3315 SIERRA ROAD RESIDENTIAL DEVELOPMENT CONSTRUCTION NOISE AND VIBRATION ASSESSMENT

San José, California

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INTRODUCTION

A 25-unit single family residential development project is proposed on a 2.7-acre site located at 3315 Sierra Road in San José, California. 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 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. 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 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.

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 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.

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.

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.

Regulatory Background – Noise

A summary of the applicable regulatory criteria is provided below.

Federal Government

Federal Transit Administration. The Federal Transit Administration (FTA) has identified construction noise thresholds in the *Transit Noise and Vibration Impact Assessment Manual*,[1] which limit daytime construction noise to 80 dBA L_{eq} at residential land uses, 85 dBA L_{eq} at commercial uses and to 90 dBA L_{eq} at industrial land uses.

City of San José

City of San José General Plan. The Environmental Leadership Chapter in the Envision San José 2040 General Plan sets forth policies with the goal of minimizing the impact of noise on people through noise reduction and suppression techniques, and through appropriate land use policies in the City of San José. The following policies are applicable to the proposed project:

EC-1.7 Require construction operations within San José to use best available noise suppression devices and techniques and limit construction hours near residential uses per the City's Municipal Code. The City considers significant construction noise impacts to occur if a project located within 500 feet of residential uses or 200 feet of commercial or office uses would:

1 Federal Transit Administration, *Transit Noise and Vibration Impact Assessment Manual*, FTA Report No. 0123, September 2018.

- Involve substantial noise generating activities (such as building demolition, grading, excavation, pile driving, use of impact equipment, or building framing) continuing for more than 12 months.

For such large or complex projects, a construction noise logistics plan that specifies hours of construction, noise, and vibration minimization measures, posting or notification of construction schedules, and designation of a noise disturbance coordinator who would respond to neighborhood complaints will be required to be in place prior to the start of construction and implemented during construction to reduce noise impacts on neighboring residents and other uses.

Regulatory Background – Vibration

City of San José

City of San José General Plan. The Environmental Leadership Chapter in the Envision San José 2040 General Plan sets forth policies to achieve the goal of minimizing vibration impacts on people, residences, and business operations in the City of San José. The following policies are applicable to the proposed project:

EC-2.3 Require new development to minimize continuous vibration impacts to adjacent uses during demolition and construction. For sensitive historic structures, including ruins and ancient monuments or building that are documented to be structurally weakened, a continuous vibration limit of 0.08 in/sec PPV (peak particle velocity) will be used to minimize the potential for cosmetic damage to a building. A continuous vibration limit of 0.20 in/sec PPV will be used to minimize the potential for cosmetic damage at buildings of normal conventional construction. Equipment or activities typical of generating continuous vibration include but are not limited to: excavation equipment; static compaction equipment; vibratory pile drivers; pile-extraction equipment; and vibratory compaction equipment. Avoid use of impact pile drivers within 125 feet of any buildings, and within 300 feet of historical buildings, or buildings in poor condition. On a project-specific basis, this distance of 300 feet may be reduced where warranted by a technical study by a qualified professional that verifies that there will be virtually no risk of cosmetic damage to sensitive buildings from the new development during demolition and construction. Transient vibration impacts may exceed a vibration limit of 0.08 in/sec PPV only when and where warranted by a technical study by a qualified professional that verifies that there will be virtually no risk of cosmetic damage to sensitive buildings from the new development during demolition and construction.

CONSTRUCTION NOISE ANALYSIS

Construction activities associated with the project are proposed to begin in September 2024 and to be completed by December 2025. Construction phases would likely include demolition, site preparation, grading, trenching/foundation, building exterior and interior construction and paving. 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.

Policy EC-1.7 of the City's General Plan requires that all construction operations within the City to use best available noise suppression devices and techniques and to limit construction hours near residential uses per the Municipal Code allowable hours, which are between the hours of 7:00 a.m. and 7:00 p.m. Monday through Friday when construction occurs within 500 feet of a residential land use. Further, the City considers significant construction noise impacts to occur if a project that is located within 500 feet of residential uses or 200 feet of commercial or office uses would involve substantial noise-generating activities (such as building demolition, grading, excavation, pile driving, use of impact equipment, or building framing) continuing for more than 12 months.

