4.13 NOISE AND VIBRATION

4.13.1 INTRODUCTION

This section addresses the noise and vibration impacts and mitigation measures for the SVRTC alternatives. Both the FTA and BART noise and vibration criteria are addressed in the impact analysis. The regulatory setting for noise and vibration is also discussed. A more detailed discussion of these issues is found in the *Noise and Vibration Technical Report* (Harris Miller Miller & Hanson [HMMH] 2003).

4.13.2 NOISE EXISTING CONDITIONS

4.13.2.1 Methods and Measures

<u>Noise Descriptors</u>

Noise is typically defined as unwanted or undesirable sound, where sound is characterized by small air pressure fluctuations above and below the atmospheric pressure. The basic parameters of environmental noise that affect human subjective response are (1) intensity or level, (2) frequency content, and (3) variation with time. The first parameter is determined by how greatly the sound pressure fluctuates above and below the atmospheric pressure and is expressed on a compressed scale in units of decibels (dB). By using this scale, the range of normally encountered sound can be expressed by values between 0 and 120 dB. On a relative basis, a 3-dB change in sound level generally represents a barely-noticeable change outside the laboratory, whereas a 10-dB change in sound level would typically be perceived as a doubling (or halving) in the loudness of a sound.

The frequency content of noise is related to the tone or pitch of the sound and is expressed based on the rate of the air pressure fluctuation in terms of cycles per second (called Hertz and abbreviated as Hz). The human ear can detect a wide range of frequencies from about 20 Hz to 17,000 Hz. Because the sensitivity of human hearing varies with frequency, the A-weighting system is commonly used when measuring environmental noise to provide a single number descriptor that correlates with human subjective response. Sound levels measured using this weighting system are called "A-weighted sound levels" and are expressed in decibel notation as "dBA." The A-weighted sound level is widely accepted for describing environmental noise. Figure 4.13-1 provides a comparison of representative dBA levels for common noise sources and environments. While the extremes range from 0 dBA (approximate threshold of hearing) to 120 dBA (jet aircraft at 500 feet), most commonly encountered noise levels fall within the range of 40 dBA to 90 dBA.

Because environmental noise fluctuates from moment to moment, it is common practice to condense all of this information into a single number called the "equivalent sound level" (Leq). Leq is a measure of sound energy over a period of time, typically 1 hour or 24 hours. It is referred to as the equivalent sound level because it is equivalent to the level of a steady sound that, over a referenced duration and location, has the same sound energy as the actual fluctuating sound. Often Leq values over a 24-hour period are used to calculate cumulative noise exposure in terms of the "day-night equivalent sound level" (Ldn). Ldn is the A-weighted Leq for a 24-hour period with an added 10-dB penalty imposed on noise that occurs during the nighttime hours (between 10 p.m. and 7 a.m.). Many surveys have shown that Ldn is well correlated with human annoyance, and therefore this descriptor is widely used for environmental noise impact assessment. Figure 4.13-2 provides examples of typical noise environment

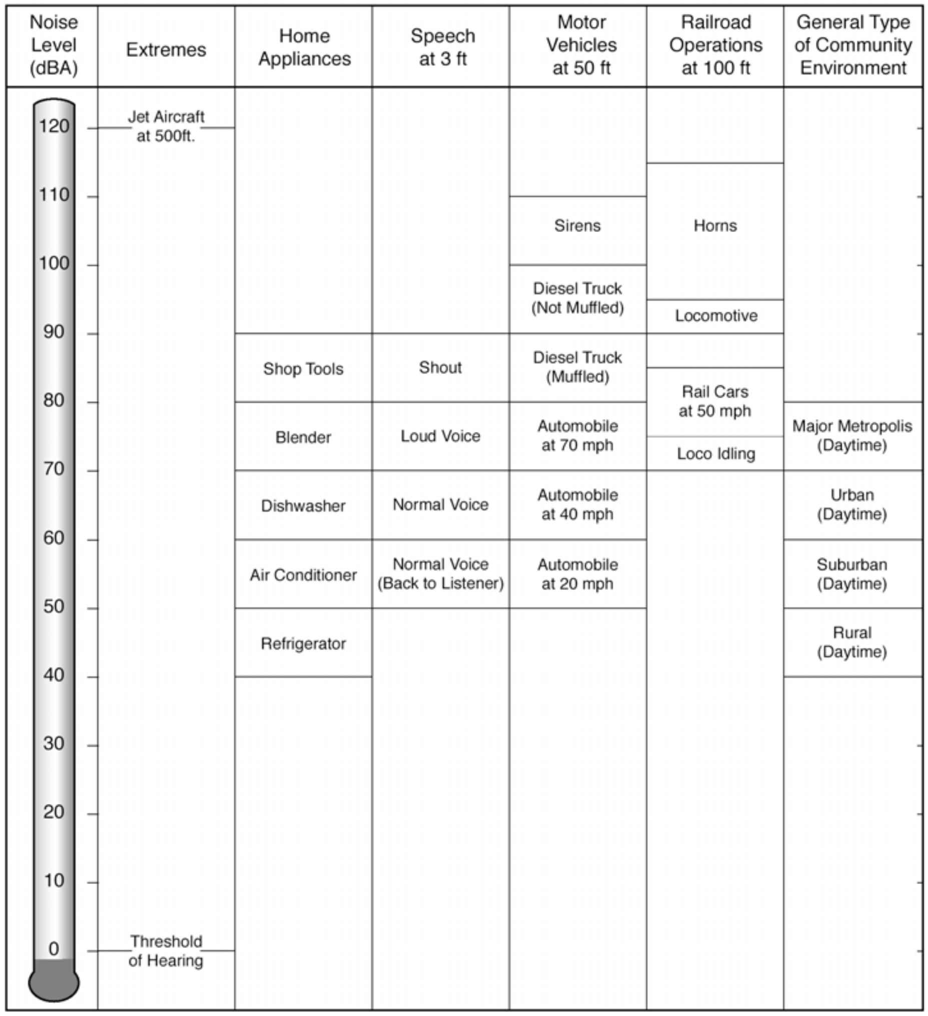


Figure 4.13-1: Comparison of Various Noise Levels

and criteria in terms of Ldn. While the extremes of Ldn range from 35 dBA in a wilderness environment to 85 dBA in noisy urban environments, Ldn generally ranges between 55 dBA and 75 dBA in most communities. As shown in Figure 4.13-2, this spans the range between an "ideal" residential environment and the threshold for an unacceptable residential environment according to the U.S. Department of Housing and Urban Development (HUD) and USEPA.

Environmental noise can also be described statistically using percentile sound levels, Ln, which refer to the sound level exceeded "n" percent of the time. For example, the sound level exceeded 90 percent of the time, denoted as L90, is often taken to represent the "background" noise in a community. Similarly, the sound level exceeded 33 percent of the time (L33) is often used to approximate the Leq in the absence of loud, intermittent sources such as aircraft and trains.

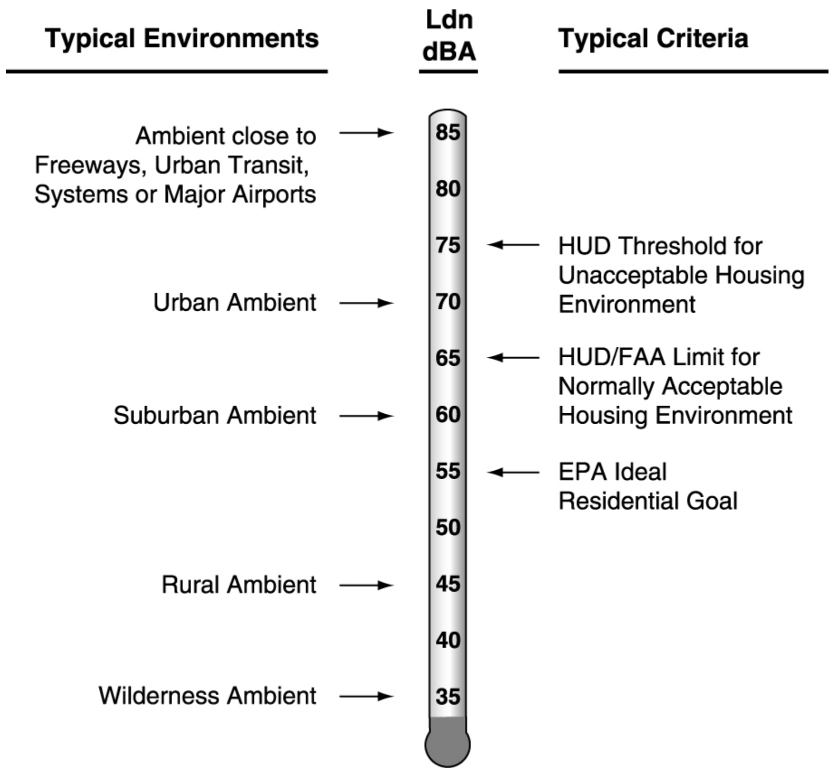


Figure 4.13-2: Examples of Typical Outdoor Noise Exposure

Noise Impact Criteria

Noise impact for this project is based on criteria defined in the FTA guidance manual *Transit Noise and Vibration Impact Assessment* (FTA Report DOT-T-95-16, April 1995). The FTA Noise Impact Criteria are founded on well-documented research on community reaction to noise and are based on change in noise exposure using a sliding scale. Although more transit noise is allowed in neighborhoods with high levels of existing noise, smaller increases in total noise exposure are allowed with increasing levels of existing noise.

The FTA Noise Impact Criteria group noise sensitive land uses into the following three categories:

- **Category 1:** Buildings or parks where quiet is an essential element of their purpose, as well as outdoor amphitheaters and concert pavilions.
- **Category 2:** Residences and buildings where people normally sleep. This includes residences, hospitals, and hotels where nighttime sensitivity is assumed to be of utmost importance.
- **Category 3:** Institutional land uses with primarily daytime and evening use. This category includes schools, libraries, churches, and certain parks and recreational facilities.

Ldn is used to characterize noise exposure for residential areas (Category 2). For other noise sensitive land uses, such as outdoor amphitheaters and school buildings (Categories 1 and 3), the maximum 1-

hour Leq during the facility's operating period is used. There are two levels of impact included in the FTA Noise Impact Criteria, as summarized below:

- **FTA Severe Impact Criteria:** Severe noise impacts are considered "significant," as this term is used in NEPA and its implementing regulations. Noise mitigation will normally be specified for severe impact areas unless there is no practical method of mitigating the noise.
- **FTA Moderate Impact Criteria:** In this range of noise impact, other project-specific factors must be considered to determine the magnitude of the impact and the need for mitigation. These other factors can include the predicted increase over existing noise levels, the types and number of noise-sensitive land uses affected, existing outdoor-indoor sound insulation, and the cost effectiveness of mitigating noise to more acceptable levels.

The FTA Noise Impact Criteria are summarized in Table 4.13-1. The first column shows the existing noise exposure, and the remaining columns show the additional noise exposure from the transit project that would cause either moderate or severe impact. The future noise exposure would be the combination of the existing noise exposure and the additional noise exposure caused by the transit project. Table 4.13-2 gives the information from Table 4.13-1 in terms of the allowable increase in cumulative noise exposure (noise from existing sources plus project noise) as a function of existing noise exposure. As the existing noise exposure increases, the amount that the rail project can increase the overall noise exposure before there is impact decreases.

BART also has developed noise criteria, which are given in terms of project-induced noise and cumulative noise criteria. Based on the BART noise criteria, a project will cause impact if noise levels exceed either the project noise criteria or the cumulative noise criteria. Because BART cumulative noise criteria are based on FTA cumulative noise criteria, the cumulative noise impact for the BART Alternative is evaluated using FTA noise criteria.

BART's operational noise criteria, described below, are based on the criteria adopted in the 1992 *BART Extensions Program System Design Criteria* (BART Design Criteria [Report]), and establish the maximum noise level (Lmax) of a passby depending on the type of receptor (single-family, multi-family, commercial) and area land use category. Table 4.13-3 presents BART Design Criteria for project-induced noise levels.

BART policy specifies that noise from fixed facilities, such as electrical substations, and vent shaft noise from a passing train be kept at or below maximum permissible levels. These limits, in Table 4.13-4 below, give permissible project-induced levels for both transient and continuous noise sources.

Baseline Alternative Methodology

Noise projections for busway operations under the Baseline Alternative were developed using methods described in the FTA guidance manual and based on the following assumptions:

- A single bus operating at 50 miles per hour (mph) on a normal roadway generates a maximum noise level of 85 dBA at 50 feet;
- "SVRTC" express buses would operate at 3 to 30 minute headways in the peak direction from 4:30 a.m. to 8:30 a.m. and from 3:00 p.m. to 7:00 p.m.; and
- The busway would be elevated either on retained fill or on aerial structure along the entire length of the connector.

Table 4.13-1: FTA Noise Impact Criteria

Existing Noise Exposure Leq or Ldn [1]	Project Noise Exposure Impact Thresholds, Leq or Ldn (dBA)			
	Category 1 or 2 Sites		Category 3 Sites	
	Moderate Impact	Severe Impact	Moderate Impact	Severe Impact
<43	Amb. + 10-15 [2]	>Amb. +15	Amb. + 15-20	>Amb. + 20
43	52-58	>58	57-63	>63
44	52-58	>58	57-63	>63
45	52-58	>58	57-63	>63
46	53-59	>59	58-64	>64
47	53-59	>59	58-64	>64
48	53-59	>59	58-64	>64
49	54-59	>59	59-64	>64
50	54-59	>59	59-64	>64
51	54-60	>60	59-65	>65
52	55-60	>60	60-65	>65
53	55-60	>60	60-65	>65
54	55-61	>61	60-66	>66
55	56-61	>61	61-66	>66
56	56-62	>62	61-67	>67
57	57-62	>62	62-67	>67
58	57-62	>62	62-67	>67
59	58-63	>63	63-68	>68
60	58-63	>63	63-68	>68
61	59-64	>64	64-69	>69
62	59-64	>64	64-69	>69
63	60-65	>65	65-70	>70
64	61-65	>65	66-70	>70
65	61-66	>66	66-71	>71
66	62-67	>67	67-72	>72
67	63-67	>67	68-72	>72
68	63-68	>68	68-73	>73
69	64-69	>69	69-74	>74
70	65-69	>69	70-74	>74
71	66-70	>70	71-75	>75
72	66-71	>71	71-76	>76
73	66-71	>71	71-76	>76
74	66-72	>72	71-77	>77
75	66-73	>73	71-78	>78
76	66-74	>74	71-79	>79
77	66-74	>74	71-79	>79
>77	66-75	>75	71-80	>80

Notes:

[1] Maximum 1-hour Leq is used for land use involving only daytime activities; Ldn is used for land uses where nighttime sensitivity is a factor.

[2] Amb. = Ambient

Source: FTA Transit Noise and Vibration Impact Assessment, April 1995.

Table 4.13-2: Cumulative Noise Level Increase Allowed by FTA Criteria

Existing Noise Exposure	Impact Thresholds for Increase in Cumulative Noise Exposure (dBA)			
	Category 1 or 2 Sites		Category 3 Sites	
Leq or Ldn	Moderate Impact	Severe Impact	Moderate Impact	Severe Impact
45	8	14	12	19
46	7	13	12	18
47	7	12	11	17
48	6	12	10	16
49	6	11	10	16
50	5	10	9	15
51	5	10	8	14
52	4	9	8	14
53	4	8	7	13
54	3	8	7	12
55	3	7	6	12
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	8
65	1.5	4	3	7
66	1.3	4	3	7
67	1.2	3	3	7
68	1.1	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	6
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 Leq is used for land use involving only daytime activities; Ldn is used for land uses where nighttime sensitivity is a factor.

Source: FTA Transit Noise and Vibration Impact Assessment, 1995.

Table 4.13-3: BART Design Criteria for Operational Noise			
BART Area Category	**Maximum Passby Noise Levels (dBA)**		
	Single-Family Dwellings	**Multi-Family Dwellings**	**Commercial Buildings**
I Low Density Residential	70	75	80
II Average Residential	75	75	80
III High Density Residential	75	80	85
IV Commercial	80	80	85
V Industrial/Highway	80	85	85
	Maximum Passby Noise Levels (dBA)		
"Quiet" Outdoor Recreation Areas	70		
Concert Halls, Radio, and TV Studios	70		
Churches, Theaters, Schools, Hospitals	75		
Source: BART Extensions Program System Design Criteria, 1992.			

Table 4.13-4: BART Design Criteria for Noise from Ancillary Equipment		
BART Area Category	**Maximum Noise Levels (dBA)**	
	Transient	**Continuous**
I Low Density Residential	50	40
II Average Residential	55	45
III High Density Residential	60	50
IV Commercial	65	55
V Industrial/Highway	70	65
Note: Criteria are reduced by 5 dBA for noises with pure tone components.		
Source: BART Extensions Program System Design Criteria, 1992.		

A screening analysis was performed to identify sensitive receptors within 500 feet of the proposed express bus connectors and to identify areas where traffic noise would increase by 1 dB. Sensitive receptors were clustered based on location, distance to the busway, and acoustical shielding between the receptors and busway. The existing noise exposure at each cluster of receptors was estimated based on the ambient noise measurements (see Section 4.13.2.2) and was used to determine the thresholds for moderate impact and severe impact using the FTA Noise Impact Criteria. Projections of future bus noise at each cluster were developed based on distance from the busway, topography, bus schedule, and bus speed. Bus noise was assessed using FTA methods along the busway and using FHWA methods in areas where the busway would join with highways.

BART Alternative Methodology

To characterize the existing noise conditions along the BART Alternative alignment, field measurements were taken in fall 2001, and spring and fall 2002. Noise measurement sites were selected based on a review of aerial photographs and a visual survey of noise-sensitive land uses (receptors) along the alignment. Eighteen sites, designated as Sites LT1 through LT18, were selected for long-term (typically 24-hour) monitoring. An additional site, designated Site LTWS, was used from the BART Warm Springs Extension study. Four sites, designated as Sites ST1 through ST4, were selected for short-term (one- to three-hour) monitoring. Noise measurements conducted for the BART Warm Springs Extension environmental document were used to characterize noise near the BART Warm Springs Station to I-880 and BART Warm Springs Station to I-680 aerial bus connectors.

Noise measurements were taken with equipment that conforms to American National Standards Institute (ANSI) Standard S1.4 for Type 1 (Precision) sound level meters. Long-term noise measurements were taken by unattended Larson Davis Model 820 and 870 portable automatic noise monitors that continuously sampled the A-weighted sound level, typically over one 24-hour period. These monitors recorded hourly results, including the Lmax, the Leq, and the Ln. The Ldn was subsequently computed from the hourly Leq data. Short-term ambient noise measurements were conducted using an attended Larson Davis Model 820 noise monitor to obtain hourly Lmax, Leq, and Ln levels for a one- to three-hour period.

Noise sources evaluated for the BART Alternative consist of train operations, ancillary equipment, the proposed Maintenance Facility, and traffic noise. For reference, a single 75-foot-long train operating at a maximum of 80 mph on ballast and tie track with continuous welded rail would generate noise of 84 dBA at a distance of 50 feet from track centerline. The following assumptions were used in conducting the noise analysis of the BART Alternative:

- Train Noise
  - Trains would operate from 4:00 a.m. to 1:30 a.m. with 6-minute headways during peak service (6:00 a.m. to 7:30 p.m.), and 20-minute headways during off-peak service (4:00 a.m. to 6:00 a.m. and 7:30 p.m. to 1:30 a.m.).
  - Ten-car BART trains were modeled (however, depending on the demand, as few as seven-car trains may be operating).
  - Operating speed of 67 mph.
  - Noise from the relocated freight trains was incorporated into the train noise projections.
- Ancillary Equipment Noise
  - Traction power substations and tunnel ventilation shafts would be the only ancillary equipment with potential to cause noise impact.
  - It is generally possible to eliminate potential for noise impact from substations and ventilation shafts by including noise limits in the procurement documents.
  - The ancillary equipment noise evaluation was based on the method included in the FTA guidance manual.
  - Ventilation shaft noise was calculated based on measurements conducted at the BART South San Francisco Station ventilation building.

- Maintenance Facility Noise
  - Maintenance Facility noise was modeled using noise from low-speed BART vehicles and noise from ancillary sources described above.
  - 5 dB was added to the train noise to account for wheel squeal from trains negotiating the storage track.
  - The model assumes that BART would implement procedures to minimize public address announcements and the use of train horns during sensitive time periods.
- Traffic Noise
  - Traffic noise was evaluated using FHWA methods and the traffic noise screening procedures described under the Baseline Alternative methodology.

A screening analysis was performed to identify sensitive receptors within 350 feet of the proposed BART alignment and 250 feet from proposed stations and ancillary equipment. The vast majority of these receptors are single and multi-family residences, falling under FTA Category 2. The remaining receptors were institutional sites falling under FTA Category 3, including two churches and two schools. The receptors were clustered based on distance to the tracks, acoustical shielding between the receptors and the tracks, and location relative to crossovers and grade crossings. The existing noise exposure at each cluster of receptors was estimated based on long- and short-term ambient noise measurements (see Section 4.13.2.2) and was used to determine the thresholds for moderate and severe impact using the FTA Noise Impact Criteria. In areas where the projections show either moderate or severe impact, mitigation measures were identified.

4.13.2.2 Existing Noise Conditions

The locations of sites where ambient noise measurements were taken are shown in Figure 4.13-3 and are described below. Long-term measurements were taken at sites LT1 through LT18. Short-term measurements were taken at sites ST1 through ST4. The primary sources observed to contribute to the existing noise environment in the project area or vicinity are motor vehicle traffic on nearby and distant roadways, aircraft overflights, UPRR operations, construction activities, and general community activities.

Noise measurement results are shown in Table 4.13-5. The long-term measurements indicate that existing Ldn ranges from 56 to 66 dBA along the corridor; these values are generally within FTA acceptability criteria thresholds. These results were used as a basis for determining existing noise conditions at all noise-sensitive receptors along the SVRTC as follows:

Site LTWS: Fremont - Old Warm Springs Road (east and west side of transit corridor). The existing Ldn near the terminus of the planned BART Warm Springs Extension is estimated to be 61 dBA. This estimate is based on long-term noise measurement made in the side yard of a single-family residence at 44788 Old Warm Springs Road in Fremont as part of the BART Warm Springs Extension environmental assessment.

Sites LT1 and LT2: Milpitas - Kato Road to Dixon Landing Road (east side). The existing Ldn north of Dixon Landing Road is estimated to be 57 dBA based on a 24-hour noise measurement made at noise monitoring location LT1, the Spinnaker Pointe Apartments, which consist of three- and four-story apartment buildings. The estimated Ldn south of Dixon Landing Road is estimated to be 59 dBA, based on a long-term noise measurement made at LT2, a mobile home park at 51 Via Ensenada.

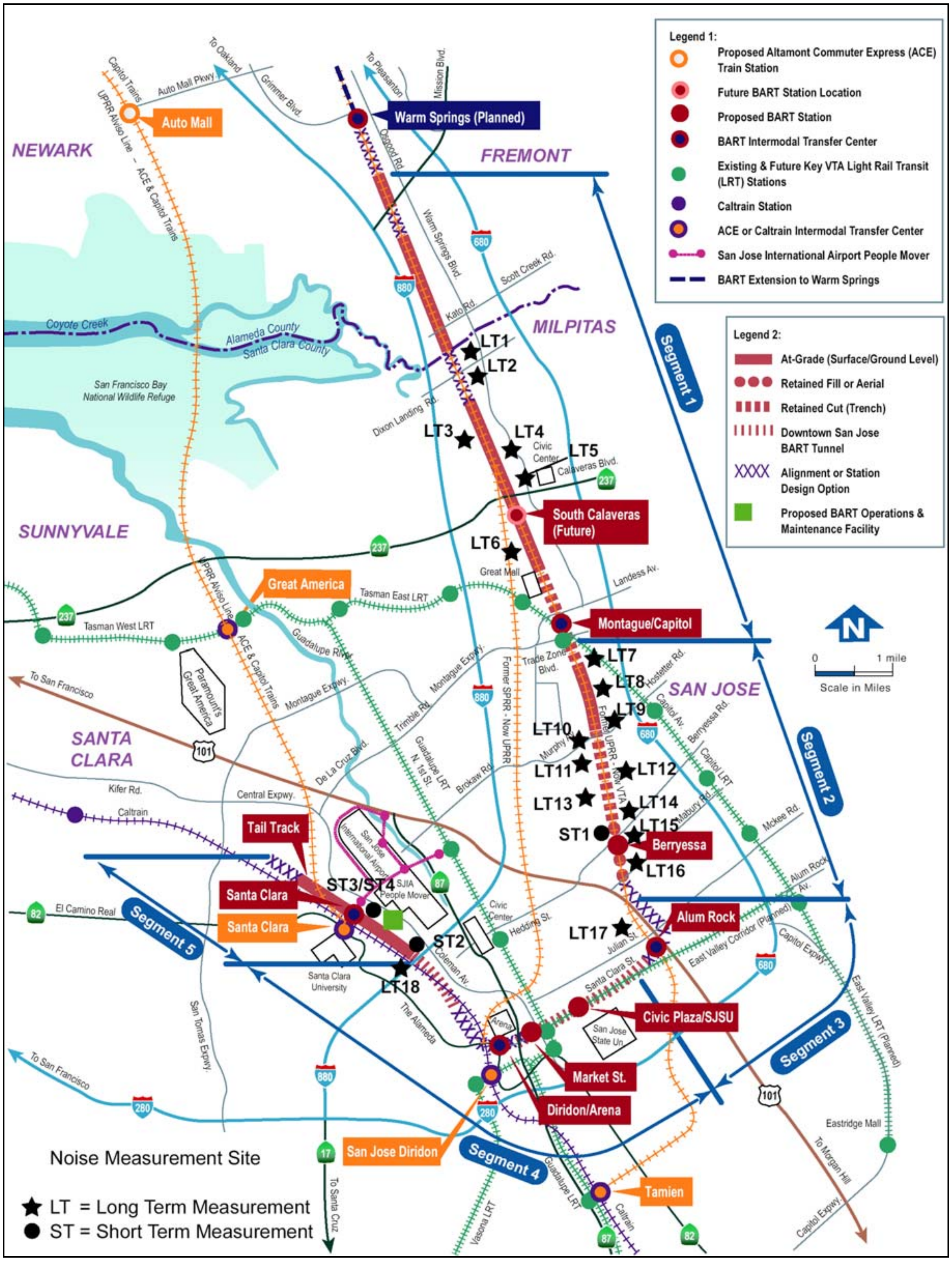


Figure 4.13-3: Existing Ambient Noise Measurement Locations

Table 4.13-5: Summary of Ambient Noise Measurement Results

Site No.	Measurement Location Description	Start of Measurement		Measurement Time (hrs)	Noise Exposure [1] (dBA)
		Date	Time		
LTWS	44788 Old Warm Springs Road	**05/15/02**	**19:00**	24	61
LT1	231 Dixon Landing Road	03/07/02	11:00	24	57
LT2	Mobile Home Park @ 51 Via Ensenada	12/5/01	09:00	24	59
LT3	S.F. Res. @ 1151 Summerwind Way	12/5/01	16:00	24	56
LT4	S.F. Res. @ 899 Erie Circle	12/5/01	16:00	24	64
LT5	Retirement Community @ 186 Beresford Court	12/4/01	18:00	24	60
LT6	Religious Temple @ 722 Main Street	01/13/02	17:00	24	62
LT7	S.F. Res. @ 1827 Flickenger Avenue	12/6/01	11:00	24	56
LT8	S.F. Res. @ 1739 Silvertree Drive	01/14/02	11:00	24	61
LT9	S.F. Res. @ 1675 Silvertree Drive	01/14/02	12:00	24	58
LT10	S.F. Res. @ 1610 Cleo Springs Court	01/14/02	10:00	24	58
LT11	S.F. Res. @ 1500 Gordy Drive	01/14/02	09:00	24	56
LT12	S.F. Res. @ 1767 Caloosa Court	12/4/01	15:00	24	61
LT13	S.F. Res. @ 1224 Royalcrest Drive	12/3/01	15:00	24	57
LT14	S.F. Res. @ 1157 Rosenbriar Way	12/3/01	16:00	24	57
LT15	1701 Holin Street	03/07/02	09:00	24	57
LT16	1666 Pala Ranch Circle	03/07/02	11:00	24	58
LT17	S.F. Res. @ 345 Wooster Street	12/6/01	12:00	24	66
LT18	918 Newhall Street	03/07/02	12:00	24	61
ST1	1655 Berryessa Road	03/08/02	10:30	1	55
ST2	Corner of Newhall and Chestnut streets	01/15/02	14:00	3	67
ST3	Railroad Avenue (Santa Clara Station)	03/07/02	12:30	1	70
ST4	Railroad Avenue (Santa Clara Station)	03/08/02	14:00	1	71

Note:

[1] Long-term noise exposure ("LT" Site Nos.) is provided in terms of Ldn and short-term noise exposure ("ST" Site Nos.) is provided in terms of Leq.

