Appendix C: Construction Noise & Vibration Assessment

171-175 MONROE STREET CONSTRUCTION NOISE & VIBRATION ASSESSMENT

Santa Clara, California

September 1, 2021

Prepared for:

Connor Tutino
Assistant Project Manager
David J. Powers & Associates, Inc.
1736 Franklin Street, Suite 300
Oakland, CA 94612

Prepared by:

Adwait Ambaskar
Michael S. Thill

ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality

429 East Cotati Avenue
Cotati, CA 94931
(707) 794-0400

Project: 21-095

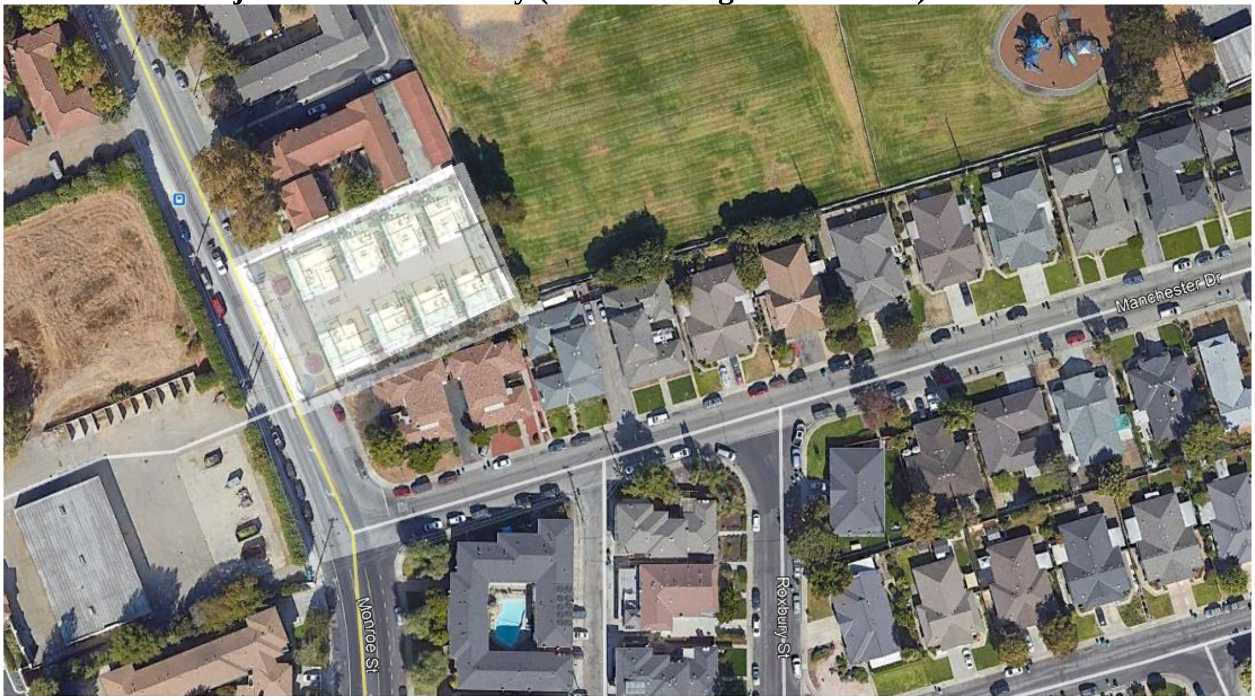
INTRODUCTION

The purpose of this report is to summarize the assessment of potential construction noise and vibration impacts due to the proposed demolition and re-development of 171-175 Monroe Street in Santa Clara, California. This report presents a summary of the proposed project, background information on environmental noise and groundborne vibration, definitions of the technical terms used in the assessment, the applicable regulatory criteria used in the assessment, and an evaluation of construction related noise and vibration impacts.

