Appendix J

Construction Noise, Vibration, and Hydroacoustic Assessment

SAMOA PENINSULA LAND-BASED AQUACULTURE PROJECT CONSTRUCTION NOISE, VIBRATION, AND HYDROACOUSTIC ASSESSMENT

Humboldt County, California

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Prepared for:

Misha Schwarz
Senior Environmental Scientist
GHD
718 3rd Street
Eureka, CA 95501

Prepared by:

Michael Thill and
Keith Pommerenck

ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality
429 East Cotati Avenue
Cotati, CA 94931
(707) 794-0400

Project: 20-144

INTRODUCTION

The Samoa Peninsula Land-Based Aquaculture Project proposes to demolish the existing pulp mill infrastructure and construct a sustainable land-based finfish aquaculture facility. The project site is located within Assessor Parcel Number (APN) 401-112-021 on the Samoa Peninsula in Humboldt County, California.

Demolition of the existing pulp mill and development of the proposed finfish aquaculture facility will require significant construction. Construction would be divided between phases among multiple buildings. A deep foundation utilizing piles will be used to construct buildings at the project site. This could include one of three options, including rammed aggregate piles, vibro displacement columns, and vibro compaction. There will be some sheet pile installation for temporary shoring of excavations where sloping is not feasible due to adjacent infrastructure. These sheet piles will be installed using a vibratory pile driver and installed to a depth of approximately 30 feet.

In addition, the Humboldt Bay Harbor, Recreation and Conservation District (HBHRCD) proposes to modernize and revitalize the operation of two water intake structures formerly operated by a pulp mill from 1966-2008.

This report summarizes the assessment of construction-related airborne noise, groundborne vibration, and underwater noise with respect to applicable regulations and plans. Operational noise associated with pumping operations is also assessed.

SETTING

Fundamentals of Environmental Noise

Noise may be defined as unwanted sound. Noise is usually objectionable because it is disturbing or annoying. The objectionable nature of sound could be caused by its *pitch* or its *loudness*. *Pitch* is the height or depth of a tone or sound, depending on the relative rapidity (*frequency*) of the vibrations by which it is produced. Higher pitched signals sound louder to humans than sounds with a lower pitch. *Loudness* is intensity of sound waves combined with the reception characteristics of the ear. Intensity may be compared with the height of an ocean wave in that it is a measure of the amplitude of the sound wave.

In addition to the concepts of pitch and loudness, there are several noise measurement scales which are used to describe noise in a particular location. A *decibel (dB)* is a unit of measurement which indicates the relative amplitude of a sound. The zero on the decibel scale is based on the lowest sound level that the healthy, unimpaired human ear can detect. Sound levels in decibels are calculated on a logarithmic basis. An increase of 10 decibels represents a ten-fold increase in acoustic energy, while 20 decibels is 100 times more intense, 30 decibels is 1,000 times more intense, etc. There is a relationship between the subjective noisiness or loudness of a sound and its intensity. Each 10 decibel increase in sound level is perceived as approximately a doubling of loudness over a fairly wide range of intensities. Technical terms are defined in Table 1.

There are several methods of characterizing sound. The most common in California is the *A-weighted sound level (dBA).* This scale gives greater weight to the frequencies of sound to which the human ear is most sensitive. Representative outdoor and indoor noise levels in units of dBA are shown in Table 2. Because sound levels can vary markedly over a short period of time, a method for describing either the average character of the sound or the statistical behavior of the variations must be utilized. Most commonly, environmental sounds are described in terms of an average level that has the same acoustical energy as the summation of all the time-varying events. This *energy-equivalent sound/noise descriptor* is called L_{eq}. The most common averaging period is hourly, but L_{eq} can describe any series of noise events of arbitrary duration.

The scientific instrument used to measure noise is the sound level meter. Sound level meters can accurately measure environmental noise levels to within about plus or minus 1 dBA. Various computer models are used to predict environmental noise levels from sources, such as roadways and airports. The accuracy of the predicted models depends upon the distance the receptor is from the noise source. Close to the noise source, the models are accurate to within about plus or minus 1 to 2 dBA.

Since the sensitivity to noise increases during the evening and at night -- because excessive noise interferes with the ability to sleep -- 24-hour descriptors have been developed that incorporate artificial noise penalties added to quiet-time noise events. The *Community Noise Equivalent Level* (*CNEL*) is a measure of the cumulative noise exposure in a community, with a 5 dB penalty added to evening (7:00 pm - 10:00 pm) and a 10 dB addition to nocturnal (10:00 pm - 7:00 am) noise levels. The *Day/Night Average Sound Level* (*DNL* or L_{dn}) is essentially the same as CNEL, with the exception that the evening time period is dropped and all occurrences during this three-hour period are grouped into the daytime period.

Effects of Noise

Sleep and Speech Interference

The thresholds for speech interference indoors are about 45 dBA if the noise is steady and above 55 dBA if the noise is fluctuating. Outdoors the thresholds are about 15 dBA higher. Steady noises of sufficient intensity (above 35 dBA) and fluctuating noise levels above about 45 dBA have been shown to affect sleep. Interior residential standards for multi-family dwellings are set by the State of California at 45 dBA DNL. Typically, the highest steady traffic noise level during the daytime is about equal to the DNL and nighttime levels are 10 dB 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 dB with open windows. With standard construction and closed windows in good condition, the noise attenuation factor is around 20 dB for an older structure and 25 dB for a newer dwelling. Sleep and speech interference is therefore of concern when exterior noise levels are about 57 to 62 dBA DNL with open windows and 65 to 70 dBA DNL if the windows are closed. Levels of 55 to 60 dBA are common along collector streets and secondary arterials, while 65 to 70 dBA is a typical value for a primary/major arterial. Levels of 75 to 80 dBA are normal noise levels at the first row of development outside a freeway right-of-way. In order to achieve an acceptable interior noise environment, bedrooms facing secondary roadways need to be able to have their windows closed, those facing major roadways and freeways typically need special glass windows.

Annoyance

Attitude surveys are used for measuring the annoyance felt in a community for noises intruding into homes or affecting outdoor activity areas. In these surveys, it was determined that the causes for annoyance include interference with speech, radio and television, house vibrations, and interference with sleep and rest. The DNL as a measure of noise has been found to provide a valid correlation of noise level and the percentage of people annoyed. People have been asked to judge the annoyance caused by aircraft noise and ground transportation noise. There continues to be disagreement about the relative annoyance of these different sources. When measuring the percentage of the population highly annoyed, the threshold for ground vehicle noise is about 50 dBA DNL. At a DNL of about 60 dBA, approximately 12 percent of the population is highly annoyed. When the DNL increases to 70 dBA, the percentage of the population highly annoyed increases to about 25-30 percent of the population. There is, therefore, an increase of about 2 percent per dBA between a DNL of 60-70 dBA. Between a DNL of 70-80 dBA, each decibel increase increases by about 3 percent the percentage of the population highly annoyed. People appear to respond more adversely to aircraft noise. When the DNL is 60 dBA, approximately 30-35 percent of the population is believed to be highly annoyed. Each decibel increase to 70 dBA adds about 3 percentage points to the number of people highly annoyed. Above 70 dBA, each decibel increase results in about a 4 percent increase in the percentage of the population highly annoyed.

TABLE 1 Definitions of Acoustical Terms Used in this Report (Airborne Noise)

Term	Definition
Decibel, dB	A unit describing, the amplitude of sound, equal to 20 times the logarithm to the base 10 of the ratio of the pressure of the sound measured to the reference pressure. The reference pressure for air is 20 micro Pascals.
Sound Pressure Level	Sound pressure is the sound force per unit area, usually expressed in micro Pascals (or 20 micro Newtons per square meter), where 1 Pascal is the pressure resulting from a force of 1 Newton exerted over an area of 1 square meter. The sound pressure level is expressed in decibels as 20 times the logarithm to the base 10 of the ratio between the pressures exerted by the sound to a reference sound pressure (e. g., 20 micro Pascals). Sound pressure level is the quantity that is directly measured by a sound level meter.
Frequency, Hz	The number of complete pressure fluctuations per second above and below atmospheric pressure. Normal human hearing is between 20 Hz and 20,000 Hz. Infrasonic sound are below 20 Hz and Ultrasonic sounds are above 20,000 Hz.
A-Weighted Sound Level, dBA	The sound pressure level in decibels as measured on a sound level meter using the A-weighting filter network. The A-weighting filter de-emphasizes the very low and very high frequency components of the sound in a manner similar to the frequency response of the human ear and correlates well with subjective reactions to noise.
Equivalent Noise Level, L_{eq}	The average A-weighted noise level during the measurement period.
L_{max}, L_{min}	The maximum and minimum A-weighted noise level during the measurement period.
L_{01}, L_{10}, L_{50}, L_{90}	The A-weighted noise levels that are exceeded 1%, 10%, 50%, and 90% of the time during the measurement period.
Day/Night Noise Level, L_{dn} or DNL	The average A-weighted noise level during a 24-hour day, obtained after addition of 10 decibels to levels measured in the night between 10:00 pm and 7:00 am.
Community Noise Equivalent Level, CNEL	The average A-weighted noise level during a 24-hour day, obtained after addition of 5 decibels in the evening from 7:00 pm to 10:00 pm and after addition of 10 decibels to sound levels measured in the night between 10:00 pm and 7:00 am.
Ambient Noise Level	The composite of noise from all sources near and far. The normal or existing level of environmental noise at a given location.
Intrusive	That noise which intrudes over and above the existing ambient noise at a given location. The relative intrusiveness of a sound depends upon its amplitude, duration, frequency, and time of occurrence and tonal or informational content as well as the prevailing ambient noise level.

Source: Handbook of Acoustical Measurements and Noise Control, Harris, 1998.

TABLE 2 Typical Noise Levels in the Environment

Common Outdoor Activities	Noise Level (dBA)	Common Indoor Activities
	110 dBA	Rock band
Jet fly-over at 1,000 feet		
	100 dBA	
Gas lawn mower at 3 feet		
	90 dBA	
Diesel truck at 50 feet at 50 mph		Food blender at 3 feet
	80 dBA	Garbage disposal at 3 feet
Noisy urban area, daytime		
Gas lawn mower, 100 feet	70 dBA	Vacuum cleaner at 10 feet
Commercial area		Normal speech at 3 feet
Heavy traffic at 300 feet	60 dBA	
		Large business office
Quiet urban daytime	50 dBA	Dishwasher in next room
Quiet urban nighttime	40 dBA	Theater, large conference room
Quiet suburban nighttime		
	30 dBA	Library
Quiet rural nighttime		Bedroom at night, concert hall (background)
	20 dBA	
		Broadcast/recording studio
	10 dBA	
	0 dBA	

Source: Technical Noise Supplement (TeNS), California Department of Transportation, September 2013.

