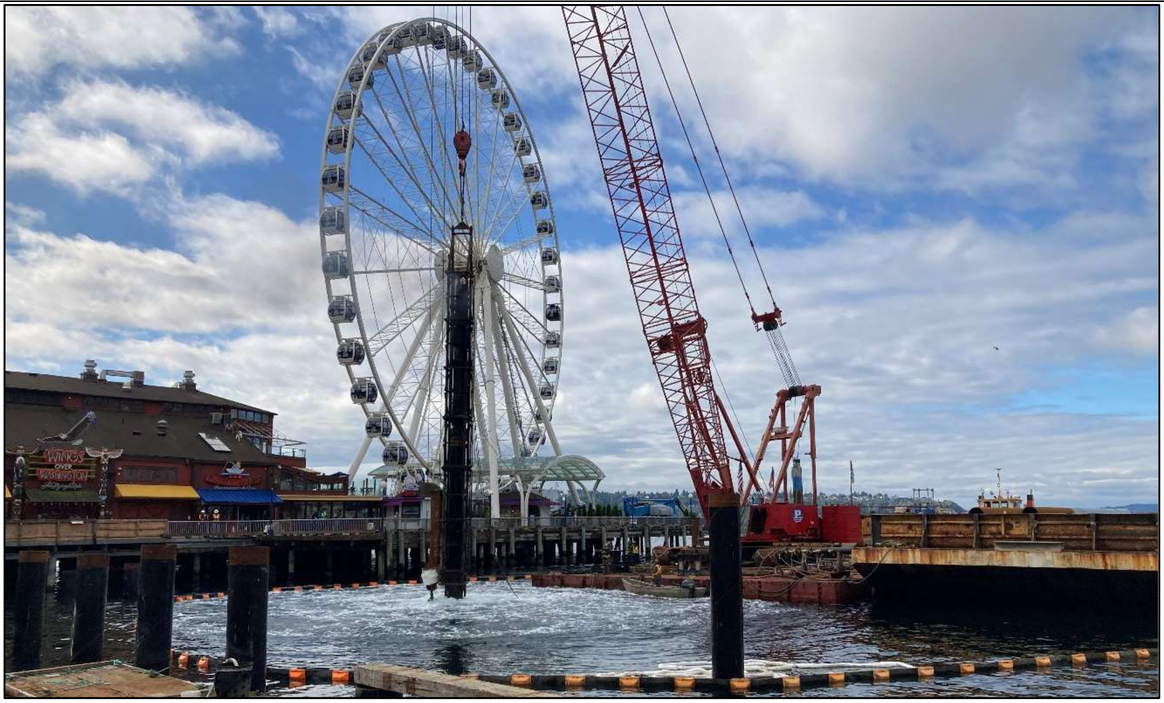
Attachment B

Pier 58 Acoustic Report



WATERFRONT PARK RECONSTRUCTION PROJECT
SEASON 2 ACOUSTIC MONITORING REPORT

May 7, 2024

Prepared For:

City of Seattle Department of Transportation

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1.0 EXECUTIVE SUMMARY

This Acoustic Monitoring Report (Report) summarizes the results of airborne and underwater sound level measurements during the installation of 30-inch diameter steel pipe piles with an APE Model 300-6 Vibratory Driver/Extractor and with an APE Model D62 diesel impact hammer. These measurements were made as part of the Waterfront Park Reconstruction Project (Project).

During vibratory pile driving, unweighted underwater 10-second root mean squared (RMS) sound levels measured by the near-field hydrophone, located 33 feet (10 meters) from the piles being driven, ranged from 126 to 178 decibels (dB) re: 1 micropascal (μPa). Ranges of underwater sound levels for each marine mammal hearing group and unweighted sound levels measured during vibratory pile driving are shown in Table 1. The highest daily unweighted cSEL measured during vibratory pile driving was 203 dB re: 1 μPa and occurred on October 2, 2023. The median airborne RMS sound level was 95 dB re: 20 μPa at 50 feet (15 meters) from the pile.

Table 1. Underwater Sound Levels – Vibratory Pile Driving, min-max (median) dB re: 1 μPa

Metric	Unweighted	Cetaceans			Pinnipeds	
		Low-Frequency	Mid-Frequency	High-Frequency	Phocid	Otariid
Peak	143-208 (173)	143-208 (173)	143-208 (173)	143-208 (173)	143-208 (173)	143-208 (173)
RMS	126-178 (157)	116-172 (150)	120-175 (151)	121-174 (152)	115-173 (146)	113-173 (145)
SEL	136-188 (167)	126-182 (160)	130-185 (161)	131-184 (162)	125-183 (156)	123-183 (155)

Note: Sound levels are normalized to 33 feet (10 meters) from piles

The median SEL measured by the far-field hydrophone was used to estimate a daily cSEL if vibratory pile driving were to occur for the maximum allowable time per day (3 hours). The resulting daily cSEL and the median RMS sound levels were used to estimate the distances for underwater sounds from vibratory pile driving to dissipate to below the injury (Level A) and disturbance (Level B) marine mammal thresholds. It was estimated that for high-frequency cetaceans up to 687 feet (209 meters) may be needed for sounds to dissipate to the Level A thresholds and up to 14 feet (4.1 meters) may be required for other marine mammal hearing groups. A distance up to 4,800 feet (1,463 meters) may be needed to reach Level B thresholds.

During impact pile driving of the 30-inch diameter piles, underwater RMS_{90} unweighted sound levels ranged from 149 to 196 dB re: 1 μPa and the highest daily unweighted cSEL was 209 dB re: 1 μPa, which occurred on October 9, 2023. The median duration of the portion of the pile strike containing 90% of the acoustical energy measured by the near-field hydrophone was 42 milliseconds. The range and median underwater sound level for each marine mammal hearing group, and unweighted sound levels are shown in Table 2. The median 1-second airborne RMS sound level measured during impact pile driving was 103 dB re: 20 μPa at 50 feet (15 meters) from the piles.

Table 2. Underwater Sound Levels – Impact Pile Driving, min-max (median) dB re: 1 μPa

Metric	Unweighted	Cetaceans			Pinnipeds	
		Low-Frequency	Mid-Frequency	High-Frequency	Phocid	Otariid
Peak	160-211 (201)	160-211 (201)	160-211 (201)	160-211 (201)	160-211 (201)	160-211 (201)
RMS_{90}	149-196 (188)	136-191 (183)	142-190 (182)	143-190 (183)	135-188 (179)	134-189 (179)
SEL	140-180 (174)	129-175 (168)	134-174 (168)	135-175 (168)	127-171 (165)	127-173 (165)

Note: Sound levels are normalized to 33 feet (10 meters) from piles

Based on the underwater sound levels measured by the far-field hydrophone during impact pile driving and the daily pile strike limit of 4,500 strikes, it was estimated that a distance of 72,871 feet (22,210 meters) would be required for underwater sound levels to dissipate to Level A marine mammal thresholds for high-frequency cetaceans, and between 34 and 1,028 feet (10 and 313 meters) for the other marine mammal hearing groups. Underwater sound levels are estimated to reach Level B marine mammal thresholds 1,232 feet (376 meters) from the piles.

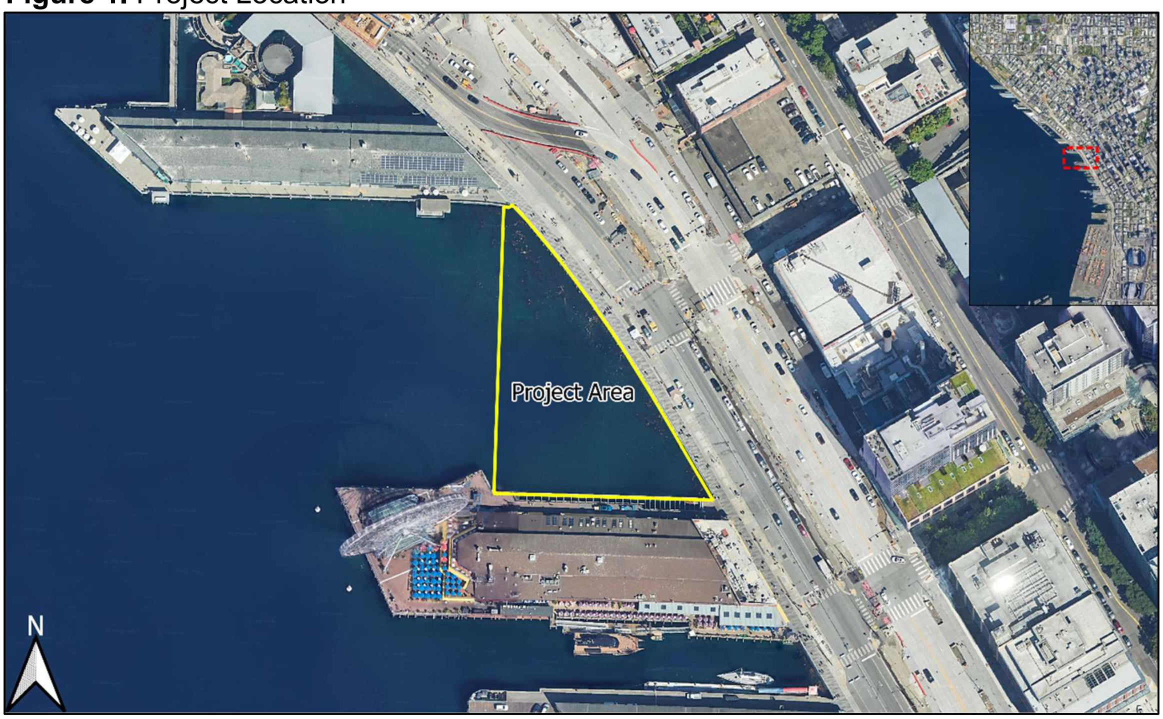
2.0 INTRODUCTION

This Report summarizes the results of airborne and underwater sound levels measured during the installation of 30-inch diameter piles with a vibratory pile driver and impact pile hammer. All measurements were conducted in October 2023.

The Marine Mammal Monitoring Plan for this Project specifies requirements for the number of days acoustic monitoring would be conducted, the number of measurement locations, signal processing, and reporting. This Report fulfills the Project's acoustic monitoring, signal processing, and reporting requirements.

The Project is located west of Alaskan Way, between University Street and Pike Street in Seattle, Washington. The Seattle Aquarium on Pier 59 is located directly north of the Project and Miners Landing on Pier 57 is south of the Project. The Project location is shown in Figure 1.

Figure 1. Project Location



3.0 NOMENCLATURE

Auditory response to sound is a complex process that occurs over a wide range of frequencies and intensities. Decibel levels, or “dB,” are a form of shorthand that compresses this broad range of intensities with a convenient, logarithmic scale.

Decibels are defined as the squared ratio of the sound pressure level (SPL) with a reference sound pressure. The reference pressure for airborne sound is 20 micropascals (μPa) and for underwater sound the reference pressure is 1 μPa. The use of 20 μPa in air is convenient because 1 dB re: 20 μPa correlates to the human threshold for hearing. It is important to note that because of these different decibel reference pressures and physical properties of water and air, airborne and underwater sound levels cannot be directly compared.

The following metrics are referenced in this Report:

- **Peak**

  The peak sound pressure level is the instantaneous absolute maximum pressure observed during a measured event. Peak pressure can be presented as a pressure or dB referenced to a standard pressure (20 μPa for airborne and 1 μPa for underwater).

- **Root Mean Square (RMS)**

  The RMS level is the square root of the average squared pressure over a given time. In hydroacoustics, the RMS level has been used by the National Marine Fisheries Service (NMFS) in criteria for assessing sound pressure impact on marine mammals.

- **90% Root Mean Square (RMS_{90})**

  The RMS_{90} level is used for the analysis of impact pile driving and is the RMS level containing 90 percent of the energy in a pile strike. The RMS_{90} energy is established between 5% and 95% of the pile energy and is calculated for each pile strike.

- **Sound Exposure Level (SEL)**

  The SEL is the squared sound pressure integrated or summed over time, referenced to a standard pressure squared (20 μPa for airborne and 1 μPa for underwater), normalized to one second, and converted to decibels.

- **Cumulative Sound Exposure Level (cSEL)**

  The cSEL is the SEL accumulated over time. In this report cSEL is calculated by combining the single strike SEL values for each pile.

4.0 REGULATORY CRITERIA

Anticipated underwater sound levels 33 feet (10 meters) from pile activities are listed in the Waterfront Park Reconstruction Project Season 2 Marine Mammal Monitoring Plan, dated September 2023 (MMM Plan), and are shown in Table 3.

Table 3. Anticipated Underwater Sound Levels, RMS dB re: 1 μPa

Type	Method	Source Sound Level
Timber pile and 14-inch steel H-pile	Vibratory Removal	145
24-inch and 16-inch steel pipe pile	Vibratory Installation and Removal	158
30-inch steel pipe pile	Vibratory Installation	170
30-inch steel pipe pile	Impact Installation	187

The MMM Plan specifies the following acoustic monitoring and reporting requirements:

- Up to four days of acoustic monitoring will be conducted with the goal of collecting data from each type of pile related activity.
- Measurements will be made with at least two hydrophones, and one microphone to record airborne sound levels. A direct line of acoustic transmission between the hydrophones and pile activities should be maintained, whenever possible.
- One hydrophone will be located 33 feet (10 meters) from the pile activities and the other hydrophone will be located approximately 3H, where H is the water depth at the pile. Due to site access and safety constraints, measurement distances may exceed 10 meters (33 feet) from the piles. Both hydrophones will be deployed near mid-water depth, but at least 3 feet (1 meter) below the surface and 3 feet (1 meter) above the seafloor.
- Results from measurements not made at 10 meters (33 feet) from the piles will be normalized to 10 meters (33 feet) using the Practical Spreading Model.
- Record sound levels continuously throughout pile installation during the monitoring period.
- Prior to monitoring, water depth will be measured to ensure the hydrophones will not drag on the bottom during tidal changes.
- Configure the hydrophones, signal conditioning, and recording equipment to acquire data without clipping.
- Underwater data will be post processed to calculate the range, logarithmic average, median, and standard deviation of peak, RMS, RMS_{90}, and SEL sound levels. The 24-hour cSEL for each day of pile driving will be reported and the frequency spectrum will be provided for each functional hearing group. All underwater source levels will be standardized to a reference distance of 33 feet (10 meters).
- Post analysis of airborne sound levels will include the range and average of unweighted RMS sound levels for each recorded pile. The average values will be used to determine the extent of the airborne isopleths relative to species specific criteria. The airborne frequency spectrum will be provided from 20 Hz to 20 kHz and all airborne source levels will be normalized to 50 feet (15 meters).
- Perform acoustic monitoring using a standardized methodology that will facilitate comparisons with other studies.

5.0 PILE AND PILE DRIVING EQUIPMENT INFORMATION

Piles installed during the monitoring period were driven to refusal with a vibratory pile driver, then an impact hammer was used for the remainder of the pile drive. Vibratory pile driving was completed using an APE Model 300-6 Vibratory Pile Driver and Extractor. The APE 300-6 operates at a maximum frequency of 1,650 VPM with a maximum driving force of 309 tons (3,079 kilonewton) and has a suspended weight of 21,200 pounds (9,616 kilograms). A cut sheet of the APE 300-6 can be found in the Appendix of this Report.

After the piles were driven to refusal with the vibratory hammer, an APE Model D62 single acting diesel impact hammer was used to drive the piles to embedment. The APE Model D62 has an energy rating of 78,956 to 153,770 foot-pounds (107,050 to 208,484 newton-meters), a piston weight of 13,669 pounds (6,200 kilograms), and a stoke length of 11.24 feet (3.42 meters). A cut sheet of the APE Model D62 diesel impact hammer can be found in the Appendix.

Photos of the APE 300-6 Vibratory Pile Driver and Extractor and APE D62 impact hammer are shown in Figure 2 and Figure 3.

Figure 2. Vibratory Pile Driver

Figure 3. Impact Pile Driver

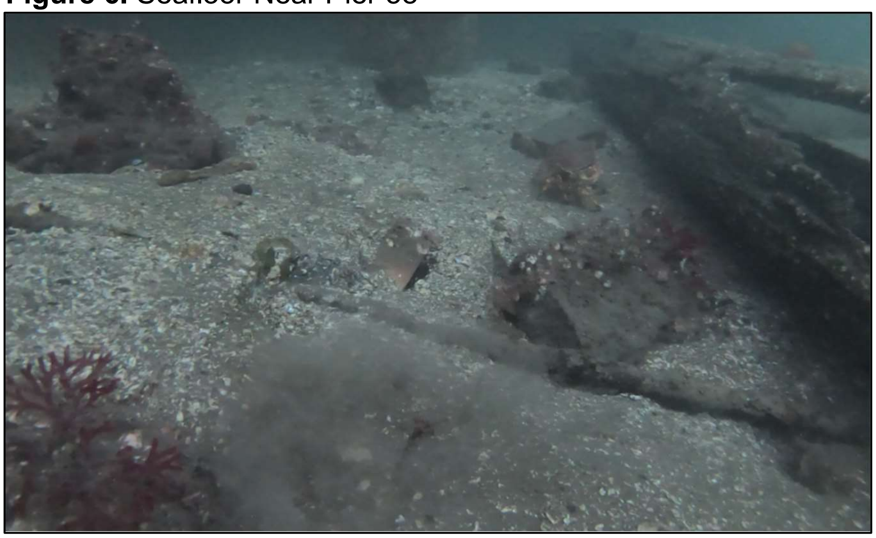
An unconfined bubble curtain was used during all impact pile driving. Photos of the bubble curtain are shown in Figure 4 and Figure 5. Design drawings of the bubble curtain are provided in the Appendix.

Figure 4. Bubble Curtain

Figure 5. Operational Bubble Curtain

The substrate the piles were driven into was generally hard, rocky, and covered with silt and marine debris. A photo of the typical seafloor is provided in Figure 6.

Figure 6. Seafloor Near Pier 58



All piles installed during Season 2 were 30-inch diameter steel pipe piles. The piles driven during the acoustic monitoring were between 99 and 127 feet (30 and 39 meters) in length. A summary of pile drives during the acoustic monitoring are shown in Table 4. This summary includes the date the pile was driven, driving method, type of sound attenuation used, approximate water depth at the pile, approximate embedment depth, and duration or number of pile strikes for each measured pile drive.

Table 4. Pile Drive Summary

Pile ID	Date	Driving Method	Sound Attenuation	Water Depth, Feet (Meters)	Embedment[1], Feet (Meters)	Duration, Seconds[2]	Number of Strikes[3]
A-6	10/2/23	Vibratory	None	37 (11)	69 (21)	640	-
B-15		Vibratory	None	19 (6)	73 (22)	2,080	-
B-16		Vibratory	None	16 (5)	64 (20)	1,160	-
C-7		Impact	Bubble Curtain	34 (10)	69 (21)	-	1,013
A-6	10/3/23	Impact	Bubble Curtain	37 (11)	69 (21)	-	847
B-11		Impact	Bubble Curtain	26 (8)	70 (21)	-	63
B-15		Impact	Bubble Curtain	19 (6)	73 (22)	-	473
B-16		Impact	Bubble Curtain	16 (5)	64 (20)	-	222
B-18		Impact	Bubble Curtain	15 (5)	64 (20)	-	72
B-12	10/9/23	Vibratory	None	23 (7)	72 (22)	790	-
		Impact	Bubble Curtain			-	921
B-13		Vibratory	None	22 (7)	72 (22)	1,320	-
		Impact	Bubble Curtain			-	899
B-14		Vibratory	None	20 (6)	72 (22)	5,030	-
		Impact	Bubble Curtain			-	899

1. Embedment depth is based on information shown in the Project’s design drawings.
2. Duration of pile drive is based on the hydroacoustic analysis and may differ from information in the pile logs.
3. The number of pile strikes are based on the hydroacoustic results and may differ from those included in the pile logs.

6.0 MEASUREMENT METHODOLOGY

The measurement equipment and methodology, including the instrumentation used to make the measurements, measurement locations and deployment methods, are discussed in Section 6.1 and Section 6.2.

6.1 Measurement Equipment

The hydroacoustic and airborne monitoring equipment used during the measurements is identified in Table 5 and Table 6. Calibration tones were recorded before and after each day of monitoring for verification of calibration factors used during post-processing. Hydrophones were calibrated using the G.R.A.S. pistonphone and the microphone was calibrated with the Larson Davis CAL200 acoustic calibrator.

Table 5. Hydroacoustic Monitoring Equipment

Make and Model	Quantity	Description	Serial Number
Brüel & Kjaer Type 2250	1	Sound Level Analyzer	3006756
Reson TC-4013	2	Hydrophone	2513032
			0712213
Brüel & Kjaer Type 2647-A	2	Charge Converter (1 mV/pC)	2582112
			2638259
Brüel & Kjaer 1704-A-002	1	Signal Conditioner	101161
G.R.A.S. Type 42AC	1	Pistonphone	201835
Tascam DR-100MKII	1	Digital Audio Recorder	0460561

Table 6. Airborne Monitoring Equipment

Make and Model	Quantity	Description	Serial Number
Svantek 979	1	Sound Level Analyzer	46177
PCB 426E01	1	Preamplifier	53673
G.R.A.S. 40 AE	1	Microphone	258193
Larson Davis CAL200	1	Acoustic Calibrator	16828

Underwater sound levels were measured using Reson TC-4013 hydrophones and Brüel & Kjaer Type 2647-A charge converters. One Reson TC-4013 hydrophone was connected to the Brüel & Kjaer Type 2250 sound level analyzer, which allowed for real-time approximations of peak sound pressure level and cSEL while the measurements were being performed. The other Reson TC-4013 hydrophone was connected to the Brüel & Kjaer 1704-A-002 signal conditioner. The signal conditioner was connected to the Tascam DR-100MKII digital audio recorder. Both the audio recorder and the Brüel & Kjaer Type 2250 sound level analyzer recorded the underwater signals as WAV files at a sample rate of 48,000 samples per second for subsequent signal analysis.

Airborne sound levels were measured using the Svantek 979 sound level analyzer, which meets the requirements of an ANSI Type 1 sound level analyzer. The airborne equipment recorded a WAV file at a sample rate of 48,000 samples per second, as well as logged 1-second unweighted RMS sound levels. 1/3 octave band RMS sound levels were also recorded at 1-second intervals.

Photographs of the monitoring equipment are provided in Figure 7 and Figure 8.

Figure 7. Hydroacoustic Equipment

Figure 8. Airborne Equipment

6.2 Measurements

Two hydrophones were used to measure underwater sound levels produced by in-water pile driving. One hydrophone was located at mid-water depth as close to 33 feet (10 meters) from the pile being driven as feasible (near-field). The second hydrophone was deployed at mid-water depth at least 3H from the activity, where H was the water depth at the location of the pile (far-field). Both hydrophones maintained an unobstructed acoustic transmission path to the piles during all pile driving activities. Due to equipment malfunctions on October 2, 2023, data from the near-field hydrophone during the installation of Pile B-15 and Pile B-16, and data from the far-field hydrophone during the installation of Pile C-7 were not valid and were excluded from the analysis.

Prior to the beginning of Season 2, pile caps and other portions of the Pier 58 superstructure were installed on top of the piles installed during Season 1. The hydrophones used during Season 2 were suspended from portions of Pier 58 that had been partially constructed. This allowed the hydrophones to be located closer to the pile activities than during Season 1. However, many of the piles were installed at a distance farther than 33 feet (10 meters) from the near-field hydrophone. During the measurements, the near-field hydrophone was positioned between 29 and 94 feet (9 and 29 meters) from the piles.

The microphone was also located on partially constructed portions of Pier 58 and was approximately 5 feet (1.5 meters) above the pier and at least 6 feet (1.8 meters) from any acoustically reflective surfaces. Distances between the microphone and pile driving ranged from 29 to 157 feet (9 to 48 meters) and a direct acoustic transmission path was maintained between the microphone and pile driving activities throughout the measurements.

The distances between the monitoring locations and the piles were measured using a laser distance measure or calculated using Project drawings and GPS coordinates of the monitoring equipment. Water depths at the hydrophone locations were measured prior to deploying the hydrophones. In addition to the water depth measurements, tidal information was obtained from NOAA Station #9447130 and was used to track tidal changes throughout the measurements. Additional information about the hydrophone locations, including the water depth at the hydrophones, depth of the hydrophones, and distances from hydrophones to piles are provided in Table 7.

Table 7. Hydrophone Location Summary, Feet (Meters)

Pile	Date	Water Depth		Hydrophone Depth		Distance to Pile	
		Near	Far	Near	Far	Near	Far
A-6	10/2/23	40(12)	16(5)	32(10)	14(4)	94(29)	155(47)
B-15[1]		-	37(11)	-	32(10)	-	140(43)
B-16[1]		-	38(12)	-	32(10)	-	153(47)
C-7[1]		43(13)	-	32(10)	-	29(9)	-
A-6	10/3/23	42(13)	20(6)	30(9)	12(4)	94(29)	159(49)
B-11		26(8)	42(13)	16(5)	30(9)	61(19)	92(28)
B-15		17(5)	39(12)	12(4)	30(9)	39(12)	143(44)
B-16		16(5)	38(12)	12(4)	30(9)	40(12)	157(48)
B-18		19(6)	49(15)	12(4)	30(9)	55(17)	185(56)
B-12	10/9/23	37(11)	42(13)	22(7)	24(7)	61(19)	103(31)
B-13		18(5)	41(12)	8(2)	24(7)	54(16)	116(35)
B-14		17(5)	40(12)	8(2)	24(7)	44(14)	129(39)

1. Due to equipment malfunction, data from the near-field location during the installation of Pile B-15 and Pile B-16 and the far-field location during the measurements of Pile C-7 have been excluded.

Figures illustrating the pile and measurement locations during each day of acoustic monitoring are provided in Figure 9 through Figure 11.