While the City of San José does not establish noise level thresholds for construction activities, this analysis uses the noise limits established by the Federal Transit Administration (FTA) to identify the potential for impacts due to substantial temporary construction noise. The FTA identifies construction noise limits in the *Transit Noise and Vibration Impact Assessment Manual*.[2] During daytime hours, an exterior threshold of 80 dBA L_{eq} shall be enforced at residential land uses, 85 dBA L_{eq} at commercial land uses and 90 dBA L_{eq} industrial land uses.

Construction activities generate considerable amounts of noise, especially during earth-moving activities when heavy equipment is used. The hauling of excavated materials and construction materials would generate truck trips on local roadways, as well. For the proposed project, pile driving, which generates excessive noise levels, is not expected. The typical range of maximum instantaneous noise levels for the proposed project would be 70 to 90 dBA L_{max} at a distance of 50 feet (see Table 4) from the equipment. Table 5 shows the hourly average noise level ranges, by construction phase, typical for various types of projects. Hourly average noise levels generated by construction are about 65 to 88 dBA L_{eq} for residential buildings, measured at a distance of 50 feet from the center of a busy construction site. 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.

2 Federal Transit Administration, *Transit Noise and Vibration Impact Assessment Manual*, FTA Report No. 0123, September 2018.

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.

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

Equipment Category	L_{max} Level (dBA)[1,2]	Impact/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.

Equipment expected to be used in each construction phase are summarized in Table 6, along with the quantity of each type of equipment to be used. Table 6 also summarizes the construction noise levels calculated at 50 feet for the two loudest pieces of equipment identified in each phase.

Standard methods for acoustical analysis of construction sites are based on the distance from the "acoustical center" or construction activity center on the site to the nearest receiving property lines of existing noise-sensitive receptors, as was the case for this analysis. The proposed pieces of construction equipment are modeled at the approximate center of the area in which most construction activity is likely to occur. The worst-case hourly average noise level, calculated from combining all equipment per phase, was propagated from the geometrical center of the project building to the property lines of the receptors (shown in Figure 1). These noise level estimates are shown in Table 7. Noise levels in Table 7 do not assume reductions due to intervening buildings or existing barriers.

FIGURE 1 Aerial Image of the Project Site and Surrounding Area with Acoustic center of Construction Activities

TABLE 6 Estimated Construction Noise Levels at 50 feet

Phase of Construction	Total Workdays	Construction Equipment (Quantity)	Estimated Construction Noise Level at 50 feet, dBA L_{eq}
Demolition	45	Concrete/Industrial Saws (1) [a] Excavators (2) Tractor/Loader/Backhoe (2)[a]	85
Site Preparation	12	Tractor/Loader/Backhoe (1)[a]	80
Grading/Excavation	96	Excavators (1) Graders (1)[a] Water Truck (1) Tractor/Loader/Backhoe (2)[a]	84
Trenching/Foundation	72	Tractor/Loader/Backhoe (2)[a] Excavators (1) [a]	82
Building Exterior	144	Forklifts (1) [a] Tractors /Loader/Backhoe (2)[a]	80
Building – Interior/ Architectural Coating	144	Air Compressors (2) [a]	74
Paving	2	Pavers (1) [a] Roller (1) [a]	77

[a] Denotes two loudest pieces of construction equipment per phase.

TABLE 7 Estimated Construction Noise Levels at Residential Property Lines

Phase of Construction	Calculated Worst-Case [a] Hourly Average Noise Levels, dBA L_{eq}					
	3604 Ivalynn Circle Residence (210 ft[b])	3592 Ivalynn Circle Residence (150 ft[b])	3581 Ivalynn Place Residence (130 ft[b])	3575 Ivalynn Place Residence (190 ft[b])	3319 Sierra Rd (230 ft[b])	South Residences (160 ft[b])
Demolition	74	77	79	75	74	77
Site Preparation	68	71	72	68	67	70
Grading/ Excavation	73	76	77	74	73	76
Trenching	72	74	76	72	71	74
Building – Exterior	71	74	75	72	70	73
Building – Interior/ Architectural Coating	64	67	68	65	63	67
Paving	64	67	68	65	63	67

[a] These noise levels represent all equipment per phase operating simultaneously and propagated to the surrounding property lines.
[b] The distances shown in the table were conservatively measured from the center of the project site to the receiving property lines.

