Attachment 3
Noise and Vibration Assessment

Noise and Vibration Fundamentals

Acoustic Fundamentals

Noise is generally defined as sound that is loud, disagreeable, or unexpected. Sound, as described in more detail below, is an audible vibration of an elastic medium.

Sound Properties

A sound wave is introduced into a medium (e.g., air) by a vibrating object. The vibrating object (e.g., vocal cords, the string and sound board of a guitar or the diaphragm of a radio speaker) is the source of the disturbance that sets the medium to vibrate and then propagates through the medium. Regardless of the type of source creating the sound wave, the particles of the medium through which the sound moves are vibrating in a back-and-forth motion at a given frequency, tone, or pitch. The frequency of a wave refers to how often the particles vibrate when a wave passes through the medium. Wave frequency is measured as the number of complete back-and-forth vibrations of a particle per unit of time. If a particle of air undergoes 1,000 longitudinal vibrations in 2 seconds, then the frequency of the wave would be 500 vibrations per second. A commonly used unit for frequency is Hertz (Hz).

Each particle vibrates as a result of the motion of its nearest neighbor. For example, the first particle of the medium begins vibrating at 500 Hz and sets the second particle of the medium into motion at the same frequency (500 Hz). The second particle begins vibrating at 500 Hz and thus sets the third particle into motion at 500 Hz. The process continues throughout the medium; hence each particle vibrates at the same frequency, which is the frequency of the original source. Subsequently, a guitar string vibrating at 500 Hz will set the air particles in the room vibrating at the same frequency (500 Hz), which carries a sound signal to the ear of a listener that is detected as a 500-Hz sound wave.

The back-and-forth vibration motion of the particles of the medium would not be the only observable phenomenon occurring at a given frequency. Because a sound wave is a pressure wave, a detector could be used to detect oscillations in pressure from high to low and back to high pressure. As the compression (high-pressure points) and rarefaction (low-pressure points) disturbances move through the medium, they would reach the detector at a given frequency. For example, a compression would reach the detector 500 times per second if the frequency of the wave were 500 Hz. Similarly, a rarefaction would reach the detector 500 times per second if the frequency of the wave were 500 Hz. Thus, the frequency of a sound wave refers not only to the number of back-and-forth vibrations of the particles per unit of time but also to the number of compression or rarefaction disturbances that pass a given point per unit of time. A detector could be used to detect the frequency of these pressure oscillations over a given period of time. The period of the sound wave can be found by measuring the time between successive compressions or the time between successive rarefactions. The frequency is simply the reciprocal of the period; thus an inverse relationship exists so that as frequency increases, the period decreases, and vice versa.

A wave is a disturbance through some medium (e.g., air, water, space) that typically transfers energy. Waves travel and transfer energy from one point to another, often with little or no permanent displacement of the particles of the medium. For example, in an ocean wave, the seawater appears to be move along the path of the wave. However, the water particles themselves are nearly stationary—it is the energy transferred through those particles (the wave) causing displacement that makes it appear that the water itself is moving.

In the case of sound (and noise), the “wave” is a vibration or disturbance moving through air particles and, at a certain range of frequencies, is audible to the human ear. The amount of energy carried by a wave is related to the amplitude (loudness) of the wave. A high-energy wave is characterized by high amplitude; a low-energy wave is characterized by low amplitude. The amplitude of a wave refers to the maximum amount of displacement of a particle from its rest position. The energy transported by a wave is directly proportional to the square of the amplitude of the wave. This means that a doubling of the amplitude of a wave indicates a quadrupling of the energy transported by the wave.

Sound and the Human Ear

Because of the ability of the human ear to detect a wide range of sound-pressure fluctuations, sound-pressure levels are expressed in logarithmic units called decibels (dB). The sound-pressure level in decibels is calculated by taking the log of the ratio between the actual sound pressure and the reference sound pressure squared. The reference sound pressure is considered the absolute hearing threshold (Caltrans 2009). Use of this logarithmic scale reveals that the total sound from two individual sources of 65 A-weighted decibels (dBA) each (see explanation of the A-weighting scale below) is 68 dBA, not 130 dBA; that is, doubling the source strength increases the sound pressure by 3 dBA.

The human ear is sensitive to frequencies from 20 Hz to 20,000 Hz (the audible range) and can detect the vibration amplitudes that are comparable in size to a hydrogen atom (EPA 1971). When damaged by noise, the ear is typically affected at the 4,000-Hz frequency first; therefore, this can be considered the most noise-sensitive frequency. The averaged frequencies of 500 Hz, 1,000 Hz, and 2,000 Hz have traditionally been employed in hearing conservation criteria because of their importance to the hearing of speech sounds.

The human ear is not equally sensitive to all sound frequencies, depending on the amplitude of the sound; therefore, a specific frequency-dependent rating scale was devised to relate noise to human sensitivity. This called the weighting scale or function. The A-weighting scale is the most commonly used and is noted as A-weighted dB, dB(A), or dBA. The dBA scale discriminates against frequencies in a manner approximating the sensitivity of the human ear when a source is at 50 dBA. The basis for compensation is a comparison of the “loudness” of tones played one at a time with a reference tone producing 50 dBA. This decibel scale has been chosen by most authorities for the purpose of regulating environmental noise. Typical indoor and outdoor noise levels are presented on Figure 1-1.

