Appendix E

1870-1876 El Camino Real, Burlingame, CA

Construction Noise and Vibration Assessment

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SUBJECT: **1870-1876 El Camino Real, Burlingame, CA**
Construction Noise and Vibration Assessment

This letter presents the results of the construction noise and vibration assessment completed for the residential project proposed at 1870 and 1876 El Camino Real in Burlingame, CA. The project proposes to construct a new 7-story residential apartment. The site is currently occupied by a gas station and two-story office building which would be demolished. The building would include 169 units and 182 parking spaces and reach a height of 75 feet. The project site is located in a primarily commercial area, with offices located adjacent to the southeast and other commercial uses to the southwest, west, and northwest. The site is bordered by El Camino Real to the southwest, Murchison Drive to the northwest, and California Drive to the northeast. Beyond California Drive are railroad tracks used by Caltrain and BART.

This assessment evaluates the potential for construction-related noise and vibration impacts to adjacent land uses. Included are a brief description of the fundamentals of environmental noise and vibration, a summary of applicable regulatory criteria, and a discussion of construction noise and vibration levels expected at receptors near the project site. Based on a review of construction information provided by the applicant, recommendations are made to mitigate construction noise and vibration impacts to less-than-significant levels.

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.

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 CNEL. Typically, the highest steady traffic noise level during the daytime is about equal to the CNEL 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 CNEL with open windows and 65-70 dBA CNEL 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 CNEL 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 CNEL. At a CNEL of about 60 dBA, approximately 12 percent of the population is highly annoyed. When the CNEL 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 CNEL of 60-70 dBA. Between a CNEL 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 CNEL 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.

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.

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 Reactions 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, September 2013.

Regulatory Background

The City of Burlingame has established regulatory criteria that are applicable in this assessment. A summary of the applicable regulatory criteria is provided below.

Noise Element of the City of Burlingame General Plan

The Noise Element in the Burlingame General Plan establishes standards by which to determine the necessity for noise studies for construction projects in the City. The following General Plan Goals and Policies are applicable to the proposed project:

Goal CS-4: Protect residents and visitors to Burlingame from excessive noise and disruptive ground vibration.

Policy CS-4.10: Require development projects subject to discretionary approval to assess potential construction noise impacts on nearby sensitive land uses and to minimize impacts on those uses consistent with Municipal Code provisions.

Policy CS-4.13: Require a vibration impact assessment for proposed projects in which heavy-duty construction equipment would be used (e.g., pile driving, bulldozing) within 200 feet of an existing structure or sensitive receptor. If applicable, require all feasible mitigation measures to be implemented to ensure that no damage or disturbance to structures or sensitive receptors would occur.

City of Burlingame Municipal Code

The Building Construction Section of the Municipal Code establishes allowable hours of construction in the City of Burlingame. Chapter 18.07.110 states that no person shall erect, demolish, alter, or repair any building or structure other than between the hours of 7:00 a.m. and 7:00 p.m. on weekdays, 9:00 a.m. and 6:00 p.m. on Saturdays, and 10:00 a.m. and 6:00 p.m. on Sundays and holidays, except under circumstances of urgent necessity in the interest of public health and safety. An exception must be approved in writing by the building official and shall be granted for a period of no more than three days for projects including structures with a gross floor area of less than 40,000 ft^2; when reasonable to accomplish the erection, demolition, alteration, or repair, the exception shall not exceed 20 days for projects including structures with a gross floor area of 40,000 ft^2 or greater.

Construction Noise Impacts

The City's Municipal Code limits construction to weekdays between 7:00 a.m. and 7:00 p.m., Saturdays between 9:00 a.m. and 6:00 p.m., and Sundays and holidays between 10:00 a.m. and 6:00 p.m. Neither the City of Burlingame nor the State of California specify quantitative thresholds for the impact of temporary increases in noise due to construction. The threshold for speech interference indoors is 45 dBA. Assuming a 15 dBA exterior-to-interior reduction for standard residential construction and a 25 dBA exterior-to-interior reduction for standard commercial construction, this would correlate to an exterior threshold of 60 dBA L_{eq} at residential land uses and 70 dBA L_{eq} at commercial land uses. Additionally, temporary construction noise would be annoying to individuals at surrounding land uses if the ambient noise environment increased by at least 5 dBA L_{eq} for an extended period of time. Therefore, the temporary construction noise impact would be considered significant if project construction activities exceeded 60 dBA L_{eq} at nearby residences or exceeded 70 dBA L_{eq} at nearby commercial or open space land uses and exceeded the ambient noise environment by 5 dBA L_{eq} or more for a period longer than one year.

