Washington State
Department of Transportation

Memorandum

September 13, 2010

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SUBJECT: SR 529 Ebey Slough Underwater and Airborne Noise Monitoring of 24-inch Steel Piles - Technical Memorandum.

Underwater Noise Levels

This memo summarizes the vibratory pile driving results measured on one pile at the SR 529 Ebey Slough Project site in an effort to determine site specific underwater noise levels and the boundary of the zone of influence for marine mammals. Data was collected during vibratory pile driving at the SR 529, Ebey Slough site during the month of September 2010.

One 24-inch diameter steel pile was driven with a vibratory hammer and monitored for underwater noise at a far field position approximately 1,046 feet from the pile. No frequency weighting (*e.g.*, A-weighting or C-weighting) was applied to the underwater acoustic measurements presented in this report. Underwater sound levels quoted in this report are given in decibels relative to the standard underwater acoustic reference pressure of 1 microPascal.

The continuous sounds that frequently occur for extended periods associated with the use of a vibratory hammer may produce harassment-level take of ESA listed marine mammals. This harassment occurs when the sound exceeds the current 120 dB RMS NMFS threshold. Therefore, this memo adopts the 120 dB RMS threshold for the present analysis.

Measurement Locations

- Far field measurement was collected 1,046 from the pile in approximately 3 feet of water on September 9th, 2010 (Figure 1). The hydrophone depth was approximately 1 foot from the bottom during low tide.

No noise mitigation was utilized as part of these vibratory measurements. Broadband (2 Hz to 10 kHz) Root Mean Square (RMS) noise levels and high pass filtered (1 kHz to 10 kHz) RMS noise levels are reported in terms of the 30-second average RMS continuous sound level computed from the Fourier transform of the pressure waveforms in 30-second time intervals.

Figure 1: Approximate locations of the far field monitoring location at the SR 529, Ebey Slough Bridge Site. ○ = Approximate pile location

During vibratory driving average broadband RMS values ranged from 170 to 176 dB RMS at the far field location with an overall average RMS value of 174 dB RMS (Figure 2). This indicates that the noise levels did not drop off appreciably over the 1,046 foot distance to the hydrophone. This is likely due to the relatively shallow and narrow channel guiding the sound waves down the channel and not attenuating as quickly.

The elimination of the frequencies below 1 kHz (High Pass Filter) was done to approximate only those sound levels that most marine mammals can hear underwater as their lower threshold does not go beyond 1 kHz in most cases. Typical marine mammal hearing range extends well past our 10 kHz upper limit of the equipment although their sensitivity to noise at the higher frequencies diminishes with increasing frequencies. So we do not know how much these additional higher frequencies might add to the overall sound levels but it is thought that it is not a substantial amount (Dahl, pers. Comm., 2010).

