THE GATEWAY
500 RAILROAD AVENUE
CONSTRUCTION NOISE AND VIBRATION ASSESSMENT

South San Francisco, California

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INTRODUCTION

This project proposes to construct seventy (70) single family townhouse units at 500 Railroad Avenue in South San Francisco, California. The site is vacant and consists of a narrow rectangular portion fronting onto Railroad Avenue on the northern end and a spur line that extends to the south. The project site is bounded by Railroad Avenue and residential uses to the north, light industrial uses and Linden Avenue to the east, light industrial uses to the west, and industrial uses, North Canal Street, and Colma Creek to the south. This report evaluates construction noise and vibration impacts due to the project with respect to applicable regulatory criteria and presents measures, where necessary, to mitigate impacts on sensitive receptors in the project vicinity.

SETTING

Fundamentals of Environmental Noise

Noise may be defined as unwanted sound. Noise is usually objectionable because it is disturbing or annoying. The objectionable nature of sound could be caused by its *pitch* or its *loudness*. *Pitch* is the height or depth of a tone or sound, depending on the relative rapidity (*frequency*) of the vibrations by which it is produced. Higher pitched signals sound louder to humans than sounds with a lower pitch. *Loudness* is the intensity of sound waves combined with the reception characteristics of the ear. Intensity may be compared with the height of an ocean wave in that it is a measure of the amplitude of the sound wave.

In addition to the concepts of pitch and loudness, there are several noise measurement scales which are used to describe noise in a particular location. A *decibel (dB)* is a unit of measurement which indicates the relative amplitude of a sound. The zero on the decibel scale is based on the lowest sound level that the healthy, unimpaired human ear can detect. Sound levels in decibels are calculated on a logarithmic basis. An increase of 10 decibels represents a ten-fold increase in acoustic energy, while 20 decibels is 100 times more intense, 30 decibels is 1,000 times more intense, etc. There is a relationship between the subjective noisiness or loudness of a sound and its intensity. Each 10 decibel increase in sound level is perceived as approximately a doubling of loudness over a fairly wide range of intensities. Technical terms are defined in Table 1.

There are several methods of characterizing sound. The most common in California is the *A-weighted sound level (dBA)*. This scale gives greater weight to the frequencies of sound to which the human ear is most sensitive. Representative outdoor and indoor noise levels in units of dBA are shown in Table 2. Because sound levels can vary markedly over a short period of time, a method for describing either the average character of the sound or the statistical behavior of the variations must be utilized. Most commonly, environmental sounds are described in terms of an average level that has the same acoustical energy as the summation of all the time-varying events. This *energy-equivalent sound/noise descriptor* is called L_{eq}. The most common averaging period is hourly, but L_{eq} can describe any series of noise events of arbitrary duration.

The scientific instrument used to measure noise is the sound level meter. Sound level meters can accurately measure environmental noise levels to within about plus or minus 1 dBA. Various

TABLE 1 Definition of Acoustical Terms Used in this Report

Term	Definition
Decibel, dB	A unit describing the amplitude of sound, equal to 20 times the logarithm to the base 10 of the ratio of the pressure of the sound measured to the reference pressure. The reference pressure for air is 20 micro Pascals.
Sound Pressure Level	Sound pressure is the sound force per unit area, usually expressed in micro Pascals (or 20 micro Newtons per square meter), where 1 Pascal is the pressure resulting from a force of 1 Newton exerted over an area of 1 square meter. The sound pressure level is expressed in decibels as 20 times the logarithm to the base 10 of the ratio between the pressures exerted by the sound to a reference sound pressure (e. g., 20 micro Pascals). Sound pressure level is the quantity that is directly measured by a sound level meter.
Frequency, Hz	The number of complete pressure fluctuations per second above and below atmospheric pressure. Normal human hearing is between 20 Hz and 20,000 Hz. Infrasonic sound are below 20 Hz and Ultrasonic sounds are above 20,000 Hz.
A-Weighted Sound Level, dBA	The sound pressure level in decibels as measured on a sound level meter using the A-weighting filter network. The A-weighting filter de-emphasizes the very low and very high frequency components of the sound in a manner similar to the frequency response of the human ear and correlates well with subjective reactions to noise.
Equivalent Noise Level, L_{eq}	The average A-weighted noise level during the measurement period.
L_{max}, L_{min}	The maximum and minimum A-weighted noise level during the measurement period.
L_{01}, L_{10}, L_{50}, L_{90}	The A-weighted noise levels that are exceeded 1%, 10%, 50%, and 90% of the time during the measurement period.
Day/Night Noise Level, L_{dn} or DNL	The average A-weighted noise level during a 24-hour day, obtained after addition of 10 decibels to levels measured in the night between 10:00 pm and 7:00 am.
Community Noise Equivalent Level, CNEL	The average A-weighted noise level during a 24-hour day, obtained after addition of 5 decibels in the evening from 7:00 pm to 10:00 pm and after addition of 10 decibels to sound levels measured in the night between 10:00 pm and 7:00 am.
Ambient Noise Level	The composite of noise from all sources near and far. The normal or existing level of environmental noise at a given location.
Intrusive	That noise which intrudes over and above the existing ambient noise at a given location. The relative intrusiveness of a sound depends upon its amplitude, duration, frequency, and time of occurrence and tonal or informational content as well as the prevailing ambient noise level.