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.

Construction noise levels would vary by phase and vary within phases based on the amount of equipment in operation and location where the equipment is operating. Typical construction noise levels at a distance of 50 feet are shown in Tables 4 and 5. Table 4 shows the average noise level range by construction phase and Table 5 shows the maximum noise level range for different construction equipment. Most construction noise ranges from 80 to 90 dBA at a distance of 50 feet from the source. 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.

TABLE 4 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.

TABLE 5 Construction Equipment 50-foot Noise Emission Levels (dBA)

Equipment Category	L_{eq}[1,2,3]	L_{max}[1,2]	Equipment Category	L_{eq}[1,2,3]	L_{max}[1,2]
Air Hose	93	100	Horizontal Bore Drill	87	88
Air-Operated Post Driver	83	85	Impact Pile Driver	99	105
Asphalt Distributor Truck (Asphalt Sprayer)	-	70	Impact Wrench	68	72
Auger Drill	88	101	Jackhammer	91	95
Backhoe	76	84	Jig Saw	92	95
Bar Bender	66	75	Joint Sealer	-	74
Blasting (Abrasive)	100	103	Man Lift	72	73
Blasting (Explosive)	83	93	Movement Alarm	79	80
Chainsaw	79	83	Mud Recycler	73	74
Chip Spreader	-	77	Nail Gun	70	74
Chipping Gun	95	100	Pavement Scarifier (Milling Machine)	-	84
Circular Saw	73	76	Paving – Asphalt (Paver, Dump Truck)	-	82
Compactor (Plate)	-	75	Paving – Asphalt (Paver, MTV, Dump Truck)	-	83
Compactor (Roller)	82	83	Paving – Concrete (Placer, Slipform Paver)	87	91
Compressor	66	67	Paving – Concrete (Texturing/Curing Machine)	73	74
Concrete Batch Plant	87	90	Paving – Concrete (Triple Roller Tube Paver)	85	88
Concrete Grinder	-	97	Power Unit (Power Pack)	81	82
Concrete Mixer Truck	81	82	Pump	73	74
Concrete Pump Truck	84	88	Reciprocating Saw	64	66
Concrete Saw	85	88	Rivet Buster	100	107
Crane	74	76	Rock Drill	92	95
Directional Drill Rig	68	80	Rumble Strip Grinding	-	87
Drum Mixer	66	71	Sander	65	68
Dump Truck (Cyclical)	82	92	Scraper	-	92
Dump Truck (Passby)	-	73	Shot Crete Pump/Spray	78	87
Excavator	76	87	Street Sweeper	-	81
Flatbed Truck	-	74	Telescopic Handler (Forklift)	-	88
Front End Loader (Cyclical)	72	81	Vacuum Excavator (Vac-Truck)	86	87
Front End Loader (Passby)	-	71	Ventilation Fan	62	63
Generator	67	68	Vibratory Concrete Consolidator	78	80
Grader (Passby)	-	79	Vibratory Pile Driver	99	105
Grinder	68	71	Warning Horn (Air Horn)	94	99
Hammer Drill	72	75	Water Spray Truck	-	72
Hoe Ram	92	99	Welding Machine	71	72

Notes: [1] Measured at 50 feet from the construction equipment, with a "slow" (1 sec.) time constant.
[2] Noise levels apply to total noise emitted from equipment and associated components operating at full power while engaged in its intended operation.
[3] Equipment without average (L_{eq}) noise levels are non-stationary and best represented only by maximum instantaneous noise level (L_{max}).