Table 6 shows that the construction noise levels for two loudest pieces of equipment per phase range from 74 to 85 dBA at 50 feet for this project. At the nearest residences, construction noise levels range from 63 to 79 dBA (as shown in Table 7). Construction noise levels would not exceed the 80 dBA L_{eq} FTA threshold at any of the residences.

Construction for this project would last for more than 12 months. Additionally, Saturday construction from 9 a.m. to 5 p.m. is also expected to take place. The following measures should be implemented to reduce construction levels emanating from the site and minimize disruption and annoyance at existing noise-sensitive receptors in the project vicinity. Prior to the issuance of any demolition or grading permits, a qualified acoustical consultant shall develop a construction noise logistics plan. The construction noise logistics plan shall include noise reduction measures to prevent substantial noise disturbances of affected sensitive receptors. A typical construction noise logistics plan shall include, but not be limited to, the following measures to reduce construction noise levels as low as feasible:

- A temporary 8-foot noise barrier shall be constructed along the north and east property line of the project site to shield adjacent residential land uses from ground-level construction equipment and activities. The noise barrier shall be solid over the face and at the base of the barrier in order to provide a 5 dBA noise reduction. The noise barrier is required for the construction period prior to the Building Interior/Architectural Coating phase to meet the construction noise standards. This temporary noise barrier shall be constructed if the project's solid sound wall and good neighbor fence (minimum 5 feet), respectively are not constructed first. Temporary noise barrier fences having a minimum surface density of 2 lbs/ft^2 (e.g. such as ¾" plywood) provide a 5 dB noise reduction if the noise barrier interrupts the line-of-sight between the noise source and the receptor and if the barrier is constructed in a manner that eliminates any cracks or gaps.

- If stationary noise-generating equipment such as power generators or pumps must be located near sensitive receptors (within 50 feet), adequate muffling (with enclosures where feasible and appropriate) shall be used. Any enclosure openings or venting shall face away from sensitive receptors.

- During final grading, substitute graders for bulldozers, where feasible. Wheeled heavy equipment are quieter than track equipment and should be used where feasible.

- 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 within 24 to 48 hours of the complaint. 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 at least one week prior to start of construction and prior to each "noisy" phase of construction including demolition, site grading, roadway paving, and framing.

Implementation of this mitigation will noticeably reduce the noise (a minimum of 5 dBA noise reduction). With the implementation of GP Policy EC-1.7, Zoning Code requirements, and the above measures, temporary construction noise would be reduced to a **less-than-significant** level (80 dBA L_{eq} or less).

CONSTRUCTION VIBRATION ANALYSIS

The construction of the project may generate vibration when heavy equipment or impact tools (e.g. jackhammers, hoe rams) are used. Construction activities would include demolition, site preparation, grading, trenching, building exterior and interior work and paving. This analysis assumes the proposed project would not require pile driving, which can cause excessive vibration.

According to Policy EC-2.3 of the City of San José General Plan, a vibration limit of 0.08 in/sec PPV shall be used to minimize the potential for cosmetic damage to sensitive historical structures, and a vibration limit of 0.2 in/sec PPV shall be used to minimize damage at buildings of normal conventional construction. With no known historical buildings in the vicinity of the project site, a significant impact would occur if nearby buildings were exposed to vibration levels in excess of 0.2 in/sec PPV. The vibration limits contained in this policy are conservative and designed to provide the ultimate level of protection for existing buildings in San José. As discussed in detail below, vibration levels exceeding these thresholds would be capable of cosmetically damaging adjacent buildings. 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.

Table 8 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. Vibration levels would vary depending on soil conditions, construction methods, and equipment used.