Source: Noise and Vibration Technical Report, HMMH, 2003.

LT3: Milpitas - Dixon Landing Road to Abel Street (west side). The existing Ldn for the single-family homes adjacent to Milmont Drive and Summerwind Way is estimated to be 56 dBA, based on a long-term noise measurement made at a residence at 1151 Summerwind Way.

LT4: Milpitas - Abel Street to Berryessa Creek (east and west side). The Ldn in this area is estimated to be 64 dBA, based on a long-term measurement taken at 899 Erie Circle.

LT5: Milpitas - Edgewater Drive to Calaveras Boulevard (east side). The existing Ldn in this area is based on a long-term measurement taken at 186 Beresford Court and is estimated to be 60 dBA.

LT6: Milpitas - UPRR Milpitas Yard to Capitol Avenue (east and west side). The existing Ldn at this location is based on a 24-hour measurement made at the JAIN Center of Northern California, a religious temple at 722 Main Street, just south of the UPRR Milpitas Yard. At this location, noise is estimated to be 62 dBA.

LT7, LT8, and LT9: San Jose - Trade Zone Boulevard to Hostetter Road (east side). The existing Ldn for this dense residential area varies from 56 to 61 dBA based on 24-hour noise measurements made throughout the area (LT7, LT8, and LT9). Site LT7 is a single-family home at 1827 Flickenger Avenue; Site LT8 is a single-family home at 1739 Silvertree Drive; and Site LT9 is a single-family home at 1675 Silvertree Drive.

LT10 - LT15: San Jose - Hostetter Road to Berryessa Road (east and west side). The estimated Ldn for this dense residential area ranges from 56 to 61 dBA based on long-term measurements. Variations in the existing noise level are based mostly on local activity, proximity to major roadways such as Lundy Avenue, and proximity to the freight railroad line. Sites LT10 through LT15 are single-family residences at the respective addresses: 1610 Cleo Springs Court, 1500 Gordy Drive, 1767 Caloosa Court, 1224 Royalcrest Drive, 1157 Rosenbriar Way, and 1701 Holin Street. The peak-hour Leq near Berryessa Road is estimated to be 55 dBA, based on a one-hour short-term measurement taken at the Black Mountain Spring Water property at 1655 Berryessa Road (ST1).

ST1: 1655 Berryessa Road. This one-hour short-term measurement was performed on the property of Black Mountain Spring Water in the gravel parking lot behind the complex. The location was across the tracks from the subdivision on the corner of Berryessa Road and Lundy Avenue, east of the San Jose Flea Market. Noise sources included vehicular traffic on Berryessa Road, forklift operations from Black Mountain Spring Water, and aircraft. No activity was occurring at the flea market during the measurement period.

LT16: San Jose - Mabury Road (east side). The existing Ldn in this mostly commercial area is estimated to be 58 dBA, based on a long-term noise measurement at a two-story home at 1666 Pala Ranch Circle.

LT17: San Jose - East Julian Street (west side). The estimated Ldn at this location is 66 dBA, as measured at a single-family home at 345 Wooster Street. The high noise level at this location is likely due to noise from Wooster Street traffic and from the body shop across the street from the measurement site.

LT18, ST2, ST3, and ST4: Santa Clara - Newhall Street to the BART Maintenance Facility (west side). The existing Ldn near the proposed BART Maintenance Facility is estimated to be 61 dBA, based on levels measured at 918 Newhall Street. Peak-hour Leq in the vicinity of the yard varies from 67 dBA to 71 dBA, based on short term measurements taken at sites ST2, ST3, and ST4. A three-hour short-term measurement was taken at ST2, a grassy area between Chestnut Street and the sidewalk at the street corner of Newhall Street. One-hour short-term measurements were taken at ST3 and ST4, on Railroad Avenue next to the Santa Clara Police Station.

4.13.3 IMPACT ASSESSMENT AND MITIGATION MEASURES

4.13.3.1 Noise Impacts

No Action Alternative

Projects planned under the No-Action Alternative would undergo their own environmental review to define noise impacts and determine appropriate mitigation measures. (See Section 3.2.1.2 for a list of future projects under the No-Action Alternative.)

Baseline Alternative

Noise sources evaluated for the Baseline Alternative consist primarily of buses idling at the BART Warm Springs Station and buses operating on the busway connectors. Other projects included in the Baseline Alternative would undergo their own environmental documentation process to address noise impacts. As shown in Table 4.13-6, noise impact is projected at two receptors near the proposed BART Warm Springs Station to I-880 busway connectors. One residence is located on the northeast corner of the South Grimmer Boulevard and Old Warm Springs Boulevard intersection. The second home is south of the busway, between Old Warm Springs Boulevard and the railroad corridor. Impact at each of these locations would be reduced to levels below FTA Noise Impact Criteria by the mitigation measures described in Section 4.13.3.3 below.

Table 4.13-6: Baseline Alternative Residential Noise Impact Without Mitigation

Location	Approx. Civil Station		Side of Guide-way	Distance to Near Lane	Max. Speed (mph)	Noise Levels (Ldn, dBA)		FTA		# Residential Impacts.	
	Beg	End				Existing	Project	Mod.	Sev.	Mod.	Sev.
South Grimmer Blvd.	39+00	41+00	S	100	45	61	65	58	64	0	1
South Grimmer Blvd.	42+00	43+00	N	163	45	61	63	58	64	1	0

Source: Noise and Vibration Technical Report, HMMH, 2003.

BART Alternative

Noise impacts from the BART Alternative, as well as the MOS scenarios, would be mitigated to below the applicable FTA and BART thresholds. Table 4.13-7 summarizes the noise impact for residential land use based on FTA Noise Impact Criteria. Table 4.13-7 lists only the locations where noise levels exceed FTA Noise Impact Criteria for moderate or severe impact before mitigation measures are applied and does not represent conditions after mitigation measures have been implemented. Noise levels at locations that are in Table 4.13-7 will be reduced to acceptable levels under FTA Noise Impact Criteria by the methods described in Section 4.13.3.3 below. If a location does not appear in the table, the properties at that location will experience no adverse noise impacts under FTA criteria.

Table 4.13-8 summarizes the noise impact for residential land use based on BART Design Criteria. As in the previous table, the only locations listed are those where noise levels would exceed BART Design Criteria before mitigation measures are applied. Noise levels at the locations listed in this table will be reduced to acceptable levels under BART Design Criteria by methods described in Section 4.13.3.3 below. Note that if a location does not appear in this table, it means that the properties at that location will not experience adverse noise impacts under BART Design Criteria.

The project noise levels shown in Tables 4.13-7 and 4.13-8 incorporate project-related noise only, including noise from BART trains, relocated freight trains, and BART ancillary facilities such as traction power substations. In general, the relocated freight trains along the northern part of the BART alignment add about 1 to 2 dB to the BART Alternative noise levels at locations west of the project alignment. The existing and projected Ldn from BART operations are shown in Table 4.13-7, while Table 4.13-8 shows the projected Lmax from BART operations. Because BART cumulative noise criteria are based on FTA Noise Impact Criteria, any noise level that is projected to exceed the FTA moderate or severe impact criteria at any receptor is also considered to have impact based on the BART cumulative noise criteria.

Noise projections indicated that under the BART Alternative, as well as the MOS scenarios, there would be no noise impacts to institutional sensitive receptors, such as churches and parks. These uses are considered to be compatible with higher noise levels than would be acceptable to low density residential uses. As such, both the FTA and BART criteria assign less stringent noise limits to these locations. As none of the institutional properties located within the SVRTC are close to BART noise generating facilities, no noise impacts were identified for institutional uses. In addition, there would be no impacts along the BART subway alignment through San Jose, because BART would be underground in this segment. Blocking the line of sight between a noise source and a receptor with a heavy material will significantly impede noise transmission. The heavy tunnel walls of the subway and the ground block the line-of-sight between receptors on the surface and the train underground, so train noise levels would not reach the surface. Noise rising through the vent shafts would be reduced by design requirements and best management practices such as adding acoustically absorptive material in the inside of the shaft and placing louvers over any opening to block noise. The exact acoustical treatment would be chosen when the vent shafts are designed.

Noise impacts along the alignment would vary depending on the design options selected; however, all noise impacts will be mitigated to meet FTA Noise Impact Criteria and BART Design Criteria. The number of residences experiencing moderate and severe noise impacts before mitigation under FTA Noise Impact Criteria would range from 127, if the Dixon Landing Road Alignment Retained Cut Option is chosen, to 192 residences if the Aerial Option is chosen. The number of residences projected to have severe impact before mitigation would range from 48 residences with the Dixon Landing Road Alignment At-grade and Retained Cut options to 94 residences with the Aerial Option. With the BART criteria, impacts range from 96 to 142 residences. Below are brief discussions of the noise impacts along the alignment.

Kato Road to Dixon Landing Road: Noise impacts vary according to alignment options.

- The Dixon Landing Road At-grade Option would result in noise impact at 15 residences. Twelve of these impacts, located at the proposed apartments north of Dixon Landing Road, are projected to

Table 4.13-7: BART Alternative Residential Noise Impact Without Mitigation Using FTA Criteria

Location	Approx. Civil Station		Side of Track	Distance to Near Track (feet)	Max. Speed (mph)	Noise Level (Ldn, dBA)		FTA Criteria		# of Residential Impacts	
	Begin	End				Existing	Project	Mod.	Sev.	Mod.	Sev.
DIXON LANDING ROAD ALIGNMENT – AERIAL OPTION											
Kato Road to Dixon Landing Road	177+00	182+00	East	30	67	57	71	56	62	0	12 [1]
Kato Road to Dixon Landing Road	182+40	184+40	East	30	67	57	71	56	62	0	10
Kato Road to Dixon Landing Road	189+50	191+00	East	30	67	57	71	56	62	0	12
Kato Road to Dixon Landing Road	184+50	188+00	East	107	67	57	64	56	62	0	16
Kato Road to Dixon Landing Road	182+40	188+00	East	222	67	57	59	56	62	12	0
Dixon Landing Road to Minnis Circle	192+40	196+80	East	49	67	59	69	57	63	0	8
Dixon Landing Road to Jurgens Dr.	193+00	195+50	West	370	67	56	57	56	62	3	0
Dixon Landing Road to Jurgens Dr.	195+50	200+00	West	222	67	56	60	56	62	3	0
Dixon Landing Road to Jurgens Dr.	197+00	200+00	West	313	67	56	56	56	62	1	0
Subtotal – Dixon Landing Road - Aerial Option										**19**	**58**
DIXON LANDING ROAD ALIGNMENT – RETAINED CUT OPTION											
Kato Road to Dixon Landing Road	177+00	182+00	East	30	67	57	71	56	62	0	12 [1]
Subtotal – Dixon Landing Road - Retained Cut Option										**0**	**12**
DIXON LANDING ROAD ALIGNMENT – AT-GRADE OPTION											
Kato Road to Dixon Landing Road	177+00	182+00	East	30	67	57	71	56	62	0	12 [1]
Dixon Landing Road to Jurgens Dr.	195+50	200+00	West	221.5	67	56	59	56	62	3	0
Subtotal – Dixon Landing Road - At-Grade Option										**3**	**12**
ALIGNMENT SOUTH OF DIXON LANDING ROAD, WITH SOUTH CALAVERAS FUTURE STATION											
Summerwind Drive to Abel Street	229+00	235+60	West	103	67	56	65	56	62	0	4
Summerwind Drive to Abel Street	236+00	241+00	West	244	67	56	58	56	62	10	0
Summerwind Drive to Abel Street	241+00	244+00	West	300	67	56	58	56	62	4	0
Abel Street to Marylinn Drive	247+00	254+00	West	222	67	56	65	56	62	0	12
Abel Street to Marylinn Drive	254+00	260+00	West	299	67	56	62	56	62	0	8
Curtis Avenue to Great Mall Drive	332+50	335+80	West	107	67	62	63	59	64	30	0

continued

Table 4.13-7: BART Alternative Residential Noise Impact Without Mitigation Using FTA Criteria											
Location	**Approx. Civil Station**		**Side of Track**	**Distance to Near Track (feet)**	**Max. Speed (mph)**	**Noise Level (Ldn, dBA)**		**FTA Criteria**		**# of Residential Impacts**	
	Begin	**End**				**Existing**	**Project**	**Mod.**	**Sev.**	**Mod.**	**Sev.**
Trade Zone Blvd to Hostetter Road	413+00	414+00	East	93	67	56	61	56	62	3	0
Trade Zone Blvd to Hostetter Road	412+80	418+00	East	176	67	56	58	56	62	4	0
Sierra Road to Berryessa Road	501+00	507+00	East	41	67	57	57	56	62	10	0
Sierra Road to Berryessa Road	514+00	519+00	East	26	53	57	69	56	62	0	6
Sierra Road to Berryessa Road	514+00	519+00	East	88	53	57	63	56	62	0	6
Sierra Road to Berryessa Road	514+00	519+00	East	144	53	57	60	56	62	3	0
Subtotal – Alignment Excluding Dixon Landing Road Options										**64**	**36**
ALIGNMENT SOUTH OF DIXON LANDING ROAD, WITHOUT SOUTH CALAVERAS FUTURE STATION:											
Summerwind Drive to Abel Street	229+00	235+60	West	103	67	56	65	56	62	0	4
Summerwind Drive to Abel Street	236+00	241+00	West	244	67	56	58	56	62	10	0
Summerwind Drive to Abel Street	241+00	244+00	West	300	67	56	58	56	62	4	0
Abel Street to Marylinn Drive	247+00	254+00	West	222	67	56	65	56	62	0	12
Abel Street to Marylinn Drive	254+00	260+00	West	299	67	56	62	56	62	0	8
Curtis Avenue to Great Mall Drive	332+50	335+80	West	107	67	62	63	59	64	30	0
Trade Zone Blvd to Hostetter Road	413+00	414+00	East	93	67	56	61	56	62	3	0
Trade Zone Blvd to Hostetter Road	412+80	418+00	East	176	67	56	58	56	62	4	0
Sierra Road to Berryessa Road	501+00	507+00	East	41	67	57	57	56	62	10	0
Sierra Road to Berryessa Road	514+00	519+00	East	26	53	57	69	56	62	0	6
Sierra Road to Berryessa Road	514+00	519+00	East	88	53	57	63	56	62	0	6
Sierra Road to Berryessa Road	514+00	519+00	East	144	53	57	60	56	62	3	0
Subtotal – Alignment Excluding Dixon Land Road Options										**64**	**36**
BART SUBWAY ALIGNMENT THROUGH SAN JOSE, ALL OPTIONS - NO NOISE IMPACTS											
BART ALIGNMENT NEAR MAINTENANCE FACILITY - NO NOISE IMPACTS											

Note:

[1] Assumes 12 units at proposed apartments located between Station 176+00 to 183+00.

Source: Noise and Vibration Technical Report, HMMH, 2003.

Table 4.13-8: BART Alternative Residential Noise Impact Without Mitigation Using BART Design Criteria								
Location	**Approx. Civil Station**		**Side of Track**	**Distance to Near Track (feet)**	**Max. Speed (mph)**	**Maximum Passby Noise Level (dBA)**	**BART Design Criterion (dBA)**	**# of Residential Impacts**
	Beg.	**End**						
DIXON LANDING ROAD ALIGNMENT – AERIAL OPTION								
Kato Road to Dixon Landing Road	182+40	184+40	East	30	67	86	75	10
Kato Road to Dixon Landing Road	189+50	191+00	East	30	67	86	75	12
Kato Road to Dixon Landing Road	184+50	188+00	East	107	67	78	75	16
Kato Road to Dixon Landing Road	177+00	182+00	East	30	67	86	75	12 [1]
Dixon Landing Road to Minnis Circle	192+40	196+80	East	49	67	83	75	8
Subtotal – Dixon Landing Road - Aerial Option								**58**
DIXON LANDING ROAD ALIGNMENT – RETAINED CUT OPTION								
Kato Road to Dixon Landing Road	177+00	182+00	East	30	67	86	75	12 [1]
Subtotal – Dixon Landing Road - Retained Cut Option								**12**
DIXON LANDING ROAD ALIGNMENT – AT-GRADE OPTION								
Kato Road to Dixon Landing Road	177+00	182+00	East	30	67	86	75	12 [1]
Subtotal – Dixon Landing Road - At-Grade Option								**12**
ALIGNMENT SOUTH OF DIXON LANDING ROAD, With SOUTH CALAVERAS FUTURE STATION								
Summerwind Drive to Abel Street	229+00	235+60	West	103	67	78	75	4
Abel Street to Marylinn Drive	247+00	254+00	West	222	67	78	75	12
Abel Street to Marylinn Drive	254+00	260+00	West	299	67	75	75	8
Curtis Avenue to Great Mall Drive	332+50	335+80	West	107	67	77	75	30
Trade Zone Boulevard to Hostetter Road	413+00	414+00	East	93	67	75	75	3
Sierra Road to Berryessa Road	514+00	519+00	East	26	53	82	75	6
Sierra Road to Berryessa Road	514+00	519+00	East	88	53	76	75	6
Subtotal – Alignment Excluding Dixon Landing Road Options								**69**

continued

Table 4.13-8: BART Alternative Residential Noise Impact Without Mitigation Using BART Design Criteria

Location	Approx. Civil Station		Side of Track	Distance to Near Track (feet)	Max. Speed (mph)	Maximum Passby Noise Level (dBA)	BART Design Criterion (dBA)	# of Residential Impacts
	Beg.	End						
ALIGNMENT SOUTH OF DIXON LANDING ROAD, Without SOUTH CALAVERAS FUTURE STATION								
Summerwind Drive to Abel Street	229+00	235+60	West	103	67	78	75	4
Abel Street to Marylinn Drive	247+00	254+00	West	222	67	78	75	12
Abel Street to Marylinn Drive	254+00	260+00	West	299	67	75	75	8
Curtis Avenue to Great Mall Drive	332+00	335+80	West	107	67	77	75	30
Trade Zone Boulevard to Hostetter Road	413+00	414+00	East	93	67	75	75	3
Sierra Road to Berryessa Road	514+00	519+00	East	26	53	82	75	6
Sierra Road to Berryessa Road	514+00	519+00	East	88	53	76	75	6
Subtotal – Alignment Excluding Dixon Landing Road Options								**69**

BART SUBWAY ALIGNMENT THROUGH SAN JOSE, ALL OPTIONS - NO NOISE IMPACTS

BART ALIGNMENT NEAR MAINTENANCE FACILITY - NO NOISE IMPACTS

Note:

[1] Assumes 12 units at proposed apartments located between Station 176+00 to 183+00.

Source: Noise and Vibration Technical Report, HMMH, 2003.

exceed the FTA severe impact threshold. These same 12 residences are projected to exceed the BART Design Criterion.[1]

- The Dixon Landing Road Aerial Option would result in noise impact at 62 residences, 50 of which would exceed FTA severe impact criteria and BART Design Criterion. The impact would be due to the high speed of the trains as well as the number of trains that pass by each day. In this area, residences with severe impact are relatively close to the tracks (as little as 30 feet away).
- The Dixon Landing Road Retained Cut Option would result in noise impact at the 12 residences at the proposed apartments discussed above. These impacts are projected to exceed the FTA severe impact criterion and the BART Design Criterion.

Dixon Landing Road to Jurgens Drive: This group of residences is also at the northern end of the alignment, but on the west side of the tracks. Under the Dixon Landing Road Aerial Option, train noise is projected to exceed the FTA Noise Impact Criteria for moderate impact at seven homes, due mostly to the frequency of trains passing by and the high speed of the trains; noise is not projected to exceed the FTA severe impact criteria. The Aerial Option would result in no impacts to residences under the BART Design Criterion.

Under the Dixon Landing Road At-grade Option, noise is projected to exceed the FTA moderate impact criteria at three residences, but train noise would not exceed the BART Design Criterion in this area.

Dixon Landing Road to Minnis Circle: Under the Dixon Landing Road Aerial Option, project noise would exceed FTA severe impact criteria at eight residences in a neighborhood located south of Dixon Landing Road and east of the tracks. Project noise would also exceed the BART Design Criterion at the same eight residences. The noise impact can be attributed to the proximity of the tracks to the residence, the number of trains that pass each day, and the speed at which the trains go by.

Summerwind Drive to Abel Street: In this neighborhood north of Abel Street on the west side of the tracks, the BART Alternative would result in noise impact to 18 residences. Four of these residences are projected to have severe impact, caused by a nearby crossover. Project noise at four residences north of Calera Creek is expected to exceed the BART Design Criterion.

Abel Street to Marylinn Drive: This neighborhood is located south of Abel Street, west of the proposed BART alignment. Noise impact is projected at 20 single-family residences, caused by noise from a nearby crossover at STA 254+00 to 260+00. Noise is projected to exceed the BART Design Criterion and the FTA severe impact criterion at all 20 residences.

Curtis Avenue to Great Mall Drive: Noise impact is projected at an apartment complex located north of the Great Mall, on the west side of the proposed BART alignment, due mostly to the high speed and frequency of the trains. Project noise would exceed FTA moderate impact criterion and the BART Design Criterion.

Trade Zone Boulevard to Hostetter Road: This neighborhood is located just north of Hostetter Road on the east side of the tracks. Residences north of this location would benefit from noise shielding

[1] Impact thresholds are referenced as criterion (singular) when there is only one threshold value under consideration and as criteria (plural) when more than one threshold value determines impact status.

because the BART tracks would run in a retained cut. At this location, the BART train would rise out of the cut, resulting in increased noise levels. Project noise at seven residences is projected to exceed FTA moderate impact criterion. The contributing factors to the impact include the high speed of the trains and the frequency of pass-bys. Project noise would exceed the BART Design Criterion at three residences.

Sierra Road to Berryessa Road: At a neighborhood between Lundy Avenue and Berryessa Road on the east side of the tracks, project noise would exceed FTA moderate impact criteria at 13 residences. Noise would exceed the severe impact criteria at 12 residences, due to the short distance between the homes and the tracks. The BART Design Criterion would also be exceeded at 12 residences.

Tables 4.13-9 and 4.13-10 summarize impacts caused by stations and ancillary facilities under FTA and BART criteria, respectively. As in the other impact tables, the only locations listed are those where noise levels are projected to exceed the criteria represented by that table prior to mitigation. All impacts will be reduced to acceptable levels through implementation of mitigation measures.

Station Noise Impact: The Montague/Capitol Station would be located approximately 50 feet from a high-density residential apartment complex near STA 380+00. Noise projections indicate that bus traffic at the station is likely to exceed the FTA moderate impact criteria as well as the BART Design Criterion at the proposed apartment complex.