PROJECT DESCRIPTION

The approximately 0.4-acre site bounded by Monroe Street to the west, residences to the north and south, and the Washington Elementary School sports field to the east, is currently developed with two single-family residences and associated accessory structures. The project proposes to rezone the project site from R-1-6L (Single-Family Residential) to PD (Planned Development), demolish the two existing residences and redevelop the site with eight new single-family residences. Each of the residences would include a two-car garage. The proposed residences would be setback a minimum of approximately 12 feet from Monroe Street, five feet from the private driveway of the residences at 177 Monroe Street (north of the project site), five feet from the rear yards of the residences at 1295 Manchester Drive (south of the project site), and four feet from the school sports field. Figure 1 shows a Google Earth snapshot of the project plan and vicinity.

FIGURE 1 – Project Plan and Vicinity (Source: Google Earth 2021)



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 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.

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.

People are usually more sensitive to noise in the nighttime than they are during the daytime. Two factors contribute to this increased sensitivity. First, during the evening and nighttime, outdoor ambient noise levels are generally lower than in the daytime. Most offices and businesses are closed, and automobile traffic has decreased. Second, as household noise levels decrease during the evening, changes in exterior nighttime noise levels can be more noticeable and annoying than such changes are during the day.

To account for this sensitivity, a calculation called the Community Noise Equivalent Level (CNEL) is used to divide the 24-hour day into three time periods: daytime (7:00 a.m. to 7:00 p.m.), evening (7:00 p.m. to 10:00 p.m.), and nighttime (10:00 p.m. to 7:00 a.m.). The evening sound levels are assigned a five decibel penalty (or weighting) and the nighttime sound levels are assigned a 10 decibel penalty (or weighting) prior to averaging with daytime hourly sound levels. In this way, the CNEL is a noise metric that, if used to regulate noise, provides for a quieter evening and nighttime environment.

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 or frequent intermittent vibration levels produce. The guidelines in Table 3 represent syntheses of vibration criteria for human response and potential damage to buildings resulting from construction vibration.

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 cause 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. 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 paint flaking or minimal extension of cracks in building surfaces; minor, including limited surface cracking; or major, that may threaten the structural integrity of the building. Safe vibration limits that can be applied to assess the potential for damaging a structure vary by researcher. The damage criteria presented in Table 3 include several categories for ancient, fragile, and historic structures, the types of structures most at risk to damage. Most buildings are included within the categories ranging from “Historic and some old buildings” to “Modern industrial/commercial buildings”. 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 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	Virtually no risk of damage to normal 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 dwellings such as plastered walls or ceilings
0.5	Severe - Vibrations considered unpleasant	Threshold at which there is a risk of damage to newer residential structures

Source: Transportation and Construction Vibration Guidance Manual, California Department of Transportation, September 2013.

REGULATORY BACKGROUND

Regulatory Background - Noise

The City of Santa Clara Municipal code (Section 9.10.230) prohibits construction activities permitted within 300 feet of residentially zoned property except within the hours of 7:00 a.m. and 6:00 p.m. on weekdays and 9:00 a.m. and 6:00 p.m. on Saturdays. No construction is permitted on Sundays or holidays. Section 9.10.070 exempts construction activities which occur during allowed hours noise limits specified in the city code (Exceptions 9.10.070 (e)).

Regulatory Background – Vibration

The City of Santa Clara does not specify a construction vibration limit. For structural damage, the California Department of Transportation recommends a vibration limit of 0.5 in/sec PPV for new residential and modern commercial/industrial structures, 0.3 in/sec PPV for older residential structures, and a limit of 0.25 in/sec PPV for historic and some old buildings.

IMPACTS

Construction Noise Impacts

Construction activities generate considerable amounts of noise, especially during earth-moving activities when heavy equipment is used. A list of typical maximum instantaneous noise levels measured at 50 feet are provided in Table 4. Maximum noise levels typically range from about 80 to 90 dBA L_{max} at 50 feet from the noise source. Typical hourly average construction-generated noise levels for residential housing projects are about 65 to 88 dBA L_{eq} measured at 50 feet from the center of the site during busy construction periods (e.g., earth moving equipment, impact tools, etc.), as shown in Table 5.