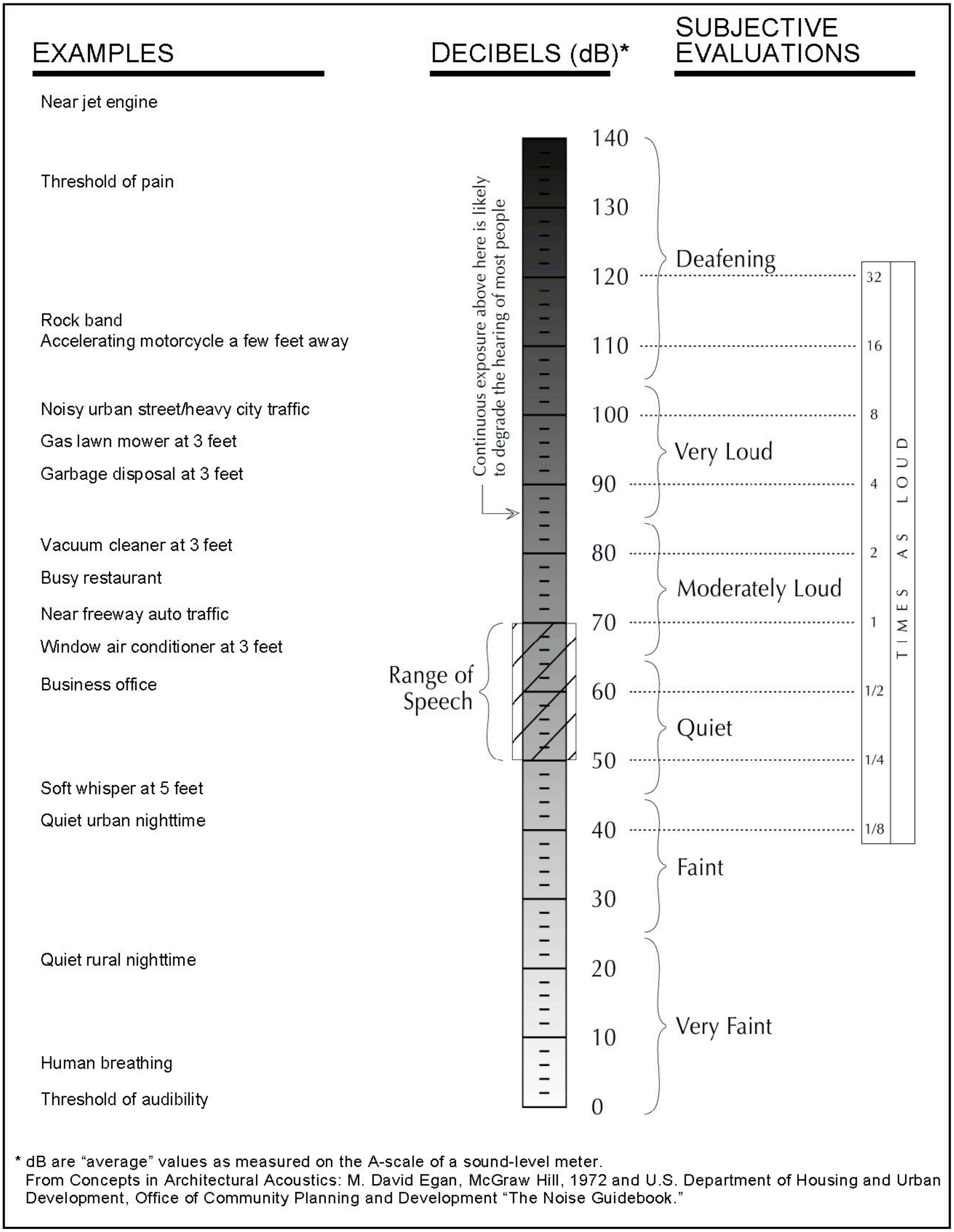

Figure 1. Typical Noise Levels

With respect to how humans perceive increases in noise levels, for pure tones or some broadband tones, a 1-dBA increase is imperceptible, a 3-dBA increase is barely perceptible, a 6-dBA increase is clearly perceptible, and a 10-dBA increase is subjectively perceived as approximately twice as loud (Egan 2007, Caltrans 2009). For this reason, an increase of 3 dBA or more is generally considered a degradation of the existing noise environment for this type of source. For more complex sources, that is, where the tones differ substantially between sources, such as for the sound of a heavy truck versus a new car or a kitchen blender, the ear perceives differences much more quickly.

Sound Propagation

As sound (noise) propagates from the source to the receptor, the attenuation, or manner of noise reduction in relation to distance, depends on surface characteristics, atmospheric conditions, and the presence of physical barriers. The inverse-square law describes the attenuation when sound travels from a point source such as an air-conditioning unit to the receptor. Sound travels uniformly outward from a point source in a spherical pattern with an attenuation rate of 6 dBA per doubling of distance (dBA/DD).

However, from a line source, such as a long line of traffic on a freeway, sound travels uniformly outward in a cylindrical pattern with an attenuation rate of 3 dBA/DD. The surface characteristics between the source and the receptor may result in additional sound absorption and/or reflection. Atmospheric conditions such as wind speed, temperature, and humidity may affect noise levels. Furthermore, the presence of a barrier between the source and the receptor may also attenuate noise levels. The actual amount of attenuation depends on the size of the barrier and the frequency of the noise. A noise barrier may be any natural or human-made feature such as a hill, building, wall, or berm (Caltrans 2009).

Noise Descriptors

The selection of a proper noise descriptor for a specific source depends on the spatial and temporal distribution, duration, and fluctuation of the noise. The noise descriptors most often encountered when dealing with traffic, community, and environmental noise are defined below (Caltrans 2009):

- L_{max} (maximum noise level) – The maximum noise level during a specific period of time. The L_{max} may also be referred to as the “highest (noise) level.”