Fundamentals of Groundborne Vibration

Ground vibration consists of rapidly fluctuating motions or waves with an average motion of zero. Several different methods are typically used to quantify vibration amplitude. One method is the Peak Particle Velocity (PPV). The PPV is defined as the maximum instantaneous positive or negative peak of the vibration wave. In this report, a PPV descriptor with units of mm/sec or in/sec is used to evaluate construction generated vibration for building damage and human complaints. Table 3 displays the reactions of people and the effects on buildings that continuous or frequent intermittent vibration levels produce. The guidelines in Table 3 represent syntheses of vibration criteria for human response and potential damage to buildings resulting from construction vibration.

Construction activities can cause vibration that varies in intensity depending on several factors. The use of pile driving and vibratory compaction equipment typically generates the highest construction related groundborne vibration levels. Because of the impulsive nature of such activities, the use of the PPV descriptor has been routinely used to measure and assess groundborne vibration and almost exclusively to assess the potential of vibration to cause damage and the degree of annoyance for humans.

The two primary concerns with construction-induced vibration, the potential to damage a structure and the potential to interfere with the enjoyment of life, are evaluated against different vibration limits. Human perception to vibration varies with the individual and is a function of physical setting and the type of vibration. Persons exposed to elevated ambient vibration levels, such as people in an urban environment, may tolerate a higher vibration level.

Structural damage can be classified as cosmetic only, such as paint flaking or minimal extension of cracks in building surfaces; minor, including limited surface cracking; or major, that may threaten the structural integrity of the building. Safe vibration limits that can be applied to assess the potential for damaging a structure vary by researcher. The damage criteria presented in Table 3 include several categories for ancient, fragile, and historic structures, the types of structures most at risk to damage. Most buildings are included within the categories ranging from “Historic and some old buildings” to “Modern industrial/commercial buildings”. Construction-induced vibration that can be detrimental to the building is very rare and has only been observed in instances where the structure is at a high state of disrepair and the construction activity occurs immediately adjacent to the structure.

The annoyance levels shown in Table 3 should be interpreted with care since vibration may be found to be annoying at lower levels than those shown, depending on the level of activity or the sensitivity of the individual. To sensitive individuals, vibrations approaching the threshold of perception can be annoying. Low-level vibrations frequently cause irritating secondary vibration, such as a slight rattling of windows, doors, or stacked dishes. The rattling sound can give rise to exaggerated vibration complaints, even though there is very little risk of actual structural damage.

TABLE 3 Reaction of People and Damage to Buildings from Continuous or Frequent Intermittent Vibration Levels

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

Source: Transportation and Construction Vibration Guidance Manual, California Department of Transportation, April 2020.

Fundamentals of Underwater Noise

When a pile driving hammer strikes a pile, a pulse is created that propagates through the pile and radiates sound into the water, the ground, and the air. The pulse amplitude and propagation are dependent on a variety of factors, including but not limited to pile size, hammer type, sediment composition, water depth, and water properties (conductivity, temperature, and pressure). Generally, the majority of the acoustic energy is confined to frequencies below 2 kilohertz (kHz) and there is very little energy above 20 kHz.

Sound pressure pulse as a function of time is referred to as the waveform. In terms of acoustics, these sounds are described by the peak pressure, the root-mean-square pressure (RMS), and the sound exposure level (SEL). The peak pressure is the highest absolute value of the measured waveform and can be a negative or positive pressure peak. For pile driving pulses, RMS level is determined by analyzing the waveform and computing the average of the squared pressures over the time that comprises that portion of the waveform containing the sound energy.[1] The pulse RMS has been approximated in the field for pile driving sounds by measuring the signal with a precision sound level meter set to the "impulse" RMS setting and is typically used to assess impacts to marine mammals. Another measure of the pressure waveform that can be used to describe the pulse is the sound energy itself. The total sound energy in the pulse is referred to in many ways, most

[1] Richardson, Greene, Malone & Thomson, *Marine Mammals and Noise,* Academic Press, 1995, and Greene, personal communication.

commonly as the "total energy flux"[2]. The "total energy flux" is equivalent to the un-weighted sound exposure level (SEL) for a plane wave propagating in a free field, a common unit of sound energy used in airborne acoustics to describe short-duration events. The unit used is dB re 1µPa^2-sec. In this report, peak pressures levels are expressed in decibels re 1 µPa; however, in other literature they can take varying forms such as a Pascals or pounds per square inch. The total sound energy in an impulse accumulates over the duration of that pulse. How rapidly the energy accumulates may be significant in assessing the potential effects of impulses on fish. Figure 1 illustrates the acoustical characteristics of an underwater pile driving pulse. Table 4 includes the definitions of terms commonly used to describe underwater sounds.

The variation of instantaneous pressure over the duration of a sound event is referred to as the waveform. The waveform can provide an indication of rise time or how fast pressure fluctuates with time; however, rise time differences are not clearly apparent for pile driving sounds due to the numerous rapid fluctuations that are characteristic to this type of impulse. A plot showing the accumulation of sound energy over the duration of the pulse (or at least the portion where much of the energy accumulates) illustrates the differences in source strength and rise time. An example of the underwater acoustical characteristics of a typical pile driving pulse is shown in Figure 1.

SEL is an acoustic metric that provides an indication of the amount of acoustical energy contained in a sound event. For pile driving, the typical event can be one pile driving pulse or many pulses such as pile driving for one pile or for one day of pile driving. Typically, SEL is measured for a single strike and a cumulative condition. The cumulative SEL associated with the driving of a pile can be estimated using the single strike SEL value and the number of pile strikes through the following equation:

$SEL_{\text{CUMULATIVE}} = SEL_{\text{SINGLE STRIKE}} + 10 \log (\# \text{ of pile strikes})$

For example, if a single strike SEL for a pile is 165 dB and it takes 1000 strikes to drive the pile, the cumulative SEL is 195 dBA (165 dB + 30 dB = 195 dB), where $10 * \text{Log}_{10}(1000) = 30$.

[2] Finerran, et. al., *Temporary Shift in Masked Hearing Thresholds in Odontocetes after Exposure to Single Underwater Impulses from a Seismic Watergun*, Journal of the Acoustical Society of America, June 2002.

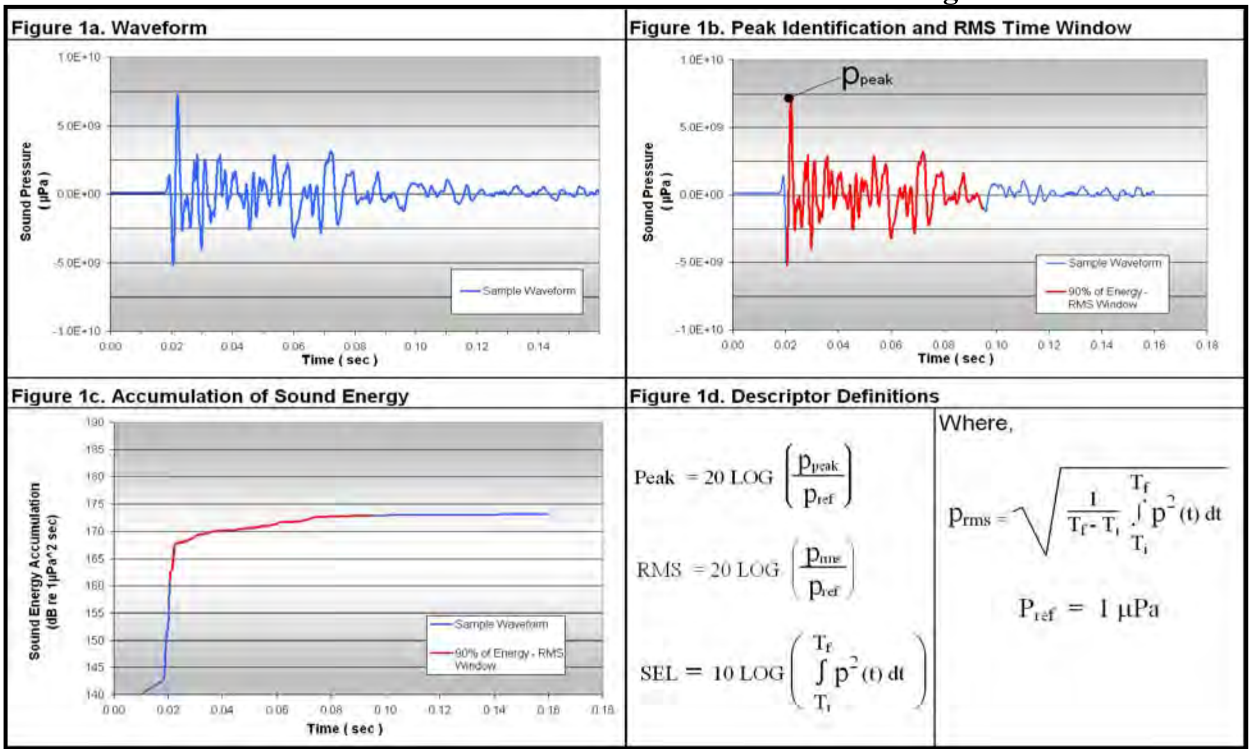
TABLE 4 Definitions of Acoustical Terms Used in this Report (Underwater Noise)

Term	Definition
Peak Sound Pressure Level, (dB re 1 μPa)	Peak sound pressure level based on the largest absolute value of the instantaneous sound pressure. This pressure is expressed in this report as a decibel (referenced to a pressure of 1 μPa) but can also be expressed in units of pressure, such as μPa or PSI.
Root-Mean-Square Sound Pressure Level, (dB re 1 μPa)	The average of the squared pressures over the time that comprise that portion of the waveform containing 90 percent of the sound energy for one pile driving impulse[3].
Sound Exposure Level, (dB re 1 μPa^2 sec)	Proportionally equivalent to the time integral of the pressure squared and is described in this report in terms of dB re 1 μPa^2 sec over the duration of the impulse. Similar to the unweighted Sound Exposure Level (SEL) standardized in airborne acoustics to study noise from single events.
Cumulative SEL, (dB re 1 μPa^2 sec)	Measure of the total energy received through a pile-driving event (here defined as pile driving that occurs with a day).
Waveforms, μPa over time	A graphical plot illustrating the time history of positive and negative sound pressure of individual pile strikes shown as a plot of μPa over time (i.e., seconds).
Frequency Spectra, dB over frequency range	A graphical plot illustrating the distribution of sound pressure vs. frequency for a waveform, dimension in rms pressure and defined frequency bandwidth.