Traction Power Substation Noise Impacts: Most of the 10 proposed traction power substations would be located more than 250 feet from the nearest sensitive residential or institutional properties, and three of the traction power substations would be located underground in the tunnel portion of the BART Alternative. Noise impacts would occur only at the following traction power substations:

- Alternate location for Traction Power Substation #4 (TPSS #4): Projected Lmax at the Residence Inn would be 48 dBA, which exceeds the BART Design Criterion for ancillary equipment.
- Proposed location for TPSS #5: The combined Ldn of the train and the substation is 53 dBA, which is below the FTA Noise Impact Criterion of 56 dBA. The projected Lmax of the power substation, however, is 40 dB, which is at the BART Design Criterion for ancillary equipment.
- One of the proposed alternate locations for TPSS # 6: The combined projected Ldn of the substation and train would be 57 dBA, which exceeds the FTA moderate impact criterion of 56 dBA. The projected Lmax of the substation is 45 dBA, which exceeds the appropriate BART Design Criterion of 40 dBA.

Bulk Substation Noise Impacts: Of the three proposed sites for bulk substations along the corridor, one would have noise impacts. At Bulk Substation SS#1 the combined projected noise level of the bulk substation and the train would be 63 dB at the nearest residence on Berryessa Road. This exceeds the FTA moderate impact criterion of 56 dBA, and the exceedence is primarily caused by the noise from the BART trains and the relocated freight trains. At the nearest residential receptor, the projected Lmax of Bulk Substation SS#1 is 45 dBA which exceeds the appropriate BART Design Criterion.

Gap Breaker Stations: None of the four proposed gap breaker station sites are located within 250 feet of the nearest sensitive receptor, so no impact is projected.

Table 4.13-9: BART Alternative Residential Noise Impact Caused by Stations and Ancillary Facilities Without Mitigation Using FTA Criteria

Location	Approx. Civil Station		Noise Source(s)	Side of Track	Noise Level (Ldn, dBA) [1]	FTA Impact Criteria (Ldn, dBA)		# of Residential Impacts	
	Beg.	End				Moderate	Severe	Moderate	Severe
Montague Expressway to Capitol Avenue	379+20	381+40	Buses at station	E	64	59	65	10	0
Sierra Road to Berryessa Road	503+20	507+00	Traction Power Substation #6 (TPSS #6) (Alt. Site)	W	57	56	62	5	0
Calero Street to Almaden Avenue	254+00	260+00	Bulk Substation SS#1 TPSS #3	W	65	56	62	0	8

Note:

[1] Noise levels shown are BART train noise levels combined with station/ancillary facility noise levels.

Source: Noise and Vibration Technical Report, HMMH, 2003.

Table 4.13-10: BART Alternative Residential Noise Impact Caused by Stations and Ancillary Facilities Without Mitigation Using BART Design Criterion

Location	Approx. Civil Station		Noise Source(s)	Side of Track	Maximum Noise Level (dBA)	BART Design Criterion (dBA)	# of Residential Impacts
	Beg.	End					
Great Mall Drive to Montague Expressway	361+40	368+50	TPSS #4 (Alt. Site)	E	48	45	20
Sierra Road to Berryessa Road	503+20	509+00	TPSS #6 (Alt. Site)	W	45	40	5

Source: Noise and Vibration Technical Report, HMMH, 2003.

Combined Noise of Ancillary Facilities: TPSS #3 and Bulk Substation SS#1 would be located in the same immediate area. The combined noise levels from these two facilities and trains would result in an Ldn of 65 dBA, which exceeds the FTA severe impact criterion at residences immediately to the west of Bulk Substation SS#1.

Tunnel Ventilation Shafts: Of the 18 proposed tunnel vent shaft locations, 3 are located within the 250-foot screening distance where a potential noise impact might occur.

- Tunnel Vent Shafts 3 and 3a option: The closest noise sensitive receptor is the Portuguese Band and Social Center. At this location, the Leq would be 48 dBA and the Lmax would be 48 dBA. Both of these noise levels are within the FTA and BART Design Criterion and would not result in an adverse noise impact.
- Tunnel Vent Shaft 4: The closest apartment building would be exposed to Ldn noise levels of 55 and Lmax noise levels of 50 dBA. These noise levels are within the FTA and BART Design Criteria and would not result in an adverse noise impact.

Tunnel Vent Shaft 13: The closest noise-sensitive receptors are single-family homes on Asbury Street. The projected noise levels at this location are 46 dBA Ldn and 40 dBA Lmax. The projected noise levels meet the FTA noise impact criterion of 58 dBA and the BART Design Criteria of 45 dBA.

Ventilation fans will require periodic testing at high speeds to ensure proper operation during emergency conditions. To the extent possible, ventilation fan testing will be scheduled to minimize noise at nearby sensitive receptors.

Emergency Power Generators: While emergency power generators would be located aboveground, they would be enclosed in either concrete or brick structures. By locating the generators within enclosed structures, there would be no noise impact associated with periodic routine testing.

Maintenance Facility Noise Impact Assessment: No noise impacts are projected from the proposed Maintenance Facility at the terminus of the BART alignment in Santa Clara. There are a few residences off Newhall Street and other local streets within 300 feet of the southern entrance to the Maintenance Facility. However, at this location, the BART trains would be moving slowly in and out of the yard, and the houses are shielded from the activity by intervening buildings. Furthermore, the existing background noise levels at this location are dominated by traffic on I-880, heavy rail commuter and freight movements along the existing railroad line and SJIA. As a result, the noise from the BART trains will not add substantially to the noise environment. Most of the noisy activities associated with a maintenance facility occur at least 800 feet from the residences and, again, will not add substantially to the noise environment.

Traffic Noise Impact Assessment: No impact from traffic noise is projected at any residential, institutional or commercial receptors. A cumulative noise level approaching 67 dBA or a change of 12 dB are the thresholds set by Caltrans for substantial impact (*Traffic Noise Analysis Protocol,* Caltrans, October 1998). The future increase in traffic is not enough to exceed 66 dBA or cause a 12 dB increase in noise levels at sensitive receptors throughout the project corridors.

4.13.3.2 Design Requirements and Best Management Practices

Baseline Alternative

Maintaining tire pressure and keeping bus engines tuned and well-maintained would minimize noise impacts from bus tires and engines. VTA and other transit agencies perform these and other best management practices as part of normal maintenance procedures.

BART Alternative

The following standard BART practices are performed regularly and would reduce noise levels from trains operating along the corridor for the BART Alternative and MOS scenarios:

- Track maintenance: Regular track maintenance activities such as rail grinding and track inspection would reduce rail defects that could lead to higher than normal noise and vibration levels. Rail grinding smoothes the surface of train tracks by using specialized machines to cut away a thin layer of steel from the top and sides of the railhead. Regular rail grinding helps to minimize wayside noise and vibration generated by train passbys over defects or corrugations on the rail.
- Vehicle maintenance: Regular vehicle maintenance activities such as periodic inspections and tests will help to identify problems and necessary corrective actions to minimize wayside noise and vibration levels. This includes wheel truing. Wheel truing is the process of cutting away a thin layer of steel on a wheel's outer diameter (the "tread") to smooth out rough spots and ensure that the wheels are perfectly round. Because flat spots or rough wheels can cause excessive noise and vibration, wheel truing is a standard BART practice to minimize wayside noise and vibration levels.

4.13.3.3 Mitigation Measures

No-Action Alternative

Projects planned under the No-Action Alternative would undergo their own environmental review process to define noise impacts and determine appropriate mitigation measures.

Baseline Alternative

Noise impacts would be mitigated by a 10-foot-tall, 600-foot long noise wall constructed on the elevated busway connector structure retaining wall. The wall would reduce the noise level by approximately 10 dBA. The primary requirements for an effective noise barrier are that (1) the barrier must be high enough and long enough to break the line of sight between the sound source and the receptor, (2) the barrier must be of an impervious material with a minimum surface density of four pounds per square foot, and (3) the barrier must not have any gaps or holes between the panels or at the bottom. Because numerous materials meet these requirements, the selection of materials for noise barriers is usually dictated by aesthetics, durability, cost, and maintenance considerations. Because the busway would be elevated on retained fill in the area where the impacts are projected, the barrier can be constructed by extending the retaining wall 10 feet above the pavement. Table 4.13-11 gives the location, design parameters and number of residences benefiting from the proposed noise walls.

Table 4.13-11: Baseline Alternative Noise Barrier Mitigation for Residential Areas							
Location	**Approx. Civil Station**		**Side of Busway**	**Barrier Height (feet)**	**Barrier Length (feet)**	**# Res. Impacts w/o barr**	**# Res. Impacts w/ barr**
	Beg.	**End**					
South Grimmer Blvd.	38+00	44+00	North	10	600	1	0
South Grimmer Blvd.	36+00	42+00	South	10	600	1	0
Source: Noise and Vibration Technical Report, HMMH, 2003.							

BART Alternative

The primary mitigation measure would be the construction of sound walls along the BART Alternative alignment where impacts are projected. This mitigation is also applicable to the MOS scenarios. Table 4.13-12 indicates the approximate noise barrier locations, lengths, heights, and side of track, as well as the number of moderate impacts and severe impacts that would be reduced to below the FTA and BART criteria thresholds. Depending on the proximity of the noise barrier to the tracks and on the track elevation, barriers range in height from 4 to 16 feet with the lower barriers being located on the aerial structures. As shown in Table 4.13-12, the noise barriers will achieve the FTA and BART noise compatibility criteria. The noise barrier locations are shown on Figures 4.13-4a through 4.13-4s. If no noise barrier is shown at a particular location, noise impacts do not warrant a noise barrier at that location.

Special trackwork would also be considered at crossovers. Because the impacts of BART wheels over rail gaps at track crossover locations increase BART noise by about 6 dBA, crossovers are a major source of noise impact when they are located in noise-sensitive areas. If crossovers cannot be relocated away from residential areas, another approach would be to use moveable point frogs in place of standard rigid frogs at turnouts. These devices would allow the flangeway gap to remain closed in the main traffic direction for revenue service trains. A movable point or spring rail frog at STA 243+00 to STA 258+00 (see Appendix A) would reduce noise levels in that area by 6 dB and reduce the length of the sound barrier near Wrigley Creek by 70 feet. These types of track frogs would be evaluated by VTA and BART for specific locations where track crossover noise may be a problem.

A 12-foot-tall noise barrier is also recommended south of the Montague/Capitol Station for all options to reduce noise from buses and station activities at the nearby apartment complex at STA 378+00 (Figure A-20). Another 12-foot-tall noise barrier, perpendicular to the proposed alignment at Aschauer Court, would mitigate the projected noise impact from TPSS #6 at STA 507+20.

4.13.4 VIBRATION EXISTING CONDITIONS

4.13.4.1 Methods and Measures

Vibration Fundamentals and Descriptors

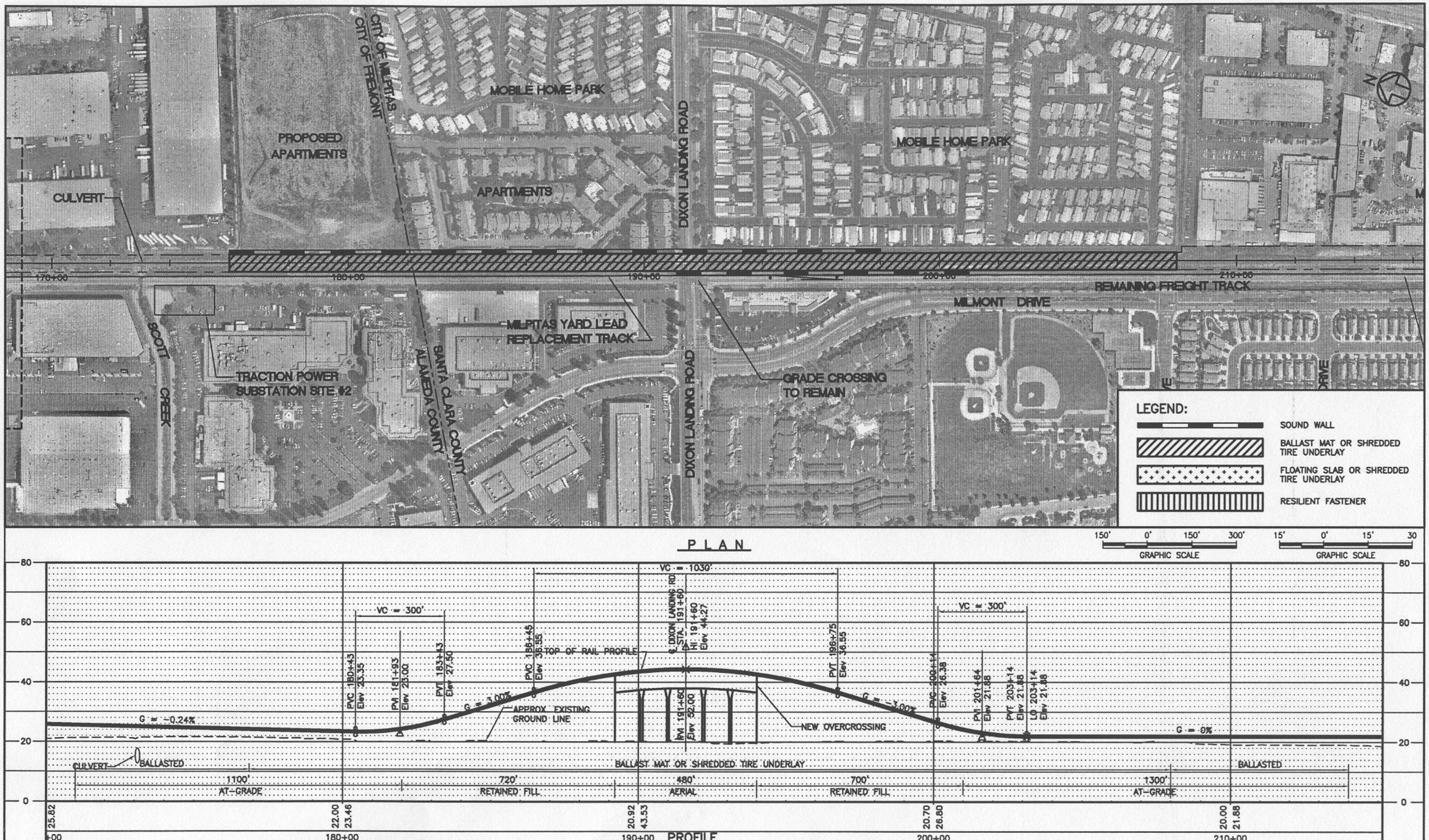
Ground-borne vibration is the oscillatory motion of the ground about an equilibrium position. It can be described in terms of displacement, velocity, or acceleration. Displacement refers to the distance an object moves away from its equilibrium position, velocity refers to the rate of change in displacement or the speed of this motion, and acceleration refers to the time rate of change in the velocity of the object.

Table 4.13-12: BART Alternative Noise Barrier Mitigation Treatment for Residential Areas

Location	Approx. Civil Station		Side of Track	Length (feet)	Approx. Barr. Height (feet)	# Impacts without Mitigation			# Impacts with Mitigation		
						FTA Criteria		BART	FTA Criteria		BART
	Beg.	End				Mod.	Sev.	Criteria	Mod.	Sev.	Criteria
DIXON LANDING ROAD ALIGNMENT – AERIAL OPTION											
Proposed Apartments	176+00	183+00	East	700	10	0	12 [1]	12 [1]	0	0	0
Spinnaker Pointe Apts., Dixon Landing Road	183+00	198+00	East	1500	4	12	46	46	0	0	0
Dixon Landing Road to Dixon Landing Park	191+00	199+00	West	800	4	3	0	0	0	0	0
Dixon Landing Road to Dixon Landing Park	199+00	201+00	West	200	6	4	0	0	0	0	0
Subtotal – Dixon Landing Road - Aerial Option				**3200**		**19**	**58**	**58**	**0**	**0**	**0**
DIXON LANDING ROAD ALIGNMENT – RETAINED CUT OPTION											
Proposed Apartments	176+00	183+00	East	700	10	0	12 [1]	12 [1]	0	0	0
Subtotal – Dixon Landing Road - Retained Cut Option				**700**		**0**	**12**	**12**	**0**	**0**	**0**
DIXON LANDING ROAD ALIGNMENT – AT-GRADE OPTION											
Proposed Apartments	176+00	183+00	East	700	10	0	12 [1]	12 [1]	0	0	0
Dixon Landing Road to Dixon Landing Park	199+00	201+00	West	200	10	3	0	0	0	0	0
Subtotal – Dixon Landing Road - At-Grade Option				**900**		**3**	**12**	**12**	**0**	**0**	**0**
ALIGNMENT EXCLUDING DIXON LANDING ROAD OPTIONS											
Summerwind Drive, Pescadero Street	228+00	245+00	West	1700	12	14	4	4	0	0	0
Wrigley Creek [2,3]	246+00	262+00	West	1600	16	0	20	20	0	0	0
Curtis Avenue	331+00	337+00	West	600	10	30	0	30	0	0	0
Montague/Capitol Station	378+00	-- [4]	East	200	12	10	0	10	0	0	0
Tradan Drive to Lagoon Way	412+00	418+00	East	600	8	7	0	3	0	0	0
Rose Briar Way	501+00	508+00	East	700	8	10	0	0	0	0	0
Aschauer Court	507+20	-- [5]	West	200	12	5	0	5	0	0	0
Winston Street to Berryessa Road	513+00	516+00	East	300	6	3	12	12	0	0	0
	516+00	520+00	East	400	4						
Subtotal - Alignment Excluding Dixon Landing Road Options				**6300**		**79**	**36**	**84**	**0**	**0**	**0**

Notes:
[1] Assumes 12 units at proposed apartments located between Station 176+00 to 183+00.
[2] Assumes barrier will be constructed west of proposed bulk substation and traction power substation locations.
[3] The use of a moveable point frog at the crossover located at STA 243+00 to 258+00 would reduce the length of this wall by 70 feet.
[4] Assumes this barrier will extend east from the alignment approximately 200 feet.
[5] Assumes this barrier will extend west from the alignment approximately 200 feet.

Source: Noise and Vibration Technical Report, HMMH, 2003.



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SILICON VALLEY RAPID TRANSIT CORRIDOR

BART – BUILD ALTERNATIVE
NOISE & VIBRATION MITIGATION
DIXON LANDING ROAD
BART AERIAL OPTION

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SCALE	1"=150'H; 1"=15'V
CADD FILE NO.	FIG4134A.DWG
DWG No.	FIG4134A
REV	0
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FIGURE 4.13-4a - NOISE AND VIBRATION MITIGATION LOCATIONS

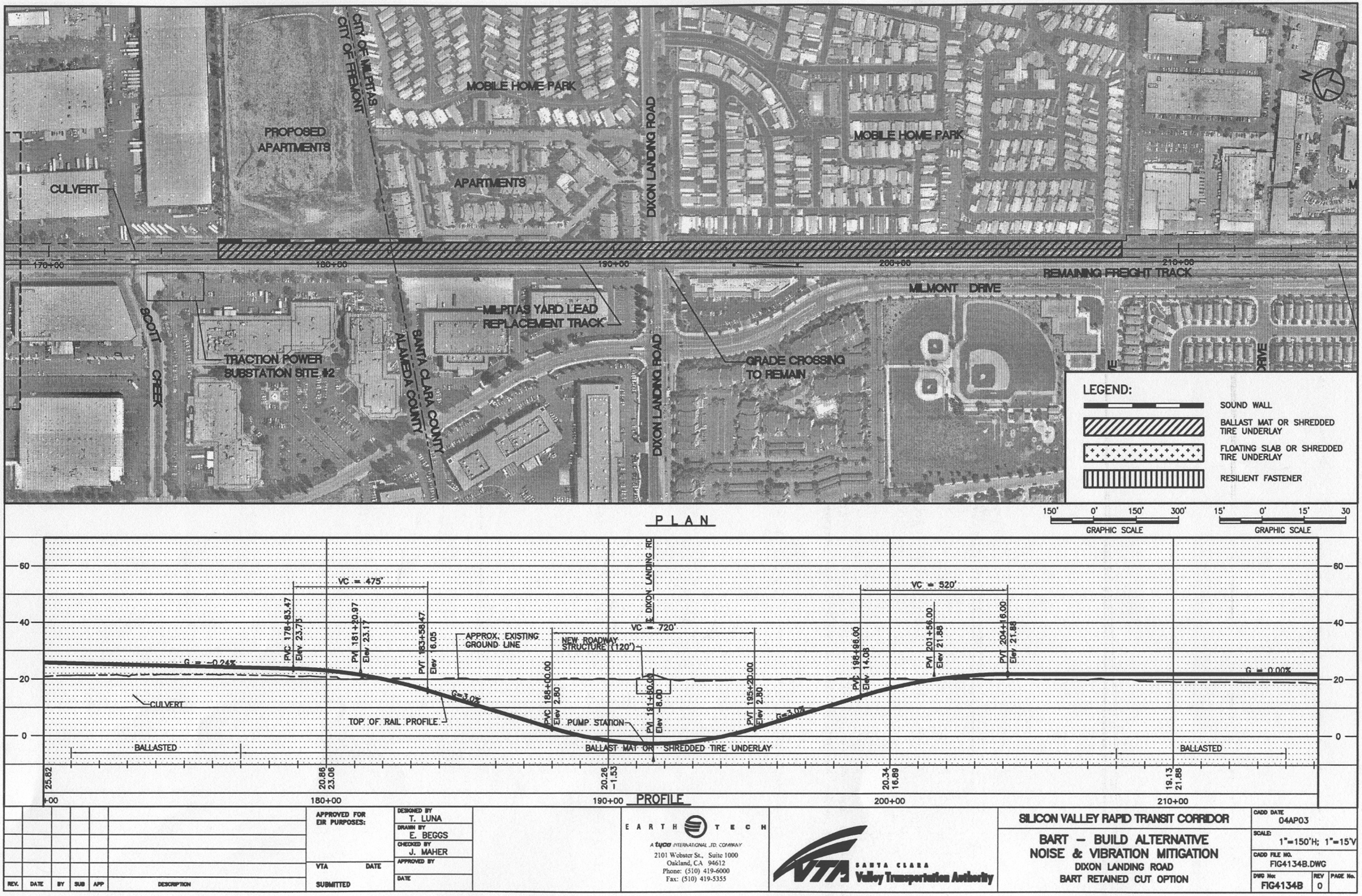
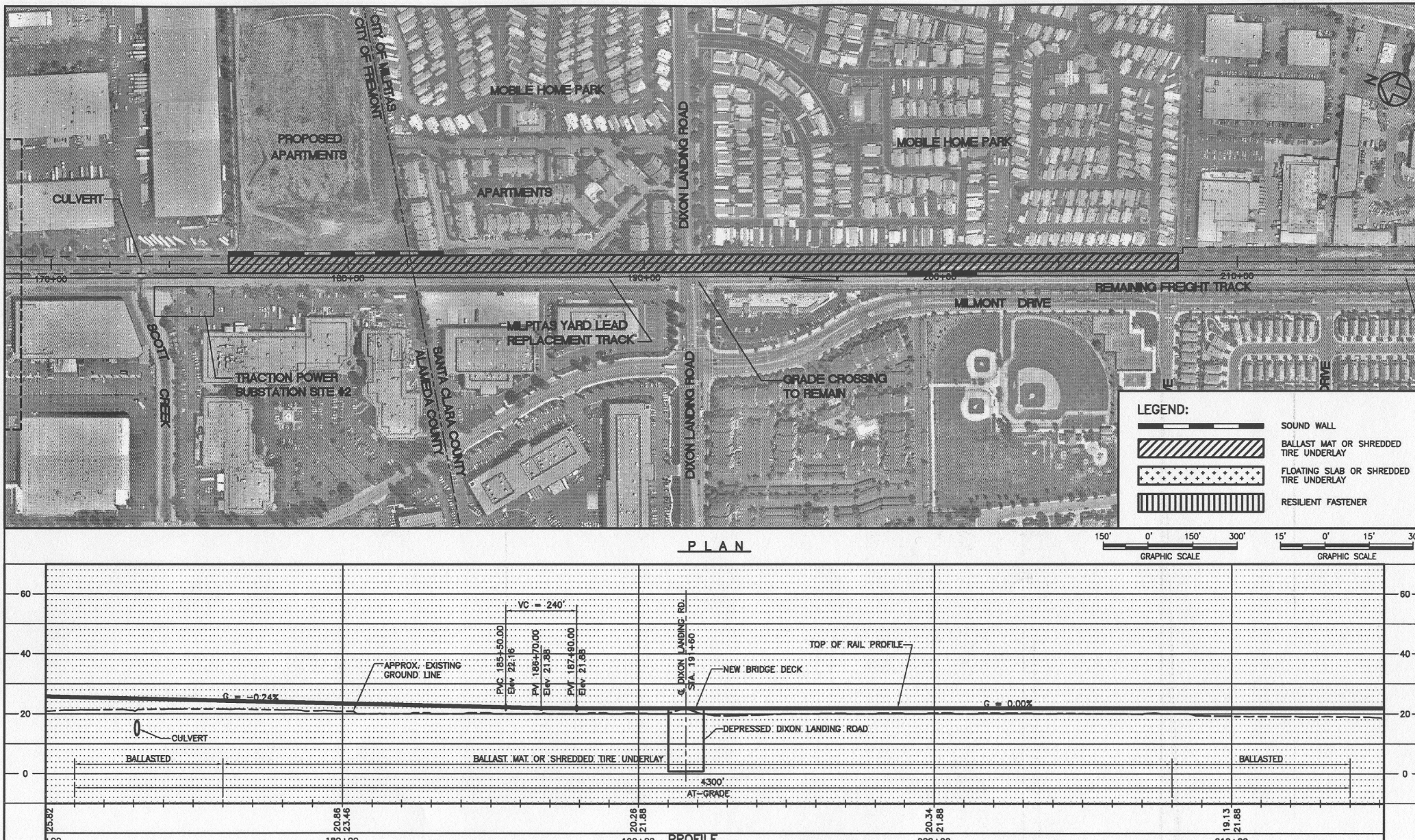


FIGURE 4.13-4b - NOISE AND VIBRATION MITIGATION LOCATIONS



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BART AT–GRADE OPTION

CADD DATE 04AP03
SCALE 1"=150'H; 1"=15'V
CADD FILE NO. FIG4134C.DWG
DWG No: FIG4134C
REV 0
PAGE No.