- L_{min} (minimum noise level) – The minimum noise level during a specific period of time.
- L_X (statistical descriptor) – The noise level exceeded X percent of a specific period of time.
- L_{eq} (equivalent noise level) – The energy mean (average) noise level. The instantaneous noise levels during a specific period of time in dBA are converted to relative energy values. From the sum of the relative energy values, an average energy value is calculated, which is then converted back to dBA to determine the L_{eq}.
- L_{dn} (day-night noise level) – The 24-hour L_{eq} with a 10-dBA "penalty" for the noise-sensitive hours between 10 p.m. and 7 a.m. The L_{dn} attempts to account for the fact that noise during this specific period of time is a potential source of disturbance with respect to normal sleeping hours.
- CNEL (community noise equivalent level) – A noise level similar to the L_{dn} described above, but with an additional 5-dBA "penalty" for the noise-sensitive hours between 7 p.m. and 10 p.m., which are typically reserved for relaxation, conversation, reading, and television. If the same 24-hour noise data are used, the CNEL is typically approximately 0.5 dBA higher than the L_{dn}.
- SEL (single-event [impulsive] noise level) – A receiver's cumulative noise exposure from a single impulsive-noise event, which is defined as an acoustical event of short duration and which involves a change in sound pressure above some reference value.

Negative Effects of Noise on Humans

Negative effects of noise exposure include physical damage to the human auditory system, speech interference, sleep interference, activity interference, and disease. Exposure to noise may result in physical damage to the auditory system, which may lead to gradual or traumatic hearing loss. Gradual hearing loss is caused by sustained exposure to moderately high noise levels over a period of time; traumatic hearing loss is caused by sudden exposure to extremely high noise levels over a short period. However, gradual and traumatic hearing loss both may result in permanent hearing damage. In addition, noise may interfere with or interrupt sleep, relaxation, recreation, and communication. Although most interference may be classified as annoying, the inability to hear a warning signal may be considered dangerous. Noise may also be a contributor to diseases associated with stress, such as hypertension, anxiety, and heart disease. The degree to which noise contributes to such diseases depends on the frequency, bandwidth, and level of the noise, and the exposure time (Caltrans 2009).

Vibration Fundamentals

Vibration is sound radiated through the ground. The rumbling sound caused by the vibration of room surfaces is called groundborne noise. Sources of groundborne vibrations include natural phenomena (e.g., earthquakes, volcanic eruptions, sea waves, and landslides) and human-made causes (e.g., explosions, machinery, traffic, trains, and construction equipment). Vibration sources may be continuous, such as factory machinery, or transient, such as explosions. As is the case with airborne sound, groundborne vibrations may be described by amplitude and frequency.

Vibration amplitudes are usually expressed in peak particle velocity (PPV) or root mean squared (RMS), as in RMS vibration velocity. The PPV and RMS velocity are normally described in inches per second (in/sec). PPV is defined as the maximum instantaneous positive or negative peak of a vibration signal. PPV is often used in monitoring of blasting vibration because it is related to the stresses that are experienced by buildings (FTA 2006).

Although PPV is appropriate for evaluating the potential for building damage, it is not always suitable for evaluating human response. It takes some time for the human body to respond to vibration signals. In a sense, the human body responds to average vibration amplitude. The RMS of a signal is the average of the squared amplitude of the signal, typically calculated over a 1-second period. As with airborne sound, the RMS velocity is often expressed in decibel notation, expressed as vibration decibels (VdB), which serves to compress the range of numbers required to describe vibration (FTA 2006).

The background vibration-velocity level in residential areas is usually approximately 50 VdB. Groundborne vibration is normally perceptible to humans at approximately 65 VdB. For most people, a vibration-velocity level of 75 VdB is the approximate dividing line between barely perceptible and distinctly perceptible levels (FTA 2006).

Typical outdoor sources of perceptible groundborne vibration are construction equipment, steel-wheeled trains, and traffic on rough roads. If a roadway is smooth, the groundborne vibration is rarely perceptible. The range of interest is from approximately 50 VdB, which is the typical background vibration-velocity level, to 100 VdB, which is the general threshold where minor damage can occur in fragile buildings. Construction activities can generate groundborne vibrations, which can pose a risk to nearby structures. Constant or transient vibrations can weaken structures, crack facades, and disturb occupants (FTA 2006).

Construction vibrations can be transient, random, or continuous. Transient construction vibrations are generated by blasting, impact pile driving, and wrecking balls. Continuous vibrations result from vibratory pile drivers, large pumps, and compressors. Random vibration can result from jackhammers, pavement breakers, and heavy construction equipment. Table 1 describes the general human response to different levels of groundborne vibration-velocity levels.

Table 1. Human Response to Different Levels of Groundborne Noise and Vibration

Vibration-Velocity Level	Human Reaction
65 VdB	Approximate threshold of perception.
75 VdB	Approximate dividing line between barely perceptible and distinctly perceptible. Many people find that transportation-related vibration at this level is unacceptable.
85 VdB	Vibration acceptable only if there are an infrequent number of events per day.

Source: FTA 2006
Key:
VdB = vibration decibel

Noise and vibration modeling results for the Investigation are included in tables following the references section.

References

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Federal Transit Administration. 2006 (FTA). Transit Noise and Vibration Impact Assessment. FTA-VA-90-1003-06. May. Available at: http://www.fta.dot.gov/documents/FTA_Noise_and_Vibration_Manual.pdf. Accessed on: April 2014.

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Summary of Modelled Construction Noise Levels at Noise-Sensitive Receptors (dBA Leq/L50)

	Noise-Sensitive Receptors in Fresno County					Noise-Sensitive Receptors in Madera County			
Location of Contruction-Related Activity	Houses Near Perkins Avenue	Two Houses On Sky Harbor Drive	Houses Near El Rado Road	Five Houses on North End of Sky Harbour Avenue	Houses on North East Side of Winchell Bay	House on Dumna Island	Hidden Lake Estates	House on Ralston Way	House North of Option A Aggregate Quarry
Building of Access Road #1	32		50						
Building of Access Road #3			47						
Building of Haul Road #1							41	72	42
Building of Haul Road #3	42			64		49	54		
Aggregate Quarry, Option A only*							39	34	36
Aggregate Quarry, Option C only									43
Batch Plant on Madera County Side, Option A only							42	25	28
Batch Plant near Dam Staging Area, Options B & C only	32			42					
Batch Plant near Diverion Tunnel, Options B & C only			33						
Coffer Dam, downstream							48	26	
Dam Site and Staging Area	38			37			50	31	
Waste Area					76				
Intake Structure		25							
Powerhouse Area	33	20	41		51	50			
Transmission Line					38				
Ventilation Shaft		27							
Reservoir Clearing							42	28	48

<u>Notes</u>

Noise attenuation calculations were only performed for the closest areas of construction activity to each receptor or receptor group.

