emergency backup generators located at the Alum Rock/28th Street and Downtown San Jose Stations (both options).

Alum Rock/28th Street Station Generator

The current design indicates that the Alum Rock/28th Street Station generator would be located at grade, within a concrete structure. Noise control measures may be required to mitigate noise impacts depending on the location of the generator intake and exhaust vents.

Such measures may include an acoustic enclosure for the generator, acoustical treatment of the generator room, and/or acoustical louvers at the exterior vents. Therefore, mitigation measures would be required unless additional noise analysis determines that the FTA criteria is not exceeded.

Downtown San Jose Station Generator

The generator for the Downtown San Jose Station would be full enclosed by the station structure. Noise control measures may be required to mitigate noise impacts depending on the location of the generator intake and exhaust vents. Such measures are the same as those indicated above for the Alum Rock/28th Street Station generator. Therefore, mitigation measures would be required unless additional noise analysis determines that the FTA criteria is not exceeded.

End-of-the-Line Newhall Maintenance Facility

The maintenance facility and storage yard tracks were studied in 2006 as part of the preliminary engineering design process. The maintenance facility and storage yard tracks location and usage have not changed significantly since 2006. Therefore, the previous noise analysis (Ref. 9 and 10) conclusions remain valid, and there would be no noise impacts from train activity within the yard, nor would there be noise impacts from facility activity.

4.1.4 Groundborne Noise and Vibration Impacts from Operations

The operational groundborne noise and vibration impacts along the tunnel alignment were evaluated using the FTA criteria. All residential land uses identified along the alignment were treated individually in the groundborne noise and vibration prediction model. Institutional land uses (e.g., schools) were also treated individually in the calculations.

At-grade Segment

All sensitive receptors adjacent to the at-grade segment of the alignment, which starts approximately 600 feet north of I-880, would be over 200 feet (i.e., 223 feet and greater) from the nearest track. The Screening Distance for a rail rapid transit system such as BART is 200 feet. Consequently, no groundborne noise and vibration impacts would be expected for the at-grade segment of the BART Extension.

Tunnel Segment

The projected levels of groundborne noise and vibration for BART train operations within the BART Extension’s tunnel were calculated using the vibration prediction models described in Sections 3.2, *Construction Noise*, and 3.3, *Construction Vibration*. There are two options being considered for the tunnel alignment. One option is for a twin-bore tunnel. The other option is for a deeper single-bore tunnel with stacked tracks one above the other.

The groundborne noise and vibration levels projected for the Twin-Bore Option tunnel have been evaluated in detail and are presented herein. The groundborne noise and vibration projected for the Single-Bore Option tunnel were evaluated by comparing the projected noise and vibration levels for selected receptors along the tunnel alignment to determine what if any differences might be expected between the two options.

Twin-Bore Option Tunnel

The projected levels of groundborne vibration for the Twin-Bore Option tunnel are provided in Table 4-12 through Table 4-16 are compared to the FTA criteria. The projected levels of groundborne noise provided in Table 4-17 through Table 4-21 are compared to the FTA criteria.

Groundborne vibration and noise levels are presented as a range of projected values reflecting the use of a modeling factor, which conservatively accounts for the various uncertainties in the model. The levels at each receptor location are based on distance to and depth of the track, train design speed, wheel/rail interaction forces, dynamic characteristics of rail support system, soil conditions, and the dynamic response of the receptor building. Determinations of noise and vibration impacts are based on the upper value of the predicted range. Table cells that are shaded indicate impacts, in which case various levels of mitigation were evaluated until one was found as indicated in the column heading that is projected to mitigate the impact.

As indicated in Table 4-12 through Table 4-16, no vibration impacts are projected for the BART Extension’s tunnel alignment when comparing the FTA 1/3-octave band criteria to the predicted levels of vibration. The analysis does indicate that groundborne noise levels are projected to exceed the FTA criteria for many receptors, as shown in as shown in Table 4-17 through Table 4-21. Groundborne noise mitigation has been evaluated for those receptors indicated as potentially impacted.

Where the unmitigated groundborne noise levels from the prediction model exceed the FTA noise criteria, an IST) was evaluated as mitigation.

Three other groundborne noise mitigation measures were considered:

1. Highly resilient direct fixation fasteners (HRDF), an example of which is known as the EGG type direct fixation fastener.
2. Rail suspension fastener (RSF) system, an example of which is the Pandrol Panguard rail fastener.
3. Very highly resilient direct fixation fastener (VHRDF), an example of which is the Amsted/RPS ADFF-6.

These types of mitigation measures are installed at track level and reduce vibration transmitted into the tunnel invert (concrete bottom of tunnel) reducing vibration that would otherwise be emitted from the tunnel structure into the surrounding soil. These four measures have varying degrees of effectiveness at reducing higher frequency vibration that would cause groundborne noise from the BART train operations.

An IST is a special form of FST system consisting of a concrete slab on top of a continuous, resilient mat. An IST can be used with RT as the track fastening system. An IST can be used for special trackwork, because standard rail fasteners or RT can be used at the rail level. An IST should be capable of providing from 10 to 13 dBA of noise reduction when properly designed. The IST concept was studied and presented in Reference 19.

The rail fastener necessary to mitigate a specific impact depends on the groundborne noise projected for the standard rail fastener and the amount of reduction necessary to satisfy the FTA criteria.

The main characteristic of a rail fastener affecting groundborne noise is the fastener's dynamic stiffness. The first level of rail fastener mitigation is the HRDF, which provides a moderate amount of groundborne noise reduction (from 4 to 8 dBA). The second level of mitigation is the RSF, which can provide a substantially higher level of groundborne noise reduction (from 9 to 13 dBA). The VHRDF (i.e., Amsted/RPS ADFF-6) has similar groundborne noise reduction performance as the RSF. Thus the VHRDF can be considered an equivalent mitigation measure to the RSF for the purpose of this environmental study.

Cells in Table 4-17 through Table 4-21 indicate whether an impact is projected with standard track design (i.e., standard RT) and where an IST would be needed as mitigation.

Table 4-12: Groundborne Vibration for the Twin-Bore Option Alignment

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBV Criteria (VdB)	Max 1/3 OB GBV Without Mitigation (VdB)	# of Receptors
584	433 N 33rd Street	MFR	48	156	51	72	57 to 61	--
585	1500 Marburg Way	SFR	48	0	54	72	60 to 64	--
590	333 N 33rd Street – Anne Darling Elementary School	Institutional	48	155	49	75	58 to 62	--
593	290 N 31st Street	SFR	48	184	50	72	59 to 63	--
595	269 N 31st Street	SFR	48	53	50	72	60 to 64	--
595	263 N 31st Street	SFR	48	120	53	72	60 to 64	--
595	261 N 31st Street	SFR	48	125	53	72	60 to 64	--
610	5 Wounds Lane – Five Wounds School	Institutional	48	280	53	75	56 to 60	--
614	24 N 26th Street – SF Nova Alliance Community Center	Institutional	48	0	52	75	61 to 65	--
615	26 N 26th Street	SFR	48	150	52	72	55 to 59	--
617	23 N 26th Street	SFR	48	140	51	72	55 to 59	--
618	1245 Santa Clara Street – Alum Rock Counseling Center	Institutional	48	0	51	75	59 to 63	--
618	9 S 26th Street	SFR	48	178	51	72	54 to 58	--
619	30 N 25th Street	SFR	48	200	51	72	54 to 58	--
619	20 N 25th Street	SFR	48	160	51	72	56 to 60	--
619	1236 Santa Clara Street	SFR	48	68	51	72	56 to 60	--
619	1241 Shortridge Avenue	MFR	48	197	51	72	56 to 60	--
619	1211 Santa Clara Street	MFR	48	21	51	72	61 to 65	--
619	1226 Santa Clara Street	SFR	48	68	51	72	59 to 63	--
620	1220 Santa Clara Street – Sociedad Filharmonica	Institutional	48	45	50	75	59 to 63	--
620	1210 Santa Clara Street	SFR	48	35	50	72	60 to 64	--
622	45 N 25th Street	SFR	48	171	50	72	54 to 58	--
622	16 S 24th Street	SFR	48	114	50	72	56 to 60	--
623	1169 Santa Clara Street	SFR	48	60	50	72	59 to 63	--
623	1161 Santa Clara Street	SFR	48	70	50	72	56 to 60	--
623	16 N 24th Street	SFR	48	90	54	72	57 to 61	--
624	11 S 24th Street	SFR	48	137	54	72	57 to 61	--

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBV Criteria (VdB)	Max 1/3 OB GBV Without Mitigation (VdB)	# of Receptors
625	13 Carnegie Square	SFR	48	149	51	72	55 to 59	--
626	1102 Santa Clara Street – East San Jose Carnegie Branch Library	Institutional	48	25	49	75	59 to 63	--
627	1115 Santa Clara Street – Portuguese Community Center	Institutional	48	45	49	75	59 to 63	--
627	11 S 23rd Street	MFR	48	132	49	72	57 to 61	--
627	15 S 23rd Street	SFR	48	163	49	72	55 to 59	--
627	9 S 23rd Street	MFR	48	103	48	72	58 to 62	--
627	1098 Santa Clara Street – Casa Do Benfica	Institutional	48	18	47	75	58 to 62	--
628	1082 Santa Clara Street	MFR	48	19	46	72	61 to 65	--
628	16 S 22nd Street	SFR	48	119	48	72	56 to 60	--
628	1072 Santa Clara Street	MFR	48	19	49	72	61 to 65	--
629	1075 Santa Clara Street – Santa Clara County Multi Service Center	Institutional	48	85	49	75	56 to 60	--
630	15 S 22nd Street	SFR	48	160	49	72	55 to 59	--
630	1050 Santa Clara Street – Daniel B Martinez, MD	Institutional	48	37	49	75	60 to 64	--
631	1049 Santa Clara Street	SFR	48	72	50	72	58 to 62	--
631	1026 Santa Clara Street	SFR	48	45	50	72	60 to 64	--
631	1047 Santa Clara Street	SFR	48	70	51	72	58 to 62	--
632	8 S 21st Street	SFR	48	140	51	72	55 to 59	--
633	16 N 21st Street	SFR	48	135	51	72	56 to 60	--
633	19 S 21st Street	SFR	48	160	51	72	55 to 59	--
633	990 Santa Clara Street – Trinh Hung Quoc, MD	Institutional	48	60	51	75	59 to 63	--
634	20 S 20th Street	SFR	48	181	52	72	54 to 58	--
635	966 Santa Clara Street	MFR	48	56	52	72	59 to 63	--
636	19 S 20th Street	SFR	48	222	52	72	51 to 55	--
637	961 Santa Clara Street – Roosevelt Youth Center	Institutional	48	0	53	75	54 to 58	--
637	901 Santa Clara Street – Roosevelt Youth Center	Institutional	48	0	53	75	54 to 58	--
640	896 Santa Clara Street	MFR	48	150	53	72	52 to 56	--
640	884 Santa Clara Street	MFR	48	200	53	72	51 to 55	--
644	802 Santa Clara – Fire Station – Battalion 1	MFR	67	110	53	72	56 to 60	--

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBV Criteria (VdB)	Max 1/3 OB GBV Without Mitigation (VdB)	# of Receptors
645	90 N 17th Street	SFR	67	240	53	72	55 to 59	--
647	765 Santa Clara Street	Institutional	67	0	53	75	55 to 59	--
648	765 Santa Clara Street	Institutional	67	0	53	75	59 to 63	--
648	10 N 16th Street	Institutional	67	0	53	75	59 to 63	--
649	675 Santa Clara Street	Hospital	67	0	53	72	55 to 59	--
649	748 Santa Clara Street	MFR	67	95	53	72	55 to 59	--
649	31 S 16th Street	SFR	67	236	53	72	55 to 59	--
651	22 S 15th Street	SFR	67	218	53	72	55 to 59	--
651	716 Santa Clara Street	MFR	67	100	53	72	55 to 59	--
651	675 Santa Clara Street	Hospital	67	0	53	72	52 to 56	--
652	12 S 15th Street #206 – Bay Area College of Nursing: Cagampan Bu	Institutional	67	78	53	75	54 to 58	--
654	25 S 15th Street – Dr Viet-Hong Bui	Institutional	67	59	55	75	55 to 59	--
654	678 Santa Clara Street – Buena Vista Eyecare Group	Institutional	67	54	55	75	57 to 61	--
655	652 Santa Clara Street – Elite Dental	Institutional	67	48	55	75	57 to 61	--
656	25 N 14th Street #Ste 55 – Norcal Care	Institutional	67	19	55	75	52 to 56	--
657	30 N 13th Street	MFR	67	122	55	72	56 to 60	--
658	602 Santa Clara Street – Indian Health Center of Santa Clara Vall	Institutional	67	31	55	75	55 to 59	--
658	28 S 13th Street	SFR	67	171	55	72	55 to 59	--
660	55 N 13th Street – Ming Li, MD	Institutional	67	119	56	75	55 to 59	--
660	26 S 12th Street	SFR	67	169	56	72	55 to 59	--
660	29 S 13th Street – Duong Bich-Hai Thi, DDS	Institutional	67	169	56	75	55 to 59	--
661	551 Santa Clara Street – Holistic Health Care Clinic (Chiropractic)	Institutional	67	31	56	75	55 to 59	--
661	32 N 12th Street	MFR	67	196	56	72	55 to 59	--
662	15 S 12th Street	SFR	67	128	56	72	60 to 64	--
663	12 S 11th Street	MFR	67	146	57	72	60 to 64	--
665	32 N 11th Street	MFR	67	182	58	72	62 to 66	--
665	478 Santa Clara Street – Santa Clara Dental	Institutional	67	29	59	75	64 to 68	--

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBV Criteria (VdB)	Max 1/3 OB GBV Without Mitigation (VdB)	# of Receptors
667	35 N 11th Street	MFR	67	180	61	72	60 to 64	--
667	23 S 11th Street	SFR	67	167	61	72	60 to 64	--
668	471 Santa Clara Street – Darling & Fischer Garden Chapel Mortuary	Institutional	67	50	63	75	59 to 63	--
668	30 N 10th Street	MFR	67	167	63	72	60 to 64	--
668	22 S 10th Street	MFR	67	167	63	72	60 to 64	--
669	11 S 10th Street	MFR	67	30	65	72	60 to 64	--
669	25 S 10th Street	MFR	67	120	65	72	60 to 64	--
670	425 Elizabeth Street	SFR	67	121	66	72	60 to 64	--
670	425 Santa Clara Street – San Jose Fire Fighters Local 230	MFR	67	33	66	72	60 to 64	--
670	39 N 10th Street	SFR	67	168	67	72	60 to 64	--
670	421 Elizabeth Street	SFR	67	121	66	72	60 to 64	--
671	417 Elizabeth Street	SFR	67	121	63	72	60 to 64	--
672	401 Santa Clara Street	MFR	67	33	65	72	60 to 64	--
672	24 N 9th Street	SFR	67	156	64	72	60 to 64	--
672	18 S 9th Street	SFR	67	135	60	72	60 to 64	--
672	23 S 9th Street	MFR	67	166	56	72	60 to 64	--
673	390 Santa Clara Street	MFR	67	31	56	72	60 to 64	--
674	26 S 8th Street	MFR	67	166	57	72	60 to 64	--
674	389 Santa Clara Street – Street. Patrick's Proto-Cathedral	Institutional	67	60	56	75	58 to 62	--
675	365 Santa Clara Street – Our Lady of La Vang Parish	Institutional	67	65	57	75	58 to 62	--
676	25 S 8th Street	MFR	67	160	57	72	60 to 64	--
677	345 Santa Clara Street – 420 Medical Doctor	Institutional	67	40	57	75	63 to 67	--
679	24 S 7th Street	MFR	48	200	57	72	54 to 58	--
680	1295 Santa Clara Street – Horace Mann Elementary	Institutional	48	33	56	75	56 to 60	--
For Downtown San Jose Station East and West Options, see Table 4-13 and Table 4-14, respectively								
707	101 W Santa Clara Street – Chamber of Commerce Silicon Valley	Institutional	33	30	55	75	52 to 56	--