Source: Project 25-49 Data, National Cooperative Highway Research Program, https://apps.trb.org/cmsfeed/trbnetprojectdisplay.asp?projectid=3889, October 2018

Project construction is anticipated to take place over a period of about 14 months, from January 2021 to March 2022. A list of construction equipment to be used during each phase of construction was provided. Pile driving is not anticipated as a method of construction. Expected noise levels originating from project construction were calculated based on data used in the Federal Highway Administration's Roadway Construction Noise Model Version 2.0. Table 6 lists the expected hourly average noise levels and maximum instantaneous noise levels at a distance of 50 feet calculated for each phase of project construction. Project construction is expected to result in hourly average noise levels of 73 to 90 dBA L_{eq} with maximum noise levels of 74 to 94 dBA L_{max} at a distance of 50 feet.

TABLE 6 Calculated Construction Noise Levels by Phase at a Distance of 50 ft (dBA)

Phase	Average Noise Level (L_{eq})	Maximum Noise Level (L_{max})
Demolition	87 to 88	93 to 94
Site Preparation	76 to 77	83
Grading/Excavation	82 to 83	91
Trenching/Foundation	85 to 87	91 to 92
Building – Exterior	80 to 81	84 to 85
Building – Interior/ Architectural Coating	73 to 75	74 to 76
Paving	89 to 90	93

Source: Project 25-49 Data, National Cooperative Highway Research Program, https://apps.trb.org/cmsfeed/trbnetprojectdisplay.asp?projectid=3889, October 2018 as modified by Illingworth & Rodkin, Inc., August 2020.

Multiple commercial uses, including restaurants, offices, and retail stores are located in the site vicinity. The nearest land use to the project site is a three-story office building, which shares the property line to the southeast and is located 120 feet from the approximate center of construction activity. Average construction noise levels at 120 feet would reach 65 to 82 dBA L_{eq} with maximum noise levels reaching 66 to 86 dBA L_{max}. Interior building construction and site preparation would not be anticipated to exceed 70 dBA L_{eq} at commercial uses.

The nearest residential land uses are apartment buildings located at 120 South El Camino Real (Pinedera), approximately 350 feet northwest of the center of construction activity, and at 88 South Broadway, about 750 feet northwest of the center of construction activity. The Pinedera site includes an outdoor use area located in the center of the site and surrounded entirely by the four-story apartment building. Not considering shielding provided by intervening structures, average construction noise levels at the apartment façade would reach 56 to 73 dBA L_{eq} with maximum noise levels reaching 57 to 77 dBA L_{max}. The Pinedera building is expected to provide approximately 20 dBA of noise reduction to the shielded courtyard, resulting in average construction noise levels of 36 to 53 dBA L_{eq} and maximum noise levels of 37 to 57 dBA L_{max} at the exterior use area. Average construction noise levels at the 88 South Broadway site would reach 49 to 66 dBA L_{eq} with maximum noise levels reaching 50 to 70 dBA L_{max}. Interior building construction and site preparation would not be anticipated to exceed 60 dBA L_{eq} at residential uses.

Construction noise could exceed 60 dBA at residences and 70 dBA at commercial uses during demolition, grading and excavation, trenching and foundation, exterior building construction, and paving phases of construction. The project site is located within the 65 dBA CNEL 2016 transportation noise contour and is within 450 feet of uses within the 60 dBA CNEL contour identified in the City of Burlingame General Plan. Unmitigated project construction could result in an increase in the ambient noise level in the site vicinity of 5 dBA or greater for a period exceeding one year. The following best construction management practices have been applied to other projects in the City of Burlingame and would reduce noise from construction activities to a **less-than-significant** level.

Best Management Practices

While the project site is not located within the boundaries defined by the City of Burlingame Downtown Specific Plan, the following best management practices included in Section 8.9.19 of Specific Plan would greatly reduce noise and should be implemented by the project contractor during construction:

- Maximize the physical separation between noise generators and noise receptors.
- Use heavy-duty mufflers for stationary equipment and barriers around particularly noisy areas of the site or around the entire site.
- Use shields, impervious fences, or other physical sound barriers to inhibit transmission of noise to sensitive receptors.
- Locate stationary equipment to minimize noise impacts on the community.
- Minimize backing movements of equipment.
- Use quiet construction equipment whenever possible.

