Washington State Department of Transportation

Memorandum

August 1, 2005

TO: Ken Schlatter

FROM: Jim Laughlin
(206) 440-4643

SUBJECT: Boulder Buster Test, US 101, Brinnon Washington, August 29, 2005.

This technical memorandum reports the underwater and airborne noise measurement results of the Boulder Buster test on the four piers under bridge 101/162 just north of Brinnon Washington (Figure 1). The four test firings of the Boulder Buster were conducted on August 29, 2005. No other report will be generated following this technical memorandum.

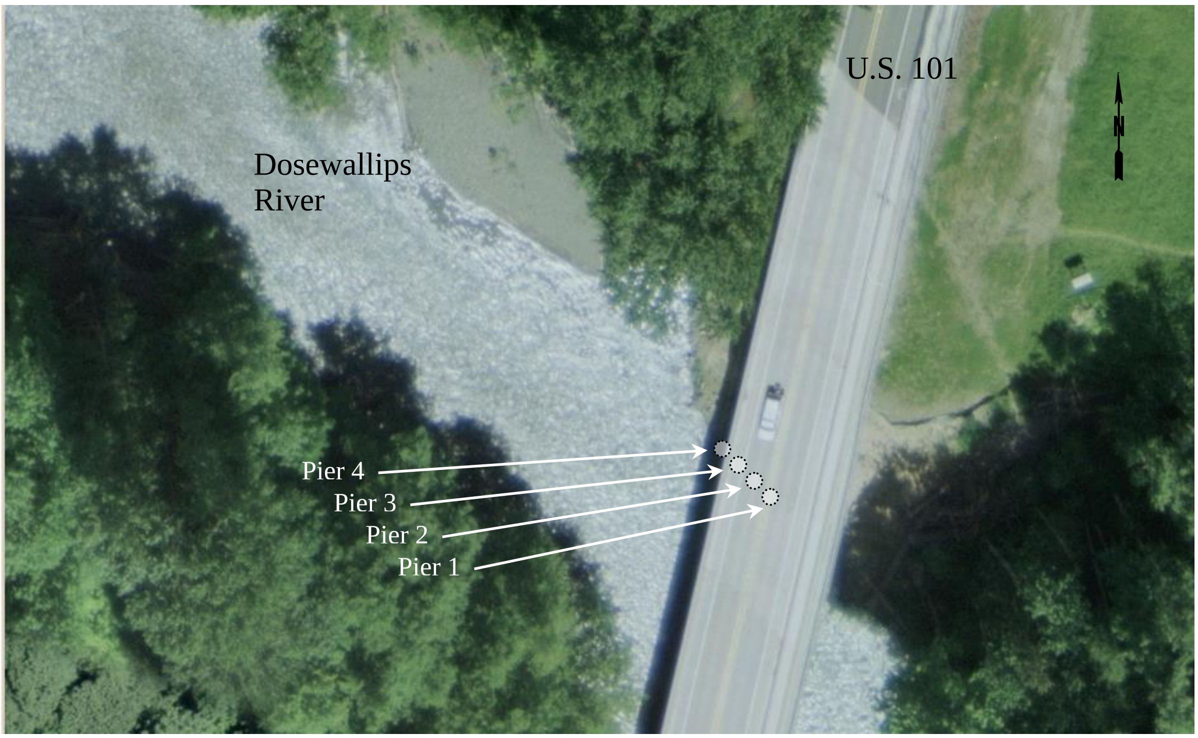


Figure 1: Vicinity map

Underwater Sound Levels

Analysis of underwater sound levels in the project area included determination of absolute peak dB, dBRMS, dBSEL (sound exposure level), and rise time. Underwater noise levels were measured on four separate concrete piers.

Two small generators were used to dewater an area where piers three and four occupied. Three to five seconds before the Boulder Buster was set off the generators were turned off to prevent interference with the noise measurements. The generators were then turned back on after the measurements were stopped.

One hydrophone was placed 33 feet from the nearest pier (pier 4) with a clear line from the pier (behind sand bags) to the hydrophone. The hydrophone was placed at mid water depth in one foot of water (six inch hydrophone depth).

The results of the four piers are shown in Table 1 below. Ambient background noise levels were approximately 152 dB without the pump generators running and 156 with the generators running.