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBV Criteria (VdB)	Max 1/3 OB GBV Without Mitigation (VdB)	# of Receptors
709	20 N Almaden Avenue	MFR	33	29	55	72	56 to 60	--
710	161 W Santa Clara Street – Masson Apartments	MFR	33	29	55	72	56 to 60	--
712	22 Almaden Avenue	MFR	33	144	55	72	56 to 60	--
715	233 W Santa Clara Street – Hotel De Anza	Hotel	33	29	55	72	50 to 54	--
716	38 N Almaden Boulevard – Axis Apartments	MFR	33	112	55	72	56 to 60	--
For Diridon Station South and North Alignment Options, see Table 4-15 and Table 4-16, respectively								
782	762 Harding Avenue	SFR	67	285	60	72	59 to 63	--
782	750 Harding Avenue	SFR	67	240	63	72	59 to 63	--
782	714 Harding Avenue	SFR	67	95	63	72	60 to 64	--
782	738 Harding Avenue	SFR	67	188	63	72	59 to 63	--
782	701 Harding Avenue	SFR	67	35	63	72	60 to 64	--
782	726 Harding Avenue	SFR	67	135	62	72	60 to 64	--
784	551 Stockton Avenue	SFR	67	35	62	72	57 to 61	--
784	713 Harding Avenue	SFR	67	85	62	72	59 to 63	--
784	761 Harding Avenue	SFR	67	280	61	72	59 to 63	--
784	749 Harding Avenue	SFR	67	235	61	72	59 to 63	--
784	737 Harding Avenue	SFR	67	185	61	72	59 to 63	--
784	725 Harding Avenue	SFR	67	135	61	72	60 to 64	--
785	714 Schiele Avenue	SFR	67	85	61	72	61 to 65	--
785	750 Schiele Avenue	SFR	67	245	61	72	59 to 63	--
785	738 Schiele Avenue	SFR	67	190	61	72	59 to 63	--
785	726 Schiele Avenue	SFR	67	145	62	72	58 to 62	--
785	599 Stockton Avenue	SFR	67	35	62	72	57 to 61	--
786	762 Schiele Avenue	SFR	67	275	62	72	59 to 63	--
787	733 Schiele Avenue	SFR	67	170	62	72	59 to 63	--
787	745 Schiele Avenue	SFR	67	217	62	72	59 to 63	--
787	757 Schiele Avenue	SFR	67	265	61	72	59 to 63	--
788	623 Stockton Avenue	SFR	67	50	61	72	58 to 62	--
788	766 Villa Avenue	SFR	67	290	61	72	59 to 63	--
788	635 Stockton Avenue	SFR	67	55	61	72	58 to 62	--

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBV Criteria (VdB)	Max 1/3 OB GBV Without Mitigation (VdB)	# of Receptors
789	641 Stockton Avenue	SFR	67	40	61	72	57 to 61	--
789	647 Stockton Avenue	SFR	67	55	61	72	58 to 62	--
790	744 Villa Avenue	SFR	67	195	61	72	59 to 63	--
790	756 Villa Avenue	SFR	67	240	61	72	59 to 63	--
790	732 Villa Avenue	SFR	67	155	61	72	60 to 64	--
794	759 Villa Street	SFR	67	260	61	72	57 to 61	--
795	765 W Taylor Street	SFR	67	270	62	72	59 to 63	--
795	755 W Taylor Street	SFR	67	235	62	72	59 to 63	--
796	745 W Taylor Street	SFR	67	185	62	72	59 to 63	--
796	724 Laurel Street	SFR	67	290	62	72	59 to 63	--
797	727 Stockton Avenue	SFR	67	60	62	72	57 to 61	--
797	733 Stockton Avenue	SFR	67	35	62	72	60 to 64	--
798	732 Asbury Street	SFR	67	160	62	72	59 to 63	--
798	742 Asbury Street	SFR	67	200	62	72	59 to 63	--
798	702 Asbury Street	SFR	67	35	62	72	60 to 64	--
798	764 Asbury Street	SFR	67	260	62	72	57 to 61	--
798	722 Asbury Street	SFR	67	120	62	72	60 to 64	--
798	712 Asbury Street	SFR	67	80	62	72	61 to 65	--
799	755 Asbury Street	SFR	67	245	62	72	59 to 63	--
801	779 Stockton Avenue	SFR	67	55	62	72	58 to 62	--
SVSX = Silicon Valley Santa Clara Extension; SFR = Single-Family Residential, MFR = Multi-Family Residential, GBV = Groundborne Vibration								

Table 4-13: Groundborne Vibration for Downtown San Jose Station East Option

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBV Criteria (VdB)	Max 1/3 OB GBV Without Mitigation (VdB)	# of Receptors
683	235 Santa Clara Street – Vintage Tower (X-Over)	MFR	48	28	50	72	64 to 68	--
684	24 N 5th Street – First United Methodist Church (X-Over)	Institutional	48	28	49	75	67 to 71	--
685	200 Santa Clara Street – San Jose City Hall (X-Over)	Institutional	48	33	49	75	66 to 70	--
691	148 Santa Clara Street	MFR	48	34	49	72	60 to 64	--
691	138 Santa Clara Street	MFR	48	34	49	72	60 to 64	--
692	134 Santa Clara Street	MFR	48	34	48	72	60 to 64	--
693	118 Santa Clara Street	MFR	48	34	48	72	60 to 64	--
693	101 Santa Clara Street	MFR	48	27	48	72	60 to 64	--
693	100 Santa Clara Street	MFR	48	34	48	72	60 to 64	--
693	60 N 3rd Street – Town Park Towers	MFR	48	203	48	72	54 to 58	--
694	97 Santa Clara Street	MFR	48	31	49	72	60 to 64	--
697	20 S Second Street	MFR	48	141	50	72	58 to 62	--
701	15 S 1st Street – MFR above Commercial	MFR	48	90	51	72	59 to 63	--
701	1 N 1st Street – Lincoln Law School	Institutional	48	30	51	75	55 to 59	--

SVSX = Silicon Valley Santa Clara Extension; SFR = Single-Family Residential, MFR = Multi-Family Residential, GBV = Groundborne Vibration

Table 4-14: Groundborne Vibration for Downtown San Jose Station West Option

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBV Criteria (VdB)	Max 1/3 OB GBV Range Without Mitigation (VdB)	# of Receptors Impacted
683	235 Santa Clara Street – Vintage Tower	MFR	48	28	56	72	55 to 59	--
684	24 N 5th Street – First United Methodist Church	Institutional	48	28	56	75	57 to 61	--
685	200 Santa Clara Street – San Jose City Hall	Institutional	48	33	55	75	56 to 60	--
691	148 Santa Clara Street	MFR	48	34	55	72	60 to 64	--
691	138 Santa Clara Street	MFR	48	34	55	72	60 to 64	--
692	134 Santa Clara Street (X-Over)	MFR	48	34	55	72	61 to 65	--
693	118 Santa Clara Street (X-Over)	MFR	48	34	55	72	65 to 69	--
693	101 Santa Clara Street (X-Over)	MFR	48	27	55	72	68 to 72‡	--
693	100 Santa Clara Street (X-Over)	MFR	48	34	55	72	68 to 72‡	--
693	60 N 3rd Street – Town Park Towers	MFR	48	203	55	72	54 to 58	--
694	97 Santa Clara Street (X-Over)	MFR	48	31	55	72	68 to 72‡	--
697	20 S Second Street (X-Over)	MFR	48	141	55	72	59 to 63	--
701	15 S 1st Street – MFR above Commercial	MFR	48	90	55	72	59 to 63	--
701	1 N 1st Street – Lincoln Law School	Institutional	48	30	55	75	55 to 59	--

SVSX = Silicon Valley Santa Clara Extension; SFR = Single-Family Residential, MFR = Multi-Family Residential, GBV = Groundborne Vibration
‡ May increase with implementation of IST

Table 4-15: Groundborne Vibration for Diridon North Alignment Option

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBV Criteria (VdB)	Max 1/3 OB GBV Without Mitigation (VdB)	# of Receptors
734	35 S Autumn Street	SFR	33	270	55	72	53 to 57	--
735	56 S Montgomery Street – Templo La Hermosa	Institutional	48	450	55	75	52 to 56	--
745	88 Bush Street – Plant 51	MFR	48	210	58	72	55 to 59	--
748	754 The Alameda – Avalon at Cahill Park	MFR	48	25	58	72	59 to 63	--
748	53 Wilson Avenue	SFR	48	425	60	72	55 to 59	--
748	51 Wilson Avenue	SFR	48	375	60	72	55 to 59	--
749	49 Wilson Avenue	SFR	48	325	61	72	55 to 59	--
749	40 Sunol Street	MFR	48	420	61	72	55 to 59	--
749	34 Sunol Street	SFR	48	380	61	72	55 to 59	--
749	30 Sunol Street	SFR	48	330	61	72	55 to 59	--
749	24 Sunol Street	SFR	48	280	61	72	55 to 59	--
750	830 The Alameda	MFR	48	80	61	72	58 to 62	--
750	20 Sunol Street	SFR	48	245	61	72	55 to 59	--
751	33 Sunol Street	SFR	48	400	61	72	55 to 59	--
751	27 Sunol Street	SFR	48	350	61	72	55 to 59	--
752	24 Cleaves Avenue	SFR	48	420	62	72	55 to 59	--
753	938 The Alameda – Billy Defrank LGBT Community Center	Institutional	48	415	64	75	55 to 59	--
755	925 The Alameda – Lofts on The Alameda	MFR	48	120	65	72	57 to 61	--
754	87 Rhodes Court	SFR	48	53	64	72	57 to 61	--
754	128 Rhodes Court	SFR	48	40	65	72	57 to 61	--
754	152 Rhodes Court	SFR	48	60	65	72	57 to 61	--
754	109 Rhodes Court	SFR	48	25	64	72	58 to 62	--
755	133 Rhodes Court	SFR	48	25	64	72	58 to 62	--
755	157 Rhodes Court	SFR	48	25	64	72	57 to 61	--
755	176 Rhodes Court (X-Over)	SFR	48	100	64	72	60 to 64	--
755	179 Rhodes Court	SFR	48	25	64	72	56 to 60	--
755	200 Rhodes Court (X-Over)	SFR	48	130	64	72	60 to 64	--
756	176 N Morrison Avenue	MFR	48	118	64	72	57 to 61	--

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBV Criteria (VdB)	Max 1/3 OB GBV Without Mitigation (VdB)	# of Receptors
756	201 Rhodes Court	SFR	48	25	64	72	57 to 61	--
756	229 Rhodes Court	SFR	48	25	64	72	57 to 61	--
757	204 N Morrison Avenue	SFR	48	86	64	72	57 to 61	--
755	224 Rhodes Court (X-Over)	SFR	48	160	64	72	60 to 64	--
756	248 Rhodes Court (X-Over)	SFR	48	180	64	72	60 to 64	--
757	173 N Morrison Avenue	Institutional	48	292	64	75	59 to 63	--
757	253 Rhodes Court	SFR	48	35	64	72	58 to 62	--
757	197 N Morrison Avenue	SFR	48	250	64	72	57 to 61	--
757	225 N Morrison Avenue	MFR	48	235	64	72	57 to 61	--
757	272 Rhodes Court (X-Over)	SFR	48	200	64	72	59 to 63	--
757	275 Rhodes Court	SFR	48	35	64	72	58 to 62	--
758	800 W Julian Street (X-Over)	SFR	48	240	62	72	59 to 63	--
758	264 N Morrison Avenue – Support Systems Homes Recovery Center	MFR	48	25	62	72	57 to 61	--
758	295 Rhodes Court	SFR	48	77	62	72	60 to 64	--
758	908 W Julian Street	SFR	48	25	62	72	57 to 61	--
758	920 W Julian Street	SFR	48	25	62	72	57 to 61	--
758	936 W Julian Street	SFR	48	25	62	72	57 to 61	--
764	909 W Julian Street	SFR	48	197	63	72	60 to 64	--
759	950 W Julian Street – Family And Children Services San Jose of	MFR	48	210	63	72	53 to 57	--
760	379 N Morrison Avenue	SFR	48	250	61	72	57 to 61	--
761	962 Cinnabar Street	SFR	48	340	61	72	59 to 63	--
761	956 Cinnabar Street	SFR	48	300	61	72	59 to 63	--
759	899 Morrison Park Dr – Avalon Morrison Park	MFR	48	25	63	72	56 to 60	--
762	910 Cinnabar Street	SFR	48	85	61	72	60 to 64	--
763	945 Cinnabar Street	SFR	48	245	60	72	59 to 63	--
762	890 Cinnabar Street	SFR	48	30	61	72	58 to 62	--
763	927 Cinnabar Street	SFR	48	210	60	72	59 to 63	--
763	870 Cinnabar Street	SFR	48	30	60	72	58 to 62	--

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBV Criteria (VdB)	Max 1/3 OB GBV Without Mitigation (VdB)	# of Receptors
763	909 Cinnabar Street	SFR	48	173	60	72	60 to 64	--
763	850 Cinnabar Street	SFR	48	25	60	72	57 to 61	--
764	875 Cinnabar Street – Cinnabar Commons Apartments	MFR	48	25	60	72	55 to 59	--
764	434 N Morrison Avenue	SFR	48	275	60	72	59 to 63	--
766	417 Stockton Avenue	SFR	48	39	59	72	59 to 63	--
768	808 Lenzen Avenue	MFR	48	335	61	72	59 to 63	--
767	790 Lenzen Avenue	MFR	48	105	61	72	56 to 60	--
771	777 Lenzen Avenue	SFR	67	300	61	72	57 to 61	--
772	476 Lenzen Court	SFR	67	310	62	72	57 to 61	--
774	774 Pershing Avenue	SFR	67	320	64	72	60 to 64	--
774	762 Pershing Avenue	SFR	67	285	64	72	60 to 64	--
773	489 Stockton Avenue	SFR	67	40	63	72	60 to 64	--
774	750 Pershing Avenue	SFR	67	240	64	72	60 to 64	--
774	738 Pershing Avenue	SFR	67	190	64	72	60 to 64	--
774	726 Pershing Avenue	SFR	67	135	64	72	60 to 64	--
774	714 Pershing Avenue	SFR	67	92	64	72	60 to 64	--
774	495 Stockton Avenue	MFR	67	37	64	72	60 to 64	--
776	749 Pershing Avenue	SFR	67	230	65	72	60 to 64	--
776	761 Pershing Avenue	SFR	67	280	65	72	60 to 64	--
776	737 Pershing Avenue	SFR	67	185	65	72	60 to 64	--
776	711 Pershing Avenue	SFR	67	84	65	72	61 to 65	--
776	725 Pershing Avenue	SFR	67	133	65	72	60 to 64	--
776	501 Stockton Avenue	SFR	67	37	65	72	60 to 64	--
SVSX = Silicon Valley Santa Clara Extension; SFR = Single-Family Residential, MFR = Multi-Family Residential, GBV = Groundborne Vibration								