Source: Handbook of Acoustical Measurements and Noise Control, Harris, 1998.

TABLE 2 Typical Noise Levels in the Environment

Common Outdoor Activities	Noise Level (dBA)	Common Indoor Activities
	110 dBA	Rock band
Jet fly-over at 1,000 feet		
	100 dBA	
Gas lawn mower at 3 feet		
	90 dBA	
Diesel truck at 50 feet at 50 mph		Food blender at 3 feet
	80 dBA	Garbage disposal at 3 feet
Noisy urban area, daytime		
Gas lawn mower, 100 feet	70 dBA	Vacuum cleaner at 10 feet
Commercial area		Normal speech at 3 feet
Heavy traffic at 300 feet	60 dBA	
		Large business office
Quiet urban daytime	50 dBA	Dishwasher in next room
Quiet urban nighttime	40 dBA	Theater, large conference room
Quiet suburban nighttime		
	30 dBA	Library
Quiet rural nighttime		Bedroom at night, concert hall (background)
	20 dBA	
		Broadcast/recording studio
	10 dBA	
	0 dBA	

Source: Technical Noise Supplement (TeNS), California Department of Transportation, September 2013.

computer models are used to predict environmental noise levels from sources, such as roadways and airports. The accuracy of the predicted models depends upon the distance the receptor is from the noise source. Close to the noise source, the models are accurate to within about plus or minus 1 to 2 dBA.

Since the sensitivity to noise increases during the evening and at night -- because excessive noise interferes with the ability to sleep -- 24-hour descriptors have been developed that incorporate artificial noise penalties added to quiet-time noise events. The *Community Noise Equivalent Level* (*CNEL*) is a measure of the cumulative noise exposure in a community, with a 5 dB penalty added to evening (7:00 pm - 10:00 pm) and a 10 dB addition to nocturnal (10:00 pm - 7:00 am) noise levels. The *Day/Night Average Sound Level* (*DNL* or L_{dn}) is essentially the same as CNEL, with the exception that the evening time period is dropped and all occurrences during this three-hour period are grouped into the daytime period.

Effects of Noise

Sleep and Speech Interference

The thresholds for speech interference indoors are about 45 dBA if the noise is steady and above 55 dBA if the noise is fluctuating. Outdoors the thresholds are about 15 dBA higher. Steady noises of sufficient intensity (above 35 dBA) and fluctuating noise levels above about 45 dBA have been shown to affect sleep. Interior residential standards for multi-family dwellings are set by the State of California at 45 dBA DNL. Typically, the highest steady traffic noise level during the daytime is about equal to the DNL and nighttime levels are 10 dBA lower. The standard is designed for sleep and speech protection and most jurisdictions apply the same criterion for all residential uses. Typical structural attenuation is 12-17 dBA with open windows. With closed windows in good condition, the noise attenuation factor is around 20 dBA for an older structure and 25 dBA for a newer dwelling[1]. Sleep and speech interference is therefore possible when exterior noise levels are about 57-62 dBA DNL with open windows and 65-70 dBA DNL if the windows are closed. Levels of 55-60 dBA are common along collector streets and secondary arterials, while 65-70 dBA is a typical value for a primary/major arterial. Levels of 75-80 dBA are normal noise levels at the first row of development outside a freeway right-of-way. In order to achieve an acceptable interior noise environment, bedrooms facing secondary roadways need to be able to have their windows closed; those facing major roadways and freeways typically need special glass windows.

Annoyance

Attitude surveys are used for measuring the annoyance felt in a community for noises intruding into homes or affecting outdoor activity areas. In these surveys, it was determined that the causes for annoyance include interference with speech, radio and television, house vibrations, and interference with sleep and rest. The DNL as a measure of noise has been found to provide a valid correlation of noise level and the percentage of people annoyed. People have been asked to judge the annoyance caused by aircraft noise and ground transportation noise. There continues to be disagreement about the relative annoyance of these different sources. When measuring the

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1 Based on the U.S. Department of Transportation Federal Highway Administration document “Highway Traffic Noise: Analysis and Abatement Guidance” (2010) and data from Illingworth & Rodkin, Inc. noise monitoring projects.

percentage of the population highly annoyed, the threshold for ground vehicle noise is about 50 dBA DNL. At a DNL of about 60 dBA, approximately 12 percent of the population is highly annoyed. When the DNL increases to 70 dBA, the percentage of the population highly annoyed increases to about 25-30 percent of the population. There is, therefore, an increase of about 2 percent per dBA between a DNL of 60-70 dBA. Between a DNL of 70-80 dBA, each decibel increase increases by about 3 percent the percentage of the population highly annoyed. People appear to respond more adversely to aircraft noise. When the DNL is 60 dBA, approximately 30-35 percent of the population is believed to be highly annoyed. Each decibel increase to 70 dBA adds about 3 percentage points to the number of people highly annoyed. Above 70 dBA, each decibel increase results in about a 4 percent increase in the percentage of the population highly annoyed[2].