Figure 9. Pile and Measurement Locations – October 2, 2023

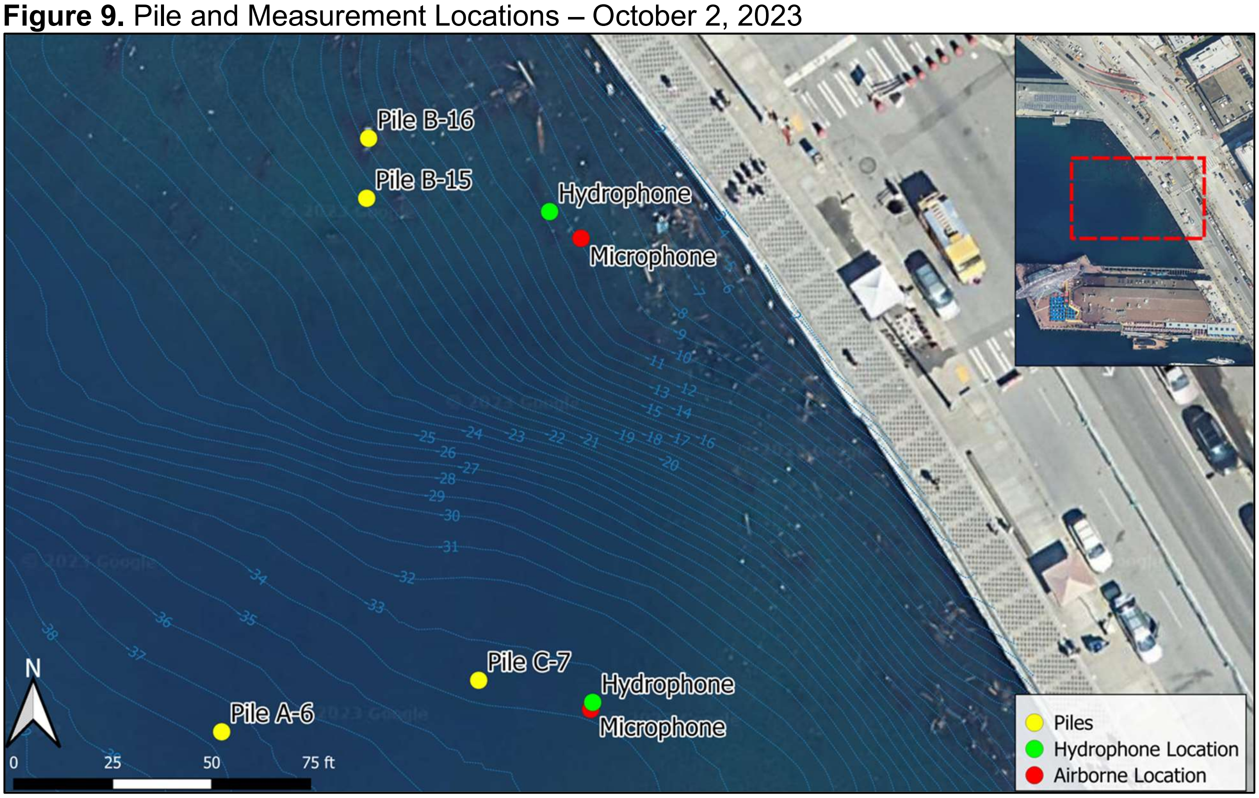


Figure 10. Pile and Measurement Locations – October 3, 2023

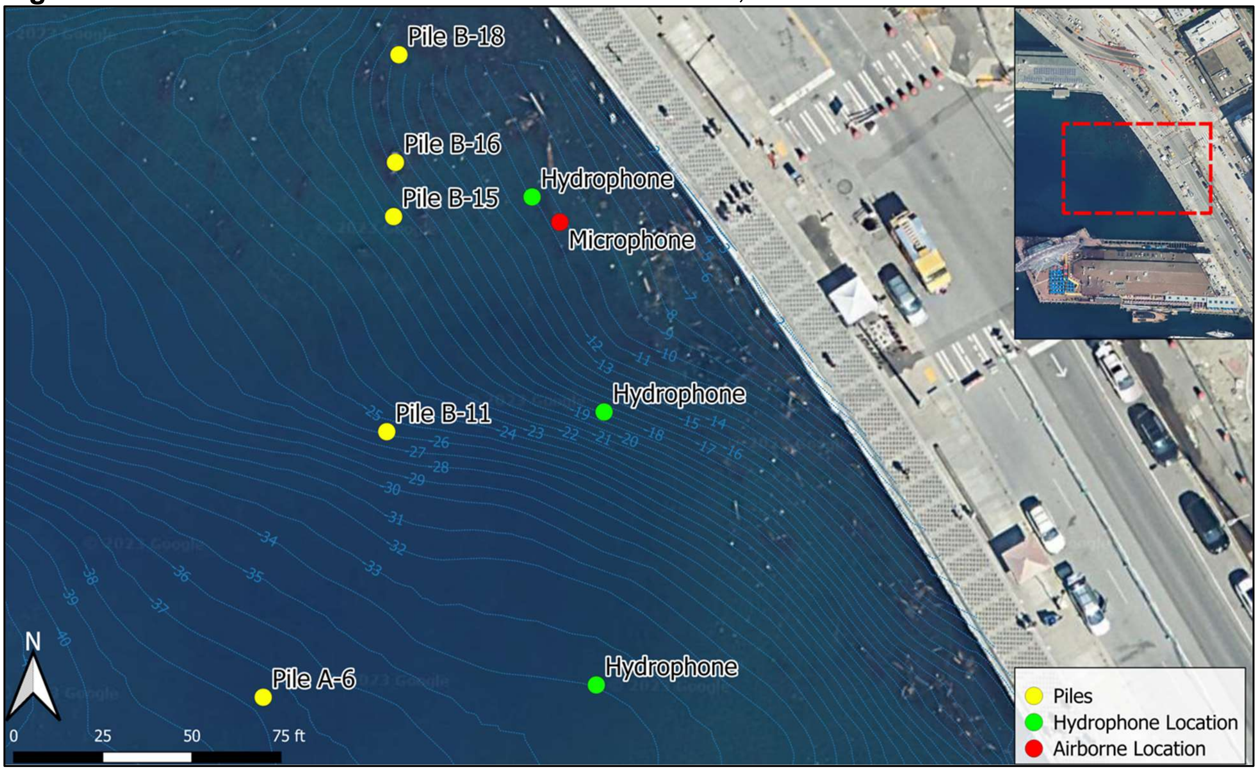
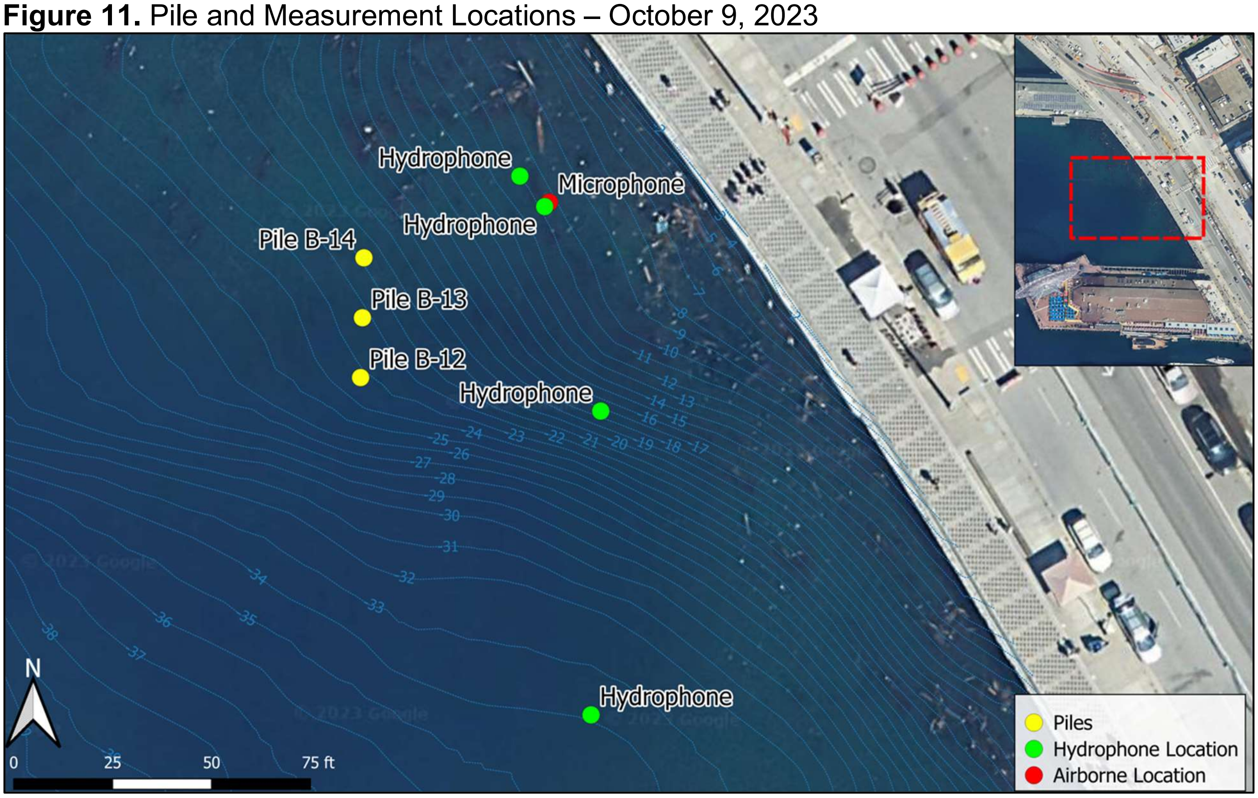


Figure 11. Pile and Measurement Locations – October 9, 2023



7.0 ANALYSIS AND RESULTS

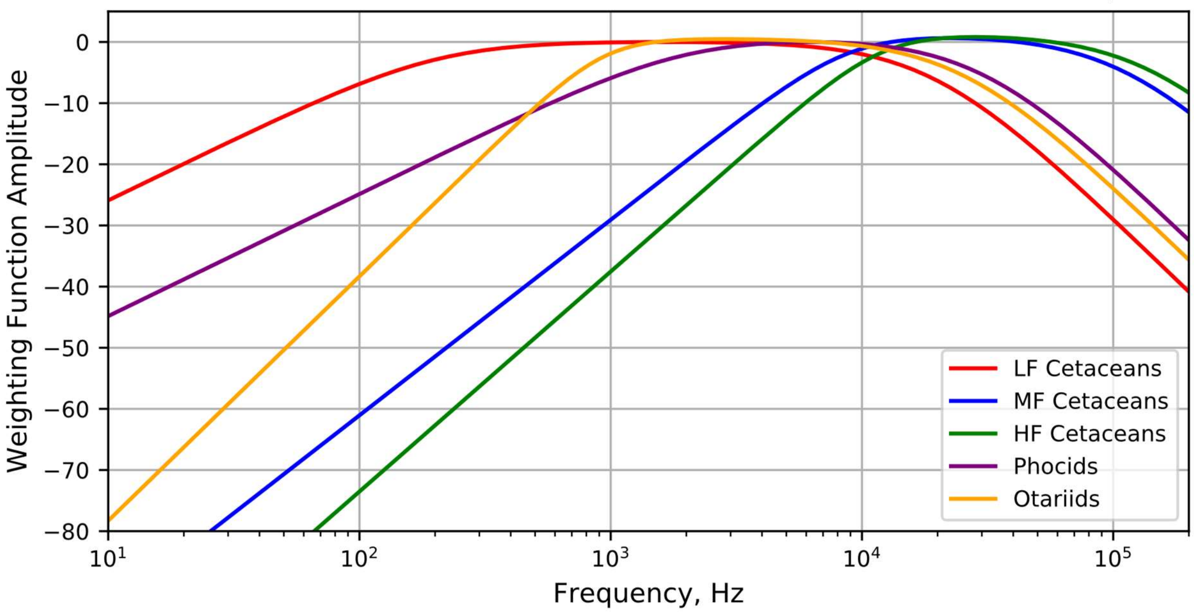
During post-processing, the hydroacoustic data were frequency-weighted for each of the marine mammal hearing groups defined in the NOAA technical guidance document titled "Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing" dated April 2018. This Technical Guidance divides marine mammals into five hearing groups, as summarized in Table 8.

Table 8. Marine Mammal Hearing Groups

Hearing Group	Generalized Hearing Frequency Range
Low-frequency (LF) cetaceans (baleen whales)	7 Hz – 35 kHz
Mid-frequency (MF) cetaceans (dolphins, toothed whales, beaked whaled, bottlenose whales)	150 Hz – 160 kHz
High-frequency (HF) cetaceans (true porpoise, *Kogia*, river dolphins, cephalorhynchid, *Lagenorhynchus cruciger & L. australis*)	275 Hz – 160 kHz
Phocid pinnipeds (PW) (underwater) (true seals)	50 Hz – 86 kHz
Otariid pinnipeds (OW) (underwater) (sea lions and fur seals)	60 Hz -39 kHz

The auditory weighting functions for each marine mammal hearing group are illustrated in Figure 12.

Figure 12. Auditory Weighting Functions for Marine Mammal Hearing Groups, dB re: 1 μPa



Underwater sound levels measured by the hydrophones were normalized to 33 feet (10 meters) from pile driving activities using the Practical Spreading Model. For additional information on the Practical Spreading Model please see Section 8.0 of this Report.

Hydroacoustic data were analyzed to determine the range, mean, median, and standard deviation of the peak, RMS, RMS_{90}, and SEL for each pile drive. Standard deviation and median sound levels were calculated from decibel levels and mean sound levels were calculated from sound pressure in pascals. The RMS sound levels and SEL values were calculated from unweighted data and for each marine mammal hearing group. Peak sound levels were calculated only from unweighted data. The cSEL for each pile were calculated by combining the

SEL values measured over the duration of each pile drive. The resulting cSEL from each pile were then combined to produce a daily cSEL. Periods when pile activities were not occurring were excluded from the analysis.

Underwater sound levels collected during vibratory pile driving were analyzed to calculate RMS sound levels and SEL over 10-second periods. The portions of each pile strike containing 90% of the acoustical energy were used to calculate RMS_{90} sound levels and single strike SEL values from impact pile driving. A SEL was calculated for each pile strike over the portion of the strike used to calculate the RMS_{90} sound level using the following formula:

$$\mathrm{SEL} = \mathrm{RMS(dB)} + 10\log_{10}(\tau)$$

Where τ is the time interval containing 90% of the acoustic energy in each pile strike.

Reported airborne sound levels were normalized to 50 feet (15 meters). Weighting functions were not applied to the airborne data during post-processing.

7.1 Vibratory Pile Driving

Underwater and airborne sound levels were measured on October 2 and October 9, 2023, during vibratory pile driving of six piles driven with an APE 300-6 vibratory hammer. An unobstructed acoustic transmission path between the piles and sensors was maintained during all vibratory pile driving.

The ranges, means, and median underwater sound levels from both hydrophones during vibratory pile driving are shown in Table 9. Airborne RMS sound levels calculated 50 feet (15 meters) from vibratory pile driving ranged from 88 to 106 dB re: 20 μPa and median RMS airborne sound levels were 95 dB re: 20 μPa. Broadband and 1/3 octave band airborne and underwater sound level summaries, and the unweighted underwater frequency spectrum from each pile are provided in the Appendix.

Table 9. Underwater Sound Levels during Vibratory Pile Driving, dB re: 1 μPa

Hearing Group	Peak				RMS				SEL			
	Max	Min	Mean	Med	Max	Min	Mean	Med	Max	Min	Mean	Med
Near-Field Hydrophone												
Unweighted	208	143	187	173	178	126	164	157	188	136	174	167
LF Cetacean					172	116	158	150	182	126	168	160
MF Cetacean					175	120	160	151	185	130	170	161
HF Cetacean					174	121	160	152	184	131	170	162
PW					173	115	158	146	183	125	168	156
OW					173	113	158	145	183	123	168	155
Far-Field Hydrophone												
Unweighted	205	142	186	174	177	128	164	158	187	138	174	168
LF Cetacean					171	120	158	151	181	130	168	161
MF Cetacean					174	122	160	152	184	132	170	162
HF Cetacean					173	123	160	152	183	133	170	162
PW					172	116	158	146	182	126	168	156
OW					172	115	158	146	182	125	168	156

Note: All sound levels are normalized to 33 feet (10 meters) from the piles.

The daily cSEL measured by the near-field hydrophone are shown in Table 10. Data collected by the far-field hydrophone was used to estimate the daily cSEL values if piles were driven for the maximum allowable driving times and are discussed in Section 8.0.

Table 10. Measured Daily cSEL during Vibratory Pile Driving, dB re: 1 μPa

Hearing Group	10/2/2023	10/9/2023
Unweighted	203	202
Low-frequency (LF) cetaceans	197	195
Mid-frequency (MF) cetaceans	199	197
High-frequency (HF) cetaceans	199	197
Phocid pinnipeds (PW)	197	194
Otariid pinnipeds (OW)	197	194

Note: Sound levels are normalized to 33 feet (10 meters) from the piles.

7.2 Impact Pile Driving

Sound levels were measured during impact pile driving on October 2, October 3, and October 9, 2023. Impact pile driving occurred after the piles had been driven to refusal by the vibratory hammer. In the case of Piles A-6, B-12, B-13, B-14 B-15, and B-16, the complete installation of the piles including both the vibratory and impact hammers were captured during the acoustic monitoring. The APE D62 impact hammer and bubble curtain were used for all impact pile driving and an unobstructed acoustic transmission path between the sensors and the piles was maintained throughout each pile drive.

Soft starts occurred at the beginning of each day of impact pile driving and were repeated if pile driving had ceased for more than 30 minutes. Soft starts occurred before driving of Pile C-7 on October 2, 2023; Pile A-6, Pile B-15, and Pile B-18 on October 3, 2023; and Pile B-14 on October 9, 2023.

On October 9, 2023, the bubble curtain was operating at a reduced capacity during the start of impact pile driving of Pile B-13. This was caught and corrected by the construction crew, who promptly increased the airflow.

The range, mean, and median underwater sound levels measured by the hydrophones during impact pile driving are shown in Table 11. The duration of the portion of the pile strike containing 90% of the acoustical energy was between 12 and 174 milliseconds with a median duration of 42 milliseconds. These durations for Piles B-15, B-16, and B-18 were the longest of the measured piles and averaged over 100 milliseconds. Airborne RMS sound levels calculated 50 feet (15 meters) from impact pile driving ranged from 84 to 109 dB re: 20 μPa and the median RMS sound level was 103 dB re: 20 μPa. Broadband and 1/3 octave band airborne sound levels and underwater sound level summaries, the waveform of the strike which generated the absolute highest peak sound pressure level, the portion of the strike containing 90% of the acoustic energy, and the unweighted underwater frequency spectrum from each pile are provided in the Appendix.

Table 11. Underwater Sound Levels during Impact Pile Driving, dB re: 1 μPa

Hearing Group	Peak				RMS_{90}				SEL			
	Max	Min	Mean	Med	Max	Min	Mean	Med	Max	Min	Mean	Med
Near-Field Hydrophone												
Unweighted	211	160	201	201	196	149	189	188	180	140	174	174
LF Cetacean					191	136	184	183	175	129	169	168
MF Cetacean					190	142	183	182	174	134	168	168
HF Cetacean					190	143	183	183	175	135	169	168
PW					188	135	180	179	171	127	165	165
OW					189	134	181	179	173	127	166	165
Far-Field Hydrophone												
Unweighted	213	147	202	201	197	136	189	189	181	128	174	174
LF Cetacean					192	127	184	184	176	120	168	169
MF Cetacean					190	132	183	183	175	125	168	168
HF Cetacean					191	132	183	183	176	125	168	169
PW					187	128	180	180	172	121	165	166
OW					189	128	181	181	173	120	166	167

Note: All sound levels are normalized to 33 feet (10 meters) from the piles.

The daily cSEL measured by the near-field hydrophone are shown in Table 12. Data collected by the far-field hydrophone was used to estimate the daily cSEL if the maximum allowable number of pile strikes were used and is discussed in Section 8.0.

Table 12. Measured Daily cSEL during Impact Pile Driving, dB re: 1 μPa

Hearing Group	10/2/2023	10/3/2023	10/9/2023
Unweighted	202	205	209
Low-frequency (LF) cetaceans	197	200	204
Mid-frequency (MF) cetaceans	197	199	203
High-frequency (HF) cetaceans	197	200	204
Phocid pinnipeds (PW)	194	196	200
Otariid pinnipeds (OW)	194	196	201

Note: Sound levels are normalized to 33 feet (10 meters) from the piles.

8.0 DISTANCE TO MARINE MAMMAL DISTURBANCE AND INJURY THRESHOLDS

Data collected during pile driving were used to estimate the distances required for underwater sound produced by pile driving to dissipate to the injury threshold (Level A), disturbance threshold (Level B), and background sound level.

In April 2018, NOAA issued updated technical guidance for determining the effects of underwater sound on marine mammals titled "Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing". The Technical Guidance utilizes dual threshold criteria for injury from impulsive sounds, such as impact pile driving. These criteria are for peak sound pressure level, and cSEL accumulated over a 24-hour period. The peak sound pressure level criteria are unweighted and the cSEL are frequency-weighted for each marine mammal hearing group. Injury criteria from non-impulsive sounds, such as vibratory pile driving and extraction, include only the 24-hour cSEL criteria. Injury thresholds provided in the Technical Guidance are summarized in Table 13.

Table 13. Injury Thresholds (Level A), dB re: 1 μPa

Hearing Group	Impulsive (Impact Pile Driving)		Non-Impulsive (Vibratory Pile Driving)
	Peak (unweighted)	cSEL (weighted)	cSEL (weighted)
Low-frequency (LF) cetaceans	219	183	199
Mid-frequency (MF) cetaceans	230	185	198
High-frequency (HF) cetaceans	202	155	173
Phocid pinnipeds (PW) (underwater)	218	185	201
Otariid pinnipeds (OW) (underwater)	232	203	219

Source: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing, April 2018

Marine mammal disturbance thresholds (Level B) from underwater sound are based on RMS sound levels from previous guidance provided by the NMFS and are shown in Table 14.

Table 14. Disturbance Thresholds (Level B), RMS dB re: 1 μPa

Marine Mammal	Disturbance Threshold	
	Vibratory Pile Driving	Impact Pile Driving
Cetaceans	120	160
Pinnipeds		

Source: National Marine Fisheries Service

The distances for underwater sound to dissipate to the marine mammal thresholds shown in Table 13 and Table 14, and background sound levels were calculated using the "practical spreading model" currently used by NOAA. The practical spreading formula is provided below.

$$\mathrm{SPL_{D2}} = \mathrm{SPL_{D1}} + \beta * \log_{10}\left(\frac{D_1}{D_2}\right)$$

Where $\mathrm{SPL_{D1}}$ is the sound pressure measured at distance, D_1 and $\mathrm{SPL_{D2}}$ is the estimated sound pressure at distance, D_2. β is the attenuation factor resulting from acoustic spreading over distance. The California Department of Transportation (Caltrans) reported in the "Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish" dated November 2015, that β can range between 5 and 30 depending upon site specific conditions such as water depth, pile type, pile length, and the substrate the pile is driven into. Currently, NOAA uses the practical spreading model with β equaling 15, which results in a 4.5 dB reduction in underwater sound levels for each doubling of distance.

The formula provided above was also used to calculate the distances for airborne noise to reach the disturbance levels for harbor seals and other pinnipeds, which is discussed later in the section. In the case of airborne noise, β is equal to 20, which is consistent with information provided in the WSDOT document "Biological Assessment Preparation for Transportation Projects-Advanced Training Manual-Version 2020" for sound propagation from a point source over hard soil.

The distances required for underwater noise to dissipate to below the marine mammal thresholds and background sound levels are estimated by solving the practical spreading formula for D_2, resulting in the following:

$$D_2 = D_1 * 10^{\left(\frac{SPL_{D1} - SP\ _{D2}}{15}\right)}$$

To estimate the distances required for underwater noise from pile driving to dissipate to the marine mammal thresholds and background sound levels, data collected by the far-field hydrophone were normalized to 33 feet (10 meters), which allowed for comparison of measured sound levels. The data collected by the far-field hydrophone was used because it provides a more accurate representation of sound levels at greater distances. After normalizing the sound levels, the median peak, RMS, RMS_{90}, and SEL were used to calculate the distance to the marine mammal thresholds and background sound levels. Instead of using the measured cSEL, the median SEL measured by the far-field hydrophone was used to calculate the daily cSEL. The measured cSEL was not used because the maximum allowable vibratory pile driving time each day (3 hours per day) and daily strike limit for impact pile driving (4,500 strikes per day) were not reached during the acoustic monitoring and therefore, the measured cSEL would not represent the maximum distance required for underwater sound levels to dissipate to the threshold criteria.

The resulting distances for underwater sound from vibratory pile driving to dissipate to the marine mammal thresholds are shown in Table 15 and distances for impact pile driving are shown in Table 16.

Table 15. Distance to Marine Mammal Thresholds during Vibratory Pile Driving, dB re: 1 μPa

Hearing Group	Measured Sound Level, dB		Marine Mammal Threshold, dB		Distance to Threshold, Feet (Meters)	
	cSEL[1]	RMS	Level A, cSEL	Level B, RMS	Level A	Level B
LF Cetaceans	191	161	199	120	10(3)	3,768(1,149)
MF Cetaceans	192	162	198		13(4)	4,377(1,334)
HF Cetaceans	193	162	173		687(209)	4,800(1,463)
Pinnipeds (Phocids)	187	156	201		4(1.1)	1,862(568)
Pinnipeds (Otariids)	186	156	219		0.2(0.06)	1,688(514)

1. Daily cSEL was calculated from the median SEL measured by the far-field hydrophone and maximum allowable duration of vibratory pile driving.

Table 16. Distance to Marine Mammal Thresholds during Impact Pile Driving, dB re: 1 μPa

Hearing Group	Measured Sound Level, dB			Marine Mammal Threshold, dB			Distance to Threshold, Feet (Meters)		
				Level A		Level B	Level A		Level B
	Peak	cSEL[1]	RMS_{90}	Peak	cSEL	RMS_{90}	Peak	cSEL	RMS_{90}
LF Cetaceans	201	205	184	219	183	160	2(0.6)	1,028(313)	1,232(376)
MF Cetaceans		205	183	230	185		0.4(0.1)	679(207)	1,040(317)
HF Cetaceans		205	183	202	155		28(9)	72,871 (22,210)	1,125(343)
Pinnipeds (Phocids)		202	180	218	185		2(0.7)	458(140)	699(213)
Pinnipeds (Otariids)		203	181	232	203		0.3(0.1)	34(10)	829(253)

1. Daily cSEL was calculated from the median SEL measured by the far-field hydrophone and maximum allowable daily pile strikes.

Disturbance thresholds from airborne noise are the same for impulsive and non-impulsive sounds and are based on RMS sound levels. The disturbance thresholds from airborne noise are provided in Table 17.

Table 17. Airborne Disturbance Thresholds, RMS dB re: 20 μPa

Marine Mammal	Disturbance Threshold (Level B)
Harbor Seal	90
Other Pinnipeds	100

The median measured 1-second RMS sound level was used to calculate the distances for airborne sound to reach disturbance thresholds for harbor seals and other pinnipeds, these distances are shown in Table 18.

Table 18. Airborne Marine Mammal Threshold Distances, dB re: 20 μPa

Driving Method	Disturbance Threshold, dB		Measured RMS Sound Level, dB	Distance to Threshold, Feet (Meters)	
	Harbor Seal	Other Pinnipeds		Harbor Seal	Other Pinnipeds
Vibratory	90	100	95	89(27)	28(9)
Impact			103	223(68)	71(22)

As shown in Table 15, up to 687 feet (209 meters) may be needed for sounds generated by vibratory pile driving to dissipate to the injury thresholds for high-frequency cetaceans and disturbance thresholds may require up to 4,800 feet (1,463 meters) to reach the disturbance thresholds. Greater distances are required to reach marine mammal thresholds from impact pile driving. Up to 22,210 feet (72,871 meters) may be required for sound to dissipate below injury thresholds for high-frequency cetaceans and up to 1,125 feet (343 meters) may be needed to reach disturbance thresholds.

The distances needed for sound to dissipate to below background sound levels were calculated using the median daytime background sound levels measured for each marine mammal hearing group between March 19 and March 22, 2018, during Season 1 of the Pier 62 Project. Pier 62 is located approximately 1,000 feet (305 meters) north of Pier 58. Background sound levels and distances to reach these background sound levels are shown in Table 19.

Table 19. Distances to Background Sound Levels, dB re: 1 μPa

Hearing Group	Background RMS Sound Level, dB	Median RMS or RMS_{90}, dB		Distance to Background, Miles (Kilometers)	
		Vibratory Pile Driving	Impact Pile Driving	Vibratory Pile Driving	Impact Pile Driving
LF Cetaceans	118	158	189	1(1.6)	147(237)
MF Cetaceans	121	151	184	0.7(1.1)	78(126)
HF Cetaceans	121	152	183	0.8(1.3)	85(137)
Phocids	115	152	183	0.8(1.2)	132(213)
Otariids	115	146	180	0.7(1.1)	157(253)

It is estimated that up to 1 mile (1.6 kilometers) may be needed for underwater RMS sound levels from vibratory pile driving to dissipate to background sound levels and RMS_{90} sound levels from impact pile driving may require up to 147 miles (237 kilometers).

9.0 MARINE MAMMAL MONITORING

Monitors observed California sea lion, harbor seal, harbor porpoise, and common bottlenose dolphin species within the monitoring zone during work activities. Monitors observed killer whales within the monitoring zone on one day when no activity was occurring, and work was delayed 30 minutes another day when killer whales were reported on Orca Network to be in the area. Aside from two instances when a California sea lion changed swimming direction at the start of hammer activity, these animals did not exhibit any changes in behavior associated with pile installation activities. Details of marine mammal monitoring are presented in a separate memorandum entitled “Waterfront Park Reconstruction Project Season 2 and Don Armeni Boat Ramp Project Marine Mammal Monitoring Report”.

10.0 REFERENCES

Anchor QEA. “Waterfront Park Reconstruction Project Season 2 Marine Mammal Monitoring Plan.” September 2023.

California Department of Transportation. “Hydroacoustic Effects of Pile Driving on Fish.” November 2015.