Table 4-16: Groundborne Vibration for Diridon South Alignment Option

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBV Criteria (VdB)	Max 1/3 OB GBV Without Mitigation (VdB)	# of Receptors
736	35 S Autumn Street	SFR	33	35	48	72	53 to 57	--
737	56 S Montgomery Street – Templo La Hermosa	Institutional	48	189	46	75	55 to 59	--
745	88 Bush Street – Plant 51	MFR	48	0	49	72	59 to 63	--
748	754 The Alameda – Avalon at Cahill Park	MFR	48	0	49	72	59 to 63	--
750	53 Wilson Avenue	SFR	48	80	54	72	59 to 63	--
750	51 Wilson Avenue	SFR	48	35	54	72	60 to 64	--
750	49 Wilson Avenue	SFR	48	0	54	72	60 to 64	--
751	40 Sunol Street	MFR	48	90	54	72	58 to 62	--
752	34 Sunol Street	SFR	48	50	54	72	60 to 64	--
752	30 Sunol Street	SFR	48	0	55	72	60 to 64	--
752	24 Sunol Street	SFR	48	0	56	72	60 to 64	--
753	830 The Alameda	MFR	48	38	56	72	59 to 63	--
753	20 Sunol Street	SFR	48	0	56	72	60 to 64	--
753	33 Sunol Street	SFR	48	85	56	72	59 to 63	--
753	27 Sunol Street	SFR	48	40	56	72	60 to 64	--
754	24 Cleaves Avenue	SFR	48	115	57	72	57 to 61	--
756	938 The Alameda – Billy Defrank LGBT Community Center	Institutional	48	125	58	75	56 to 60	--
758	925 The Alameda – Lofts on The Alameda	MFR	48	0	62	72	59 to 63	--
759	87 Rhodes Court	SFR	48	115	64	72	55 to 59	--
758	128 Rhodes Court	SFR	48	250	62	72	53 to 57	--
759	152 Rhodes Court	SFR	48	276	64	72	53 to 57	--
759	109 Rhodes Court	SFR	48	130	64	72	54 to 58	--
760	133 Rhodes Court	SFR	48	107	61	72	55 to 59	--
760	157 Rhodes Court	SFR	48	132	61	72	60 to 64	--
760	176 Rhodes Court (X-Over)	SFR	48	0	61	72	59 to 63	--
760	179 Rhodes Court	SFR	48	151	61	72	54 to 58	--
760	200 Rhodes Court (X-Over)	SFR	48	0	61	72	59 to 63	--

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBV Criteria (VdB)	Max 1/3 OB GBV Without Mitigation (VdB)	# of Receptors
761	176 N Morrison Avenue	MFR	48	20	62	72	56 to 60	--
761	201 Rhodes Court	SFR	48	169	62	72	60 to 64	--
761	229 Rhodes Court	SFR	48	186	62	72	60 to 64	--
761	204 N Morrison Avenue	SFR	48	40	62	72	57 to 61	--
761	224 Rhodes Court (X-Over)	0	48	0	62	72	59 to 63	--
761	248 Rhodes Court (X-Over)	0	48	0	62	72	59 to 63	--
762	173 N Morrison Avenue	Institutional	48	45	62	75	59 to 63	--
762	253 Rhodes Court	SFR	48	200	62	72	60 to 64	--
762	197 N Morrison Avenue	SFR	48	30	62	72	57 to 61	--
762	225 N Morrison Avenue	MFR	48	15	62	72	56 to 60	--
762	272 Rhodes Court (X-Over)	0	48	0	62	72	59 to 63	--
762	275 Rhodes Court	SFR	48	213	62	72	60 to 64	--
763	800 W Julian Street (X-Over)	0	48	0	62	72	59 to 63	--
763	264 N Morrison Avenue – Support Systems Homes Recovery Center	MFR	48	40	62	72	57 to 61	--
763	295 Rhodes Court	SFR	48	263	62	72	60 to 64	--
763	908 W Julian Street	SFR	48	224	62	72	60 to 64	--
763	920 W Julian Street	SFR	48	182	62	72	60 to 64	--
763	936 W Julian Street	SFR	48	141	62	72	60 to 64	--
764	909 W Julian Street	SFR	48	246	62	72	60 to 64	--
763	950 W Julian Street – Family And Children Services San Jose of	MFR	48	0	62	72	55 to 59	--
766	379 N Morrison Avenue	SFR	48	70	62	72	57 to 61	--
766	962 Cinnabar Street	SFR	48	175	62	72	60 to 64	--
766	956 Cinnabar Street	SFR	48	140	62	72	60 to 64	--
766	899 Morrison Park Dr – Avalon Morrison Park	MFR	48	0	62	72	55 to 59	--
768	910 Cinnabar Street	SFR	48	0	63	72	57 to 61	--
768	945 Cinnabar Street	SFR	48	110	63	72	60 to 64	--
768	890 Cinnabar Street	SFR	48	0	63	72	57 to 61	--
768	927 Cinnabar Street	SFR	48	75	63	72	60 to 64	--

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBV Criteria (VdB)	Max 1/3 OB GBV Without Mitigation (VdB)	# of Receptors
768	870 Cinnabar Street	SFR	48	29	63	72	58 to 62	--
769	909 Cinnabar Street	SFR	48	45	63	72	59 to 63	--
769	850 Cinnabar Street	SFR	48	62	63	72	60 to 64	--
769	875 Cinnabar Street – Cinnabar Commons Apartments	MFR	48	0	63	72	55 to 59	--
769	434 N Morrison Avenue	SFR	48	150	63	72	60 to 64	--
771	417 Stockton Avenue	SFR	48	41	62	72	59 to 63	--
772	808 Lenzen Avenue	MFR	48	240	63	72	59 to 63	--
773	790 Lenzen Avenue	MFR	48	20	63	72	55 to 59	--
775	777 Lenzen Avenue	SFR	67	278	63	72	57 to 61	--
776	476 Lenzen Court	SFR	67	280	63	72	57 to 61	--
778	774 Pershing Avenue	SFR	67	310	64	72	59 to 63	--
778	762 Pershing Avenue	SFR	67	250	64	72	59 to 63	--
778	489 Stockton Avenue	SFR	67	10	64	72	56 to 60	--
778	750 Pershing Avenue	SFR	67	210	64	72	59 to 63	--
778	738 Pershing Avenue	SFR	67	160	64	72	59 to 63	--
779	726 Pershing Avenue	SFR	67	115	65	72	60 to 64	--
779	714 Pershing Avenue	SFR	67	70	65	72	61 to 65	--
779	495 Stockton Avenue	MFR	67	10	65	72	56 to 60	--
780	749 Pershing Avenue	SFR	67	220	65	72	59 to 63	--
780	761 Pershing Avenue	SFR	67	270	65	72	59 to 63	--
780	737 Pershing Avenue	SFR	67	170	65	72	59 to 63	--
780	711 Pershing Avenue	SFR	67	70	65	72	61 to 65	--
780	725 Pershing Avenue	SFR	67	120	65	72	60 to 64	--
780	501 Stockton Avenue	SFR	67	26	65	72	59 to 63	--

SVSX = Silicon Valley Santa Clara Extension; SFR = Single-Family Residential, MFR = Multi-Family Residential, GBV = Groundborne Vibration

Table 4-17: Groundborne Noise for the Twin-Bore Option Alignment

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
584	433 N 33rd Street	MFR	48	156	54	35	20 to 24	--	--
585	1500 Marburg Way	SFR	48	0	52	35	24 to 28	--	--
590	333 N 33rd Street – Anne Darling Elementary School	Institutional	48	155	49	40	20 to 24	--	--
593	290 N 31st Street	SFR	48	184	50	35	25 to 29	--	--
595	269 N 31st Street	SFR	48	53	50	35	29 to 33	--	--
595	263 N 31st Street	SFR	48	120	50	35	27 to 31	--	--
595	261 N 31st Street	SFR	48	125	50	35	27 to 31	--	--
610	5 Wounds Lane – Five Wounds School	Institutional	48	280	49	40	21 to 25	--	--
614	24 N 26th Street – Sf Nova Alliance Community Center	Institutional	48	0	50	40	35 to 39	--	--
615	26 N 26th Street	SFR	48	150	52	35	30 to 34	--	--
617	23 N 26th Street	SFR	48	140	52	35	31 to 35	--	--
618	1245 Santa Clara Street – Alum Rock Counseling Center	Institutional	48	0	52	40	33 to 37	--	--
618	9 S 26th Street	SFR	48	178	52	35	29 to 33	--	--
619	30 N 25th Street	SFR	48	200	53	35	28 to 32	--	--
619	20 N 25th Street	SFR	48	160	53	35	21 to 25	--	--
619	1236 Santa Clara Street	SFR	48	68	53	35	29 to 33	--	--
619	1241 Shortridge Avenue	MFR	48	197	53	35	21 to 25	--	--
619	1211 Santa Clara Street	MFR	48	21	53	35	35 to 39	4	23 to 27
619	1226 Santa Clara Street	SFR	48	68	53	35	36 to 40	1	25 to 29
620	1220 Santa Clara Street – Sociedad Filharmonica	Institutional	48	45	53	40	31 to 35	--	--

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
620	1210 Santa Clara Street	SFR	48	35	53	35	39 to 43	1	28 to 32
622	45 N 25th Street	SFR	48	171	55	35	29 to 33	--	--
622	16 S 24th Street	SFR	48	114	55	35	32 to 36	1	22 to 26
623	1169 Santa Clara Street	SFR	48	60	56	35	37 to 41	1	26 to 30
623	1161 Santa Clara Street	SFR	48	70	56	35	29 to 33	--	--
623	16 N 24th Street	SFR	48	90	56	35	34 to 38	1	23 to 27
624	11 S 24th Street	SFR	48	137	56	35	22 to 26	--	--
625	13 Carnegie Square	SFR	48	149	56	35	30 to 34	--	--
626	1102 Santa Clara Street – East San Jose Carnegie Branch Library	Institutional	48	25	57	40	33 to 37	--	--
627	1115 Santa Clara Street – Portugese Community Center	Institutional	48	45	57	40	31 to 35	--	--
627	11 S 23rd Street	MFR	48	132	57	35	23 to 27	--	--
627	15 S 23rd Street	SFR	48	163	57	35	30 to 34	--	--
627	9 S 23rd Street	MFR	48	103	57	35	24 to 28	--	--
627	1098 Santa Clara Street – Casa Do Benfica	Institutional	48	18	57	40	33 to 37	--	--
628	1082 Santa Clara Street	MFR	48	19	57	35	35 to 39	5	23 to 27
628	16 S 22nd Street	SFR	48	119	57	35	32 to 36	1	22 to 26
628	1072 Santa Clara Street	MFR	48	19	57	35	35 to 39	10	23 to 27
629	1075 Santa Clara Street – Santa Clara County Multi Service Center	Institutional	48	85	58	40	28 to 32	--	--
630	15 S 22nd Street	SFR	48	160	58	35	30 to 34	--	--
630	1050 Santa Clara Street – Daniel B Martinez, MD	Institutional	48	37	58	40	39 to 43	1	27 to 31
631	1049 Santa Clara Street	SFR	48	72	58	35	36 to 40	1	25 to 29
631	1026 Santa Clara Street	SFR	48	45	58	35	38 to 42	1	27 to 31

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
631	1047 Santa Clara Street	SFR	48	70	58	35	36 to 40	1	25 to 29
632	8 S 21st Street	SFR	48	140	59	35	31 to 35	--	--
633	16 N 21st Street	SFR	48	135	59	35	31 to 35	--	--
633	19 S 21st Street	SFR	48	160	59	35	30 to 34	--	--
633	990 Santa Clara Street – Trinh Hung Quoc, MD	Institutional	48	60	59	40	37 to 41	1	26 to 30
634	20 S 20th Street	SFR	48	181	60	35	29 to 33	--	--
635	966 Santa Clara Street	MFR	48	56	60	35	31 to 35	--	--
636	19 S 20th Street	SFR	48	222	61	35	24 to 28	--	--
637	961 Santa Clara Street – Roosevelt Youth Center	Institutional	48	0	62	40	30 to 34	--	--
637	901 Santa Clara Street – Roosevelt Youth Center	Institutional	48	0	62	40	30 to 34	--	--
640	896 Santa Clara Street	MFR	48	150	67	35	26 to 30	--	--
640	884 Santa Clara Street	MFR	48	200	67	35	24 to 28	--	--
644	802 Santa Clara – Fire Station – Battalion 1	MFR	67	110	65	35	31 to 35	--	--
645	90 N 17th Street	SFR	67	240	65	35	25 to 29	--	--
647	765 Santa Clara Street	Institutional	67	0	65	35	33 to 37	1	22 to 26
648	765 Santa Clara Street	Institutional	67	0	63	40	43 to 47	1	30 to 34
648	10 N 16th Street	Institutional	67	0	63	40	43 to 47	1	30 to 34
649	675 Santa Clara Street	Hospital	67	0	62	35	35 to 39	1	23 to 27
649	748 Santa Clara Street	MFR	67	95	62	35	31 to 35	--	--

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
649	31 S 16th Street	SFR	67	236	62	35	18 to 22	--	--
651	22 S 15th Street	SFR	67	218	58	35	25 to 29	--	--
651	716 Santa Clara Street	MFR	67	100	58	35	31 to 35	--	--
651	675 Santa Clara Street	Hospital	67	0	58	35	30 to 34	--	--
652	12 S 15th Street #206 – Bay Area College of Nursing: Cagampan Bu	Institutional	67	78	58	40	27 to 31	--	--
654	25 S 15th Street – Dr Viet-Hong Bui	Institutional	67	59	57	40	29 to 33	--	--
654	678 Santa Clara Street – Buena Vista Eyecare Group	Institutional	67	54	57	40	36 to 40	--	--
655	652 Santa Clara Street – Elite Dental	Institutional	67	48	56	40	37 to 41	1	25 to 29
656	25 N 14th Street #Ste 55 – Norcal Care	Institutional	67	19	56	40	30 to 34	--	--
657	30 N 13th Street	MFR	67	122	57	35	22 to 26	--	--
658	602 Santa Clara Street – Indian Health Center of Santa Clara Vall	Institutional	67	31	57	40	33 to 37	--	--
658	28 S 13th Street	SFR	67	171	57	35	26 to 30	--	--
660	55 N 13th Street – Ming Li, MD	Institutional	67	119	57	40	29 to 33	--	--
660	26 S 12th Street	SFR	67	169	57	35	26 to 30	--	--
660	29 S 13th Street – Duong Bich-Hai Thi, DDS	Institutional	67	169	57	40	26 to 30	--	--
661	551 Santa Clara Street – Holistic Health Care Clinic (Chiropractic)	Institutional	67	31	57	40	33 to 37	--	--
661	32 N 12th Street	MFR	67	196	57	35	18 to 22	--	--
662	15 S 12th Street	SFR	67	128	56	35	29 to 33	--	--

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
663	12 S 11th Street	MFR	67	146	56	35	28 to 32	--	--
665	32 N 11th Street	MFR	67	182	54	35	19 to 23	--	--
665	478 Santa Clara Street – Santa Clara Dental	Institutional	67	29	54	40	41 to 45	1	28 to 32
667	35 N 11th Street	MFR	67	180	53	35	25 to 29	--	--
667	23 S 11th Street	SFR	67	167	53	35	26 to 30	--	--
668	471 Santa Clara Street – Darling & Fischer Garden Chapel Mortuary	Institutional	67	50	54	40	34 to 38	--	--
668	30 N 10th Street	MFR	67	167	54	35	26 to 30	--	--
668	22 S 10th Street	MFR	67	167	54	35	26 to 30	--	--
669	11 S 10th Street	MFR	67	30	55	35	43 to 47	6	30 to 34
669	25 S 10th Street	MFR	67	120	55	35	43 to 47	8	30 to 34
670	425 Elizabeth Street	SFR	67	121	55	35	30 to 34	--	--
670	425 Santa Clara Street – San Jose Fire Fighters Local 230	MFR	67	33	55	35	42 to 46	1	29 to 33
670	39 N 10th Street	SFR	67	168	55	35	26 to 30	--	--
670	421 Elizabeth Street	SFR	67	121	55	35	30 to 34	--	--
671	417 Elizabeth Street	SFR	67	121	54	35	30 to 34	--	--
672	401 Santa Clara Street	MFR	67	33	53	35	42 to 46	6	29 to 33
672	24 N 9th Street	SFR	67	156	53	35	27 to 31	--	--
672	18 S 9th Street	SFR	67	135	53	35	29 to 33	--	--
672	23 S 9th Street	MFR	67	166	53	35	26 to 30	--	--
673	390 Santa Clara Street	MFR	67	31	53	35	43 to 47	4	29 to 33
674	26 S 8th Street	MFR	67	166	53	35	26 to 30	--	--
674	389 Santa Clara Street – Street. Patrick's Proto-Cathedral	Institutional	67	60	53	40	32 to 36	--	--
675	365 Santa Clara Street – Our Lady of La Vang Parish	Institutional	67	65	53	40	31 to 35	--	--
676	25 S 8th Street	MFR	67	160	52	35	27 to 31	--	--