Construction Noise Attenuation Calcluations

Receptor(s) by Noise Source(s) by County	Reference Noise Level noise level (dBA)	@	distance (ft)	Attenuation Characteristics Ground Type (soft/hard)	Source Height (ft)	Receiver Height (ft)	Ground Factor	Attenuated Noise Level at Receptor (through distance alone) noise level (dBA)	@	distance (ft)		Source of Reference Noise Level	Attenuation Features	Attenuation by Intervening Hills (5 dBA min)	Resultant Noise Level at Receptor (dBA)	Exceedance of Noise Standard? daytime 50 dBA L_{50}	nighttime 45 dBA L_{50}	Analysis/Conclusion Notes	A/C Notes-2
In Fresno County, daytime L_{50} of 50 dBA, nightime L_{50} of 50 dBA																			
Five Houses on North End of Sky Harbour Avenue																			
Building of Haul Road #3	88.0	@	50	soft	8	5	0.63	64.2	@	400	worst	EPA 1971:18 (wksht)	direct line of sight over land	0	64	yes	yes	Restrict activity to daytime hours.	LTSwMM
Dam Staging Area	89.0	@	50	soft	8	5	0.63	42.4	@	2,950		EPA 1971:18 (wksht)	over land, intervening hills	5	37	no	no	LTS	
Batch Plant near Dam Staging Area, Op	89.8	@	50	hard	25	5	0.00	52.0	@	3,890		Batch Plant wksht	over some land, intervening hills	10	42	no	no	LTS	
Houses Near Perkins Avenue																			
Dam Staging Area	89.0	@	50	soft	8	5	0.63	42.6	@	2,900		EPA 1971:18 (wksht)	over land, intervening hills	5	38	no	no	LTS	
Batch Plant near Dam Staging Area, Op	89.8	@	50	soft	25	5	0.48	42.3	@	4,100		Batch Plant wksht	over land, intervening hills	10	32	no	no	LTS	
Quarry, Option B	85.0	@	100	soft	8	5	0.63	44.9	@	3,325		Napa Co 2014:3.8-21	over land, intervening hills	10	35	no	no	LTS	
Powerhouse area	89.0	@	50	soft	8	5	0.63	37.5	@	4,500		EPA 1971:18 (wksht)	over land, intervening hills	5	33	no	no	LTS	
Building of Haul Road #3	88.0	@	50	soft	8	5	0.63	51.6	@	1,200		EPA 1971:18 (wksht)	over land, intervening hills	10	42	no	no	LTS	
Building of Access Road #1	88.0	@	50	soft	8	5	0.63	42.4	@	2,700		EPA 1971:18 (wksht)	over land, intervening hills	10	32	no	no	LTS	
Houses Near El Rado Road																			
Batch Plant near Diversion Tunnel	89.8	@	50	soft	25	5	0.48	43.4	@	3,700		Batch Plant wksht	over land, intervening hills	10	33	no	no	LTS	
Powerhouse area	89.0	@	50	soft	8	5	0.63	41.1	@	3,300		EPA 1971:18 (wksht)	direct line of sight over land	0	41	no	no	LTS	
Quarry, Option B	85.0	@	100	soft	8	5	0.63	46.1	@	3,000		Napa Co 2014:3.8-21	over land, intervening hills	10	36	no	no	LTS	
Building of Access Road #1	88.0	@	50	soft	8	5	0.63	49.9	@	1,400		EPA 1971:18 (wksht)	direct line of sight over land	0	50	no	yes	Restrict activity to daytime hours.	LTSwMM
Building of Access Road #3	88.0	@	50	soft	8	5	0.63	51.6	@	1,200		EPA 1971:18 (wksht)	over land, intervening hills	5	47	no	yes	Restrict activity to daytime hours.	LTSwMM
Houses Near Winchell Bay																			
Waste Area	89.0	@	50	soft	8	5	0.63	75.7	@	160		EPA 1971:18 (wksht)	direct line of sight over land	0	76	yes	yes	Construct berm along SW side of Waste A	S&U
Powerhouse Area	89.0	@	50	hard	8	5	0.00	51.4	@	3,800		FTA 2006	direct line of sight over water	0	51	yes	yes	Restrict activity to daytime hours.	LTSwMM
Transmission Line	88.3	@	50	soft	8	5	0.63	37.6	@	4,200		TRPA/USFS/CPUC 2013:4.14	direct line of sight over land	0	38	no	no	LTS	
Houses On Sky Harbor Drive																			
Ventilation Shaft	89.0	@	50	soft	8	5	0.63	36.6	@	4,900		FTA 2006	over land, intervening hills	10	27	no	no	LTS	
Intake Structure	89.0	@	50	soft	8	5	0.63	35.3	@	5,450		FTA 2006	over land, intervening hills	10	25	no	no	LTS	
Powerhouse Area	89.0	@	50	soft	8	5	0.63	30.0	@	8,700		FTA 2006	over land, intervening hills	10	20	no	no	LTS	

