VJB VINEYARDS WINERY & TASTING ROOM PARKING LOT ADDITION NOISE AND VIBRATION ASSESSMENT

Kenwood, Sonoma County, California

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INTRODUCTION

This report summarizes the evaluation of noise and vibration levels attributable to construction activities and project operations due a proposed parking lot for VJB Vineyards Winery and Tasting Room located on a currently vacant lot at 75 Shaw Avenue with respect to the regulatory criteria established by the Sonoma County General Plan and the Sonoma County Guidelines for the Preparation of Noise Analysis. The report first describes the project, study area, and existing noise levels in the project vicinity. The report then summarizes the applicable regulatory criteria used in the assessment of project-generated noise and vibration levels. Standard best management practices are recommended to reduce temporary construction noise levels to less-than-significant levels. With the incorporation of mitigation measures, construction vibration and project operational noise levels would not be expected to result in significant impacts upon nearby residential land uses. A brief discussion of the fundamentals of environmental noise and groundborne vibration is presented in Appendix A for those unfamiliar with acoustical terms or concepts.

PROJECT DESCRIPTION

The project proposes to convert a vacant lot at 75 Shaw Avenue, which is currently used as an informal parking area, to a fully improved 53 space parking lot for tasting room guests and employees.

NOISE ANALYSIS STUDY AREA

The project site is a vacant flat parcel developed. The site is bordered by a single-family residential and a commercial use to the north, a single-family residential use to the west, Shaw Avenue and the VJB Vineyards Winery and Tasting Room to the south and a commercial use to the east. A review of the site plan and surrounding uses indicates that the residential uses to the north and west are the only noise sensitive uses adjacent to the proposed site improvements. Figure 1, in Appendix B, shows the site plan of the proposed project, adjacent land uses and receptor locations, and noise monitoring locations selected during the noise survey.

EXISTING NOISE ENVIRONMENT

Ambient noise levels were measured by *Illingworth & Rodkin, Inc.* between 2pm on Friday, April 19th and Tuesday, April 23rd, 2019. Noise measurements were made with Larson Davis Model 820 Integrating Sound Level Meters (SLM) set at “slow” response. The sound level meters were equipped with G.R.A.S. Type 40AQ ½-inch random incidence microphone and fitted with windscreens. The sound level meters were calibrated prior to the noise measurements using a Larson Davis Model CAL200 acoustical calibrator. The response of the systems were checked after each measurement session and was always found to be within 0.1 dBA. No calibration adjustments were made to the measured sound levels. At the completion of the monitoring event, the measured interval noise level data were obtained from the SLM using the Larson Davis SLM utility software program. Weather conditions during the measurement period were generally good for noise monitoring.

The first long-term sound level measurement (see LT-1 in Figure 1) was made on the western property line shared with the single-family residential lot to the west and identified as Residence 1 in Figure 1. The monitoring equipment was installed on the existing property line fence at a height of approximately 8 feet above grade. Noise levels measured at this site primarily resulted from existing parking uses, adjacent residential sounds and roadway noise from Shaw Avenue and the more distant Hwy 12 traffic. The hourly trend in noise levels at this location, including the energy equivalent noise level (L_{eq}), maximum (L_{max}), minimum (L_{min}), and the noise levels exceeded 2,8,25, and 50 percent of the time (indicated as L_2, L_8, L_{25}, and L_{50}) are shown on Chart 1 (see Appendix B).

A review of Chart 1 shows that the average weekday noise levels at LT-1 ranged from 47 to 66 dBA L_{eq} during the day, and 40 to 55 dBA L_{eq} at night, and average weekend noise levels ranged from 48 to 58 dBA L_{eq} during the day and 38 to 49 dBA L_{eq} at night. The calculated average day/night noise level (L_{dn}) at this location was 57 dBA for weekdays and 53 dBA for weekends. The average, maximum, minimum levels measured for the daytime and nighttime periods for the entire LT-1 measurement along with the corresponding Sonoma County Table NE-2 Noise Standards are shown in Table 1.