Additionally, construction activities for the proposed project should include the following best management practices to reduce noise from construction activities near sensitive land uses:

- In compliance with Chapter 18.07.110 of the Municipal Code, construction activities, including truck traffic coming to and from the construction site for any purpose, shall be limited to the hours between 7:00 a.m. and 7:00 p.m., Monday through Friday, Saturdays between 9:00 a.m. and 6:00 p.m., and Sundays and Holidays between 10:00 a.m. and 6:00 p.m., unless permission is granted with a development permit or other planning approval.
- Construction staging areas shall be established at locations that will create the greatest distance between the construction-related noise sources and noise-sensitive receptors nearest the project site during all project construction.
- Avoid the use of circular saws, miter/chop saws, and radial arm saws near the adjoining noise-sensitive receptors. Where feasible, shield saws with a solid screen with material having a minimum surface density of 2 lbs/ft^2 (e.g., such as ¾” plywood).

- Unnecessary idling of internal combustion engines should be strictly prohibited.

- Control noise from construction workers' radios to a point where they are not audible at existing residences bordering the project site.

- Maintain smooth vehicle pathways for trucks and equipment accessing the site and avoid local residential neighborhoods as much as possible.

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

- During interior construction, locate noise-generating equipment within the building to break the line-of-sight to the adjoining receptors.

- The contractor shall prepare a detailed construction plan identifying the schedule for major noise-generating construction activities. The construction plan shall identify a procedure for coordination with adjacent residential land uses so that construction activities can be scheduled to minimize noise disturbance.

- Designate a "disturbance coordinator" who would be responsible for responding to any complaints about construction noise. The disturbance coordinator will determine the cause of the noise complaint (e.g. bad muffler, etc.) and will 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.

Implementation of the above best management practices would reduce construction noise levels emanating from the site, limit construction hours, and minimize disruption and annoyance. With the implementation of these measures and recognizing that noise generated by construction activities would occur over a temporary period, the impact would be **less-than-significant**.

Construction Vibration Impacts

The City of Burlingame 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 structures, 0.3 in/sec PPV older residential structures, and a limit of 0.25 in/sec PPV for historic and some old buildings (see Table 3). There are no historic structures in the project vicinity. The 0.5 in/sec PPV vibration limit would be applicable to structures in the vicinity of the project.

The construction of the project may generate perceptible vibration when heavy equipment or impact tools are used. Construction activities would include demolition, site preparation grading and excavation, trenching and foundation, building (exterior), interior/architectural coating, and paving. Credible worst-case vibration levels were calculated at the nearest buildings surrounding the site, as measured from the project's boundaries. Pile driving is not anticipated as a method of construction.

The closest structure to the project site is a three-story office building located approximately 5 feet from the site boundary to the southeast at 1860 El Camino Real. Additional commercial structures are located across Murchison Drive approximately 85 feet from the site boundary to the northwest. The nearest residential structure is the Pinedera apartment building located approximately 225 feet from the site boundary to the northwest.

Table 7 presents vibration levels from construction equipment at a reference distance of 25 feet and levels calculated at various distances representative of nearby structures. Vibration levels are highest close to the source, and then attenuate with increasing distance at the rate of $(D_{ref}/D)^{1.1}$, where D is the distance from the source in feet and D_{ref} is the reference distance of 25 feet. When construction is located adjacent to shared property lines, construction vibration levels due to heavy construction are calculated to reach 1.233 in/sec PPV at the 1860 El Camino Real office building to the southeast, 0.055 in/sec PPV at commercial structure across Murchison Drive to the northwest, and 0.019 in/sec PPV at the Pinedera apartment building to the northwest.

TABLE 7 Vibration Levels for Construction Equipment at Various Distances

Equipment		PPV at 25 ft. (in/sec)	PPV at 5 ft. (in/sec)	PPV at 85 ft. (in/sec)	PPV at 225 ft. (in/sec)
Clam shovel drop		0.202	**1.186**	0.053	0.018
Hydromill (slurry wall)	In soil	0.008	0.047	0.002	0.001
	In rock	0.017	0.100	0.004	0.002
Vibratory Roller		0.210	**1.233**	0.055	0.019
Hoe Ram		0.089	**0.523**	0.023	0.008
Large bulldozer		0.089	**0.523**	0.023	0.008
Caisson drilling		0.089	**0.523**	0.023	0.008
Loaded trucks		0.076	0.446	0.020	0.007
Jackhammer		0.035	0.206	0.009	0.003
Small bulldozer		0.003	0.018	0.001	0.000

Source: Transit Noise and Vibration Impact Assessment, United States Department of Transportation, Office of Planning and Environment, Federal Transit Administration, October 2018 as modified by Illingworth & Rodkin, Inc., August 2020.