Table 1: Summary of Underwater Sound Level Measurements

		Sound Levels @ 33 ft.				
Pier	**Pier Hole Depth (in.)**	**dB_{peak}**	**dB_{RMS}**	**dB_{SEL}**	**Rise Time (Seconds)**	**MitigationMeasures**
1	14	182	171	153	2.2	Dewatered Coffer Dam
2	40	163	151	138	6.1	Dewatered Coffer Dam
3	29	185[1]	175	157	3.0	Dewatered Coffer Dam
4	17	186	175	157	1.5	Dewatered Coffer Dam

[1] – Absolute peak level is negative for this measurement.

Waveform analysis plots for the underwater measurements are given in Appendix A. As the waveform analysis for each pier indicates all the energy is limited to frequencies below about 800 Hz. This implies that the sound generated from the blasts are all low frequencies with no higher frequencies. These lower frequencies do not propagate through water that is less than about two feet deep according to Urich, 1985.

The waveforms also indicate a relatively slow rise time and accumulation of energy. This implies that the energy from the blast is not of the intensity to cause injury to fish (Hastings and Popper, 2005).

Characteristics of Underwater Sound

Several descriptors are used to describe underwater noise impacts. Two common descriptors are the instantaneous peak sound pressure level (SPL) and the Root Mean Square (RMS) pressure level during the impulse, which are sometimes referred to as the SPL or RMS level respectively. The peak pressure is the instantaneous maximum or minimum pressure observed during each pulse and can be presented as a pressure such as Kilopascals (kPa) or decibel (dB) referenced to a standard pressure of 1 micropascal (μPa). Since water and air are two distinctly different media, a different sound pressure level reference pressure is used for each. In water, the reference pressure is 1 μPa whereas the reference pressure for air is 20 μPa. The equation to calculate the sound pressure level is:

Sound Pressure Level (SPL) = 20 log (p/p_{ref}), where p_{ref} is the reference pressure (i.e., 1 μPa for water)

The SPL or RMS level is the square root of the energy divided by the duration. This level, presented in dB re: 1 μPa, is equivalent to the mean square pressure level of the pulse. It has been used by NOAA Fisheries in criteria for judging impacts to marine mammals from underwater impulse-type sounds. The majority of literature uses peak sound pressures to evaluate injuries to fish. Except where otherwise noted, sound levels reported in this report are expressed in kPa and also converted to dB re: 1 μPa.

Rise time is another descriptor used in wave form analysis to quantify the energy being generated. Rise time is the time in microseconds (ms) it takes the wave form to go from background levels to absolute peak level.

Sound Exposure Level (SEL) frequently used for human exposures has recently been suggested as a possible metric to quantify impacts to fish (Hastings pers. comm.). SEL is calculated by squaring the energy values in micropascals collected during one impulse, typically where 95% of the energy occurs during the impulse. Then these values are cumulatively summed over the duration of the impulse. Finally the cumulative values are converted to dB and the last value to be summed is the SEL. The SEL values for selected impulses will be presented here for comparison.

Airborne Sound Levels

Airborne measurements were collected by placing a noise meter 50 feet from the nearest pier (pier #4) and setting the meter to take five-minute Laeq measurements. Ambient airborne noise levels without the generators running are approximately 60 dBA. The results of the airborne noise measurements are given in Table 2 below.

Table 2: Summary of Airborne Noise Measurement Results

Pier	Lmax	Leq
1	90	76
2	91	76
3	90	76
4	92	76

Biological Observations

No fish were observed by on-site biologists from Washington State Department of Fish and Wildlife to be stressed or injured as a result of the Boulder Buster demolition.