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
677	345 Santa Clara Street – 420 Medical Doctor	Institutional	67	40	52	40	42 to 46	1	31 to 35
679	24 S 7th Street	MFR	48	200	51	35	22 to 26	--	--
680	1295 Santa Clara Street – Horace Mann Elementary	Institutional	48	33	50	40	33 to 37	--	--
For Downtown San Jose Station East and West Options, see Table 4-18 and Table 4-19, respectively									
707	101 W Santa Clara Street – Chamber of Commerce Silicon Valley	Institutional	33	30	50	40	23 to 27	--	--
709	20 N Almaden Avenue		33	29	52	35	32 to 36	10	18 to 22
710	161 W Santa Clara Street – Masson Apartments	MFR	33	29	53	35	32 to 36	16	19 to 23
712	22 Almaden Avenue	MFR	33	144	57	35	29 to 33	--	--
715	233 W Santa Clara Street – Hotel De Anza	Hotel	33	29	60	35	19 to 23	--	--
716	38 N Almaden Boulevard – Axis Apartments	MFR	33	112	63	35	27 to 31	--	--
For Diridon Station South and North Alignment Options, see Table 4-20 and Table 4-21, respectively									
782	762 Harding Avenue	SFR	67	285	68	35	32 to 36	1	23 to 27
782	750 Harding Avenue	SFR	67	240	68	35	32 to 36	1	23 to 27
782	714 Harding Avenue	SFR	67	95	68	35	36 to 40	1	25 to 29
782	738 Harding Avenue	SFR	67	188	68	35	32 to 36	1	23 to 27
782	701 Harding Avenue	SFR	67	35	68	35	39 to 43	1	28 to 32
782	726 Harding Avenue	SFR	67	135	68	35	34 to 38	1	24 to 28
784	551 Stockton Avenue	SFR	67	35	69	35	38 to 42	1	27 to 31
784	713 Harding Avenue	SFR	67	85	69	35	35 to 39	1	25 to 29
784	761 Harding Avenue	SFR	67	280	69	35	32 to 36	1	23 to 27

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
784	749 Harding Avenue	SFR	67	235	69	35	32 to 36	1	23 to 27
784	737 Harding Avenue	SFR	67	185	69	35	32 to 36	1	23 to 27
784	725 Harding Avenue	SFR	67	135	69	35	34 to 38	1	24 to 28
785	714 Schiele Avenue	SFR	67	85	70	35	36 to 40	1	26 to 30
785	750 Schiele Avenue	SFR	67	245	70	35	32 to 36	1	23 to 27
785	738 Schiele Avenue	SFR	67	190	70	35	32 to 36	1	23 to 27
785	726 Schiele Avenue	SFR	67	145	70	35	26 to 30	--	--
785	599 Stockton Avenue	SFR	67	35	70	35	38 to 42	1	27 to 31
786	762 Schiele Avenue	SFR	67	275	70	35	32 to 36	1	23 to 27
787	733 Schiele Avenue	SFR	67	170	70	35	32 to 36	1	22 to 26
787	745 Schiele Avenue	SFR	67	217	70	35	32 to 36	1	23 to 27
787	757 Schiele Avenue	SFR	67	265	70	35	32 to 36	1	23 to 27
788	623 Stockton Avenue	SFR	67	50	70	35	37 to 41	1	26 to 30
788	766 Villa Avenue	SFR	67	290	70	35	32 to 36	1	23 to 27
788	635 Stockton Avenue	SFR	67	55	70	35	37 to 41	1	26 to 30
789	641 Stockton Avenue	SFR	67	40	69	35	38 to 42	1	27 to 31
789	647 Stockton Avenue	SFR	67	55	69	35	37 to 41	1	26 to 30
790	744 Villa Avenue	SFR	67	195	68	35	32 to 36	1	23 to 27
790	756 Villa Avenue	SFR	67	240	68	35	32 to 36	1	23 to 27
790	732 Villa Avenue	SFR	67	155	68	35	33 to 37	1	24 to 28
794	759 Villa Street	SFR	67	260	64	35	25 to 29	--	--
795	765 W Taylor Street	SFR	67	270	65	35	32 to 36	1	23 to 27
795	755 W Taylor Street	SFR	67	235	65	35	32 to 36	1	23 to 27
796	745 W Taylor Street	SFR	67	185	66	35	32 to 36	1	23 to 27
796	724 Laurel Street	SFR	67	290	66	35	32 to 36	1	23 to 27
797	727 Stockton Avenue	SFR	67	60	66	35	30 to 34	--	--
797	733 Stockton Avenue	SFR	67	35	66	35	39 to 43	1	28 to 32
798	732 Asbury Street	SFR	67	160	63	35	33 to 37	1	23 to 27

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
798	742 Asbury Street	SFR	67	200	63	35	32 to 36	1	23 to 27
798	702 Asbury Street	SFR	67	35	63	35	39 to 43	1	28 to 32
798	764 Asbury Street	SFR	67	260	63	35	24 to 28	--	--
798	722 Asbury Street	SFR	67	120	63	35	34 to 38	1	24 to 28
798	712 Asbury Street	SFR	67	80	63	35	37 to 41	1	26 to 30
799	755 Asbury Street	SFR	67	245	62	35	32 to 36	1	23 to 27
801	779 Stockton Avenue	SFR	67	55	60	35	37 to 41	1	26 to 30
SVSX = Silicon Valley Santa Clara Extension; SFR = Single-Family Residential, MFR = Multi-Family Residential, GBN = Groundborne Noise, IST = Isolated Slab Track									

Table 4-18: Groundborne Noise for Downtown San Jose Station East Option

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
683	235 Santa Clara Street – Vintage Tower (X-Over)	MFR	48	28	50	35	37 to 41	60	26 to 30
684	24 N 5th Street – First United Methodist Church (X-Over)	Institutional	48	28	49	40	42 to 46	1	31 to 35
685	200 Santa Clara Street – San Jose City Hall (X-Over)	Institutional	48	33	49	40	41 to 45	1	30 to 34
691	148 Santa Clara Street	MFR	48	34	49	35	29 to 33	-	--
691	138 Santa Clara Street	MFR	48	34	49	35	29 to 33	-	--
692	134 Santa Clara Street	MFR	48	34	48	35	29 to 33	-	--
693	118 Santa Clara Street	MFR	48	34	48	35	29 to 33	-	--
693	101 Santa Clara Street	MFR	48	27	48	35	31 to 35	-	--
693	100 Santa Clara Street	MFR	48	34	48	35	29 to 33	-	--
693	60 N 3rd Street – Town Park Towers	MFR	48	203	48	35	12 to 16	-	--
694	97 Santa Clara Street	MFR	48	31	49	35	36 to 40	4	23 to 27
697	20 S Second Street	MFR	48	141	50	35	24 to 28	-	--
701	15 S 1st Street – MFR above Commercial	MFR	48	90	51	35	29 to 33	-	--
701	1 N 1st Street – Lincoln Law School	Institutional	48	30	51	40	28 to 32	-	--

SVSX = Silicon Valley Santa Clara Extension; SFR = Single-Family Residential, MFR = Multi-Family Residential, GBN = Groundborne Noise, IST = Isolated Slab Track

Table 4-19: Groundborne Noise for Downtown San Jose Station West Option

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
683	235 Santa Clara Street – Vintage Tower	MFR	48	28	50	35	29 to 33	--	--
684	24 N 5th Street – First United Methodist Church	Institutional	48	28	49	40	34 to 38	--	--
685	200 Santa Clara Street – San Jose City Hall	Institutional	48	33	49	40	33 to 37	--	--
691	148 Santa Clara Street	MFR	48	30	49	35	29 to 33	--	--
691	138 Santa Clara Street	MFR	48	30	49	35	29 to 33	--	--
692	134 Santa Clara Street (X-Over)	MFR	48	30	48	35	31 to 35	--	--
693	118 Santa Clara Street (X-Over)	MFR	48	30	48	35	33 to 37	6	22 to 26
693	101 Santa Clara Street (X-Over)	MFR	48	27	48	35	40 to 44	4	28 to 32
693	100 Santa Clara Street (X-Over)	MFR	48	30	48	35	38 to 42	3	27 to 31
693	60 N 3rd Street – Town Park Towers	MFR	48	203	48	35	12 to 16	--	--
694	97 Santa Clara Street (X-Over)	MFR	48	31	49	35	44 to 48	4	31 to 35
697	20 S Second Street (X-Over)	MFR	48	141	50	35	27 to 31	--	--
701	15 S 1st Street – MFR above Commercial	MFR	48	90	51	35	29 to 33	--	--
701	1 N 1st Street – Lincoln Law School	Institutional	48	30	51	40	28 to 32	--	--

SVSX = Silicon Valley Santa Clara Extension; SFR = Single-Family Residential, MFR = Multi-Family Residential, GBN = Groundborne Noise, IST = Isolated Slab Track

Table 4-20: Groundborne Noise for Diridon North Alignment Option

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
734	35 S Autumn Street	SFR	33	270	55	35	24 to 28	--	-
735	56 S Montgomery Street – Templo La Hermosa	Institutional	48	450	55	40	21 to 25	--	-
745	88 Bush Street – Plant 51	MFR	48	210	58	35	13 to 17	--	-
748	754 The Alameda – Avalon at Cahill Park	MFR	48	25	58	35	33 to 37	218	20 to 24
748	53 Wilson Avenue	SFR	48	425	60	35	19 to 23	--	-
748	51 Wilson Avenue	SFR	48	375	60	35	19 to 23	--	-
749	49 Wilson Avenue	SFR	48	325	61	35	19 to 23	--	-
749	40 Sunol Street	MFR	48	420	61	35	19 to 23	--	-
749	34 Sunol Street	SFR	48	380	61	35	19 to 23	--	-
749	30 Sunol Street	SFR	48	330	61	35	19 to 23	--	-
749	24 Sunol Street	SFR	48	280	61	35	19 to 23	--	-
750	830 The Alameda	MFR	48	80	61	35	22 to 26	--	-
750	20 Sunol Street	SFR	48	245	61	35	19 to 23	--	-
751	33 Sunol Street	SFR	48	400	61	35	19 to 23	--	-
751	27 Sunol Street	SFR	48	350	61	35	19 to 23	--	-
752	24 Cleaves Avenue	SFR	48	420	62	35	19 to 23	--	-
753	938 The Alameda – Billy Defrank LGBT Community Center	Institutional	48	415	64	40	13 to 17	--	-
755	925 The Alameda – Lofts on The Alameda	MFR	48	120	65	35	17 to 21	--	-
754	87 Rhodes Court	SFR	48	53	64	35	30 to 34	--	-
754	128 Rhodes Court	SFR	48	40	65	35	32 to 36	1	22 to 26
754	152 Rhodes Court	SFR	48	60	65	35	30 to 34	--	-
754	109 Rhodes Court	SFR	48	25	64	35	37 to 41	1	25 to 29
755	133 Rhodes Court	SFR	48	25	64	35	37 to 41	1	25 to 29
755	157 Rhodes Court	SFR	48	25	64	35	31 to 35	--	-
755	176 Rhodes Court	SFR	48	100	64	35	31 to 35	--	-

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
755	179 Rhodes Court	SFR	48	25	64	35	24 to 28	--	-
755	200 Rhodes Court	SFR	48	130	64	35	31 to 35	--	-
756	176 N Morrison Avenue	MFR	48	118	64	35	30 to 34	--	-
756	201 Rhodes Court	SFR	48	25	64	35	31 to 35	--	-
756	229 Rhodes Court	SFR	48	25	64	35	31 to 35	--	-
757	204 N Morrison Avenue	SFR	48	86	64	35	31 to 35	--	-
755	224 Rhodes Court	SFR	48	160	64	35	30 to 34	--	-
756	248 Rhodes Court	SFR	48	180	64	35	30 to 34	--	-
757	173 N Morrison Avenue	Institutional	48	292	64	40	30 to 34	--	-
757	253 Rhodes Court	SFR	48	35	64	35	31 to 35	--	-
757	197 N Morrison Avenue	SFR	48	250	64	35	28 to 32	--	-
757	225 N Morrison Avenue	MFR	48	235	64	35	28 to 32	--	-
757	272 Rhodes Court	SFR	48	200	64	35	30 to 34	--	-
757	275 Rhodes Court	SFR	48	35	64	35	31 to 35	--	-
758	800 W Julian Street	SFR	48	240	62	35	30 to 34	--	-
758	264 N Morrison Avenue – Support Systems Homes Recovery Center	MFR	48	25	62	35	31 to 35	--	-
758	295 Rhodes Court	SFR	48	77	62	35	32 to 36	1	23 to 27
758	908 W Julian Street	SFR	48	25	62	35	31 to 35	--	-
758	920 W Julian Street	SFR	48	25	62	35	31 to 35	--	-
758	936 W Julian Street	SFR	48	25	62	35	31 to 35	--	-
764	909 W Julian Street	SFR	48	197	63	35	30 to 34	--	-
759	950 W Julian Street – Family And Children Services San Jose of	MFR	48	210	63	35	20 to 24	--	-
760	379 N Morrison Avenue	SFR	48	250	61	35	28 to 32	--	-
761	962 Cinnabar Street	SFR	48	340	61	35	30 to 34	--	-
761	956 Cinnabar Street	SFR	48	300	61	35	30 to 34	--	-
759	899 Morrison Park Dr – Avalon Morrison Park	MFR	48	25	63	35	24 to 28	--	-
762	910 Cinnabar Street	SFR	48	85	61	35	32 to 36	1	23 to 27

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
763	945 Cinnabar Street	SFR	48	245	60	35	30 to 34	--	-
762	890 Cinnabar Street	SFR	48	30	61	35	31 to 35	--	-
763	927 Cinnabar Street	SFR	48	210	60	35	30 to 34	--	-
763	870 Cinnabar Street	SFR	48	30	60	35	31 to 35	--	-
763	909 Cinnabar Street	SFR	48	173	60	35	30 to 34	--	-
763	850 Cinnabar Street	SFR	48	25	60	35	31 to 35	--	-
764	875 Cinnabar Street – Cinnabar Commons Apartments	MFR	48	25	60	35	25 to 29	--	-
764	434 N Morrison Avenue	SFR	48	275	60	35	30 to 34	--	-
766	417 Stockton Avenue	SFR	48	39	59	35	31 to 35	--	-
768	808 Lenzen Avenue	MFR	48	335	61	35	32 to 36	5	24 to 28
767	790 Lenzen Avenue	MFR	48	105	61	35	23 to 27	--	-
771	777 Lenzen Avenue	SFR	67	300	61	35	24 to 28	--	-
772	476 Lenzen Court	SFR	67	310	62	35	24 to 28	--	-
774	774 Pershing Avenue	SFR	67	320	64	35	32 to 36	1	23 to 27
774	762 Pershing Avenue	SFR	67	285	64	35	32 to 36	1	23 to 27
773	489 Stockton Avenue	SFR	67	40	63	35	38 to 42	1	27 to 31
774	750 Pershing Avenue	SFR	67	240	64	35	32 to 36	1	23 to 27
774	738 Pershing Avenue	SFR	67	190	64	35	32 to 36	1	23 to 27
774	726 Pershing Avenue	SFR	67	135	64	35	34 to 38	1	24 to 28
774	714 Pershing Avenue	SFR	67	92	64	35	36 to 40	1	26 to 30
774	495 Stockton Avenue	MFR	67	37	64	35	38 to 42	2	27 to 31
776	749 Pershing Avenue	SFR	67	230	65	35	32 to 36	1	23 to 27
776	761 Pershing Avenue	SFR	67	280	65	35	32 to 36	1	23 to 27
776	737 Pershing Avenue	SFR	67	185	65	35	32 to 36	1	23 to 27
776	711 Pershing Avenue	SFR	67	84	65	35	36 to 40	1	26 to 30
776	725 Pershing Avenue	SFR	67	133	65	35	34 to 38	1	24 to 28
776	501 Stockton Avenue	SFR	67	37	65	35	39 to 43	1	27 to 31