Project construction is expected to start in October 2021 and would be built out over a period of approximately 10 months (to be completed by August 2022). Construction hours are assumed to be 7:00 a.m. to 6:00 p.m. Monday through Friday and 9:00 a.m. to 6:00 p.m. on Saturdays. The construction of the proposed project would involve demolition, site preparation, grading/excavation, trenching/ground improvement, building structure – exterior, building interior and offsite/onsite improvements as per the supplied construction data sheet. During each stage of construction, there would be a different mix of equipment operating, and noise levels would vary by stage and vary within stages, based on the amount of equipment in operation and the location at which the equipment is operating. These construction activities along with the respective levels expected from each phase of construction are summarized in Table 6 below.

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.

Source: Mitigation of Nighttime Construction Noise, Vibrations and Other Nuisances, National Cooperative Highway Research Program, 1999.

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 at site. **II** - Minimum required equipment present at site.								

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

The construction noise levels during the daytime work were calculated to range from 78 to 84 dBA L_{max} and from 77 to 84 dBA L_{eq} at 50 feet, using FHWA's Roadway Construction Noise Model (Table 6), which assumes that all the equipment could be operated simultaneously. These project-specific construction noise levels generally agree with the range of typical maximum and average noise levels presented above. 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 can provide an additional 5 to 10 dBA noise reduction at distant receptors.

Noise sensitive residential land uses are located to the north and south of the project site. Theoretically, the maximum noise levels could reach 100 to 110 dBA at the property plane if equipment is used within about 5 feet. Typically, however, a receptor would not be located at the property line of the adjacent property when construction occurs in close proximity. Standard methods for acoustical analysis of construction sites are based on the distance from the "acoustical center" or construction activity center of the site to the nearest noise-sensitive receptor, as was the case for this analysis. In other words, the proposed pieces of construction equipment are not modeled at the construction area boundary, but rather at the approximate center of the area in which most construction activity is likely to occur. The nearest existing residences are located at distances ranging 65 to 70 feet north and south, from the center of the project site. At the closest residence (65 feet away), maximum noise levels generated by project construction would typically range from about 76 to 82 dBA L_{max}, and hourly average noise levels would typically range from about 75 to 82 dBA L_{eq} for daytime construction.

TABLE 6 Total Calculated L_{max} and L_{eq} Noise Levels from RCNM

Description	Equipment	Quantity	Total Calculated (dBA) at 50 feet	
			L_{max}*	L_{eq}
Demolition	Excavators	1	81	77
Site Preparation	Tractors/Loaders/Backhoes	1	84	80
Grading/Excavation	Scrapers	1	84	84
	Excavators	1		
	Tractors/Loaders/Backhoes	1		
Trenching/Ground Improvement	Tractors/Loaders/Backhoes	1	84	82
	Excavators	1		
Building Structure/Exterior	Cement trucks	2	79	78
	Forklifts	1		
Building - Interior/Architectural Coating	Air compressors	3	78	79
	Aerial Lift	2		
Offsite/Onsite improvements	Paving Equipment	1	84	81
	Tractors/Loaders/Backhoes	1		

* Total L_{max} is the value for the loudest piece of equipment

Implementation of the following construction best management practices would regulate the hours of construction, reduce construction noise levels emanating from the site, and minimize disruption and annoyance at existing noise-sensitive receptors in the project vicinity.

Construction Best Management Practices

- Construction will be limited to the hours of 7:00 a.m. to 6:00 p.m. Monday through Friday and 9:00 a.m. to 6:00 p.m. on Saturdays. 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, such as residential uses (a minimum of 200 feet).

- Ensure that generators, compressors, and pumps are housed in acoustical enclosures.

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

- A "noise disturbance coordinator" shall be designated to respond to any local complaints about construction noise. The disturbance coordinator would determine the cause of the noise complaints (e.g., beginning work too early, bad muffler, etc.) and institute reasonable measures warranted to correct the problem. A telephone number for the disturbance coordinator would be conspicuously posted at the construction site.