FIGURE 4.13-4c – NOISE AND VIBRATION MITIGATION LOCATIONS

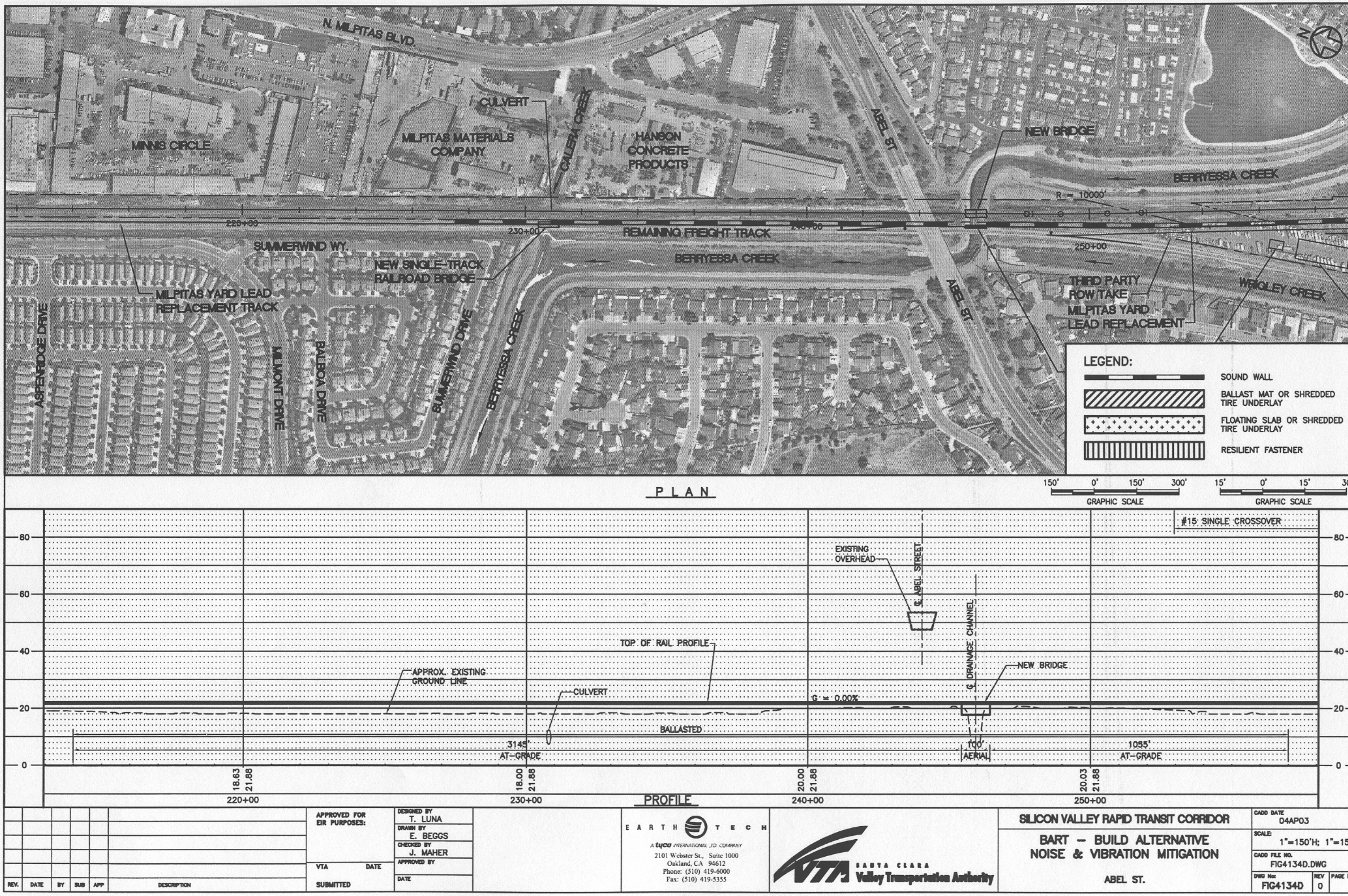
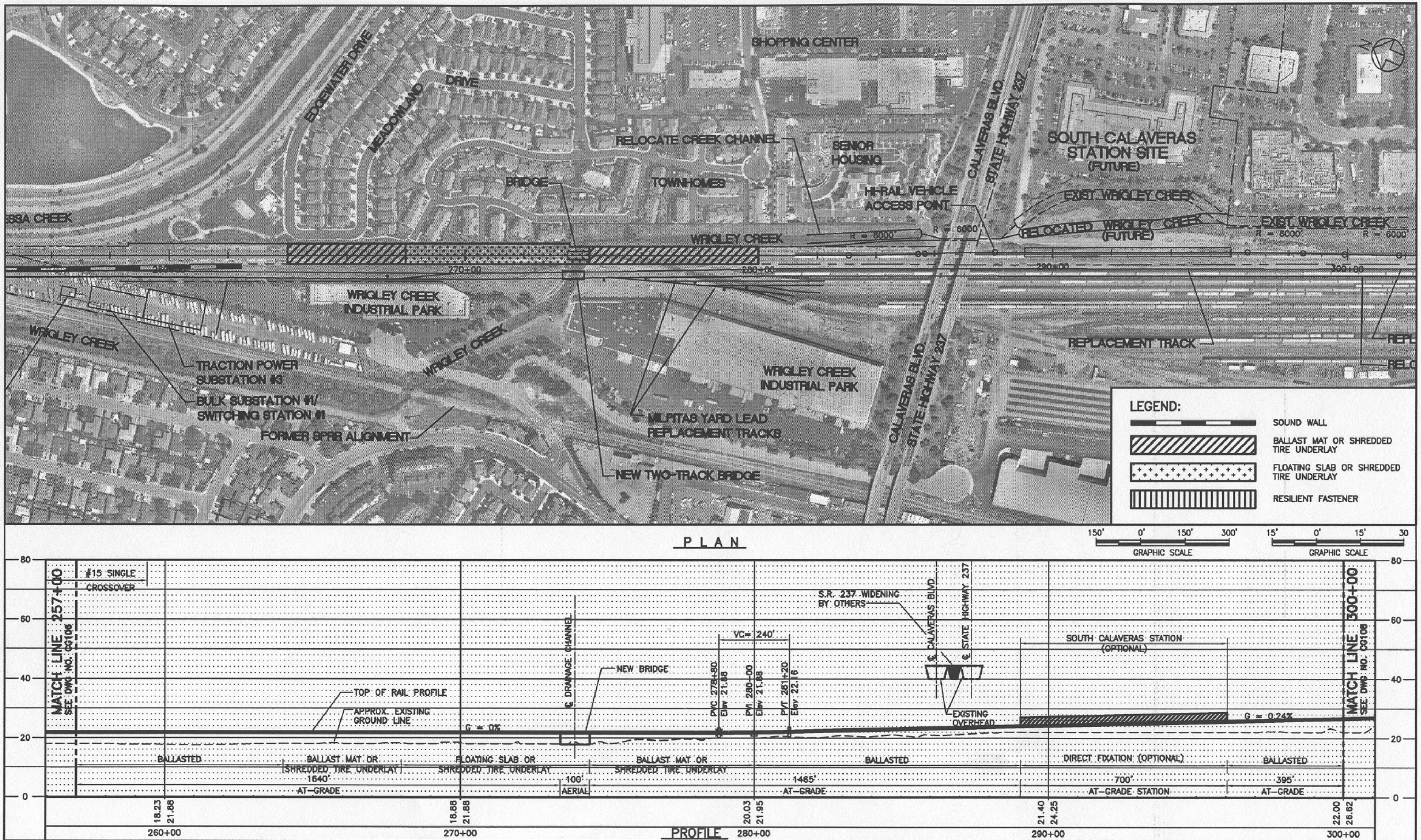


FIGURE 4.13-4d - NOISE AND VIBRATION MITIGATION LOCATIONS



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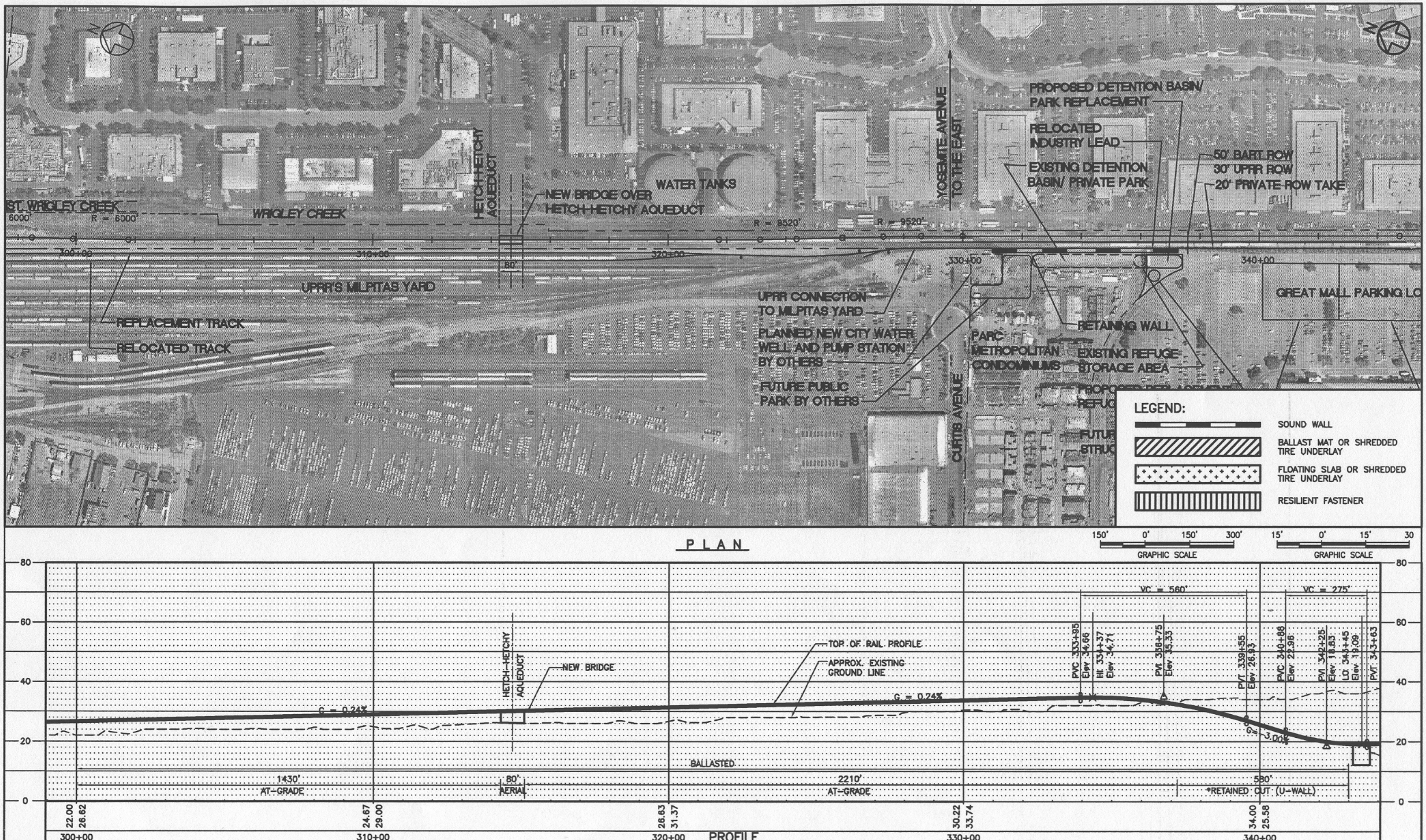
NOISE & VIBRATION MITIGATION

CALAVERAS BLVD.

CADD DATE 04AP03
SCALE: 1"=150'H; 1"=15'V
CADD FILE NO. FIG4134E.DWG
DWG No. FIG4134E
REV 0
PAGE No.

FIGURE 4.13-4e – NOISE AND VIBRATION MITIGATION LOCATIONS



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BART – BUILD ALTERNATIVE
NOISE & VIBRATION MITIGATION

GREAT MALL

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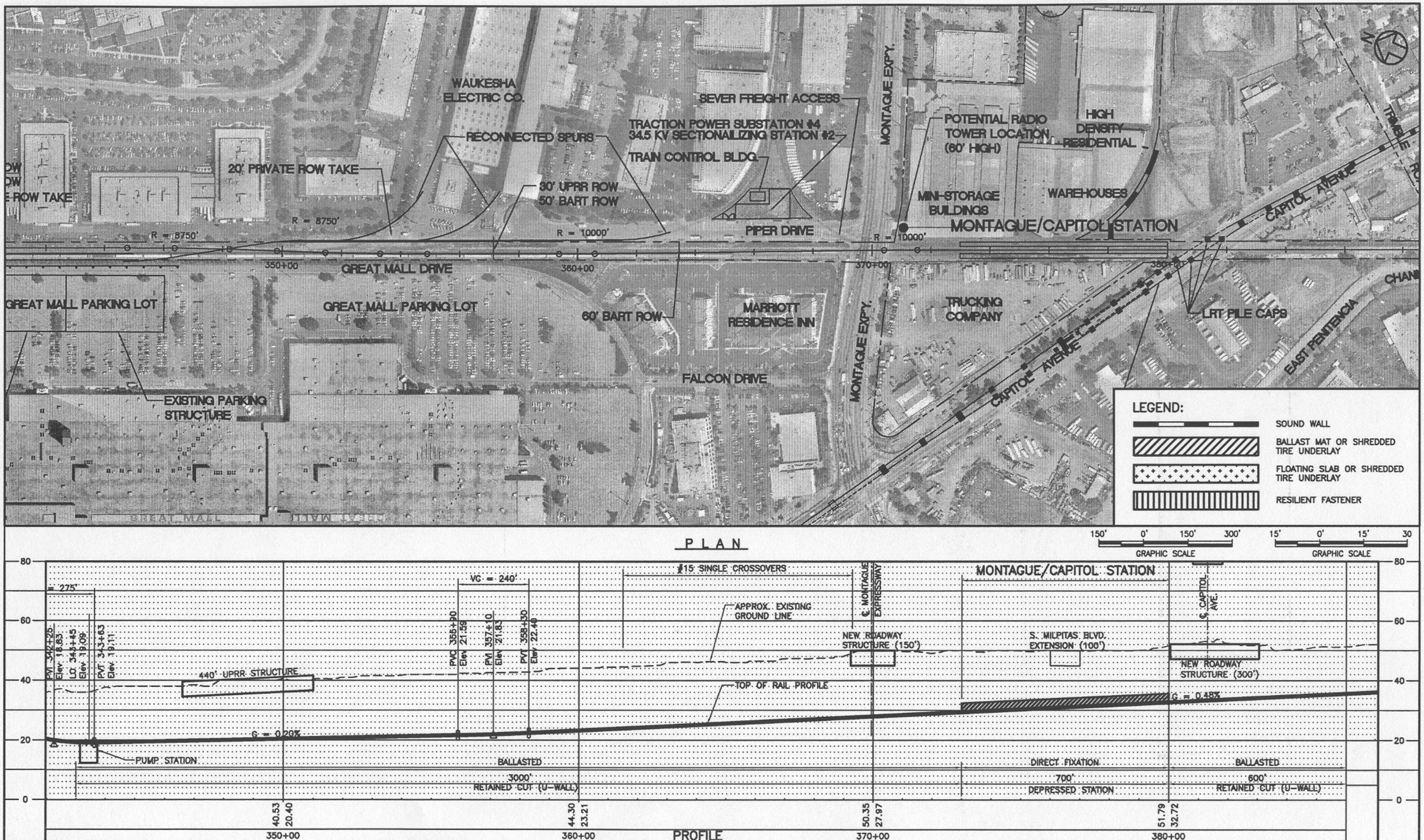
SCALE: 1"=150'H; 1"=15'V
CADD FILE NO. FIG4134F.DWG
DWG No: FIG4134F REV 0 PAGE No.

FIGURE 4.13-4f - NOISE AND VIBRATION MITIGATION LOCATIONS



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NOISE & VIBRATION MITIGATION

MONTAGUE EXPRESSWAY

CADD DATE 04AP03
SCALE: 1"=150'H; 1"=15'V
CADD FILE NO. FIG4134G.DWG
DWG No: FIG4134G
REV 0
PAGE No.

FIGURE 4.13-4g NOISE AND VIBRATION MITIGATION LOCATIONS

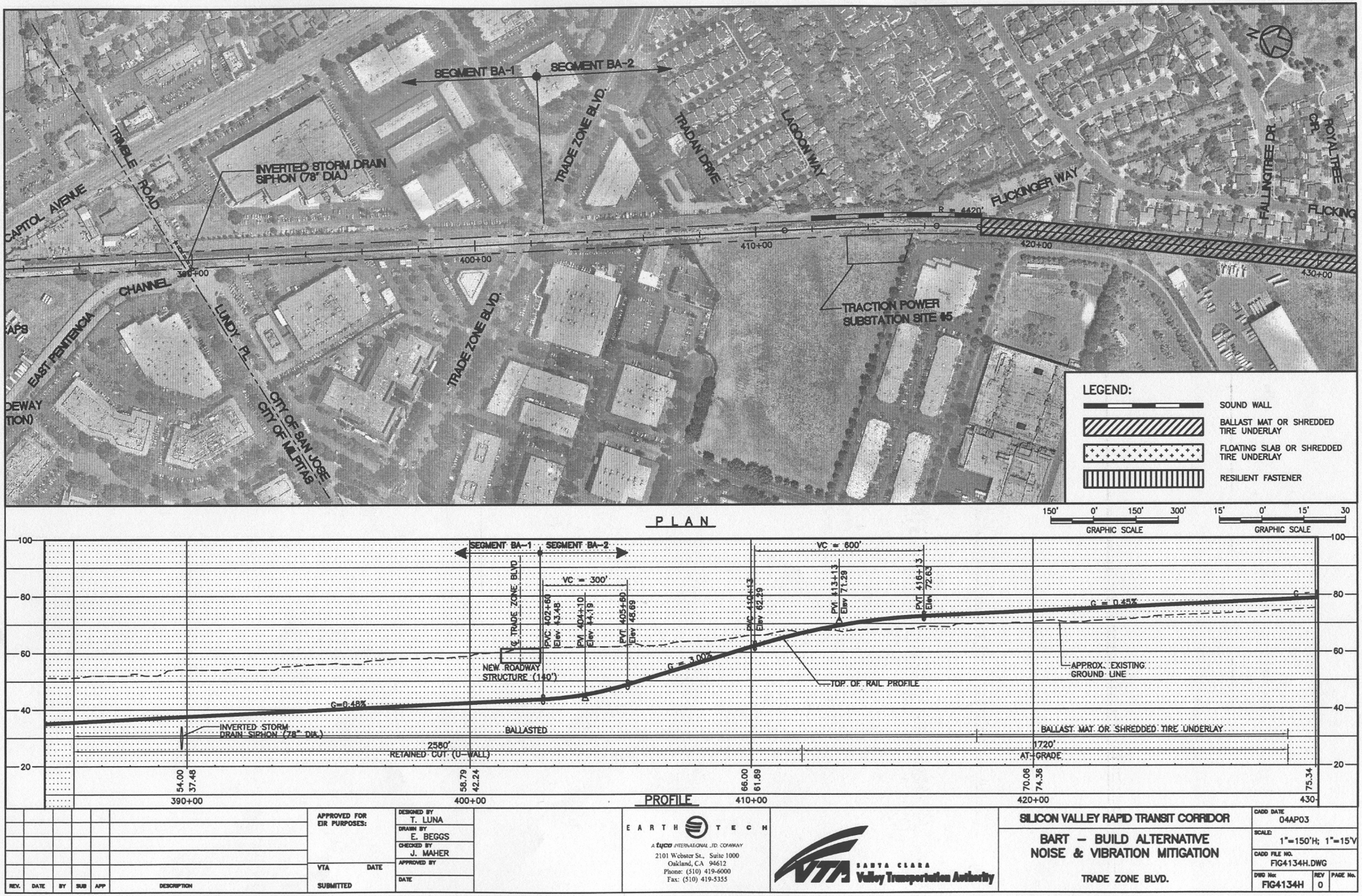


Figure 4.13-4h - NOISE AND VIBRATION MITIGATION LOCATIONS

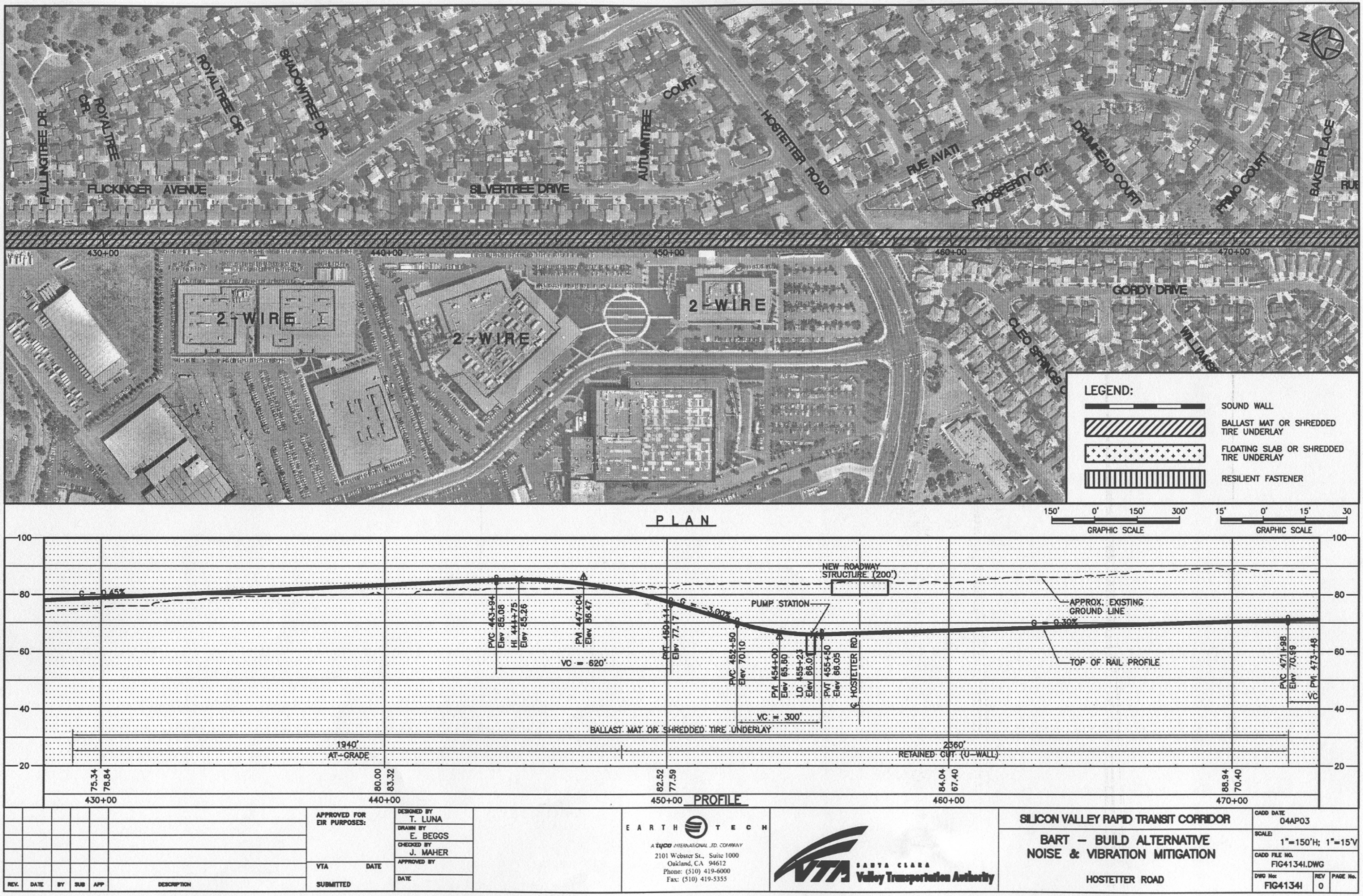
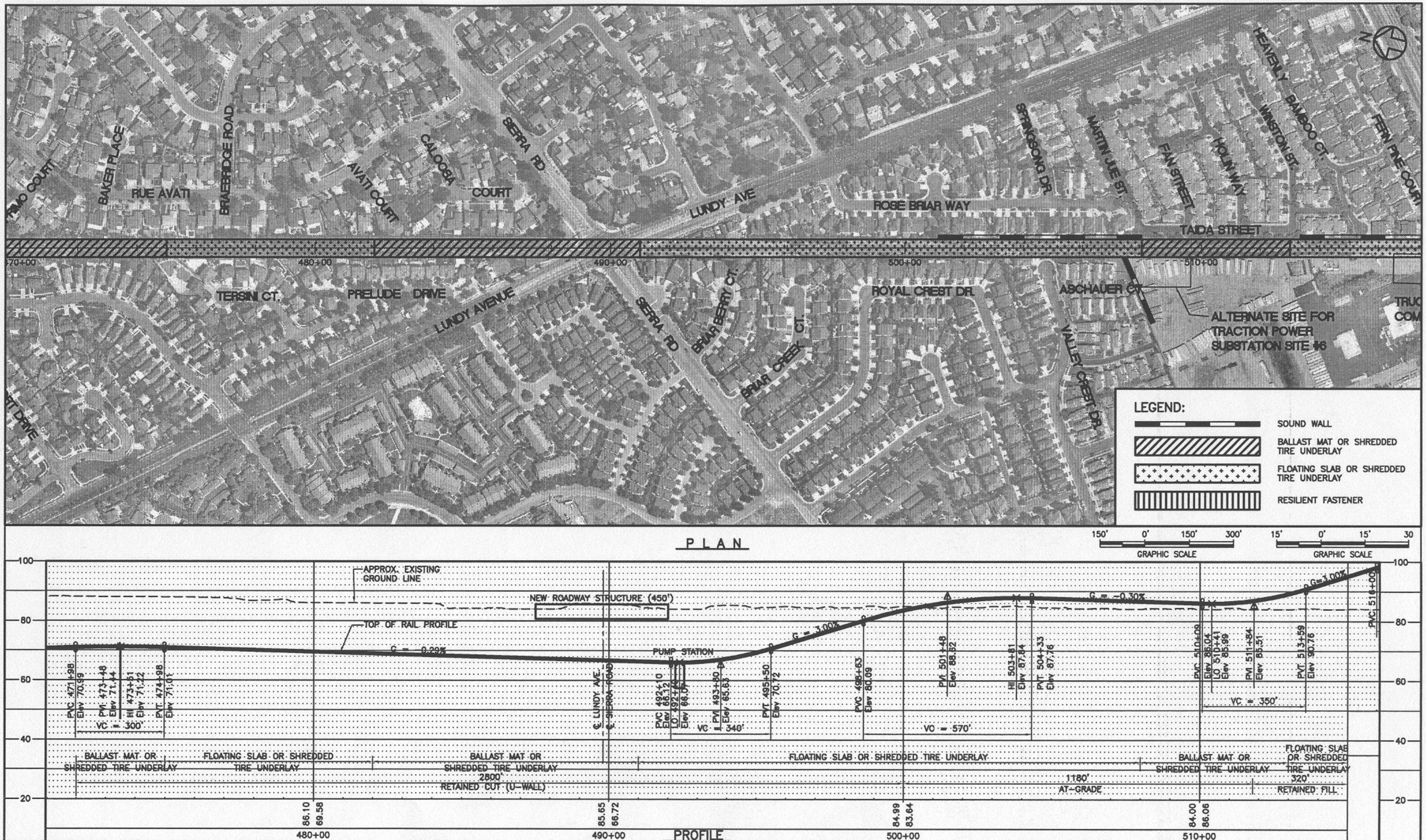


FIGURE 4.13-4i - NOISE AND VIBRATION MITIGATION LOCATIONS



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LUNDY AVENUE

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SCALE: 1"=150'H; 1"=15'V
CADD FILE NO. FIG4134J.DWG
DWG No: FIG4134J
REV 0
PAGE No.