SVSX = Silicon Valley Santa Clara Extension; SFR = Single-Family Residential, MFR = Multi-Family Residential, GBN = Groundborne Noise, IST = Isolated Slab Track

Table 4-21: Groundborne Noise for Diridon South Alignment Option

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
736	35 S Autumn Street	SFR	33	35	48	35	30 to 34	--	-
737	56 S Montgomery Street – Templo La Hermosa	Institutional	48	189	46	40	27 to 31	--	-
745	88 Bush Street – Plant 51	MFR	48	0	49	35	32 to 36	265	20 to 24
748	754 The Alameda – Avalon at Cahill Park	MFR	48	0	49	35	32 to 36	218	20 to 24
750	53 Wilson Avenue	SFR	48	80	54	35	26 to 30	--	-
750	51 Wilson Avenue	SFR	48	35	54	35	33 to 37	1	22 to 26
750	49 Wilson Avenue	SFR	48	0	54	35	36 to 40	1	24 to 28
751	40 Sunol Street	MFR	48	90	54	35	25 to 29	--	-
752	34 Sunol Street	SFR	48	50	54	35	30 to 34	--	-
752	30 Sunol Street	SFR	48	0	55	35	36 to 40	1	24 to 28
752	24 Sunol Street	SFR	48	0	56	35	36 to 40	1	24 to 28
753	830 The Alameda	MFR	48	38	56	35	28 to 32	--	-
753	20 Sunol Street	SFR	48	0	56	35	36 to 40	1	24 to 28
753	33 Sunol Street	SFR	48	85	56	35	26 to 30	--	-
753	27 Sunol Street	SFR	48	40	56	35	32 to 36	1	21 to 25
754	24 Cleaves Avenue	SFR	48	115	57	35	23 to 27	--	-
756	938 The Alameda – Billy Defrank LGBT Community Center	Institutional	48	125	58	40	17 to 21	--	-
758	925 The Alameda – Lofts on The Alameda	MFR	48	0	62	35	33 to 37	40	20 to 24
759	87 Rhodes Court	SFR	48	115	64	35	24 to 28	--	-
758	128 Rhodes Court	SFR	48	250	62	35	20 to 24	--	-
759	152 Rhodes Court	SFR	48	276	64	35	20 to 24	--	-
759	109 Rhodes Court	SFR	48	130	64	35	23 to 27	--	-
760	133 Rhodes Court	SFR	48	107	61	35	25 to 29	--	-
760	157 Rhodes Court	SFR	48	132	61	35	31 to 35	--	-

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
760	176 Rhodes Court	SFR	48	0	61	35	30 to 34	--	-
760	179 Rhodes Court	SFR	48	151	61	35	21 to 25	--	-
760	200 Rhodes Court	SFR	48	0	61	35	30 to 34	--	-
761	176 N Morrison Avenue	MFR	48	20	62	35	31 to 35	--	-
761	201 Rhodes Court	SFR	48	169	62	35	30 to 34	--	-
761	229 Rhodes Court	SFR	48	186	62	35	30 to 34	--	-
761	204 N Morrison Avenue	SFR	48	40	62	35	31 to 35	--	-
761	224 Rhodes Court	0	48	0	62	35	30 to 34	--	-
761	248 Rhodes Court	0	48	0	62	35	30 to 34	--	-
762	173 N Morrison Avenue	Institutional	48	45	62	40	32 to 36	--	-
762	253 Rhodes Court	SFR	48	200	62	35	30 to 34	--	-
762	197 N Morrison Avenue	SFR	48	30	62	35	31 to 35	--	-
762	225 N Morrison Avenue	MFR	48	15	62	35	31 to 35	--	-
762	272 Rhodes Court	0	48	0	62	35	30 to 34	--	-
762	275 Rhodes Court	SFR	48	213	62	35	30 to 34	--	-
763	800 W Julian Street	0	48	0	62	35	30 to 34	--	-
763	264 N Morrison Avenue – Support Systems Homes Recovery Center	MFR	48	40	62	35	31 to 35	--	-
763	295 Rhodes Court	SFR	48	263	62	35	30 to 34	--	-
763	908 W Julian Street	SFR	48	224	62	35	30 to 34	--	-
763	920 W Julian Street	SFR	48	182	62	35	30 to 34	--	-
763	936 W Julian Street	SFR	48	141	62	35	31 to 35	--	-
764	909 W Julian Street	SFR	48	246	62	35	30 to 34	--	-
763	950 W Julian Street – Family And Children Services San Jose of	MFR	48	0	62	35	24 to 28	--	-
766	379 N Morrison Avenue	SFR	48	70	62	35	31 to 35	--	-
766	962 Cinnabar Street	SFR	48	175	62	35	30 to 34	--	-
766	956 Cinnabar Street	SFR	48	140	62	35	31 to 35	--	-
766	899 Morrison Park Dr – Avalon Morrison Park	MFR	48	0	62	35	24 to 28	--	-

Civil Station	Receiver Location	Land Use	SVSX Design Speed (mph)	Horizontal Distance to Near Track CL (feet)	Rail Depth (feet)	FTA GBN Criteria (dBA)	GBN Without Mitigation (dBA)	# of Receptors	GBN with IST Mitigation (dBA)
768	910 Cinnabar Street	SFR	48	0	63	35	31 to 35	--	-
768	945 Cinnabar Street	SFR	48	110	63	35	31 to 35	--	-
768	890 Cinnabar Street	SFR	48	0	63	35	31 to 35	--	-
768	927 Cinnabar Street	SFR	48	75	63	35	32 to 36	1	23 to 27
768	870 Cinnabar Street	SFR	48	29	63	35	31 to 35	--	-
769	909 Cinnabar Street	SFR	48	45	63	35	32 to 36	1	23 to 27
769	850 Cinnabar Street	SFR	48	62	63	35	32 to 36	1	23 to 27
769	875 Cinnabar Street – Cinnabar Commons	MFR	48	0	63	35	25 to 29	--	-
769	434 N Morrison Avenue	SFR	48	150	63	35	30 to 34	--	-
771	417 Stockton Avenue	SFR	48	41	62	35	32 to 36	1	22 to 26
772	808 Lenzen Avenue	MFR	48	240	63	35	32 to 36	5	24 to 28
773	790 Lenzen Avenue	MFR	48	20	63	35	25 to 29	--	-
775	777 Lenzen Avenue	SFR	67	278	63	35	24 to 28	--	-
776	476 Lenzen Court	SFR	67	280	63	35	24 to 28	--	-
778	774 Pershing Avenue	SFR	67	310	64	35	32 to 36	1	23 to 27
778	762 Pershing Avenue	SFR	67	250	64	35	32 to 36	1	23 to 27
778	489 Stockton Avenue	SFR	67	10	64	35	39 to 43	1	28 to 32
778	750 Pershing Avenue	SFR	67	210	64	35	32 to 36	1	23 to 27
778	738 Pershing Avenue	SFR	67	160	64	35	33 to 37	1	23 to 27
779	726 Pershing Avenue	SFR	67	115	65	35	35 to 39	1	25 to 29
779	714 Pershing Avenue	SFR	67	70	65	35	37 to 41	1	27 to 31
779	495 Stockton Avenue	MFR	67	10	65	35	39 to 43	2	28 to 32
780	749 Pershing Avenue	SFR	67	220	65	35	32 to 36	1	23 to 27
780	761 Pershing Avenue	SFR	67	270	65	35	32 to 36	1	23 to 27
780	737 Pershing Avenue	SFR	67	170	65	35	33 to 37	1	23 to 27
780	711 Pershing Avenue	SFR	67	70	65	35	37 to 41	1	27 to 31
780	725 Pershing Avenue	SFR	67	120	65	35	34 to 38	1	24 to 28
780	501 Stockton Avenue	SFR	67	26	65	35	40 to 44	1	28 to 32

SVSX = Silicon Valley Santa Clara Extension; SFR = Single-Family Residential, MFR = Multi-Family Residential, GBN = Groundborne Noise, IST = Isolated Slab Track

Single-Bore Option Tunnel

The second tunnel option is a single bore with bi-level tracks. Typically, the Single-Bore Option tunnel would be approximately 70 feet below ground compared to 40 feet with the Twin-Bore Option tunnel. On the lower level of the Single-Bore Option tunnel the tracks would be supported on the tunnel invert similar to Twin-Bore Option tunnel. On the upper level the tracks would be supported on a structural concrete slab spanning the width of the tunnel. Based on analyses for a similar bi-level tunnel, groundborne noise from the upper level are projected to be less than for the lower level by a significant amount.

Groundborne noise and vibration level projections were projected for the train operation on the lower track level of the Single-Bore Option for a limited number of receptors and compared to the levels for the Twin-Bore Option tunnel. The vibration projection model for the deeper tunnel was somewhat hindered due to the lack of vibration propagation test data at deeper depths because the tests did not, at the time (2004), envision a deeper tunnel.

Due to the greater depth of the Single-Bore Option tunnel, the projected groundborne noise levels would be less than those from the Twin-Bore Option tunnel. However, the difference is only projected to be in the range of 1 to 2 dBA less. In the engineering phase of the project, vibration propagation test data would be required for tunnel depths of the Single-Bore Option tunnel to define the specific mitigation required, if this is the selected alternative. For purposes of this analysis, where groundborne noise levels for the Twin-Bore Option exceed the noise criterion by 1 dBA or less in Table 4-17 through Table 4-21, mitigation would not be required for the Single-Bore Option.

4.1.5 Airborne Noise Impacts from Motor Vehicle Traffic

Traffic noise will increase over the existing ambient conditions due to an increase in the volume of traffic. The magnitude of increase in noise is proportional to the increase in traffic as presented in Section 3.4.1, *Prediction Model for Transit Vehicle Wayside Noise*. There will be a general increase in traffic associated with the No Project Alternative due to increased population and development in the region. For the Project Alternative, traffic associated with BART stations would also contribute to ambient noise in the future. The increase in noise for both the No Project Alternative and the Project Alternative is projected to be relatively small. Consequently, the increase in noise for the two alternatives can be assessed on a cumulative basis as presented in Chapter 5, *Cumulative Impacts*.

4.2 BART Extension plus Transit-Oriented Joint Development

The TOJD includes construction of commercial and residential buildings in the vicinity of the four stations and the two ventilation structures.

4.2.1 Construction Impacts

Construction impacts associated with TOJD would be similar to similarly sized building construction. Where existing residences are in proximity, there could be noise impacts. Construction activities would be conducted in accordance with City of San Jose and Santa Clara noise ordinances, thus minimizing the potential for noise impacts.

Alum Rock/28th Street Station TOJD

There are no residences adjacent to the construction area. Construction noise impacts associated with TOJD at this site would be similar to those for construction of the Alum Rock/28th Street Station.

Downtown San Jose Station TOJD

There are residences near both station options. Construction noise impacts associated with TOJD at this site would be similar to those for construction of the Downtown San Jose Station East and West Options.

Diridon Station TOJD

There are no residences adjacent to the construction area. Construction noise impacts associated with TOJD at this site would be similar to those for construction of the Diridon Station South and North Options.

Santa Clara Station TOJD

There are no residences adjacent to the construction area. The closest residences are across the existing railroad tracks and to the south. Construction noise impacts associated with TOJD at this site would be similar to those for construction of the Santa Clara Station.

Santa Clara and 13th Street Ventilation Structure TOJD

Residences are located to the north of and adjacent to the site. Construction noise impacts associated with TOJD at this site would be similar to those for construction of this ventilation structure, which would be enclosed within a building.

Stockton Avenue Ventilation Structure TOJD

Residences are located to the southwest and across Stockton Avenue. Construction noise impacts associated with TOJD at this site would be similar to those for construction of the ventilation structure, which would be enclosed within a building.

4.2.2 Operation Impacts

BART Extension and TOJD operational noise and vibration impacts are similar at all locations except for the Alum Rock/28th Street Station. At the Alum Rock/28th Street Station operation of the BART trains may result in impacts on the proposed TOJD residences due to their proximity to BART train operations. Projections indicate that the groundborne noise inside the residences could be as much as 36 dBA, or slightly over the FTA criterion. To mitigate these impacts, IST could be installed in the station area (see Section 4.1.3, *Ancillary Facilities Impacts from Operations*), or residential buildings may need to be vibration-isolated. Therefore, vibration mitigation would be required for the TOJD if residential units would be exposed to vibration levels exceeding the FTA criteria.

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5.1 Study Area

Although traffic would increase throughout the area, the increases are small enough not to produce significant increases in noise. Consequently, the noise analysis focuses just on the areas around the stations and compares the existing conditions with 2035 No Project conditions and 2035 with the BART Extension and TOJD conditions. Vibration impacts would not be cumulative because they are site specific and no other substantial generators of vibration are anticipated along the alignment or near the stations and facilities.

5.2 Noise Impact Discussion

Table 5-1 shows the projected increase in traffic volumes at intersections that are associated with the BART Extension stations and TOJD (also termed *the Project* for CEQA purposes). Also shown are the expected increase in peak hour noise levels due to these traffic increases.

Most of the intersections shown in Table 5-1 are not in residential neighborhoods. The intersection at N. 28th Street and Santa Clara Street is in a residential area. It is representative of the changes in traffic that could occur along Santa Clara Street.

With the Project, the increase is 2.4 dBA, which is 1.0 dBA greater than the increase for the No Project. As shown in Table 4-6, the L_{dn} along Santa Clara Street is 69 dBA. An increase in L_{dn} by 1.1 dBA from 69 (i.e., future L_{dn} of 70.1) would result in a moderate impact. An increase of 2.9 dBA would result in a severe impact. Consequently, a combined increase due to the No Project plus the Project of 2.4 dBA would result in a moderate impact of which 1.0 dBA was attributable to the Project and 1.4 dBA was due to an increase in traffic without the Project. This is the intersection with the greatest increase in noise of the Project Alternative compared to the No Project Alternative.

In general, the cumulative noise increases from the year 2015 to 2035 without the Project due to projected traffic increases ranges from 0.4 to 1.9 dBA. Traffic associated with the Project would increase the traffic noise from the year 2015 an additional 0.1 to 1.0 dBA, for a cumulative increase of from 1.2 to 2.0 dBA. Consequently, the Project would not result in a significant noise impact due to increases in traffic. Furthermore, there would be no cumulative impact from traffic noise for the Project.