Fundamentals of Groundborne Vibration

Ground vibration consists of rapidly fluctuating motions or waves with an average motion of zero. Several different methods are typically used to quantify vibration amplitude. One method is the Peak Particle Velocity (PPV). The PPV is defined as the maximum instantaneous positive or negative peak of the vibration wave. In this report, a PPV descriptor with units of mm/sec or in/sec is used to evaluate construction generated vibration for building damage and human complaints. Table 3 displays the reactions of people and the effects on buildings that continuous vibration levels produce.

The annoyance levels shown in Table 3 should be interpreted with care since vibration may be found to be annoying at much lower levels than those shown, depending on the level of activity or the sensitivity of the individual. To sensitive individuals, vibrations approaching the threshold of perception can be annoying. Low-level vibrations frequently cause irritating secondary vibration, such as a slight rattling of windows, doors, or stacked dishes. The rattling sound can give rise to exaggerated vibration complaints, even though there is very little risk of actual structural damage.

Construction activities can cause vibration that varies in intensity depending on several factors. The use of pile driving, and vibratory compaction equipment typically generates the highest construction related groundborne vibration levels. Because of the impulsive nature of such activities, the use of the PPV descriptor has been routinely used to measure and assess groundborne vibration and almost exclusively to assess the potential of vibration to induce structural damage and the degree of annoyance for humans.

The two primary concerns with construction-induced vibration, the potential to damage a structure and the potential to interfere with the enjoyment of life, are evaluated against different vibration limits. Studies have shown that the threshold of perception for average persons is in the range of 0.008 to 0.012 in/sec PPV. Human perception to vibration varies with the individual and is a function of physical setting and the type of vibration. Persons exposed to elevated ambient vibration levels, such as people in an urban environment, may tolerate a higher vibration level.

Structural damage can be classified as cosmetic only, such as minor cracking of building elements, or may threaten the integrity of the building. Safe vibration limits that can be applied to assess the

2 Kryter, Karl D. The Effects of Noise on Man. Menlo Park, Academic Press, Inc., 1985.

TABLE 3 Reaction of People and Damage to Buildings from Continuous or Frequent Intermittent Vibration Levels

Velocity Level, PPV (in/sec)	Human Reaction	Effect on Buildings
0.01	Barely perceptible	No effect
0.04	Distinctly perceptible	Vibration unlikely to cause damage of any type to any structure
0.08	Distinctly perceptible to strongly perceptible	Recommended upper level of the vibration to which ruins and ancient monuments should be subjected
0.1	Strongly perceptible	Threshold at which there is a risk of damage to fragile buildings with no risk of damage to most buildings
0.25	Strongly perceptible to severe	Threshold at which there is a risk of damage to historic and some old buildings.
0.3	Strongly perceptible to severe	Threshold at which there is a risk of damage to older residential structures
0.5	Severe - Vibrations considered unpleasant	Threshold at which there is a risk of damage to new residential and modern commercial/industrial structures

Source: Transportation and Construction Vibration Guidance Manual, California Department of Transportation, April 2020.

potential for damaging a structure vary by researcher and there is no general consensus as to what amount of vibration may pose a threat for structural damage to the building. Construction-induced vibration that can be detrimental to the building is very rare and has only been observed in instances where the structure is at a high state of disrepair and the construction activity occurs immediately adjacent to the structure.

The annoyance levels shown in Table 3 should be interpreted with care since vibration may be found to be annoying at lower levels than those shown, depending on the level of activity or the sensitivity of the individual. To sensitive individuals, vibrations approaching the threshold of perception can be annoying. Low-level vibrations frequently cause irritating secondary vibration, such as a slight rattling of windows, doors, or stacked dishes. The rattling sound can give rise to exaggerated vibration complaints, even though there is very little risk of actual structural damage.

Regulatory Background – Noise

A summary of the applicable regulatory criteria established by the City of South San Francisco is provided below.

City of South San Francisco 2040 General Plan. The City of South San Francisco has established goals and policies in the Noise Element of the 2040 General Plan to control noise. General Plan goals and policies include:

GOAL NOI-1: Residents and employees of South San Francisco are exposed to acceptable noise levels.

> Policy NOI-1.2: Enforce Noise Performance Standards. The City enforces the Noise Ordinance noise performance standards.