Source: Technical Guidance for Assessment of Mitigation of the Hydroacoustic Effects of Pile Driving on Fish, California Department of Transportation, November 2015.

[3] The underwater sound measurement results obtained during the Pile Installation Demonstration Project indicated that most pile driving impulses occurred over a 50 to 100 millisecond (msec) period. Most of the energy was contained in the first 30 to 50 msec. Analysis of that underwater acoustic data for various pile strikes at various distances demonstrated that the acoustic signal measured using the standard “impulse exponential-time-weighting” (35-msec rise time) correlated to the RMS (impulse) level measured over the duration of the impulse.

FIGURE 1 Underwater Acoustical Characteristics of a Pile Driving Pulse



Regulatory Criteria

Humboldt County Noise Element

The goals of the 2017 Noise Element of the Humboldt County General Plan are to provide a quiet and healthful environment with limited disagreeable noise and to arrange land uses to reduce annoyance and complaints and minimize the exposure of community residents to excessive noise. The following policies and standards would be applicable to the project:

N-P1. Minimize Noise from Stationary and Mobile Sources. Minimize stationary noise sources and noise emanating from temporary activities by applying appropriate standards for average and short-term noise levels during permit review and subsequent monitoring.

N-P2. Guide to Land Use Planning. Evaluate current noise levels and mitigate projected noise levels when making community planning and zoning decisions to minimize the exposure of community residents to nuisance noise levels. Minimize vehicular and aircraft noise exposure by planning land uses compatible with transportation corridors and airports and applying noise attenuation designs and construction standards. Avoid zoning patterns that permit people to "move to the nuisance" unless mitigated through project conditions or recorded notice.

N-P4. Protection from Excessive Noise. Protect persons from existing or future excessive levels of noise which interfere with sleep, communication, relaxation, health or legally permitted use of property.

N-S4. Noise Study Requirements. When a discretionary project has the potential to generate noise levels in excess of Plan standards, a noise study together with acceptable plans to assure compliance with the standards shall be required. The noise study shall measure or model as appropriate, Community Noise Equivalent Level (CNEL) and Maximum Noise Level (L_{max}) levels at property lines and, if feasible, receptor locations. Noise studies shall be prepared by qualified individuals using calibrated equipment under currently accepted professional standards and include an analysis of the characteristics of the project in relation to noise levels, all feasible mitigations, and projected noise impacts. The Noise Guidebook published by the U.S. Department of Housing and Urban Development, or its equivalent, shall be used to guide analysis and mitigation recommendations.

N-S7. Short-term Noise Performance Standards (L_{max}). The following noise standards, unless otherwise specifically indicated, shall apply to all property within their assigned noise zones and such standards shall constitute the maximum permissible noise level within the respective zones.

SHORT-TERM NOISE STANDARDS (Lmax)		
Zoning Classification	Day (maximum) 6:00 a.m. to 10:00 p.m. dBA	Night (maximum) 10:00 p.m. to 6:00 a.m. dBA
MG, MC, AE, TPZ,TC, AG, FP, FR, MH	80	70
CN, MB, ML, RRA, CG, CR C-1, C-2. C-3,	75	65
RM, R-3, R-4	65	60
RS, R-1, R-2, NR	65	60

Humboldt Bay Area Plan – Local Coastal Program

There are no policies in the Humboldt Bay Area Plan pertaining to construction-related noise.

NMFS Underwater Criteria for Fish and Marine Mammals

Fish

A Fisheries Hydroacoustic Workgroup (FHWG) that consisted of transportation officials, resources agencies, the marine construction industry (including Ports), and experts was formed in 2003 to address the underwater sound issues associated with marine construction. The first order of business was to document all that was clearly known about the effects of sound on fish. The result of this effort was a report prepared by Dr. Mardi Hastings and Dr. Arthur Popper, titled Effects of Sound on Fish[4]. This report provided recommended preliminary guidance to protect fish. Research to further investigate the effects of pile driving sounds on fish was also

[4] Hastings, M and A. Popper. 2005. Effects of Sound on Fish. Prepared for the California Department of Transportation. January 28 (revised August 23).

recommended in this report. Some of these recommendations were taken up in an ongoing National Cooperative Highway Research Program (NCHRP 25-28). This NCHRP study is intended to develop guidelines for the prediction and mitigation of the impacts on fish from underwater sound pressure and particle motion caused by pile driving.

To provide additional explanation of the injury criteria recommended in the "Effects of Sound on Fish" and to provide a practical means to apply the criteria, Caltrans commissioned Dr. Popper and other leading experts to prepare a subsequent report. This report is entitled "Interim Criteria for Injury of Fish Exposed to Pile Driving Operations: A White Paper", (*White Paper*).[5] This *White Paper* recommended a dual criterion for evaluating the potential for injury to fish from pile driving operations. The dual approach considered that a single pile strike with high enough amplitude, as measured by zero to peak (either negative or positive pressure) could cause injury. To account for the energy in a single strike, the SEL metric proposed by Hastings and Popper[4] was included as the second part of the duel criteria.

On June 12, 2008, NOAA's National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service, California, Oregon, and Washington Departments of Transportation, California Department of Fish and Game and the U.S. Federal Highway Administration agreed in principal to interim criteria to protect fish from pile driving activities (Table 5).

The primary difference between the adopted criteria and previous recommendations is that the single strike SEL was replaced with a cumulative SEL over a day of pile driving. NMFS does not consider sound that produce a SEL per strike of less than 150 dB to accumulate and cause injury. Thus, where underwater pile driving noise exceeds 206 dB or cumulatively exceeds 187 dB SEL it can cause injury to fish in that location. All fish species of concern for this project are assumed to be two grams or larger.

The adopted criteria listed in Table 5 are for pulse-type sounds (e.g., pile driving) and does not address sound from vibratory driving. There are no adopted criteria for impacts to fish therefore the SEL criteria are not applied to vibratory driving sounds.

TABLE 5 Fish Criteria Used for Injury and Area of Effect

Interim Criteria	Sound Levels Agreed in Principle
Peak	206 dB re: 1 μPa (for all size of fish)
Cumulative SEL	187 dB re: 1 μPa^2-sec – for fish size of two grams or greater. 183 dB re: 1 μPa^2-sec – for fish size of less than two grams.

Source: Memorandum from the Fisheries Hydroacoustic Working Group, June 12, 2008.

[5] Popper, A., Carlson, T., Hawkins, A., Southall, B., and Gentry, R. 2006. Interim Criteria for Injury of Fish Exposed to Pile Driving Operations: A White Paper. May 15.

Marine Mammals

Under the Marine Mammal Protection Act, NMFS has defined levels of harassment for marine mammals. Level A harassment is defined as "Any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild." Level B harassment is defined as "Any act of pursuit, torment, or annoyance which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including but not limited to migration, breathing, nursing, breeding, feeding or sheltering."

Table 6 below outlines the current adopted Level A and Behavioral Harassment (Level B) criteria. The application of the 120 dB RMS threshold for vibratory pile driving can sometimes be problematic because this threshold level can be either at or below the ambient noise level of certain locations. For continuous sounds, NMFS Northwest Region has provided guidance for reporting RMS sound pressure levels. RMS levels are based on a time-constant of 10 seconds; RMS levels should be averaged across the entire event. For impact pile driving, the overall RMS level should be characterized by integrating sound for each acoustic pulse across 90 percent of the acoustic energy in each pulse and averaging all the RMS for all pulses.

NMFS has provided marine mammal acoustic technical guidance for predicting onset of permanent threshold shift (PTS) and temporary threshold shifts (TTS) in marine mammal hearing from sound sources.[6] For this project location, the functional hearing groups are low-frequency cetaceans (humpback and gray whales), high-frequency cetaceans (harbor porpoises), phocid pinnipeds (harbor seals) and otariid pinnipeds (Stellar and California sea lions and northern elephant seals). For pile driving, the majority of the acoustic energy is confined to frequencies below 2 kilohertz (kHz) and there is very little energy above 20 kHz. The underwater acoustic criteria for marine mammals are shown in Table 6. Table 7 shows a summary of the functional hearing groups and their hearing ranges as defined by the NMFS guidance.

[6] NMFS. 2020 Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts. July.

TABLE 6 Underwater Acoustic Criteria for Marine Mammals

Species	Underwater Noise Thresholds (dB re: 1µPa)					In Air Noise Thresholds (dB re: 20µPa)
	Vibratory Pile Driving Disturbance Threshold *(Level B Harassment)*	**Impact Pile Driving Disturbance Threshold** *(Level B Harassment)*	**Marine Mammal Hearing Group (See Table 7)**	**PTS SEL_{cum} Threshold Peak – dB re 1µPa (SEL_{cum} -dB re 1µPa^2sec)**		**Impact and Vibratory Driving Disturbance Threshold**
				Impulsive *(Impact Pile Driving)*	**Non-Impulsive** *(Vibratory Pile Driving)*	
Cetaceans	120 dB RMS	160 dB RMS	Low frequency	219 dB_{Peak} 183 dB SEL_{cum}	199 dB SEL_{cum}	NA
			Mid frequency	230 dB_{Peak} 185 dB SEL_{cum}	198 dB SEL_{cum}	NA
			High frequency	202 dB_{Peak} 155 dB SEL_{cum}	173 dB SEL_{cum}	NA
Pinnipeds	120 dB RMS	160 dB RMS	Phocid	218 dB_{Peak} 185 dB SEL_{cum}	201 dB SEL_{cum}	90 dB RMS
			Otariid	232 dB_{Peak} 203 dB SEL_{cum}	219 dB SEL_{cum}	100 dB RMS

Source: National Marine Fisheries Service. 2018. 2018 Revisions to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commerce., NOAA. NOAA Technical Memorandum NMFS-OPR-59, 167 p.

TABLE 7 Definition of Marine Mammal Hearing Groups

Marine Mammal Hearing Groups	
Functional Hearing Group	**Functional Hearing Range**
Low-frequency cetaceans - gray whales	7 Hz to 35 kHz
Mid frequency cetaceans - Dolphins, toothed whales, beaked whales, bottlenose whales	150 Hz to 160 kHz
High frequency cetaceans - True porpoises, *Kogia*, river dolphins, cehalorhynchid, *Lagenorhynchus cruciger & L. australis*	275 Hz to 160 kHz
Phocid pinnipeds - True seals including harbor seals	50 Hz to 86 kHz
Otariid pinnipeds - Sea lions and fur seals	60 Hz to 39 kHz

Source: National Marine Fisheries Service. 2018. 2018 Revisions to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commerce., NOAA. NOAA Technical Memorandum NMFS-OPR-59, 167 p.