As indicated in Table 7, heavy vibration generating construction equipment, such as vibratory rollers and clam shovel drops, would have the potential to produce vibration levels greater than 0.5 in/sec PPV within about 12 feet of heavy construction. The office building sharing the southeast property line is located within this distance.

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 1 presents the damage probability as reported in USBM RI 8507 and reproduced by Dowding assuming maximum vibration levels of 1.25 in/sec PPV and 0.5 in/sec PPV. As shown on Figure 1, these studies indicate an approximate 5% probability of "threshold

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[1] 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.

damage" (referred to as cosmetic damage elsewhere in this report) and no observations of "minor damage" or "major damage" at vibration levels of 0.5 in/sec PPV or less. At a maximum vibration level of 1.25 in/sec PPV, these studies indicate an approximate 25% probability of "threshold damage", a 3% probability of "minor damage", and no observations of "major damage". Based on these data, cosmetic or threshold damage could occur when heavy construction is located within 12 feet of the 1860 El Camino Real office building located to the southeast and would be manifested in the form of hairline cracking in plaster, the opening of old cracks, the loosening of paint or the dislodging of loose objects. Minor damage (e.g., hairline cracking in masonry or the loosening of plaster) or major structural damage (e.g., wide cracking or shifting of foundation or bearing walls) resulting from project construction would not be anticipated at this or any other structures in the vicinity of the site.

Groundborne vibration levels from project construction would be anticipated to exceed 0.5 in/sec PPV when construction is located within 12 feet of the office building at 1860 El Camino Real. Vibration levels may still be perceptible in areas further from the site during periods of heavy construction but would not be expected to cause architectural or structural damage. This is a **potentially significant impact**.

Vibration Mitigation Measures: Implementation of the following measures would reduce the vibration impact to a less-than-significant level at the adjoining 1860 El Camino Real office building to the southeast of the project:

- A list of all heavy construction equipment to be used for this project known to produce high vibration levels (tracked vehicles, vibratory compaction, jackhammers, hoe rams, etc.) shall be submitted to the City by the contractor. This list shall be used to identify equipment and activities that would potentially generate substantial vibration and to define the level of effort for reducing vibration levels below the thresholds.

- Place operating equipment on the construction site as far as possible from vibration-sensitive receptors.

- Use smaller equipment to minimize vibration levels below the limits.

- Avoid using vibratory rollers and tampers within 20 feet of the 1860 El Camino Real building.

- Select demolition methods not involving impact tools.

- Modify/design or identify alternative construction methods to reduce vibration levels below the limits.

- Avoid dropping heavy objects or materials.

- Notify neighbors within 100 feet of the construction site of the construction schedule and that there could be noticeable vibration levels during project construction activities.

- If heavy construction is proposed within 20 feet of the 1860 El Camino Real building, a construction vibration-monitoring plan shall be implemented prior to, during, and after vibration generating construction activities located within these setbacks. All plan tasks shall be undertaken under the direction of a licensed Professional Structural Engineer in the State of California and be in accordance with industry accepted standard methods. The construction vibration monitoring plan should be implemented to include the following tasks:

  - Performance of a photo survey, elevation survey, and crack monitoring survey for the 1860 El Camino Real building. Surveys shall be performed prior to and after completion of vibration generating construction activities located within 20 feet of the structure. The surveys shall include internal and external crack monitoring in the structure, settlement, and distress, and shall document the condition of the foundation, walls and other structural elements in the interior and exterior of the structure.

  - Conduct a post-survey on the 1860 El Camino Real building where either monitoring has indicated high levels or complaints of damage. Make appropriate repairs in accordance with the Secretary of the Interior’s Standards where damage has occurred as a result of construction activities.

  - The results of any vibration monitoring shall be summarized and submitted in a report shortly after substantial completion of each phase identified in the project schedule. The report will include a description of measurement methods, equipment used, calibration certificates, and graphics as required to clearly identify vibration-monitoring locations. An explanation of all events that exceeded vibration limits will be included together with proper documentation supporting any such claims.

  - 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.

The implementation of these measures would reduce the impact to a **less-than-significant** level.