NMFS Northwest Region and Northwest Fisheries Science Center. “Guidance Document: Data Collection Methods to Characterize Impact and Vibratory Pile Driving Source Levels Relevant to Marine Mammals.” January 31, 2012.

NOAA. “Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts.” April 2018.

Washington State Department of Transportation. “Biological Assessment Preparation for Transportation Projects-Advanced Training Manual-August 2020.”

APPENDIX

Table of Contents

1.0 VIBRATORY PILE DRIVING

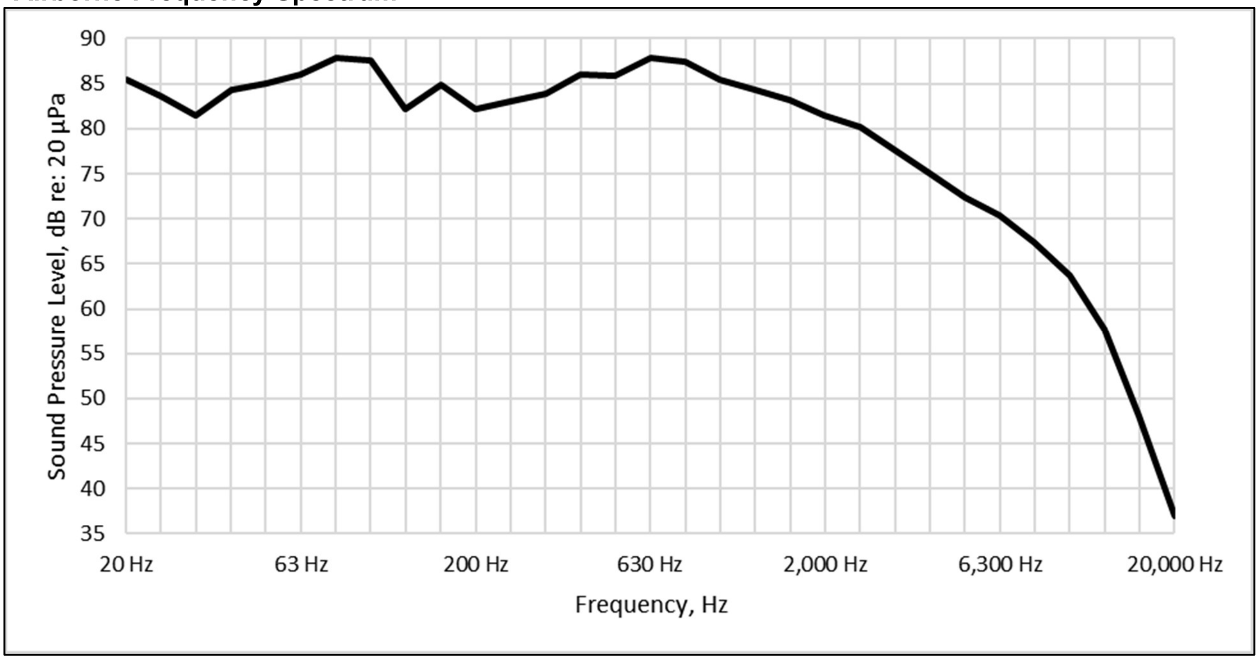
PILE A-6

October 2, 2023

Airborne Sound Levels, dB re: 20 μPa

Median	Minimum	Maximum
99	93	106

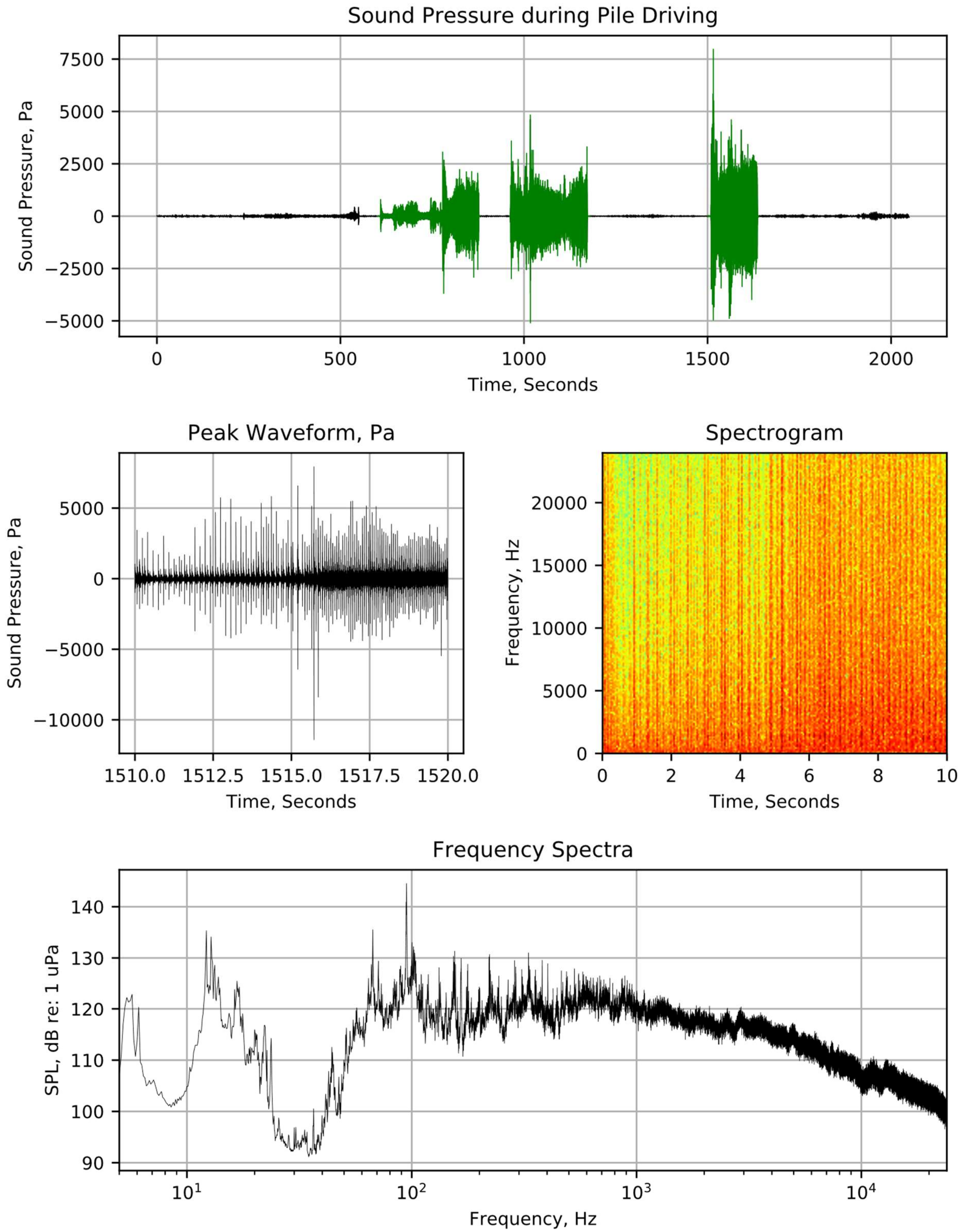
Airborne Frequency Spectrum



Underwater Sound Levels, dB re: 1 μPa

Frequency Range	Peak					RMS					SEL					cSEL
	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	
Near-Field Hydrophone																
Unweighted	208	167	8.2	197	194	178	153	5.4	173	173	188	163	5.4	183	183	201
LF Cetacean						172	147	6.6	168	168	182	157	6.6	178	178	196
MF Cetacean						175	150	6.1	170	169	185	160	6.1	180	179	198
HF Cetacean						174	150	5.9	169	169	184	160	5.9	179	179	197
PW						173	145	7.8	168	168	183	155	7.8	178	178	196
OW						173	142	8.5	168	168	183	152	8.5	178	178	196
Far-Field Hydrophone																
Unweighted	205	169	7.9	195	193	177	154	6.6	172	172	187	164	6.6	182	182	200
LF Cetacean						171	146	7.3	167	167	181	156	7.3	177	177	195
MF Cetacean						174	148	7.3	168	168	184	158	7.3	178	178	196
HF Cetacean						173	148	7.1	168	168	183	158	7.1	178	178	196
PW						172	141	8.5	167	167	182	151	8.5	177	177	195
OW						172	139	9.0	167	167	182	149	9.0	177	177	195

Note: Measurement distances normalized to 33 feet (10 meters)


Sound Pressure during Pile Driving
Sound Pressure, Pa
Time, Seconds
Peak Waveform, Pa
Sound Pressure, Pa
Time, Seconds
Spectrogram
Frequency, Hz
Time, Seconds
Frequency Spectra
SPL, dB re: 1 uPa
Frequency, Hz

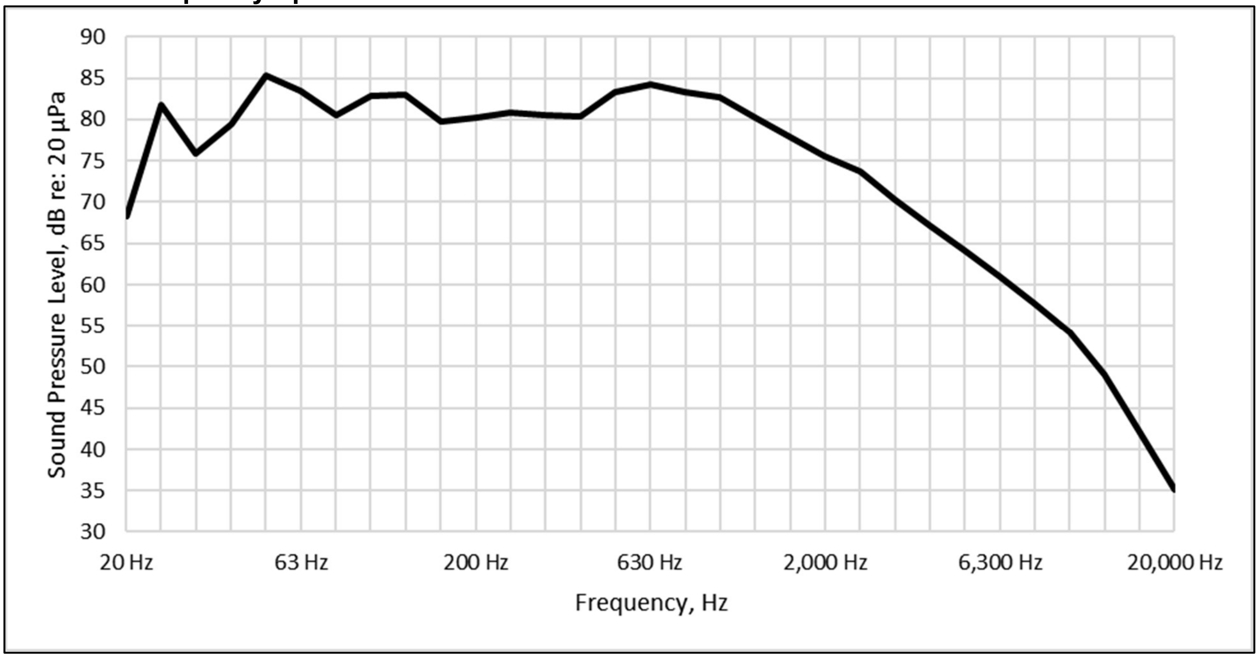
PILE B-15

October 2, 2023

Airborne Sound Levels, dB re: 20 μPa

Median	Minimum	Maximum
95	89	101

Airborne Frequency Spectrum

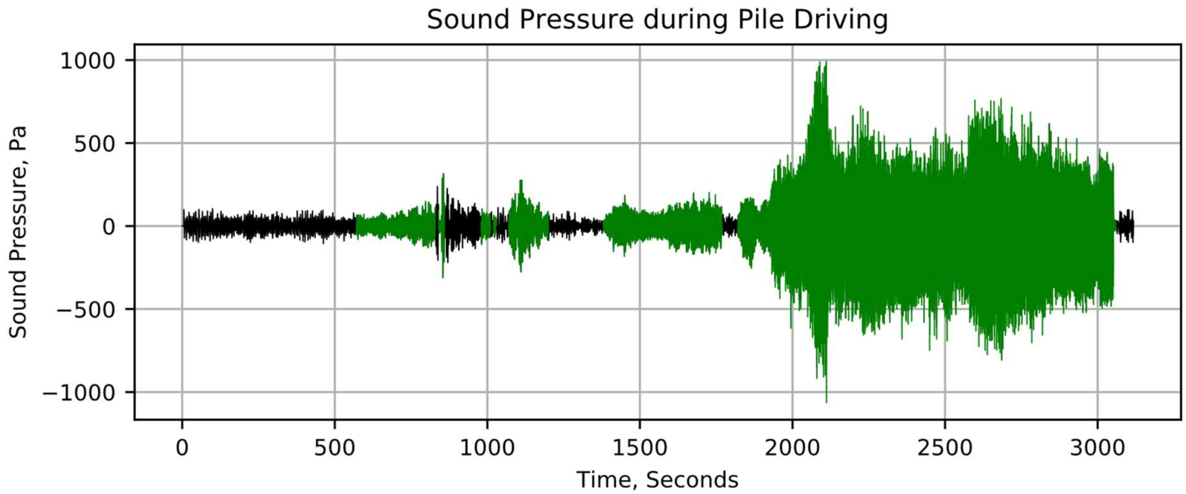


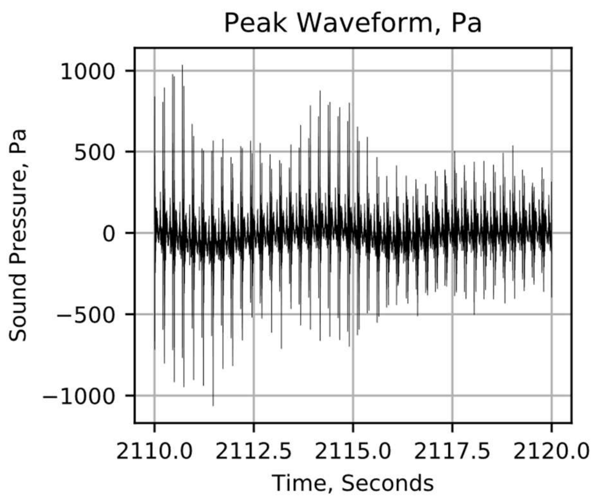
Underwater Sound Levels, dB re: 1 μPa[1]

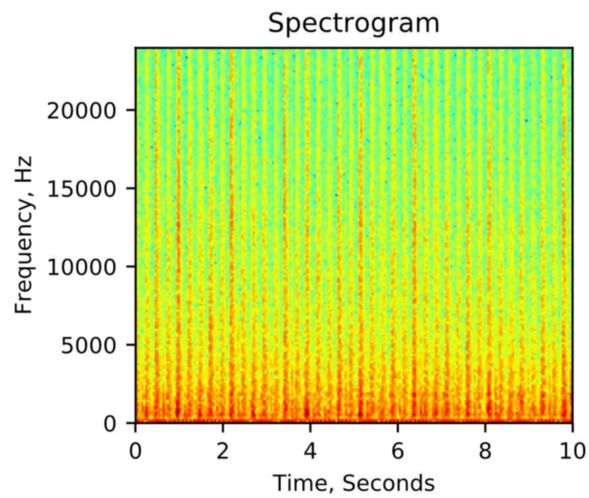
Frequency Range	Peak					RMS					SEL					cSEL
	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	
Unweighted	190	155	9.7	183	182	168	132	7.4	163	163	178	142	7.4	173	173	196
LF Cetacean						162	121	7.7	157	156	172	131	7.7	167	166	190
MF Cetacean						163	126	7.7	158	158	173	136	7.7	168	168	191
HF Cetacean						163	126	7.6	158	158	173	136	7.6	168	168	191
PW						160	121	8.8	155	154	170	131	8.8	165	164	188
OW						161	120	9.4	156	155	171	130	9.4	166	165	189

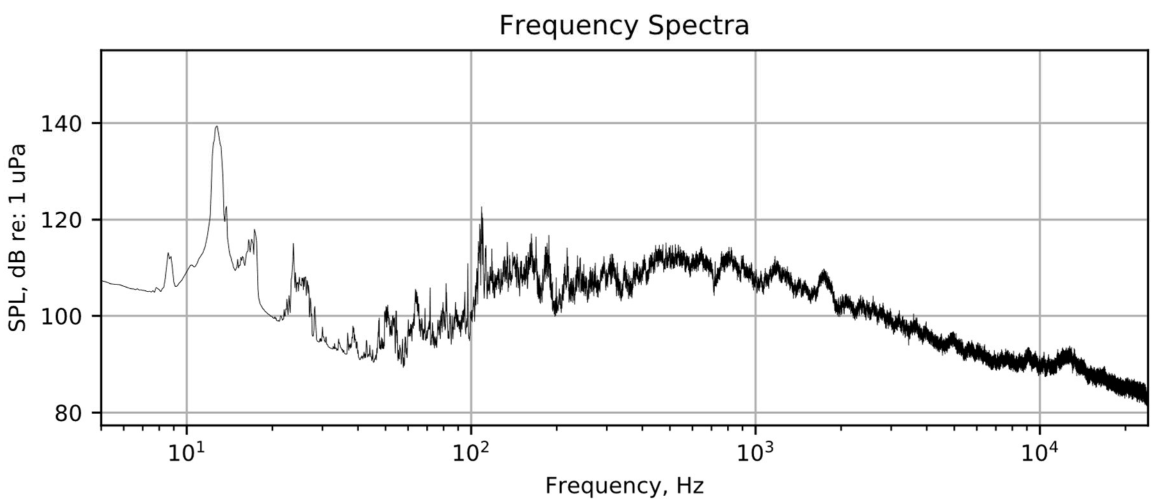
1. Due to an equipment issue data from one hydrophone has been excluded.

Note: Measurement distances normalized to 33 feet (10 meters)


Sound Pressure during Pile Driving
Sound Pressure, Pa
Time, Seconds
1000
500
0
−500
−1000
0
500
1000
1500
2000
2500
3000


Peak Waveform, Pa
Sound Pressure, Pa
Time, Seconds
1000
500
0
−500
−1000
2110.0
2112.5
2115.0
2117.5
2120.0


Spectrogram
Frequency, Hz
Time, Seconds
20000
15000
10000
5000
0
0
2
4
6
8
10


Frequency Spectra
SPL, dB re: 1 uPa
Frequency, Hz
140
120
100
80
10^1
10^2
10^3
10^4

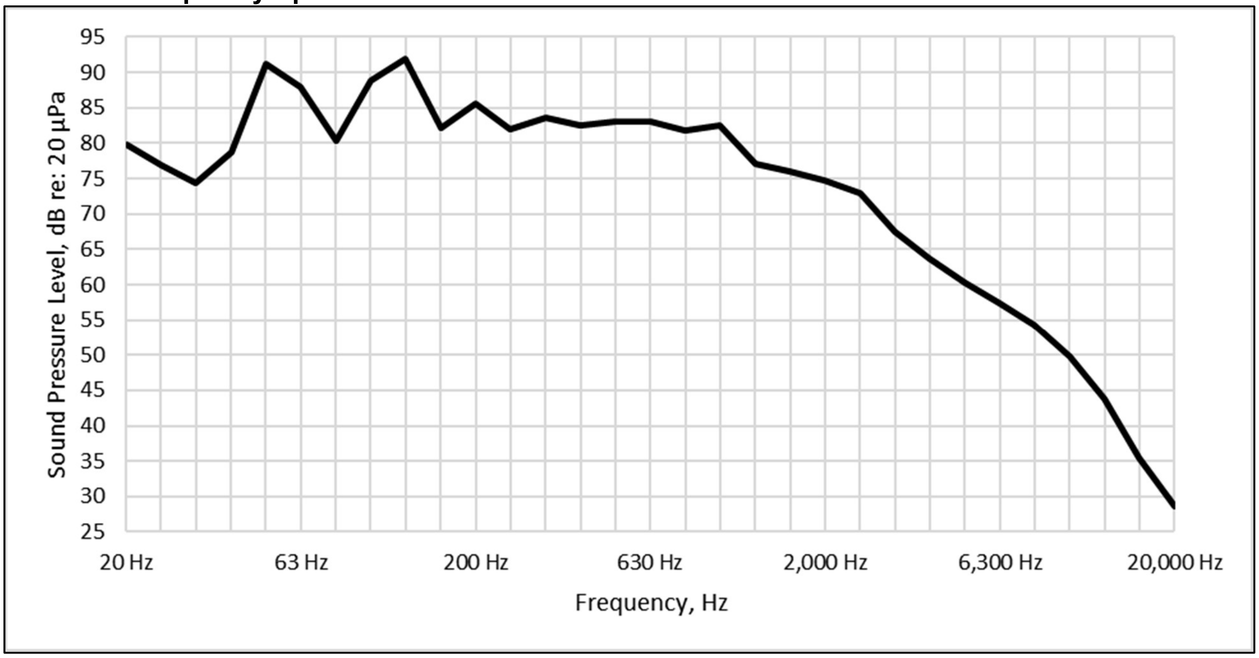
PILE B-16

October 2, 2023

Airborne Sound Levels, dB re: 20 μPa

Median	Minimum	Maximum
98	96	103

Airborne Frequency Spectrum

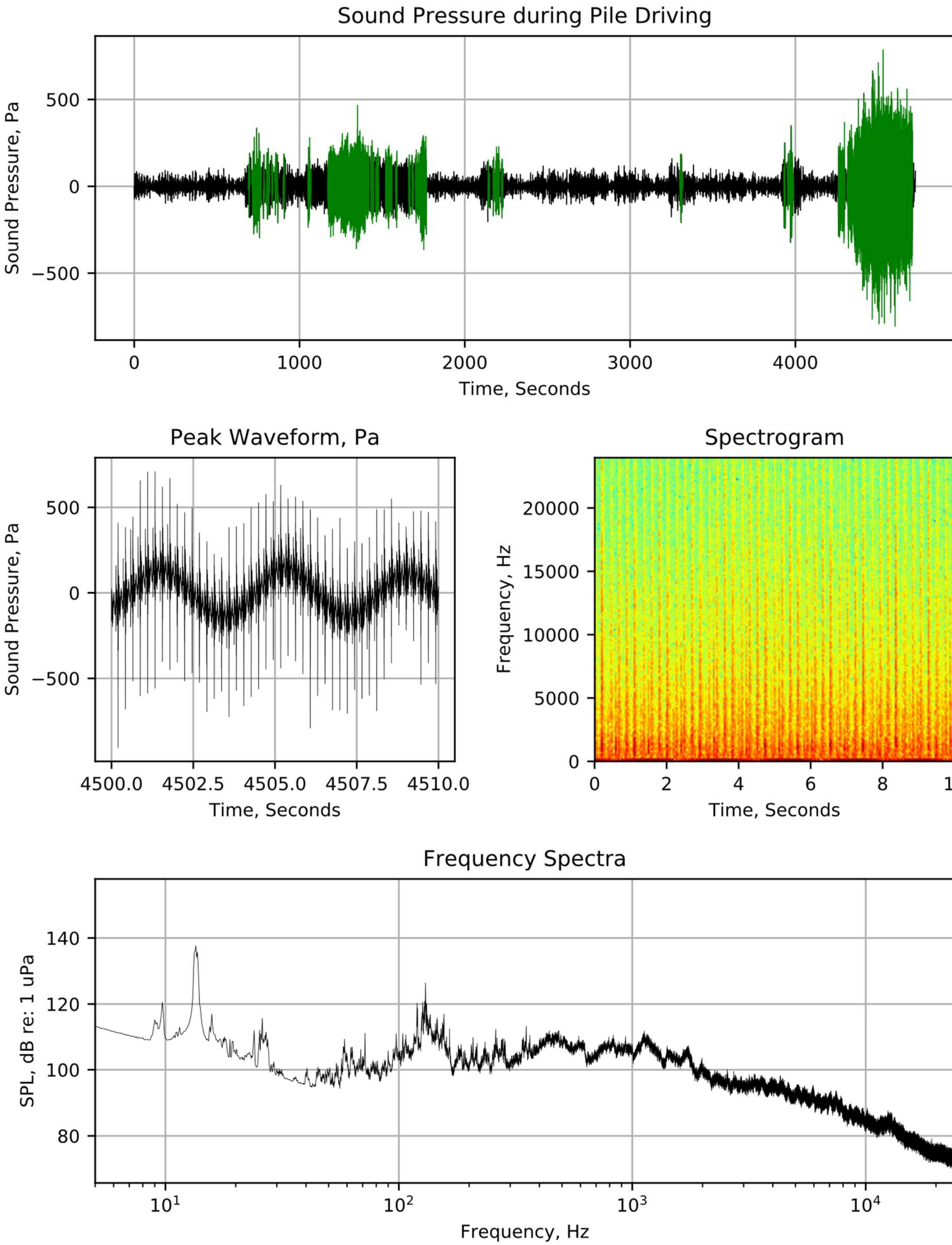


Underwater Sound Levels, dB re: 1 μPa[1]

Frequency Range	Peak					RMS					SEL					cSEL
	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	
Unweighted	188	162	6.3	182	178	166	138	7.2	161	160	176	148	7.2	171	170	191
LF Cetacean						160	123	8.8	154	153	170	133	8.8	164	163	185
MF Cetacean						161	132	7.2	155	154	171	142	7.2	165	164	186
HF Cetacean						161	132	7.2	156	154	171	142	7.2	166	164	186
PW						160	124	8.6	153	150	170	134	8.6	163	160	183
OW						160	122	9.3	154	151	170	132	9.3	164	161	184

1. Due to an equipment issue data from one hydrophone has been excluded.

Note: Measurement distances normalized to 33 feet (10 meters)


Sound Pressure during Pile Driving
Sound Pressure, Pa
Time, Seconds
Peak Waveform, Pa
Sound Pressure, Pa
Time, Seconds
Spectrogram
Frequency, Hz
Time, Seconds
Frequency Spectra
SPL, dB re: 1 uPa
Frequency, Hz