In Madera County, daytime 50 dBA hourly Leq, nightime 50 dBA hourly Leq

Receptor(s)	noise level (dBA)	@	distance (ft)	Ground Type	Source Height (ft)	Receiver Height (ft)	Ground Factor	noise level (dBA)	@	distance (ft)	Source of Reference Noise Level	Attenuation Features	Attenuation by Intervening Hills (5 dBA min)	Resultant Noise Level at Receptor (dBA)	Exceedance of Noise Standard? daytime 50 dBA hr Leq	nightime 45 dBA hr Leq	Analysis/Conclusion Notes	A/C Notes-2
Hidden Lake Estates																		
Dam Site and Staging Area	89.0	@	50	hard	8	5	0.00	49.7	@	4,630	EPA 1971:18 (wksht)	direct line of sight over water	0	50	no	yes	Restrict activity to daytime hours.	LTSwMM
Coffer Dam, downstream	89.0	@	50	hard	8	5	0.00	47.9	@	5,700	EPA 1971:18 (wksht)	direct line of sight over water	0	48	no	yes	Restrict activity to daytime hours.	LTSwMM
Batch Plant on Madera County side	89.8	@	50	hard	25	5	0.00	46.6	@	7,200	Batch Plant wksht	over some land, intervening hills	5	42	no	no	LTS	
Aggregate Quarry, Option A North Site	85.0	@	100	hard	8	5	0.00	49.1	@	6,225	Napa Co 2014:3.8-21	direct line of sight over water &	10	39	no	no	LTS	
Building of Haul Road #3	88.0	@	50	hard	8	5	0.00	53.8	@	2,550	EPA 1971:18 (wksht)	direct line of sight over water	0	54	yes	yes	Restrict activity to daytime hours.	LTSwMM
Building of Haul Road #1	88.0	@	50	soft	8	5	0.63	40.9	@	3,080	EPA 1971:18 (wksht)	direct line of sight over land	0	41	no	no	LTS	
Reservoir Clearing	83.0	@	50	hard	8	5	0.00	41.9	@	5,700	EPA 1971:18 (wksht)	over land, varies	0	42	no	no	See Contour Distance Analysis	
House on Ralston Way																		
Building of Haul Road #1	88.0	@	50	soft	8	5	0.63	72.1	@	200	EPA 1971:18 (wksht)	direct line of sight over land	0	72	yes	yes	Relocate Haul Road and/or Restrict activit	S&U
Aggregate Quarry, North Site	85.0	@	100	soft	8	5	0.63	38.6	@	5,800	Napa Co 2014:3.8-21	over land, intervening hills	5	34	no	no	LTS	
Batch Plant, Madera Side, Option A	89.8	@	50	soft	25	5	0.48	35.2	@	7,890	Batch Plant wksht	over land, intervening hills	10	25	no	no	LTS	
Dam Site and Staging Area	89.0	@	50	soft	8	5	0.63	31.0	@	7,950	EPA 1971:18 (wksht)	over land, intervening hills	0	31	no	no	LTS	
Coffer Dam, downstream	89.0	@	50	soft	8	5	0.63	30.8	@	8,100	EPA 1971:18 (wksht)	over land, intervening hills	5	26	no	no	LTS	
Reservoir Clearing	83.0	@	50	soft	8	5	0.63	28.4	@	5,900	EPA 1971:18 (wksht)	direct line of sight over land	0	28	no	no	LTS	
House North of Option A Aggregate Quarry (North Site)																		
Aggregate Quarry, Option A North Site	85.0	@	100	soft	8	5	0.63	45.9	@	3,050	Napa Co 2014:3.8-21	over land, intervening hills	10	36	no	no	LTS	
Aggregate Quarry, Option C	85.0	@	100	soft	8	5	0.63	43.2	@	3,850	Napa Co 2014:3.8-21	over land, intervening hills	0	43	no	no	LTS	
Building of Haul Road #1	88.0	@	50	soft	8	5	0.63	47.0	@	1,800	EPA 1971:18 (wksht)	direct line of sight over land	5	42	no	no	LTS	
Batch Plant on Madera County side	89.8	@	50	soft	25	5	0.48	37.7	@	6,300	Batch Plant wksht	over land, intervening hills	10	28	no	no	LTS	
Reservoir Clearing	83.0	@	50	soft	8	5	0.63	47.6	@	1,100	EPA 1971:18 (wksht)	direct line of sight over land	0	48	no	yes	See Contour Distance Analysis	
House on Dumna Island																		
Powerhouse area	89.0	@	50	hard	8	5	0.00	50.1	@	4,400	FTA 2006	direct line of sight over water	0	50	yes	yes	Restrict activity to daytime hours.	LTSwMM
Building of Haul Road #3	88.0	@	50	hard	8	5	0.00	49.1	@	4,400	EPA 1971:18 (wksht)	direct line of sight over water	0	49	no	yes	Restrict activity to daytime hours.	LTSwMM

KEY:
- Orange cells are for input.
- Grey and blue cells are intermediate calculations performed by the model.
- Green cells are data to present in a written analysis (output).

Notes:

Estimates of attenuated noise levels do not account for reductions from intervening barriers, including walls, trees, vegetation, or structures of any type.

Computation of the attenuated noise level is based on the equation presented on pg. 12-3 and 12-4 of FTA 2006

Computation of the ground factor is based on the equation presentd in Figure 6-23 on pg. 6-23 of FTA 2006, where the distance of the reference noise leve can be adjusted and the usage factor is not applied (i.e., the usage factor is equal to 1).

Attenuation Calculations for Stationary Noise Sources

KEY: Orange cells are for input.
Grey cells are intermediate calculations performed by the model.
Green cells are data to present in a written analysis (output).

Construction Activity	Reference Noise Level			Attenuation Characteristics				Contour Distance to Noise Standard			Source of Reference Noise Level
	noise level (dBA)	@	distance (ft)	Ground Type (soft/hard)	Source Height (ft)	Receiver Height (ft)	Ground Factor	noise level (dBA)	@	distance (ft)	
Ground Clearing daytime (over land)	83.0	@	50	soft	8	5	0.63	50.0	@	895	EPA 1971:18
Ground Clearing, nighttime (over land)	83.0	@	50	soft	8	5	0.63	44.9	@	1400	EPA 1971:18

Notes:

Estimates of attenuated noise levels do not account for reductions from intervening barriers, including hills, walls, trees, vegetation, or structures of any type.