FIGURE 4.13-4j - NOISE AND VIBRATION MITIGATION LOCATIONS

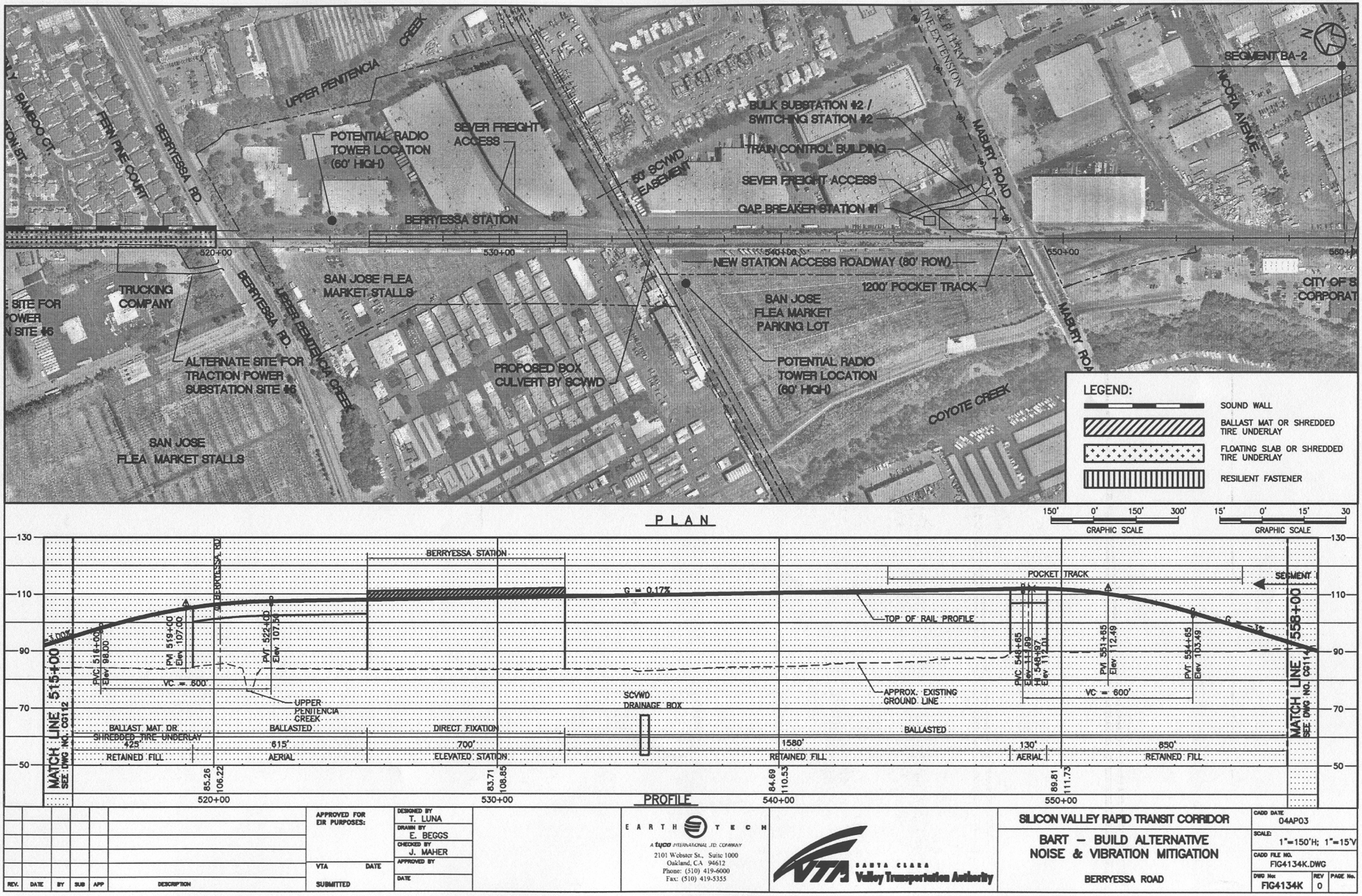
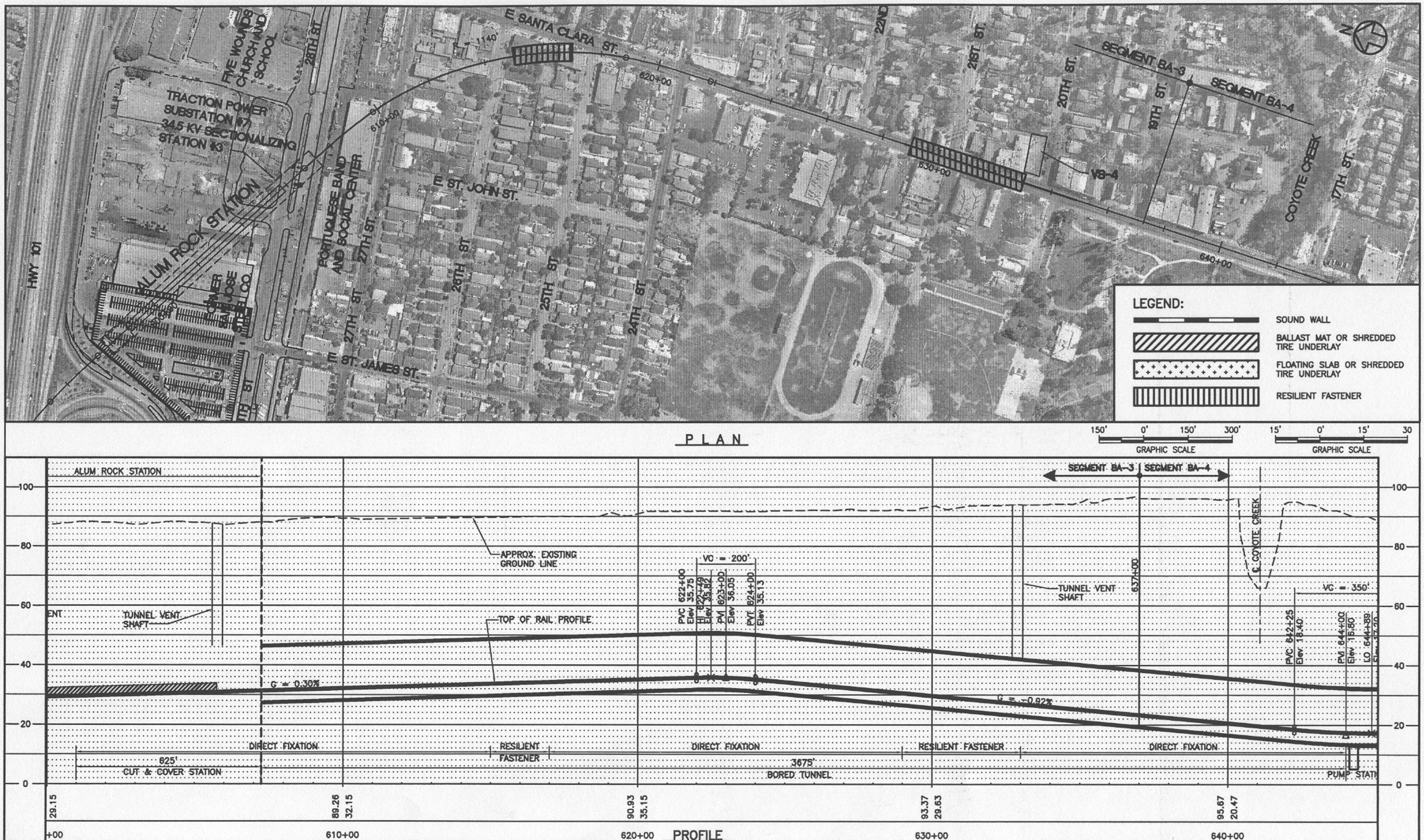


Figure 4.13-4k - Noise and Vibration Mitigation Locations



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ALUM ROCK STATION
US 101/DIAGONAL OPTION

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SCALE: 1"=150'H; 1"=15'V
CADD FILE NO. FIG4134L.DWG
DWG No: FIG4134L REV 0 PAGE No.

FIGURE 4.13-41 - NOISE AND VIBRATION MITIGATION LOCATIONS

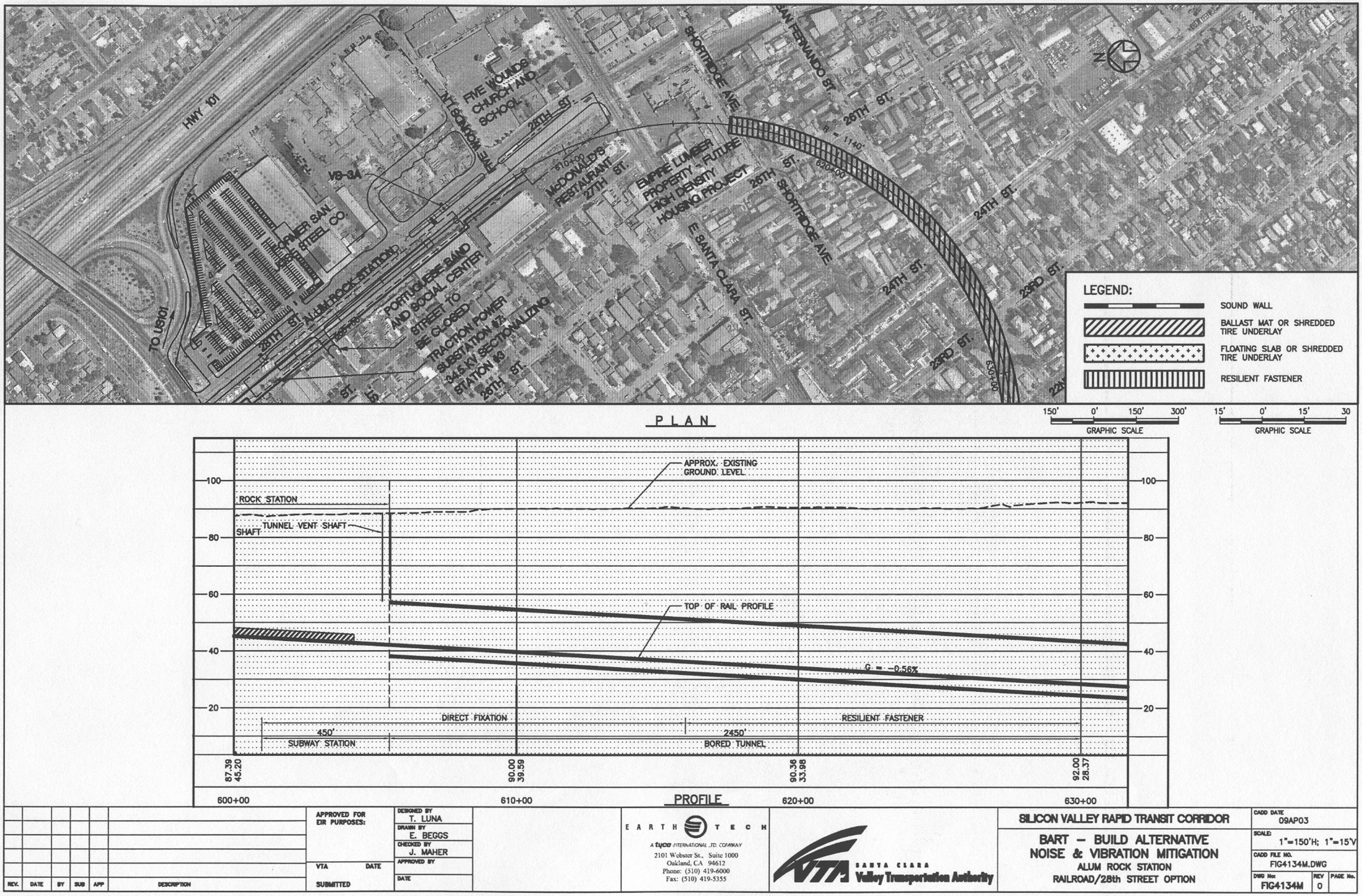
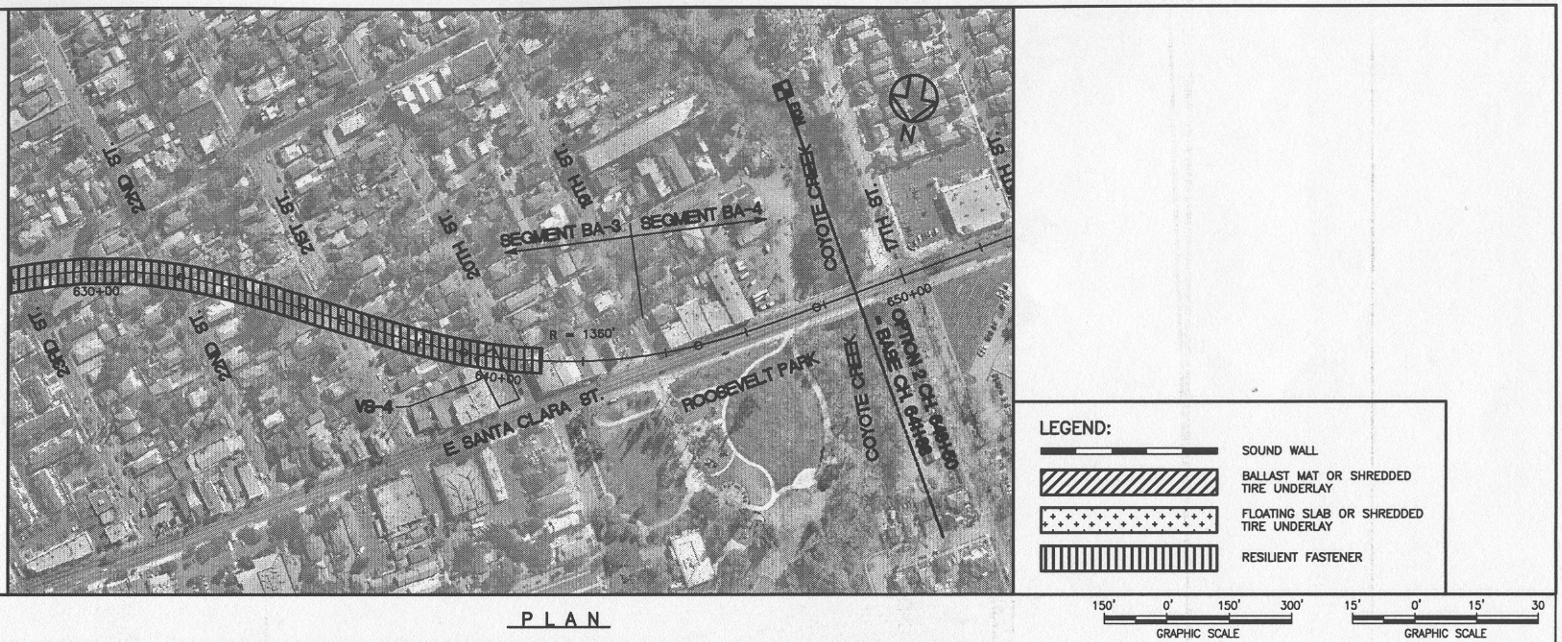
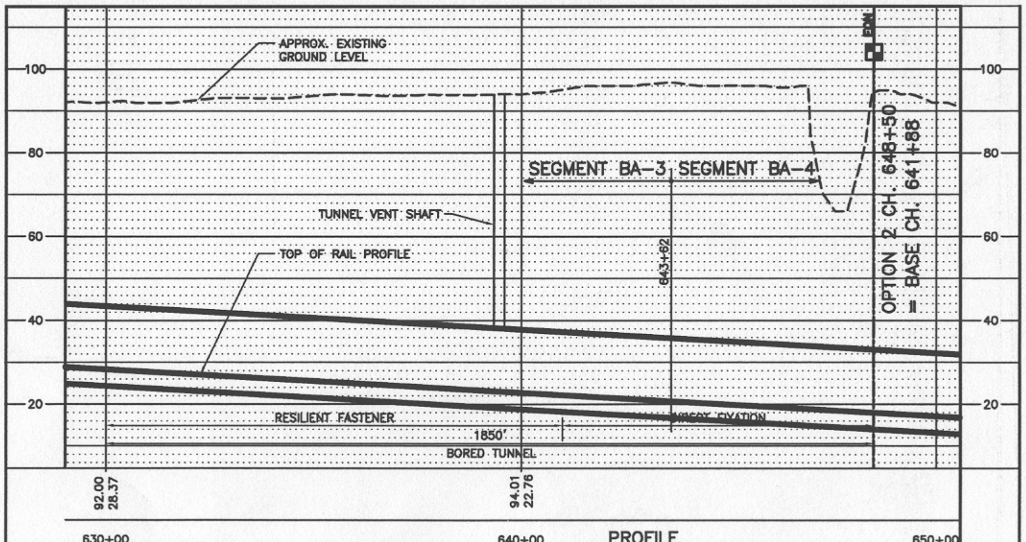


Figure 4.13-4m - NOISE AND VIBRATION MITIGATION LOCATIONS





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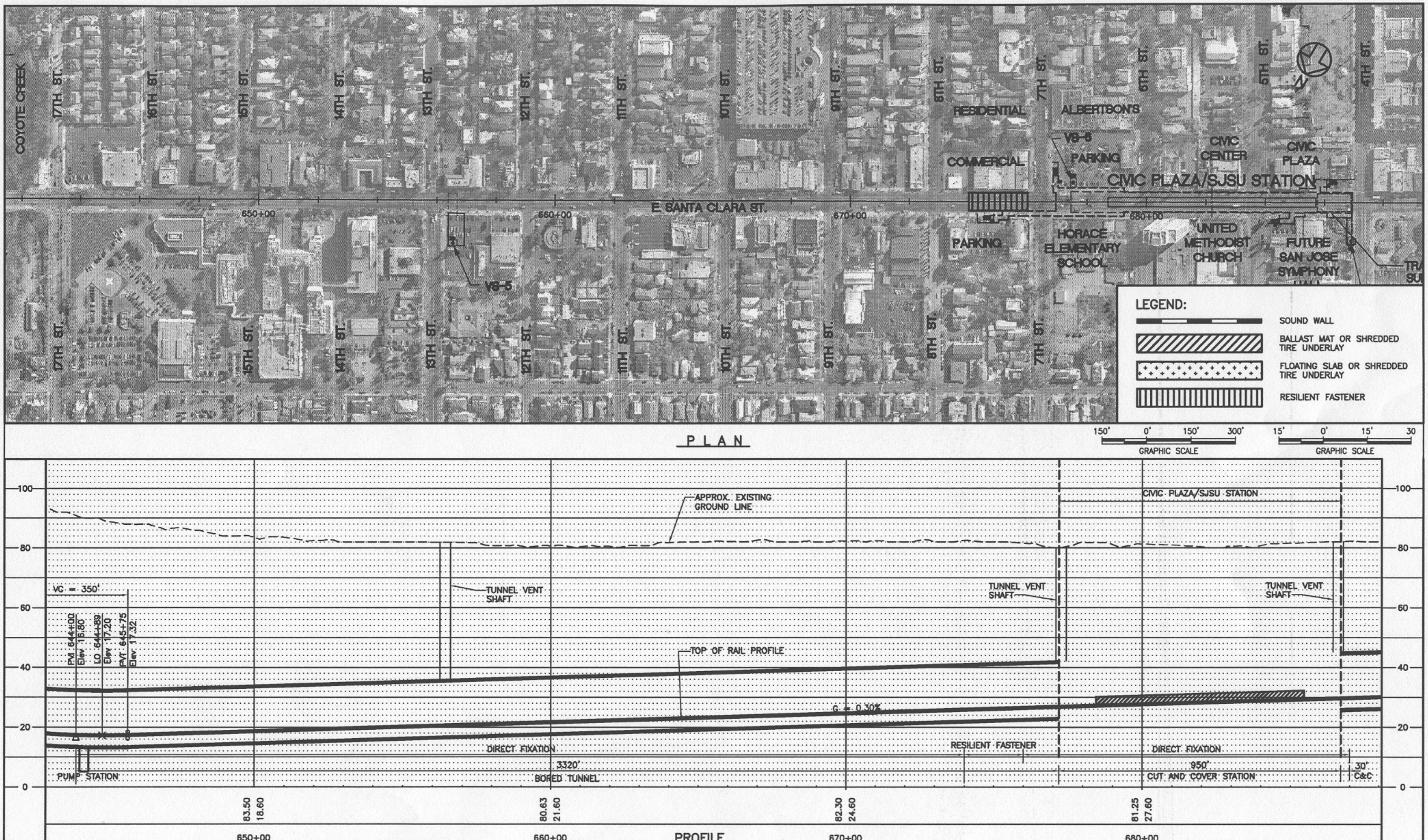
RAILROAD/28th STREET OPTION

CADD DATE 09AP03
SCALE: 1"=150'H; 1"=15'V
CADD FILE NO. FIG4134N.DWG
DWG No: FIG4134N
REV 0
PAGE No.

Figure 4.13-4n - Noise and Vibration Mitigation Locations



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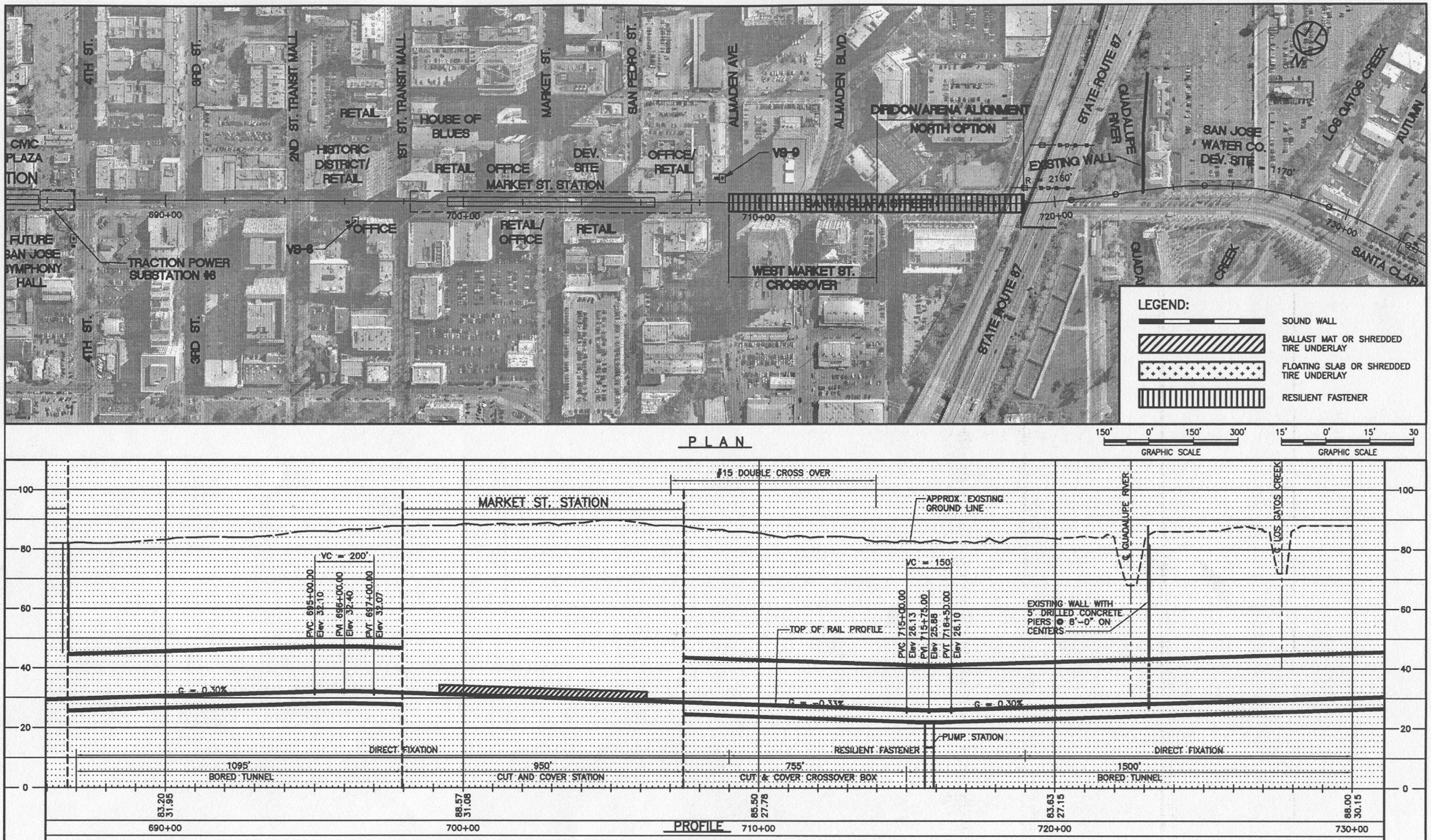
CIVIC PLAZA/SJSU STATION

CADD DATE: 04AP03
SCALE: 1"=150'H; 1"=15'V
CADD FILE NO. FIG41340.DWG
DWG No. FIG41340
REV 0
PAGE No.