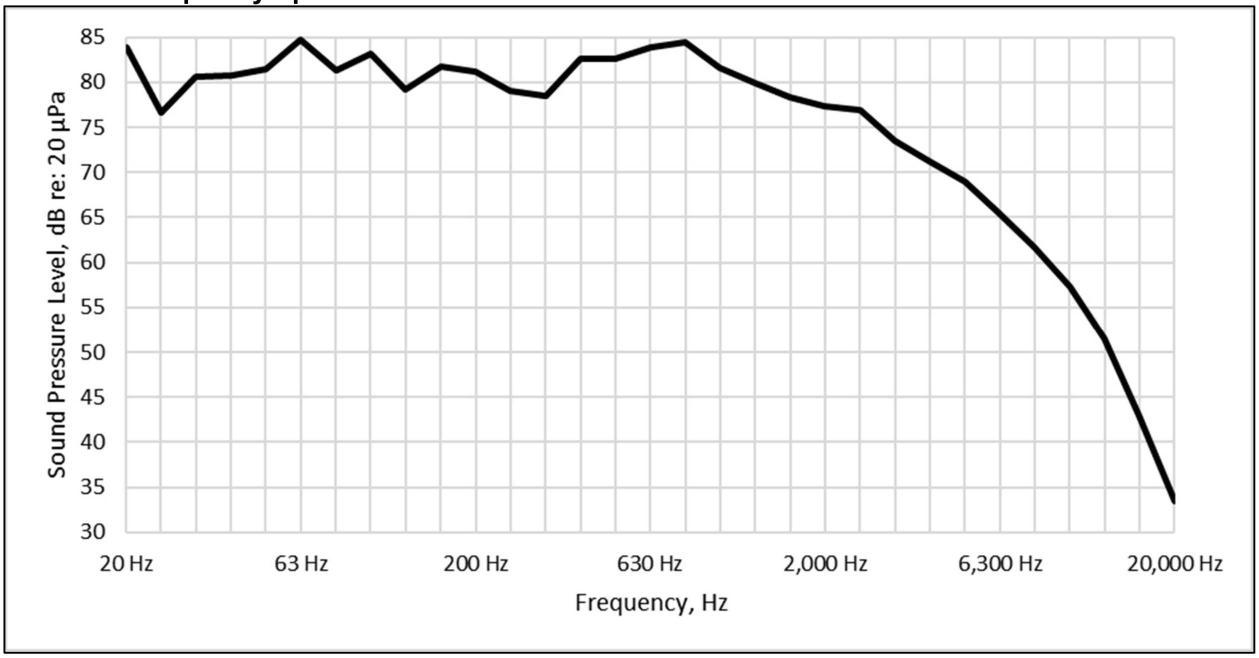
PILE B-12

October 9, 2023

Airborne Sound Levels, dB re: 20 µPa

Median	Minimum	Maximum
93	88	101

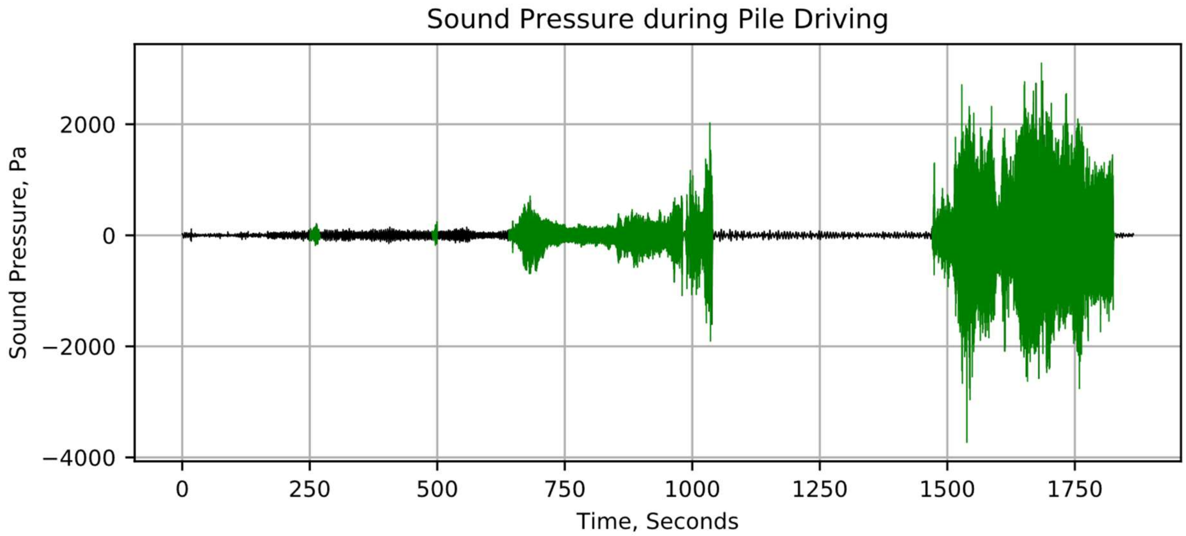
Airborne Frequency Spectrum

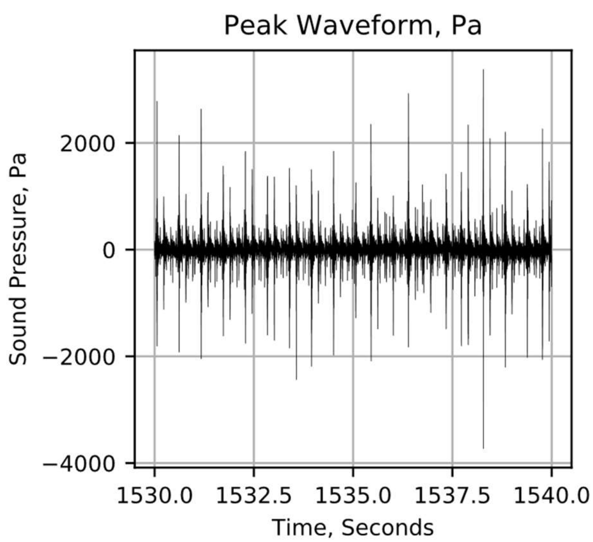


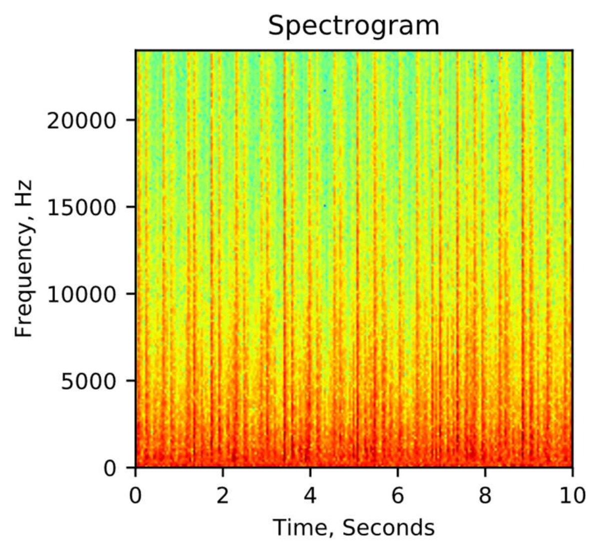
Underwater Sound Levels, dB re: 1 µPa

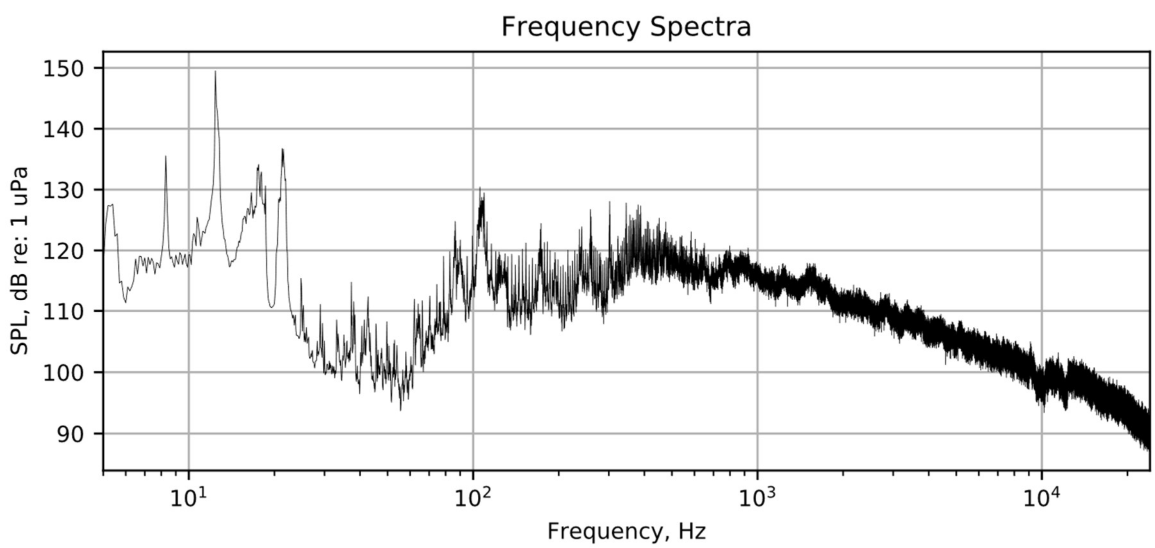
Frequency Range	Peak					RMS					SEL					cSEL
	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	
Near-Field Hydrophone																
Unweighted	195	166	8.9	189	184	171	149	5.4	165	162	181	159	5.4	175	172	194
LF Cetacean						166	142	6.1	159	155	176	152	6.1	169	165	188
MF Cetacean						167	143	6.1	161	156	177	153	6.1	171	166	190
HF Cetacean						167	144	5.9	161	157	177	154	5.9	171	167	190
PW						164	138	7.5	158	152	174	148	7.5	168	162	187
OW						165	137	7.9	159	153	175	147	7.9	169	163	188
Far-Field Hydrophone																
Unweighted	197	168	8.6	189	186	172	153	5.0	167	164	182	163	5.0	177	174	196
LF Cetacean						167	144	6.3	161	157	177	154	6.3	171	167	190
MF Cetacean						167	147	5.5	162	158	177	157	5.5	172	168	191
HF Cetacean						167	147	5.3	162	158	177	157	5.3	172	168	191
PW						166	141	7.4	160	155	176	151	7.4	170	165	189
OW						167	139	8.0	161	155	177	149	8.0	171	165	190

Note: Measurement distances normalized to 33 feet (10 meters)


Sound Pressure during Pile Driving
Sound Pressure, Pa
2000
0
−2000
−4000
0
250
500
750
1000
1250
1500
1750
Time, Seconds


Peak Waveform, Pa
Sound Pressure, Pa
2000
0
−2000
−4000
1530.0
1532.5
1535.0
1537.5
1540.0
Time, Seconds


Spectrogram
Frequency, Hz
20000
15000
10000
5000
0
0
2
4
6
8
10
Time, Seconds


Frequency Spectra
SPL, dB re: 1 uPa
150
140
130
120
110
100
90
10^1
10^2
10^3
10^4
Frequency, Hz

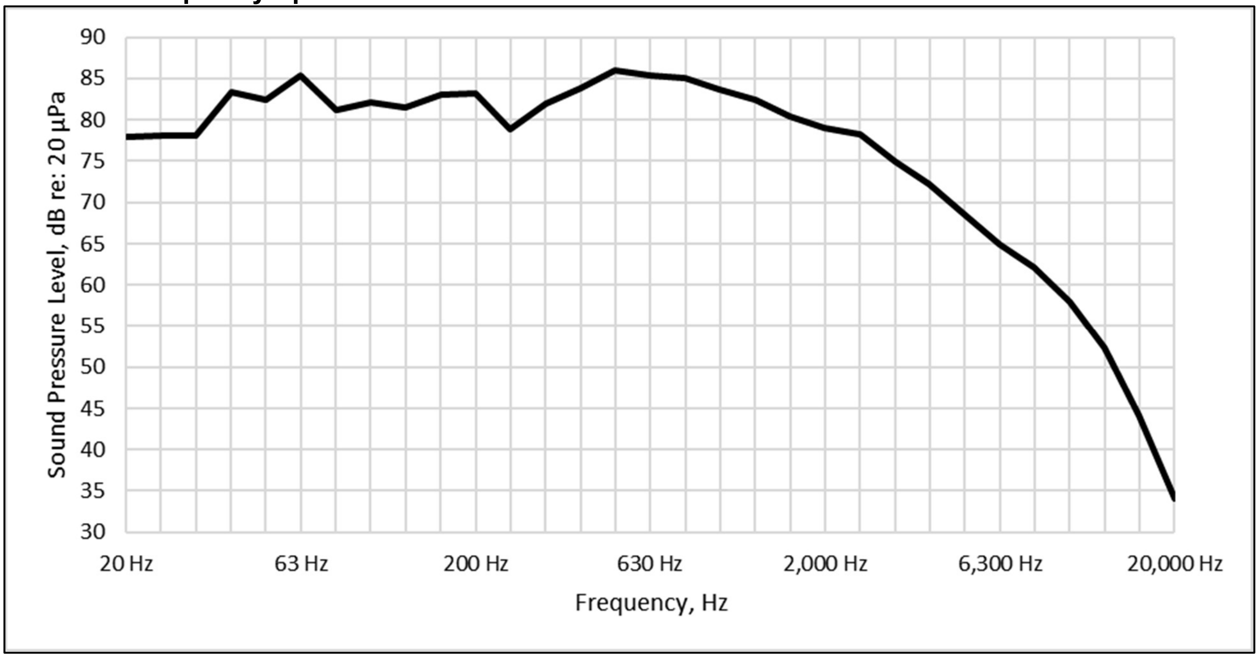
PILE B-13

October 9, 2023

Airborne Sound Levels, dB re: 20 μPa

Median	Minimum	Maximum
96	89	101

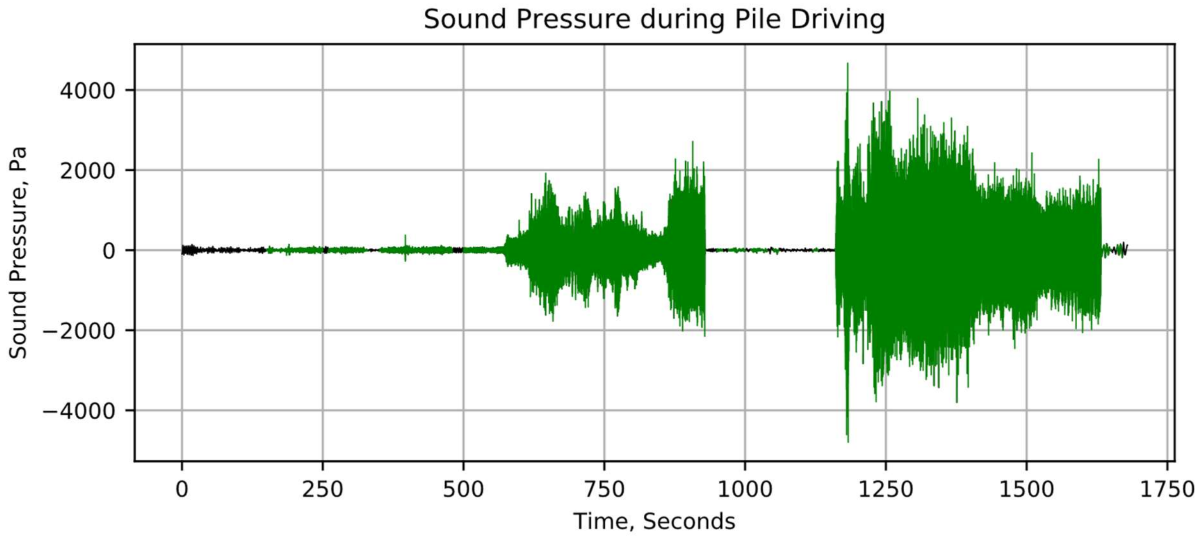
Airborne Frequency Spectrum

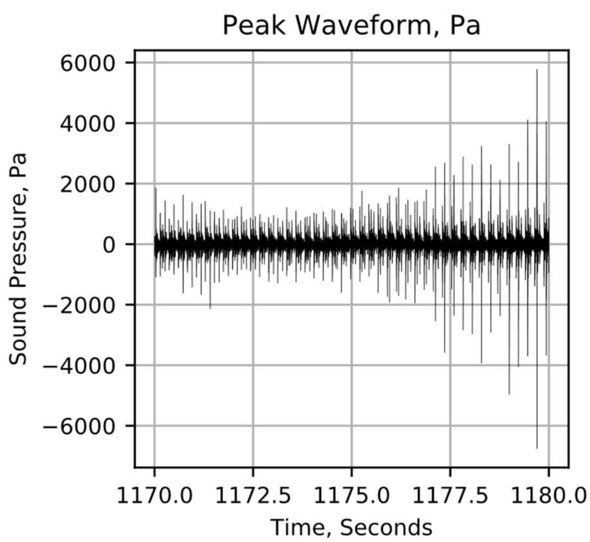


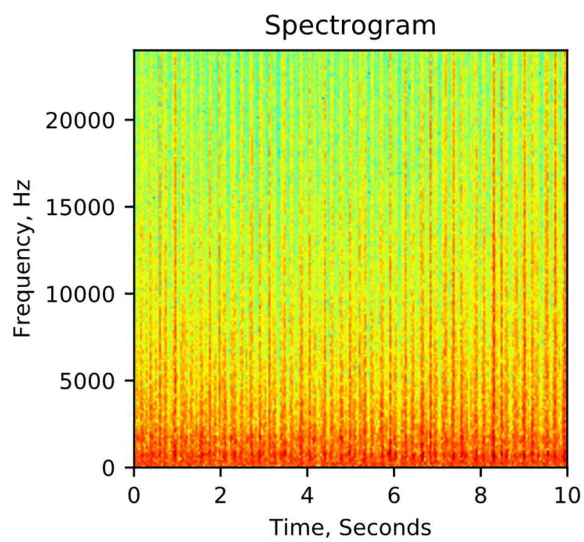
Underwater Sound Levels, dB re: 1 μPa

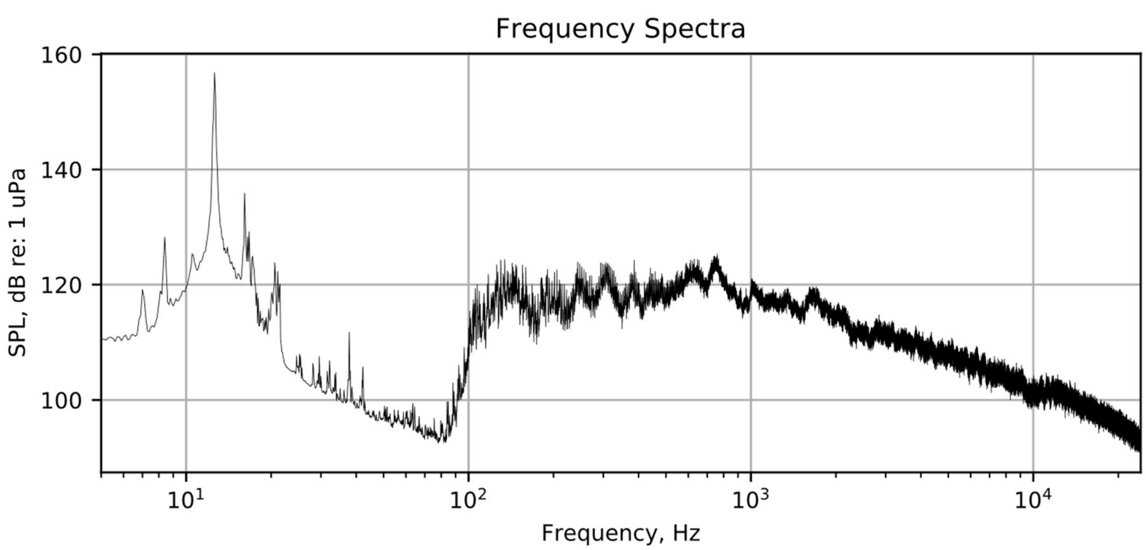
Frequency Range	Peak					RMS					SEL					cSEL
	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	
Near-Field Hydrophone																
Unweighted	200	149	16.0	190	186	173	126	14.4	168	164	183	136	14.4	178	174	199
LF Cetacean						167	119	14.6	161	159	177	129	14.6	171	169	192
MF Cetacean						169	120	14.6	163	159	179	130	14.6	173	169	194
HF Cetacean						169	121	14.5	163	159	179	131	14.5	173	169	194
PW						167	115	15.3	160	156	177	125	15.3	170	166	191
OW						167	114	15.7	160	157	177	124	15.7	170	167	192
Far-Field Hydrophone																
Unweighted	201	148	15.2	189	186	173	133	12.0	167	165	183	143	12.0	177	175	198
LF Cetacean						167	126	12.7	161	159	177	136	12.7	171	169	192
MF Cetacean						168	128	12.4	162	159	178	138	12.4	172	169	193
HF Cetacean						168	128	12.2	162	160	178	138	12.2	172	170	193
PW						167	124	13.7	160	157	177	134	13.7	170	167	191
OW						167	121	14.1	161	158	177	131	14.1	171	168	192

Note: Measurement distances normalized to 33 feet (10 meters)


Sound Pressure during Pile Driving
Sound Pressure, Pa
4000
2000
0
−2000
−4000
0
250
500
750
1000
1250
1500
1750
Time, Seconds


Peak Waveform, Pa
Sound Pressure, Pa
6000
4000
2000
0
−2000
−4000
−6000
1170.0
1172.5
1175.0
1177.5
1180.0
Time, Seconds


Spectrogram
Frequency, Hz
20000
15000
10000
5000
0
0
2
4
6
8
10
Time, Seconds


Frequency Spectra
SPL, dB re: 1 uPa
160
140
120
100
10^1
10^2
10^3
10^4
Frequency, Hz

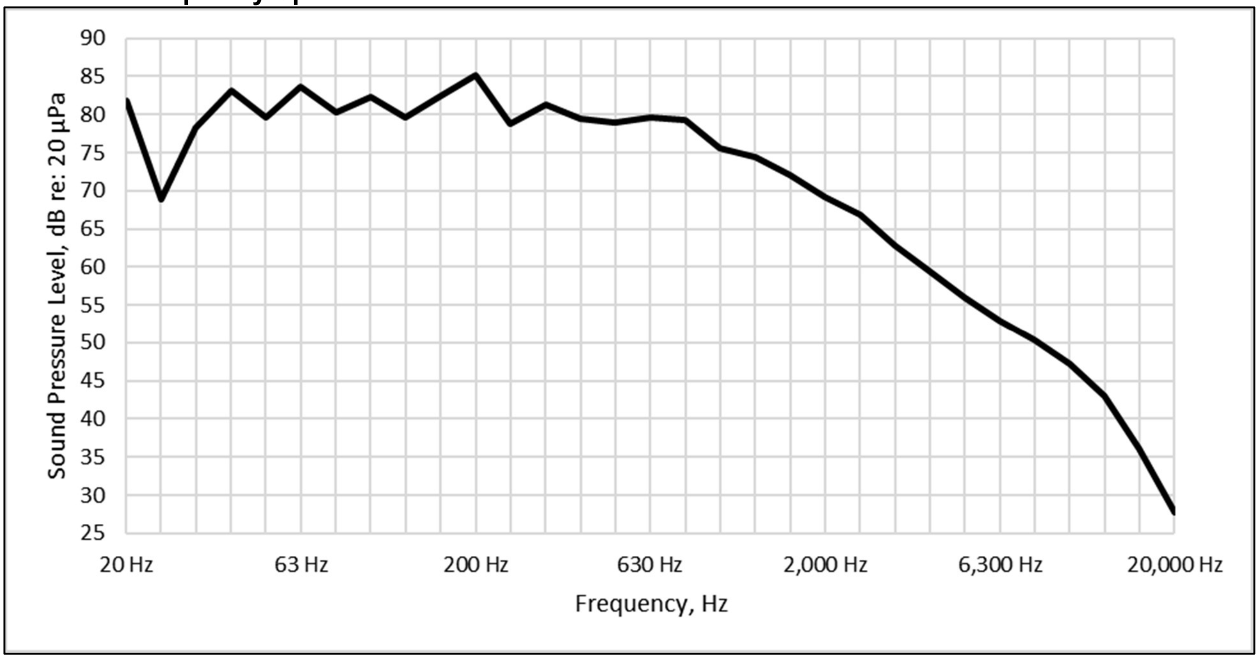
PILE B-14

October 9, 2023

Airborne Sound Levels, dB re: 20 μPa

Median	Minimum	Maximum
93	90	102

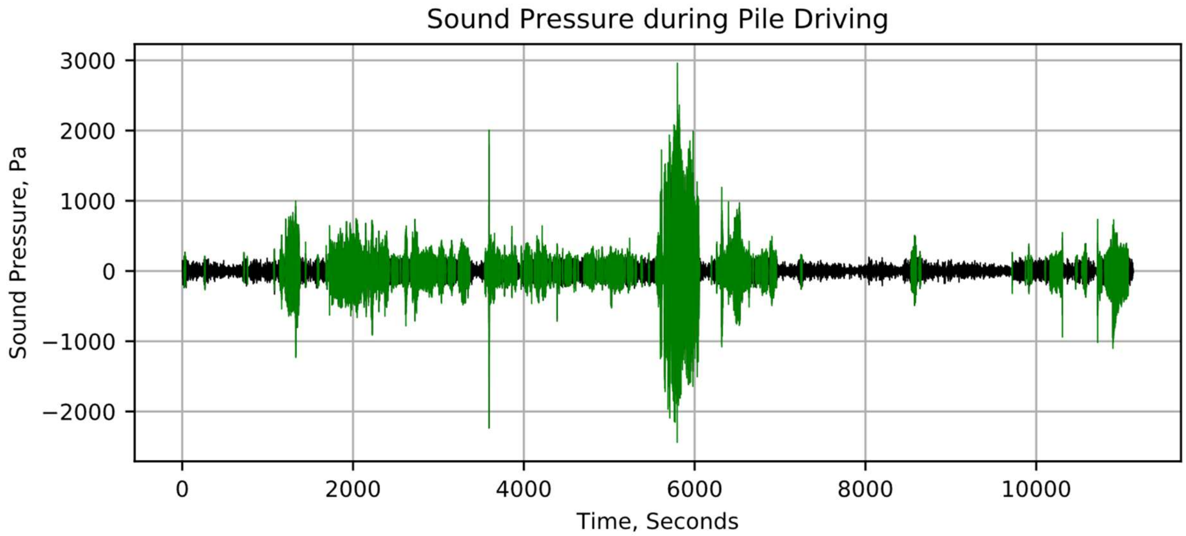
Airborne Frequency Spectrum

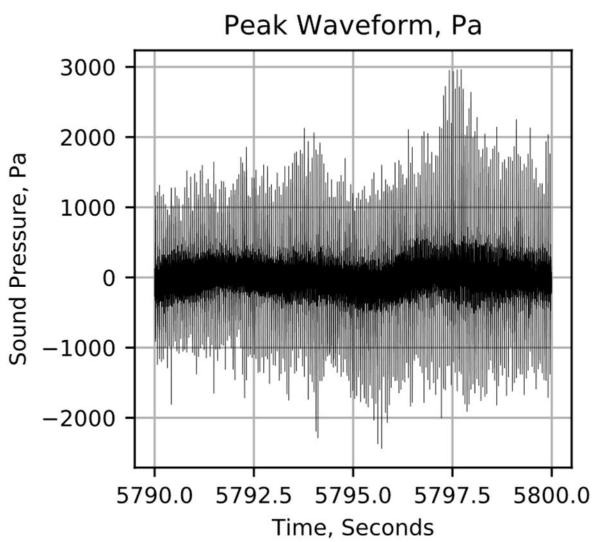


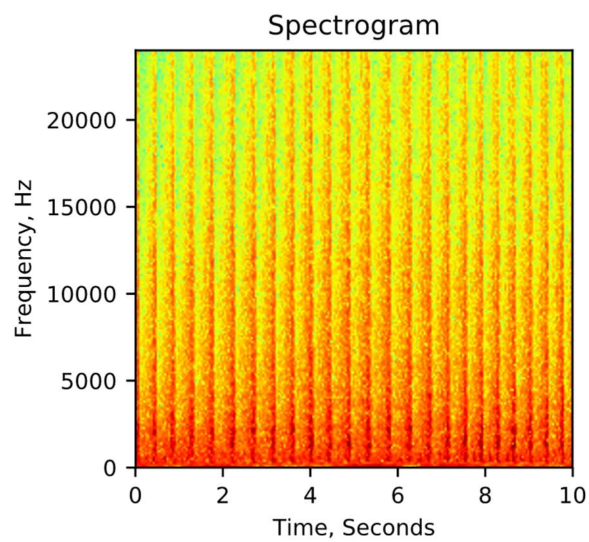
Underwater Sound Levels, dB re: 1 μPa

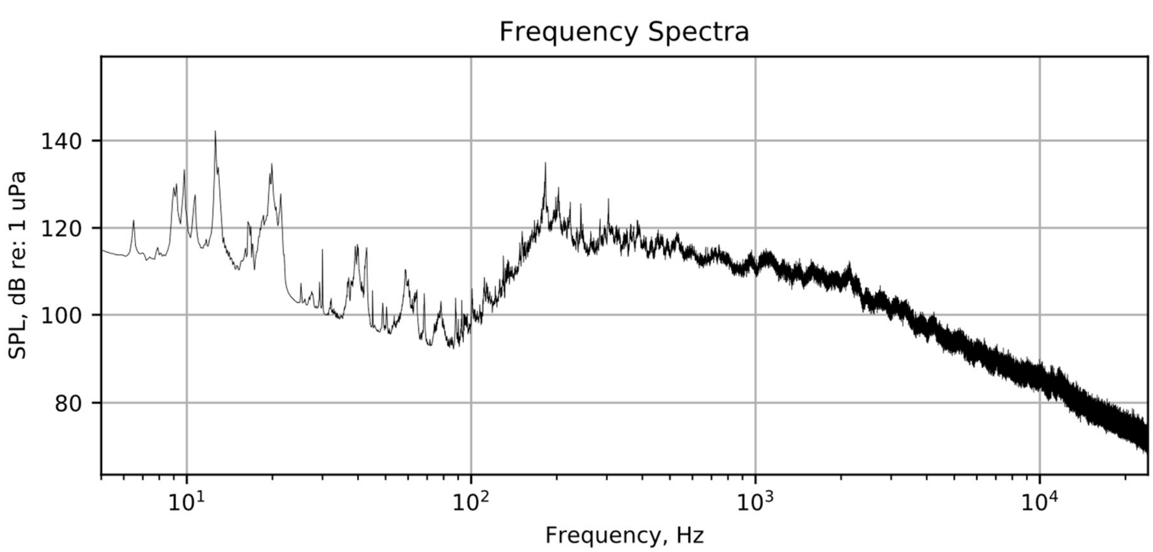
Frequency Range	Peak					RMS					SEL					cSEL
	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	
Near-Field Hydrophone																
Unweighted	191	143	6.6	178	171	170	126	6.8	160	155	180	136	6.8	170	165	197
LF Cetacean						165	116	8.0	154	148	175	126	8.0	164	158	191
MF Cetacean						165	121	6.8	154	149	175	131	6.8	164	159	191
HF Cetacean						165	121	6.8	154	150	175	131	6.8	164	160	191
PW						164	115	7.5	151	144	174	125	7.5	161	154	188
OW						165	113	7.8	151	143	175	123	7.8	161	153	188
Far-Field Hydrophone																
Unweighted	188	142	7.1	176	170	168	128	7.1	159	155	178	138	7.1	169	165	196
LF Cetacean						163	120	7.2	153	148	173	130	7.2	163	158	190
MF Cetacean						162	122	7.1	153	149	172	132	7.1	163	159	190
HF Cetacean						163	123	7.1	153	149	173	133	7.1	163	159	190
PW						161	116	7.2	149	143	171	126	7.2	159	153	186
OW						162	115	7.4	150	143	172	125	7.4	160	153	187