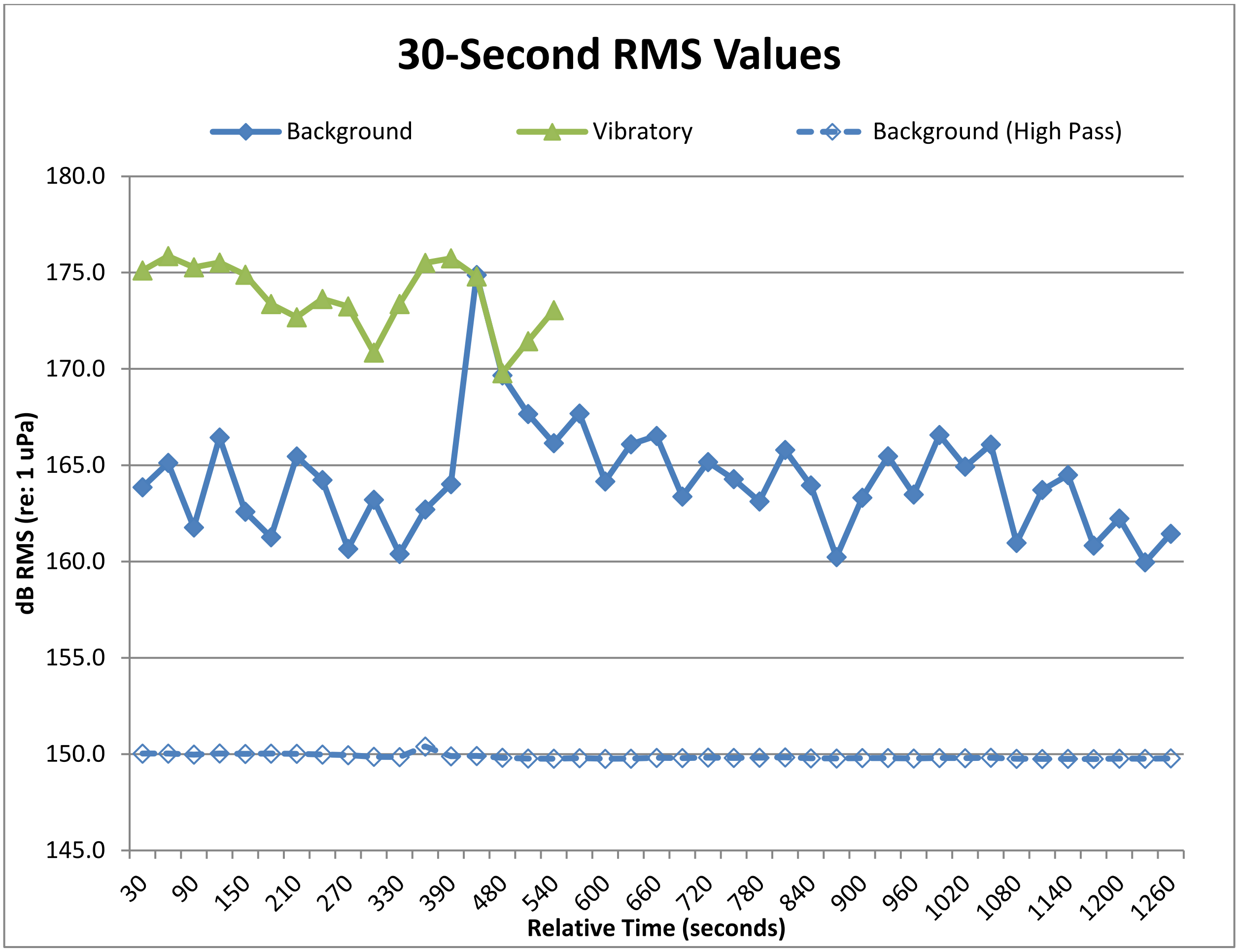

Figure 2: 30-second RMS values for the vibratory pile driving and background noise levels both with and without high pass filter applied.

The vibratory and background data was plotted in 1/3-octave bands (Figure 3). As Figure 3 shows the pattern of the frequencies for both the vibratory measurement and the background noise levels follow the same trend with only the amplitude differing with the exception of the 31.5 Hz band for the background measurement. This could be due to the rock core drill operation happening on land to the east of the pile driving operation, but it is uncertain.

One-third octave band analysis offers a more convenient way to look at the composition of the sound and is an improvement over the spectral density plots. One-third octave bands are frequency bands whose upper limit in hertz is $2^{1/3}$ (1.26) times the lower limit. The width of a given band is 23% of its center frequency. For example, the 1/3-octave band centered at 100 Hz extends from 89 to 112 Hz, whereas the band centered at 1000 Hz extends from 890 to 1120 Hz. The 1/3-octave band level is calculated by integrating the spectral densities between the band frequency limits. Conversion to decibels is

= 10*LOG(sum of squared pressures in the band)