GOAL NOI-2: Prevent the exposure of residents and employees of South San Francisco unacceptable vibration levels.

> Policy NOI-2.1: Require vibration analysis for sensitive receptors. A vibration analysis shall be prepared by a qualified acoustical consultant for any construction-related activities, located within 100-feet of residential or other sensitive receptors, that require the use of pile driving or other construction method that has the potential to produce high vibration levels.

GOAL NOI-3: Historic structures are not exposed to unacceptable vibration levels.

> Policy NOI-3.1: Require vibration analysis for historic structure protection. Prior to issuance of grading permits for any development project that is located within 150 feet of a historic structure and, if construction activities will require either: (1) pile driving within 150 feet; or (2) utilization of mobile construction equipment within 50 feet of the historic structure, the property owner/developer shall retain an acoustical engineer to conduct a vibration analysis for potential impacts from construction-related vibration impacts onto the historic structure. The vibration analysis shall determine the vibration levels created by construction activities at the historic structure, and if necessary, develop mitigation to reduce the vibration levels to within Caltrans threshold of 0.12 inches per second PPV for historic buildings.

City of South San Francisco Municipal Code. Title 8 of the City's Municipal Code establishes construction noise standards in the health and welfare section. Additionally, Title 20 (Zoning) includes performance standards for construction vibration. The applicable sections are as follows:

Section 8.32.050 Special Provisions

(d) Construction. Construction, alteration, repair or landscape maintenance activities which are authorized by a valid city permit shall be allowed on weekdays between the hours of eight a.m. and eight p.m., on Saturdays between the hours of nine a.m. and eight p.m., and on Sundays and holidays between the hours of ten a.m. and six p.m., or at such other hours as may be authorized by the permit, if they meet at least one of the following noise limitations:

(1) No individual piece of equipment shall produce a noise level exceeding ninety dB at a distance of twenty-five feet. If the device is housed within a structure or trailer on the property, the measurement shall be made outside the structure at a distance as close to twenty-five feet from the equipment as possible.

(2) The noise level at any point outside of the property plane of the project shall not exceed ninety dB. (Ord. 1088 § 1, 1990)

Section 20.300.010 Performance Standards

D. Location of Measurement for Determining Compliance. Measurements necessary for determining compliance with the standards of this chapter shall be taken at the lot line of the establishment or use that is the source of a potentially objectionable condition, hazard, or nuisance.

3. Vibration. No vibration shall be produced that is transmitted through the ground and is discernible without the aid of instruments by a reasonable person at the lot lines of the site.

a. Vibration Analysis Required. A vibration analysis prepared by a qualified acoustical consultant is required for the following activities:

i. All construction-related activities located within 100 feet of residential or other sensitive receptors that require the use of pile driving or other construction method that has the potential to produce high vibration levels.

ii. All new land use development located within 200 feet of existing rail lines.

iii. Exemptions. Vibrations from temporary construction, demolition, and vehicles that enter and leave the subject lot (e.g., construction equipment, trains, trucks, etc.) are exempt from this standard.

b. Historic Structure Protection.

i. For any development project that is located within 150 feet of a historic structure and requires either: (1) pile driving within 150 feet; or (2) utilization of mobile construction equipment within 50 feet of the historic structure, the property owner/developer shall retain an acoustical engineer to conduct a vibration analysis for potential impacts from construction-related vibration impacts onto the historic structure. The vibration analysis shall determine the vibration levels created by construction activities at the historic structure, and if necessary, develop mitigation to reduce the vibration levels to within the Caltrans threshold of 0.12 inches per second peak particle velocity (PPV) for historic buildings.

ii. Require vibration analysis for historic structure protection. Prior to issuance of grading permits for any development project that is located within 150 feet of a historic structure and, if construction activities will require either: (1) pile driving within 150 feet; or (2) utilization of mobile construction equipment within 50 feet of the historic structure, the property owner/developer shall retain an acoustical engineer to conduct a vibration analysis for potential impacts from construction-related vibration impacts onto the historic structure. The vibration analysis shall determine the vibration levels created by construction activities at the historic structure, and if necessary, develop mitigation to reduce the vibration levels to within Caltrans threshold of 0.12 inches per second PPV for historic buildings.

CONSTRUCTION NOISE ANALYSIS

Project construction activities include site preparation, grading and excavation, building construction, architectural coatings, and paving. Project construction is estimated to take a total of 24 months. Soil excavation to a maximum depth of 10 feet would be necessary to accommodate the project's utilities, building foundations, and footings. The soil would remain on-site; no soil would be exported or imported from the project site. During each phase of construction, there would be a different mix of equipment operating, and noise levels would vary by phase and vary within phases, based on the amount of equipment in operation and the location at which the equipment is operating.