Note: Measurement distances normalized to 33 feet (10 meters)


Sound Pressure during Pile Driving
Sound Pressure, Pa
Time, Seconds


Peak Waveform, Pa
Sound Pressure, Pa
Time, Seconds


Spectrogram
Frequency, Hz
Time, Seconds


Frequency Spectra
SPL, dB re: 1 uPa
Frequency, Hz

2.0 IMPACT PILE DRIVING

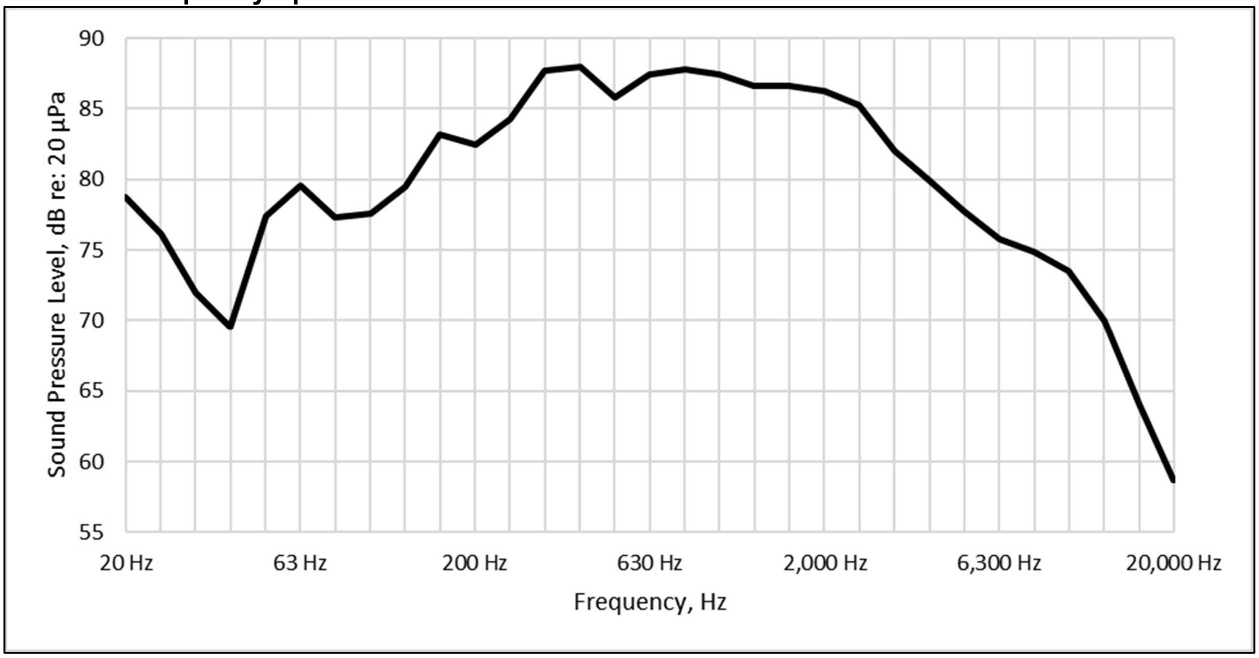
PILE C-7

October 2, 2023

Airborne Sound Levels, dB re: 20 μPa

Median	Minimum	Maximum
98	84	102

Airborne Frequency Spectrum

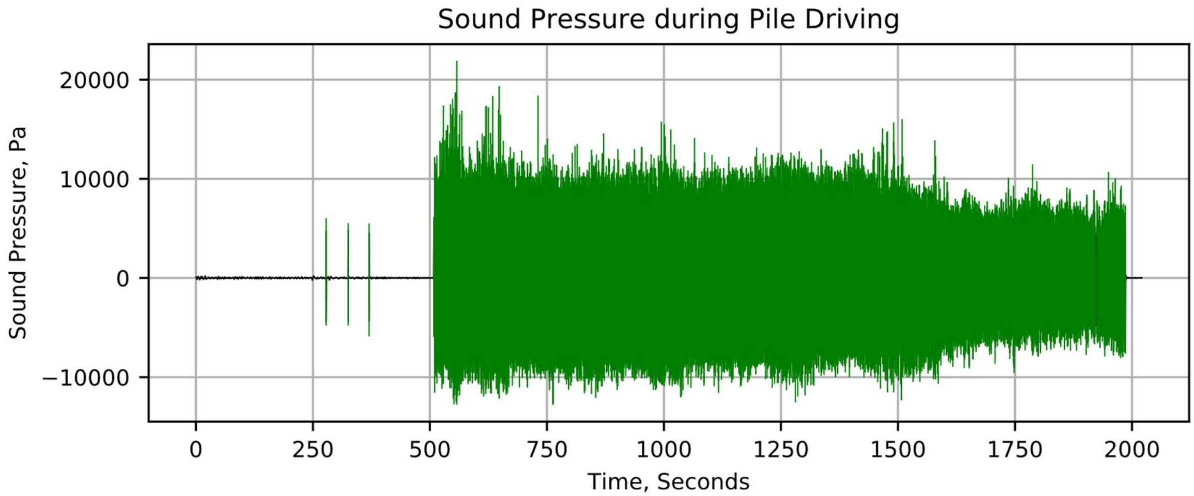


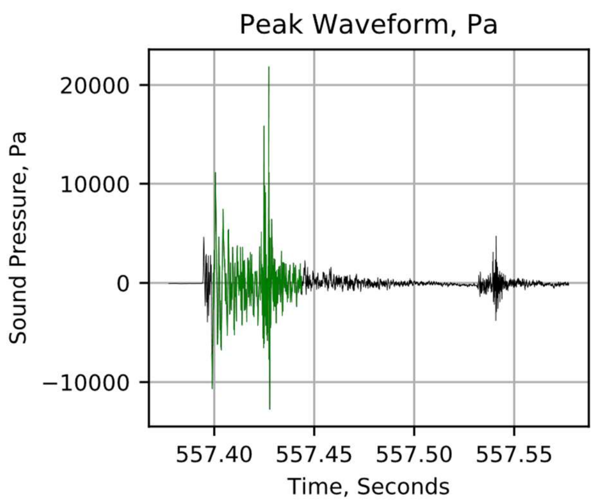
Underwater Sound Levels, dB re: 1 μPa[1]

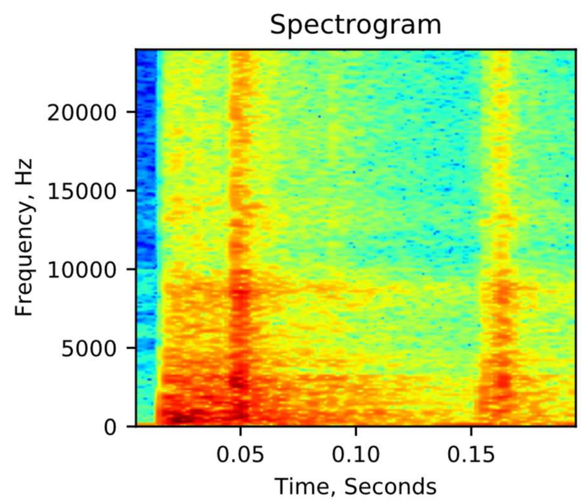
Frequency Range	Peak					RMS_{90}					SEL					cSEL
	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	
Unweighted	206	193	2.0	199	199	189	176	3.9	185	185	175	166	1.8	172	172	202
LF Cetacean						183	170	4.1	179	179	170	160	1.9	167	167	197
MF Cetacean						183	170	4.0	179	177	170	160	1.9	167	166	197
HF Cetacean						183	170	4.0	179	178	170	161	1.9	167	167	197
PW						181	165	4.1	175	172	168	156	2.3	164	163	194
OW						181	165	4.1	176	172	168	156	2.4	164	164	194

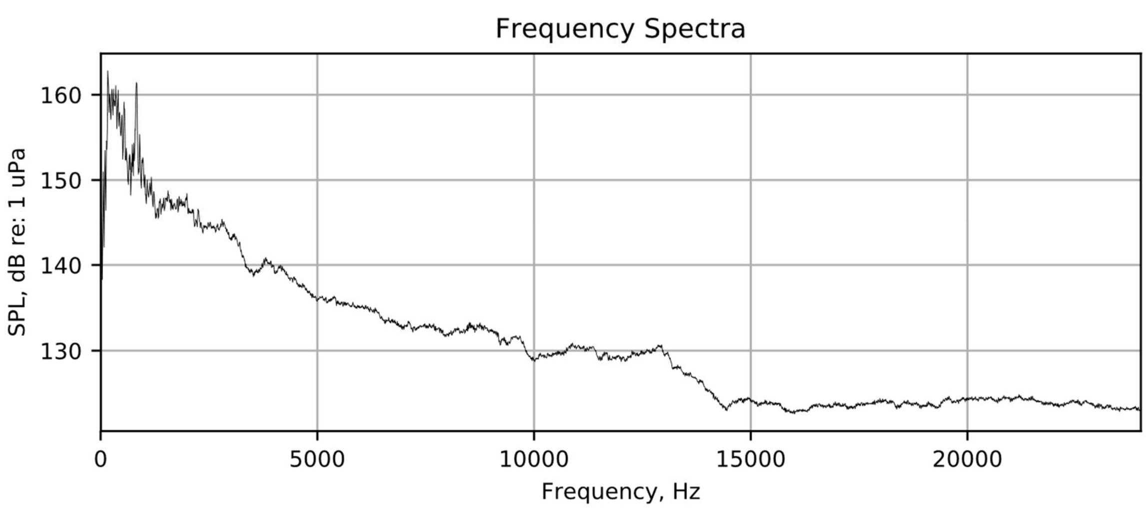
1. Due to an equipment issue data from one hydrophone has been excluded.

Note: Measurement distances normalized to 33 feet (10 meters)


Sound Pressure during Pile Driving
Sound Pressure, Pa
20000
10000
0
−10000
0
250
500
750
1000
1250
1500
1750
2000
Time, Seconds


Peak Waveform, Pa
Sound Pressure, Pa
20000
10000
0
−10000
557.40
557.45
557.50
557.55
Time, Seconds


Spectrogram
Frequency, Hz
20000
15000
10000
5000
0
0.05
0.10
0.15
Time, Seconds


Frequency Spectra
SPL, dB re: 1 uPa
160
150
140
130
0
5000
10000
15000
20000
Frequency, Hz

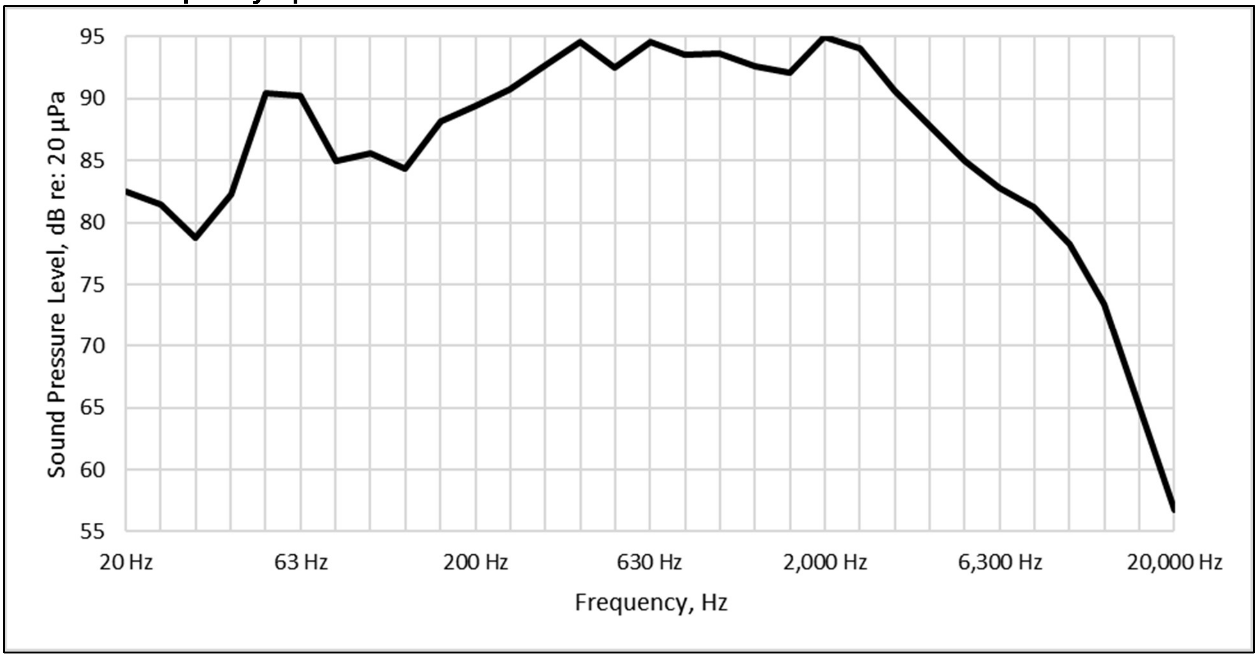
PILE A-6

October 3, 2023

Airborne Sound Levels, dB re: 20 μPa

Median	Minimum	Maximum
106	94	109

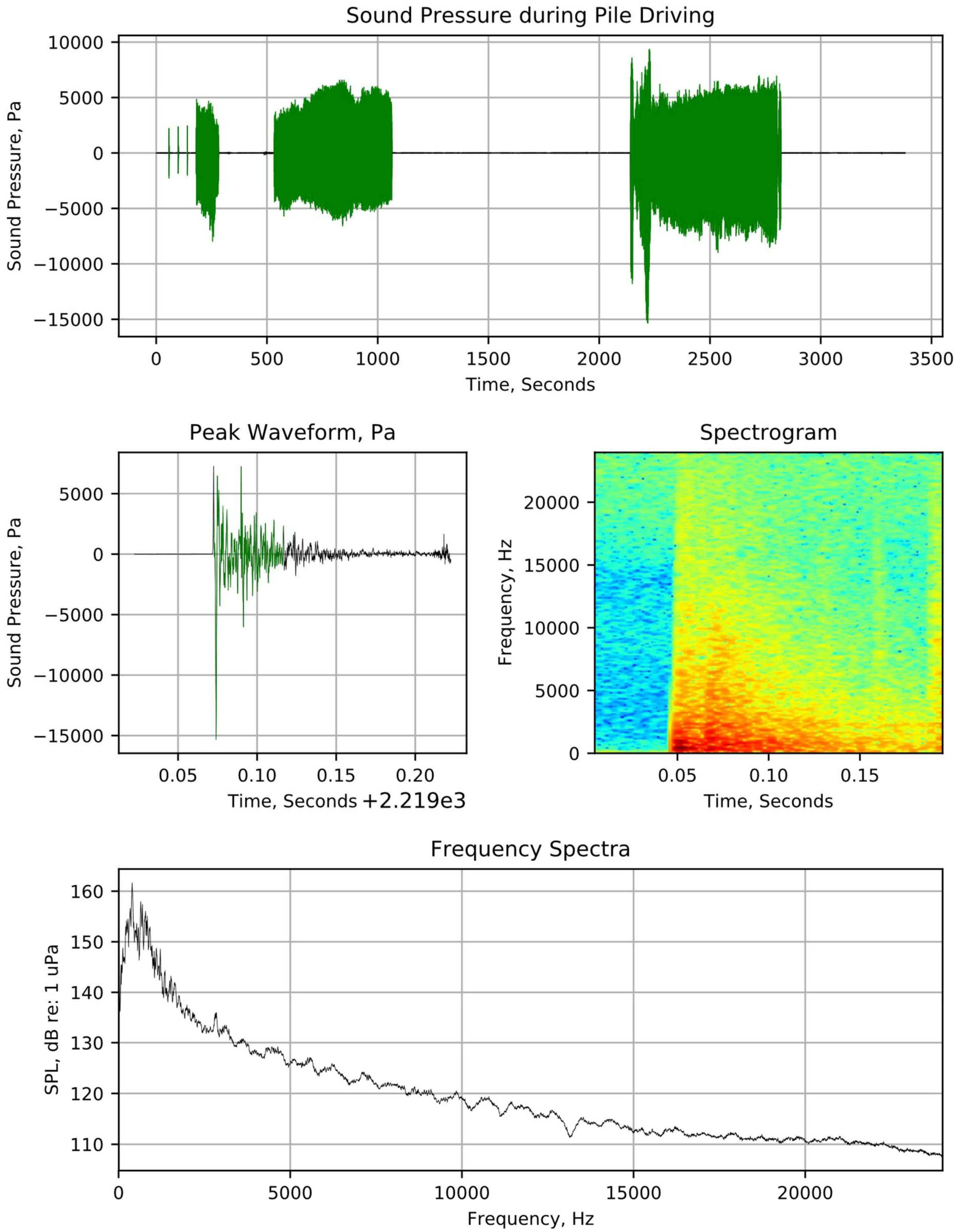
Airborne Frequency Spectrum



Underwater Sound Levels, dB re: 1 μPa

Frequency Range	Peak					RMS$_{90}$					SEL					cSEL
	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	
Near-Field Hydrophone																
Unweighted	211	194	2.2	203	202	195	177	1.9	190	190	180	166	1.5	176	176	205
LF Cetacean						189	171	1.9	184	184	175	160	1.5	170	170	200
MF Cetacean						189	170	1.9	183	183	174	160	1.5	170	170	199
HF Cetacean						189	171	1.9	184	184	175	160	1.5	170	170	200
PW						184	166	1.9	179	179	171	156	1.5	166	166	196
OW						185	166	1.9	180	180	171	156	1.5	167	167	196
Far-Field Hydrophone																
Unweighted	206	186	2.2	197	196	194	171	2.3	185	184	179	161	1.8	172	171	201
LF Cetacean						188	165	2.3	179	178	173	155	1.7	166	166	195
MF Cetacean						188	165	2.4	178	177	173	155	1.7	166	165	195
HF Cetacean						188	165	2.4	179	178	173	156	1.7	166	166	196
PW						183	161	2.4	174	173	169	152	1.6	162	162	192
OW						184	162	2.4	174	173	170	152	1.7	163	162	192

Note: Measurement distances normalized to 33 feet (10 meters)


Sound Pressure during Pile Driving
Sound Pressure, Pa
Time, Seconds
Peak Waveform, Pa
Sound Pressure, Pa
Time, Seconds +2.219e3
Spectrogram
Frequency, Hz
Time, Seconds
Frequency Spectra
SPL, dB re: 1 uPa
Frequency, Hz

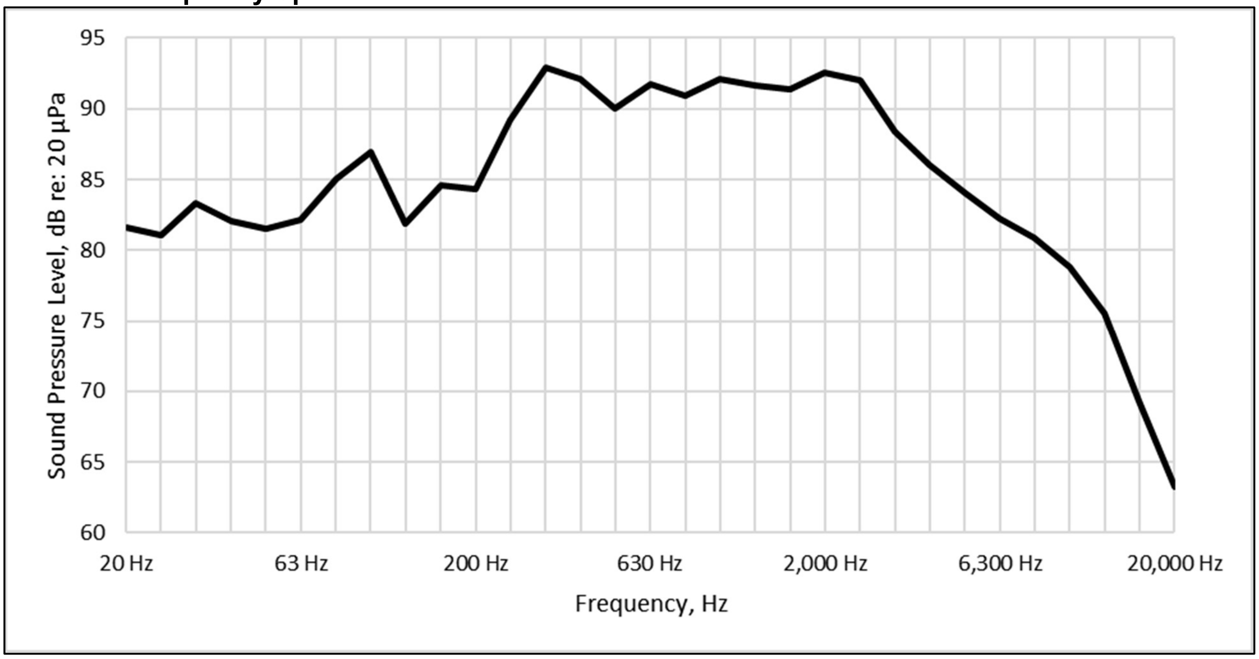
PILE B-11

October 3, 2023

Airborne Sound Levels, dB re: 20 μPa

Median	Minimum	Maximum
103	90	107

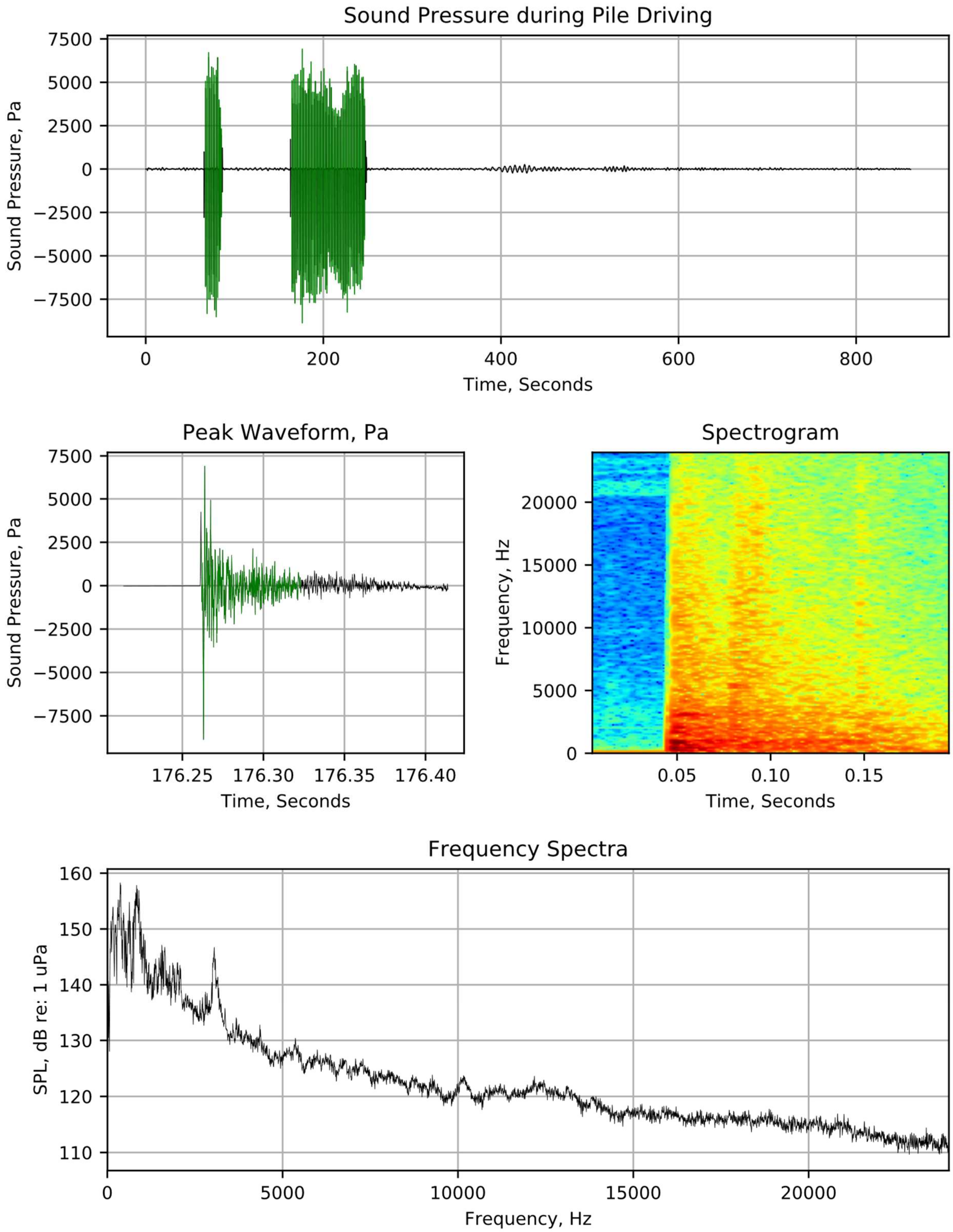
Airborne Frequency Spectrum



Underwater Sound Levels, dB re: 1 μPa

Frequency Range	Peak					RMS90					SEL					cSEL
	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	
Near-Field Hydrophone																
Unweighted	203	193	1.6	201	201	185	177	1.3	184	184	173	165	1.2	172	172	190
LF Cetacean						180	171	1.3	178	178	167	159	1.2	166	166	184
MF Cetacean						179	171	1.4	178	178	167	159	1.2	166	166	184
HF Cetacean						180	171	1.4	178	178	167	160	1.2	166	167	184
PW						176	167	1.6	175	175	164	156	1.4	163	163	181
OW						177	167	1.6	175	176	165	156	1.5	164	164	182
Far-Field Hydrophone																
Unweighted	213	205	1.7	212	212	197	188	2.1	195	195	181	173	1.6	179	180	197
LF Cetacean						192	183	2.2	190	190	175	167	1.6	174	174	192
MF Cetacean						190	182	1.9	188	189	175	167	1.5	173	174	191
HF Cetacean						191	183	1.9	189	189	175	167	1.5	174	174	192
PW						187	178	1.7	185	185	172	163	1.5	170	171	188
OW						187	178	1.7	185	186	172	163	1.5	171	171	189

Note: Measurement distances normalized to 33 feet (10 meters)


Sound Pressure during Pile Driving
Sound Pressure, Pa
Time, Seconds
Peak Waveform, Pa
Sound Pressure, Pa
Time, Seconds
Spectrogram
Frequency, Hz
Time, Seconds
Frequency Spectra
SPL, dB re: 1 uPa
Frequency, Hz