Table 1: Comparison of Noise Measurements Results and Sonoma County Noise Standards at Property line of Residence 1

Type of Level		Noise Level, dBA			
		L_{50}	L_{25}	L_8	L_2
Daytime Levels	NE-2 Noise Standard	50	55	60	65
	Measured Ambient Level[1]	**48**	**51**	**53**	**55**
	Measured Range (Max/Min)	*44/54*	*48/56*	*51/59*	*53/63*
Nighttime Levels	NE-2 Noise Standard	45	50	55	60
	Measured Ambient Level[1]	**38**	**41**	**47**	**51**
	Measured Range (Max/Min)	*33/54*	*35/56*	*40/58*	*47/59*

[1] Calculated based on an average of the four quietest L_{eq} hours in each measured 24-hour period

The second long-term sound level measurement (see LT-2 in Figure 1) was made on the northern property line of the project site shared with the single-family residential lot to the north and identified as Residence 2 in Figure 1. The monitoring equipment was installed on the existing property line fence at a height of approximately 8 feet above grade. Noise levels measured at this site primarily resulted from adjacent residential sounds and roadway noise from distant Shaw Avenue, Randolph Avenue and Hwy 12 traffic. Chart 2 in Appendix B, shows the hourly trend in noise levels at this site, including the energy equivalent noise level (L_{eq}), maximum (L_{max}), minimum (L_{min}), and the noise levels exceeded 2,8,25, and 50 percent of the time (indicated as L_2, L_8, L_{25}, and L_{50}).

A review of Chart 2 indicates that the average weekday noise levels at LT-2 ranged from 43 to 67 dBA L_{eq} during the day and 36 to 52 dBA L_{eq} at night, and average weekend noise levels ranged from 47 to 54 dBA L_{eq} during the day and 39 to 48 dBA L_{eq} at night. The calculated average day/night noise level (L_{dn}) at this location was 55 dBA for weekdays and 51 dBA for weekends. The average, maximum, minimum levels measured for the daytime and nighttime periods for the entire LT-2 measurement along with the corresponding Sonoma County Table NE-2 Noise Standards are shown in Table 2.

Table 2: Comparison of Noise Measurements Results and Sonoma County Noise Standards at Property line of Residence 2

Type of Level		Noise Level, dBA			
		L_{50}	L_{25}	L_8	L_2
Daytime Levels	NE-2 Noise Standard	50	55	60	65
	Measured Ambient Level[1]	**47**	**49**	**51**	**54**
	Measured Range (Max/Min)	*43/53*	*47/55*	*50/57*	*51/60*
Nighttime Levels	NE-2 Noise Standard	45	50	55	60
	Measured Ambient Level[1]	**39**	**42**	**46**	**50**
	Measured Range (Max/Min)	*37/52*	*38/55*	*41/56*	*46/58*

[1] Calculated based on an average of the four quietest L_{eq} hours in each measured 24-hour period

REGULATORY CRITERIA

Goals, objectives, and policies designed to protect noise-sensitive uses from exposure to excessive noise are set forth in the Noise Element of the Sonoma County General Plan 2020. The primary goal of the Noise Element is to, "Protect people from the adverse effects of exposure to excessive noise and to achieve an environment in which people and land uses function without impairment from noise." Objectives and policies of the Noise Element that are applicable in the assessment of the proposed project are as follows:

Objective NE-1.3: Protect the present noise environment and prevent intrusion of new noise sources which would substantially alter the noise environment.

Objective NE-1.4: Mitigate noise from recreational and visitor serving uses.

Policy NE-1c: Control non-transportation related noise from new projects. The total noise level resulting from new sources shall not exceed the standards in Table NE-2 (Table 3 of this report) of the recommended revised policies as measured at the exterior property line of any adjacent noise sensitive land use. Limit exceptions to the following:

(1) If the ambient noise level exceeds the standard in Table NE-2, adjust the standard to equal the ambient level, up to a maximum of 5 dBA above the standard, provided that no measurable increase (i.e. +/- 1.5 dBA) shall be allowed.