Noise impacts resulting from construction depend upon the noise generated by various pieces of construction equipment, the timing and duration of noise-generating activities, and the distance between construction noise sources and noise-sensitive areas. Construction noise impacts primarily result when construction activities occur during noise-sensitive times of the day (e.g., early morning, evening, or nighttime hours), the construction occurs in areas immediately adjoining noise-sensitive land uses, or when construction lasts over extended periods of time.

Table 4 shows the typical range of maximum instantaneous noise levels produced by each piece of equipment at 50 feet. Table 5 shows the hourly average noise level ranges by construction phase, typical for various types of projects measured at 50 feet. For the proposed project, impact or vibratory pile driving, which generates excessive noise levels, is not expected.

Federal Highway Administration's (FHWA's) Roadway Construction Noise Model (RCNM) was used to calculate the hourly average noise levels for each phase of construction, assuming the two loudest pieces of equipment would operate simultaneously, as recommended by the FTA for construction noise evaluations. This construction noise model includes representative sound levels for the most common types of construction equipment and the approximate usage factors of such equipment that were developed based on an extensive database of information gathered during the construction of the Central Artery/Tunnel Project in Boston, Massachusetts (CA/T Project or "Big Dig"). The usage factors represent the percentage of time that the equipment would be operating at full power.

The quantity of construction equipment by phase, the maximum instantaneous noise level (L_{max}) produced by individual pieces of construction equipment at 25 feet, and the average noise level (L_{eq}) at 25 feet assuming the operation of the two loudest pieces of construction equipment for each construction phase are shown in Table 6. Noise levels in Table 6 do not assume reductions due to intervening buildings or existing barriers. Construction-generated noise levels drop off at a rate of about 6 dBA per doubling of the distance between the source and receptor. Shielding by buildings or terrain often results in lower construction noise levels at distant receptors.

TABLE 4 Construction Equipment 50-Foot Noise Emission Limits

Equipment Category	L_{max} Level (dBA)[1,2]	Impact/Continuous
Arc Welder	73	Continuous
Auger Drill Rig	85	Continuous
Backhoe	80	Continuous
Bar Bender	80	Continuous
Boring Jack Power Unit	80	Continuous
Chain Saw	85	Continuous
Compressor[3]	70	Continuous
Compressor (other)	80	Continuous
Concrete Mixer	85	Continuous
Concrete Pump	82	Continuous
Concrete Saw	90	Continuous
Concrete Vibrator	80	Continuous
Crane	85	Continuous
Dozer	85	Continuous
Excavator	85	Continuous
Front End Loader	80	Continuous
Generator	82	Continuous
Generator (25 KVA or less)	70	Continuous
Gradall	85	Continuous
Grader	85	Continuous
Grinder Saw	85	Continuous
Horizontal Boring Hydro Jack	80	Continuous
Hydra Break Ram	90	Impact
Impact Pile Driver	105	Impact
Insitu Soil Sampling Rig	84	Continuous
Jackhammer	85	Impact
Mounted Impact Hammer (hoe ram)	90	Impact
Paver	85	Continuous
Pneumatic Tools	85	Continuous
Pumps	77	Continuous
Rock Drill	85	Continuous
Scraper	85	Continuous
Slurry Trenching Machine	82	Continuous
Soil Mix Drill Rig	80	Continuous
Street Sweeper	80	Continuous
Tractor	84	Continuous
Truck (dump, delivery)	84	Continuous
Vacuum Excavator Truck (vac-truck)	85	Continuous
Vibratory Compactor	80	Continuous
Vibratory Pile Driver	95	Continuous
All other equipment with engines larger than 5 HP	85	Continuous

Notes:

[1] Measured at 50 feet from the construction equipment, with a "slow" (1 sec.) time constant.

[2] Noise limits apply to total noise emitted from equipment and associated components operating at full power while engaged in its intended operation.

[3] Portable Air Compressor rated at 75 cfm or greater and that operates at greater than 50 psi.

TABLE 5 Typical Ranges of Construction Noise Levels at 50 Feet, L_{eq} (dBA)

	Domestic Housing		Office Building, Hotel, Hospital, School, Public Works		Industrial Parking Garage, Religious Amusement & Recreations, Store, Service Station		Public Works Roads & Highways, Sewers, and Trenches	
	I	**II**	**I**	**II**	**I**	**II**	**I**	**II**
Ground Clearing	83	83	84	84	84	83	84	84
Excavation	88	75	89	79	89	71	88	78
Foundations	81	81	78	78	77	77	88	88
Erection	81	65	87	75	84	72	79	78
Finishing	88	72	89	75	89	74	84	84

I - All pertinent equipment present on site.
II - Minimum required equipment present at site.

Source: U.S.E.P.A., Legal Compilation on Noise, Vol. 1, p. 2-104, 1973.