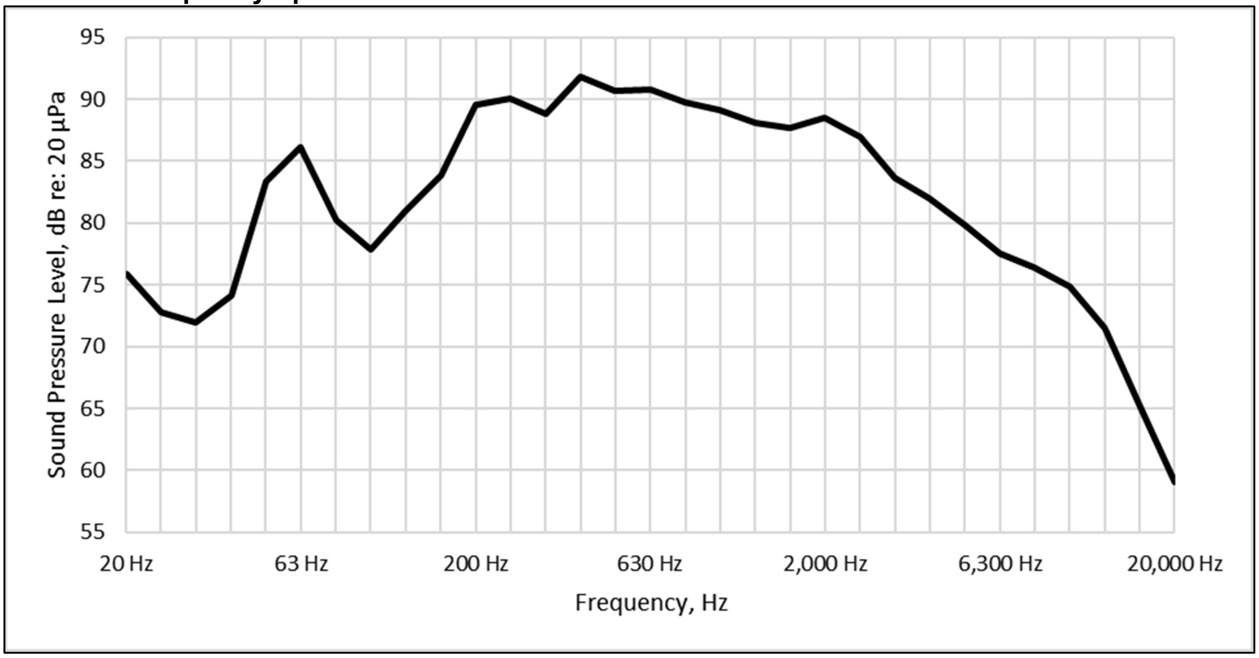
PILE B-15

October 3, 2023

Airborne Sound Levels, dB re: 20 µPa

Median	Minimum	Maximum
102	87	107

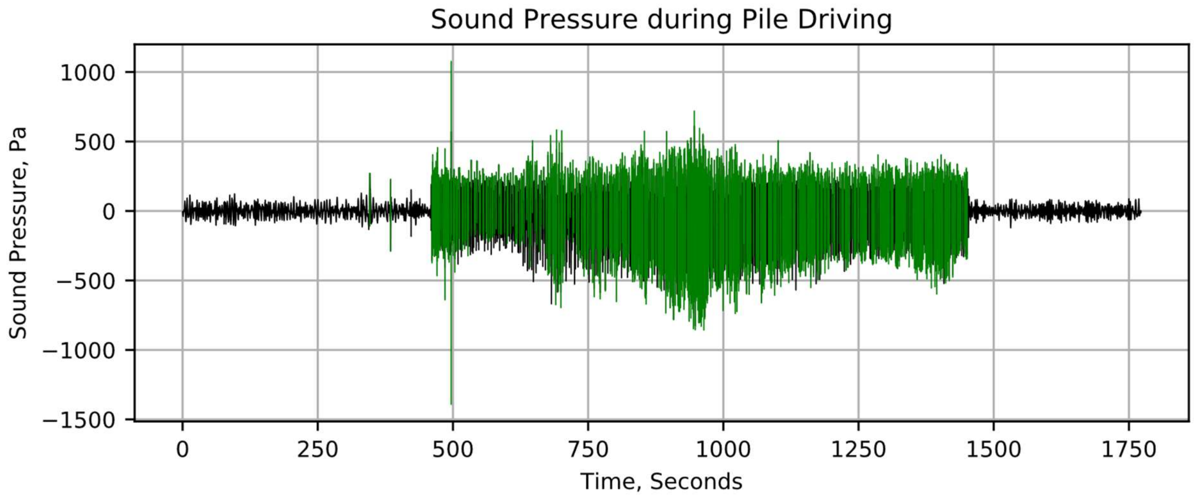
Airborne Frequency Spectrum

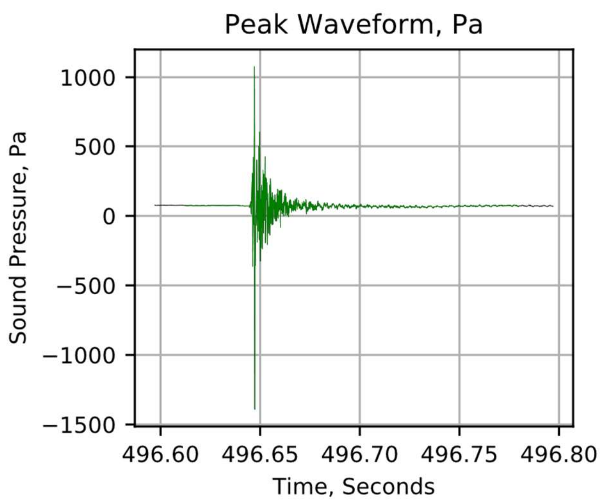


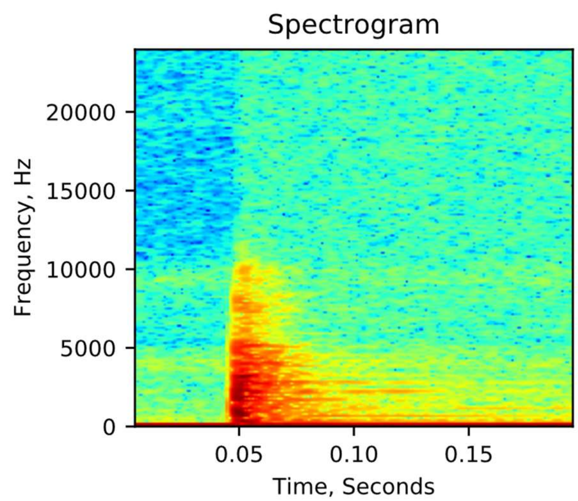
Underwater Sound Levels, dB re: 1 µPa

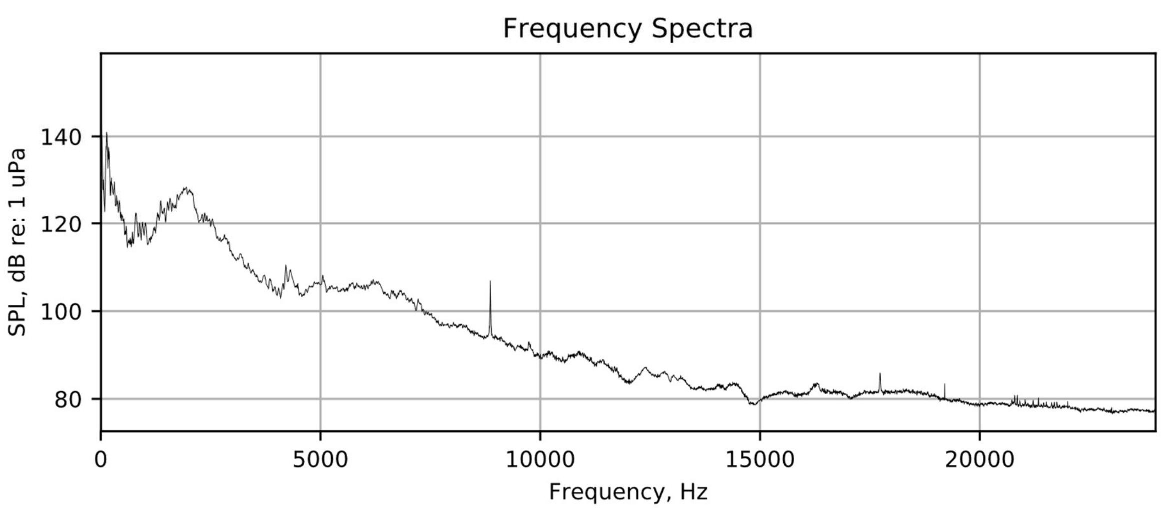
Frequency Range	Peak					RMS_{90}					SEL					cSEL
	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	
Near-Field Hydrophone																
Unweighted	185	165	3.1	174	173	163	149	1.2	160	160	153	140	1.6	151	151	178
LF Cetacean						165	137	3.1	151	151	144	130	2.4	141	141	168
MF Cetacean						158	144	1.2	154	154	147	134	1.4	145	145	172
HF Cetacean						158	144	1.2	154	154	148	135	1.5	145	146	172
PW						164	140	2.5	150	149	143	131	2.0	140	140	167
OW						165	136	3.4	150	149	144	129	2.6	140	140	167
Far-Field Hydrophone																
Unweighted	181	147	4.7	177	177	166	136	4.4	164	165	157	128	4.3	155	155	182
LF Cetacean						161	127	5.5	158	159	150	120	4.8	147	148	174
MF Cetacean						160	132	4.2	158	158	151	125	4.0	149	149	176
HF Cetacean						161	132	4.3	158	159	152	125	4.1	149	150	176
PW						154	128	4.1	152	153	145	121	3.8	143	144	170
OW						154	128	4.0	151	152	144	120	3.7	142	143	169

Note: Measurement distances normalized to 33 feet (10 meters)


Sound Pressure during Pile Driving
Sound Pressure, Pa
1000
500
0
−500
−1000
−1500
0
250
500
750
1000
1250
1500
1750
Time, Seconds


Peak Waveform, Pa
Sound Pressure, Pa
1000
500
0
−500
−1000
−1500
496.60
496.65
496.70
496.75
496.80
Time, Seconds


Spectrogram
Frequency, Hz
20000
15000
10000
5000
0
0.05
0.10
0.15
Time, Seconds


Frequency Spectra
SPL, dB re: 1 uPa
140
120
100
80
0
5000
10000
15000
20000
Frequency, Hz

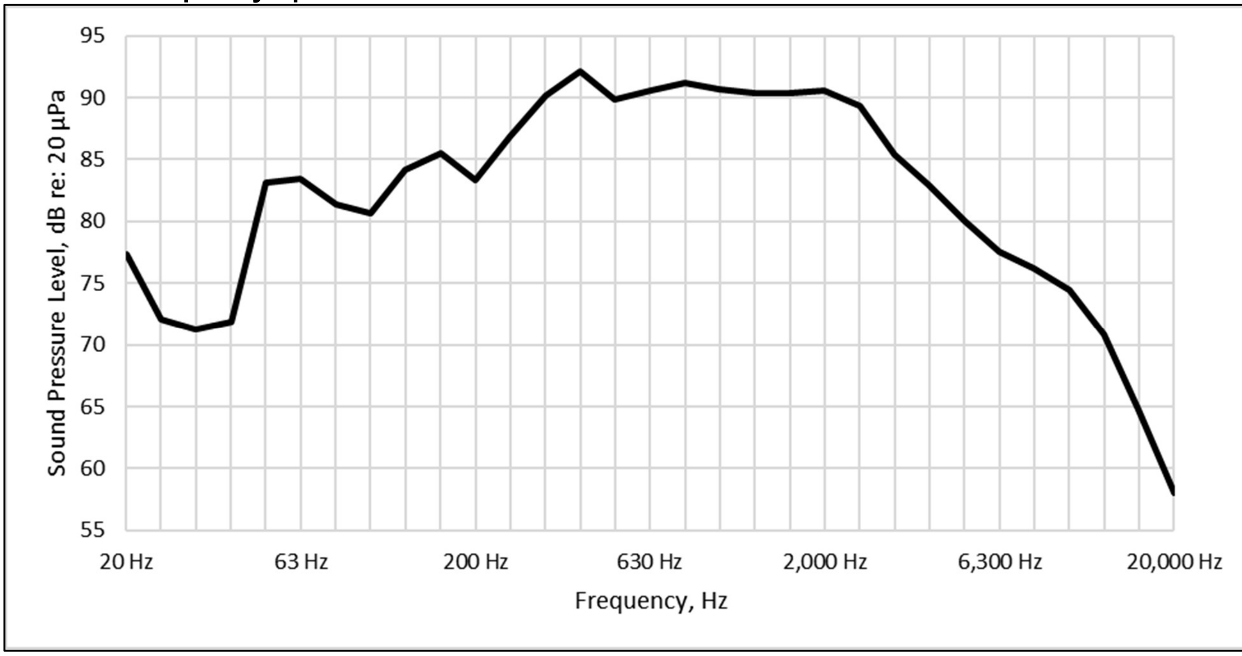
PILE B-16

October 3, 2023

Airborne Sound Levels, dB re: 20 μPa

Median	Minimum	Maximum
103	88	105

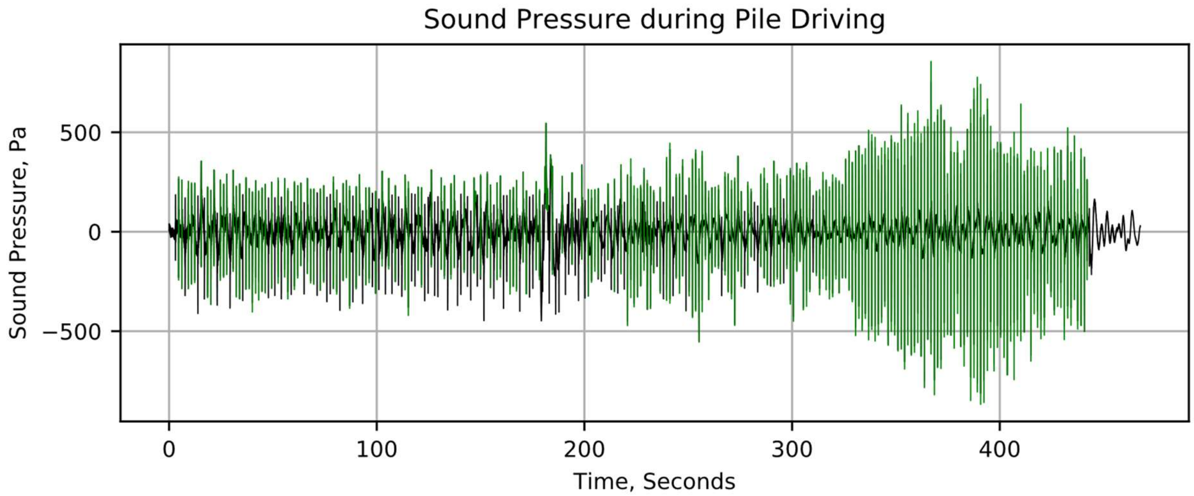
Airborne Frequency Spectrum

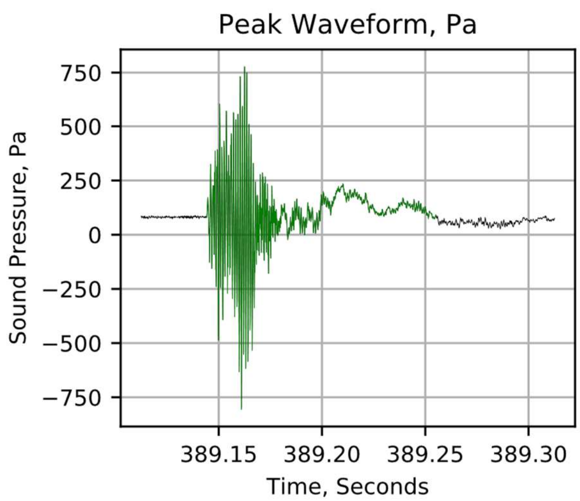


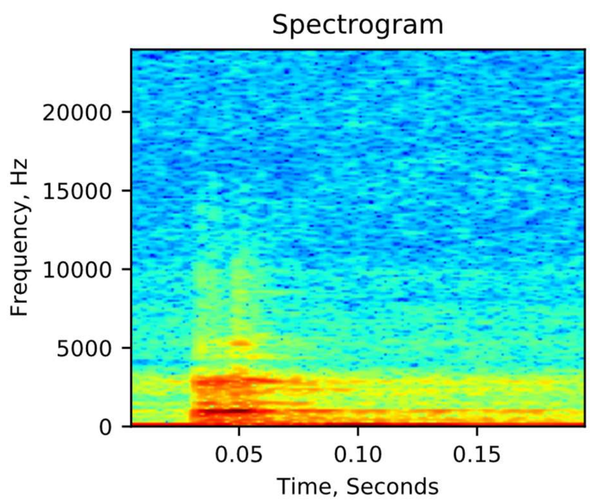
Underwater Sound Levels, dB re: 1 μPa

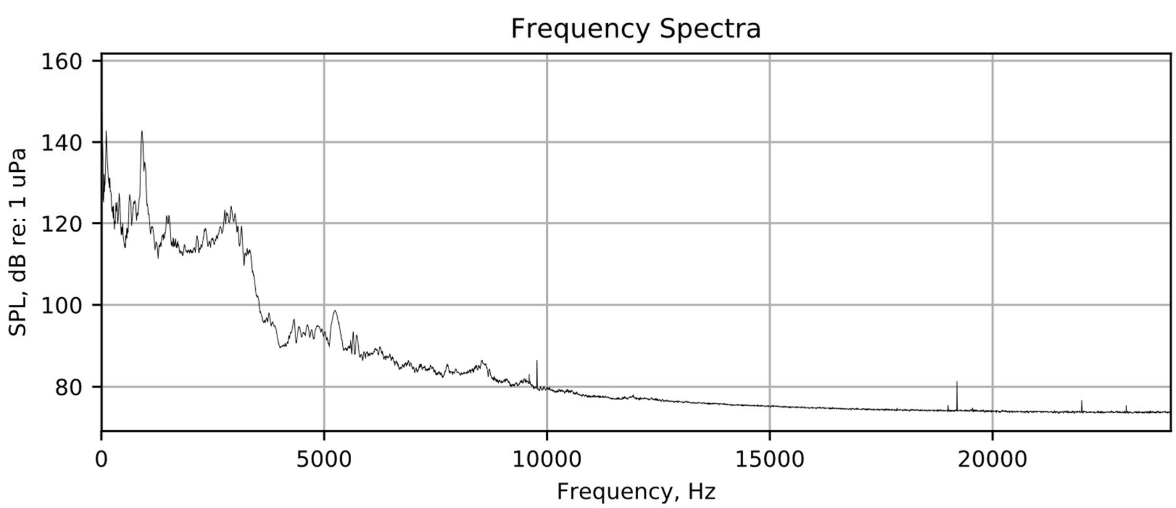
Frequency Range	Peak					RMS90					SEL					cSEL
	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	
Near-Field Hydrophone																
Unweighted	180	164	3.4	173	171	168	153	2.4	161	160	156	145	1.8	151	151	175
LF Cetacean						167	136	6.4	158	152	150	129	3.9	143	141	167
MF Cetacean						162	147	2.5	155	153	150	139	1.9	145	145	169
HF Cetacean						162	147	2.4	155	154	150	139	1.8	146	145	169
PW						164	138	5.7	154	148	147	130	3.4	141	139	164
OW						166	135	7.5	157	150	149	127	4.5	142	139	165
Far-Field Hydrophone																
Unweighted	182	148	5.2	176	175	164	136	4.4	162	162	155	129	4.2	153	154	177
LF Cetacean						158	129	5.1	155	155	147	122	4.4	145	145	169
MF Cetacean						157	133	4.0	156	156	149	126	3.8	147	147	171
HF Cetacean						158	133	4.1	156	156	149	126	3.9	148	148	171
PW						155	130	4.1	151	151	146	122	3.8	142	142	166
OW						157	129	4.4	152	151	147	122	4.1	142	142	166

Note: Measurement distances normalized to 33 feet (10 meters)


Sound Pressure during Pile Driving
Sound Pressure, Pa
500
0
−500
0
100
200
300
400
Time, Seconds


Peak Waveform, Pa
Sound Pressure, Pa
750
500
250
0
−250
−500
−750
389.15
389.20
389.25
389.30
Time, Seconds


Spectrogram
Frequency, Hz
20000
15000
10000
5000
0
0.05
0.10
0.15
Time, Seconds


Frequency Spectra
SPL, dB re: 1 uPa
160
140
120
100
80
0
5000
10000
15000
20000
Frequency, Hz

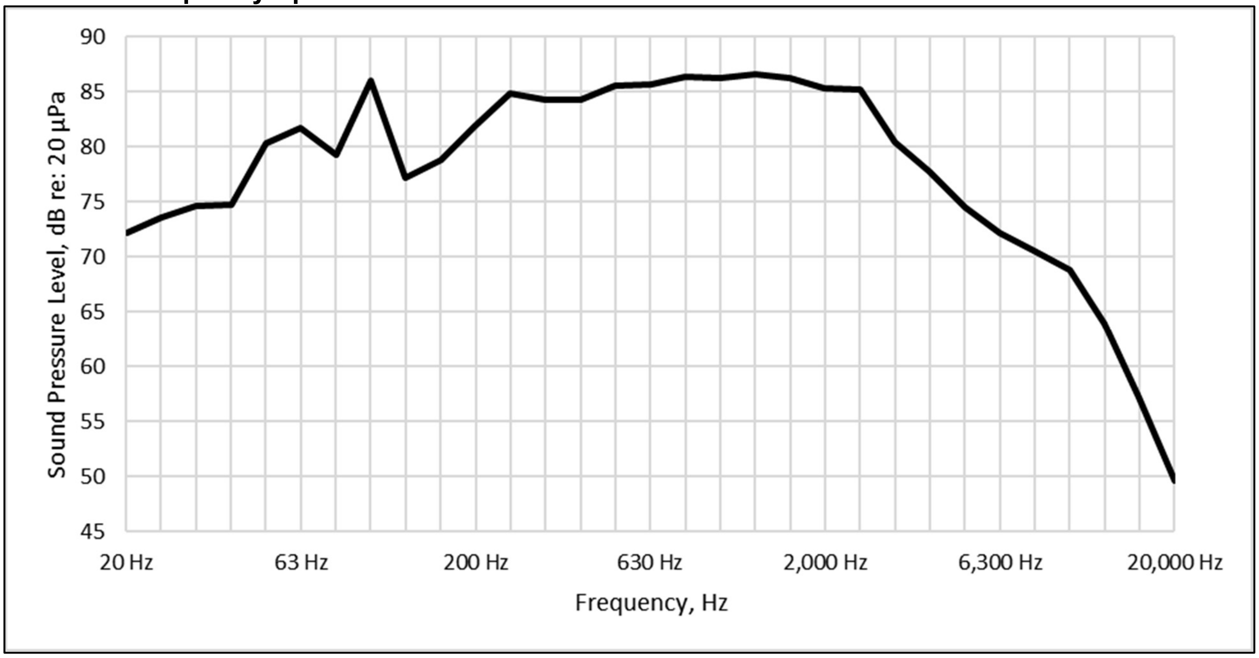
PILE B-18

October 3, 2023

Airborne Sound Levels, dB re: 20 μPa

Median	Minimum	Maximum
90	88	106

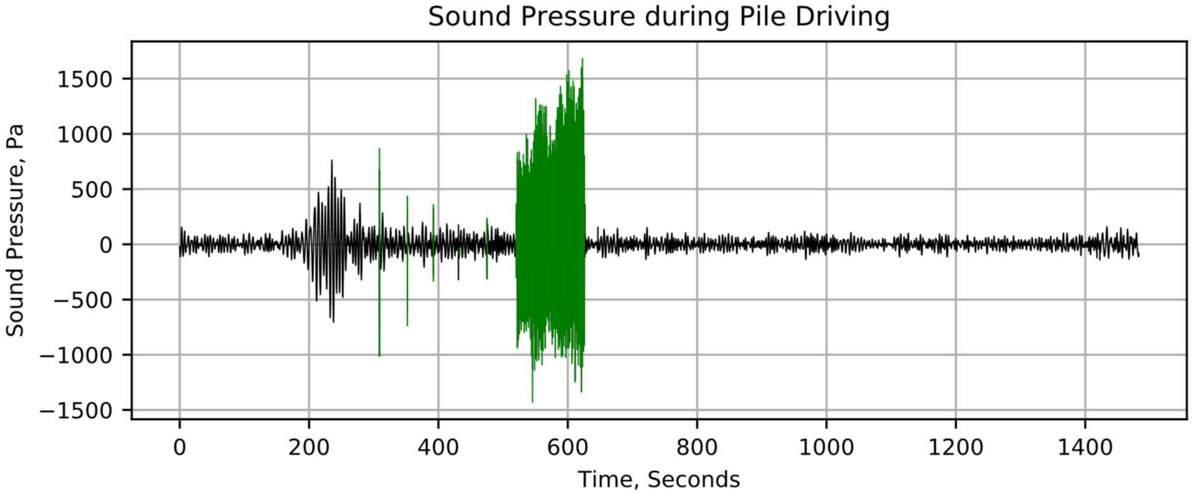
Airborne Frequency Spectrum

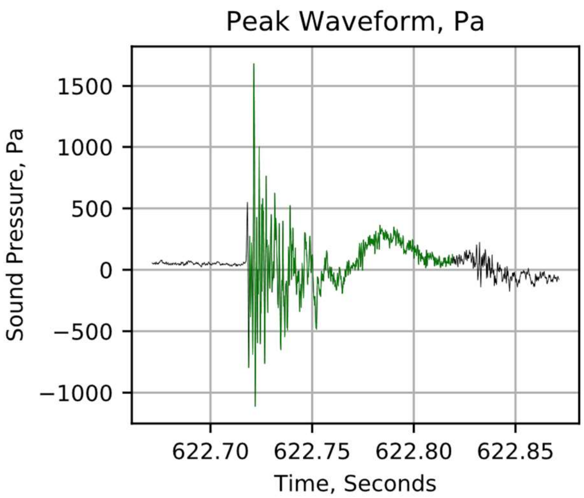


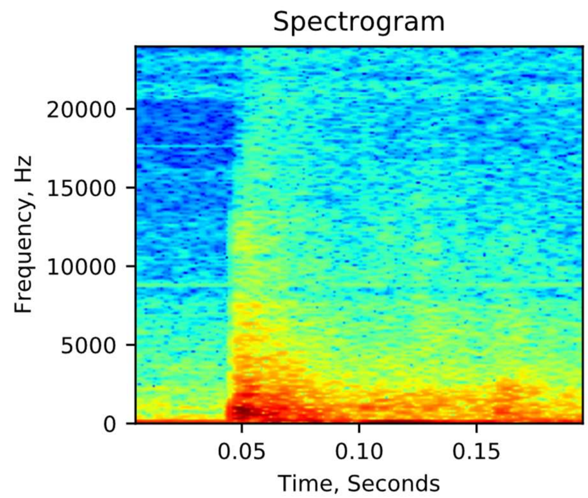
Underwater Sound Levels, dB re: 1 μPa

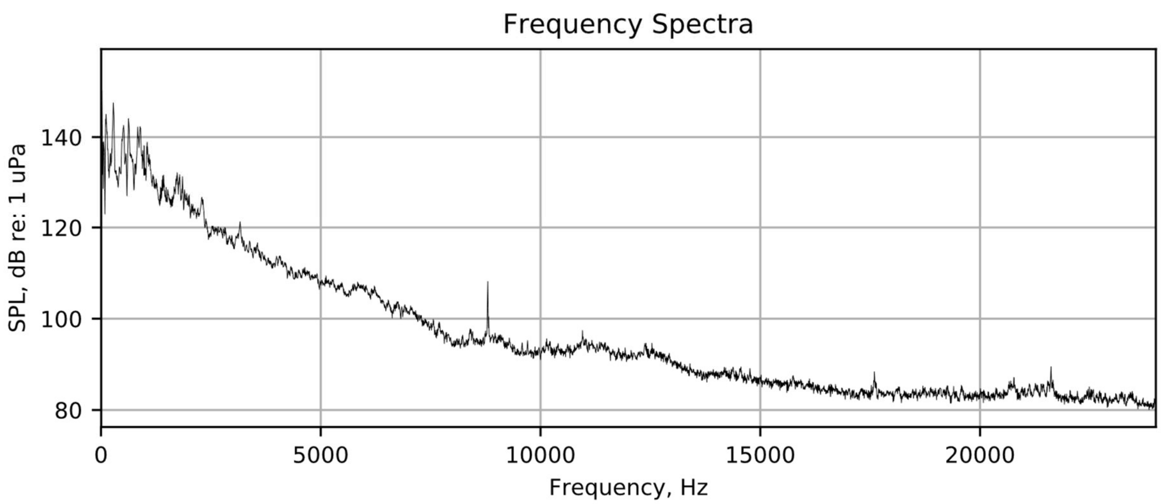
Frequency Range	Peak					RMS_{90}					SEL					cSEL
	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	
Near-Field Hydrophone																
Unweighted	188	160	3.9	184	184	170	149	3.1	168	169	161	141	2.9	159	159	178
LF Cetacean						167	136	4.1	163	163	154	129	3.5	152	153	171
MF Cetacean						164	142	3.0	162	162	155	134	2.9	153	153	172
HF Cetacean						164	143	3.0	163	163	155	135	2.9	154	154	172
PW						160	135	3.4	158	158	151	127	3.2	149	149	167
OW						161	134	3.6	159	159	151	127	3.3	149	150	168
Far-Field Hydrophone																
Unweighted	186	161	3.2	181	181	169	146	3.0	167	167	160	139	2.9	158	158	176
LF Cetacean						163	139	3.1	160	160	153	131	2.9	150	150	168
MF Cetacean						163	141	2.9	160	161	154	134	2.8	151	152	170
HF Cetacean						164	142	2.9	161	161	154	134	2.8	152	152	171
PW						159	137	2.8	156	156	149	129	2.6	146	146	165
OW						160	136	2.9	156	156	150	128	2.8	146	147	165