Marbled Murrelets

The Marbled Murrelet, which is a federally threatened species, are known to forage in Humboldt Bay, and an increase in underwater noise levels could affect seabird behavior. Other terrestrial birds (e.g., Osprey; California Department of Fish and Wildlife Watch List species) are potentially present in or immediately adjacent to the Project Site may be impacted by elevated in-air noise levels due to blasting (i.e., 140 dBA to avoid hearing damage to birds). Table 8 shows the guidance for injury and harassment for the Marbled Murrelet. Airborne noise from construction activities may have a behavioral effect resulting in disturbance to Marbled Murrelets.[7] All calculations for impacts to Marbled Murrelets are shown in Attachment 1.

TABLE 8 - Proposed Guidelines for Impacts to Marbled Murrelets[8]

	Underwater Noise			Terrestrial Noise
	Mortality and Potential Mortal Injury	**Recoverable Injury**	**Behavior**	**Airborne**
Marbled Murrelet	208 dB SEL	202 dB SEL	150 dB RMS	92 dBA

Source: https://wsdot.wa.gov/sites/default/files/2017/12/12/ENV-FW-MamuThresholds.pdf.

[7] U.S. Fish and Wildlife Service (USFWS). 2012. Agreement for Criteria for injury to Marbled Murrelet from noise. Memorandum from the Federal Highway Administration (FHWA), U.S. Fish and Wildlife Service (USFWS), and Washington State Department of Transportation, Lacey, Washington, USA.

ASSESSMENTS

Construction Noise Assessment

The project site is located on the Samoa Peninsula in Humboldt County, California. The Pacific Ocean is approximately 0.2 miles west and Humboldt Bay bounds the project site to the east. The project site is approximately 0.1 miles east of a water storage tank, 0.15 miles north of a woodchip distribution facility, 0.2 miles northeast of a biomass facility, and 2.3 miles south of the Samoa Dunes State Recreation Area. The nearest noise-sensitive residential land uses are located approximately 0.4 miles to the south and 0.8 miles to the north and the nearest schools are located over 1 mile from the site. Additional industrial and commercial land uses are in the City of Eureka, approximately 0.5 miles to the east. The modernization and revitalization of the two water intake structures would extend to within approximately 1,100 feet of the nearest noise-sensitive residential land uses along Bayview Avenue.

Noise impacts resulting from construction depend upon the noise generated by various pieces of construction equipment, the timing and duration of noise-generating activities, and the distance between construction noise sources and noise sensitive areas. Construction noise impacts primarily result when construction activities occur during noise-sensitive times of the day (e.g., early morning, evening, or nighttime hours), the construction occurs in areas immediately adjoining noise sensitive land uses or habitats, or when construction lasts over extended periods of times.

Construction activities generate considerable amounts of noise, especially during earth moving activities when heavy equipment is used. Typical construction noise levels at a distance of 50 feet are shown in Tables 9 and 10. Table 9 shows the average noise level ranges, by construction phase, and Table 10 shows the maximum noise level ranges for different construction equipment. Most demolition and construction noise fall within the range of 80 to 90 dBA at a distance of 50 feet from the source. Atypical demolition activities (e.g., stack and boiler implosion) may involve the use of explosives. Based on data supplied by the project applicant, maximum instantaneous noise levels would range from 106 to 114 dBA at 800 to 1100 feet and from 105 to 106 dBA at 1,300 to 1,500 feet. Blast noise levels would exceed 140 dBA at locations within 130 feet of the blast using the same attenuation rate experienced between 800 and 1,500 feet. Construction-generated noise levels drop off at a rate of about 6 dBA per doubling of the distance between the source and receptor. Shielding by buildings or terrain can provide an additional 5 to 10 dBA noise reduction at distant receptors.

TABLE 9 Typical Ranges of Construction Noise Levels at 50 Feet, L_{eq} (dBA)

	Domestic Housing		Office Building, Hotel, Hospital, School, Public Works		Industrial Parking Garage, Religious Amusement & Recreations, Store, Service Station		Public Works Roads & Highways, Sewers, and Trenches	
	I	II	I	II	I	II	I	II
Ground Clearing	83	83	84	84	84	83	84	84
Excavation	88	75	89	79	89	71	88	78
Foundations	81	81	78	78	77	77	88	88
Erection	81	65	87	75	84	72	79	78
Finishing	88	72	89	75	89	74	84	84

I - All pertinent equipment present at site.
II - Minimum required equipment present at site.

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

TABLE 10 Construction Equipment 50-Foot Noise Emission Limits

Equipment Category	L_{max} Level (dBA)[1,2]	Impact/Continuous
Arc Welder	73	Continuous
Auger Drill Rig	85	Continuous
Backhoe	80	Continuous
Bar Bender	80	Continuous
Boring Jack Power Unit	80	Continuous
Chain Saw	85	Continuous
Compressor[3]	70	Continuous
Compressor (other)	80	Continuous
Concrete Mixer	85	Continuous
Concrete Pump	82	Continuous
Concrete Saw	90	Continuous
Concrete Vibrator	80	Continuous
Crane	85	Continuous
Dozer	85	Continuous
Excavator	85	Continuous
Front End Loader	80	Continuous
Generator	82	Continuous
Generator (25 KVA or less)	70	Continuous
Gradall	85	Continuous
Grader	85	Continuous
Grinder Saw	85	Continuous
Horizontal Boring Hydro Jack	80	Continuous
Hydra Break Ram	90	Impact
Impact Pile Driver	105	Impact
Insitu Soil Sampling Rig	84	Continuous

Equipment Category	L_{max} Level (dBA)[1,2]	Impact/Continuous
Jackhammer	85	Impact
Mounted Impact Hammer (hoe ram)	90	Impact
Paver	85	Continuous
Pneumatic Tools	85	Continuous
Pumps	77	Continuous
Rock Drill	85	Continuous
Scraper	85	Continuous
Slurry Trenching Machine	82	Continuous
Soil Mix Drill Rig	80	Continuous
Street Sweeper	80	Continuous
Tractor	84	Continuous
Truck (dump, delivery)	84	Continuous
Vacuum Excavator Truck (vac-truck)	85	Continuous
Vibratory Compactor	80	Continuous
Vibratory Pile Driver	95	Continuous
All other equipment with engines larger than 5 HP	85	Continuous

Notes: [1] Measured at 50 feet from the construction equipment, with a "slow" (1 sec.) time constant.
[2] Noise limits apply to total noise emitted from equipment and associated components operating at full power while engaged in its intended operation.
[3] Portable Air Compressor rated at 75 cfm or greater and that operates at greater than 50 psi.

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

The proposed project would be constructed in three phases. The first phase (Phase 0) would consist of a brownfield redevelopment, including asbestos abatement, soil remediation, structure demolition, and waste stream characterization, transportation, and disposal. The second phase (Phase 1) would consist of additional brownfield redevelopment and construction of most of the project buildings. The third phase (Phase 2) would consist of additional soil remediation, expansion of utilities, and construction of additional modules. Each phase is anticipated to take approximately 22 to 25 months to complete and will contain several sub-phases. These sub-phases are likely to include some variation of the phases shown in Table 11. The intakes will be modernized, new screens, new pumps, and the pipeline will be installed following permit approvals as early as the summer of 2022.

In order to mitigate risk for seismic and tsunami activity, construction could include one of three methods, including rammed aggregate piles, vibro displacement columns, and vibro compaction. Based on a review of the equipment anticipated, construction noise levels of all three methods are anticipated to be below 88 dBA L_{eq} at 50 feet. However, the options would be similar to vibratory pile driving, in which case, noise levels could be up to 93 dBA L_{max} at 50 feet. Therefore, it was assumed that deep foundation piling could generate continuous noise levels of 88 dBA L_{eq} and intermittent noise levels of up to 93 dBA L_{max} at 50 feet. These levels were used as conservative levels to assess impacts on nearby land uses, terrestrial habitat, aquatic habitat, and areas along the waters of the Pacific Ocean and Humboldt Bay where there may be pinniped haul-out areas.

TABLE 11 Estimated Construction Noise Levels at Nearby Land Uses

Phase	Calculated Hourly Average L_{eq} at Noise-Sensitive Receptors, dBA			Calculated RMS, at Nearest Shoreline Areas, dB	
	Industrial South (800 feet)	Residential South (2,000 feet)	Residential North (4,500 feet)	Humboldt Bay East (215 feet)	Pacific Ocean West (1,200 feet)
Demolition	64	56	49	75	60
Ground Clearing	60	52	45	71	56
Grading & Excavation	64	56	49	75	60
Trenching & Foundation	64	56	49	75	60
Building Erection	55	47	40	66	51
Finishing	60	52	45	71	56
Calculated L_{max}					
Maximum Levels	69	61	54	80	65

Intake construction noise would primarily result from the excavation of trenches, which would be accomplished by a backhoe or similar. Table 12 summarizes the construction noise levels expected as a result of the intake construction.

TABLE 12 Estimated Construction Noise Levels at Nearby Land Uses from Intakes

Phase	Calculated Hourly Average L_{eq} at Noise-Sensitive Receptors, dBA			Calculated RMS, at Nearest Shoreline Areas, dB	
	Industrial South (800 feet)	Residential North (1,100 feet)	Residential East (2,800 feet)	Humboldt Bay East (50 feet)	Pacific Ocean West 2,700 feet)
Intakes	50	47	39	74	39
Calculated L_{max}					
Maximum Levels	54	51	43	78	43

Humboldt County does not establish quantitative limits for construction-related noise. Based on criteria commonly used throughout California, this analysis considers construction noise impacts to be significant where noise from construction activities exceeds 60 dBA L_{eq} and exceeds the ambient noise environment by at least 5 dBA L_{eq} at noise-sensitive uses (residential) in the project vicinity for a period exceeding one year. For commercial uses, a significant impact would be identified if construction noise were to exceed 70 dBA L_{eq} and exceeds the ambient noise environment by at least 5 dBA L_{eq} for a period exceeding one year. As shown in Table 11, the nearest sensitive residential receptors along Fay Street to the south would be exposed to levels between 47 to 56 dBA L_{eq} and sensitive residential receptors along Cutten Street to the north would be exposed to levels between 40 to 49 dBA L_{eq}. This is below 60 dBA L_{eq}. The nearest commercial/industrial uses adjacent to the project site on Vance Avenue would be exposed to levels between 55 to 64 dBA L_{eq}, which would be below 70 dBA. While construction duration will last longer than one year, and may intermittently exceed ambient levels at nearby receptors, construction operations would not be anticipated to result in a substantial temporary increase in noise levels at the nearest land uses.