Table 5-1: Traffic Noise Impacts

Intersection	Station	Peak Hour Traffic Counts			Peak Hour Noise Increase (dBA)	
		Existing Conditions (AM / PM)	2035 Cumulative No Project (AM / PM)	2035 Cumulative With Project (AM / PM)	2035 Cumulative – No Project Over Existing (AM / PM)	2035 Cumulative – With Project Over Existing (AM / PM)
US 101 and Santa Clara Street	Alum Rock/ 28th Street	2,011 / 2,722	2,475 / 3,683	2,631 / 3,940	0.9 / 1.3	1.2 / 1.6
US 101 southbound ramps and E. Julian Street	Alum Rock/ 28th Street	2,834 / 2,982	3,519 / 3,621	3,887 / 3,906	0.9 / 0.8	1.4 / 1.2
US 101 northbound ramps and McKee Road	Alum Rock/ 28th Street	2,919 / 3,332	3,833 / 4,219	4,004 / 4,361	1.2 / 1.0	1.4 / 1.2
N. 28th Street and Santa Clara Street	Alum Rock/ 28th Street	1,858 / 1,996	2,546 / 2,357	3,205 / 2,959	1.4 / 0.7	2.4 / 1.7
24th Street and Santa Clara Street	Alum Rock/ 28th Street	2,081 / 2,244	3,088 / 3,043	3,360 / 3,326	1.7 / 1.3	2.1 / 1.7
N. 28th Street and E. Julian Street	Alum Rock/ 28th Street	2,011 / 1,949	2,401 / 2,145	2,935 / 2,683	0.8 / 0.4	1.6 / 1.4
26th Street and Santa Clara Street	Alum Rock/ 28th Street	1,369 / 1,659	1,821 / 1,928	2,113 / 2,137	1.2 / 0.7	1.9 / 1.1
Coleman Avenue and I-880 southbound ramps	Santa Clara	4,837 / 4,515	7,064 / 6,452	7,102 / 6,529	1.6 / 1.6	1.7 / 1.6
El Camino Real and Benton Street	Santa Clara	2,024 / 2,385	3,114 / 3,549	3,203 / 3,654	1.9 / 1.7	2.0 / 1.9
El Camino Real and Railroad Avenue	Santa Clara	2,109 / 2,302	3,150 / 3,382	3,202 / 3,514	1.7 / 1.7	1.8 / 1.8
El Camino Real and The Alameda	Santa Clara	2,353 / 2,978	3,075 / 4,027	3,303 / 4,140	1.2 / 1.3	1.5 / 1.4

Chapter 6
Mitigation Measures

6.1 Construction Noise and Vibration Mitigation

Construction impacts can be mitigated by implementing noise control measures and limiting the types of equipment and activity that create high vibration levels.

6.1.1 Construction Noise Mitigation

Where noise sensitive uses are potentially impacted by construction noise, long-term noise monitoring will be implemented based on a detailed noise control plan. The plan will include temporary measures that will be implemented where feasible to reduce construction noise impacts to nearby, noise-sensitive receivers such as residences, schools, and hospitals. Such temporary measures could include but are not limited to noise walls or noise blankets.

Construction activities would be carried out in compliance with FTA criteria and guidelines, and any applicable local regulations. In addition, specific property line noise and vibration limits should be developed during final design and included in the construction noise and vibration specifications for the Project, and regular noise and vibration monitoring should be performed during construction to verify compliance with these limits. This approach allows the contractor flexibility to meet the noise and vibration limits in the most efficient and cost-effective manner. Following are noise and vibration control measures that may be applied as needed to meet the noise and vibration limits:

- Window treatments should be upgraded.
- A comprehensive construction noise and vibration specification should be incorporated into all construction bid documents. The existence and importance of noise and vibration control specifications should be emphasized at pre-bid and preconstruction conferences, if necessary.
- Stationary equipment, such as generators and compressors, should be located as far as feasible from noise- and vibration-sensitive sites, and be acoustically treated. Grout batch plants, and grout silos, mixers, and pumps, and diesel pumping equipment should also be located as far as feasible from noise-sensitive sites and be acoustically treated, if necessary.
- Temporary noise barriers, as shown in Figure 6-1 and Figure 6-2, or noise control blankets should be constructed in areas between noisy activities and noise-sensitive receptors, where practical and effective. Temporary noise barriers can reduce construction noise by 5 to 15 dB, depending on the height and placement of the barrier. To be most effective, the barrier should be placed as close as possible to the noise source

or the sensitive receptor. Temporary barriers tend to be particularly effective because they can be easily moved as work progresses to optimize performance. If temporary noise barriers and site layout do not result in compliance with the noise criteria, retrofitting existing windows and doors with new acoustically rated units may be considered for the residential structures.

- Electric instead of diesel-powered equipment, hydraulic tools instead of pneumatic impact tools, and electric instead of air- or gasoline driven saws should be used where feasible.
- Augering drill-rigs should be used for setting piles in lieu of impact pile drivers.
- Equipment should be operated so as to minimize banging, clattering, buzzing, and other annoying types of noises, especially near residential areas during the nighttime hours.
- Idling equipment should be turned off whenever possible.
- Hoppers, conveyor transfer points, storage bins, and chutes should be lined or covered with sound-deadening material.
- Construction-related truck traffic should be routed along truck routes and roadways that would cause the least disturbance to residents. Loading and unloading zones should be laid out to minimize truck idling near sensitive receptors and to minimize truck reversing so back-up alarms do not affect residences.
- At nighttime and weekends, strobe warning lights and/or back-up observers should be used during any back-up operations, where permitted by the local jurisdiction.
- Haul truck beds should be lined with rubber or sand to reduce impact noise, if needed and requested by the Resident Engineer.
- Steel and/or concrete plates over excavated holes and trenches should be secured to reduce rattling when vehicles pass over. Use of thicker plates, stiffer beams beneath the plates, and rubber gaskets between the beams and plates would also reduce rattling noise.
- The Contractor should use the best available practices to reduce the potential for excessive noise and vibration from construction activities. This may require the use of equipment with special exhaust silencers, construction of temporary enclosures or noise barriers around activities, and tracks for the tracked vehicles to be in good condition.
- Local jurisdiction construction time periods should be adhered to, to the extent feasible, recognizing that nighttime and weekend construction may be necessary and/or preferred by VTA and local jurisdictions to reduce other related environmental impacts such as traffic. Note that the Cities of San Jose and Santa Clara have limitations on construction operations during the nighttime and weekends.

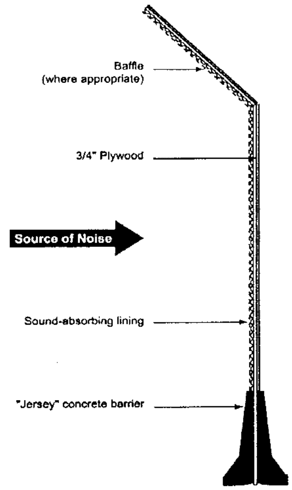

Figure 6-1: Example of Temporary Noise Wall

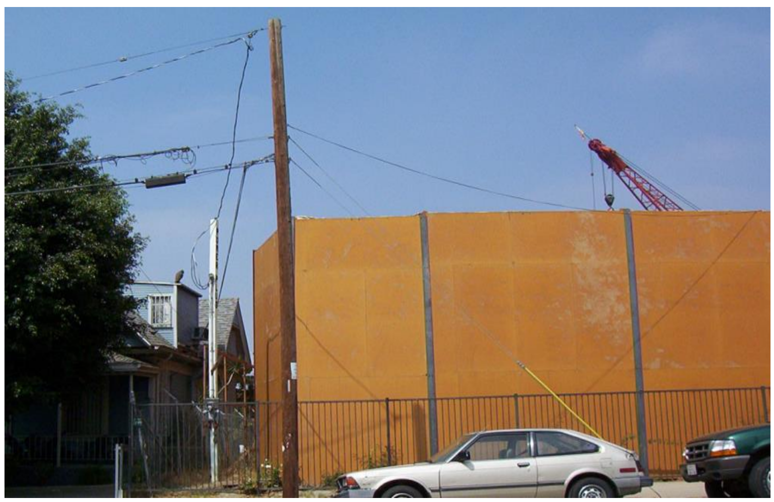

Figure 6-2: Photo of a Temporary Noise Wall

- The Contractor should be required to perform preconstruction ambient noise measurements at the East and West Portal construction staging areas, at the station and ventilation shaft areas, and at the gap breaker station areas. This will serve to document the noise environment prior to start of construction. These measurements should be performed over a minimum of 10 days at the staging areas and station and ventilation shaft areas. At the gap breaker station sites, 4 days of noise measurements would be sufficient.
- The contractor should be required to submit to the Resident Engineer a Noise Control Plan and a Noise Monitoring Plan, prepared by a qualified Acoustical Engineer. The qualifications and activities of the Acoustical Engineer should be subject to approval of the Resident Engineer. The Noise Control Plan should be updated every 3 months and include all the pertinent information about the equipment and the construction site layout, the projected noise levels, and the noise mitigation measures that may be required to

comply with the noise limits for each sensitive receptor. The Noise Monitoring Plan should outline the equipment and procedures used by the contractor to perform noise measurements, and to identify noise-sensitive structures in the immediate vicinity of construction operations, including details regarding the noise measurement locations. The results of noise monitoring should be documented and reported. In the event that levels exceed allowable limits, the Resident Engineer should ensure that contractually required corrective measures are implemented.

- The minimum qualifications for the Acoustical Engineer should be a Bachelor of Science or Engineering degree, from a qualified program in engineering or physics offered by an accredited university or college, and 5 years of experience in noise control engineering and construction noise analysis.
- The Contractor should be required to *not* operate noise-generating equipment at the construction site prior to VTA approval of the Noise Monitoring Plan and the Noise Control Plan.
- The Contractor should install permanent noise monitors at the Downtown San Jose Station and Diridon Station during all construction phases, sampling continuously at two monitoring location at each station. The monitoring location may be moved as the construction site progresses. At the Alum Rock/28th Street Station and the West Portal staging area, permanent noise monitors should also be initially installed, which may be removed if the noise levels are in compliance with the noise limits when the construction activities are closest to the sensitive receptors.

  In addition to these permanent noise monitors, 30-minute noise sampling should also be required weekly at the station sites and at other construction sites, including the ventilation shafts and gap breaker station sites to ensure compliance with the noise criteria. If required, additional noise monitoring site(s) may be added by the Resident Engineer to address any specific situation and concern.

  The noise data should be submitted to the Resident Engineer on a weekly basis, including details and location of construction activity, and details and sketch of noise monitoring location.
- For equipment to be used at the surface of the construction site for a total duration greater than 5 days, equipment should be used that is pre-certified by the Acoustical Engineer during field measurements at a test site or guaranteed by the equipment vendor to meet the noise limits developed for construction equipment, as shown in Table 6-1. The final limits to be applied should be re-examined and developed during final design. Construction equipment should be retested at 6-month intervals while in use on site. Any equipment used during construction may be subject to confirmatory noise level testing by the Contractor at the request of the Resident Engineer.

Table 6-1: Noise Emission Limits for Construction Equipment

Equipment Type	Typical L_{max} Sound Level at 50 feet (dBA)
Excavators	82
Dump trucks	81
Front end loaders	81
Dozers	82
Concrete trucks	77
Cranes	81
Backhoes	75
Compactors	77
Concrete pumping trucks	77
Small construction vehicles (pickup trucks)	68
Large and small diameter auger drill-rigs	81
Diesel generators	69*
Flat-bed semi-trucks	81
Diesel pumping equipment	77
Compressed-air construction tools	81
Rail welding plant	77
Air compressors	70*
Muck conveyor	70
Grout batch plant	80
Welding equipment	73
Grout silos	70
Grout mixers	71
Grout pumps	77
* Assumed acoustically treated	

- A public notification program should be implemented to alert residents and institutions well in advance of particular disruptive construction activities.
- A complaint resolution procedure should also be put in place to rapidly address any noise and vibration problems that may develop during construction.

With incorporation of the construction noise mitigation measures presented above and development of comprehensive construction noise specifications, and a noise mitigation and monitoring plan, construction noise impacts for either the Twin-Bore Option or Single-Bore Option tunnel, stations, and alignment options can be minimized. However, construction noise impacts at the Downtown San Jose (East and West Options) and Diridon Stations would remain significant and unavoidable for all options.

6.1.2 Construction Vibration Mitigation

A comprehensive and detailed Vibration Monitoring Plan will be developed prior to construction and will include the following requirements:

- Develop comprehensive construction vibration specifications that limit the contractor from exceeding thresholds that would cause structural or cosmetic damage to adjacent structures.
- Conduct long-term vibration monitoring during construction for buildings that are sensitive to construction vibration.
- Conduct vibration monitoring daily at the nearest representative affected buildings during major construction activities. Vibration measurements should be measured in the vertical direction on ground surface or building floor and measured during peak vibration-generating construction activities. If the measured vibration data is in compliance with the vibration limits, either in terms of velocity levels in dB re 10^{-6} inch/second or PPV, vibration monitoring may be performed weekly instead of the daily monitoring.
- Perform vertical direction vibration (RMS) monitoring on the ground at the nearest representative residential structure during supply train operations in the tunnels. These measurements should be repeated at approximately 1-mile intervals along the tunnel construction.
- Monitor vibration for PPV where vibration is expected to approach the applicable limit based on the building type and condition.

With incorporation of construction vibration mitigation measures presented above, construction vibration impacts for either the Twin-Bore Option or Single-Bore Option tunnel, stations, alignment options, and cut-and-cover activities would be mitigated to less than significant.

6.2 Operational Groundborne Noise Mitigation

Mitigation measures necessary to reduce groundborne noise impacts are presented in Section 4.1.2. Mitigation measures are also indicated in the tables in Section 4.1.3. During the engineering phase of the Project, the specific groundborne noise mitigation measures to be implemented will be re-evaluated based on the final design parameters to ensure that the FTA criteria is achieved.

6.2.1 Twin-Bore Option Tunnel Alignment Mitigation

The types of mitigation measures and their extents along the tunnel alignment are indicated in Table 6-2 for the Twin-Bore Option alignment excluding the four options (Downtown San Jose Station East and West Options and Diridon Station South and North Options). Table 6-3 and Table 6-4 indicate the extent of mitigation for the Downtown San Jose Station East and

West Options, respectively. Tables 6-5 and 6-5 indicate the extent of mitigation for the Diridon Station South and North Options.

For the Downtown San Jose Station West Option crossover, mitigation includes either an IST or FST. To mitigate with an IST, a total length of approximately 1,100 feet of IST would be installed underneath the entire crossover (approximately from 692+00 to 697+50). The IST may increase vibration at nearby receptors, for example at 97 Santa Clara Street. Alternatively, an FST would mitigate amplification of vibration at frequencies affecting these receptors.

Table 6-2: Groundborne Noise Mitigation – Twin-Bore Option Alignment

S1 Track	S2 Track
617+50 to 638+75	618+00 to 639+50
645+75 to 656+00	646+25 to 656+50
662+25 to 677+50	663+00 to 678+00
For Downtown San Jose Station East and West Options see Tables 6-3 and 6-4, respectively	
708+00 to 713+00	708+50 to 713+50
For Diridon Station South and North Options, see Tables 6-5 and 6-6, respectively	
782+00 to 802+75	783+00 to 803+75
Total IST: 14,500 feet	
IST = Isolated Slab Track	

Table 6-3: Groundborne Noise Mitigation – Twin-Bore, Downtown San Jose Station (East Option)

S1 Track	S2 Track
682+25 to 695+50	682+75 to 696+00
Total IST: 2,650 feet	
IST = Isolated Slab Track	

Table 6-4: Groundborne Noise Mitigation – Twin-Bore, Downtown San Jose Station (West Option)

S1 Track	S2 Track
692+00 to 697+50	692+50 to 698+00
Total IST: 1,100 feet	
IST = Isolated Slab Track	

Table 6-5: Groundborne Noise Mitigation – Twin-Bore, Diridon Station (South Option)

S1 Track	S2 Track
744+25 to 761+75	744+75 to 763+00
767+25 to 773+25	769+00 to 774+50
777+75 to 782+00	779+00 to 783+00
Total IST: 5,550 feet	
IST = Isolated Slab Track	

Table 6-6: Groundborne Noise Mitigation – Twin-Bore, Diridon Station (North Option)

S1 Track	S2 Track
745+75 to 758+75	746+50 to 760+00
761+50 to 769+25	762+75 to 770+50
773+00 to 777+00	774+00 to 778+00
Total IST: 5,000 feet	
IST = Isolated Slab Track	

6.2.2 Single-Bore Option Tunnel Alignment Mitigation

Because of the greater depth, mitigation for the Single-Bore Option tunnel will be less than for the Twin-Bore Option tunnel. A conservative analysis approach as outlined in Section 4.1.4, *Groundborne Noise and Vibration Impacts from Operations,* was used to evaluate the Single-Bore Option tunnel alignment. The conclusion was that mitigation would only be required for locations with groundborne noise levels greater than 1 dBA above the Twin-Bore Option projection.