Computation of the noise level contour is based on the attenuation equation presented on pg. 12-3 and 12-4 of FTA 2006.

Computation of the ground factor is based on the equation presentd in Figure 6-23 on pg. 6-23 of FTA 2006, where the distance of the reference noise leve can be adjusted and the usage factor is not applied (i.e., the usage factor is equal to 1).

Sources:

Federal Transit Association (FTA). 2006 (May). Transit Noise and Vibration Impact Assessment. FTA-VA-90-1003-06. Washington, D.C. Available: <http://www.fta.dot.gov/documents/FTA_Noise_and_Vibration_Manual.pdf>. Accessed: September 24, 2010.

Receptors Located within 895 feet of inundation area where reservoir clearing would take place.

Description

Houses on north end of Welbarn Road (if they aren't removed because they are in the inundation area)

Contour Distance Calculations for construction of transmisison line that would connect the powerhouse to the existing Kerckhoff-Sange line

KEY: Orange cells are for input.
Grey cells are intermediate calculations performed by the model.
Green cells are data to present in a written analysis (output).

Construction Activity	Reference Noise Level			Attenuation Characteristics				Contour Distance to Noise Standard			Source of Reference Noise Level
	noise level (dBA)	@	distance (ft)	Ground Type (soft/hard)	Source Height (ft)	Receiver Height (ft)	Ground Factor	noise level (dBA)	@	distance (ft)	
Houses within X feet of Transmission Line	88.3	@	50	soft	8	5	0.63	50.0	@	1,425	wksht Trans Line Constr
Houses within X feet of Transmission Line	88.3	@	50	soft	8	5	0.63	45.0	@	2,200	wksht Trans Line Constr

Notes:

Estimates of attenuated noise levels do not account for reductions from intervening barriers, including hills, walls, trees, vegetation, or structures of any type.
Computation of the noise level contour is based on the attenuation equation presented on pg. 12-3 and 12-4 of FTA 2006.

Computation of the ground factor is based on the equation presentd in Figure 6-23 on pg. 6-23 of FTA 2006, where the distance of the reference noise leve can be adjusted and the usage factor is not applied (i.e., the usage factor is equal to 1).

Sources:

Federal Transit Association (FTA). 2006 (May). Transit Noise and Vibration Impact Assessment. FTA-VA-90-1003-06. Washington, D.C. Available: <http://www.fta.dot.gov/documents/FTA_Noise_and_Vibration_Manual.pdf>. Accessed: September 24, 2010.

Receptors Located within 1,425 feet of the Transmission Line Corridor that would connect the Powerhouse southeast to the existing Kerckhoff–Sanger line.

Approx. Distance to Transmission Line (ft)	Description
625	Three houses on south side of Sky Harbour Dr. near the intersection with Sky Harbour Rd. (east and west of the transmission line)
within 1,425	Houses in neighborhood along Auberry Road (on both sides of the transmission line corridor).

All affected receptors located in Fresno County.

Transmission Line Installation

Equipment	Reference Emission Noise Levels (L_{max}) at 50 feet[1]	Usage Factor[1]	
Dump Truck	84	0.4	
Flat Bed Truck	84	0.4	
Flat Bed Truck	84	0.4	
Scraper	85	0.4	
Scraper	85	0.4	
Front End Loader	80	0.4	
Pickup Truck	55	0.4	Pick up truck represents water truck
Pickup Truck	55	0.4	Pick up truck represents water truck
Backhoe	80	0.4	
Dozer	85	0.4	

Ground Type	Soft
Source Height	8
Receiver Height	5
Ground Factor[2]	0.63

Predicted Noise Level[3]	L_{eq} dBA at 50 feet[3]
Dump Truck	80.0
Flat Bed Truck	80.0
Flat Bed Truck	80.0
Scraper	81.0
Scraper	81.0
Front End Loader	76.0
Pickup Truck	51.0
Pickup Truck	51.0
Backhoe	76.0
Dozer	81.0

Combined Predicted Noise Level (L_{eq} dBA at 50 feet)

88.3

Sources:

[1] Obtained from the FHWA Roadway Construction Noise Model, January 2006. Table 1.

[2] Based on Figure 6-5 from the Federal Transit Noise and Vibration Impact Assessment, 2006 (pg 6-23).

[3] Based on the following from the Federal Transit Noise and Vibration Impact Assessment, 2006 (pg 12-3).

L_{eq}(equip) = E.L.+10*log (U.F.) - 20*log (D/50) - 10*G*log (D/50)

Where: E.L. = Emission Level;

U.F.= Usage Factor;

G = Constant that accounts for topography and ground effects (FTA 2006: pg 6-23); and

D = Distance from source to receiver.

Reference Noise Levels Provided by EPA 1971

Activity	Activity Similar to	Noise Level dBA @50 ft
Access or Haul Road Construction	Public Works Roads, Highways, Sewers, & Trenches	88
Dam Site and Staging Area	Excavation for an Industrial Site	89
Coffer Dam	Excavation for an Industrial Site	89
Powerhouse area	Excavation for an Industrial Site	89
Reservoir Clearing	Ground Clearing for a Domestic Housing project	83
Waste Area	Excavation for an Industrial Site	89

Source:
U.S. Environmental Protection Agency. 1971 (December 31). *Noise from Construction Equipment and Operations, Building Equipment and Home Appliances*. Office of Noise Abatement and Control, Washington, D.C.—Table I-a, Typical Ragnes of Noise Levels at Construction Sties with 50 dB(A) Ambient Typical Suburban Residential Areas, on page 18.