TABLE 8 Vibration Source Levels for Construction Equipment

Equipment		**PPV at 25 ft. (in/sec)**	**Minimum Distance to Meet 0.2 in/sec PPV (feet)**
Clam shovel drop		0.202	26
Hydromill (slurry wall)	in soil	0.008	2
	in rock	0.017	3
Vibratory Roller		0.210	27
Hoe Ram		0.089	13
Large bulldozer		0.089	13
Caisson drilling		0.089	13
Loaded trucks		0.076	11
Jackhammer		0.035	6
Small bulldozer		0.003	<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., October 2023.

Table 9 summarizes the vibration levels at each of 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. Further, construction vibration impacts are assessed based on damage to buildings on receiving land uses, not receptors at the nearest property lines. Therefore, the distances used to propagate construction vibration levels (as shown in Table 9), which are different than the distances used to propagate construction noise levels (as shown in Table 7), were estimated under the assumption that each piece of equipment from Table 7 was operating along the nearest boundary of the busy construction site, which would represent the worst-case scenario.

Project construction activities would potentially generate vibration levels up to 1.233 in/sec PPV at the 3319 Sierra Road residence near 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[6] and reproduced by Dowding,[7] Figure 2 presents the damage probability, in terms of "threshold damage" (described above as cosmetic damage), "minor damage," and "major damage," at varying vibration levels. Threshold damage, or cosmetic damage, 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 2, maximum vibration levels of 1.233 in/sec PPV or lower would result in about 25% probability of cosmetic/threshold damage. This vibration level would result in a less than 5% probability of minor or major damage to the buildings immediately adjacent to the project site.

Neither cosmetic, minor, or major damage would occur at conventional buildings located 30 feet or more from 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

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.

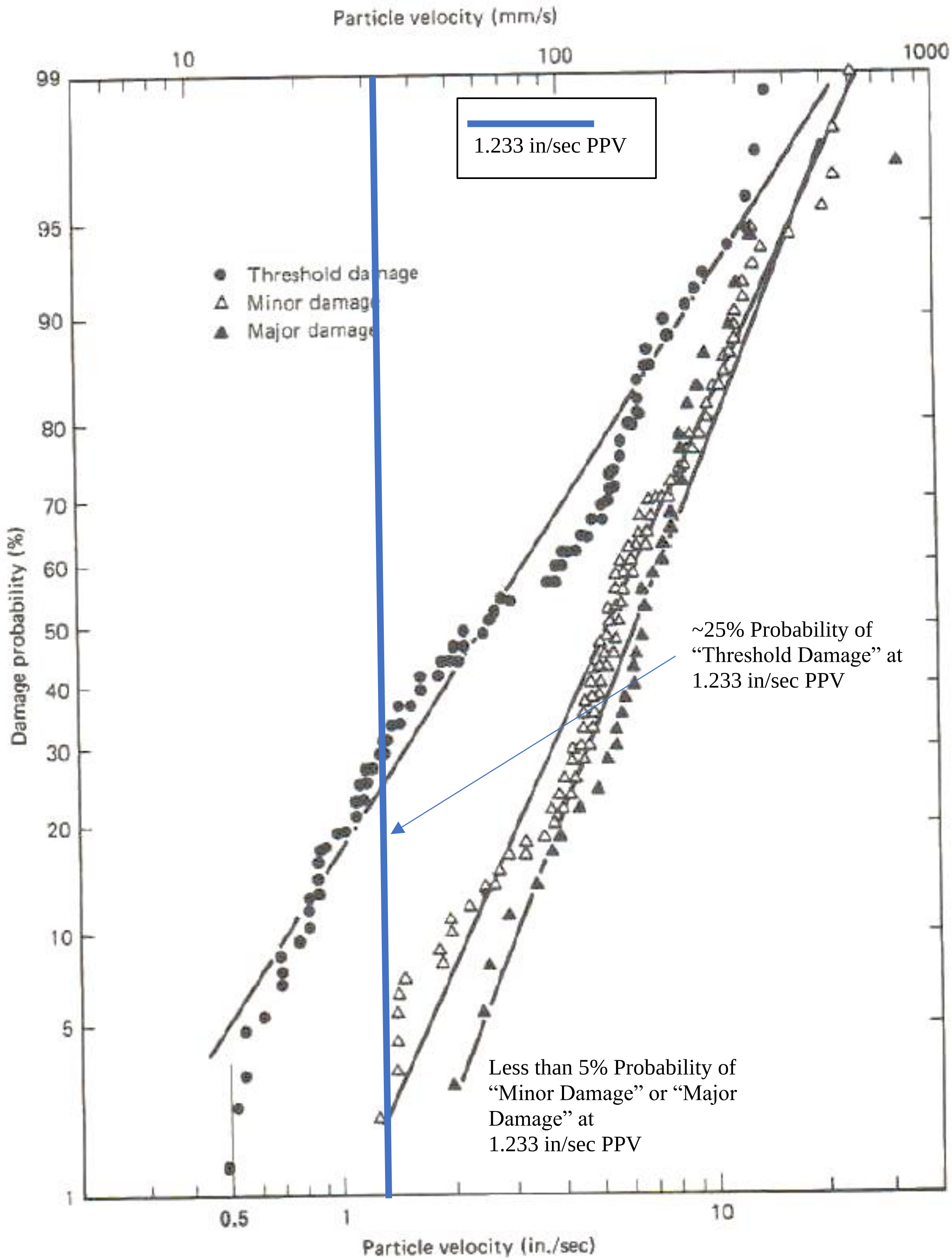
controls, such as notifying neighbors of scheduled construction activities and scheduling construction activities with the highest potential to produce perceptible vibration during hours with the least potential to affect nearby businesses, perceptible vibration can be kept to a minimum.