Note: Measurement distances normalized to 33 feet (10 meters)


Sound Pressure during Pile Driving
Sound Pressure, Pa
1500
1000
500
0
−500
−1000
−1500
0
200
400
600
800
1000
1200
1400
Time, Seconds


Peak Waveform, Pa
Sound Pressure, Pa
1500
1000
500
0
−500
−1000
622.70
622.75
622.80
622.85
Time, Seconds


Spectrogram
Frequency, Hz
20000
15000
10000
5000
0
0.05
0.10
0.15
Time, Seconds


Frequency Spectra
SPL, dB re: 1 uPa
140
120
100
80
0
5000
10000
15000
20000
Frequency, Hz

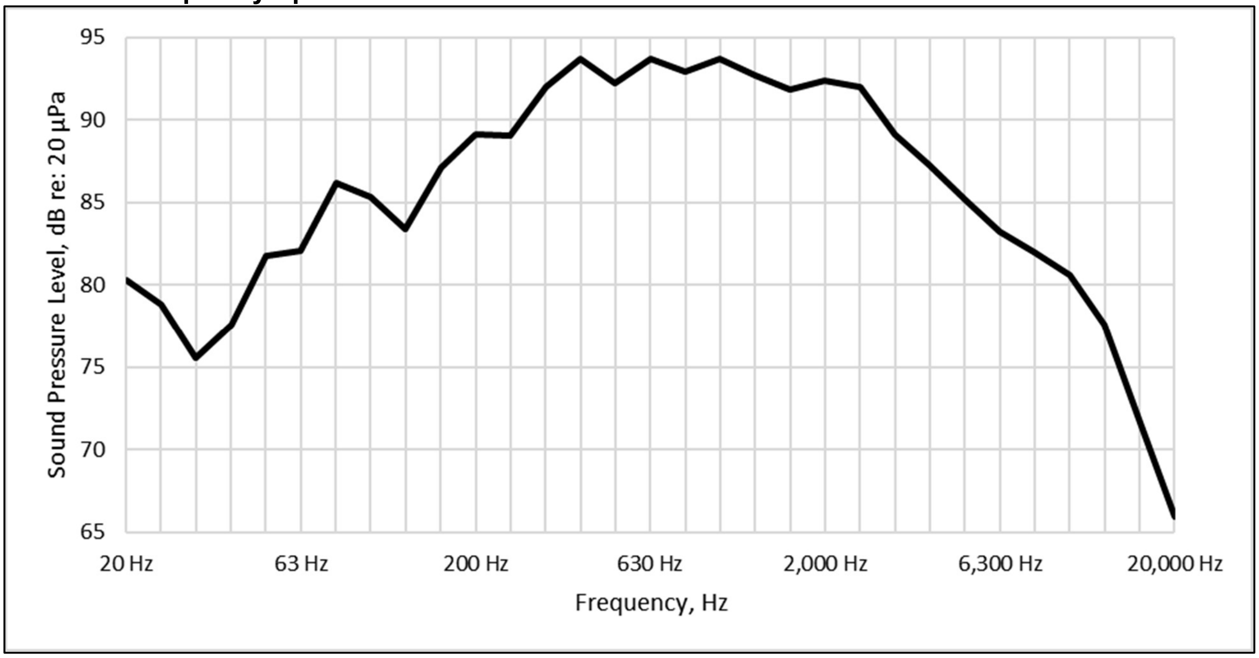
PILE B-12

October 9, 2023

Airborne Sound Levels, dB re: 20 μPa

Median	Minimum	Maximum
105	88	109

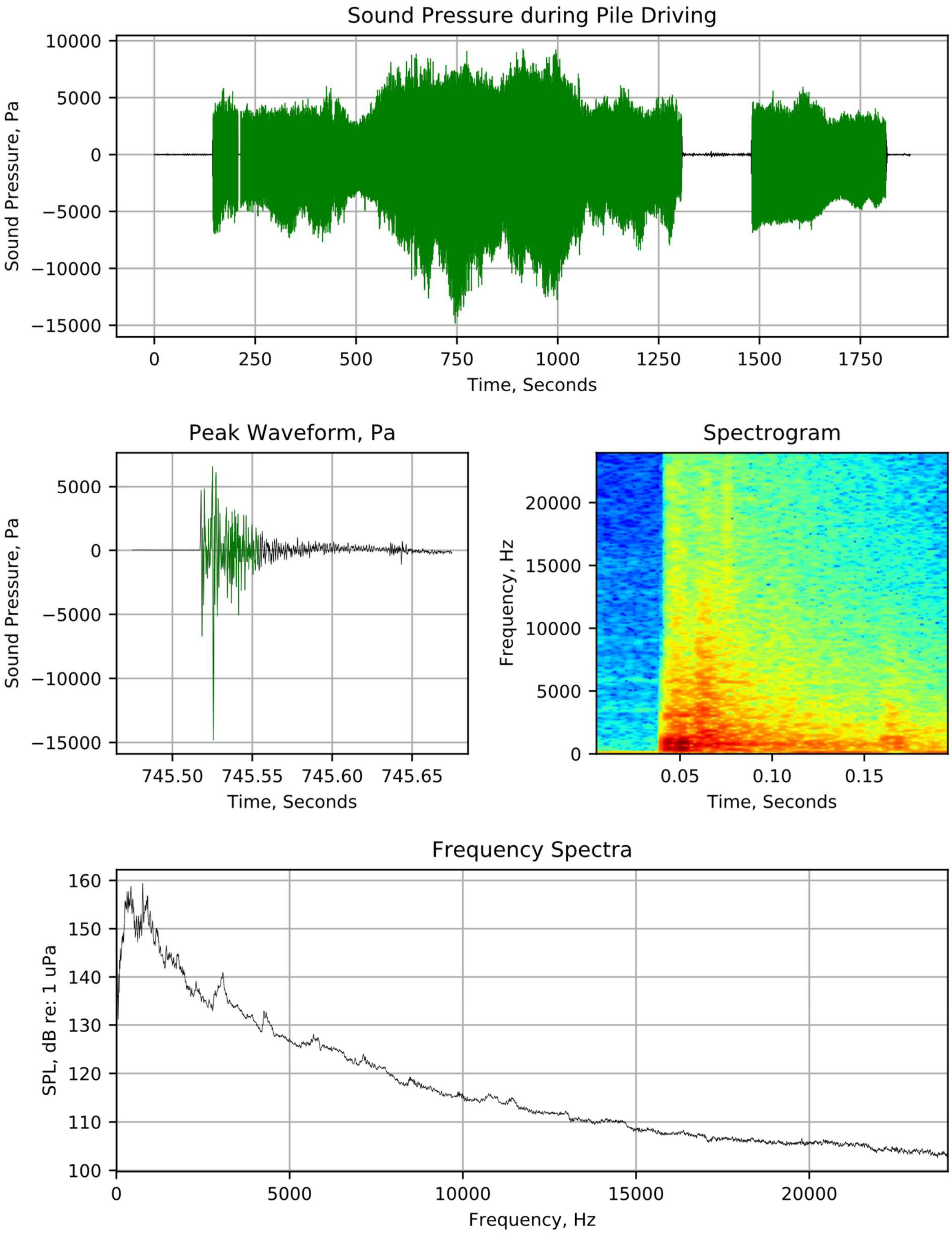
Airborne Frequency Spectrum



Underwater Sound Levels, dB re: 1 μPa

Frequency Range	Peak					RMS_{90}					SEL					cSEL
	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	
Near-Field Hydrophone																
Unweighted	208	193	2.9	201	200	193	181	2.9	188	186	178	169	2.1	174	173	203
LF Cetacean						188	176	2.7	183	181	173	163	2.2	168	167	198
MF Cetacean						187	174	3.0	181	180	172	163	2.1	168	167	197
HF Cetacean						187	175	3.0	182	181	173	163	2.1	168	167	198
PW						185	171	3.2	179	177	171	159	2.5	165	163	194
OW						187	171	3.6	179	177	172	160	2.7	165	164	195
Far-Field Hydrophone																
Unweighted	209	204	0.8	207	207	196	190	0.9	194	193	181	175	0.8	177	177	207
LF Cetacean						191	185	0.9	189	188	176	169	0.8	172	172	202
MF Cetacean						190	184	0.9	187	187	175	168	0.8	171	171	201
HF Cetacean						191	185	0.9	188	188	176	169	0.8	172	172	201
PW						187	181	1.1	184	184	172	165	0.8	168	168	198
OW						189	182	1.4	185	185	173	166	0.8	169	169	199

Note: Measurement distances normalized to 33 feet (10 meters)


Sound Pressure during Pile Driving
Sound Pressure, Pa
Time, Seconds
Peak Waveform, Pa
Sound Pressure, Pa
Time, Seconds
Spectrogram
Frequency, Hz
Time, Seconds
Frequency Spectra
SPL, dB re: 1 uPa
Frequency, Hz

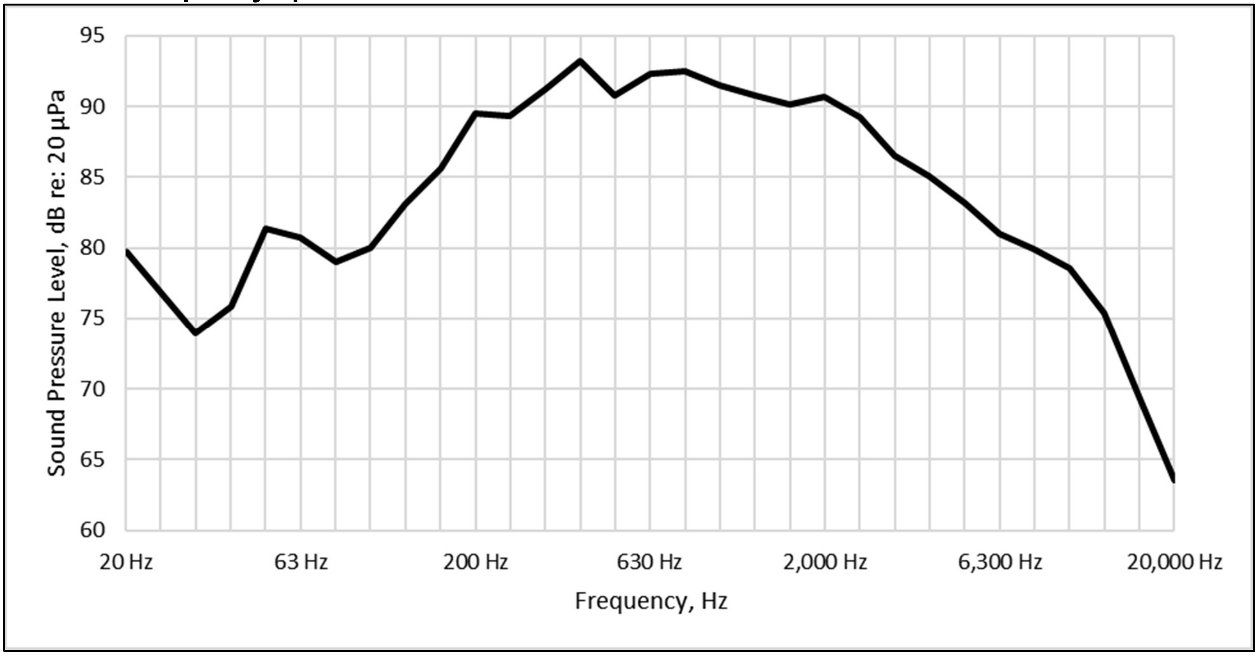
PILE B-13

October 9, 2023

Airborne Sound Levels, dB re: 20 μPa

Median	Minimum	Maximum
104	87	107

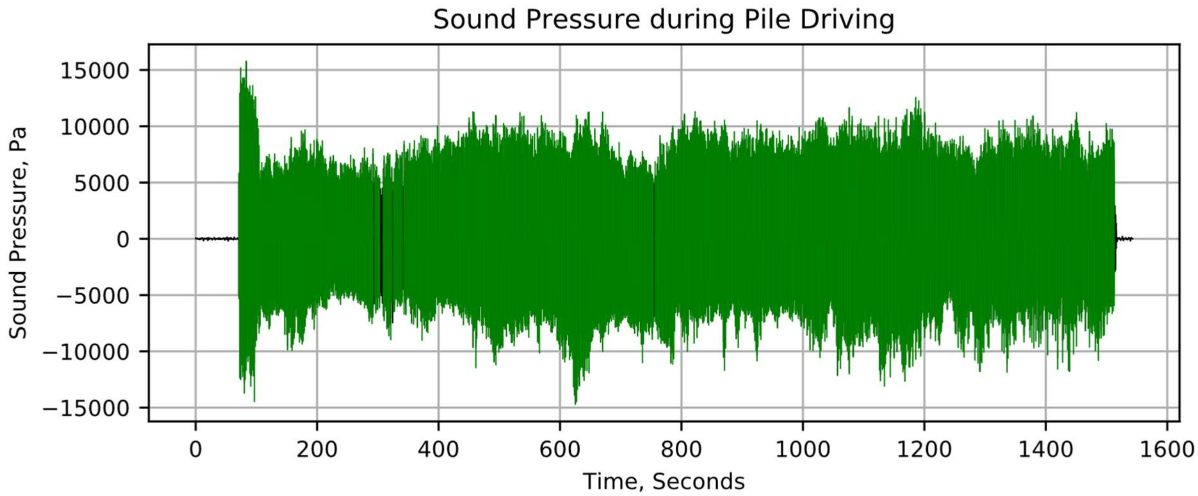
Airborne Frequency Spectrum

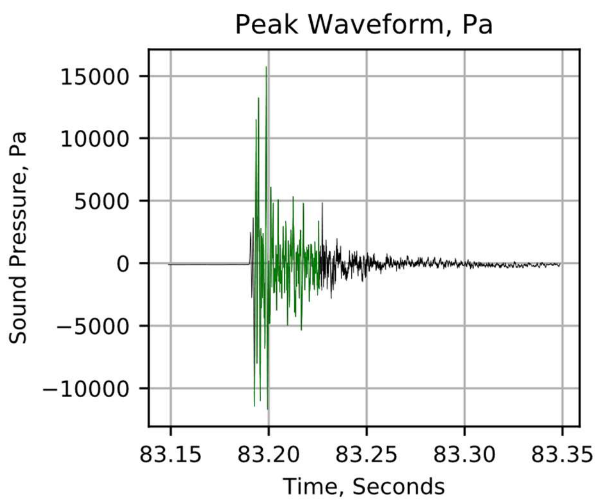


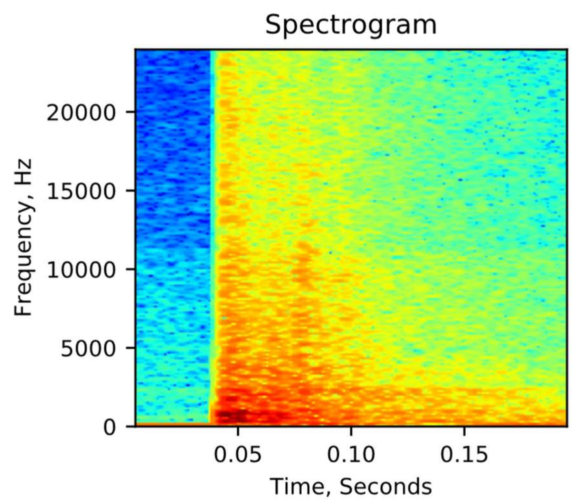
Underwater Sound Levels, dB re: 1 μPa

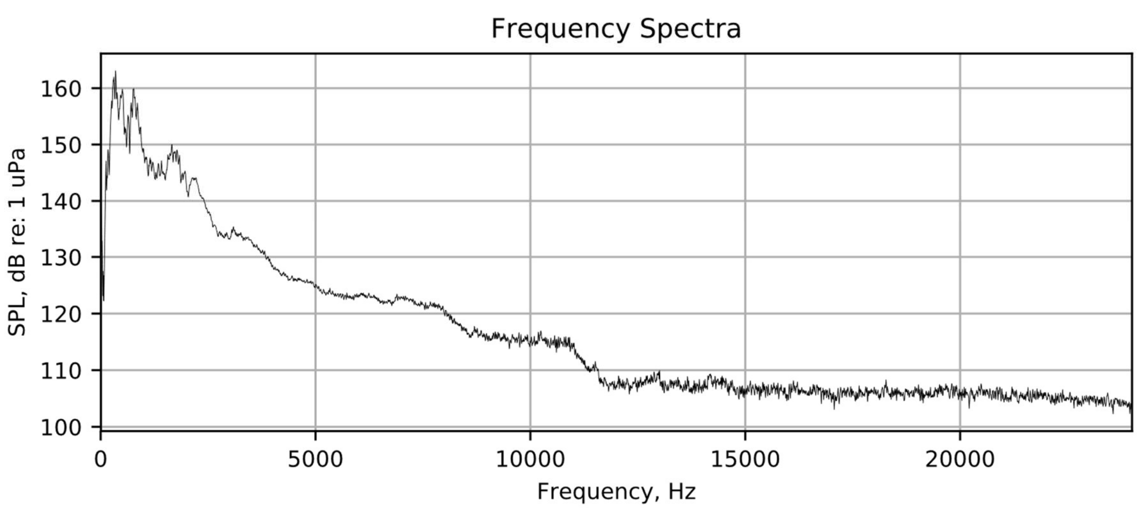
Frequency Range	Peak					RMS_{90}					SEL					cSEL
	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	
Near-Field Hydrophone																
Unweighted	207	198	1.5	202	202	195	187	1.3	190	190	180	172	1.2	175	175	205
LF Cetacean						190	181	1.4	185	184	175	167	1.3	170	169	199
MF Cetacean						189	181	1.3	184	184	174	166	1.2	169	169	199
HF Cetacean						190	181	1.3	185	184	175	167	1.2	170	169	199
PW						186	176	1.4	181	180	171	162	1.4	166	165	195
OW						187	176	1.5	181	181	172	162	1.5	166	166	196
Far-Field Hydrophone																
Unweighted	210	195	1.7	204	204	196	182	1.6	191	191	181	169	1.4	176	176	206
LF Cetacean						191	177	1.6	186	186	175	163	1.4	171	171	200
MF Cetacean						190	176	1.6	185	185	175	163	1.4	170	170	200
HF Cetacean						190	177	1.6	185	185	175	163	1.4	171	170	200
PW						186	174	1.4	182	182	171	160	1.3	167	167	197
OW						186	175	1.4	183	183	172	161	1.3	168	168	198

Note: Measurement distances normalized to 33 feet (10 meters)


Sound Pressure during Pile Driving
Sound Pressure, Pa
15000
10000
5000
0
−5000
−10000
−15000
0 200 400 600 800 1000 1200 1400 1600
Time, Seconds


Peak Waveform, Pa
Sound Pressure, Pa
15000
10000
5000
0
−5000
−10000
83.15 83.20 83.25 83.30 83.35
Time, Seconds


Spectrogram
Frequency, Hz
20000
15000
10000
5000
0
0.05 0.10 0.15
Time, Seconds


Frequency Spectra
SPL, dB re: 1 uPa
160
150
140
130
120
110
100
0 5000 10000 15000 20000
Frequency, Hz

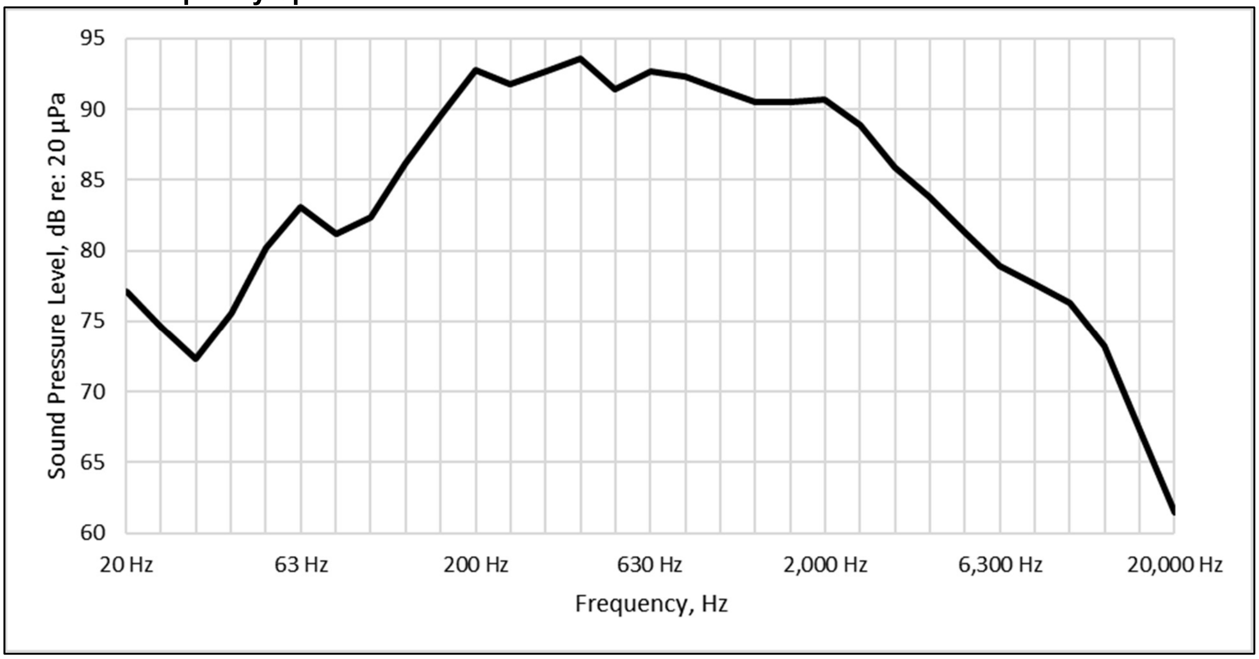
PILE B-14

October 9, 2023

Airborne Sound Levels, dB re: 20 µPa

Median	Minimum	Maximum
104	87	108

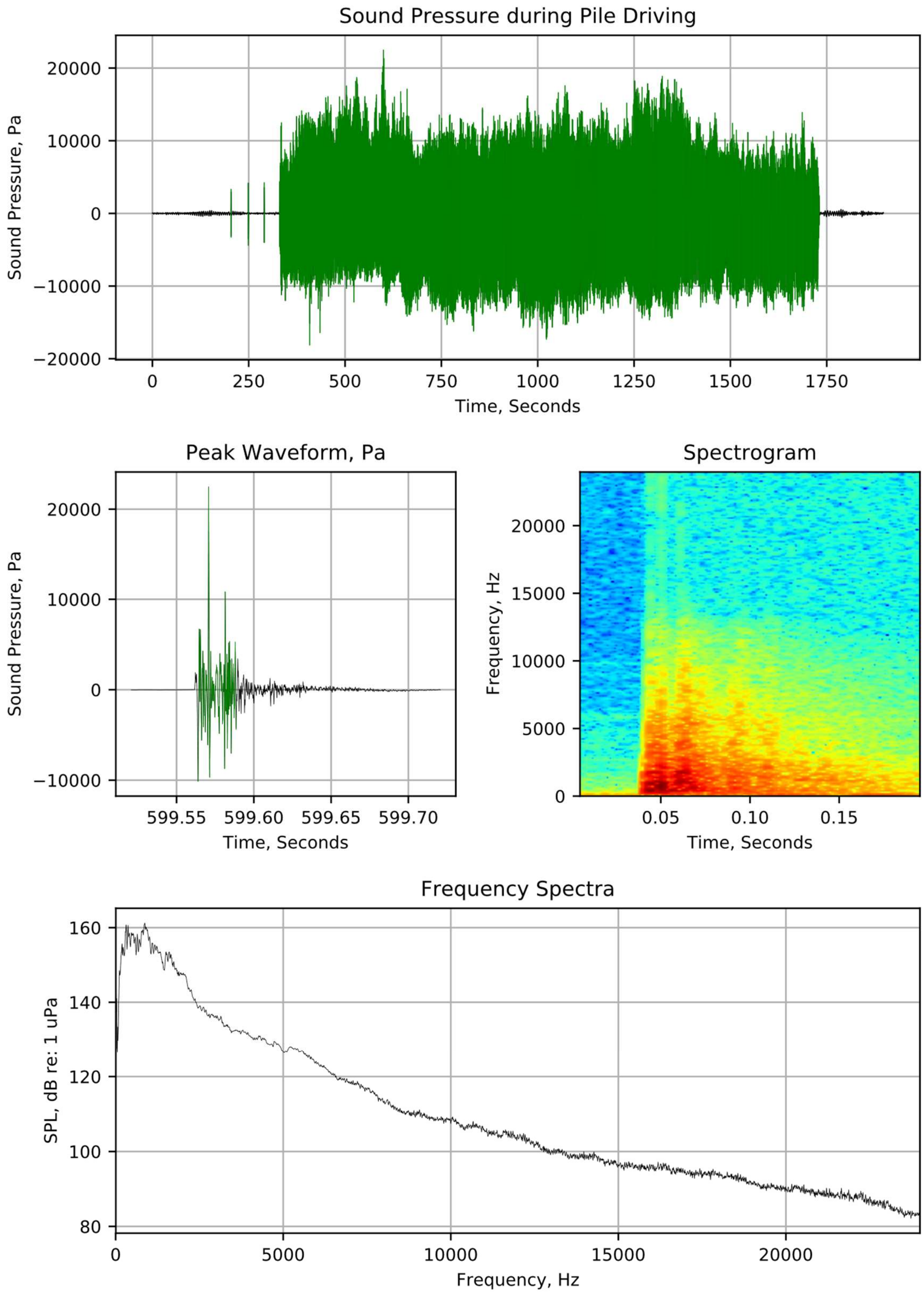
Airborne Frequency Spectrum



Underwater Sound Levels, dB re: 1 µPa

Frequency Range	Peak					RMS_{90}					SEL					cSEL
	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	Max	Min	SD	Mean	Med	
Near-Field Hydrophone																
Unweighted	209	189	1.7	204	204	196	178	1.7	192	192	179	162	1.8	176	176	205
LF Cetacean						191	173	1.7	187	187	174	157	1.8	171	171	200
MF Cetacean						190	172	1.8	186	186	173	156	1.8	170	170	199
HF Cetacean						190	173	1.7	187	187	174	157	1.8	170	170	200
PW						188	168	1.9	184	184	171	152	2.0	167	167	197
OW						189	168	2.0	185	185	173	152	2.1	169	169	198
Far-Field Hydrophone																
Unweighted	203	187	1.2	201	201	191	172	1.4	188	188	177	159	1.3	174	174	203
LF Cetacean						186	169	1.3	183	183	172	154	1.4	168	168	198
MF Cetacean						185	166	1.4	182	182	171	153	1.4	168	168	197
HF Cetacean						185	167	1.4	183	183	172	154	1.4	168	168	198
PW						183	164	1.3	180	180	170	150	1.4	165	165	195
OW						184	165	1.3	181	181	171	150	1.4	166	166	196