Appendix A

Boulder Buster - Pier 1: 33 Feet from Pile

Figure a. Waveform

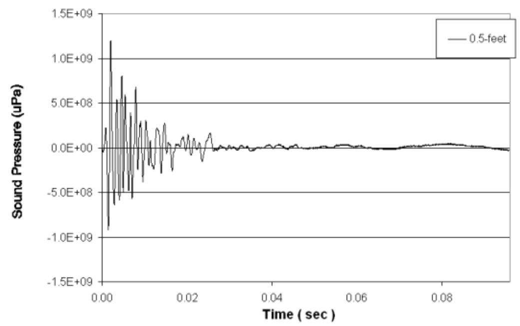


Figure b. Narrow Band Frequency Spectra

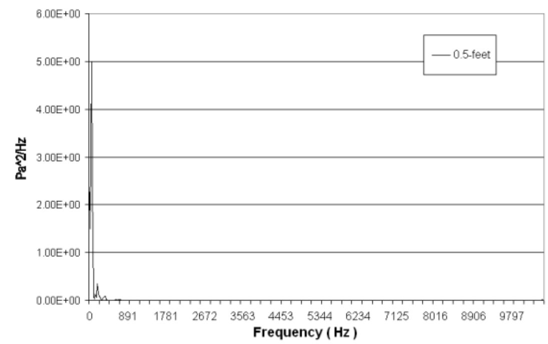


Figure c. Accumulation of Sound Energy

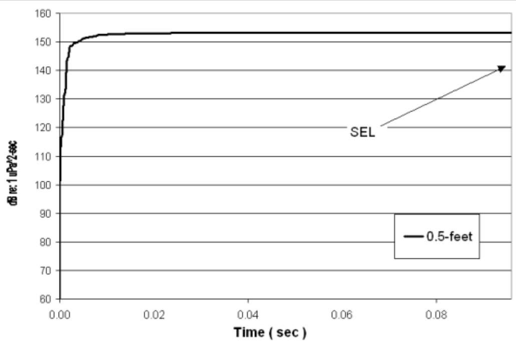


Figure d. Sound Pressure and Sound Energy Levels

Signal Analysis Sound Pressure / Energy Levels

0.5-feet - 00:00:00	Peak	RMS90%*	SEL
0.5-feet	182	171	153

*Impulse averaged over 90% of accumulated energy (5% to 95%)

Boulder Buster - Pier 2: 33 Feet from Pile

Figure a. Waveform

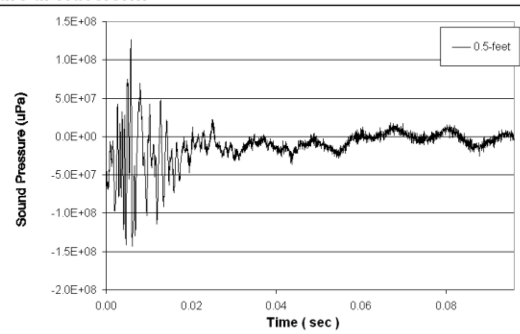


Figure b. Narrow Band Frequency Spectra

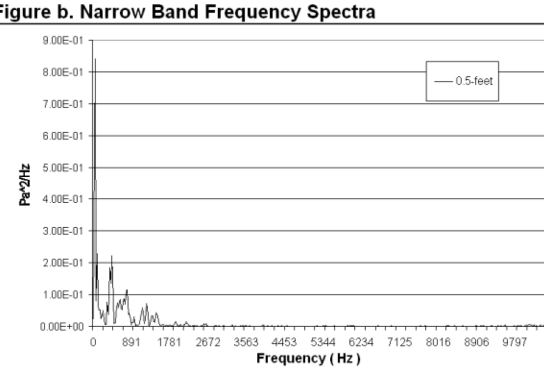


Figure c. Accumulation of Sound Energy

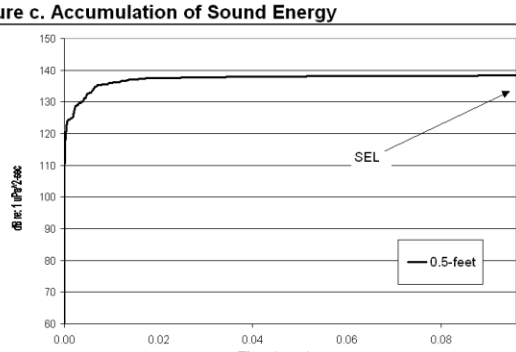


Figure d. Sound Pressure and Sound Energy Levels

Signal Analysis Sound Pressure / Energy Levels

0.5-feet - 00:00:00	Peak	RMS90%*	SEL
0.5-feet	163	151	138

*Impulse averaged over 90% of accumulated energy (5% to 95%)