(2) Reduce the applicable standards in Table NE-2 by 5 dBA for simple tone noises, noises consisting primarily of speech or music, or for recurring impulsive noises, such as pile drivers and dog barking at kennels.

(3) Reduce the applicable standards in Table NE-2 by 5 decibels if the proposed use exceeds the ambient level by 10 or more decibels.

(4) For short-term noise sources, which are permitted to operate no more than six days per year, such as concerts or race events, the allowable noise exposures shown in Table NE-2 may be increased by 5 dB. These events shall be subject to a noise management plan including provisions for maximum noise level limits, noise monitoring, complaint response and allowable hours of operation. The plan shall address potential cumulative noise impacts from all events in the area.

(5) Noise levels may be measured at the location of the outdoor activity area of the noise sensitive land use, instead of at the exterior property line of the adjacent noise sensitive use where:

(a) The property on which the noise sensitive use is located has already been substantially developed pursuant to its existing zoning, and

(b) There is available open land on these noise sensitive lands for noise attenuation. This exception may not be used for vacant properties, which are zoned to allow noise sensitive uses.

This exception may not be used on vacant properties which are zoned to allow noise sensitive uses.

TABLE NE-2: Maximum Allowable Exterior Noise Exposures for Non-Transportation Noise Sources

Hourly Noise Metric[1], dBA	Daytime (7 a.m. to 10 p.m.)	Nighttime (10 p.m. to 7 a.m.)
L_{50} (30 minutes in any hour)	50	45
L_{25} (15 minutes in any hour)	55	50
L_{08} (5 minutes in any hour)	60	55
L_{02} (1 minute in any hour)	65	60

[1] The sound level exceeded n% of the time in any hour. For example, the L_{50} is the value exceeded 50% of the time or 30 minutes in any hour; this is the median noise level. The L_{02} is the sound level exceeded 1 minute in any hour.

It is clear for the footnote of Table NE-2 that the applicable noise standard is based on the *"sound level exceeded n% of the time in any hour"*, such that the L_{50} is the value exceeded 50% of the time or 30 minutes in any hour or more, the L_{25} is the value exceeded 25% of the time or 15 minutes in any hour or more, L_{08} is the value exceeded 8% of the time or 5 minutes in any hour or more, and the L_{02} is the value exceeded 2% of the time or 1 minute in any hour or more.

NOISE IMPACT ANALYSIS

Noise generated by the proposed use permit update was assessed against the Table NE-2 guidelines presented in the County's Noise Element. The guidelines establish daytime and nighttime noise limits for noise events of varying durations. The primary daytime noise sources associated with the project are expected to be winery mechanical equipment, bottling, maintenance, and forklift operations, and crush related activities. No additional tasting room visitation or special events are requested so the project would have no impact on nighttime noise levels or the typical daily trip generation of the tasting room.

Estimating the expected noise produced by, and impacts from, the proposed changes to the existing use permit at adjacent noise sensitive uses requires three elements; the first is an assessment of what noise producing operations are likely to occur, the second is typical noise source levels for those operations, and the third is to determine the temporal nature of the operations.

I. Identification of Noise Producing operations/uses

Parking lot activities at the proposed 53 stall lot may result in off-site noise level increases. Automobile and light vehicle traffic on site would occur during the daytime hours and noise produced is expected to include the sounds of vehicles accessing parking areas, engine starts, door slams. These noises typically range from a maximum of 53 dBA to 63 dBA at 50 feet.