♦ ♦ ♦

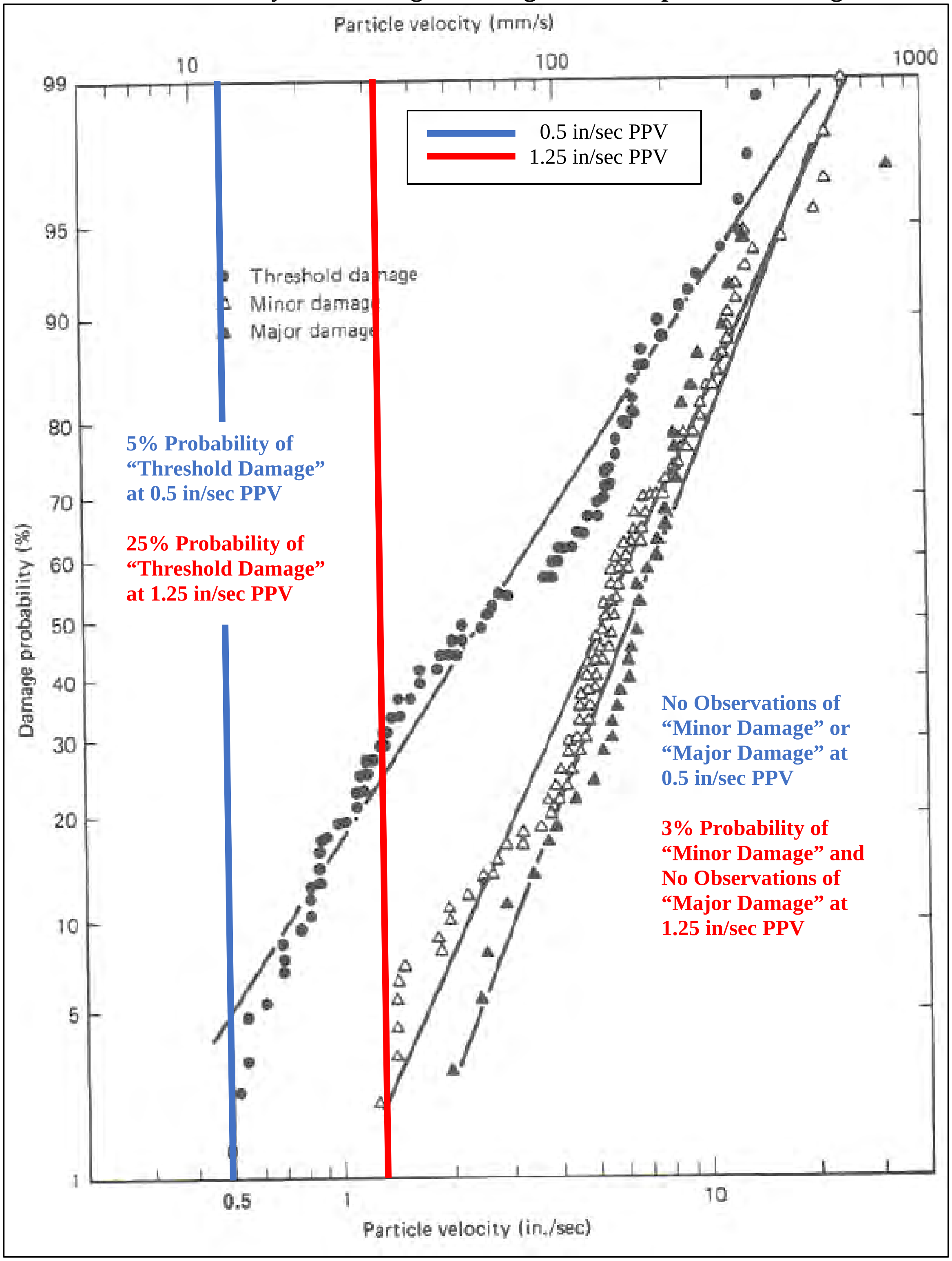
Please feel free to contact us with any questions on the analysis or if we can be of further assistance.

Sincerely,

Steve J. Deines
Illingworth & Rodkin, Inc.

Dana M. Lodico, PE, INCE Bd. Cert.
Illingworth & Rodkin, Inc.

FIGURE 4 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 2020