RIVERFRONT DEVELOPMENT NOISE AND VIBRATION ASSESSMENT PETALUMA, CALIFORNIA

March 8, 2013

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Job No.: 13-045

Introduction

This report presents the results of the environmental noise assessment completed for the Riverfront mixed-use residential project proposed at 500 Hopper Street in Petaluma, California. The project proposes single- and multi-family residences, a hotel, office, commercial space, open space, and a community boat house. Included in this report is a brief description of the fundamentals of environmental noise and vibration, a summary of the applicable regulatory criteria, and the results of the project's noise monitoring survey. Future noise levels at the site are calculated and summarized. The report provides an assessment of interior and exterior noise levels with respect to the State of California Building Code and City of Petaluma General Plan Guidelines. Mitigation is presented to reduce exterior interior noise levels to acceptable levels.

SETTING

Fundamentals of Environmental Acoustics

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 or 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.

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 is the Peak Particle Velocity (PPV) and another is the Root Mean Square (RMS) velocity. The PPV is defined as the maximum instantaneous positive or negative peak of the vibration wave. The RMS velocity is defined as the average of the squared amplitude of the signal. The PPV and RMS vibration velocity amplitudes are used to evaluate human response to vibration. 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. In high noise environments, which are more prevalent where groundborne vibration approaches perceptible levels, this rattling phenomenon may also be produced by loud airborne environmental noise causing induced vibration in exterior doors and windows.

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 ground-borne vibration levels. Because of the impulsive nature of such activities, the use of the peak particle velocity descriptor (PPV) has been routinely used to measure and assess ground-borne 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.

Rail operations are potential sources of substantial ground-borne vibration depending on distance, the type and the speed of trains, and the type of railroad track. People's response to ground-borne vibration has been correlated best with the velocity of the ground. The velocity of the ground is expressed on the decibel scale. The reference velocity is 1 x 10-6 in. /sec. RMS, which equals 0 VdB, and 1 in. /sec. equals 120 VdB. Although not a universally accepted notation, the abbreviation "VdB" is used in this document for vibration decibels to reduce the potential for confusion with sound decibels.

Vibration levels below 65 VdB are below the threshold for human perception. Typical background vibration levels in residential areas are usually 50 VdB or lower, well below the threshold of perception for most humans. Perceptible vibration levels inside residences are attributed to the operation of heating and air conditioning systems, door slams and foot traffic. Construction activities, train operations, and street traffic are some of the most common external sources of vibration that can be perceptible inside residences.

The U.S. Department of Transportation, Federal Transit Administration (FTA) has developed rational vibration limits that can be used to evaluate human annoyance to ground-borne vibration. These criteria are primarily based on experience with passenger train operations, such as rapid transit and commuter rail systems. The main difference between passenger and freight operations is the time duration of individual events; a passenger train lasts a few seconds whereas a long freight train may last several minutes, depending on speed and length. Table 3.10-4 summarizes the Federal Transit Administration Groundborne Vibration Impact Criteria.

TABLE 1 Definitions of Acoustical Terms Used in this Report

Term	Definitions
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.
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. The hourly L_{eq} used for this report is denoted as dBA $L_{eq[h]}$.
Day-Night Level, DNL or L_{dn}	The equivalent noise level for a continuous 24-hour period with a 10-decibel penalty imposed during nighttime and morning hours (10:00 pm to 7:00 am).
Community Noise Exposure Level, CNEL	CNEL is the equivalent noise level for a continuous 24-hour period with a 5-decibel penalty imposed in the evening (7:00 pm to 10:00 pm) and a 10-decibel penalty imposed during nighttime and morning hours (10:00 pm to 7:00am)
L_1, 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.
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 Noise Source	Noise Level (dBA)	Common Indoor Noise Source
	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), Caltrans, November 2009.

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
0.3	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-Induced Vibration Guidance Manual, California Department of Transportation, June 2004.