Table 11 also shows anticipated noise levels at the nearest shorelines for comparison with airborne acoustic thresholds for pinnipeds. The production modules building located near the southeastern corner of the project site would be as close as approximately 215 feet from the shoreline of Humboldt Bay. At this distance, the highest noise levels could be up to 75 dBA L_{eq} and during deep foundation piling, could be up to 80 dBA L_{max}. The shoreline of the Pacific Ocean would be approximately 1,200 feet from the nearest building to the west of the project site. At this distance, the highest noise levels could be up to 60 dBA L_{eq} and during deep foundation piling, could be up to 65 dBA L_{max}. These levels are below the 90- and 100-dB RMS in-air thresholds for pinnipeds and below the 92 dBA for Marbled Murrelets.

As shown in Table 12, construction noise levels associated with the intakes are anticipated to reach 78 dBA L_{max} and produce and hourly average noise level of 74 dBA L_{eq} at 50 feet. At the nearest land uses, these levels would attenuate to between 43 and 54 dBA L_{max} and 39 and 50 dBA L_{eq}. Construction noise levels associated with the intakes would not exceed the criteria for residential or commercial land uses in the area, nor the in-air thresholds for pinnipeds or Marbled Murrelets.

Airborne noise resulting from the finfish aquaculture facility and seawater intakes would be considered a less-than-significant impact to all receptors, marine mammals and birds and no additional mitigation would be required.

Construction Vibration Assessment

Humboldt County does not establish vibration limits to minimize the potential for cosmetic damage to buildings. However, the California Department of Transportation recommends a vibration limit of 0.5 in/sec PPV for buildings structurally sound and designed to modern engineering standards, 0.3 in/sec PPV for buildings that are found to be structurally sound but where structural damage is a major concern, and a conservative limit of 0.08 in/sec PPV for ancient buildings or buildings that are documented to be structurally weakened. No known ancient buildings or buildings that are documented to be structurally weakened adjoin the project area. Conservatively, continuous, or frequent intermittent groundborne vibration levels exceeding 0.3 in/sec PPV would have the potential to result in a significant vibration impact.

Table 13 presents typical vibration levels that could be expected from construction equipment at 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. Any of the deep foundation piling options could generate substantial vibration in the immediate vicinity. The equipment specifications for each deep foundation piling option were reviewed and calculated for comparison at a common reference level of 25 feet..

Vibration levels would vary depending on soil conditions, construction methods, and equipment used. The water storage tank to the west would be as close as 600 feet from the shared property line. At these distances, construction would generate vibration levels of up to 0.022 in/sec PPV. This may be slightly perceptible but would be unlikely to cause damage to any structure. The woodchip distribution facility, biomass facility, and residential buildings located further to the south would be exposed to lower vibration levels. Similarly, construction vibration levels attributable to the modernization and revitalization of the water intake structures would be well below potential damage thresholds given the distance separating these construction activities from the nearest receptors (approximately 1,100 feet) and the minimal amount of construction equipment required for installation (i.e., trenches will be dug with a backhoe or similar). This is a less-than-significant impact to sensitive land uses and structures near the site and no additional mitigation would be required.

TABLE 13 Vibration Source Levels for Construction Equipment

Equipment	PPV at 25 ft. (in/sec)	Vibration Levels at Nearest Buildings (in/sec PPV)		
		Water Tank West 600 ft	Woodchip Facility South 800 ft	Residential Building South 2,000 ft
Sonic Pile Driver (upper range)	0.734	0.022	0.016	0.006
Sonic Pile Driver (typical)	0.170	0.005	0.004	0.001
Rammed Aggregate Piles	0.300	0.009	0.007	0.002
Vibro Displacement Columns	0.101	0.003	0.002	0.001
Vibro Compaction	0.073	0.002	0.002	0.001
Clam shovel drop	0.202	0.006	0.004	0.002
Vibratory Roller	0.210	0.006	0.005	0.002
Hoe Ram	0.089	0.003	0.002	0.001
Large bulldozer	0.089	0.003	0.002	0.001
Loaded trucks	0.089	0.003	0.002	0.001
Jackhammer	0.076	0.002	0.002	0.001
Small bulldozer	0.035	0.001	0.001	0.000

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., October 2020.

Implosion Assessment

A 270 foot tall smokestack will be imploded as part of the demolition proposed for the project. The smokestack is 900 feet from a water tank located to the west, 1,500 feet from a woodchip facility located to the south, and 2,500 feet from the nearest residences located to the south. Vibration caused by the collapse of the structure and the air overpressure (noise) caused by the detonation of the explosives are of primary concern at these receptors.

The California Department of Transportation and others have established criteria relating the likelihood of damage to structures from vibration. For residences, vibration levels should not exceed 0.5 to 1 in/sec PPV in order to avoid "threshold damage". Threshold damage is defined as "loosening of paint; small plaster cracks at joints between construction elements; lengthening of old cracks". The damage threshold for load bearing masonry walls, engineered structures, heavy commercial buildings, or higher levels of damage to residential structures, is 2 in/sec PPV or greater. Damage to old or poorly glazed windows does not occur until air-overpressure reaches about 150 dB(L) according to the United States Department of the Interior, Bureau of Mines (USBM).

Ground vibration from implosion of the smoke stack would occur when the imploded structure impacts the ground. Data supplied by the project applicant for a similar, but much larger implosion project (JEA St. John's River Power Plant Boilers and Chimney[9]), was reviewed to credibly estimate worst-case vibration levels expected with the proposed implosion of the 270 foot tall smokestack. The similar implosion project involved the implosion of two boiler units and one 650 foot tall stack. At distances of approximately 800 to 1,100 feet, ground vibration levels produced by the larger implosion project ranged from 0.160 to 0.610 in/sec PPV. At distances of 1,300 to 1,500 feet, ground vibration levels produced by the larger implosion project ranged from 0.150 to 0.360 in/sec PPV. Vibration levels would be less at distances of 2,500 feet or further, representing the nearest residential receptors. The data from the similar, but larger implosion project indicate that the residential threshold (0.5 to 1 in/sec) or engineered structures (2 in/sec PPV or greater) thresholds would not be exceeded with the implosion of the 270 foot tall smokestack.

At distances of approximately 800 to 1,100 feet, air-overpressure levels produced by the larger implosion project ranged from 142 to 150 dB(L), and at distances of 1,300 to 1,500 feet, air-overpressure levels produced by the larger implosion project ranged from 141 to 142 dB(L). Air-overpressure levels would be less at distances of 2,500 feet or further, representing the nearest residential receptors. Air-overpressure levels resulting from the implosion of the 270 foot tall smokestack would be expected to fall below 150 dB(L) at any buildings having windows at the woodchip facility and at the nearest residences to the south.

Hydroacoustic Assessment

Underwater Sound Generating Activities

There are three alternatives[10] for the preparation of the foundation for the project:

- Rammed Aggregate Piles (RAP) - Rammed Aggregate Pier installation using the Geopier system is constructed by drilling out a volume of compressible soil to create a cavity and then ramming select aggregate into the cavity in thin lifts using the patented beveled tamper.

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[9] Source: TLG, LLC. 2019. 2018 Revisions to: Vibration & Air Overpressure Monitoring Report for the Demolition of the JEA St. Johns River Power Park, p. 4.

[10] Source: email from Austin Fears Gilbane Company to Scott Thompson (Nordic), Misha Schwarz (GHD) and Keith Pommerenck (I&R); dated September 25, 2020

- Vibro Displacement Columns (VDC) - VDC is a soil-displacement, sand, aggregate, soil cement, and grout column ground improvement method commonly called vibro compaction and vibro replacement. VDC uses dynamic, vibratory energy and displacement technology to construct strong, engineered, “composite ground” for support of slabs and foundations and to reduce liquefaction settlement.
- Vibro Compaction (VC) **-** VC is a soil-displacement, sand, aggregate, soil cement, and grout column ground improvement method commonly called vibro compaction and vibro replacement. VC uses dynamic, vibratory energy and displacement technology to construct strong, engineered, “composite ground” for support of slabs and foundations and to reduce liquefaction settlement.

These were assumed to have a worst-case noise level similar to the maximum noise of vibratory pile installation. There will be some sheet piles installed for shoring around foundations these sheet piles would be installed by vibratory methods up to 30 feet deep.

Intake work would consist of limited in-water work performed by divers. Noise from these activities would be minor in the water and would not have any effect on species in the vicinity.

Discussion of Underwater Noise Levels from Construction

Results of Past Studies

In November 2015, Caltrans published the *Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish*[11]. Appendix 1 of that document contains measurement data for numerous pile driving activities. This data was utilized to make predictions of underwater sound that would occur from this project. While there have been no measurements for proposed construction alternatives surrogates can be used to give a very conservative prediction of the sound levels in Humboldt Bay from the proposed work. Sounds from similar sized drilling operations and pile driving operations were used as surrogates to the proposed alternatives. For the rammed aggregate piles alternative, vibro displacement columns alternative and the vibro compaction alternative the data from the vibratory installation of 24-inch piles at the Prichard Lake Water Treatment plant was used due to the similar pile size of the holes to be drilled. The proposed installation of sheet piles was compared to data collected along the San Joaquin River near Lathrop, California. For this project a coffer dam was constructed approximately 20 feet from the river’s edge to 10 feet into the river. Data used in this analysis was from the farthest point on land from the river.

Prichard Lake Pumping Plant Project

Underwater noise measurements were made during the installation of 24-inch steel shell piles used to construct a new pumping station in the Sacramento River north of Sacramento, California. Twelve 24-inch steel pipe piles were driven into the bank adjacent to the river using a vibratory

[11] Caltrans. 2020. *Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish*. November. Document prepared by ICF Jones & Stokes and Illingworth & Rodkin, Inc. under contract to Caltrans.

hammer. Measurements were made at 10 meters from the piles being driven. The maximum Peak level was 181 dB and the median RMS and one-second SEL was 153 dB.

South Lathrop Outfall Project [12]

Hydroacoustic monitoring conducted for the temporary cofferdam surrounding the construction of an outfall structure on the east bank of the San Joaquin River. To construct the cofferdam, 24-inch sheet piles were driven with a vibratory hammer on land down the levee into the water. Temporary sheet piles were installed with a vibratory hammer over the course of eight days. The installation duration typically lasted 200 to 600 seconds per pile, but ultimately ranged from 51 to 2,626 seconds. Approximately two months later, piles were removed with a vibratory hammer over the course of two days. The removal duration typically lasted 90 to 120 seconds, but ultimately ranged from 62 to 167 seconds. For the piles driven on land farthest from the water the median RMS levels ranged from 119 dB to 127 dB.