Construction Vibration Impacts

Proposed construction phases would include demolition, site preparation, grading/excavation, trenching/ground improvement, building structure, building interior/architectural coating and offsite/onsite improvements. Perceptible vibration may occur when heavy equipment or impact tools are used in close proximity to sensitive receptors. However, the proposed project would not require pile driving, which can cause excessive vibration.

The City of Santa Clara does not specify any construction vibration limit. For structural damage, the California Department of Transportation recommends a vibration limit of 0.5 in/sec PPV for buildings structurally sound and designed to modern engineering standards, 0.3 in/sec PPV for buildings that are found to be structurally sound but where structural damage is a major concern, and a conservative limit of 0.25 in/sec PPV for historic and some old buildings. The nearest vibration-sensitive historic structure is located about 1,000 feet northwest of the project site (Berryessa Adobe), which is unlikely to be affected by project generated vibration. The 0.3 in/sec PPV vibration limit would thus be applicable to properties in the immediate vicinity of the project site.

Vibration levels would vary depending on soil conditions, construction methods, and equipment used. Jackhammers typically generate vibration levels of 0.035 in/sec PPV and drilling typically generates vibration levels of 0.09 in/sec PPV at 25 feet. Vibration levels are highest close to the source, and then attenuate with increasing distance at the rate $(D_{ref}/D)^{1.1}$, where D is the distance from the source in feet, and D_{ref} is the reference distance of 25 feet. Table 8 presents typical vibration levels that could be expected from construction equipment at 25 feet and summarizes the expected vibration levels at residences bordering the site, the closest being 12 feet away from the project site. At this distance (12 feet), vibration levels due to construction are conservatively calculated to reach up to 0.47 in/sec PPV for a vibratory, which would exceed the 0.3 in/sec PPV threshold for conventional buildings.

The US Bureau of Mines has analyzed the effects of blast-induced vibration on buildings in USBM RI 8507,[1] and these findings have been applied to vibrations emanating from construction equipment on buildings.[2] Figure 2 presents the damage probability, as reported in USBM RI 8507

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.

2 Dowding, C.H., Construction Vibrations, Prentice Hall, Upper Saddle River, 1996.

and reproduced by Dowding, assuming a maximum vibration level of 0.45 in/sec PPV. Based on the data summarized in Figure 2, there would be a <5% probability of “threshold damage,” and no observation of “minor damage,” or “major damage” at buildings of normal conventional construction when vibration levels were 0.47 in/sec PPV or less.

Project-generated vibration levels would fall below the 0.3 in/sec PPV structural damage threshold at all surrounding residential buildings, apart from a vibratory roller. Neither cosmetic, minor, or major damage would occur beyond 25 feet. At these locations and in other surrounding areas where vibration would not be expected to cause structural 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. By use of administrative 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 residences, perceptible vibration can be kept to a minimum.

TABLE 7 Construction Vibration Levels at Nearby Buildings

Equipment		PPV (in/sec)	
		Source Level (25 ft)	North/South Residences (12 ft)
Clam shovel drop		0.202	**0.453**
Hydromill (slurry wall)	in soil	0.008	0.018
	in rock	0.017	0.038
Vibratory Roller		0.210	**0.471**
Hoe Ram		0.089	0.200
Large bulldozer		0.089	0.200
Caisson drilling		0.089	0.200
Loaded trucks		0.076	0.170
Jackhammer		0.035	0.078
Small bulldozer		0.003	0.007

Source: Transit Noise and Vibration Impact Assessment Manual, Federal Transit Administration, Office of Planning and Environment, U.S. Department of Transportation, FTA Report No. 0123, September 2018, as modified by Illingworth & Rodkin, Inc., September 2021.

