December 21, 2007

TO: Paul Wolf, WSDOT

FROM: Shawn Gilbertson, WSDOT Acoustics
(206) 440-4543

SUBJECT: Sound-Level Measurements for Over-Water Geotechnical Test Boring Activities

This technical memorandum provides results of the sound-level monitoring that the WSDOT Acoustics, Air Quality and Energy group performed for the WSDOT Headquarters Regulatory Compliance Office. The acoustics group performed these measurements in support of the Statewide Programmatic Permit re-newel efforts for Sediment Test Boring / Geotechnical Survey activities. These monitoring results will be used in support of the State Environmental Policy Act (SEPA) Determination. The analysis was conducted to determine the airborne and underwater noise levels at the Mukilteo Ferry terminal during sediment test boring / geotechnical survey activities on November
8, 2007 (see figure 1).

Figure 1. Sound-Level Measurement Locations

Measurements for underwater and airborne noise were taken during the boring operations and during operational down time in order to measure ambient sound levels. The hydrophone was secured at a location of 10 meters from the boring machine at a water depth of 22.5 feet below the water surface. The overall water depth was 45 feet at the boring location. The airborne noise meter was placed on the

adjacent dock at a distance of 124 feet from the boring operation. Table 1 below summarizes the sound level results from all underwater measurements taken during the operation.

Table 1. Summary of Underwater Sound Measurement Results

Measurement	Time	Activity	Drill Depth, ft	# of strikes	Peak, dB[1]	Peak Average, dB	RMS, dB	SEL, dB[1]
Underwater 1	11:08 a.m.	Ambient	n/a	n/a	n/a	n/a	141	n/a
Underwater 2	11:09 a.m.	Hammering	32	49	181	178	158[2]	148
Underwater 3	11:26 a.m.	Drilling	37	n/a	152	151	143	n/a
Underwater 4	11:38 a.m.	Hammering	37	26	180	177	158[2]	148
Underwater 5	11:53 a.m.	Hammering	42	20	177	174	154[2]	147

*** - Underwater noise levels are reported as dB referenced to 1uPa.**

1 - Highest strike measured.

2 – Average of all strikes.

n/a – not applicable

Note: Comparatively; the WSDOT acoustics group measured a 36" steel pile in 2006 at this same general location which generated a peak value of 206 dB, an average RMS value of 195 dB, and a Sound Exposure Level (SEL) of 180 dB.

Figure 2 below shows the underwater sound energy generated during the loudest recorded strike during the boring operation.

Figure 2. Waveform Analysis - Coring

Figure a. Waveform

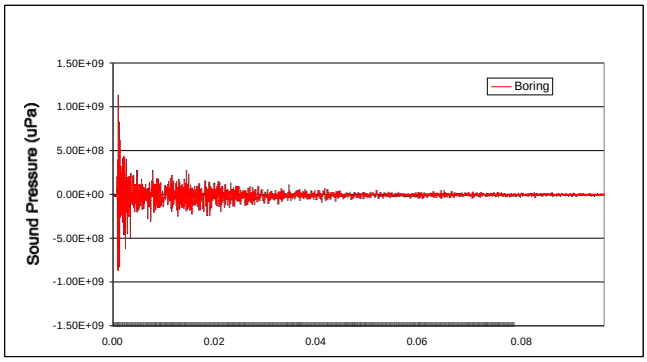

Figure b. Narrow Band Frequency Spectra

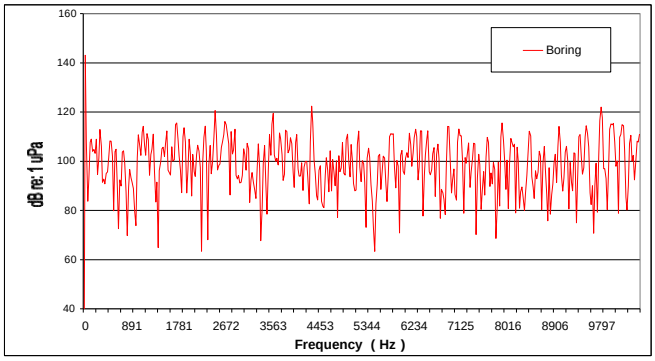

Figure c. Accumulation of Sound Energy

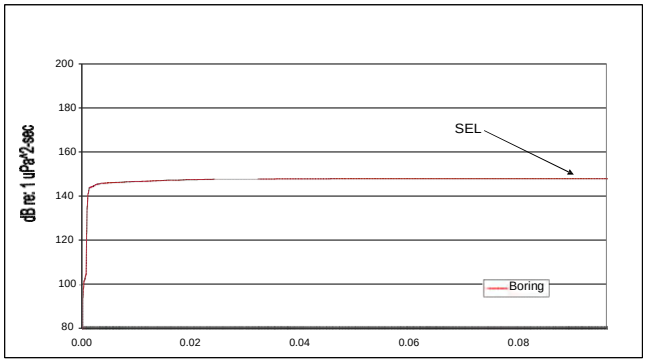

Figure d. Sound Pressure and Sound Energy Levels

Signal Analysis Sound Pressure / Energy Levels			
	Peak	RMS90%*	SEL
Boring (11/07)	181	165	148