Prediction of Underwater Sound Levels from Project Pile Driving

Table 14 shows the measured levels for vibratory driving of 24-inch CISS piles driven with a vibratory hammer at the Prichard Lake Water Treatment Outflow project. The adjustments show the reduction for the difference between water and land-based driving and distance, the reduction was calculated to be 18-dB reduction. Table 15 shows the levels for sheet piles at 20 meters and the levels adjusted reflect the 69-meter distance. The additional attenuation was calculated to be 13 dB. The reductions were based on the data in the 2020 Caltrans Compendium (page 2-19) and adjustments based on the difference in distances. For example, the data in the Compendium shows a conservative 7 dB reduction between land-based piles and pile measured in the water. By applying the 7 dB reduction and then using a 15-log reduction to account for the difference in the distance analyzed, the result is an 18 dB reduction *(181 dB minus 7 dB = 174 dB, the reduction from 10 meters to 69 meters is 11 dB – 7dB +11 dB = 18dB).*

TABLE 14 Measured Vibratory Pile Driving Levels

Pile Type	Distance (Meters)	Peak (dB re 1µPa)	RMS (dB re 1µPa)	One Second SEL (dB re 1µPa)
24-inch Steel Shell Pile	10	181	153	153
Levels adjusted to compensate for the difference between water and land-based driving and distance	69	163	135	135

[12] *Pile Driving Noise Measurements for the South Lathrop Regional Outfall Project Final Report,* Report prepared by Illingworth & Rodkin for Monk & Associates, October 2019.

TABLE 15 Measured Vibratory Sheet Pile Driving Levels

Pile Type	Distance (Meters)	Peak (dB re 1µPa)	RMS (dB re 1µPa)	One Second SEL (dB re 1µPa)
Sheet Pile	20	153	127	127
Levels adjusted to compensate for the distance	69	140	114	114

The RAP, VDC, and VC alternatives would be considered a continuous noise and therefore, the only threshold that would be applicable is the harassment criteria of 150 dB $_{RMS}$, the cumulative SEL thresholds for fish do not apply. Underwater sound levels would not be expected to exceed the 150 dB RMS in the water, therefore, there would be no impact to fish if either the RAP, VDC, or the VC alternatives are used.

Predicted Impacts to Marine Mammals

The following threshold distances were computed to assess impacts to marine mammals:

- Distance to onset PTS Isopleth for each hearing group
- Distance for Unweighted 120-dB vibratory Behavior Isopleth

The NMFS Companion User Spreadsheet (Version 2.0 [July 2020]) to the *National Marine Fisheries Service (NMFS): Technical Guidance for Assessing the Effects of Anthropogenic Noise on Marine Mammal Hearing: Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts* (dated July 2020) was used to predict zones where the onset of Permanent Threshold Shift to marine mammal hearing could occur. A spreading loss calculation was used to predict the distance to the onset PTS and Peak sound pressure. Since the onset of PTS based on SEL_{cum} is computed as further from the pile than it would be using Peak sound pressure computations, the onset of PTS is based on SEL computations; therefore, the onset of PTS based on peak sound levels is not provided in this assessment.

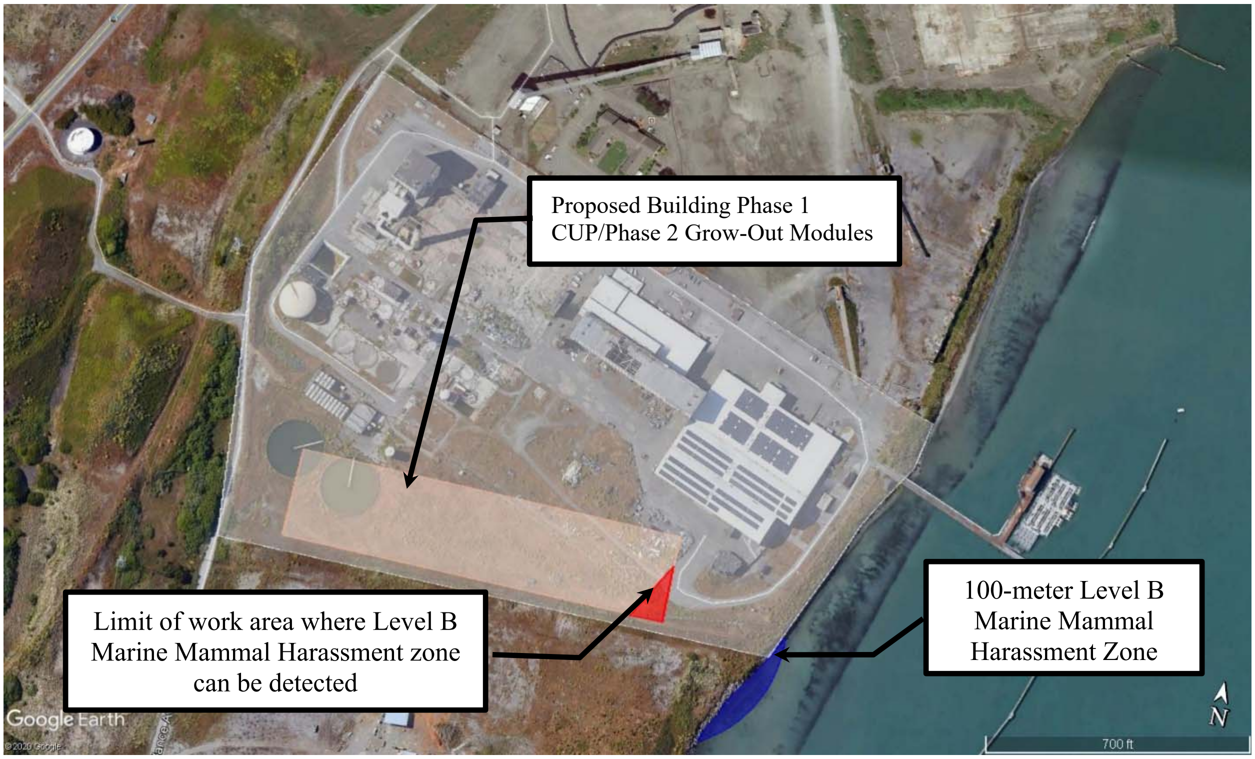
Table 16 shows the anticipated distances to the various adopted Marine Mammal thresholds. When the continuous operations are employed, the cumulative SEL thresholds for fish do not apply and the Peak PTS Thresholds that apply to marine mammals will not be reached beyond four meters from the Humboldt Bay shoreline adjacent to the Project Site. Distances are shown for all alternatives considered.

TABLE 16 Distance to the adopted Marine Mammal Thresholds for Different Alternatives (meters)

<table>
<tr><th colspan="2" rowspan="3">Activity</th><th rowspan="3">Units Per day</th><th colspan="5">Level A Injury Zone (m) SEL $_{CUM}$ Threshold</th><th colspan="5">Level B Harassment Zone (m)</th></tr>
<tr><th colspan="3">Cetaceans</th><th colspan="2">Pinnipeds</th><th colspan="3">Cetaceans</th><th colspan="2">Pinnipeds</th></tr>
<tr><th>LF</th><th>MF</th><th>HF</th><th>PW</th><th>OW</th><th>LF</th><th>MF</th><th>HF</th><th>PW</th><th>OW</th></tr>
<tr><td>RAP</td><td>Vibratory</td><td>90</td><td>3.3</td><td>0.3</td><td>4.9</td><td>2.0</td><td>0.1</td><td colspan="5">100</td></tr>
<tr><td>VDC</td><td>Vibratory</td><td>80</td><td>3.5</td><td>0.3</td><td>5.1</td><td>2.1</td><td>0.1</td><td colspan="5">100</td></tr>
<tr><td>VC</td><td>Vibratory</td><td>160</td><td>3.5</td><td>0.3</td><td>5.1</td><td>2.1</td><td>0.1</td><td colspan="5">100</td></tr>
<tr><td>Sheet Pile</td><td>Vibratory</td><td>20</td><td>0.1</td><td>0.0</td><td>0.1</td><td>0.0</td><td>0.0</td><td colspan="5">0</td></tr>
</table>

The RAP, VDC and VC Alternatives the distance to the Level B (120 dB RMS) harassment would be approximately 100 meters from the southeast corner of the Phase 1 CUP/Phase 2 Grow-Out Modules Building, See Figure 2. The harassment zone would encroach into the bay by approximately 20 meters, at the worst case. For the sheet pile installation, the distance to the Level B (120 dB RMS) harassment would not reach the water. The fish criteria do not apply to continuous noise sources such as the RAP, VDC, and VC alternatives and sheet pile installation. Figure 2 graphically shows the extent of the Level B Marine Mammal Harassment Zone for All Alternatives. Impact zones less than 30 meters are not drawn. Calculations are shown in Attachment 1.

FIGURE 2 – Level B Marine Mammal Harassment Zone for All Alternatives



Conclusion

General Demolition

The use of hammer hoes, excavators, trucks, dozers are the primary noise sources associated with the demolition of buildings and concrete slabs. These sources are mobile and will be at any given area in the overall work area for a short period of time. The maximum noise level associated with these types of equipment is 90 dBA Lmax at 50 feet and the maximum vibration levels would be 0.089 in/sec PPV at 25 feet. At the closet point to Humboldt Bay, approximately 50 meters (165 feet), these levels will be below any of the adopted thresholds of significance for marine mammals. There is the potential for implosion (explosive demolition) of the concrete chimney stack which is approximately 445 meters (1,460 feet) from Humboldt Bay and 465 meters (1,525 feet) from the Pacific Ocean. Blasting source levels would be 94 dBA L_{max} at 50 feet[13] at 445 meters (1,460 feet) the airborne nose level would be 66 dBA L_{max} well below any noise criteria for marine mammals.

Sheet Piles

The predicted noise levels for Marine Mammal impacts with the vibratory driving of the Sheet Piles are not anticipated to reach the Level B Harassment level of 120 dB_{RMS} in the water. The distance to the PTS Threshold for Low frequency and High Frequency Cetaceans is anticipated to be approximately 0.1 meters.

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[13] U.S. Department of Transportation, Federal Highway Administration, Office of Planning, Environmental, &Realty, Construction Noise Handbook, August 2006.

There are no adopted injury thresholds for continuous noise sources such as vibratory pile driving, therefore the only threshold would be the harassment threshold of 150 dB_{RMS} for fish. The RMS levels are not expected to reach or approach the harassment threshold for fish.

Rammed Aggregate Piles

For the Rammed Aggregate Piles Alternative, the predicted noise levels to reach the Level B Harassment level of 120dB_{RMS} out to 100 meters (see Figure A2). The distance to the PTS Threshold for all Cetaceans and Pinnipeds is anticipated to be approximately 5 meters or less.