FIGURE 4.13-4o - NOISE AND VIBRATION MITIGATION LOCATIONS



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BART – BUILD ALTERNATIVE
NOISE AND VIBRATION MITIGATION
STATE ROUTE 87
WEST OF MARKET ST. STATION OPTION

CADD DATE: 09AP03
SCALE: 1"=150'H; 1"=15'V
CADD FILE NO.: FIG4134P.DWG
DWG No: FIG4134P
REV: 0
PAGE No.:

FIGURE 4.13-4p - NOISE AND VIBRATION MITIGATION LOCATIONS

FIGURE 4.13-4q - NOISE AND VIBRATION MITIGATION LOCATIONS

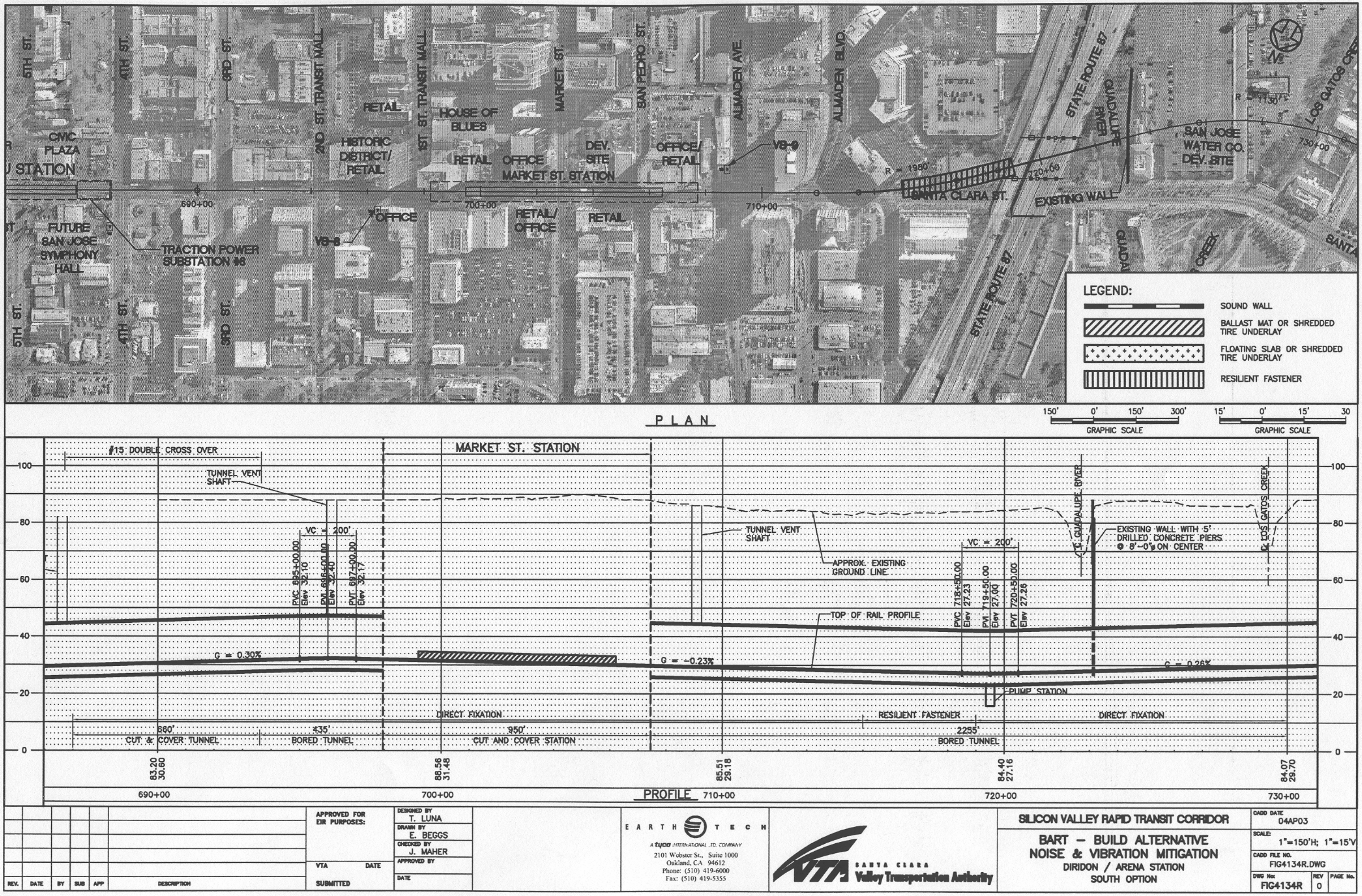
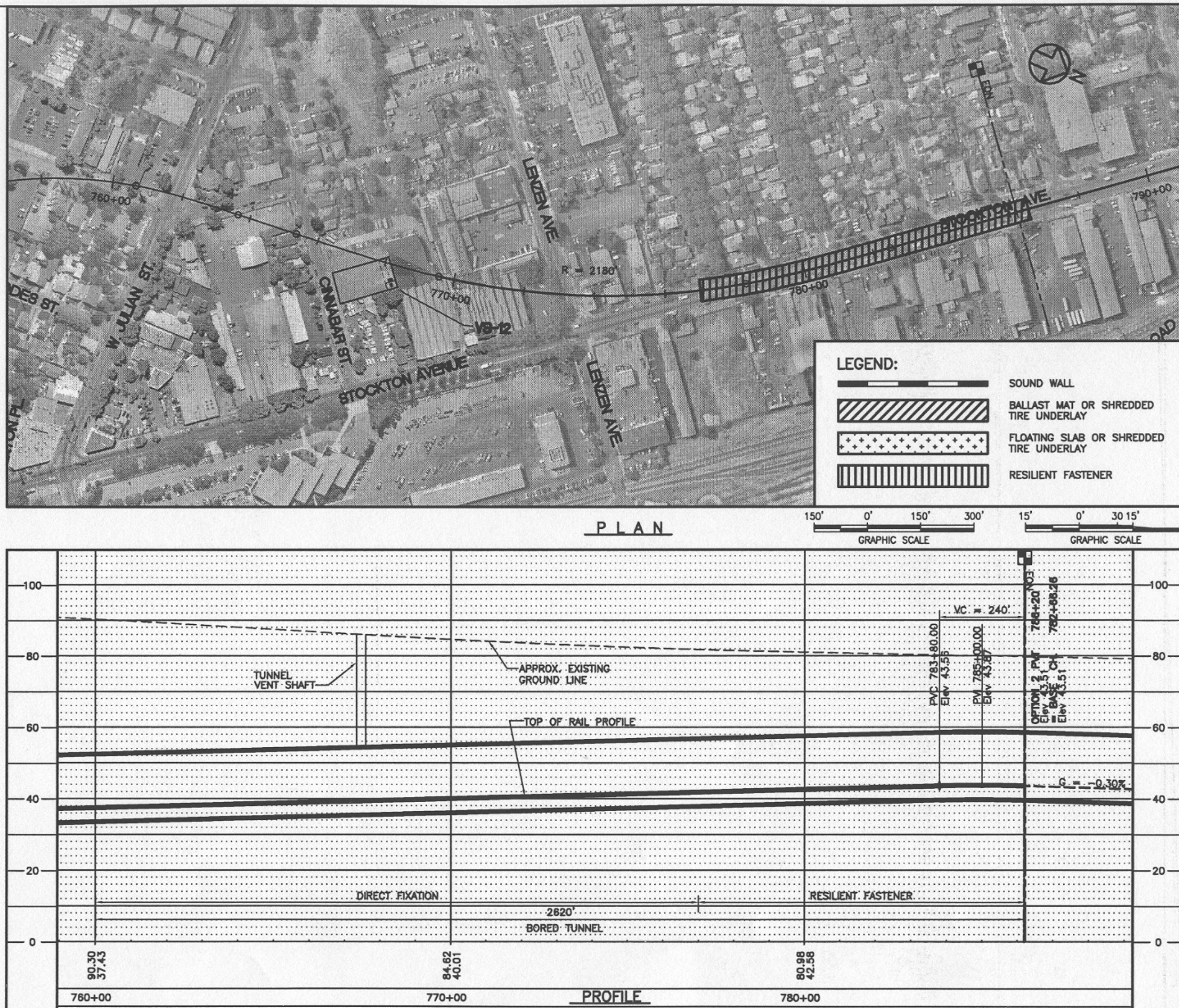


FIGURE 4.13-4r - NOISE AND VIBRATION MITIGATION LOCATIONS



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NOISE & VIBRATION MITIGATION
DIRIDON / ARENA STATION
SOUTH OPTION

CADD DATE 09AP03
SCALE 1"=150'H; 1"=15'V
CADD FILE NO. FIG4134S.DWG
DWG No: FIG4134S REV 0 PAGE No.

FIGURE 4.13-4s – NOISE AND VIBRATION MITIGATION LOCATIONS

Although displacement is easier to understand than velocity or acceleration, it is rarely used for describing ground-borne vibration. One reason for this is that most sensors used for measuring ground-borne vibration are designed to provide output signals proportional to either velocity or acceleration. Even more important, the response of humans, buildings, and equipment to vibration is more accurately described using velocity or acceleration. Sensitivity to vibration typically corresponds to the amplitude of vibration velocity within the low frequency range of most concern for environmental vibration (roughly 5 to 100 Hz). Therefore, vibration velocity is used in this analysis as the primary measure to evaluate the effects of vibration.

Vibration velocity level can be expressed in terms of decibels (VdB) relative to one micro-inch (µin) per second (1×10^{-6} inch per second). Figure 4.13-5 illustrates typical ground-borne vibration levels for common sources, as well as criteria for human and structural response to ground-borne vibration.

As shown, the range is from approximately 50 VdB to 100 VdB, from imperceptible background vibration to the threshold of damage. Although the threshold of human perception to vibration is approximately 65 VdB, annoyance is not usually substantial unless the vibration exceeds 70 VdB.

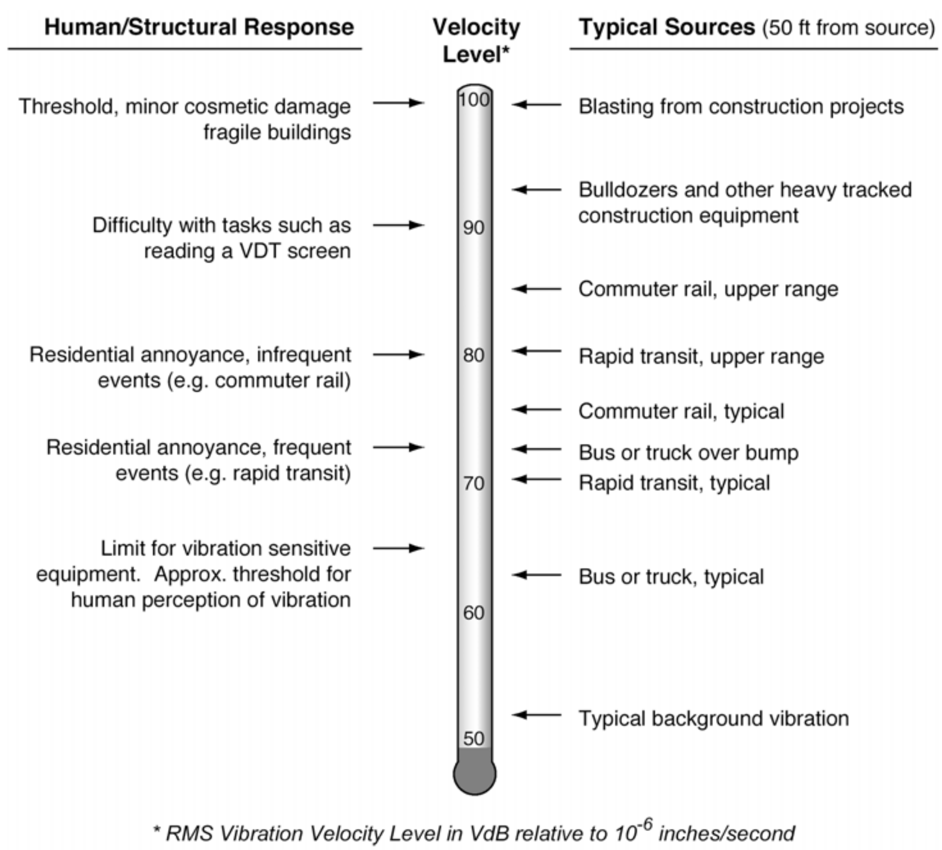

Figure 4.13-5: Typical Ground-Borne Vibration Levels and Criteria

Vibration Impact Criteria

FTA Vibration Impact Criteria

The FTA ground-borne vibration impact criteria are based on land use and train frequency, as shown in Table 4.13-13. Some buildings, such as concert halls, recording studios, and theaters, can be very sensitive to vibration but do not fit into any of the three categories listed in Table 4.13-13. Due to the sensitivity of these buildings, they usually warrant special attention during the environmental evaluation of a transit project. Table 4.13-14 gives criteria for acceptable levels of ground-borne vibration for these types of special buildings.

It should also be noted that Tables 4.13-13 and 4.13-14 include separate FTA criteria for ground-borne noise, the "rumble" that can be radiated from the motion of room surfaces in buildings due to ground-borne vibration. Although expressed in dBA, which emphasizes the more audible middle and high frequencies, the criteria are set lower than for airborne noise to account for the annoying low-frequency character of ground-borne noise. Because airborne noise often masks ground-borne noise for aboveground (i.e., at-grade or elevated) rail systems, ground-borne noise criteria are primarily applied to subway operations where airborne noise is not a factor.

Table 4.13-13: FTA Ground-Borne Vibration and Noise Impact Criteria by Land Use Category

Land Use Category	Ground-Borne Vibration Impact Levels (VdB re 1 µin/sec)		Ground-Borne Noise Impact Levels (dBA re 20 micro Pascals)	
	Frequent Events [1]	Infrequent Events [2]	Frequent Events [1]	Infrequent Events [2]
Category 1: Buildings where low ambient vibration is essential for interior operations.	65 VdB [3]	65 VdB [3]	-- [4]	-- [4]
Category 2: Residences and buildings where people normally sleep.	72 VdB	80 VdB	35 dBA	43 dBA
Category 3: Institutional land uses with primarily daytime use.	75 VdB	83 VdB	40 dBA	48 dBA

Notes:

[1] "Frequent Events" is defined as more than 70 vibration events per day. Most transit projects fall intothis category.

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

[3] 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.

[4] Vibration-sensitive equipment is not sensitive to ground-borne noise.

Source: FTA Transit Noise and Vibration Impact Assessment, 1995.

Table 4.13-14: FTA Ground-Borne Vibration and Noise Impact Criteria for Special Buildings

Type of Building [1] or Room	Ground-Borne Vibration Impact Levels (VdB re 1 μin/sec)		Ground-Borne Noise Impact Levels (dBA re 20 micro Pascals)	
	Frequent Events [2]	Infrequent Events [3]	Frequent Events [2]	Infrequent Events [3]
Concert Halls	65 VdB	65 VdB	25 dBA	25 dBA
TV Studios	65 VdB	65 VdB	25 dBA	25 dBA
Recording Studios	65 VdB	65 VdB	25 dBA	25 dBA
Auditoriums	72 VdB	80 VdB	30 dBA	38 dBA
Theaters	72 VdB	80 VdB	35 dBA	43 dBA

Notes:

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

[2] "Frequent Events" is defined as more than 70 vibration events per day. Most transit projects fall into this category.

[3] "Infrequent Events" is defined as fewer than 70 vibration events per day. This category includes most commuter rail systems.

Source: FTA Transit Noise and Vibration Impact Assessment, 1995.

BART Design Criteria for Ground-Borne Vibration

The BART Design Criteria are based on the maximum vibration level (Lmax) of a passby and depend on the type of the receptor (single-family, multi-family, commercial) and the area land use category. Table 4.13-15 presents the BART Design Criteria for operational ground-borne vibration. The bottom section of the table shows the criteria for special receptors. Table 4.13-16 shows the BART ground-borne noise criteria for residential receptors.

Methodology

Baseline Alternative

Ground-borne vibration was projected for the Baseline Alternative based on a generalized curve of vibration level by distance for rubber-tired vehicles as given in the FTA guidance manual. In general, vibration from buses or other rubber-tired vehicles is rarely high enough to create impact. Nonetheless, discontinuities in the roadway, such as potholes or other obstructions, can result in perceptible vibration levels from buses.

BART Alternative

Vibration impact for the BART Alternative was evaluated based on FTA Vibration and Noise Impact Criteria and the *BART Extensions Program System Design Criteria* (BART Design Criteria [Report]). Test locations for ground conditions along the proposed BART alignment are discussed in the following section.

Table 4.13-15: BART Design Criteria for Operational Ground-Borne Vibration			
BART Area Category	**Ground-Borne Vibration Maximum Passby Velocity Levels (VdB, µin/sec)**		
	Single-Family Dwellings	**Multi-Family Dwellings**	**Commercial Buildings**
I Low Density Residential	70	70	70
II Average Residential	70	70	75
III High Density Residential	70	75	75
IV Commercial	70	75	75
V Industrial/Highway	75	75	75
	Maximum Passby Vibration Velocity Levels (VdB, µin/sec)		
Concert Halls and TV Studios	65		
Churches and Theaters	70-75		
Hospital Sleeping Rooms	70-75		
Courtrooms, Schools, Libraries	75		
Offices	75-80		
Commercial and Industrial Buildings	75-85		
Vibration-Sensitive Industry or Research	60-70		
Source: BART Extensions Program System Design Criteria, 1992.			

Table 4.13-16: BART Design Criteria for Ground-Borne Noise from Train Operations			
Community Area Category	**Maximum Passby Noise Level (dBA re 20 micro Pascals)**		
	Single-Family Dwellings	**Multi-Family Dwellings**	**Hotel/Motel Buildings**
Low Density Residential	30	35	40
Average Residential	35	40	45
High Density Residential	35	40	45
Commercial	40	45	45
Industrial/Highway	40	45	50
Source: BART Extensions Program System Design Criteria, 1992.			

4.13.4.2 Existing Vibration Conditions

Baseline Alternative

Roadway traffic is the primary source of existing vibration in the vicinity of facilities proposed under the Baseline Alternative. Vibration levels are not perceptible except near areas where the roadway may be in disrepair and potholes amplify vibration from heavy trucks or buses; therefore, vibration testing is neither applicable nor necessary for properties near the busway connectors under this alternative.

BART Alternative

Freight trains along the railroad corridor and heavy truck traffic on nearby roadways are the primary contributors to the existing vibration environment along the alignment for the BART Alternative and MOS scenarios. A measurement program was carried out in the fall and winter of 2001 and 2002 to characterize ground-borne vibration propagation at representative sites. Vibration measurement test sites were selected based on a review of aerial photographs, supplemented by a visual land-use survey. Nine sites were selected to represent a range of soil conditions in areas along the corridor that include a substantial number of vibration-sensitive receptors.

Test Locations

Both surface and borehole vibration propagation measurements were performed to characterize the ground for both surface and subsurface BART operation. The locations of the vibration measurement test sites are indicated in Figure 4.13-6 and are described below.

- **Site SV1.** A surface vibration propagation test was conducted on Dixon Landing Road in Milpitas, which runs parallel to the proposed BART Alternative alignment. The test site is representative of the ground conditions for this area of the alignment.
- **Site SV2.** A surface vibration propagation test was conducted in the courtyard of an apartment complex near Arroyo de Los Coches on SR 237 in Milpitas. This test site was chosen to represent the residential areas in the vicinity of the proposed South Calaveras Future Station.
- **Site SV3.** A surface vibration propagation test was conducted to the west of the corridor, in the parking lot of BD Biosciences, on Qume Drive in San Jose. This measurement is representative of the ground characteristics in the surrounding residential areas.
- **Site SV4.** A surface vibration propagation test was conducted in the northwest corner of the railroad corridor and Berryessa Road intersection in San Jose. This propagation site was selected to be representative of the residential areas in the vicinity of this section of the proposed BART Alternative alignment.
- **Site BV1.** A borehole vibration propagation test was conducted near the corner of East Santa Clara St and 26th Street in San Jose, near the eastern end of the BART subway tunnel. This site is representative of the propagation conditions near the Alum Rock Station.
- **Site BV2.** A borehole vibration propagation test was conducted in an empty lot along East Santa Clara Street, located between 17th Street and 19th Street, adjacent to Roosevelt Park in San Jose. This site is representative of ground conditions near San Jose Medical Center.
- **Site BV3.** A borehole vibration propagation test was conducted in the parking lot on the southeast corner of the intersection of East Santa Clara Street and 5th Street in San Jose. This vibration propagation site was selected to represent the ground characteristics along East Santa Clara Street in the vicinity of SJSU.
- **Site BV4.** A borehole vibration propagation test was conducted in a parking lot adjacent to West Santa Clara Street and between Cahill and Montgomery streets in San Jose. The measurement results for this site represent the ground characteristics in the vicinity of the Diridon/Arena Station.
- **Site BV5.** A borehole vibration propagation test was conducted in the street near the corner of Morrison Avenue and West Julian Street in San Jose. This site represents the ground conditions near the western end of the BART subway tunnel.

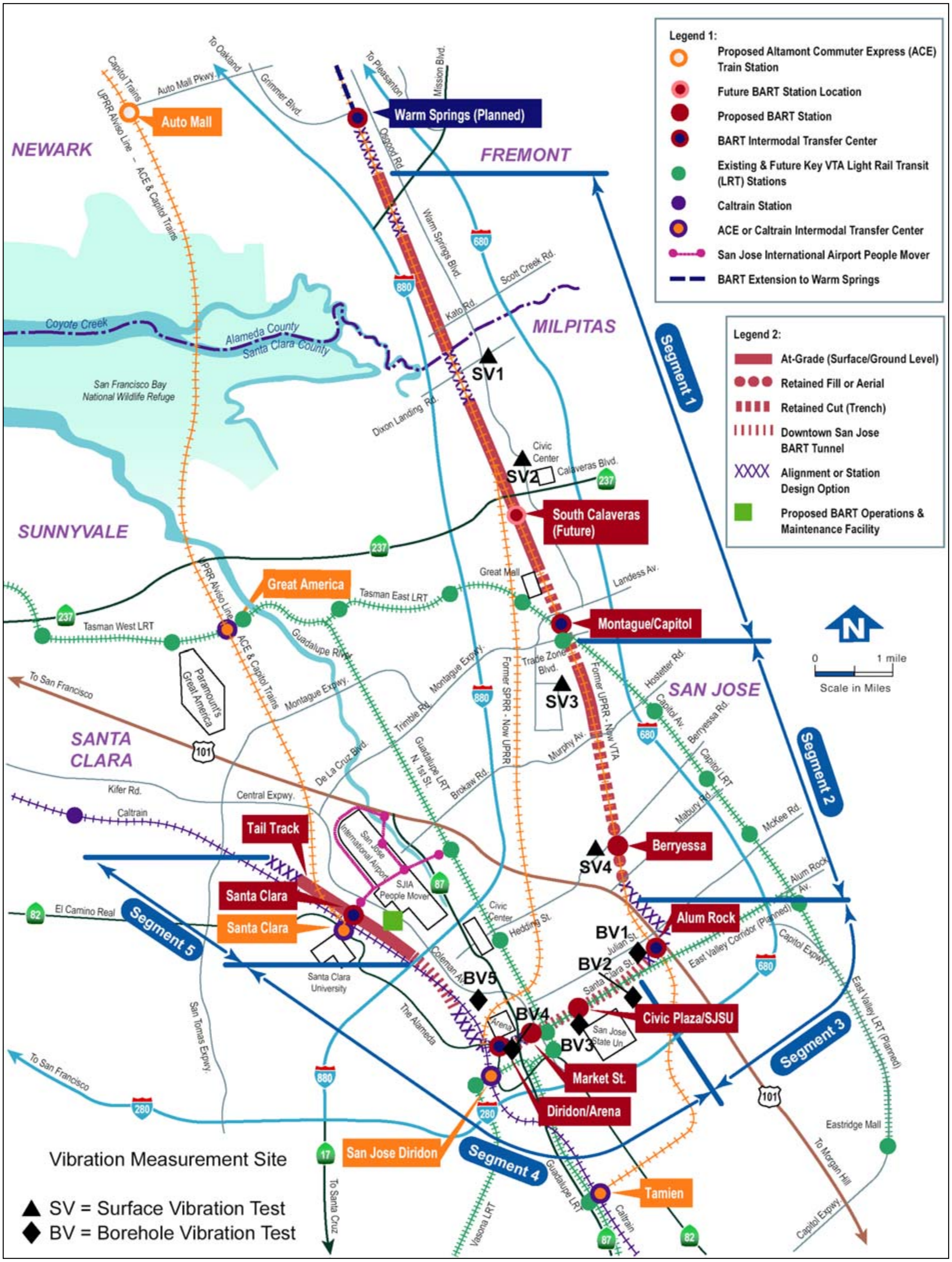

Figure 4.13-6: Vibration Measurement Test Locations

Test Results

At sites SV1, SV3, and SV4, the transfer mobilities (the relationship between the input force and the ground surface vibration) peak around 25 to 31.5 Hz. The transfer mobilities measured at site SV2 are relatively flat, with a broad peak centered around 50 Hz. At all the surface vibration measurement sites, frequencies higher than 25 to 31.5 Hz attenuate rapidly with increasing distance, while lower frequencies decline at a slower rate. Because transfer mobility is directly proportional to ground-borne vibration, an examination of the measured data gives an indication of the magnitude of future vibration. Vibration levels at locations characterized by Site SV2 would be the highest, while vibration levels at locations characterized by Site SV3 would be lowest.