TABLE 4 FTA Groundborne Vibration Impact Criteria

	Impact Levels (VdB re 1 micro-inch /sec)		
Land Use Category	**Frequent Events[1]**	**Occasional Events[2]**	**Infrequent Events[3]**
Category 1: Buildings where vibration would interfere with interior operations.	65 VdB4	65 VdB4	65 VdB4
Category 2: Residences and buildings where people normally sleep.	72 VdB	75 VdB	80 VdB
Category 3: Institutional land uses with primarily daytime use.	75 VdB	78 VdB	83 VdB

Source: US Department of Transportation Federal Transit Administration 2006

Notes:

1. "Frequent Events" is defined as more than 70 vibration events per day. Most rapid transit projects fall into this category.
2. "Occasional Events" is defined as between 30 and 70 vibration events of the same source per day. Most commuter trunk lines have this many operations.
3. "Infrequent Events" is defined as fewer than 30 vibration events per day. This category includes most commuter rail systems.
4. This limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes.

Regulatory Background

The State of California and the City of Petaluma establishes guidelines, regulations, and policies designed to limit noise exposure at noise sensitive land uses. The State of California Building Code and the Health and Safety Element of the Petaluma General Plan 2025, present the following:

2010 California Building Code. The State of California establishes exterior sound transmission control standards for new hotels, motels, dormitories, apartment houses, and dwellings other than detached single-family dwellings as set forth in the 2010 California Building Code (Chapter 12, Section 1207.11). Where the exterior noise level exceeds 60 dBA CNEL the interior noise level attributable to exterior environmental noise sources shall not exceed 45 dBA CNEL in any habitable room. When exterior noise levels (the higher of existing or future) where residential structures are to be located exceed 60 dBA CNEL, a report must be submitted with the building plans describing the noise control measures that have been incorporated into the design of the project to meet the noise limit.

City of Petaluma General Plan: General Plan 2025. Section 10.2 of the City of Petaluma's Health and Safety Element includes objectives and policies applicable to the proposed single-family residential project. The City's objective is to, "...protect public health and welfare by eliminating or minimizing the effects of existing noise problems, and by minimizing the increase of noise levels in the future." Multi-family residential and hotel land uses are considered "normally acceptable" up to 65 dBA CNEL and "conditionally acceptable" up to 70 dBA CNEL in common outdoor use areas. Single-family residential land uses are considered "normally acceptable" up to 60 dBA CNEL and "conditionally acceptable" up to 70 dBA CNEL in private outdoor use areas. The following policies applicable to this project support the City's goal:

Policy A: Continue efforts to incorporate noise considerations into land use planning decisions, and guide the locations and design of transportation facilities to minimize the effects of noise on adjacent land uses.

Policy B: Discourage location of new noise-sensitive uses, primarily homes, in areas with projected noise levels greater than 65 dB CNEL. Where such uses are permitted, require incorporation of mitigation measures to ensure that interior noise levels do not exceed 45 dB CNEL.

Policy C: Ensure that the City's Noise Ordinance and other regulations:

- *i)* Require that applicants for new noise-sensitive development in areas subject to noise levels greater than 65 dB CNEL obtain the services of a professional acoustical engineer to provide a technical analysis and design of mitigation measures.
- *ii)* Require placement of fixed equipment, such as air conditioning units and condensers, inside or in the walls of new buildings or on roof-tops of central units in order to reduce noise impacts on any nearby sensitive receptors.

Policy D: Continue to require control of noise or mitigation measures for any noise-emitting construction equipment or activity. The City's Noise Ordinance establishes controls on construction-related noise.

Policy E: As part of development review, use Figure 10-2: Land Use Compatibility Standards to determine acceptable uses and installation requirements in noise-impacted areas.

Policy F: Discourage the use of sound walls anywhere except along Highway 101 and/or along the NWPRA corridor, without findings that such walls will not be detrimental to community character. When sound walls are deemed necessary, integrate them in the streetscape.