There are no adopted injury thresholds for continuous noise sources such as Rammed Aggregate Piles, therefore the only threshold would be the harassment threshold of 150 dB_{RMS} for fish. The RMS levels are not expected to reach or approach the harassment threshold for fish.

Vibro Displacement Columns

For the Vibro Displacement Columns Alternative, the predicted noise levels to reach the Level B Harassment level of 120dB_{RMS} out to 100 meters (see Figure 2). The distance to the PTS Threshold for all Cetaceans and Pinnipeds is anticipated to be approximately 5 meters or less.

There are no adopted injury thresholds for continuous noise sources such as Vibro Displacement Columns, therefore the only threshold would be the harassment threshold of 150 dB_{RMS} for fish. The RMS levels are not expected to reach or approach the harassment threshold for fish.

Vibro Compaction

For the Vibro Compaction Alternative, the predicted noise levels to reach the Level B Harassment level of 120dB_{RMS} out to 100 meters (see Figure 2).The distance to the PTS Threshold for all Cetaceans and Pinnipeds is anticipated to be approximately 5 meters or less.

There are no adopted injury thresholds for continuous noise sources such as Vibro Compaction, therefore the only threshold would be the harassment threshold of 150 dB_{RMS} for fish. The RMS levels are not expected to reach or approach the harassment threshold for fish.

Discussion of Underwater Noise Levels from Operation of Intake Pumps

There is very little data on underwater noise levels from pumping operations. The following data were located after an extensive literature search.

Victorian Desalination Project:

Underwater acoustic noise modelling was conducted to investigate the noise likely to be produced during operation of the Marine Structures and the propagation of the noise through the marine environment. Only noise from the intake pumps was modeled using measurements made at the AGL Torrens Island power station. Underwater noise modeling predicted that the intake pumps would generate a sound source level of 145 decibels at a distance of one meter from the source (Bassett 2008, Technical Appendix 22).

Assessment:

The pumping capabilities of the Victorian Desalination project is approximately 25 to 30 times greater than the proposed project (i.e., roughly 240,000 gallons per minute versus 8,250 gallons per minute) and far exceeds the requirements for the proposed project. However, because there is no other data to support using lower source levels, the data from the Victorian Desalination project was used in the assessment of impacts from the operation of the intake pumps. The intake heads are located in the sea chest which is a wooden box with a screen on one side which would prevent marine mammals from coming within close proximity to the noise source. Using a 15log attenuation rate and a source level of 145 dB at 1-meter, the distance to the Level B Harassment zone of 120 dB is expected to be 45 meters from the intake.

Discussion of Airborne Noise Levels from Operation of Intake Pumps

The primary noise sources associated with the operations of the dock intake structures would be the two intake pumps that are proposed to be mounted above each intake structure on a concrete pad. The proposed design includes up to two new vertical turbine pumps per dock, providing up to a maximum of 2,750 gpm. The pumps will operate on variable speed drives in order to provide a variable flow rate depending on demand and pipe pressure.

A pump selection analysis has not been completed at the time of this analysis to determine the precise pump specifications. Preliminary calculations indicate that the power requirements for the Red Tank Dock pumps will be 75-100 hp, and RMT II dock pumps will be 100-125 hp. Assuming a speed rating on 1600 to 1800 rpm, the operation of two pumps would produce a noise level of approximately 95 dBA L_{max}/L_{eq} at 3 feet.

The nearest receptor to the north (residential land uses along Bayview Avenue) would be approximately 1,600 feet from the Red Tank Dock pumps and approximately 4,300 feet from the RMT II pumps, and would be exposed to a combined operational noise level of 41 dBA L_{max}/L_{eq} and 47 dBA CNEL assuming 24-hour per day operations of all four pumps.

To the to the south (residential land uses along Bay Street), the nearest receptor would be approximately 2,600 feet from the RMT II Dock pumps and approximately 5,300 feet from the Red Tank Dock pumps, and would be exposed to a combined operational noise level of 40 dBA L_{max}/L_{eq} and 46 dBA CNEL assuming 24-hour per day operations of all four pumps.

The nearest receptor to the east (marina) would be approximately 2,600 feet from the RMT II Dock pumps and approximately 3,500 feet from the Red Tank Dock pumps, and would be exposed to a combined operational noise level of 40 dBA L_{max}/L_{eq} and 46 dBA CNEL assuming 24-hour per day operations of all four pumps.
Operational noise levels produced by the intake pumps would be well below the Humboldt County noise levels thresholds of 60 dBA CNEL, 80 dBA Lmax (daytime), and 70 dBA Lmax (nighttime) at the property lines of the nearest sensitive receptors.

ATTACHMENT 1 - NMFS Excel Worksheets

A.1: Vibratory Pile Driving (STATIONARY SOURCE: Non-Impulsive, Continuous)

VERSION 2.1: 2020

KEY

	Action Proponent Provided Information
	NMFS Provided Information (Technical Guidance)
	Resultant Isopleth

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	Nordic Aquafarms
PROJECT/SOURCE INFORMATION	Prichard Lake 24-inch piles vibrated in, levels adjusted

Please include any assumptions

PROJECT CONTACT	Misha Schwarz, (707) 599-6977

STEP 2: WEIGHTING FACTOR ADJUSTMENT

		Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value
Weighting Factor Adjustment (kHz)[¥]	2.5	

[¥]Broadband: 95% frequency contour percentile (kHz) OR Narrowband frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 48), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

STEP 3: SOURCE-SPECIFIC INFORMATION

Sound Pressure Level (L_{rms}), specified at "x" meters (Cell B30)	135
Number of piles within 24-h period	80
Duration to drive a single pile (minutes)	6
Duration of Sound Production within 24-h period (seconds)	28800
10 Log (duration of sound productior	44.59
Transmission loss coefficient	15
Distance of sound pressure level (L_{rms}) measurement (meters)	69

NOTE: The User Spreadsheet tool provides a means to estimates distances associated with the Technical Guidance's PTS onset thresholds. Mitigation and monitoring requirements associated with a Marine Mammal Protection Act (MMPA) authorization or an Endangered Species Act (ESA) consultation or permit are independent management decisions made in the context of the proposed activity and comprehensive effects analysis, and are beyond the scope of the Technical Guidance and the User Spreadsheet tool

RESULTANT ISOPLETHS

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	199	198	173	201	219
PTS Isopleth to threshold (meters)	3.5	0.3	5.1	2.1	0.1

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
a	1	1.6	1.8	1	2
b	2	2	2	2	2
f_1	0.2	8.8	12	1.9	0.94
f_2	19	110	140	30	25
C	0.13	1.2	1.36	0.75	0.64
Adjustment (-dB)†	-0.05	-16.83	-23.50	-1.29	-0.60

NOTE: If user decided to override these Adjustment values, they need to make sure to download another copy to ensure the built-in calculations function properly.

$$W(f) = C + 10\log_{10}\left\{\frac{(f/f_1)^{2a}}{[1+(f/f_1)^2]^a[1+(f/f_2)^2]^b}\right\}$$

A.1: Vibratory Pile Driving (STATIONARY SOURCE: Non-Impulsive, Continuous)

VERSION 2.1: 2020

KEY

(green)	**Action Proponent Provided Information**
(pink)	**NMFS Provided Information (Technical Guidance)**
(blue)	**Resultant Isopleth**

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	Nordic Aquafarms
PROJECT/SOURCE INFORMATION	Prichard Lake 24-inch piles vibrated in, levels adjusted

Please include any assumptions

PROJECT CONTACT	Misha Schwarz, (707) 599-6977

STEP 2: WEIGHTING FACTOR ADJUSTMENT

		Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value
Weighting Factor Adjustment (kHz)[¥]	2.5	

[¥]Broadband: 95% frequency contour percentile (kHz) OR Narrowband frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 48), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

STEP 3: SOURCE-SPECIFIC INFORMATION

Sound Pressure Level (L_{rms}), specified at "x" meters (Cell B30)	135
Number of piles within 24-h period	90
Duration to drive a single pile (minutes)	5
Duration of Sound Production within 24-h period (seconds)	27000
10 Log (duration of sound production	44.31
Transmission loss coefficient	15
Distance of sound pressure level (L_{rms}) measurement (meters)	69

NOTE: The User Spreadsheet tool provides a means to estimates distances associated with the Technical Guidance's PTS onset thresholds. Mitigation and monitoring requirements associated with a Marine Mammal Protection Act (MMPA) authorization or an Endangered Species Act (ESA) consultation or permit are independent management decisions made in the context of the proposed activity and comprehensive effects analysis, and are beyond the scope of the Technical Guidance and the User Spreadsheet tool.

RESULTANT ISOPLETHS

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	199	198	173	201	219
PTS Isopleth to threshold (meters)	3.3	0.3	4.9	2.0	0.1

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
a	1	1.6	1.8	1	2
b	2	2	2	2	2
f_1	0.2	8.8	12	1.9	0.94
f_2	19	110	140	30	25
C	0.13	1.2	1.36	0.75	0.64
Adjustment (-dB)†	-0.05	-16.83	-23.50	-1.29	-0.60

NOTE: If user decided to override these Adjustment values, they need to make sure to download another copy to ensure the built-in calculations function properly.

$$W(f) = C + 10\log_{10}\left\{\frac{(f/f_1)^{2a}}{[1+(f/f_1)^2]^a[1+(f/f_2)^2]^b}\right\}$$

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	Nordic Aquafarms
PROJECT/SOURCE INFORMATION	Prichard Lake 24-inch piles vibrated in, levels adjusted

Please include any assumptions

PROJECT CONTACT	Misha Schwarz, (707) 599-6977

STEP 2: WEIGHTING FACTOR ADJUSTMENT

		Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value
Weighting Factor Adjustment (kHz)[¥]	2.5	

[¥] Broadband: 95% frequency contour percentile (kHz) OR Narrowband frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 48), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

STEP 3: SOURCE-SPECIFIC INFORMATION

Sound Pressure Level (L_{rms}), specified at "x" meters (Cell B30)	135
Number of piles within 24-h period	160
Duration to drive a single pile (minutes)	3
Duration of Sound Production within 24-h period (seconds)	28800
10 Log (duration of sound productio	44.59
Transmission loss coefficient	15
Distance of sound pressure level (L_{rms}) measurement (meters)	69

NOTE: The User Spreadsheet tool provides a means to estimates distances associated with the Technical Guidance's PTS onset thresholds. Mitigation and monitoring requirements associated with a Marine Mammal Protection Act (MMPA) authorization or an Endangered Species Act (ESA) consultation or permit are independent management decisions made in the context of the proposed activity and comprehensive effects analysis, and are beyond the scope of the Technical Guidance and the User Spreadsheet tool.