III. Propagation of sound

The final step in estimating the project noise levels is assessing the propagation of sound to the sensitive receptors. To do this, it is necessary to assume some rate of sound attenuation between the operations and receiver locations. The most dominant physical effect is due to the spreading out of sound waves with distance. Noise from moving vehicular noise sources in the parking typically attenuate at 3 dB per doubling of distance from the source, while noise from fixed sources such as parked cars people talking in the parking area can be considered to attenuate at a rate of 6 per doubling of distance from the source. Other effects can modify these fall-off rates such as partial shielding from buildings or topography, atmospheric attenuation of sound, and meteorological effects. These effects almost always reduce the noise in addition to that due to sound divergence. As most of these effects will vary with time due to changing environmental conditions, it is most conservative to assume only attenuation due to divergence for outdoor activities, realizing that the actual noise level will be at or, most likely, below those predicted using these assumptions at any one time.

NOISE IMPACT ASSESSMENT

The proposed Parking lot would include 53 parking spaces and may result in increased noise levels at the residential uses adjacent to the lot. The project does not request any changes in facility structures, mechanical equipment, tasting room visitation or the number, size or type of special events, therefore changes to any of these aspects of the VJB operations are not included in this impact assessment.

Impact 1: Parking Lot Activities

The proposed 53 stall parking area is a vacant flat unimproved (open dirt and field grass) lot in which some informal vehicular parking currently occurs with a 6-foot high solid fence at the northern, western and eastern perimeters. This fence is built with galvanized sheet metal siding on both sides of a layer of 1/2" plywood, and upon inspection appears to be built without cracks or gaps in the face or large or continuous gaps at the base. Based on the used two layers of Galvanized steel siding (typical surface weight of 0.8 lb./ft^2), and single layer of 1/2" plywood (typical surface weight of 1.4 lb./ft^2), this wall has a surface weight of 3.0 lbs. per sq. ft. and will meet the solidity and mass requirements to act as a noise barrier.

The parking lot would only be used during daytime hours and is proposed primarily for employee parking, though some overflow visitor use may also occur. Considering the intended use of the parking area and the presence of other parking opposite Shaw Avenue and immediately adjacent to the winery and tasting room buildings, the typical cumulative duration of maximum noise from intermittent parking lot noise is anticipated to be less than five minutes in any hour, and fall in the 5 minutes per hour or L_{02} NE-2 daytime category of 65 dBA (see Table NE-2, above). However, during events or on busy weekends, when the main lot is full and visitor parking occurs in the newly proposed lot, maximum noise from parking lot activities may occur more frequently at more than 5 minutes per hour but less than 15 minutes per hour and fall in the L_{08} NE-2 daytime category of 60 dBA.

Based on a review of the project site plan and distance information obtained via Google Earth, 19 of the 53 proposed parking stalls, would be immediately adjacent to residential property lines, with the closet portion of the spaces approximately 6 feet and the center of the spaces approximately 14.5 feet from the property lines of Residences 1 and 2. Using the maximum source levels discussed in the Typical Noise Source Level section above, a 6-dB sound increase for each halving of the distance, and the calculated barrier loss of the currently installed 6 foot high property line fence, parking lot noise could produce L_{08} levels of up to 57 dBA at the property line of Residence 1. Table 3, below, presents and summarizes the assessment of this intermittent parking lot noise versus County Noise Standards.

Table 3: Increased Parking Lot Activities

	L_{08} (Noise Level Exceeded 15 Minutes or more in any Hour), dBA	
	Residence 1 Property Line	**Residence 2 Property Line**
Unadjusted Table NE-2 Daytime Limit	60	60
Daytime Ambient Noise Levels	53	51
New Parking Lot Noise at Receiver	**57**	**57**
Operations Exceed Ambient by 10 dBA?	No	No
NE-2 Adjustment	0	0
Adjusted Table NE-2 Daytime Limit	60	60
New Parking Lot Noise Exceeds NE-2?	**No**	**No**

As shown in Table 3, parking lot noise is not expected to result in noise levels on the residential side of the adjacent residential property lines that would exceed the adjusted daytime L_{08} noise limit.

Impact 2: Construction Noise

Noise impacts resulting from grading, paving and site improvements of the new parking area depends on the noise generated by various pieces of construction equipment, the timing and duration of noise-generating activities, the distance between construction noise sources and noise-sensitive receptors, the shielding provided by the existing property line noise barriers, and ambient noise levels. Construction noise impacts primarily result when construction activities occur during noise-sensitive times of the day (early morning, evening, or nighttime hours), when construction occurs in areas immediately adjoining noise-sensitive land uses, or when construction durations last over extended periods of time.