Boulder Buster - Pier 3: 33 Feet from Pile

Figure a. Waveform

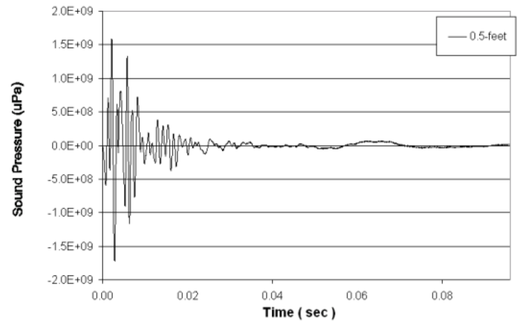


Figure b. Narrow Band Frequency Spectra

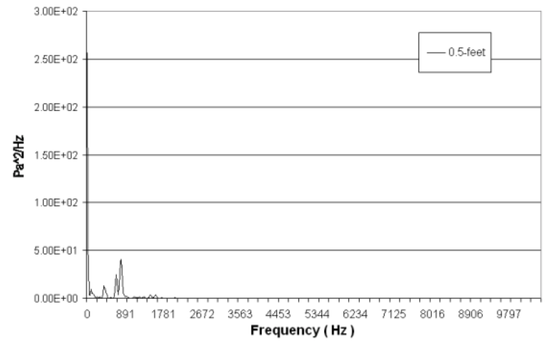


Figure c. Accumulation of Sound Energy

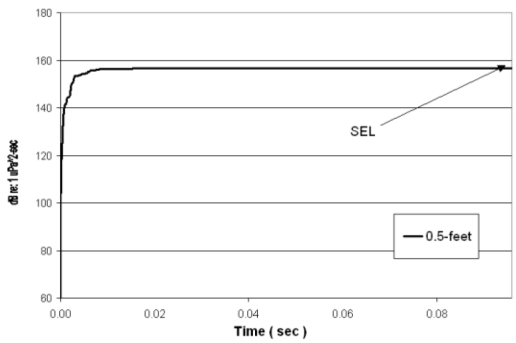


Figure d. Sound Pressure and Sound Energy Levels

Signal Analysis Sound Pressure / Energy Levels

0.5-feet - 00:00:00	Peak	RMS90%*	SEL
0.5-feet	185	175	157

*Impulse averaged over 90% of accumulated energy (5% to 95%)

Boulder Buster - Pier 4: 33 Feet from Pile

Figure a. Waveform

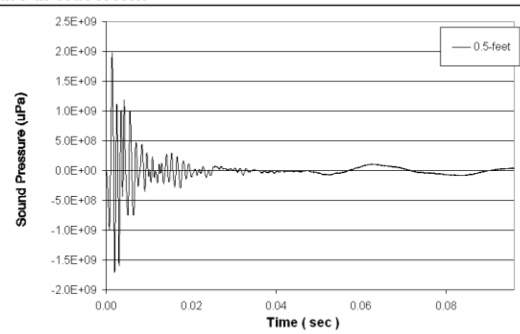
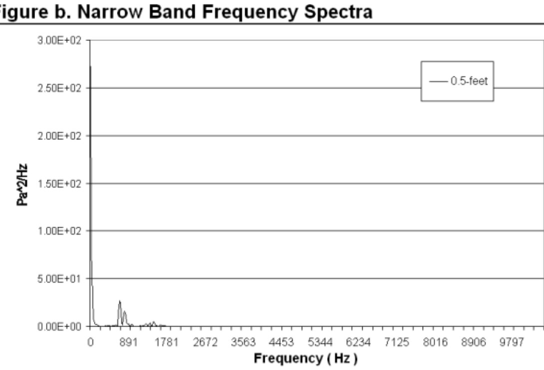


Figure b. Narrow Band Frequency Spectra



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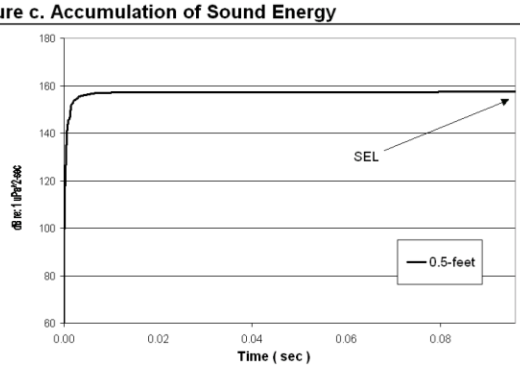

Figure d. Sound Pressure and Sound Energy Levels

Signal Analysis Sound Pressure / Energy Levels

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