The following measures shall be implemented where vibration levels due to construction activities would exceed 0.3 in/sec PPV at nearby buildings to reduce the impact to a less-than-significant level:

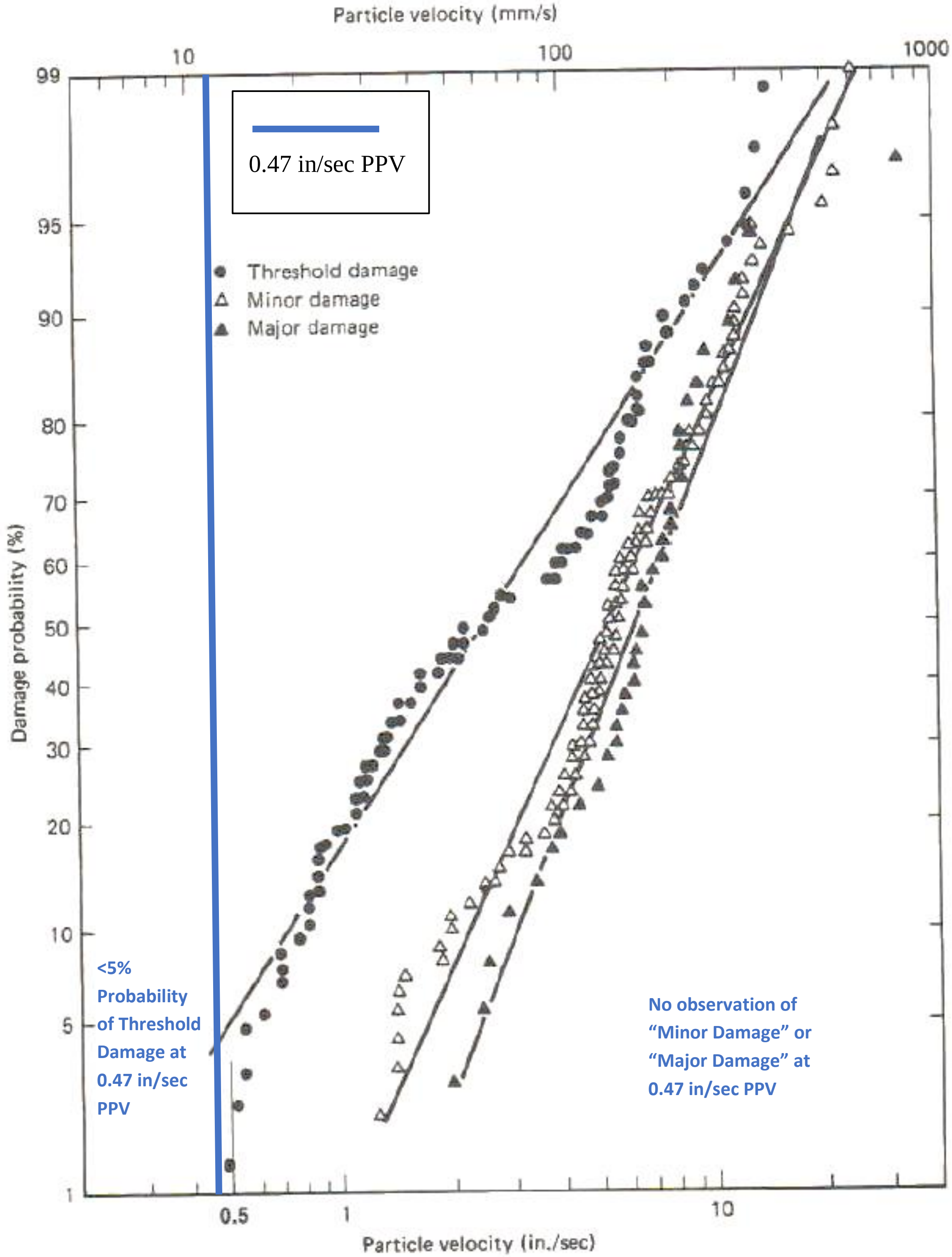
- Prohibit the use of heavy vibration-generating construction equipment within 20 feet of adjacent residential buildings.

- Use a smaller vibratory roller, such as the Caterpillar model CP433E vibratory compactor, when compacting materials within 20 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 20 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.

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 & Rodkin, Inc., August 2021.