TABLE 9 Construction Vibration Levels at Nearest Buildings

Equipment		PPV at 25 ft. (in/sec)	Estimated Vibration Levels at Structures Surrounding the Project Site, in/sec PPV					
			3604 Ivalynn Circle Residence (30 ft)	3592 Ivalynn Circle Residence (30 ft)	3581 Ivalynn Place Residence (15 ft)	3575 Ivalynn Place Residence (30 ft)	3319 Sierra Rd (5 ft)	South Residences (60 ft)
Clam shovel drop		0.202	0.165	0.165	**0.354**	0.165	**1.186**	0.077
Hydromill (slurry wall)	in soil	0.008	0.007	0.007	0.014	0.007	0.047	0.003
	in rock	0.017	0.014	0.014	0.030	0.014	0.100	0.006
Vibratory Roller		0.210	0.172	0.172	**0.368**	0.172	**1.233**	0.080
Hoe Ram		0.089	0.073	0.073	0.156	0.073	**0.523**	0.034
Large bulldozer		0.089	0.073	0.073	0.156	0.073	**0.523**	0.034
Caisson drilling		0.089	0.073	0.073	0.156	0.073	**0.523**	0.034
Loaded trucks		0.076	0.062	0.062	0.133	0.062	**0.446**	0.029
Jackhammer		0.035	0.029	0.029	0.061	0.029	**0.206**	0.013
Small bulldozer		0.003	0.002	0.002	0.005	0.002	0.018	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., October 2023.

FIGURE 2 Probability of Cracking and Fatigue from Repetitive Loading



Source: Dowding, C.H., Construction Vibrations, Prentice Hall, Upper Saddle River, 1996 as modified by Illingworth and Rodkin, inc. (October 2023).

In summary, the construction of the project would potentially generate vibration levels exceeding the 0.2 in/sec PPV threshold at residences adjoining the project site. This would be a significant impact.

Mitigation Measure:

The project applicant shall prepare a vibration construction plan to reduce construction impacts at buildings where vibration levels due to construction activities would exceed 0.2 in/sec PPV. The plan shall include but is not limited to, the following:

- Prohibit the use of heavy vibration-generating construction equipment within 30 feet of adjacent residential buildings.

- Use a smaller vibratory roller, such as the Caterpillar model CP433E vibratory compactor, when compacting materials within 30 feet of adjacent residential buildings. Only use the static compaction mode when compacting materials within 15 feet of residential buildings.

- Avoid dropping heavy equipment and use alternative methods for breaking up existing pavement, such as a pavement grinder, instead of dropping heavy objects, within 30 feet of adjacent residential buildings.

- Designate a person responsible for registering and investigating claims of excessive vibration. The contact information of such person shall be clearly posted on the construction site.

Implementation of these mitigation measures would reduce the impact due to construction vibration to a less-than-significant level.