TABLE 6 Construction Noise Levels at 25 feet

Phase of Construction	Total Workdays	Construction Equipment (Quantity)	Maximum Instantaneous Noise Level, L_{max}	Hourly Average Noise Level, L_{eq}
Demolition	22 days	Excavator (1)[a]	87	83
Site Preparation	10 days	Tractor/Loader/Backhoe (1)[a]	90/85/84	86
Grading / Excavation	15 days	Excavator (1)[a] Tractor/Loader/Backhoe (1)[a]	87 90/85/84	88
Trenching / Foundation	15 days	Tractor/Loader/Backhoe (1) [a] Excavator (1) [a]	90/85/84 87	88
Building – Exterior	180 days	Crane (1) [a] Forklift (1) Tractor/Loader/Backhoe (1) [a] Welder (2)	87 81 90/85/84 80	87
Building – Interior	307 days	Air Compressor (1) [a] Aerial Lift (1) [a]	84 81	81
Paving	38 days	Paving Equipment (1) Roller (1) [a] Tractor/Loader/Backhoe (1) [a]	83 86 90/85/84	87

[a] Indicates loudest equipment by phase.

As shown in Table 6, none of the construction equipment is expected to produce maximum instantaneous noise levels exceeding 90 dBA at 25 feet. Additionally, none of the construction phases would produce average noise levels exceeding 90 dBA at 25 feet. At 50 feet, which represents the nearest offsite residential receptor locations north of the site (across Railroad Avenue), construction noise levels would be expected to be 6 decibels lower than the levels shown in Table 6 and below the City's standards. Industrial uses adjacent to the project site towards the south would experience construction noise levels exceeding 90 dBA within 25 feet. Beyond 25 feet, these construction noise levels are not expected to exceed the City's standards.

Table 6 shows that construction noise levels for each piece of equipment do not exceed 90 dBA at 25 feet and noise levels do not exceed 90 dBA at any point outside the project property line beyond 25 feet. Therefore, temporary construction noise impacts would be considered **less-than-significant**.

The following best management practices would help to further reduce construction noise levels emanating from the site and minimize disruption and annoyance at existing noise-sensitive receptors in the project vicinity.

- Construction shall be limited to the hours from 8:00 a.m. to 8:00 p.m. Monday through Friday, Saturdays between 9:00 a.m. and 8:00 p.m. and Sundays and holidays between 10 a.m. and 6:00 p.m. Any work outside of these hours by the construction contractors should require a special permit from the City Engineer. There should be compelling reasons for permitting construction outside of these designated hours.

- The contractor shall use "new technology" power construction equipment with state-of-the-art noise shielding and muffling devices. All internal combustion engines used on the project site shall be equipped with adequate mufflers and shall be in good mechanical condition to minimize noise created by faulty or poorly maintained engines or other components.

- Staging areas and stationary noise-generating equipment shall be located as far as possible from noise-sensitive receptors.

- Substitute nail guns for manual hammering and electrically powered tools for noisier pneumatic tools, where feasible.

- A designated "noise disturbance coordinator" would respond to any local complaints about construction noise. The disturbance coordinator shall determine the cause of the noise complaint (e.g., bad muffler, etc.) and shall require that reasonable measures be implemented to correct the problem. Conspicuously post a telephone number for the disturbance coordinator at the construction site and include it in the notice sent to neighbors regarding the construction schedule.

CONSTRUCTION VIBRATION ANALYSIS

The primary concern of the vibration analysis is the potential for construction vibration to damage a structure. Demolition and construction activities often require heavy equipment or impact tools that can generate perceptible vibration levels at nearby sensitive land uses and, in some cases, building damage. Building damage generally falls into three categories:

- Cosmetic damage (also known as threshold damage) is defined as hairline cracking in plaster, the opening of old cracks, the loosening of paint or the dislodging of loose objects.
- Minor damage is defined as hairline cracking in masonry or the loosening of plaster.
- Major structural damage is defined as wide cracking or the shifting of foundation or bearing walls.

Critical factors pertaining to the potential impact of construction vibration include the proximity of the existing structures to the project site, the soundness of the structures, soil conditions, and the methods of construction used.

The City of South San Francisco does not establish acceptable vibration levels for buildings of conventional construction. Caltrans identifies a vibration limit of 0.5 in/sec Peak Particle Velocity (PPV) as the threshold at which there is a potential risk of damage to new residential and modern commercial/industrial structures, 0.3 in/sec PPV for older residential structures, and a conservative limit of 0.25 in/sec PPV for historic and some old buildings (see Table 3). The City of South San Francisco has adopted Caltrans' threshold of 0.12 in/sec PPV to protect historic buildings. There is one City historic landmark, South City Lumber located at 499 Railroad Avenue. The nearest historic structure on the property is 130 feet southwest of the site. The 0.12 in/sec PPV threshold will be applicable for this property.