Table 6-7 indicates the mitigation for the Single-Bore Option alignment. Tables 6-8 and 6-9 indicate the mitigation for the Diridon Station South and North Options alignment, respectively. The mitigation for the Downtown San Jose Station East and West Options is the same as the mitigation for the Twin-Bore Option tunnel based on this conservative evaluation.

The mitigation indicated in these tables does not account for the mitigating effects of the upper track in the Single-Bore Option. This would reduce groundborne noise, which would result in less mitigation, if not eliminate the need for mitigation on the upper track level.

Table 6-7 Groundborne Noise Mitigation – Single-Bore Alignment

S1 Track	S2 Track
618+00 to 632+50	618+25 to 633+00
645+00 to 653+50	645+75 to 654+00
662+25 to 677+50	663+00 to 678+00
For Downtown San Jose Station East and West Options see Tables 6-3 and 6-4, respectively	
For Diridon Station South and North Options see Tables 6-8 and 6-9, respectively	
782+00 to 791+00	783+00 to 792+00
796+00 to 801+00	797+00 to 802+00
Total IST: 10,425 feet	
IST = Isolated Slab Track	

Table 6-8 Groundborne Noise Mitigation – Single-Bore, Diridon Station (South Option)

S1 Track	S2 Track
749+25 to 755+00	750+00 to 756+00
777+75 to 782+00	779+00 to 783+00
Total IST: 2,000 feet	

Table 6-9 Groundborne Noise Mitigation – Single-Bore, Diridon Station (North Option)

S1 Track	S2 Track
745+75 to 757+00	746+50 to 758+00
773+00 to 777+00	774+00 to 778+00
Total IST: 3,075 feet	
IST = Isolated Slab Track	

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Chapter 7
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Chapter 8
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Appendix A: Vibration Propagation Test Data

Table A-1: Borehole BH-3 Line Source Response Coefficients at 50-foot Depth

Frequency (Hz)	A	B	C	D
6.3	12.91	2.95	0	0
8	21.12	-0.24	0	0
10	23.77	-1.68	0	0
12.5	19.96	0.42	0	0
16	25.00	-4.04	0	0
20	27.85	-5.70	0	0
25	27.51	-5.33	0	0
31.5	37.08	-12.40	0	0
40	28.25	-10.02	0	0
50	26.99	-13.21	0	0
63	18.75	-8.81	0	0
80	19.81	-9.88	0	0
100	27.10	-13.47	0	0
125	10.17	-7.73	0	0
160	-1.03	-4.35	0	0

$$LSR = A + B \cdot \log(d) + C \cdot \log^2(d) + D \cdot \log^3(d)$$

Figure A- 1: Borehole BH-3 Line Source Response at 50-foot Depth

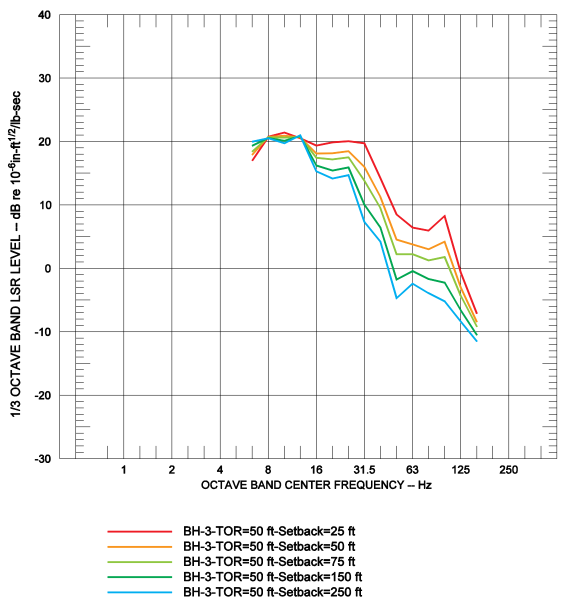

Table A-2: Borehole BH-10 Line Source Response Coefficients at 59-foot Depth

Frequency (Hz)	A	B	C	D
6.3	20.45	-4.62	0	0
8	21.91	-4.76	0	0
10	22.59	-4.00	0	0
12.5	14.51	1.19	0	0
16	34.30	-9.92	0	0
20	33.94	-8.93	0	0
25	33.58	-8.47	0	0
31.5	38.33	-10.97	0	0
40	34.06	-10.29	0	0
50	35.15	-13.31	0	0
63	45.35	-18.35	0	0
80	44.71	-18.07	0	0
100	45.46	-20.53	0	0
125	39.77	-21.62	0	0
160	17.78	-13.31	0	0

$$LSR=A+B\cdot\log(d)+C\cdot\log^2(d)+D\cdot\log^3(d)$$

Figure A-2: Borehole BH-10 Line Source Response at 59-foot Depth

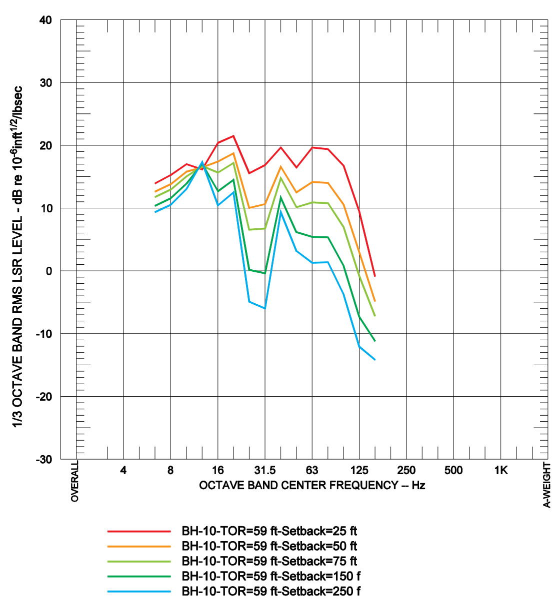

Table A-3: Borehole BH-10 Line Source Response Coefficients at 64-foot Depth

Frequency (Hz)	A	B	C	D
6.3	14.95	-2.04	0	0
8	20.68	-4.54	0	0
10	18.63	-2.52	0	0
12.5	13.88	0.67	0	0
16	28.96	-7.91	0	0
20	29.09	-7.14	0	0
25	32.21	-8.98	0	0
31.5	36.11	-10.82	0	0
40	36.58	-12.46	0	0
50	38.90	-15.46	0	0
63	44.66	-18.31	0	0
80	47.62	-20.29	0	0
100	43.33	-20.01	0	0
125	44.20	-23.83	0	0
160	19.79	-13.87	0	0

$$LSR=A+B\cdot\log(d)+C\cdot\log^2(d)+D\cdot\log^3(d)$$

Figure A-3: Borehole BH-10 Line Source Response at 64-foot Depth

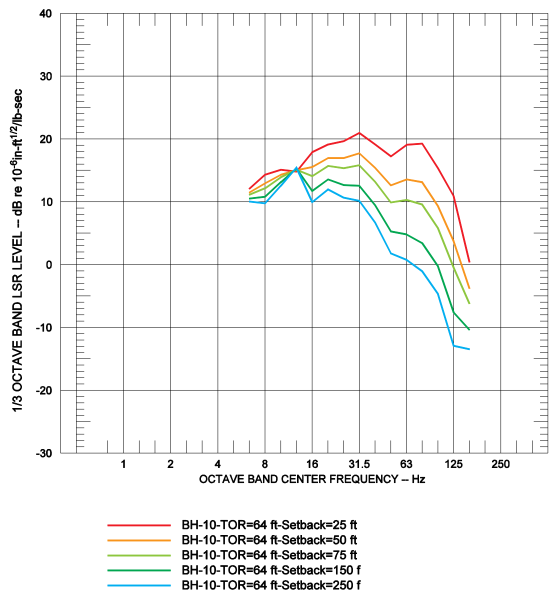

Table A-4: Borehole BH-10 Line Source Response Coefficients at 69-foot Depth

Frequency (Hz)	A	B	C	D
6.3	11.53	-0.47	0	0
8	20.21	-4.62	0	0
10	15.82	-1.38	0	0
12.5	10.33	1.83	0	0
16	27.59	-8.11	0	0
20	27.30	-6.77	0	0
25	31.93	-9.56	0	0
31.5	37.87	-12.12	0	0
40	43.48	-15.83	0	0
50	45.24	-18.44	0	0
63	45.73	-18.58	0	0
80	47.40	-19.83	0	0
100	48.06	-22.33	0	0
125	52.69	-27.72	0	0
160	23.96	-15.37	0	0

$$LSR=A+B\cdot\log(d)+C\cdot\log^2(d)+D\cdot\log^3(d)$$

Figure A-4: Borehole BH-10 Line Source Response at 69-foot Depth

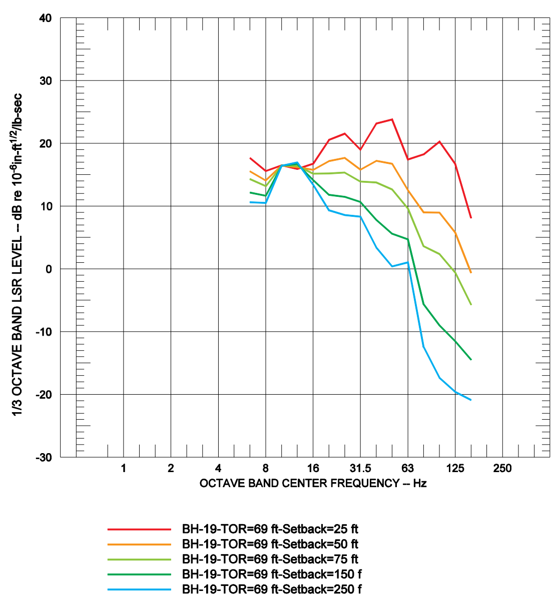

Table A-5: Borehole BH-15 (with contributions from BH-10)
Line Source Response Coefficients at 80-foot Depth

Frequency (Hz)	A	B	C	D
6.3	15.59	-4.31	0	0
8	18.77	-5.36	0	0
10	19.30	-3.75	0	0
12.5	20.84	-4.18	0	0
16	29.99	-8.74	0	0
20	31.20	-9.38	0	0
25	25.51	-5.84	0	0
31.5	26.11	-6.60	0	0
40	20.95	-6.46	0	0
50	26.80	-10.24	0	0
63	36.98	-15.38	0	0
80	46.13	-21.30	0	0
100	38.83	-19.35	0	0
125	38.68	-22.13	0	0
160	29.63	-20.13	0	0

$$LSR=A+B\cdot\log(d)+C\cdot\log^2(d)+D\cdot\log^3(d)$$

Figure A-5: Borehole BH-15 (contributions from BH-10)
Line Source Response at 80-foot Depth

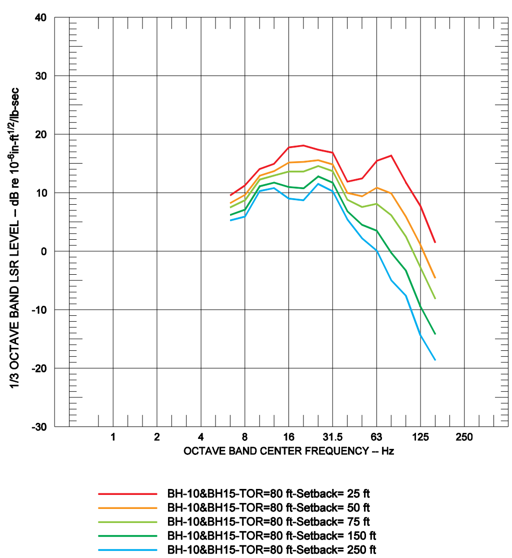

Table A-6: Borehole BH-15 (with contributions from BH-19)
Line Source Response Coefficients at 83-foot Depth

Frequency (Hz)	A	B	C	D
6.3	13.42	-2.59	0	0
8	15.16	-3.47	0	0
10	13.10	-0.17	0	0
12.5	14.26	-1.04	0	0
16	21.70	-4.98	0	0
20	28.24	-8.49	0	0
25	22.70	-5.14	0	0
31.5	21.29	-4.97	0	0
40	28.71	-10.16	0	0
50	38.92	-15.54	0	0
63	33.83	-13.68	0	0
80	47.26	-23.18	0	0
100	52.05	-27.02	0	0
125	57.68	-31.45	0	0
160	50.89	-30.22	0	0

$$LSR=A+B\cdot\log(d)+C\cdot\log^2(d)+D\cdot\log^3(d)$$

Figure A-6: Borehole BH-15 (contributions from BH-19)
Line Source Response at 83-foot Depth