Each construction phase would include a different mix of equipment operating. The highest noise level expected during parking lot construction would be site grading and excavation activities as these phases often require the simultaneous use of multiple pieces of heavy equipment, such as dozers, excavators, scrapers, and loaders. Lower noise levels result from construction activities when less heavy equipment is required to complete the tasks.

Typical construction noise levels at a distance of 50 feet are shown in Table 4. Table 4 illustrates the average noise level range by typical construction phase type.

TABLE 4: Typical Ranges of Noise Levels at 50 Feet from Construction Sites (dBA L_{eq})

	Public Works, Roads & Highways, Sewers, and Trenches	
	I	II
Ground Clearing	84	84
Excavation	88	78
Foundations	88	88

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.

Parking lot and site improvements are expected to be completed during one building season[1] within the allowable hours of 8:00 am and 5:00 pm. Extreme noise generating construction methods, such as impact pile driving, are not expected or proposed. Given the small project area, multiple pieces of heavy construction equipment are also not anticipated.

The nearest residential property would be located between 20 and 175 feet from areas of the site that would undergo major construction activities. Considering these distances and the noise attenuation resulting from the existing property line noise barrier, construction noise levels would be anticipated to range from 86 to 90 dBA L_{eq} at the closest residential property (20 feet) during busy construction periods and would drop off at a rate of about 6 dBA per doubling of distance between the noise source and the receptor. Construction noise levels would range from 61 to 71 dBA L_{eq} at 175 feet opposite the property line noise barrier.

Standard best management practices would implemented to limit construction hours to daytime periods only, reduce construction noise levels emanating from the site, and minimize disruption and annoyance at adjacent noise sensitive uses:

- Limit construction to between the hours of 8:00 am to 5:00 pm.
- Limit work to non-motorized equipment on Sundays and holidays.
- Locate construction staging areas as far as practical from nearby sensitive receptors.
- Locate stationary noise-generating equipment, such as air compressors or portable power generators, as far as practical from nearby sensitive receptors.
- Equip all internal combustion engine-driven equipment with intake and exhaust mufflers that are in good condition and appropriate for the equipment. Air compressors and pneumatic equipment should be equipped with mufflers, and impact tools should be equipped with shrouds or shields.
- Prohibit all unnecessary idling of internal combustion engines.

[1] One building season is typically defined as an approximately 8-month period between the cessation of the rainy season in the Spring and the start of a subsequent rainy season the next Fall.

Impact 4: Construction Vibration

The construction of the project may generate perceptible vibration at the adjacent residential land uses when heavy equipment is used near the perimeter of the project site. Vibration-producing activities would occur when heavy equipment is used to during site preparation work, grading and excavation, trenching, and paving. Foundation construction techniques involving impact or vibratory pile driving, which can cause excessive vibration, are not anticipated as part of the project.

There are no applicable Federal, state, or local quantitatively defined regulations relating to vibration resulting from construction activities. Based on the thresholds provided by Caltrans, a vibration limit of 0.3 in/sec PPV would minimize damage at buildings of normal conventional construction. A significant impact would occur if buildings adjacent to the proposed construction site were exposed to vibration levels in excess of 0.3 in/sec PPV. The closest portion of the structure of Residence 1 would be about 100 feet and the closest potion of Residence 2 would be about 40 feet from the closest proposed site improvements.

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 of the activities, but the vibration levels would be expected to attenuate with distance from the source. Table 5 presents typical vibration levels that could be expected from construction equipment at distances of 40 feet.

A review of this table indicates that vibration levels at Residence 1 due to construction activities would reach 0.004 to 0.104 in/sec PPV with work near the property line. Considering these results, vibration levels may at times be perceptible to occupants within Residence 1, however, project construction activity would not have the potentially result in any cosmetic damage to the nearest residential building. 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 the nearby residence, perceptible vibration can be kept to a minimum.