Construction phases would include site preparation, grading/excavation, trenching/foundation, building exteriors, architectural coatings and paving. Table 7 presents typical vibration levels that could be expected from construction equipment at a distance of 25 feet. Project construction activities, such as drilling, the use of jackhammers, rock drills and other high-power or vibratory tools, and rolling stock equipment (tracked vehicles, compactors, etc.), may generate substantial vibration in the immediate vicinity. Jackhammers typically generate vibration levels of 0.035 in/sec PPV and drilling typically generates vibration levels of 0.09 in/sec PPV at a distance of 25 feet. Table 7 summarizes the minimum setback distances of various types of construction equipment to ensure that the 0.3 in/sec PPV threshold and the 0.12 in/sec threshold are not exceeded.

Table 8 summarizes the vibration levels at the surrounding buildings in the project vicinity. Vibration levels are highest close to the source and then attenuate with increasing distance at the rate $\left({D_{ref}}/{D}\right)^{1.1}$, where D is the distance from the source in feet and D_{ref} is the reference distance of 25 feet. While construction noise levels increase based on the cumulative equipment in use simultaneously, construction vibration levels would be dependent on the location of individual pieces of equipment. That is, equipment scattered throughout the site would not generate a collective vibration level, but a vibratory roller, for instance, operating near the project site boundary would generate the worst-case vibration levels for the receptor sharing that property line.

TABLE 7 Vibration Source Levels for Construction Equipment

Equipment		PPV at 25 ft. (in/sec)	Minimum Distance to Meet 0.12 in/sec PPV (feet)	Minimum Distance to Meet 0.3 in/sec PPV (feet)
Clam shovel drop		0.202	40	18
Hydromill (slurry wall)	in soil	0.008	2	1
	in rock	0.017	4	2
Vibratory Roller		0.210	42	19
Hoe Ram		0.089	19	9
Large bulldozer		0.089	19	9
Caisson drilling		0.089	19	9
Loaded trucks		0.076	17	8
Jackhammer		0.035	8	4
Small bulldozer		0.003	1	<1

Source: Transit Noise and Vibration Impact Assessment Manual, Federal Transit Administration, Office of Planning and Environment, U.S. Department of Transportation, September 2018, as modified by Illingworth & Rodkin, Inc., November 2024.

TABLE 8 Vibration Source Levels for Construction Equipment

Equipment		PPV (in/sec) Estimated at Nearest Buildings Adjoining the Project Site		
		North Residences (60 ft)	South Industrial (45 ft)	South City Lumber Historic Building (130 ft)
Clam shovel drop		0.077	0.106	0.033
Hydromill (slurry wall)	in soil	0.003	0.004	0.001
	in rock	0.006	0.009	0.003
Vibratory Roller		0.080	0.110	0.034
Hoe Ram		0.034	0.047	0.015
Large bulldozer		0.034	0.047	0.015
Caisson drilling		0.034	0.047	0.015
Loaded trucks		0.029	0.040	0.012
Jackhammer		0.013	0.018	0.006
Small bulldozer		0.001	0.002	<0.001

Source: Transit Noise and Vibration Impact Assessment Manual, Federal Transit Administration, Office of Planning and Environment, U.S. Department of Transportation, September 2018, as modified by Illingworth & Rodkin, Inc., November 2024.

Further, construction vibration impacts are assessed based on the potential for damage to buildings on receiving land uses, not at receptors at the nearest property lines. Therefore, the distances used to propagate construction vibration levels (as shown in Table 8), were estimated under the assumption that each piece of equipment from Table 7 was operating along the nearest portion of the active construction site where the worst vibration-generating equipment would operate, which would represent the worst-case scenario.

Construction activities at the project site would not exceed the 0.3 in/sec PPV threshold at buildings consisting of conventional materials and also it would not exceed the 0.12 in/sec PPV threshold at the historic site (499 Railroad Avenue) surrounding the project site. A study completed by the US Bureau of Mines analyzed the effects of blast-induced vibration on buildings in USBM RI 8507.[3] The findings of this study have been applied to buildings affected by construction-generated vibrations.[4] As reported in USBM RI 8507[1] and reproduced by Dowding,[2] Figure 2 presents the damage probability, in terms of "threshold damage," "minor damage," and "major damage," at varying vibration levels. Threshold damage, which is described as cosmetic damage in this report, would entail hairline cracking in plaster, the opening of old cracks, the loosening of paint or the dislodging of loose objects. Minor damage would include hairline cracking in masonry or the loosening of plaster, and major structural damage would include wide cracking or shifting of foundation or bearing walls.

As shown in Figure 1, maximum vibration levels of 0.110 in/sec PPV or lower would not result in any chance of cosmetic damage. The vibration levels at the historic structures (with the nearest structure 130 feet southwest of the site) on 499 Railroad Avenue would be 0.034 in/sec PPV or lower. No cosmetic, minor or major damage would be expected at the conventional buildings immediately adjoining the project site. At these locations, and in other surrounding areas where vibration would not be expected to cause cosmetic damage, vibration levels may still be perceptible. However, as with any type of construction, this would be anticipated and would not be considered significant, given the intermittent and short duration of the phases that have the highest potential of producing vibration (use of jackhammers and other high-power tools). By use of administrative controls, such as notifying neighbors of scheduled construction activities, the effects of perceptible vibration can be minimized. Impacts due to temporary construction vibration would be considered **less-than-significant**.