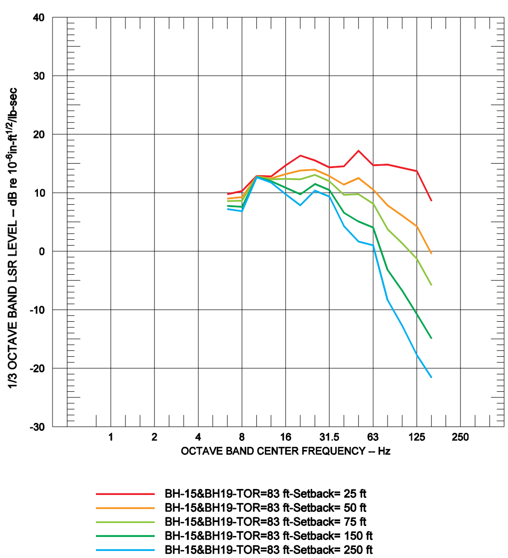

Table A-7: Borehole BH-19 Line Source Response Coefficients at 64-foot Depth

Frequency (Hz)	A	B	C	D
6.3	23.26	-4.97	0	0
8	24.10	-6.30	0	0
10	16.93	-0.91	0	0
12.5	15.20	0.81	0	0
16	24.11	-4.97	0	0
20	33.51	-9.75	0	0
25	41.50	-13.93	0	0
31.5	38.64	-12.70	0	0
40	46.25	-17.62	0	0
50	55.09	-22.61	0	0
63	48.42	-20.32	0	0
80	67.52	-33.48	0	0
100	76.27	-38.89	0	0
125	72.64	-37.94	0	0
160	55.09	-31.19	0	0

$$LSR = A + B \cdot \log(d) + C \cdot \log^2(d) + D \cdot \log^3(d)$$

Figure A-7: Borehole BH-19 Line Source Response at 64-foot Depth

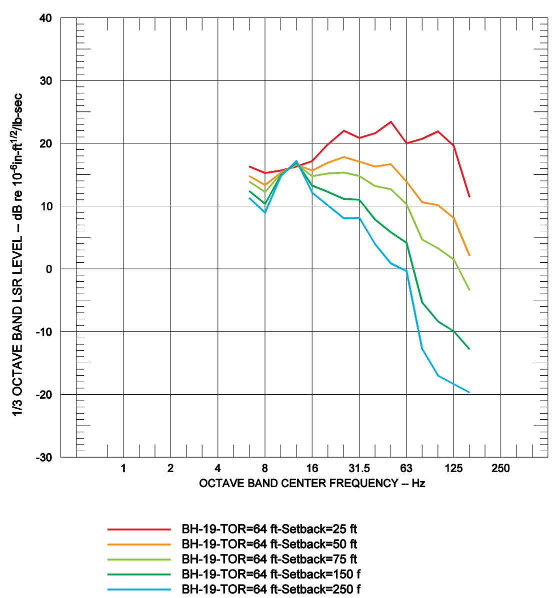

Table A-8: Borehole BH-23 Line Source Response Coefficients at 53-foot Depth

Frequency (Hz)	A	B	C	D
6.3	19.05	-3.19	0	0
8	23.95	-4.71	0	0
10	19.58	-1.75	0	0
12.5	25.20	-2.80	0	0
16	32.62	-6.54	0	0
20	28.41	-6.31	0	0
25	30.69	-7.69	0	0
31.5	33.07	-10.44	0	0
40	38.38	-13.79	0	0
50	27.29	-12.92	0	0
63	38.81	-14.96	0	0
80	55.86	-24.88	0	0
100	56.53	-25.92	0	0
125	44.47	-22.43	0	0
160	28.96	-18.61	0	0

$$LSR=A+B\cdot\log(d)+C\cdot\log^2(d)+D\cdot\log^3(d)$$

Figure A-8: Borehole BH-23 Line Source Response at 53-foot Depth

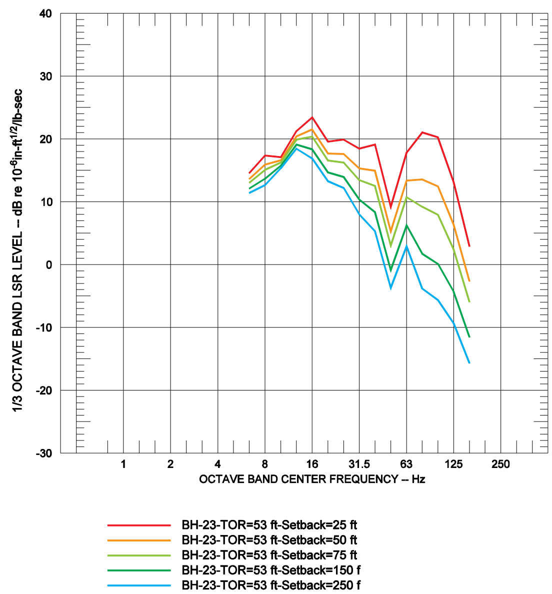

Table A-9: Borehole BH-27 Line Source Response Coefficients at 51-foot Depth

Frequency (Hz)	A	B	C	D
6.3	22.00	-3.40	0	0
8	22.00	-2.49	0	0
10	30.75	-7.34	0	0
12.5	18.61	-0.92	0	0
16	26.52	-5.16	0	0
20	25.24	-4.84	0	0
25	18.18	-1.95	0	0
31.5	13.57	-0.27	0	0
40	28.56	-7.16	0	0
50	37.48	-12.18	0	0
63	33.95	-12.29	0	0
80	37.13	-15.95	0	0
100	34.18	-17.78	0	0
125	54.02	-29.17	0	0
160	35.67	-22.76	0	0

$$LSR=A+B \cdot \log(d)+C \cdot \log^2(d)+D \cdot \log^3(d)$$

Figure A-9: Borehole BH-27 Line Source Response at 51-foot Depth

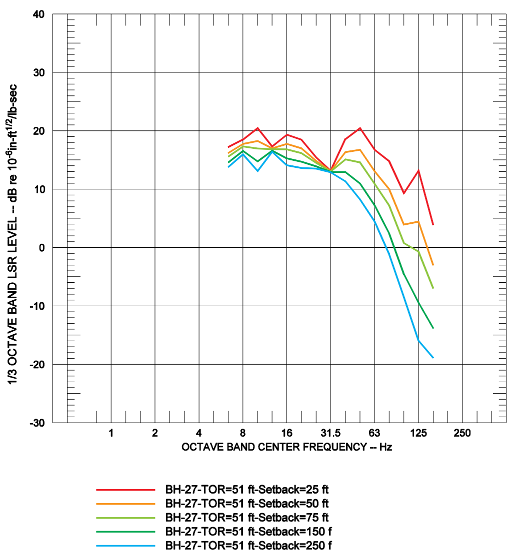

Table A-10: Borehole BH-27 Line Source Response Coefficients at 60-foot Depth

Frequency (Hz)	A	B	C	D
6.3	14.38	-0.10	0.00	0
8	18.67	-1.09	0.00	0
10	22.85	-4.04	0.00	0
12.5	14.70	-0.26	0.00	0
16	20.84	-3.99	0.00	0
20	22.34	-5.13	0.00	0
25	-2.21	13.56	-3.16	0
31.5	-3.96	13.58	-3.13	0
40	15.98	-2.56	0.00	0
50	23.82	-7.60	0.00	0
63	25.17	-9.93	0.00	0
80	31.67	-14.69	0.00	0
100	37.77	-19.32	0.00	0
125	44.13	-24.36	0.00	0
160	17.12	-14.45	0.00	0

$$LSR=A+B\cdot\log(d)+C\cdot\log^2(d)+D\cdot\log^3(d)$$

Figure A-10: Borehole BH-27 Line Source Response at 60-foot Depth

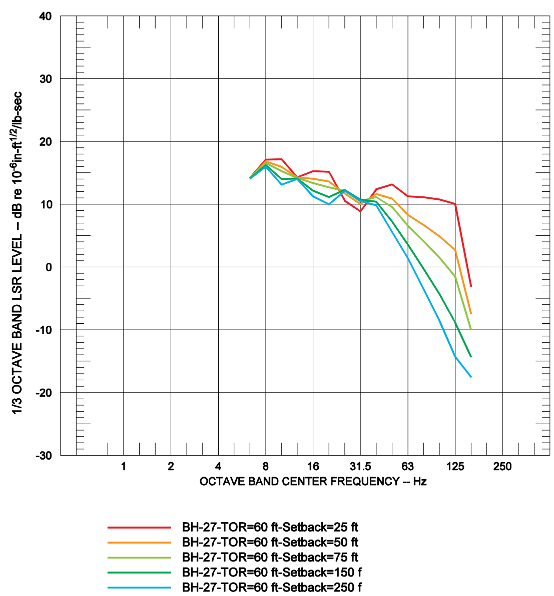

Table A-11: Waterwells ST-10 and ST-11
Line Source Response Coefficients at 50-foot Depth

Frequency (Hz)	A	B	C	D
6.3	6.62	8.50	-3.02	0
8	7.11	9.62	-3.02	0
10	6.57	10.67	-3.00	0
12.5	-56.16	87.33	-25.99	0
16	-79.44	117.23	-35.11	0
20	5.68	9.79	-3.02	0
25	9.32	6.58	-2.96	0
31.5	-88.47	126.34	-38.35	0
40	-83.13	122.17	-37.20	0
50	5.06	11.20	-2.96	0
63	10.21	5.69	-2.92	0
80	26.70	-7.49	-2.04	0
100	36.14	-16.90	-1.44	0
125	31.74	-15.70	-1.51	0
160	37.37	-23.54	-1.09	0

$$LSR=A+B\cdot\log(d)+C\cdot\log^2(d)+D\cdot\log^3(d)$$

Figure A-11: Waterwells ST-10 and ST-11 Line Source Response at 50-foot Depth

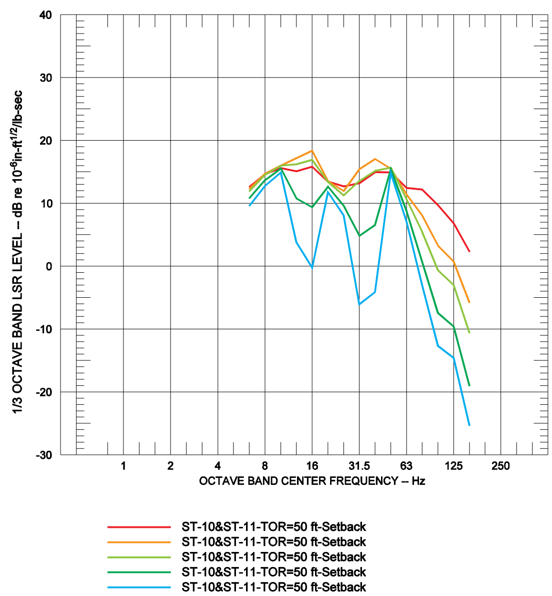

Table A-12: Borehole BH-35 Line Source Response Coefficients at 55-foot Depth

Frequency (Hz)	A	B	C	D
6.3	9.17	11.52	-3.70	0
8	10.45	10.49	-3.80	0
10	10.64	9.69	-3.84	0
12.5	4.56	12.53	-3.53	0
16	12.72	10.08	-3.82	0
20	17.11	7.48	-3.90	0
25	13.69	8.52	-3.88	0
31.5	19.04	5.51	-3.89	0
40	19.42	2.14	-3.82	0
50	26.47	-3.97	-3.61	0
63	18.06	-2.41	-3.67	0
80	26.95	-8.64	-3.40	0
100	57.93	-25.50	-2.66	0
125	42.20	-20.38	-2.88	0
160	21.48	-12.72	-3.22	0

$$LSR = A + B \cdot \log(d) + C \cdot \log^2(d) + D \cdot \log^3(d)$$

Figure A-12: Borehole BH-35 Line Source Response at 55-foot Depth

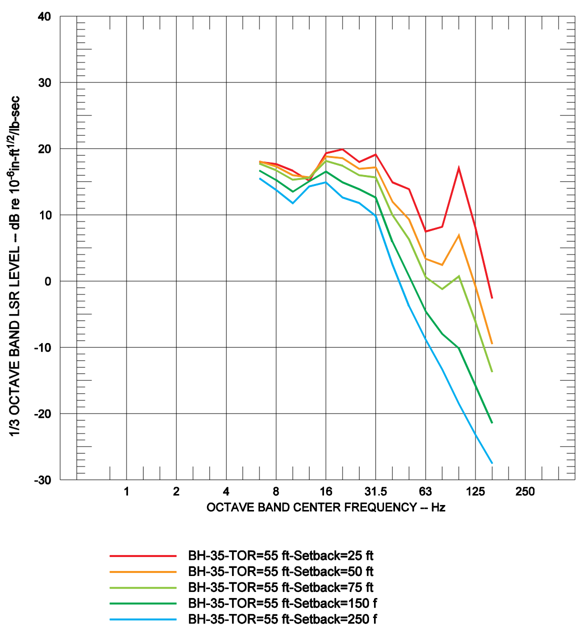

Table A-13: Borehole BH-40 (with contributions from Waterwell ST-12) Line Source Response Coefficients at 55-foot Depth

Frequency (Hz)	A	B	C	D
6.3	-1.81	13.62	-2.95	0
8	-1.36	13.49	-3.13	0
10	1.23	12.94	-3.42	0
12.5	-0.85	13.62	-2.96	0
16	0.41	13.45	-3.16	0
20	5.14	11.47	-3.71	0
25	9.81	9.70	-3.84	0
31.5	10.09	9.89	-3.83	0
40	4.98	12.80	-3.46	0
50	14.45	7.46	-3.90	0
63	13.98	4.41	-3.88	0
80	-0.81	9.79	-3.84	0
100	8.89	2.12	-3.82	0
125	3.69	2.28	-3.83	0
160	-7.60	5.98	-3.90	0

$$LSR = A + B\cdot\log(d) + C\cdot\log^2(d) + D\cdot\log^3(d)$$

Figure A-13: Borehole BH-40 (with contributions from Waterwell ST-12) Line Source Response Coefficients at 55-foot Depth

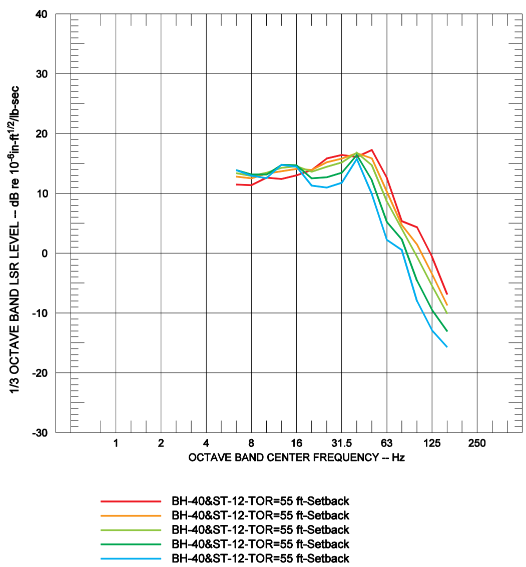

Table A-14: Borehole BH-81 Line Source Response Coefficients at 60-foot Depth

Frequency (Hz)	A	B	C	D
6.3	11.03	9.39	-3.22	0
8	8.05	11.28	-3.12	0
10	7.84	10.14	-3.20	0
12.5	3.12	10.93	-3.16	0
16	0.73	11.86	-3.05	0
20	2.84	11.13	-3.14	0
25	5.47	10.90	-3.16	0
31.5	8.25	10.59	-3.18	0
40	-69.34	110.68	-34.87	0
50	19.19	2.11	-3.00	0
63	33.71	-7.49	-2.44	0
80	33.44	-9.14	-2.34	0
100	30.12	-9.23	-2.33	0
125	25.80	-8.94	-2.35	0
160	22.01	-13.24	-2.10	0

$$LSR = A + B \cdot \log(d) + C \cdot \log^2(d) + D \cdot \log^3(d)$$

Figure A-14: Borehole BH-81 Line Source Response Coefficients at 60-foot Depth

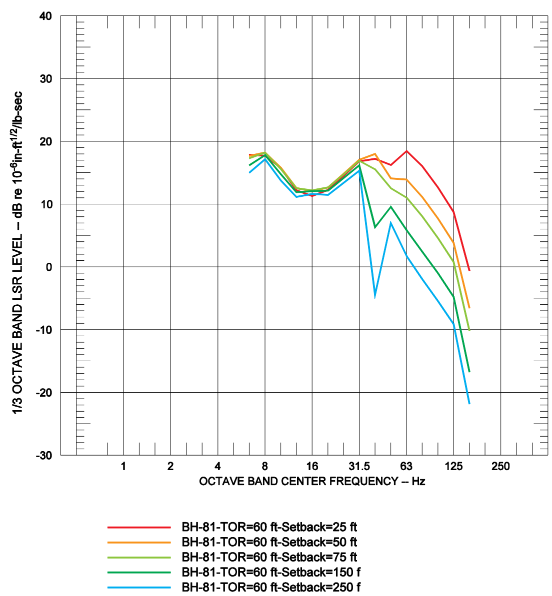

Table A-15: Borehole BH-81 Line Source Response Coefficients at 70-foot Depth

Frequency (Hz)	A	B	C	D
6.3	7.23	11.69	-3.07	0
8	4.05	12.37	-2.92	0
10	3.59	12.53	-2.86	0
12.5	1.19	11.94	-3.03	0
16	0.69	11.53	-3.10	0
20	2.64	10.59	-3.18	0
25	1.41	12.10	-3.00	0
31.5	5.78	11.07	-3.15	0
40	8.41	9.26	-3.22	0
50	15.20	4.52	-3.11	0
63	28.93	-4.36	-2.62	0
80	24.73	-3.41	-2.68	0
100	30.37	-9.20	-2.33	0
125	15.47	-3.30	-2.69	0
160	21.98	-12.50	-2.14	0

$$LSR=A+B\cdot\log(d)+C\cdot\log^2(d)+D\cdot\log^3(d)$$

Figure A-15: Borehole BH-81 Line Source Response Coefficients at 70-foot Depth