Policy G: In making a determination of impact under the California Environmental Quality Act (CEQA) consider an increase of four or more dBA to be "significant" if the resulting noise level would exceed that described as normally acceptable for the affected use in Figure 10-3: Land Use Compatibility for Community Noise Environments.

Petaluma Noise Ordinance. The Noise Ordinance, in Municipal Code Section 22-301, establishes quantitative noise limits for stationary noise sources such as machinery and activities such as loading docks to protect the public from disturbance caused by unnecessary or excessive noise. The basic noise limit is a level of 60 dBA L_{eq} measured on a receiving property. Noise generating construction activities are prohibited between 10 PM and 7 AM.

Existing Noise Environment

The project site is currently undeveloped. The major noise source affecting the site is vehicular traffic on U.S. Highway 101. The highway is elevated above the site because of the bridge over Lakeville Highway and the railroad, and the bridge over the Petaluma River. The differential in elevation between the site and the highway has a significant effect on the highway noise, substantially reducing the noise below what it would be if the site were at grade with the highway.

Illingworth & Rodkin, Inc. measured noise levels over a 24-hour period adjacent to U.S. Highway 101 on the KB Homes site just south of the Petaluma River Bridge in October 2003. These data are used in this report in conjunction with short-term measurements conducted in 2005 and February 2013 adjacent to U.S. Highway 101 where it adjoins the project site in order to establish existing conditions for this site. Noise measurements were made in 2005 and 2013 during midday at a location approximately 365 feet from the edge of U.S. Highway 101 and about 400 feet south of the project's Hopper Street property line. The measured average noise level during the 15-minute measurement was 60 dBA in 2005 and 63 dBA L_{eq} in 2013. During the 2005 survey a measurement made near the U.S. Highway 101 right-of- way demonstrated that the noise level lowers by up to 2 dBA as one approaches the highway because of the additional shielding provided by the edge of shoulder along the elevated roadway section. During the 2013 noise survey an additional measurements were made about 1000 feet from the highway near the site center and just across the Petaluma River from the southeast corner of the site where the measured mid-day noise levels were 49 dBA L_{eq} and 57 dBA L_{eq}, respectively. By correlating these midday measurements with data from the previous 24-hour measurements, it was possible to determine the existing 24-hour average noise level on the project site. The existing level ranges from a high of 64 dBA CNEL down to 57 dBA CNEL near the highway from north to south along the site's highway frontage. Three to four hundred feet from the edge of the highway structure the existing level ranges from a high of 66 dBA CNEL down to 59 dBA CNEL from north to south along the site's highway frontage.

The western side of the site adjoins the abandoned sewage treatment plant ponds and the old Pomeroy facility. Activities on these properties no longer contribute to the noise environment on the project site.

Future Railroad Train Noise Exposure

The old Northwest Pacific Railroad (NWPR) tracks adjoin the Hopper Street side of the project site. These tracks will carry freight traffic and the Sonoma-Marin Area Rail Transit (SMART) system for commuter rail usage in the future. Future noise levels along the Northwestern Pacific Rail corridor, as described in the SMART EIR Revised Cumulative Impacts Section dated March 2008, assuming SMART trains plus six freight train passby's during the daytime, are estimated to reach 60 dBA L_{dn} (or CNEL) at a distance of 50 feet assuming a train speed of 25 mph through Petaluma, not including the effects of train warning horns. All crossings in Petaluma will be improved to "Quiet Zone Standards" and the City will be pursuing Quiet Zone status between now and 2016, the projected start date of passenger rail, according to Curt Bates, the City Engineer. Day-night average noise levels would exceed 60 dBA L_{dn} at these areas if Quiet Zone designations are not approved and trains were required to sound their whistles, or if there are nighttime freight trains. Where residential development is located adjacent to at-grade rail crossings (without implementation of a Quiet Zone), these sensitive uses would be subject to maximum instantaneous noise levels (L_{max}) from train warning whistles that range from approximately 90 to 100 dBA L_{max} outdoors 50 feet from the tracks.