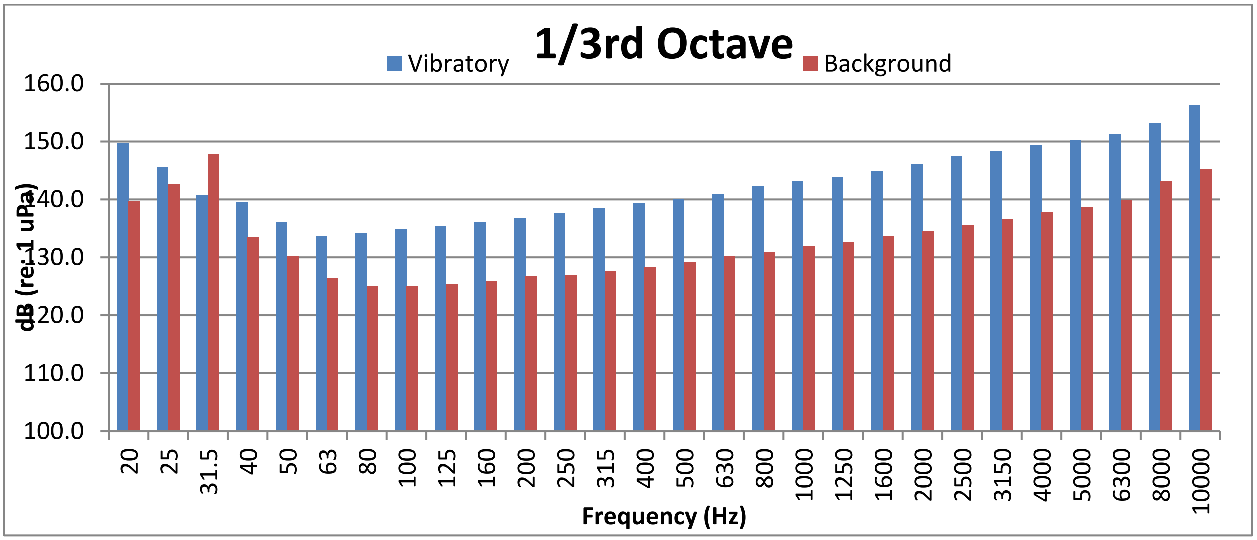

Figure 3: 1/3rd Octave band plot for the vibratory pile driving and background noise levels.

Sound levels are often presented for 1/3-octave bands because the effective filter bandwidth of mammalian hearing systems is roughly proportional to frequency and often about 1/3-octave. In other words a mammal's perception of a sound at a given frequency will be strongly affected by other sounds within a 1/3-octave band around that frequency. The overall level (summing all frequencies) of a broadband sound exceeds the level in any single 1/3-octave band.

Background Measurements

Background measurements between 2 Hz and 10 kHz were collected on September 9th, 2010 when there was no vibratory pile driving occurring (Figure 2). Root Mean Square (RMS) background noise levels are reported in terms of the 30-second average continuous sound level and have been computed from the Fourier transform of pressure waveforms in 30-second time intervals. Background levels were measured at 1,046 feet from the pile.

Following the 2009 NMFS guidance on collecting and reporting underwater background noise levels each 30-second RMS value both with and without the high pass filter applied was plotted (Figure 2). Background sound levels ranged between 160 and 175 dB RMS and between was a relatively constant 150 dB RMS with the high pass filter applied. The overall average background is 165 dB RMS and 150 with the high pass filter applied. Therefore, using the either the broadband background noise level or the high pass filtered noise levels the vibratory driving noise levels will attenuate to background levels before they reach the 120 dB RMS threshold.

Airborne Noise Measurements

Conclusions

Far field measurements were taken in addition to background measurements at the SR 529, Ebey Slough Bridge project site during vibratory pile driving. The vibratory sound levels recorded are typical for 24-inch steel piles. The average broadband RMS sound levels at 1,046 feet from the pile is 174 dB RMS.

Average RMS levels measured during vibratory pile driving indicate that the Practical Spreading model is the most appropriate model for this area. Background noise levels filtered through a high pass filter were determined to be 150 dB RMS and the vibratory noise levels will attenuate to background before reaching the 120 dB RMS threshold. Therefore, the previously established biological monitoring limits should not be modified as a result of these measurements.

If you have any questions please call me at (206) 440-4643.

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