Batch Plant Noise Level

Equipment	Reference Emission Noise Levels (L_{max}) at 50 feet[1]	Usage Factor[1]	Source
concrete mixer truck	85	1	FHWA Roadway Construction Noise Model, January 2006. Table 1.
concrete mixer truck	85	1	FHWA Roadway Construction Noise Model, January 2006. Table 1.
conveyor	85	1	Napa County 2013, County Jail Project EIR

Predicted Noise Level[3]	L_{eq} dBA at 50 feet[3]
concrete mixer truck	85
concrete mixer truck	85
conveyor	85

Combined Predicted Noise Level (L_{eq} dBA at 50 feet)
89.8

Notes

[1] Obtained from the FHWA Roadway Construction Noise Model, January 2006. Table 1.

[2] Based on Figure 6-5 from the Federal Transit Noise and Vibration Impact Assessment, 2006 (pg 6-23).

[3] Based on the following from the Federal Transit Noise and Vibration Impact Assessment, 2006 (pg 12-3).

L_{eq}(equip) = E.L.+10*log (U.F.) - 20*log (D/50) - 10*G*log (D/50)

Where: E.L. = Emission Level;

U.F.= Usage Factor;

G = Constant that accounts for topography and ground effects (FTA 2006: pg 6-23); and

D = Distance from source to receiver.

Helicopter Noise Level

A helicopter would be used in remote locations, where access is limited, to transport material and to assist in construction of transmission lines, recreational facilities, or other infrastructure. The noise level generated from operating a Kaman K-Max K-1200 helicopter is approximately 83 dBA SEL below the helicopter and at a hover distance of 492 feet above the ground. If the helicopter were to hover as low as 50 feet from the ground it would result in approximately 100 dBA SEL at 50 feet from the construction site at ground level (i.e., someone standing 50 feet from the construction site would be exposed to this noise level). However, helicopters do not operate in one place for extended periods of time and therefore a more likely noise level of 72 dBA hourly Leq would occur at 50 feet from the construction site where a helicopter is hovering for 10 minutes.

Kaman K-Max K-1200 Helicopter
83 dBA SEL @ 492 feet

Source: Kaman Aerospace Corporation. 1993 (November). FAR Part 36 Noise Certification Compliance Report: Kaman K-1200.

Distance Propagation Calculations for Stationary Sources of Ground Vibration

ASCENT ENVIRONMENTAL

KEY: Orange cells are for input.
Grey cells are intermediate calculations performed by the model.
Green cells are data to present in a written analysis (output).

HUMAN DISTURBANCE ASSESSMENT

Identify the vibration source and enter the reference vibration level (VdB) and distance.

Select the distance to the receiver.

Propagation of vibration decibels (VdB) with distance

Noise Source/ID	Reference Noise Level vibration level (VdB)	@	distance (ft)	Attenuated Noise Level at Receptor vibration level (VdB)	@	distance (ft)
blasting	109	@	25	79.5	@	240
caisson drill	87.0	@	25	79.3	@	45
loaded truck	86.000	@	25	79.9	@	40

Identify the vibration source and enter the reference peak particle velocity (PPV) and distance.

Select the distance to the receiver.

Propagation of peak particle velocity (PPV) with distance

Noise Source/ID	Reference Noise Level vibration level (PPV)	@	distance (ft)	Attenuated Noise Level at Receptor vibration level (PPV)	@	distance (ft)
blasting	1.130	@	25	0.095	@	130
caisson drill/(dozer)	0.089	@	25	0.089	@	25
loaded truck	0.076	@	25	0.099	@	21

STRUCTURAL DAMAGE ASSESSMENT

Identify the vibration source and enter the reference peak particle velocity (PPV) and distance.

Select the distance to the receiver.

Propagation of peak particle velocity (PPV) with distance

Noise Source/ID	Reference Noise Level vibration level (PPV)	@	distance (ft)	Attenuated Noise Level at Receptor vibration level (PPV)	@	distance (ft)
blasting	1.130	@	25	0.197	@	80
caisson drill/(dozer)	0.089	@	25	0.191	@	15

Notes:

Computation of propagated vibration levels is based on the equations presented on pg. 12-11 of FTA 2006. Estimates of attenuated vibration levels do not account for reductions from intervening underground barriers or other underground structures of any type, or changes in soil type.

Sources:

Federal Transit Association (FTA). 2006 (May). Transit Noise and Vibration Impact Assessment. FTA-VA-90-1003-06. Washington, D.C. Available: <http://www.fta.dot.gov/documents/FTA_Noise_and_Vibration_Manual.pdf>. Accessed: September 24, 2010.

Powerhouse Noise Attenuation Calcluations

Receptor(s) by Noise Source(s) by County	Reference Noise Level: noise level (dBA)	@	Reference Noise Level: distance (ft)	Attenuation Characteristics: Ground Type (soft/hard)	Source Height (ft)	Receiver Height (ft)	Ground Factor	Attenuated Noise Level at Receptor (through distance alone): noise level (dBA)	@	distance (ft)	Source of Reference Noise Level	Attenuation Features	Attenuation by Intervening Hills	Resultant Noise Level at Receptor	Exceedance of daytime 50 dBA L_{50}	Exceedance of nighttime 45 dBA L_{50}
Countour Distances Calculations																
Powerhouse-Contour	74.3	@	20	hard	8	5	0.00	44.8	@	600	Short-Term Meas #5	direct line of sight over water				
In Fresno County, daytime L_{50} of 50 dBA, nightime L_{50} of 50 dBA																
Houses Near Perkins Avenue																
Powerhouse	74.3	@	20	soft	8	5	0.63	12.3	@	4,500	Short-Term Meas #5	over land, intervening hills	5	7	no	no
Houses Near El Rado Road																
Powerhouse area	74.3	@	20	soft	8	5	0.63	15.9	@	3,300	Short-Term Meas #5	direct line of sight over land	0	16	no	no
Houses Near Winchell Bay																
Powerhouse Area	74.3	@	20	hard	8	5	0.00	28.7	@	3,800	Short-Term Meas #5	direct line of sight over water	0	29	no	no
Houses On Sky Harbor Drive																
Powerhouse Area	74.3	@	20	soft	8	5	0.63	4.8	@	8,700	Short-Term Meas #5	over land, intervening hills	10	-5	no	no