RESULTANT ISOPLETHS

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	199	198	173	201	219
PTS Isopleth to threshold (meters)	3.5	0.3	5.1	2.1	0.1

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
a	1	1.6	1.8	1	2
b	2	2	2	2	2
f_1	0.2	8.8	12	1.9	0.94
f_2	19	110	140	30	25
C	0.13	1.2	1.36	0.75	0.64
Adjustment (-dB)†	-0.05	-16.83	-23.50	-1.29	-0.60

NOTE: If user decided to override these Adjustment values, they need to make sure to download another copy to ensure the built-in calculations function properly.

$$W(f) = C + 10\log_{10}\left\{\frac{(f/f_1)^{2a}}{[1+(f/f_1)^2]^a[1+(f/f_2)^2]^b}\right\}$$

A.1: Vibratory Pile Driving (STATIONARY SOURCE: Non-Impulsive, Continuous)

VERSION 2.1: 2020

KEY

(green)	**Action Proponent Provided Information**
(pink)	**NMFS Provided Information (Technical Guidance)**
(blue)	**Resultant Isopleth**

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	Nordic Aquafarms
PROJECT/SOURCE INFORMATION	South Lathrop Outfall Project

Please include any assumptions

PROJECT CONTACT	Misha Schwarz, (707) 599-6977

STEP 2: WEIGHTING FACTOR ADJUSTMENT

		Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value
Weighting Factor Adjustment (kHz)[¥]	2.5	

[¥]Broadband: 95% frequency contour percentile (kHz) OR Narrowband frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 48), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

STEP 3: SOURCE-SPECIFIC INFORMATION

Sound Pressure Level (L_{rms}), specified at "x" meters (Cell B30)	114
Number of piles within 24-h period	20
Duration to drive a single pile (minutes)	10
Duration of Sound Production within 24-h period (seconds)	12000
10 Log (duration of sound production	40.79
Transmission loss coefficient	15
Distance of sound pressure level (L_{rms}) measurement (meters)	69

NOTE: The User Spreadsheet tool provides a means to estimates distances associated with the Technical Guidance's PTS onset thresholds. Mitigation and monitoring requirements associated with a Marine Mammal Protection Act (MMPA) authorization or an Endangered Species Act (ESA) consultation or permit are independent management decisions made in the context of the proposed activity and comprehensive effects analysis, and are beyond the scope of the Technical Guidance and the User Spreadsheet tool.

RESULTANT ISOPLETHS

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	199	198	173	201	219
PTS Isopleth to threshold (meters)	0.1	0.0	0.1	0.0	0.0

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
a	1	1.6	1.8	1	2
b	2	2	2	2	2
f_1	0.2	8.8	12	1.9	0.94
f_2	19	110	140	30	25
C	0.13	1.2	1.36	0.75	0.64
Adjustment (-dB)†	-0.05	-16.83	-23.50	-1.29	-0.60

NOTE: If user decided to override these Adjustment values, they need to make sure to download another copy to ensure the built-in calculations function properly.

$$W(f) = C + 10\log_{10}\left\{\frac{(f/f_1)^{2a}}{[1+(f/f_1)^2]^a[1+(f/f_2)^2]^b}\right\}$$

Sound Exposure Level Calculator for Marbled Murrelet - RAP, VDC, VC Alternatives

This spreadsheet was developed as an in-house tool for USFWS staff to use when assessing the effects to marbled murrelets (MAMU) from impact pile driving. The USFWS makes this spreadsheet available to other users, and assumes no responsibility for errors when this tool is used by non-USFWS staff. Use this spreadsheet to calculate the distance to various thresholds for both MAMU and bull trout. The calculations incorporate the concept of effective quiet (EQ) wherein we assume that the energy from pile strikes below a certain SEL does not accumulate to cause injury.

Please contact the following USFWS staff member to report errors or submit questions:
Lindsy Wright, USFWS, Washington Fish and Wildlife Office, Lacey, WA, 360-753-6037, lindsy_wright@fws.gov

Green cells = input. Input expected sound levels, distance, attenuation, and pile strikes
Blue cells = results. Results shown are based on the information in the green and yellow cells. DO NOT CHANGE
Yellow cells = threshold values and transmission loss constant. DO NOT CHANGE

	Peak	SEL	RMS	Single Strike SEL for Effective Quiet	Attenuation		
Unattenuated single strike (dB)	163	135	135	150	0		
Attenuated single strike (dB)	163	135	135				
Distance (m)	69	69	69				
Piles per day	150		Distance (m) to Bull Trout thresholds (SEL)		Distance (m) to MAMU thresholds		
Estimated maximum # strikes per pile	40		Fish ≤ 2g	Fish > 2g	Auditory Injury (SEL)	Barotrauma (SEL)	Distance to EQ
Estimated maximum # strikes per day	6000		183	187	202	208	
Cum SEL at measured distance	172.8	>>------------>>>	7	7	1	0	7
Transmission loss constant	15						

	Behavior
	dBrms
Potential Behavioral Response Zone	150
Distance (m)	7

* **Note**: If you have a project with different sized piles, you will run this analysis for each size of pile, and use the greater distance of the two to determine the distance to murrelet auditory injury threshold.

Version 3/3/14 L.Wright
Key:

Distance (m) [B12-D12]	This is the distance that the sound pressure levels you are entering were measured at. The hydrophones were placed at this distance from pile driving locations during sound measurements. This distance can vary, so be sure to verify the distance that the measurements were taken from.
Piles per day [B3]	Enter the maximum number of piles that would be installed in a day.
Attenuation [F10]	Enter the amount of attenuation that will be verified by hydroacoustic monitoring. If hydroacoustic monitoring would not occur, enter zero.
Masking Zone; piles <36-inch [F16]	For projects that entail impact-pile-driving steel piles that is more than intermittent proofing and the pile sizes are less than 36-inch diameter. Monitoring for marbled murrelets in the masking zone should only occur from land-based locations.
Masking Zone; piles ≥ 36-inch [G16]	For projects that entail impact-pile-driving steel piles that is more than intermittent proofing and pile sizes are 36-inch-diameter or larger. Monitoring for marbled murrelets in the masking zone should only occur from land-based locations.
Area of effect Auditory Injury (m) [H16]	This value represents the radius of the "area of effect" where we would anticipate auditory injury could occur. Monitoring for marbled murrelets in the area of auditory injury can be done from boats or land (see USFWS Marbled Murrelet Monitoring Protocol).
Distance to EQ [J16]	This is the distance with which the energy from pile driving would no longer be accumulating and harmful to fish. It is not ambient.
Distance (m) Potential Behavioral Response Zone [B22]	This is the distance that sound would travel underwater until the sound pressure levels drop below 150 dB RMS. This is only a guideline for when we would no longer expect potential behavioral effects to salmonids. We use it for bull trout and marbled murrelets. This is not the distance that sound would travel until attenuating to ambient conditions or when it would be undetectable (background is the sound in an area in the absence of your project noise).

Sound Exposure Level Calculator for Marbled Murrelet Vibratory Installation of Sheet Piles

This spreadsheet was developed as an in-house tool for USFWS staff to use when assessing the effects to marbled murrelets (MAMU) from impact pile driving. The USFWS makes this spreadsheet available to other users, and assumes no responsibility for errors when this tool is used by non-USFWS staff. Use this spreadsheet to calculate the distance to various thresholds for both MAMU and bull trout. The calculations incorporate the concept of effective quiet (EQ) wherein we assume that the energy from pile strikes below a certain SEL does not accumulate to cause injury.

Please contact the following USFWS staff member to report errors or submit questions:
Lindsy Wright, USFWS, Washington Fish and Wildlife Office, Lacey, WA, 360-753-6037, lindsy_wright@fws.gov

Green cells = input. Input expected sound levels, distance, attenuation, and pile strikes
Blue cells = results. Results shown are based on the information in the green and yellow cells. DO NOT CHANGE
Yellow cells = threshold values and transmission loss constant. DO NOT CHANGE

	Peak	SEL	RMS	Single Strike SEL for Effective Quiet	Attenuation		
Unattenuated single strike (dB)	140	114	114	150	0		
Attenuated single strike (dB)	140	114	114				
Distance (m)	69	69	69				
Piles per day	150		Distance (m) to Bull Trout thresholds (SEL)		Distance (m) to MAMU thresholds		
Estimated maximum # strikes per pile	40		Fish ≤ 2g	Fish > 2g	Auditory Injury (SEL)	Barotrauma (SEL)	Distance to EQ
Estimated maximum # strikes per day	6000		183	187	202	208	
Cum SEL at measured distance	151.8	>>------------>>>	0	0	0	0	0
Transmission loss constant	15						

	Behavior
	dBrms
Potential Behavioral Response Zone	150
Distance (m)	0

* **Note**: If you have a project with different sized piles, you will run this analysis for each size of pile, and use the greater distance of the two to determine the distance to murrelet auditory injury threshold.

Version 3/3/14 L.Wright
Key:

Distance (m) [B12-D12]	This is the distance that the sound pressure levels you are entering were measured at. The hydrophones were placed at this distance from pile driving locations during sound measurements. This distance can vary, so be sure to verify the distance that the measurements were taken from.
Piles per day [B3]	Enter the maximum number of piles that would be installed in a day.
Attenuation [F10]	Enter the amount of attenuation that will be verified by hydroacoustic monitoring. If hydroacoustic monitoring would not occur, enter zero.
Masking Zone; piles <36-inch [F16]	For projects that entail impact-pile-driving steel piles that is more than intermittent proofing and the pile sizes are less than 36-inch diameter. Monitoring for marbled murrelets in the masking zone should only occur from land-based locations.
Masking Zone; piles ≥ 36-inch [G16]	For projects that entail impact-pile-driving steel piles that is more than intermittent proofing and pile sizes are 36-inch-diameter or larger. Monitoring for marbled murrelets in the masking zone should only occur from land-based locations.
Area of effect Auditory Injury (m) [H16]	This value represents the radius of the "area of effect" where we would anticipate auditory injury could occur. Monitoring for marbled murrelets in the area of auditory injury can be done from boats or land (see USFWS Marbled Murrelet Monitoring Protocol).
Distance to EQ [J16]	This is the distance with which the energy from pile driving would no longer be accumulating and harmful to fish. It is not ambient.
Distance (m) Potential Behavioral Response Zone [B22]	This is the distance that sound would travel underwater until the sound pressure levels drop below 150 dB RMS. This is only a guideline for when we would no longer expect potential behavioral effects to salmonids. We use it for bull trout and marbled murrelets. This is not the distance that sound would travel until attenuating to ambient conditions or when it would be undetectable (background is the sound in an area in the absence of your project noise).