At close distances, the transfer mobilities for the borehole tests (BV1 to BV5) are relatively flat across lower frequencies, with peaks centered around 100 Hz. The higher frequencies tend to fall off sharply with increasing distance, which indicates that low frequency vibration will likely dominate vibration level at distances beyond 100 feet. These results suggest that ground-borne noise, which is caused by high-frequency vibration, would decrease rapidly with increasing distance from the subway. The measurement results indicate that subway vibration would likely be highest in the areas characterized by measurement Site BV4 because the transfer mobilities measured at Site BV4 had the highest overall levels. Similarly, subway vibration would be lowest in areas characterized by Site BV5 because the transfer mobilities measured near Site BV5 had the lowest levels.

4.13.5 IMPACT ASSESSMENT AND MITIGATION MEASURES

4.13.5.1 Vibration Impacts

No-Action Alternative

Projects planned under the No-Action Alternative would undergo their own environmental review to define vibration impacts and determine appropriate mitigation measures.

Baseline Alternative

No vibration impact is projected for the Baseline Alternative due to the relatively low vibration levels generated by buses, and the distance between the busway and the nearest residential properties. No mitigation is required.

BART Alternative

Vibration projections and impact assessment using FTA criteria for residential buildings are summarized in Table 4.13-17. The table includes the approximate location of the receptors, the approximate distance to the receptor nearest the tracks, projected vibration and ground-borne noise level (where applicable), and the appropriate criterion. The projection of ground-borne vibration from BART operations was based on the force density spectrum for the BART heavy rail vehicle, the ground vibration propagation test results at nine representative locations (see Section 4.13.4.2), and vehicle operating speeds. Because airborne noise often masks ground-borne noise for aboveground (i.e. at-grade or elevated) rail systems, ground-borne noise criteria have been applied to tunnel operations where airborne noise is not a factor.

The number of impacts before mitigation depends on the design options selected. As indicated in Table 4.13-17, the number of impacts to residential buildings ranges from 305 (with Alum Rock Alignment US 101/Diagonal Option, and Diridon/Arena Alignment North Option) to 426 (with Alum Rock Alignment Railroad/28th Street Option, West of Market Street Station Crossover Option, and Diridon/Arena Alignment South Option). The number of residences impacted by each option is summarized below for the BART Alternative and MOS scenarios:

- Dixon Landing Road Alignment (All options) – 34 residences
- Remainder of Surface Corridor – 216 residences
- Alum Rock Alignment (US 101 Diagonal Option) – 0
- Alum Rock Alignment (Railroad/28th Street Option) – 20 residences
- Tunnel Corridor (9th Street) – 8 residences
- West of Market Street Station Crossover Option– 100 residences
- Diridon/Arena Alignment (North Option) – 47 residences
- Diridon/Arena Alignment (South Option) – 48 residences

Vibration projections and impact assessment using the BART Design Criteria for residential buildings are summarized in Table 4.13-18. The number of impacts to residential land uses before mitigation would range from 344 (with Alum Rock Alignment US 101/Diagonal Option, and Diridon/Arena Alignment North Option) to 484 (with Alum Rock Alignment Railroad/28th Street Option, West of Market Street Station Crossover Option, and Diridon/Arena Alignment South Option). The number of residences impacted by each option is summarized below for the BART Alternative and MOS scenarios:

- Dixon Landing Road Alignment (All options) – 64 residences
- Remainder of Surface Corridor – 262 residences
- Alum Rock Alignment (US 101 Diagonal Option) – 3 residences
- Alum Rock Alignment (Railroad/28th Street Option) – 42 residences
- Tunnel Corridor (9th Street) – 8 residences
- West of Market Street Station Crossover Option– 100 residences
- Diridon/Arena Alignment (North Option) – 7 residences
- Diridon/Arena Alignment (South Option) – 8 residences

Table 4.13-17 lists only the locations where vibration levels exceed FTA criteria for impact before mitigation measures are applied. Likewise, Table 4.13-18 lists only the locations where vibration levels exceed BART Design Criteria for impact before mitigation measures are applied. If a location does not appear in Table 4.13-17 or Table 4.13-18, the properties at that location will not experience vibration impacts from the BART Alternative. Vibration levels at locations that are in either table will be reduced to acceptable levels under FTA and BART criteria through implementation of mitigation measures, as described in Section 4.13.5.3 below except as noted.

Projected vibration impacts for each area along the proposed BART Alternative alignment are discussed below.

Table 4.13-17: BART Alternative Residential Vibration Impacts Without Mitigation Using FTA Criteria

Location	Land Use	Approx. Civil Station		Distance to Near Track (ft)	Side of Track	Max. Speed (mph)	Project Vibration Level (VdB re 1 μin/s)	Vibration Impact Criterion	Project Ground-Borne Noise Level (dBA)	Ground-Borne Noise Criterion	# of Res. Impacts
		Beg.	End								
DIXON LANDING ROAD ALIGNMENT – AERIAL OPTION											
Kato Road to Dixon Landing Road	MF	177+00	182+00	35	E	67	75	72	--	--	12 [1]
Kato Road to Dixon Landing Road	MF	182+40	184+40	35	E	67	75	72	--	--	10
Kato Road to Dixon Landing Road	MF	189+50	191+00	35	E	67	75	72	--	--	12
Subtotal – Dixon Landing Road - Aerial Option											**34**
DIXON LANDING ROAD ALIGNMENT – RETAINED CUT OPTION											
Kato Road to Dixon Landing Road	MF	177+00	182+00	35	E	67	75	72	--	--	12 [1]
Kato Road to Dixon Landing Road	MF	182+40	184+40	35	E	67	75	72	--	--	10
Kato Road to Dixon Landing Road	MF	189+50	191+00	35	E	67	75	72	--	--	12
Subtotal – Dixon Landing Road - Retained Cut Option											**34**
DIXON LANDING ROAD ALIGNMENT – AT-GRADE OPTION											
Kato Road to Dixon Landing Road	MF	177+00	182+00	35	E	67	75	72	--	--	12 [1]
Kato Road to Dixon Landing Road	MF	182+40	184+40	35	E	67	75	72	--	--	10
Kato Road to Dixon Landing Road	MF	189+50	191+00	35	E	67	75	72	--	--	12
Subtotal – At-Grade Option											**34**
REMAINDER OF SURFACE CORRIDOR											
Edgewater Dr. to Calaveras Blvd.	SF	264+50	268+50	77	E	67	75	72	--	--	6
Edgewater Dr. to Calaveras Blvd.	SF	268+50	269+00	43	E	67	81	72	--	--	17
Trade Zone Blvd. to Hostetter Rd.	SF	419+00	420+20	44	E	67	75	72	--	--	12
Trade Zone Blvd. to Hostetter Rd.	SF	420+50	422+40	46	E	67	75	72	--	--	30
Trade Zone Blvd. to Hostetter Rd.	SF	422+50	424+60	41	E	67	76	72	--	--	4
Trade Zone Blvd. to Hostetter Rd.	SF	428+20	430+50	51	E	67	74	72	--	--	5
Trade Zone Blvd. to Hostetter Rd.	SF	435+20	437+50	46	E	67	75	72	--	--	4
Trade Zone Blvd. to Hostetter Rd.	SF	444+60	448+40	51	E	67	74	72	--	--	6

Table 4.13-17: BART Alternative Residential Vibration Impacts Without Mitigation Using FTA Criteria

Location	Land Use	Approx. Civil Station		Distance to Near Track (ft)	Side of Track	Max. Speed (mph)	Project Vibration Level (VdB re 1 µin/s)	Vibration Impact Criterion	Project Ground-Borne Noise Level (dBA)	Ground-Borne Noise Criterion	# of Res. Impacts
		Beg.	End								
Trade Zone Blvd. to Hostetter Rd.	SF	448+40	452+80	46	E	67	75	72	--	--	6
Trade Zone Blvd. to Hostetter Rd.	SF	453+60	455+40	50	E	67	74	72	--	--	1
Hostetter Road to Sierra Road	SF	460+20	466+80	40	E	67	76	72	--	--	8
Hostetter Road to Sierra Road	SF	471+00	474+40	60	W	67	76	72	--	--	9
Hostetter Road to Sierra Road	SF	475+00	479+00	50	W	67	78	72	--	--	7
Hostetter Road to Sierra Road	SF	479+50	486+00	51	W	67	78	72	--	--	11
Hostetter Road to Sierra Road	SF	469+50	471+60	50	E	67	78	72	--	--	2
Hostetter Road to Sierra Road	SF	471+60	475+20	59	E	67	77	72	--	--	6
Hostetter Road to Sierra Road	SF	475+20	480+00	41	E	67	81	72	--	--	6
Hostetter Road to Sierra Road	SF	480+00	483+50	51	E	67	78	72	--	--	4
Hostetter Road to Sierra Road	SF	483+20	488+00	56	E	67	77	72	--	--	7
Sierra Road to Berryessa Road	SF	493+00	497+80	43	E	67	80	72	--	--	5
Sierra Road to Berryessa Road	SF	497+40	501+00	41	E	67	81	72	--	--	7
Sierra Road to Berryessa Road	SF	501+00	507+00	41	E	67	81	72	--	--	10
Sierra Road to Berryessa Road	SF	507+20	513+20	69	E	67	75	72	--	--	8
Sierra Road to Berryessa Road	SF	514+00	519+00	26	E	50	83	72	--	--	6
Sierra Road to Berryessa Road	SF	491+00	494+40	38	W	67	81	72	--	--	6
Sierra Road to Berryessa Road	SF	495+00	497+50	40	W	67	81	72	--	--	4
Sierra Road to Berryessa Road	SF	498+00	503+00	40	W	67	81	72	--	--	13
Sierra Road to Berryessa Road	SF	503+20	507+00	26	W	67	85	72	--	--	6
Subtotal – Remainder of Surface Corridor											**216**
ALUM ROCK ALIGNMENT – US 101 DIAGONAL OPTION: NO IMPACTS											
ALUM ROCK ALIGNMENT – RAILROAD/28TH STREET OPTION											
28th Street to 19th Street	SF	617+50	618+00	55	W	67	73	72	38	35	1

Location	Land Use	Approx. Civil Station		Distance to Near Track (ft)	Side of Track	Max. Speed (mph)	Project Vibration Level (VdB re 1 µin/s)	Vibration Impact Criterion	Project Ground-Borne Noise Level (dBA)	Ground-Borne Noise Criterion	# of Res. Impacts
		Beg.	End								
28th Street to 19th Street	SF	617+00	617+40	54	W	67	73	72	38	35	1
28th Street to 19th Street	SF	616+50	617+00	54	E	67	73	72	38	35	1
28th Street to 19th Street	SF	618+00	618+50	54	E	67	73	72	38	35	1
28th Street to 19th Street	SF	617+50	618+00	60	E	67	73	72	36	35	1
28th Street to 19th Street	SF	616+50	617+00	57	E	67	73	72	37	35	1
28th Street to 19th Street	SF	618+50	619+00	55	E	67	73	72	38	35	1
28th Street to 19th Street	SF	619+00	619+50	61	W	67	72	72	36	35	1
28th Street to 19th Street	SF	620+00	621+00	56	W	67	73	72	37	35	1
28th Street to 19th Street	SF	620+00	620+50	61	W	67	72	72	36	35	1
28th Street to 19th Street	SF	621+20	622+00	57	E	67	73	72	37	35	1
28th Street to 19th Street	SF	621+00	621+60	57	W	67	73	72	37	35	1
28th Street to 19th Street	SF	621+70	622+00	57	W	67	73	72	37	35	1
28th Street to 19th Street	SF	622+00	622+50	57	W	67	73	72	37	35	1
28th Street to 19th Street	SF	622+90	623+30	58	E	67	73	72	36	35	1
28th Street to 19th Street	SF	623+50	624+00	58	E	67	73	72	36	35	1
28th Street to 19th Street	SF	625+00	625+60	59	E	67	73	72	36	35	1
28th Street to 19th Street	SF	626+60	627+20	60	E	67	72	72	36	35	1
28th Street to 19th Street	SF	638+00	639+00	74	E	67	62	72	38	35	1
28th Street to 19th Street	SF	640+00	640+50	77	E	67	62	72	37	35	1
Subtotal – Alum Rock Alignment – Railroad/28th Street Option											**20**
TUNNEL CORRIDOR											
9th Street	MF	667+80	668+20	65	E	65	78	72	43	35	8
Subtotal – Tunnel Corridor											**8**

Table 4.13-17: BART Alternative Residential Vibration Impacts Without Mitigation Using FTA Criteria

Table 4.13-17: BART Alternative Residential Vibration Impacts Without Mitigation Using FTA Criteria

Location	Land Use	Approx. Civil Station		Distance to Near Track (ft)	Side of Track	Max. Speed (mph)	Project Vibration Level (VdB re 1 μin/s)	Vibration Impact Criterion	Project Ground-Borne Noise Level (dBA)	Ground-Borne Noise Criterion	# of Res. Impacts
		Beg.	End								
MARKET STREET STATION - WEST OF MARKET STREET STATION CROSSOVER OPTION											
Market Street to SR 87	MF	711+50	713+00	61	W	50	72	72	45	35	100
Subtotal – Market Street Station - West of Market Street Station Crossover Option											**100**
DIRIDON/ARENA ALIGNMENT – NORTH OPTION											
Almaden Boulevard to SR 87	Hotel	716+20	718+00	64	W	67	64	72	37	35	40
Lenzen Avenue to West Taylor St.	SF	774+00	775+00	43	E	67	69	72	36	35	1
Lenzen Avenue to West Taylor St	SF	775+50	776+50	39	E	67	70	72	38	35	1
Lenzen Avenue to West Taylor St.	SF	777+20	778+00	42	E	67	69	72	37	35	1
Lenzen Avenue to West Taylor St.	SF	778+80	779+60	38	E	67	70	72	38	35	1
Lenzen Avenue to West Taylor St.	SF	781+90	782+50	38	E	67	70	72	38	35	2
Lenzen Avenue to West Taylor St.	SF	783+00	783+50	41	E	67	69	72	37	35	1
Subtotal – Diridon Arena Alignment – North Option											**47**
DIRIDON/ARENA ALIGNMENT – SOUTH OPTION											
Almaden Boulevard to SR 87	Hotel	716+20	718+00	54	W	67	66	72	40	35	40
Lenzen Avenue to West Taylor St.	SF	777+40	778+00	40	E	67	69	72	37	35	1
Lenzen Avenue to West Taylor St.	SF	778+90	779+50	43	E	67	69	72	36	35	1
Lenzen Avenue to West Taylor St.	SF	778+90	779+50	41	E	67	69	72	37	35	1
Lenzen Avenue to West Taylor St.	SF	780+50	781+00	41	E	67	69	72	37	35	1
Lenzen Avenue to West Taylor St.	SF	782+00	782+70	37	E	67	70	72	39	35	1
Lenzen Avenue to West Taylor St.	SF	784+60	785+40	39	E	67	70	72	38	35	2
Lenzen Avenue to West Taylor St.	SF	786+00	786+50	39	E	67	70	72	38	35	1
Subtotal – Diridon/Arena Alignment – South Option											**48**

Note:
[1] Assumes 12 units at proposed apartments located between Station 176+00 to 183+00. SF = single-family residential; MF = multi-family residential.
Source: Noise and Vibration Technical Report, HMMH, 2003.

Table 4.13-18: BART Alternative Residential Vibration Impact Without Mitigation Using BART Design Criteria											
Location	**Land Use**	**Approx. Civil Station**		**Distance to Near Track (ft)**	**Side of Track**	**Speed (mph)**	**Project Vibration Level (VdB re 1 µin/s)**	**Vibration Impact Criterion**	**Project Ground-Borne Noise Level (dBA)**	**Ground-Borne Noise Criterion**	**# of Res. Impacts**
		Beg.	**End**								
DIXON LANDING ROAD ALIGNMENT – AERIAL OPTION											
Kato Road to Dixon Landing Road	MF	177+00	182+00	35	E	67	75	70	--	--	12 [1]
Kato Road to Dixon Landing Road	MF	182+40	184+40	35	E	67	75	70	--	--	10
Kato Road to Dixon Landing Road	MF	189+50	191+00	35	E	67	75	70	--	--	12
Dixon Landing Road to Minnis Circle	SF	192+40	196+80	49	E	67	71	70	--	--	8
Dixon Landing Road to Minnis Circle	SF	196+50	201+50	49	E	67	71	70	--	--	10
Dixon Landing Road to Minnis Circle	SF	202+20	208+00	45	E	67	72	70	--	--	12
Subtotal – Dixon Landing Road Alignment – Aerial Option											**64**
DIXON LANDING ROAD ALIGNMENT – RETAINED CUT OPTION											
Kato Road to Dixon Landing Road	MF	177+00	182+00	35	E	67	75	70	--	--	12 [1]
Kato Road to Dixon Landing Road	MF	182+40	184+40	35	E	67	75	70	--	--	10
Kato Road to Dixon Landing Road	MF	189+50	191+00	35	E	67	75	70	--	--	12
Dixon Landing Road to Minnis Circle	SF	192+40	196+80	49	E	67	71	70	--	--	8
Dixon Landing Road to Minnis Circle	SF	196+50	201+50	49	E	67	71	70	--	--	10
Dixon Landing Road to Minnis Circle	SF	202+20	208+00	45	E	67	72	70	--	--	12
Subtotal – Dixon Landing Road - Retained Cut Option											**64**
DIXON LANDING ROAD ALIGNMENT – AT-GRADE OPTION											
Kato Road to Dixon Landing Road	MF	177+00	182+00	35	E	67	70	70	--	--	12 [1]
Kato Road to Dixon Landing Road	MF	182+40	184+40	35	E	67	70	70	--	--	10
Kato Road to Dixon Landing Road	MF	189+50	191+00	35	E	67	70	70	--	--	12
Dixon Landing Road to Minnis Circle	SF	192+40	196+80	49	E	67	71	70	--	--	8
Dixon Landing Road to Minnis Circle	SF	196+50	201+50	49	E	67	71	70	--	--	10
Dixon Landing Road to Minnis Circle	SF	202+20	208+00	45	E	67	72	70	--	--	12
Subtotal – Dixon Landing Road - At-Grade Option											**64**

Table 4.13-18: BART Alternative Residential Vibration Impact Without Mitigation Using BART Design Criteria											
Location	**Land Use**	**Approx. Civil Station**		**Distance to Near Track (ft)**	**Side of Track**	**Speed (mph)**	**Project Vibration Level (VdB re 1 µin/s)**	**Vibration Impact Criterion**	**Project Ground-Borne Noise Level (dBA)**	**Ground-Borne Noise Criterion**	**# of Res. Impacts**
		Beg.	**End**								
REMAINDER OF SURFACE CORRIDOR											
Edgewater Drive to Calaveras Boulevard	SF	264+50	268+50	77	E	67	75	70	--	--	6
Edgewater Drive to Calaveras Boulevard	SF	268+50	269+00	43	E	67	81	70	--	--	17
Edgewater Drive to Calaveras Boulevard	MF	276+20	281+00	103	E	67	71	70	--	--	12
Trade Zone Boulevard to Hostetter Rd.	SF	419+00	420+20	44	E	67	75	70	--	--	12
Trade Zone Boulevard to Hostetter Rd.	SF	420+50	422+40	46	E	67	75	70	--	--	30
Trade Zone Boulevard to Hostetter Rd.	SF	422+50	424+60	41	E	67	76	70	--	--	4
Trade Zone Boulevard to Hostetter Rd.	SF	425+00	428+20	64	E	67	72	70	--	--	4
Trade Zone Boulevard to Hostetter Rd.	SF	428+20	430+50	51	E	67	74	70	--	--	5
Trade Zone Boulevard to Hostetter Rd.	SF	431+00	435+20	64	E	67	72	70	--	--	8
Trade Zone Boulevard to Hostetter Rd.	SF	435+20	437+50	46	E	67	75	70	--	--	4
Trade Zone Boulevard to Hostetter Rd.	SF	437+50	439+00	62	E	67	72	70	--	--	3
Trade Zone Boulevard to Hostetter Rd.	SF	440+50	444+50	62	E	67	72	70	--	--	6
Trade Zone Boulevard to Hostetter Rd.	SF	444+60	448+40	51	E	67	74	70	--	--	6
Trade Zone Boulevard to Hostetter Rd.	SF	448+40	452+80	46	E	67	75	70	--	--	6
Trade Zone Boulevard to Hostetter Rd.	SF	453+60	455+40	50	E	67	74	70	--	--	1
Hostetter Road to Sierra Road	SF	460+20	466+80	40	E	67	76	70	--	--	8
Hostetter Road to Sierra Road	SF	458+60	462+20	62	W	67	72	70	--	--	6
Hostetter Road to Sierra Road	SF	467+20	470+80	88	W	67	71	70	--	--	7
Hostetter Road to Sierra Road	SF	471+00	474+40	60	W	67	76	70	--	--	9
Hostetter Road to Sierra Road	SF	475+00	479+00	50	W	67	78	70	--	--	7
Hostetter Road to Sierra Road	SF	479+50	486+00	51	W	67	78	70	--	--	11
Hostetter Road to Sierra Road	SF	469+50	471+60	50	E	67	78	70	--	--	2
Hostetter Road to Sierra Road	SF	471+60	475+20	59	E	67	77	70	--	--	6

Table 4.13-18: BART Alternative Residential Vibration Impact Without Mitigation Using BART Design Criteria

Location	Land Use	Approx. Civil Station		Distance to Near Track (ft)	Side of Track	Speed (mph)	Project Vibration Level (VdB re 1 µin/s)	Vibration Impact Criterion	Project Ground-Borne Noise Level (dBA)	Ground-Borne Noise Criterion	# of Res. Impacts
		Beg.	End								
Hostetter Road to Sierra Road	SF	475+20	480+00	41	E	67	81	70	--	--	6
Hostetter Road to Sierra Road	SF	480+00	483+50	51	E	67	78	70	--	--	4
Hostetter Road to Sierra Road	SF	483+20	488+00	56	E	67	77	70	--	--	7
Sierra Road to Berryessa Road	SF	493+00	497+80	43	E	67	80	70	--	--	5
Sierra Road to Berryessa Road	SF	497+40	501+00	41	E	67	81	70	--	--	7
Sierra Road to Berryessa Road	SF	501+00	507+00	41	E	67	81	70	--	--	10
Sierra Road to Berryessa Road	SF	507+20	513+20	69	E	67	75	70	--	--	8
Sierra Road to Berryessa Road	SF	514+00	519+00	26	E	50	83	70	--	--	6
Sierra Road to Berryessa Road	SF	491+00	494+40	38	W	67	81	70	--	--	6
Sierra Road to Berryessa Road	SF	495+00	497+50	40	W	67	81	70	--	--	4
Sierra Road to Berryessa Road	SF	498+00	503+00	40	W	67	81	70	--	--	13
Sierra Road to Berryessa Road	SF	503+20	507+00	26	W	67	85	70	--	--	6
Subtotal – Remainder of Surface Corridor											**262**
ALUM ROCK ALIGNMENT – US 101 DIAGONAL OPTION											
28th St to 19th Street	SF	616+00	616+50	67	W	67	71	70	33	35	1
28th Street to 19th Street	SF	629+00	630+00	68	W	67	71	70	33	35	1
28th Street to 19th Street	SF	631+50	632+00	66	E	67	71	70	33	35	1
Subtotal – Alum Rock Alignment – Diagonal Option											**3**
ALUM ROCK ALIGNMENT – RAILROAD/28TH STREET OPTION											
28th Street to 19th Street	SF	617+50	618+00	55	W	67	73	70	38	35	1
28th Street to 19th Street	SF	617+00	617+40	54	W	67	73	70	38	35	1
28th Street to 19th Street	SF	616+50	617+00	54	E	67	73	70	38	35	1
28th Street to 19th Street	SF	618+00	618+50	54	E	67	73	70	38	35	1
28th Street to 19th Street	SF	617+50	618+00	60	E	67	73	70	36	35	1

Table 4.13-18: BART Alternative Residential Vibration Impact Without Mitigation Using BART Design Criteria											
Location	**Land Use**	**Approx. Civil Station**		**Distance to Near Track (ft)**	**Side of Track**	**Speed (mph)**	**Project Vibration Level (VdB re 1 µin/s)**	**Vibration Impact Criterion**	**Project Ground-Borne Noise Level (dBA)**	**Ground-Borne Noise Criterion**	**# of Res. Impacts**
		Beg.	**End**								
28^{th} Street to 19^{th} Street	SF	616+50	617+00	57	E	67	73	70	37	35	1
28^{th} Street to 19^{th} Street	SF	618+50	619+00	55	E	67	73	70	38	35	1
28^{th} Street to 19^{th} Street	SF	618+40	618+80	70	E	67	70	70	32	35	1
28^{th} Street to 19^{th} Street	SF	619+00	619+50	61	W	67	72	70	36	35	1
28^{th} Street to 19^{th} Street	SF	620+00	621+00	56	W	67	73	70	37	35	1
28^{th} Street to 19^{th} Street	SF	620+00	620+50	61	W	67	72	70	36	35	1
28^{th} Street to 19^{th} Street	SF	619+60	620+00	63	W	67	72	70	35	35	1
28^{th} Street to 19^{th} Street	SF	621+20	622+00	57	E	67	73	70	37	35	1
28^{th} Street to 19^{th} Street	SF	621+00	621+60	57	W	67	73	70	37	35	1
28^{th} Street to 19^{th} Street	SF	621+70	622+00	57	W	67	73	70	37	35	1
28^{th} Street to 19^{th} Street	SF	622+00	622+50	57	W	67	73	70	37	35	1
28^{th} Street to 19^{th} Street	SF	622+50	623+00	62	W	67	72	70	35	35	1
28^{th} Street to 19^{th} Street	SF	623+00	623+40	63	W	67	72	70	35	35	1
28^{th} Street to 19^{th} Street	SF	622+90	623+30	58	E	67	73	70	36	35	1
28^{th} Street to 19^{th} Street	SF	623+50	624+00	58	E	67	73	70	36	35	1
28^{th} Street to 19^{th} Street	SF	623+50	624+00	63	E	67	72	70	35	35	1
28^{th} Street to 19^{th} Street	SF	625+00	625+60	59	E	67	73	70	36	35	1
28^{th} Street to 19^{th} Street	MF	626+00	627+50	65	W	67	71	70	34	40	3
28^{th} Street to 19^{th} Street	SF	626+60	627+20	60	E	67	72	70	36	35	1
28^{th} Street to 19^{th} Street	SF	628+20	628+80	63	W	67	72	70	35	35	1
28^{th} Street to 19^{th} Street	SF	628+20	629+50	63	W	67	72	70	35	35	1
28^{th} Street to 19^{th} Street	SF	628+50	630+50	64	W	67	71	70	34	35	1
28^{th} Street to 19^{th} Street	SF	629+80	630+60	64	W	67	71	70	34	35	1
28^{th} Street to 19^{th} Street	SF	630+00	631+00	64	W	67	71	70	34	35	1