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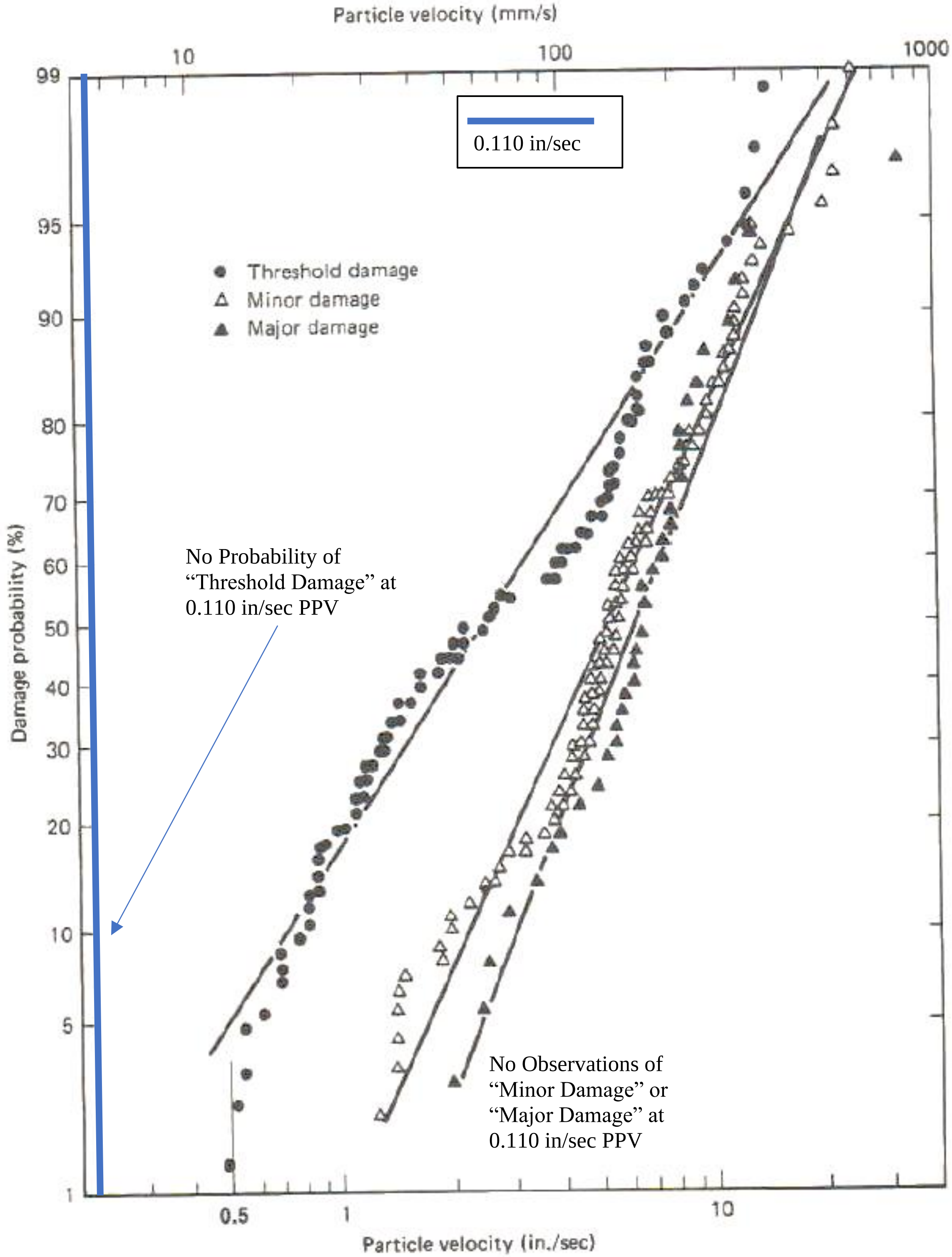
[3] Siskind, D.E., M.S. Stagg, J.W. Kopp, and C.H. Dowding, Structure Response and Damage Produced by Ground Vibration form Surface Mine Blasting, RI 8507, Bureau of Mines Report of Investigations, U.S. Department of the Interior Bureau of Mines, Washington, D.C., 1980.

[4] Dowding, C.H., Construction Vibrations, Prentice Hall, Upper Saddle River, 1996.

FIGURE 1 Probability of Cracking and Fatigue from Repetitive Loading



Source: Dowding, C.H., Construction Vibrations, Prentice Hall, Upper Saddle River, 1996 as modified by Illingworth & Rodkin, Inc., November 2024.