TABLE 5: Vibration Source Levels for Construction Equipment

Equipment	PPV at 40 ft. (in/sec)
Vibratory Roller	0.104
Large bulldozer	0.044
Loaded trucks	0.038
Caisson drilling	0.044
Small bulldozer	0.004

Source: Transit Noise and Vibration Impact Assessment Manual, Federal Transit Administration, Office of Planning and Environment, U.S. Department of Transportation, September 2018, as modified by Illingworth & Rodkin, Inc., May 2019.

Impact 5: Cumulative Noise Environment

There are no other known noise-generating projects proposed in the site vicinity. Operational noise levels from other potential projects would not add to noise levels produced by operations at the project site.

MITIGATION MEASURES

None Needed with the current property line noise barrier fence in place.

CEQA INITIAL STUDY CHECKLIST QUESTIONS

The California Environmental Quality Act (CEQA) includes qualitative guidelines for determining the significance of environmental noise impacts. The CEQA Initial Study checklist questions are listed below:

(a) Generation of a substantial temporary or permanent increase in ambient noise levels in the vicinity of the project in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies;

The primary noise sources associated with the project are is parking lot and on-site vehicle circulation. The currently installed six-foot noise barrier on the property lines shared with adjacent uses will reduce noise levels to a degree which would comply with the Sonoma County limits. ***Less-than-Significant Impact with Mitigation.***

Construction would be conducted within allowable hours and would occur over a period of less than one-year. Pile driving is not anticipated as a method of construction. With implementation of standard best management practices this would be a ***Less-than-Significant Impact****.*

(b) Generation of excessive groundborne vibration or groundborne noise levels;

Construction would not result in groundborne vibration levels which the 0.3 in/sec PPV vibration limit recommended by the California Department of Transportation at any adjacent residential structures. This is a ***Less-than-Significant Impact.***

(c) For a project located within the vicinity of a private airstrip or an airport land use plan or where such a plan has not been adopted within two miles of a public airport or public use airport, if the project would expose people residing or working in the project area to excessive noise levels.

The project is not located within 2 miles of the private airstrip or an airport. This is a ***Less-than-Significant Impact.***

SUMMARY/CONCLUSIONS

Based on the above findings, noise associated with project operations would be reduced to levels below the Sonoma County noise standards residential properties in the site vicinity with the currently installed six-foot noise barrier on the property lines shared with adjacent uses. Temporary construction noise would be reduced by the implementation of standard best management practices.

Appendix A: Fundamentals of Noise and Vibration

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 A1.

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 A2. 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* (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 L_{dn}. Typically, the highest steady traffic noise level during the daytime is about equal to the L_{dn} 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 to 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 to 62 dBA L_{dn} with open windows and 65 to 70 dBA L_{dn} with standard construction if the windows are closed.

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 L_{dn} 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 L_{dn}. At a L_{dn} of about 60 dBA, approximately 12 percent of the population is highly annoyed. When the L_{dn} increases to 70 dBA, the percentage of the population highly annoyed increases to about 25 to 30 percent of the population. There is, therefore, an increase of about 2 percent per dBA between a L_{dn} of 60 to 70 dBA. Between a L_{dn} of 70 to 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 L_{dn} is 60 dBA, approximately 30 to 35 percent of the population is believed to be highly annoyed.