IMPACTS AND MITIGATION MEASURES

Significance Criteria

Appendix G of the CEQA Guidelines states that a project would normally be considered to result in significant noise impacts if noise levels conflict with adopted environmental standards or plans or if noise generated by the project would substantially increase existing noise levels at sensitive receivers over a permanent or temporary basis. A significant impact would be identified for a proposed land use if it would be exposed to noise levels exceeding established guidelines or standards for noise and land use compatibility. A substantial permanent noise increase would occur if the noise level increase resulting from the project is 4 dBA CNEL as established by the Petaluma General Plan. A substantial temporary noise level increase would occ ur where noise from construction activities exceeds 60 dBA L_{eq} and the ambient noise environment by at least 5 dBA L_{eq} at adjacent land uses in the project vicinity for a period of one year or more. Railroad train vibration would be significant if it is projected to exceed FTA thresholds. Vibration levels generated during demolition or construction activities would be significant if they cause cosmetic or structural damage to adjacent buildings.

Impact 1: **Noise and Land Use Compatibility.** The project could expose people to noise levels that could conflict with the Petaluma 2025 General Plan's Land Use Compatibility for Community Noise Environments guidelines or the City of Petaluma Noise Ordinance or applicable standards of other agencies. **This is a potentially significant impact.**

Future Exterior Noise Environment

According to the Petaluma 2025 General Plan Draft EIR, future noise levels, due to general growth in the area and the potential widening of the highway, could be expected to increase 1 to 2 dBA over the next 10-15 years. The project site's future noise exposure is, therefore, conservatively characterized to be a maximum of 65-68 dBA CNEL within 400 feet of the highway in the northwestern corner of the site ranging down to 58-61 dBA CNEL in the southern portion of the site. The goal for outdoor areas in Petaluma associated with residential developments is 60 dBA CNEL for single family and 65 dBA for multi-family. The site's noise exposure is, therefore, up to 3 dBA in excess of the City's goals for the multi-family residential proposed in the northern portion of the site, and up to 1 dBA CNEL in excess of the City's goal for single family residential proposed in the southern portion of the site, and falls within the "conditionally acceptable" noise and land use compatibility category in the General Plan. As buildings are constructed, the buildings will buffer the public and private outdoor activities areas from the highway noise. The noise exposure at the Central Green and Active Park would be less than 60 dBA CNEL. The noise exposure would typically be less than 60 dBA CNEL in the yards of any of the single family residences once the site is developed and the buildings will buffer the noise. The noise from the future rail operations results from a number of relatively loud, but short duration events. Given the infrequent number of trains that would use the rail corridor, the effect on outdoor areas would be insignificant. The effect of railroad train noise is discussed below.

Mixed-use buildings within the project could expose future residents of the development to noise from heating, ventilating, and air conditioning equipment, loading docks, or maintenance activities. These sources are regulated by Chapter 21 of the Petaluma Municipal Code, Noise Ordinance, and as such would be controlled by the businesses so as not to exceed the quantitative noise thresholds in the code or create a nuisance.

Future Interior Noise Environment

The State of California Building Code and the City of Petaluma requires that interior noise levels within new residential units not exceed 45 dBA CNEL. In buildings of typical construction, with the windows partially open, interior noise levels are approximately 15 dBA lower than exterior noise levels. With the windows closed, standard residential construction typically provides 20 to 25 decibels of exterior to interior noise reduction. Where exterior day-night average noise levels are 65 dBA CNEL or less, interior noise levels can typically be maintained below State standards (45 dBA CNEL) with the incorporation of forced air mechanical ventilation systems in residential units. These systems allow the occupant the option of controlling noise by maintaining the windows shut. Where noise levels exceed 65 dBA CNEL, forced-air mechanical ventilation systems and sound-rated building elements are normally required. To minimize the intrusiveness of noise from railroad trains, the maximum instantaneous noise level during a train passage should not exceed 55 dBA L_{max} inside residential buildings including the hotel.