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

For comparison, sound waveforms from a November 2006 WSDOT project where steel pile driving was conducted are overlaid on the waveforms from the November 2007 Mukilteo Ferry terminal boring operation and are depicted in figure 3 below. Figure 3 shows that the underwater sound pressure

associated with the loudest strike measured during the boring operation is significantly lower and shorter in duration than the pile strike measured in Nov 2006. Figure 3 (b) shows that the noise levels produced by the boring operation are fairly consistent across the frequency spectrum, where pile driving strikes have a heightened level of sound energy in the frequencies below 5000 Hz. Figure 3 (c) shows that the accumulated sound energy for a single strike (SEL) during the boring operation is 32 dB lower than a typical pile driving strike.

Figure 3. Waveform Comparison – Boring and 36" Pile

Figure a. Waveform

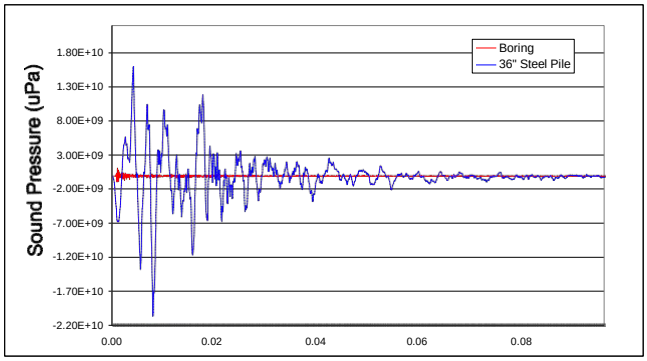

Figure b. Narrow Band Frequency Spectra

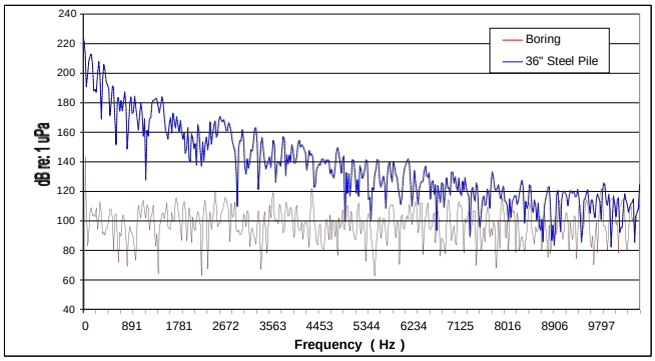

Figure c. Accumulation of Sound Energy

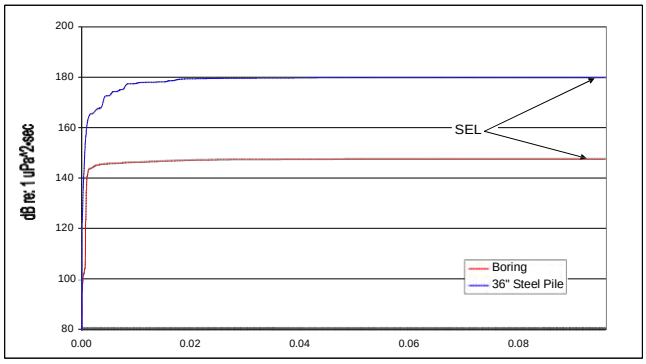

Figure d. Sound Pressure and Sound Energy Levels

Signal Analysis Sound Pressure / Energy Levels			
	Peak	RMS90%*	SEL
Boring (11/07)	181	165	148
36" Steel Pile (11/06)	206	195	180

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

Table 2. Summary of Airborne Sound Measurement Results

Measurement	Time	Activity	Drill Depth, ft	Distance from boring, ft	Leq, dBA	Lmax, dBA
Airborne 1	11:53 a.m.	Hammering	42	124	67.9	75.0
Airborne 2	12:02 p.m.	Drilling	42	124	64.7	65.3
Airborne 3	12:03 p.m.	Ambient	42	124	52.0	54.7

Note: Comparatively; the WSDOT acoustics group measured a 36" steel pile in 2006 at this same general location which generated a peak value of 94.8 dBA Lmax at a distance of 300 feet (110 dBA, Lmax when corrected to 50 feet).

Standard sound pressure calculations for point sources (such as the boring operation) show that for each doubling of distance, sound levels decrease by approximately 6 dBA over hard surfaces such as water. This would mean that at a distance of 50 feet, this operation can be expected to produce a noise level of approximately 83 dBA, Lmax.

If you have any questions please call me at (206) 440-4543.

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