In Madera County, daytime 50 dBA hourly Leq, nightime 50 dBA hourly Leq

Receptor(s)	noise level (dBA)	@	distance (ft)	Ground Type	Source Height (ft)	Receiver Height (ft)	Ground Factor	noise level (dBA)	@	distance (ft)	Source of Reference Noise Level	Attenuation Features	Attenuation by Intervening Hills (5 dBA min)	Resultant Noise Level at Receptor (dBA)	Exceedance of Noise Standard? daytime 50 dBA hr Leq	Exceedance of Noise Standard? nightime 45 dBA hr Leq
House on Dumna Island																
Powerhouse area	74.3	@	20	hard	8	5	0.00	27.5	@	4,400	Short-Term Meas #5	direct line of sight over water	0	27	no	no

KEY: Orange cells are for input.
Grey and blue cells are intermediate calculations performed by the model.
Green cells are data to present in a written analysis (output).

Notes:

It is assumed that the noise level generated by the proposed 160 MW powerhouse would be similar to that of the existing Kerckhoff Powerhouse. The short-term noise measurement of the Kerckhoff Powerhouse, collected at Site ST5, as shown in Figure 18-2 and summarized in Table 18-2, indicates a steady noise level of approximately 74.3 dBA Leq at a distance of 20 feet.

Computation of the attenuated noise level is based on the equation presented on pg. 12-3 and 12-4 of FTA 2006

Computation of the ground factor is based on the equation presentd in Figure 6-23 on pg. 6-23 of FTA 2006, where the distance of the reference noise leve can be adjusted and the usage factor is not applied (i.e., the usage factor is equal to 1).

Powerhouse Noise Attenuation Calcluations

Receptor(s) by Noise Source(s) by County	Reference Noise Level: noise level (dBA)	@	distance (ft)	Attenuation Characteristics: Ground Type (soft/hard)	Source Height (ft)	Receiver Height (ft)	Ground Factor	Attenuated Noise Level at Receptor (through distance alone): noise level (dBA)	@	distance (ft)	Source of Reference Noise Level	Attenuation Features
Countour Distances Calculations												
Recreational Watercraft												
Attenuation Over Water												
Leq	86.0	@	50	hard	3	5	0.00	49.9	@	3,200	DBW	over water
Lmax	86.0	@	50	hard	3	5	0.00	69.9	@	320	DBW	over water
Attenuation Over Land												
Leq	86.0	@	50	soft	3	5	0.60	49.9	@	1,225	DBW	over land
Lmax	86.0	@	50	soft	3	5	0.60	69.8	@	210	DBW	over land

In Fresno County, daytime L_{50} of 50 dBA, nightime L_{50} of 50 dBA

Receptor(s)	noise level (dBA)	@	distance (ft)	Ground Type	Source Height (ft)	Receiver Height (ft)	Ground Factor	noise level (dBA)	@	distance (ft)	Source of Reference Noise Level	Attenuation Features	Attenuation by Intervening Hills (5 dBA min)	Resultant Noise Level at Receptor (dBA)	Exceedance of Noise Standard? daytime 50 dBA L_{50}	daytime 70 dBA Lmax
Houses Along Sky Harbor Road																
Leq/Lmax	86.0	@	50	soft	3	5	0.60	40.6	@	2,800	DBW	overland, Pincushion Mtn	10	31	no	no
House closest to Proposed Welbarn Road Boat Ramp																
Leq/Lmax	86.0	@	50	soft	3	5	0.60	42.8	@	2,300	DBW	over land	0	43	no	no

In Madera County, daytime 50 dBA hourly Leq, nightime 50 dBA hourly Leq

Receptor(s)	noise level (dBA)	@	distance (ft)	Ground Type	Source Height (ft)	Receiver Height (ft)	Ground Factor	noise level (dBA)	@	distance (ft)	Source of Reference Noise Level	Attenuation Features	Attenuation by Intervening Hills (5 dBA min)	Resultant Noise Level at Receptor (dBA)	Exceedance of Noise Standard? daytime 50 dBA hrly Leq	daytime 70 dBA Lmax
House East of Hildreth																
Leq/Lmax	86.0	@	50	soft	3	5	0.60	36.0	@	4,200	DBW	over land	0	36	no	no
Houses in Hildreth																
Leq/Lmax	86.0	@	50	soft	3	5	0.60	36.3	@	4,100	DBW	over land	0	36	no	no
House North of Aggregate Plant																
Leq/Lmax	86.0	@	50	soft	3	5	0.60	48.4	@	1,400	DBW	over land, intervening hills	10	38	no	no

KEY: Orange cells are for input.
Grey and blue cells are intermediate calculations performed by the model.
Green cells are data to present in a written analysis (output).

Notes:

The reference noise level for boats is 86 dBA at 50 feet. This is based on California Boating Law, Section 654.06. See page 59 of Department of Boating and Waterways. 2012. California Boating Law. Available: http://dbw.ca.gov/PDF/LawEnforc/2012CBL.pdf. Accessed April 22, 2014.

Computation of the attenuated noise level is based on the equation presented on pg. 12-3 and 12-4 of FTA 2006

Computation of the ground factor is based on the equation presentd in Figure 6-23 on pg. 6-23 of FTA 2006, where the distance of the reference noise leve can be adjusted and the usage factor is not applied (i.e., the usage factor is equal to 1).