Mitigation 1:

Environmental Noise in Exterior Areas – None required.

Environmental Noise Inside Buildings – Pursuant to Noise Element Policy C and the State Building Code, the applicant shall utilize the services of a qualified acoustical specialist during the detailed design phase to determine the noise control treatments necessary to include in the design of the residential buildings and hotel to meet local and state standards. To achieve the necessary noise reduction required to meet the requirements of the State Building Code, some form of forced air mechanical ventilation, satisfactory to the local building official, would be required in all residential units and the hotel. Special sound rated building elements may be necessary to reduce the intrusiveness of the train noise given that typical noise levels could reach 95 dBA Lmax outside the nearest townhomes if Quiet Zone status is not approved. Incorporation of these mitigation measures would reduce this impact to *less-than-significant.*

Impact 2: **Ground Vibration.** Vibration levels generated during construction activities may be perceptible at neighboring land uses, but would not be excessive or cause cosmetic or structural damage to buildings. Railroad train vibration would be below FTA guidelines. **This is a less-than-significant impact.**

The construction of the project may generate perceptible vibration when heavy equipment or impact tools (e.g. jackhammers, hoe rams, pile drivers) are used. Construction activities would include demolition of existing structures, excavation, site preparation work, foundation work, and new building framing and finishing.

For structural damage, the California Department of Transportation uses a vibration limit of 0.5 inches/second, peak particle velocity (in/sec, PPV) for buildings structurally sound and designed to modern engineering standards.

Table 5 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. Vibration levels from typical construction activities would be expected to be 0.2 in/sec PPV or less, below the 0.5 in/sec PPV significance threshold. Vibration generated by construction activities near the common property line would at times be perceptible, however, would not be expected to result in “architectural” damage to these buildings.

The nearest vibration sensitive structures or persons are located in the McNear Landing residential development to the southwest and across the Petaluma River from the project site, more than 300 feet from where the nearest construction activities would occur. Pile driving is not anticipated anywhere on the project site, and would definitely not be required for the construction of the single family homes in the southern portion of the site. Given the distance to the nearest receptors, vibration would not be perceptible and would be substantially below levels that would cause “architectural” damage to these buildings. This is a less-than-significant impact.

Trains on the NMPR tracks through Petaluma are proposed to travel at a maximum speed of 25 mph. The nearest building to the tracks would be the Office Building proposed about 60 feet from the near track. The next nearest building would be a townhouse proposed in the northeast corner of the site at a distance of about 100 feet from the near track. There could be up to about 30 trains per day using the corridor. The applicable FTA criteria from Table 4 would be 78 VdB for the office and 75 VdB for the housing. Given the low train speed of 25 mph or less proposed through Petaluma, and information set forth in the SMART DEIR, vibration levels would be below the FTA thresholds.

TABLE 5 Vibration Source Levels for Construction Equipment[1]

Equipment		**PPV at 25 ft. (in/sec)**	**Approximate L_v at 25 ft. (VdB)**
Pile Driver (Impact)	upper range	1.158	112
	typical	0.644	104
Pile Driver (Sonic)	upper range	0.734	105
	typical	0.170	93
Clam shovel drop		0.202	94
Hydromill (slurry wall)	in soil	0.008	66
	in rock	0.017	75
Vibratory Roller		0.210	94
Hoe Ram		0.089	87
Large bulldozer		0.089	87
Caisson drilling		0.089	87
Loaded trucks		0.076	86
Jackhammer		0.035	79
Small bulldozer		0.003	58

Source: Transit Noise and Vibration Impact Assessment, United States Department of Transportation, Office of Planning and Environment, Federal Transit Administration, May 2006.