Table 4.13-18: BART Alternative Residential Vibration Impact Without Mitigation Using BART Design Criteria											
Location	**Land Use**	**Approx. Civil Station**		**Distance to Near Track (ft)**	**Side of Track**	**Speed (mph)**	**Project Vibration Level (VdB re 1 µin/s)**	**Vibration Impact Criterion**	**Project Ground-Borne Noise Level (dBA)**	**Ground-Borne Noise Criterion**	**# of Res. Impacts**
		Beg.	**End**								
28th Street to 19th Street	SF	631+20	632+00	70	E	67	71	70	33	35	1
28th Street to 19th Street	SF	631+50	632+20	65	E	67	71	70	34	35	1
28th Street to 19th Street	SF	631+90	632+50	65	E	67	71	70	34	35	1
28th Street to 19th Street	SF	632+20	633+00	66	W	67	71	70	33	35	1
28th Street to 19th Street	SF	633+60	634+20	72	E	67	70	70	32	35	1
28th Street to 19th Street	SF	634+50	635+50	72	W	67	70	70	32	35	1
28th Street to 19th Street	SF	636+80	637+10	69	W	67	71	70	33	35	1
28th Street to 19th Street	SF	636+50	637+00	69	E	67	71	70	33	35	1
28th Street to 19th Street	SF	636+00	636+50	69	E	67	71	70	33	35	1
28th Street to 19th Street	SF	638+00	639+00	74	E	67	62	70	38	35	1
28th Street to 19th Street	SF	640+00	640+50	77	E	67	62	70	37	35	1
Subtotal – Alum Rock Alignment – Railroad/28th Street Option											**42**
TUNNEL CORRIDOR											
9th Street	MF	677+80	668+20	65	E	65	78	70	43	40	8
Subtotal – Tunnel Corridor											**8**
MARKET STREET STATION - WEST OF MARKET STREET STATION CROSSOVER OPTION											
Market Street to SR 87	MF	711+50	713+00	61	W	50	72	70	45	40	100
Subtotal – Market Street Station – West of Market Street Station Crossover Option											**100**
DIRIDON/ARENA ALIGNMENT – NORTH OPTION											
Lenzen Avenue to West Taylor Street	SF	774+00	775+00	43	E	67	69	70	36	35	1
Lenzen Avenue to West Taylor Street	SF	775+50	776+50	39	E	67	70	70	38	35	1

Table 4.13-18: BART Alternative Residential Vibration Impact Without Mitigation Using BART Design Criteria

Location	Land Use	Approx. Civil Station		Distance to Near Track (ft)	Side of Track	Speed (mph)	Project Vibration Level (VdB re 1 µin/s)	Vibration Impact Criterion	Project Ground-Borne Noise Level (dBA)	Ground-Borne Noise Criterion	# of Res. Impacts
		Beg.	End								
Lenzen Avenue to West Taylor Street	SF	777+20	778+00	42	E	67	69	70	37	35	1
Lenzen Avenue to West Taylor Street	SF	778+80	779+60	38	E	67	70	70	38	35	1
Lenzen Avenue to West Taylor Street	SF	781+90	782+50	38	E	67	70	70	38	35	2
Lenzen Avenue to West Taylor Street	SF	783+00	783+50	41	E	67	69	70	37	35	1
Subtotal – Diridon/Arena Alignment – North Option											**7**
DIRIDON/ARENA ALIGNMENT – SOUTH OPTION											
Lenzen Avenue to West Taylor Street	SF	777+40	778+00	40	E	67	69	70	37	35	1
Lenzen Avenue to West Taylor Street	SF	778+90	779+50	43	E	67	69	70	36	35	1
Lenzen Avenue to West Taylor Street	SF	778+90	779+50	41	E	67	69	70	37	35	1
Lenzen Avenue to West Taylor Street	SF	780+50	781+00	41	E	67	69	70	37	35	1
Lenzen Avenue to West Taylor Street	SF	782+00	782+70	37	E	67	70	70	39	35	1
Lenzen Avenue to West Taylor Street	SF	784+60	785+40	39	E	67	70	70	38	35	2
Lenzen Avenue to West Taylor Street	SF	786+00	786+50	39	E	67	70	70	38	35	1
Subtotal – Diridon/Arena Alignment – South Option											**8**

Note:

[1] Assumes 12 units at proposed apartments located between Station 176+00 to 183+00. SF = single–family residential; MF = multi-family residential

Source: Noise and Vibration Technical Report, HMMH, 2003.

Kato Road to Dixon Landing Road (Dixon Landing Alignment - Aerial, At-Grade, and Retained Cut Options): Ground conditions at this location are characterized by Region SV1. Vibration levels in this area are expected to exceed FTA and BART criteria at a number of apartment buildings. Assuming 12 residences in the proposed multi-family residence, 34 residences would experience vibration impact under both criteria. The vibration impacts would be due to a combination of the speed of the BART vehicles (67 mph) and the proximity of the residences to the tracks (within 100 feet). Vibration levels for the Dixon Landing Alignment - Aerial and Retained Cut options are projected to be similar to the At-grade Option because the aerial and retained cut track structures would still provide a direct path between the tracks and the soil.

Dixon Landing Road to Minnis Circle (Dixon Landing Alignment - Aerial, At-Grade, and Retained Cut Options): Ground conditions at this location are characterized by Region SV1. Vibration from BART trains is projected to exceed the BART Design Criterion at 30 single-family residences located east of the alignment. The vibration impacts would be due to a combination of the speed of the BART vehicles (67 mph) and the proximity of the residences to the tracks (within 100 feet). Vibration is not projected to exceed the FTA impact criterion at these locations because the FTA criterion allows for slightly higher vibration levels than does the BART Design Criterion.

Edgewater Drive to Calaveras Boulevard: Ground conditions at this location are characterized by Region SV2. Train vibration is projected to exceed the FTA Vibration Impact Criterion at 23 single-family residences. Vibration levels are projected to exceed the BART Design Criterion at 35 residences. The vibration impacts would be due to a combination of the high speed of the BART vehicles and the proximity of the residences to the tracks (within 100 feet).

Trade Zone Boulevard to Hostetter Road: Ground conditions at this location are characterized by Region SV3. There are 68 single-family residences projected to have vibration impact under the FTA Vibration Impact Criterion. When using the BART Design Criterion, the number of impacts would rise to 89 residences due to the more stringent BART requirements. The vibration impacts would be due to a combination of the speed of the BART vehicles and the proximity of the residences to the tracks.

Hostetter Road to Sierra Road: Ground conditions at this location are characterized by Region SV4. There are 60 single-family residences projected to experience vibration impact under the FTA Vibration Impact Criterion. Seventy-three residences are projected to experience impact under the more stringent BART Design Criterion. The vibration impacts would be due to a combination of the speed of the BART vehicles (67 mph) and the proximity of the residences to the tracks (within 100 feet).

Sierra Road to Berryessa Road: Ground conditions at this location are characterized by Region SV4. Vibration is projected to exceed the FTA Vibration Impact Criterion at 65 single-family residences. When using the BART Design Criterion, the number of impacts is also 65 residences. The vibration impacts would be due to a combination of the speed of the BART vehicles (67 mph) and the proximity of the residences to the tracks (within 100 feet).

28th Street to 19th Street (US 101 Diagonal Option): Ground conditions at this location are characterized by Region BV1. In this area, the BART alignment would transition to subway, and vibration impact may be caused by either ground-borne vibration or ground-borne noise. When using the FTA criterion, there are no vibration impacts. When using the more stringent BART Design Criterion, three single-family residences would experience impacts. The vibration impacts would be due to a combination of the speed of the BART vehicles (67 mph), the proximity of the residences to the subway's horizontal position (within 100 feet), and the depth of the subway.

28th Street to 19th Street (Railroad to 28th Street Option): Ground conditions at this location are characterized by Region BV1. In this area, the BART alignment would transition to subway, and vibration impact may be caused by either ground-borne vibration or ground-borne noise. When using the FTA criterion, there are 20 single-family residences impacted. When using the more stringent BART Design Criterion, 39 single-family and 3 multi-family residences would experience impacts. The vibration impacts would be due to a combination of the speed of the BART vehicles (67 mph), the proximity of the residences to the subway's horizontal position (within 100 feet), and the depth of the subway.

9th Street (Tunnel Corridor): Ground conditions at this location are characterized by Region BV4. Vibration levels are projected to exceed the BART Design Criterion and FTA ground-borne noise criterion at a multi-family residence (eight units) near 9th Street. This impact is attributed to the location of the track and not the crossover that is on the other side of the Civic Plaza/SJSU Station.

Market Street to SR 87 (Market Street Station - West of Market Street Station Crossover Option): Ground conditions at this location are characterized by Region BV4. In this option, a crossover would be located west of the Market Street Station. Vibration is projected to exceed the FTA vibration criterion at 100 units in a hotel located east of SR 87 and near the crossover. Vibration levels would exceed the BART Design Criterion at the same 100 hotel units.

Almaden Boulevard to SR 87 (Diridon/Arena Station North and South Options): Ground conditions at this location are characterized by Region BV4. Train vibration is projected to exceed the FTA ground-borne noise criterion at a proposed Marriott Hotel to be located just east of SR 87 for both Diridon Station options. Ground-borne noise levels would not exceed the BART Design Criterion because the BART Design Criterion has a less restrictive limit for ground-borne noise in multi-family residences and hotels.

SR 87 to Autumn Street (Diridon/Arena Alignment South Option): Ground conditions at this location are characterized by Region BV4. The subway would pass just south of a historic office building located next to the Guadalupe River. Vibration levels from passing trains are projected neither to approach cosmetic or structural damage thresholds nor to exceed annoyance levels.

White Street to Bush Street (Diridon/Arena Alignment South Option): Ground conditions at this location are characterized by Region BV5. In this option, the subway would pass underneath the historic Del Monte Cannery building. Vibration levels from passing trains are expected neither to approach structural or cosmetic damage thresholds nor to exceed annoyance levels.

Lenzen Ave to West Taylor Street (Diridon/Arena Alignment North Option): Ground conditions at this location are characterized by Region BV5. Vibration levels at seven single-family residences are expected to exceed both FTA and BART vibration impact criteria. The vibration impacts would be due to a combination of the speed of the BART vehicles (67 mph) and the shallow depth of the subway (25 ft).

Lenzen Ave to West Taylor Street (Diridon/Arena Alignment South Option): Ground conditions at this location are characterized by Region BV5. There are eight single-family residences projected to have vibration impact under both FTA and BART vibration criteria. The vibration impacts would be due to a combination of the speed of the BART vehicles (67 mph) and the shallow depth of the subway (25 ft).

A vibration assessment was conducted in the vicinity of several institutional land uses identified along the BART Alternative alignment, including San Jose Medical Center and several historical properties along Santa Clara Street. No vibration impact (damage or annoyance) is projected at any of these properties.

For the most part, the institutional receptors are relatively massive buildings. As documented in the FTA guidance manual, large masonry buildings do not respond easily to ground-borne vibration. Furthermore, no vibration-sensitive activities within these buildings occur in close proximity to the BART alignment, so none of the institutional receptors identified in the analysis would be subject to the more stringent vibration limits for special buildings such as recording studios.

The east track of the existing freight rail alignment north of Montague Expressway would be moved approximately 45 feet to the west to allow for room for the new BART tracks in the railroad corridor. Freight trains on the relocated freight rail tracks would increase vibration levels at homes on the west side of the railroad corridor; however, these vibration levels are not projected to exceed the FTA Vibration Impact Criteria. The dominant vibration source for homes located on the west side of the railroad corridor would continue to be freight trains running on the remaining freight rail tracks that would be located about 14 feet closer than the existing tracks.

4.13.5.2 Design Requirements and Best Management Practices

The following design requirements and best management practices would reduce vibration impact at the source.

<u>Baseline Alternative</u>

Maintaining tire pressure and keeping bus engines tuned and well-maintained would minimize noise impacts from bus tires and engines. VTA and other transit agencies perform these and other best management practices as part of normal maintenance procedures.

<u>BART Alternative</u>

The following standard BART practices are performed regularly and would reduce vibration levels from trains operating along the corridor for the BART Alternative and MOS scenarios:

- **Track maintenance:** Regular track maintenance activities such as rail grinding and track inspection would reduce rail defects that could lead to higher than normal noise and vibration levels. Rail grinding smoothes the surface of train tracks by using specialized machines to cut away a thin layer of steel from the top and sides of the railhead. Regular rail grinding helps to minimize wayside noise and vibration generated by train passbys over defects or corrugations on the rail.
- **Vehicle maintenance:** Regular vehicle maintenance activities such as periodic inspections and tests will help to identify problems and necessary corrective actions to minimize wayside noise and vibration levels. This includes wheel truing. Wheel truing is the process of cutting away a thin layer of steel on a wheel's outer diameter (the "tread") to smooth out rough spots and ensure that the wheels are perfectly round. Because flat spots or rough wheels can cause excessive noise and vibration, wheel truing is a standard BART practice to minimize wayside noise and vibration levels.

4.13.5.3 Mitigation Measures

<u>No-Action Alternative</u>

Projects planned under the No-Action Alternative would undergo their own environmental review process to define vibration impacts and determine appropriate mitigation measures.

Baseline Alternative

No adverse vibration impacts are projected under the Baseline Alternative; therefore, no mitigation is required.

BART Alternative

A number of mitigation measures are available and will be applied individually or in combination to reduce vibration levels to below FTA Vibration Impact Criteria and BART Design Criteria. The implementation of the vibration mitigation measures, listed below, would also mitigate ground-borne noise impacts, since these measures are also effective in reducing ground-borne noise. The decision on which measures to implement will be made during final design. A combination of the following mitigation measures will be implemented for the BART Alternative and MOS scenarios to reduce ground-borne vibration from rail operations:

- **Ballast Mats:** A ballast mat consists of a pad made of rubber or rubber-like material placed on an asphalt or concrete base with the normal ballast, ties, and rail on top. The reduction in ground-borne vibration provided by a ballast mat is strongly dependent on the frequency content of the vibration and design and support of the mat. Ballast mats typically achieve a 3-4 dB of vibration reduction.
- **Shredded Tire Underlay:** Shredded tire underlay consists of a layer of shredded tires that is placed beneath the ballast and provides a resilient foundation for the track system. Tests conducted using VTA light rail vehicles indicate that shredded tire underlay may perform better than ballast mats at lower cost, but not as effective as floating slab trackbed. However, there are no data available to assess the performance of the shredded tire underlay when used with BART vehicles. If shredded tire underlay is shown to provide greater vibration attenuation than ballast mats under BART operating conditions, then shredded tire underlay could be used in areas where ballast mats cannot reduce BART vibration levels below FTA criteria. The use of shredded tire underlay will be further investigated during the detailed design phases.
- **Resilient Fasteners:** Resilient fasteners can be used in place of standard track fasteners to attach the track to concrete slabs. Resilient fasteners are typically much less stiff when compared with standard fasteners and can provide substantial vibration reduction, particularly at frequencies above 40 Hz. Vibration reductions would be roughly comparable to ballast mat depending on vibration frequency.
- **Resiliently Supported Ties:** Resiliently supported ties consist of concrete ties supported on rubber pads. Vibration reduction is achieved through the isolation of the track system on the rubber elements. As with resilient fasteners, resiliently supported ties are effective at reducing high frequency vibration and are more effective than resilient fasteners in reducing low frequencies in the 30 to 40 Hz range. Vibration reductions would be roughly comparable to ballast mat depending on vibration frequency.
- **Floating Slabs:** Floating slabs consist of thick concrete slabs supported by resilient pads on a concrete foundation; the tracks are mounted on top of the floating slab. Floating slabs are designed to provide vibration reduction at lower frequencies than ballast mats. Most successful floating slab installations are in subways, and their use for at-grade track is rare. While floating slabs can achieve a 5-13 dB reduction depending on thickness, they are extremely expensive to install and maintain. These factors need to be considered in determining whether the use of floating slabs is "reasonable" per FTA guidelines and BART operations and maintenance practices.
- **Lower Tunnel Depths:** Vibration levels decrease with increasing distance between the train and sensitive receptors. While surface alignments may be constrained by the railroad corridor or other

obstructions, increasing the depth of the subway could reduce vibration near subway alignments. A 10-foot increase in the depth of the top-of-rail can reduce vibration and ground-borne noise levels by 2 to 3 dB. Note that the depth of the subway is also subject to operational or physical constraints, so the impact of lowering the subway tunnel may need to be evaluated with respect to the potential mitigation benefits.

- **Underground Barrier:** Vibration levels could also be decreased by the construction of an underground barrier between the trackway and the sensitive land use. The barrier would need to be approximately 30 feet deep and of a material that would dampen the transmission of vibration. While this would be a costly mitigation, this measure could reduce vibration impacts by 3 to 5 dB.

Table 4.13-19 and Figure 4.13-4a through Figure 4.13-4s identify the specific locations where vibration mitigation measures will be required based on the impact assessment results shown in Tables 4.13-17 and 4.13-18. Even with the mitigation as proposed, 12 residences located north of Berryessa Road and adjacent to the alignment would be potentially exposed to vibration levels exceeding FTA and/or BART criteria. This includes six residences to the east of the alignment on Arbington Court, Heavenly Bamboo Court and Fern Pine Court and six residences to the west of the alignment on Aschauer Court and Valley Crest Drive. Note that the only locations that are listed on Table 4.13-19 are locations impacted that require mitigation. If a location is not on this table, it means that the properties at that location would not exceed the FTA and/or BART vibration criteria.

On average, pre-mitigation vibration levels at the affected receptors along the at-grade portion of the alignment are projected to exceed the FTA Vibration Impact Criterion by 8 dB and the BART Design Criterion by 10 dB, for the closest receptors. Ballast mats will typically achieve a 3 to 4 dB of vibration reduction, while floating slab track will reduce vibration by 5 to 13 dB, depending on the thickness of the floating slab. The reduction in vibration is highly dependent on the design of the mitigation measure (for ballast mats or floating slab track), and on the vibration characteristics specific to the site and the vehicle. Although floating slab track would achieve better vibration reduction than ballast mats, floating slabs are substantially more expensive (at least $600 per track foot for floating slab versus $250 per track foot for ballast mat, not including maintenance costs). Both cost and performance would need to be considered in establishing appropriateness of floating slabs for the mitigation of at-grade vibration impacts.

Ballast mats are often the preferred method to mitigate vibration from trains running along the surface, because installation and maintenance costs are typically low. However, vibration projections show that ballast mats will not reduce vibration levels below the FTA or BART criteria in several areas. Further investigation during the design phase will determine the extent of vibration impact at residences where ballast mats are predicted to reduce vibration levels to within 2 dB of the FTA vibration criterion. If detailed analysis indicates that ballast mats will not be sufficient to eliminate vibration impact, other mitigation methods such as shredded tire underlayment, or floating slabs will be investigated. If the shredded tire underlayment is proven to reduce BART vibration levels better than ballast mats, shredded tire underlayment may be used as vibration mitigation in areas where ballast mat is currently recommended. In at-grade track locations where BART vibration is indicated to exceed the FTA criteria by 6 dB or more, floating slab track, which would reduce the vibration levels to below the criteria, may be installed as vibration mitigation. In areas of greater vibration impact, underground barriers would also be considered.

Vibration levels near the subway tunnels generally exceed the FTA and BART criteria by no more than 5 dB, except at one location at Station 668+00 where the vibration levels exceed the FTA and BART criteria by 6 and 8 dB, respectively. The projected wayside vibration near the subway is dominated by high-frequency vibration. Therefore, a resilient fastening system or a resiliently supported track system

Table 4.13-19: BART Alternative Vibration Impact Mitigation Locations

Location	Potential Mit. Type [1]	Approx Civil Station		Length (feet)	# Res. Impacts w/o Mit.		# Res. Impacts w/ Mit.	
		Beg.	End		FTA Criteria	BART Criteria	FTA Criteria	BART Criteria
AT-GRADE ALIGNMENT INCLUDING ALL DIXON LANDING OPTIONS								
Kato Road to Dixon Landing Road	Ballast Mat	176+00	186+00	1000	22	22	0	0
Dixon Landing Road Crossing	Ballast Mat	188+00	191+00	300	12	12	0	0
Dixon Landing Rd. to Minnis Circle	Ballast Mat	192+00	208+00	1600	0	30	0	0
Edgewater Drive to Calaveras Blvd.	Ballast Mat	264+00	268+00	400	6	6	0	0
Edgewater Drive to Calaveras Blvd.	Float. Slab	268+00	274+00	600	17	17	0	0
Edgewater Drive to Calaveras Blvd.	Ballast Mat	276+00	280+00	400	0	12	0	0
Trade Zone Blvd to Hostetter Road	Ballast Mat	418+00	456+50	3850	68	89	0	0
Hostetter Road to Sierra Road	Ballast Mat	457+00	475+00	1800	8	21	0	0
Hostetter Road to Sierra Road	Float. Slab	475+00	482+00	700	45	45	0	0
Hostetter Road to Sierra Road	Ballast Mat	482+00	491+00	900	7	7	0	0
Sierra Road to Berryessa Road	Float. Slab	491+00	508+00	1700	51	51	6	6
Sierra Road to Berryessa Road	Ballast Mat	508+00	513+00	500	8	8	0	0
Sierra Road to Berryessa Road	Float. Slab	513+00	520+00	700	6	6	6	6
Subtotal – At-Grade Alignment Including All Dixon Landing Options				**15050**	**250**	**326**	**12**	**12**
ALUM ROCK ALIGNMENT – US 101/DIAGONAL OPTION								
28th Street to 19th Street	Res. Fast	615+00	617+00	200	0	1	0	0
28th Street to 19th Street	Res. Fast	629+00	633+00	400	0	2	0	0
Subtotal – Alum Road Alignment Including All Dixon Landing Opt.				**600**	**0**	**3**	**0**	**0**
ALUM ROCK ALIGNMENT – RAILROAD/28TH STREET OPTION								
28th Street to 19th Street	Res. Fast	616+00	641+00	2500	20	42	0	0
Subtotal				**2500**	**20**	**42**	**0**	**0**

Table 4.13-19: BART Alternative Vibration Impact Mitigation Locations

Location	Potential Mit. Type [1]	Approx Civil Station		Length (feet)	# Res. Impacts w/o Mit.		# Res. Impacts w/ Mit.	
		Beg.	End		FTA Criteria	BART Criteria	FTA Criteria	BART Criteria
TUNNEL CORRIDOR								
9th Street	Res. Fast	674+00	676+00	200	8	8	0	0
Subtotal – Tunnel Corridor				**200**	**8**	**8**	**0**	**0**
MARKET STREET STATION CROSSOVER OPTION - WEST OF MARKET STREET STATION CROSSOVER OPTION								
Market St. to Almaden Blvd.	Res. Fast	709+00	714+00	500	100	100	0	0
Subtotal – West Market Street Station Crossover Option				**700**	**100**	**100**	**0**	**0**
DIRIDON/ARENA ALIGNMENT – NORTH OPTION								
Almaden Boulevard to SR 87	Res. Fast.	714+00	719+00	500	40	0	0	0
Lenzen Avenue to West Taylor St.	Res. Fast	771+00	785+00	1400	7	7	0	0
Subtotal – Diridon/Arena Alignment – North Option				**1900**	**47**	**7**	**0**	**0**
DIRIDON/ARENA ALIGNMENT – SOUTH OPTION								
Almaden Boulevard to SR 87	Res. Fast	715+00	719+00	400	40	0	0	0
Lenzen Avenue to West Taylor St.	Res. Fast	777+00	787+00	1000	8	8	0	0
Subtotal – Diridon/Arena Alignment – South Option				**1400**	**48**	**8**	**0**	**0**

Notes:

[1] Mitigation types assumed:

- Ballast Mats: elastomer ballast mat on concrete or asphalt subbase
- Float. Slab: floating slab track on concrete subbase
- Res. Fast: direct fixation track, resilient fastener with 60-80,000 lb/in stiffness
- Additional analysis will be performed during the design phases to refine the vibration projections and to select and implement mitigation that will ensure that there are no exceedances of FTA and/or BART vibration criteria. In some cases, a combination of mitigation types may be necessary to achieve the required reduction.

Source: Noise and Vibration Technical Report, HMMH, 2003.

would be a cost effective method ($300 per track foot) to mitigate all of the vibration impact near the subway, except where floating slab would be needed to mitigate the vibration impacts for the multi-family residences near Station 668+00. Any resilient fastener used to mitigate vibration in the tunnels would be a softer connection between the tracks and BART vehicle than BART's standard direct-fixation frog (currently 90,000 to 100,000 lbs/in).