TABLE A1 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 A2 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 A3 displays the reactions of people and the effects on buildings that continuous vibration levels produce. The guidelines in Table A3 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 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. 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 A3 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 A3 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 A3 Reaction of People and Damage to Buildings from Continuous or Frequent Intermittent Vibration Levels

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

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

Appendix B: Figures and Noise Measurement Charts

Figure 1: Site Plan Showing Noise Monitoring Locations, Nearby Land Uses, and Receptor Locations

Chart 1: Measured Noise Levels at LT-1

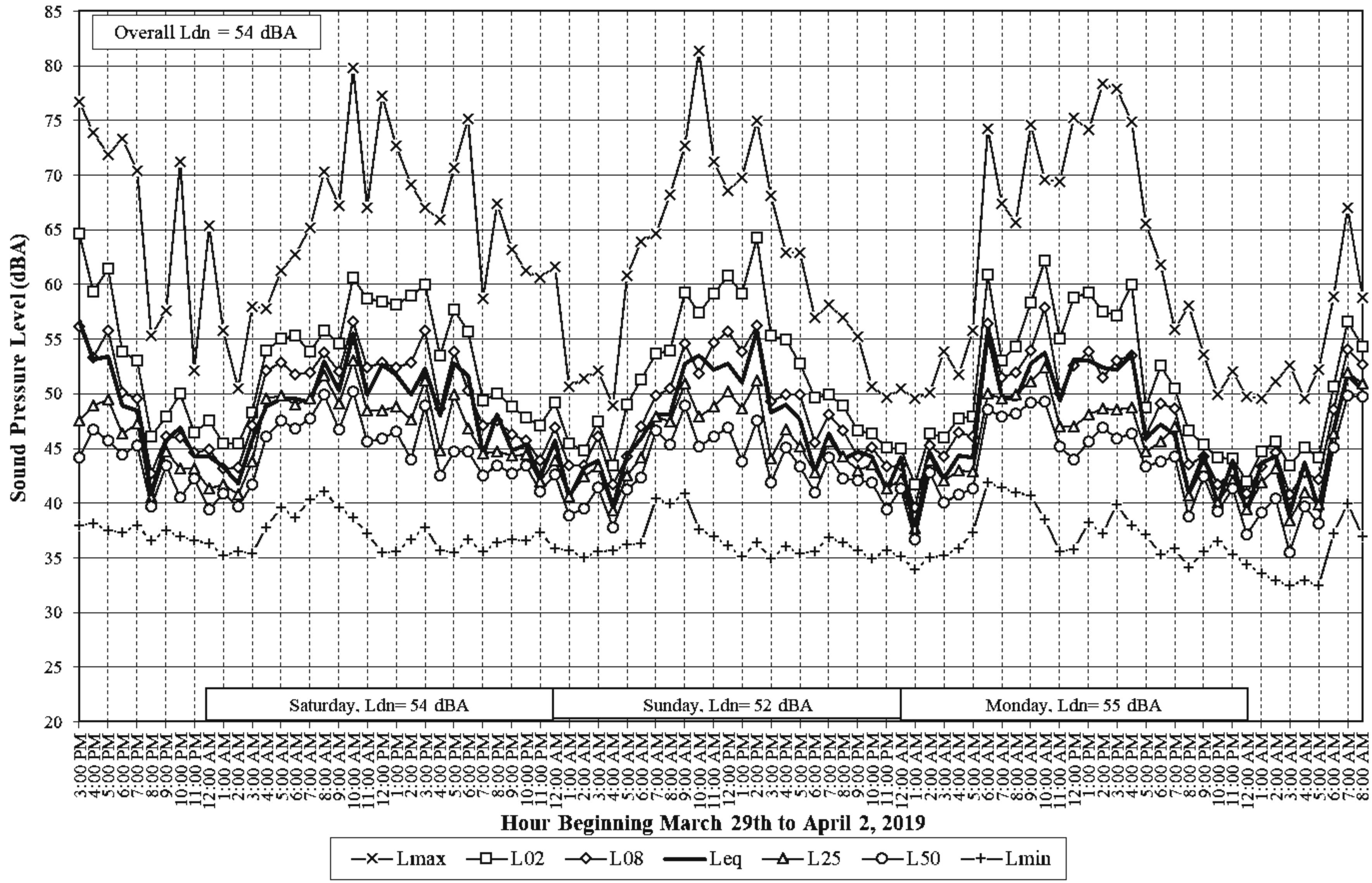

Chart 2: Measured Noise Levels at LT-2