Mitigation Measures: **None required.**

Impact 3: **Increased Traffic Noise.** Traffic noise levels are calculated to increase by about 1 dBA CNEL as result of project traffic, less than the threshold level of 4 dBA CNEL. **This is a less-than-significant impact**

Traffic impacts for the Project were assessed by W-Trans in March 2012. Increases in traffic noise levels on local streets were calculated by comparing existing traffic volumes to existing volumes with the project traffic added, and by comparing future cumulative traffic volumes to existing volumes. The traffic noise is calculated to increase about 1 dBA CNEL as a result of the addition of project trips, and about the same when other future baseline trips are added as well. The City of Petaluma General Plan establishes an increase of 4 dBA CNEL or greater as significance threshold for increased noise. This is a *less-than-significant* impact.

Impact 4: **Construction Noise.** Noise generated by construction activities at the project site would not exceed 70 dBA L_{eq} and the ambient noise environment by 5 dBA L_{eq}. **This is a less-than-significant impact.**

Noise impacts resulting from construction depend on 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 receptors. Where noise from construction activities exceeds 60 dBA L_{eq} and the ambient noise environment by 5 dBA L_{eq} or more at nearby residential land uses for a period of more than one year, the impact would be considered significant.

Construction activities are noisy, especially during the construction of project infrastructure when heavy equipment is used. Table 5 presents the typical range of hourly average noise levels generated by different phases of construction measured at a distance of 50 feet. Hourly average noise levels generated by demolition and construction are about 77 dBA to 89 dBA L_{eq} 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 distance between the source and receptor. Shielding provided by barriers or structures can provide an additional 5 to 10 dBA noise reduction at distant receivers.

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

	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: United States Environmental Protection Agency, 1973, Legal Compilation on Noise, Vol. 1, p. 2-104.

With implementation of the following standard controls noise levels would be below 60 dBA L_{eq} at the nearest residences located across the Petaluma River from the project site except during the period when work would occur in the southwestern quadrant of the project site within about 750 feet of the residences. This work is anticipated to occur for a period of less than 1 year. Construction noise would result in a *less-than significant* impact.

Standard Construction Noise Controls:

- Construction activities would only occur between 7 AM and 10 PM as stipulated in the Petaluma Noise Ordinance.
- The construction contractor shall designate a "noise disturbance coordinator" who shall be responsible for responding to any local complaints about construction noise. The disturbance coordinator shall determine the cause of the noise complaints (e.g., beginning work too early, bad muffler) and institute reasonable measures warranted to correct the problem. A telephone number for the disturbance coordinator shall be conspicuously posted at the construction site.
- During all project site excavation and on-site grading, the construction contractor shall equip all construction equipment, fixed or mobile, with properly operating and maintained mufflers consistent with manufacturers' standards.
- The construction contractor shall locate stationary noise generating equipment such as air compressors or portable power generators as far as possible from sensitive receptors.
- The construction contractor shall locate equipment staging in areas that will create the greatest possible distance between construction-related noise sources and noise-sensitive receptors nearest the project site during all project construction.
- The construction contractor shall utilize "quiet" air compressors and other stationary noise sources where technology exists.
- The construction contractor shall route all construction traffic to and from the project site via designated truck routes and prohibit construction related heavy truck traffic in residential areas where feasible.

Mitigation Measures: None Required.

Impact 5: **Aircraft Noise.** The Petaluma Airport is located about 1.75 miles northeast of the project site. Aircraft noise causes **no impact.**

The Petaluma Airport is located about 1.75 miles northeast of the project site. Most aircraft activity is concentrated in the Airport's immediate environs. The noise exposure map for the

Airport included in the 2025 General Plan shows the 55 dBA CNEL noise contour located east of S. Ely Boulevard. The site is not adversely affected by aircraft noise.

Mitigation Measures: None required.