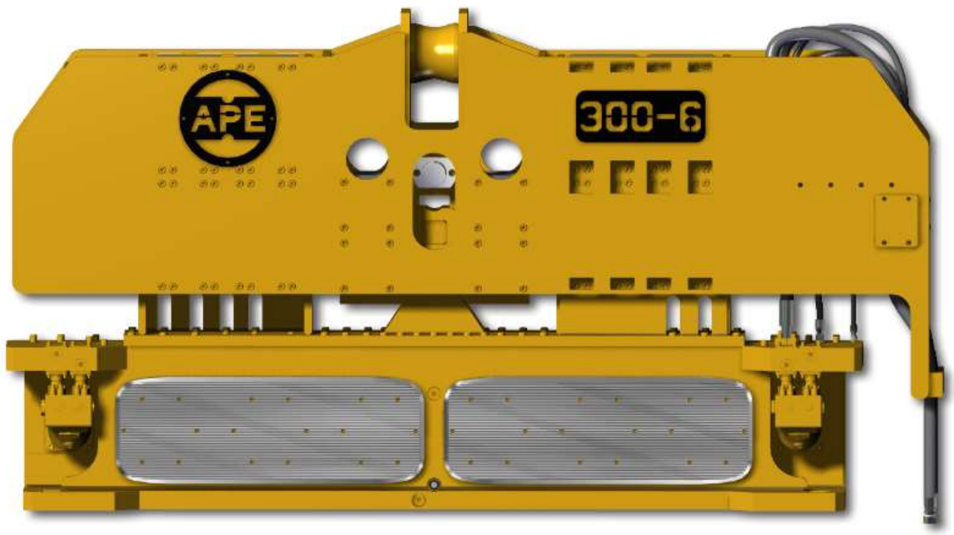
Note: Measurement distances normalized to 33 feet (10 meters)


Sound Pressure during Pile Driving
Sound Pressure, Pa
Time, Seconds
Peak Waveform, Pa
Sound Pressure, Pa
Time, Seconds
Spectrogram
Frequency, Hz
Time, Seconds
Frequency Spectra
SPL, dB re: 1 uPa
Frequency, Hz

3.0 APE MODEL 300-6 VIBRATORY PILE DRIVER

APE Model 300-6 Vibratory Driver Extractor

The World's Largest Provider of Foundation Construction Equipment



SPECIFICATION	800 POWER UNIT	950 POWER UNIT
Eccentric Moment	7980 in-lbs (91.93 kgm)	7980 in-lbs (91.93 kgm)
Drive Force	309 tons (2744 kN)	388 tons (3,449 kN)
Frequency Maximum (VPM)	0-1650 vpm	0-1850 vpm
Max Line Pull	185 tons (1,645 kN)	185 tons (1,645 kN)
Bare Hammer Weight w/o Clamp	21,200 lbs (9,616 kg)	21,200 lbs (9,616 kg)
Shipping Weight w/ 200' Bundle	25,000 lbs (11,340 kg)	25,000 lbs (11,340 kg)
Throat Width	23" (58 cm)	23" (58 cm)
Length	155" (394 cm)	155" (394 cm)
Height w/o Clamp	82" (207 cm)	82" (207 cm)
Power Unit Engine Type	CAT C18 TIER IV STAGE V DUAL CERTIFIED	CAT C27 TIER IV STAGE V DUAL CERTIFIED
Power Unit Horsepower	800 HP (597 kW)	950 HP (708 kW)

Note: Total Shipping weight set up equipped w/ Stand & Sheet Clamp

Specifications may vary due to site conditions, specific hammer conditions or product set up.
Specifications may change without notice.
Consult the factory for details on any specific product (800) 248-8498.

WWW.AMERICANPILEDRIVING.COM
(800) 248-8498
Ape@americanpiledriving.com

4.0 APE MODEL D62 SINGLE ACTING IMPACT HAMMER

APE Model D62-22 Single Acting Impact Hammer

operates on diesel or bio-diesel for all types of impact pile driving

Bottom drive system for large diameter piles

MODEL D62-22 (6.2 metric ton ram)

SPECIFICATIONS

Maximum Rated Energy	153,770 ft/lbs (208,484 Nm)
Minimum Rated Energy	78,956 ft/lbs (107,050 Nm)
Stroke at Rated Energy	11.24 ft (3.42 m)
Maximum Obtainable Stroke	12.5 ft (3.81 m)
Speed (blows per minute)	36-50

WEIGHTS (Approximate)

Piston	13,669 lbs (6,200 kg)
Anvil	2,833 lbs (1,285 kg)
Hammer Weight (includes trip device)	28,272 lbs (12,823 kg)
Hammer weight w/ DB-32 Drive Base	31,744 lbs (14,399 kg)
Typical Operating Weight w/ Drive Cap	Varies- consult factory

CAPACITIES

Fuel Tank (runs on diesel or bio-diesel)	25.89 gal (98 liter)
Oil Tank	8.32 gal (31.5 liter)

CONSUMPTION

Diesel or Bio-Diesel Fuel	5.28 gal/hour (20 liter/ hour)
Lubrication Oil	.84 gal/hour (3.2 liter/hour)
Grease	twice per day

DIMENSIONS OF HAMMER

a	Length overall	232.68 in (5,910 mm)
a	Length over cylinder extension	272 in (6,908 mm)
a	Length over trip tubes	308 in (7,823 mm)
b	Impact block diameter	27.91 in (709 mm)
c	Width over bolts	35.6 in (904 mm)
d	Hammer width overall	31.5 in (800 mm)
e	Width for guiding- face to face	32 in (812 mm)
f	Hammer center to pump guard	19.3 in (490 mm)
g	Hammer center to bolt center	15 in (381 mm)
h	Hammer depth overall	38.2 in (970 mm)
H	Minimum clearance for leads	19.7 in (500 mm)

Features

Fuel and lube pumps with 50% less parts than ICE
Hardened piston needs no high maintenance wear rings
Optional direct drive for high speed production on steel piles
Fuel pump mounted where heat will not harm it
Variable mechanical cam fuel pump- no air pistons or rings
Optional hydraulic variable fuel remote control
Heavy duty trip system for years of fault free operation
Chrome rings for super long life
Low maintenance and extremely low parts pricing
German design at a reasonable price
Two year APE warranty

AMERICAN PILEDRIVING EQUIPMENT, INC. APE

Corporate Offices
7032 South 196th
Kent, Washington 98032 USA
(800) 248-8498 & (253) 872-0141
(253) 872-8710 Fax

2/06

Visit our WEB site:
www.apevibro.com
e-mail: ape@apevibro.com

We reserve the right to modify specifications without notice. Contact APE directly for updated literature.

5.0 UNCONFINED BUBBLE CURTAIN

Pacific Pile&Marine

BUBBLE CURTAIN DEPLOYMENT AND OPERATION

Prior to deploying the Unconfined Bubble Curtain (hereafter Bubble Curtain) it is inspected at the PPM storage facility and again once onboard the barge prior to deployment for operation.

This Inspection Includes:

- Compressors
- Manifolds
- Connector Fittings
- Pressure Guages
- Hoses
- Rings
- Ring Spacing
- Rollers
- Bubble Diffusers
- Nozzles
- Saddle Plate
- Globe Valve
- Hand Wheel

Deployment:

- Bubble Curtain Leads are attached to Hammer
- Hammer and Bubble Curtain are hoisted over the top of Pile
- Prior to lowering Bubble Curtain into Water Column Bubble Curtain is activated
- As Bubble Curtain is lowered into Water Column each ring is confirmed to operate correctly
- Spacing of Bubble Curtain Rings is confirmed by crew onsite
- Bubbles are confirmed to encircle pile prior to engaging in Impact Work

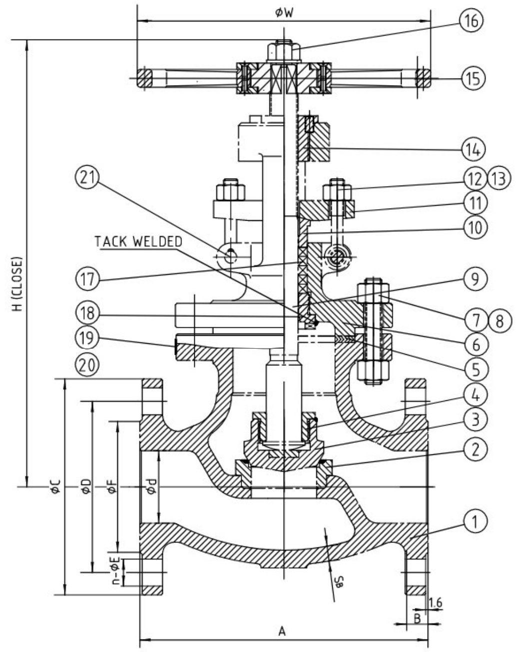
Operation:

- In order for successful operation of Bubble Curtain it must be inspected regularly to confirm that it is clear of debris and that all Bubble Diffusers are operating correctly.
- Bubble Curtain is to remain active for approximately 30 seconds following completion of Impact Pile Driving Work before it is removed from the water column

For further questions and specifics of operation Steven Spencer (Engineer) 425-861-6054 and Ryan Stewart (PPM Foreman) 360-535-0014 are available for consultation.

www.pacificpile.com

Wm. E. Williams No. 152F4AB Class 150 RF Globe Valve ASTM A 216 WCB (Aluminum Bronze Trim)



BILL OF MATERIALS		
ITEM	PART	MATERIAL
1	BODY	ASTM A216-WCB
2	SEAT	ASTM A105+ALUM BRONZE
3	DISC	ASTM A105+ALUM BRONZE
4	DISC COVER	ASTM A276-410
5	GASKET	SS304+GRAPHITE
6	BONNET	ASTM A216-WCB
7	BONNET BOLT	ASTM A193-B7
8	BONNET NUT	ASTM A194-2H
9	STEM	ALUMINUM BRONZE
10	GLAND	ASTM A276-410
11	GLAND FLANGE	ASTM A216-WCB
12	EYE BOLT	ASTM A193-B7
13	EYE BOLT NUT	ASTM A194-2H
14	STEM NUT	ASTM A439-D-2
15	HANDWHEEL	NODULAR CAST IRON
16	HANDWHEEL NUT	ASTM A29-1035
17	PACKING RING	GRAPHITE
18	BACKSEAT BUSHING	ASTM A276-410
19	NAMEPLATE	304SS
20	RIVET	304SS
21	PIN	ASTM A29-1035

SIZE	d	A	B	C	D	n	E	F	H	W	SB
2"	51	203	16	152	120.7	4	19	92.1	327	200	9
2-1/2"	64	216	17.5	178	139.7	4	19	104.8	343	250	9.5
3"	76	241	19	190	152.4	4	19	127	350	250	10.3
4"	102	292	24	229	190.5	8	19	157.2	441	300	11.2
5"	127	356	24	254	215.9	8	22	185.7	460	300	11.5
6"	152	406	26	279	241.3	8	22	215.9	468	350	11.9
8"	203	495	29	343	298.5	8	22	269.9	542	450	12.7
10"	254	622	31	406	362	12	25	323.8	636	450	14
12"	305	698	32	483	431.8	12	25	381	830	560	16
14"	337	787	35	533	476.3	12	29	412.8	877	560	17
16"	387	914	37	597	539.8	16	29	469.9	878	560	17.5

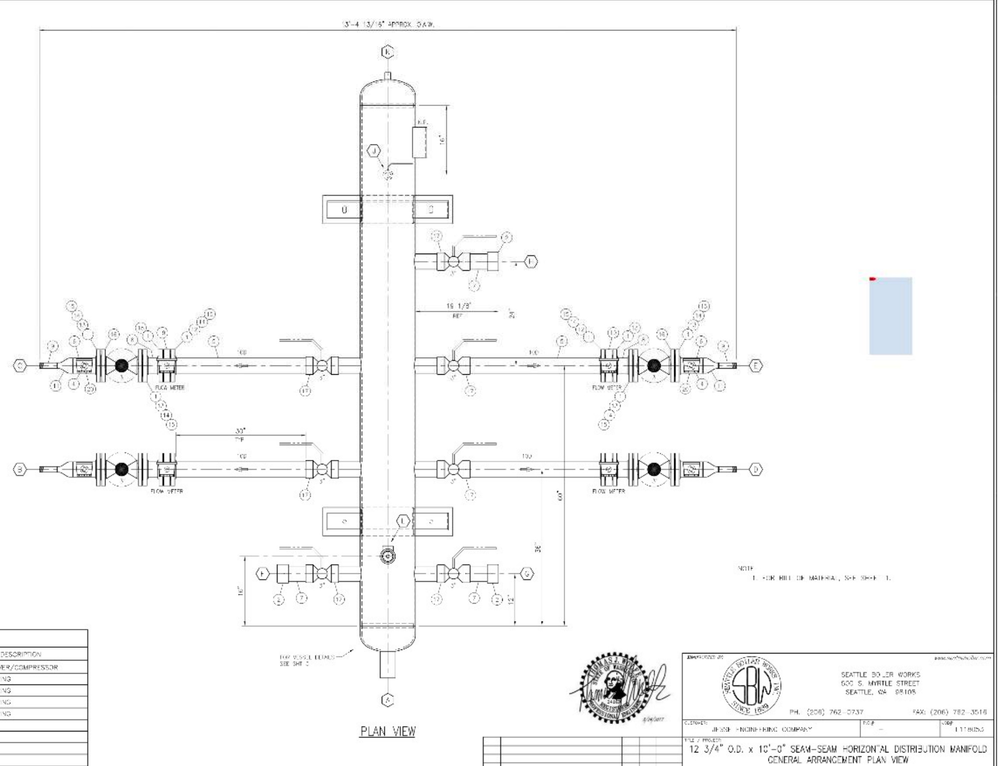
WILLIAM E. WILLIAMS VALVE CORPORATION
WWW.WILLIAMSVALVE.COM
38-52 REVIEW AVENUE, LONG ISLAND CITY, NY 11101
TEL: 718-392-1660 FAX: 718-729-5106

TITLE: CAST STEEL GLOBE VALVE
CLASS 150 - ALUMINUM BRONZE TRIM - B,B R,F OS&Y

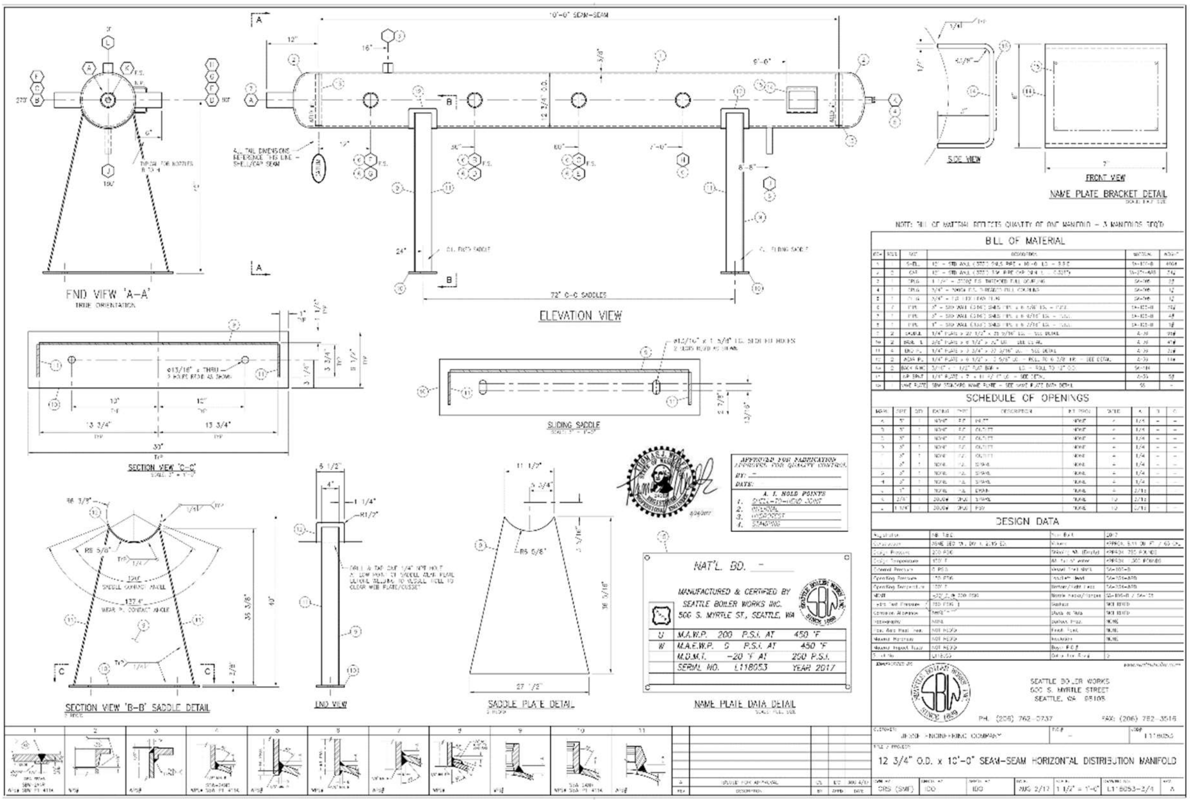
MARKING SYSTEM	MSS-SP-25	INSPECTION & TEST: API 598			
DIM.OF FLANGE	ANSI B16.5	SHELL	HYDRO	450PSI	
FACE TO FACE	ANSI B16.10	HPC SEAT	HYDRO	315PSI	
WALL THICKNESS	BS1873	BACK SEAT	HYDRO	315PSI	
DESIGNED	BS1873, ANSI B16.34				

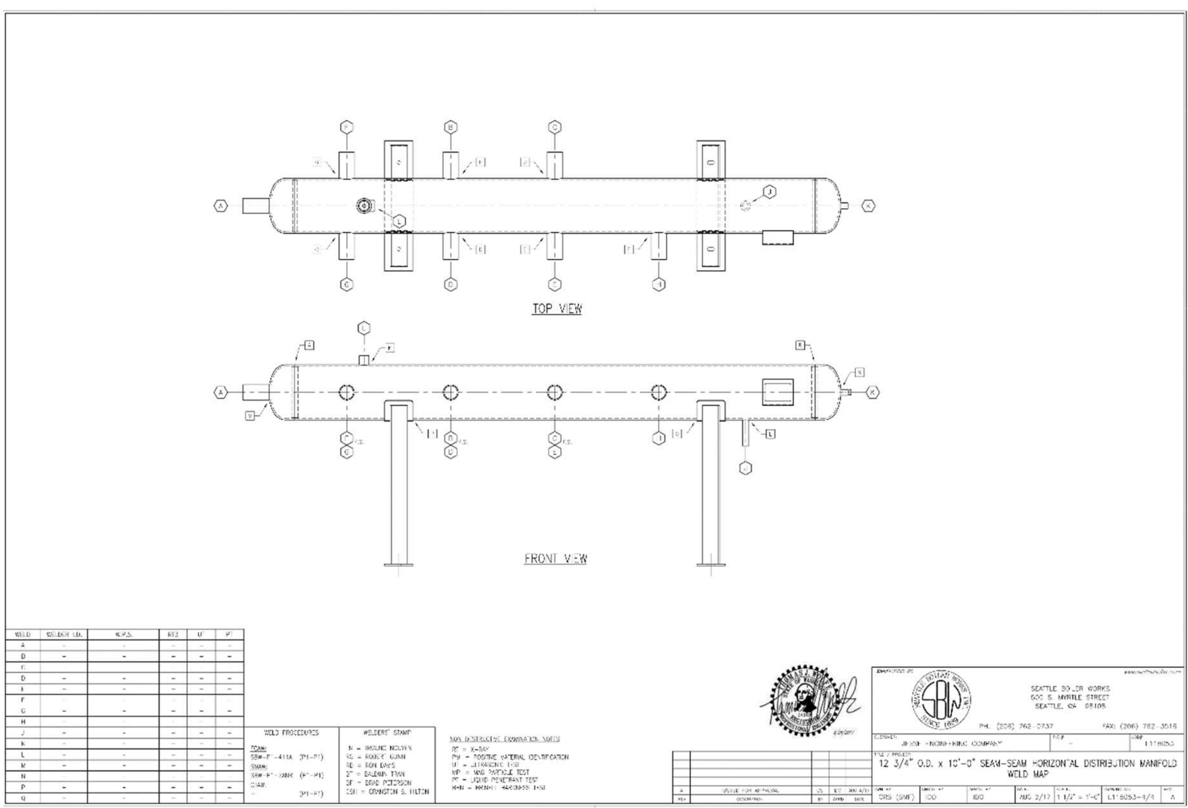
NO.	DATE	DESCRIPTION	PRP'D	REV'D	APP'D
⚠	6/12/15	RELEASED	F.J.	R.P.	R.P.

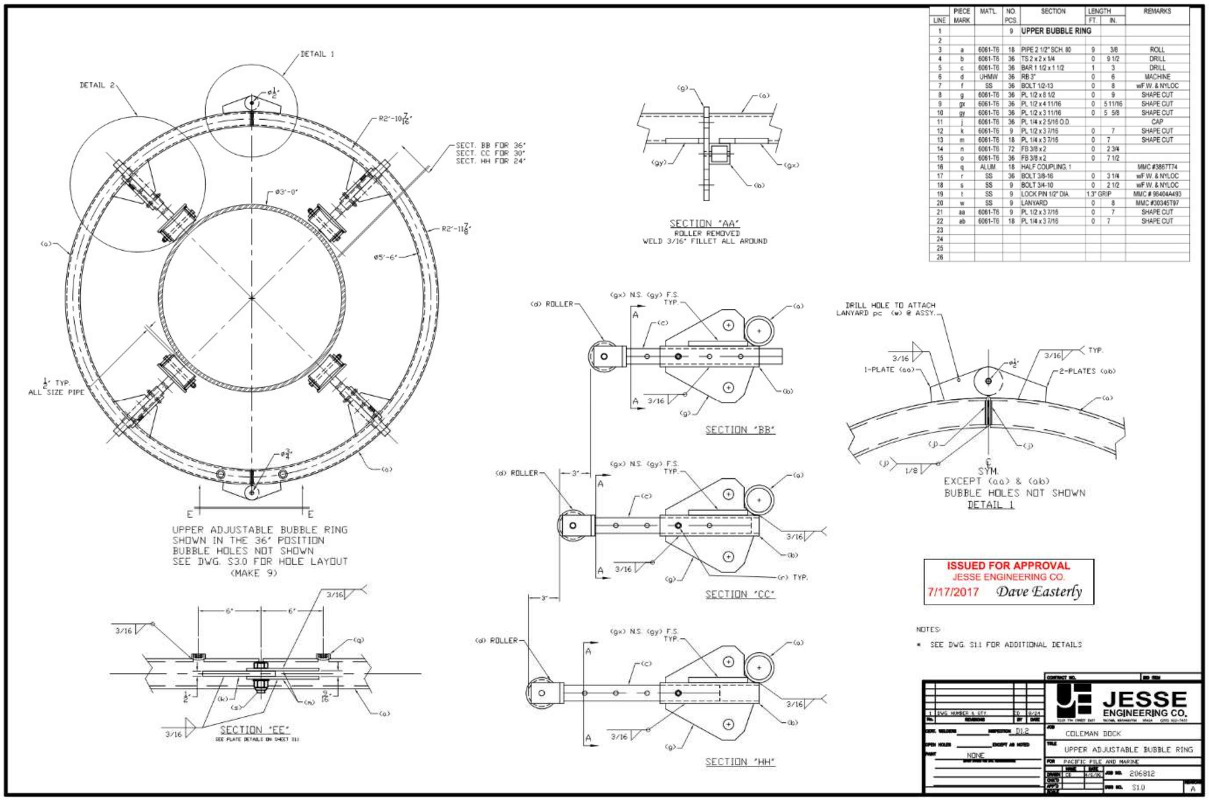
MATERIAL: ASTM A216 GR.WCB
UNITS: Inch, mm
CLASS: 150
DATE: 06/12/15
SCALE: N.T.S.
SIZE: 2" - 16"
FIG. No.: 152F-4AB
DRAWN BY: F.J.
CHK'D & APR'D BY: R.P.
REV: 1
DWG No.: 60GL120141-28

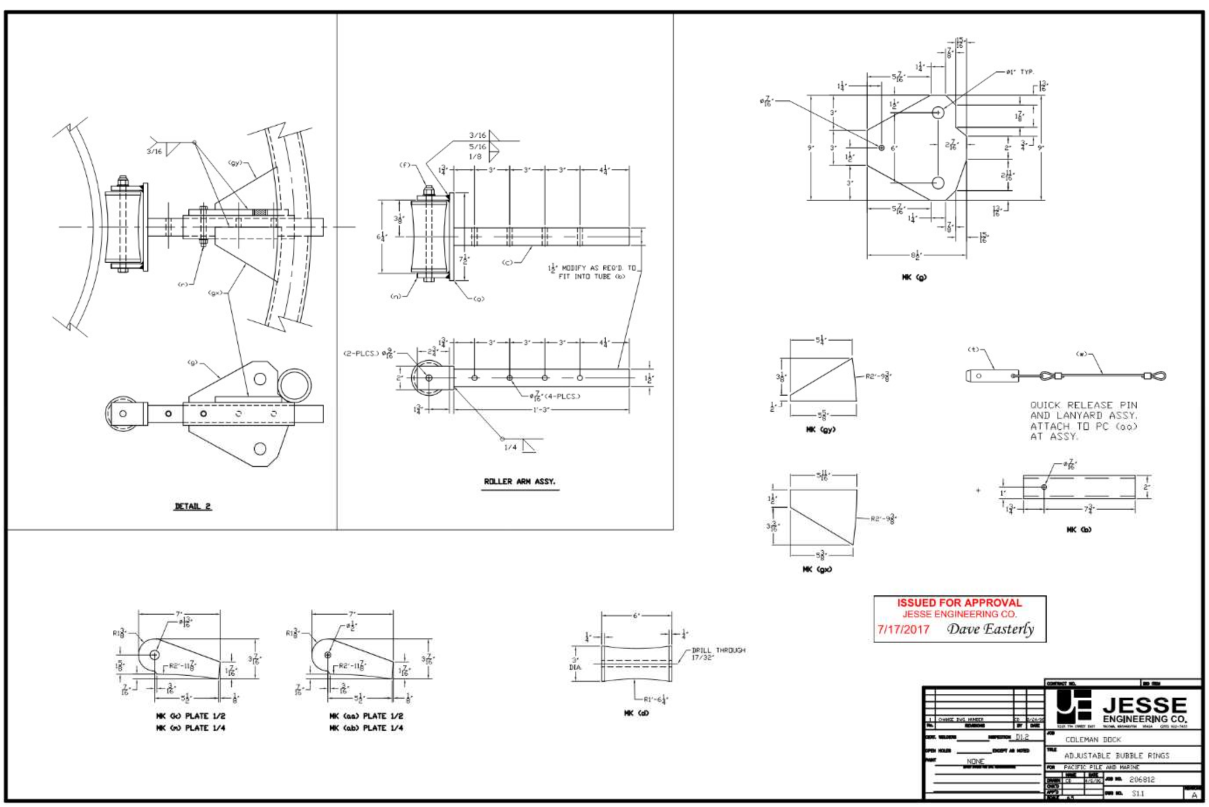


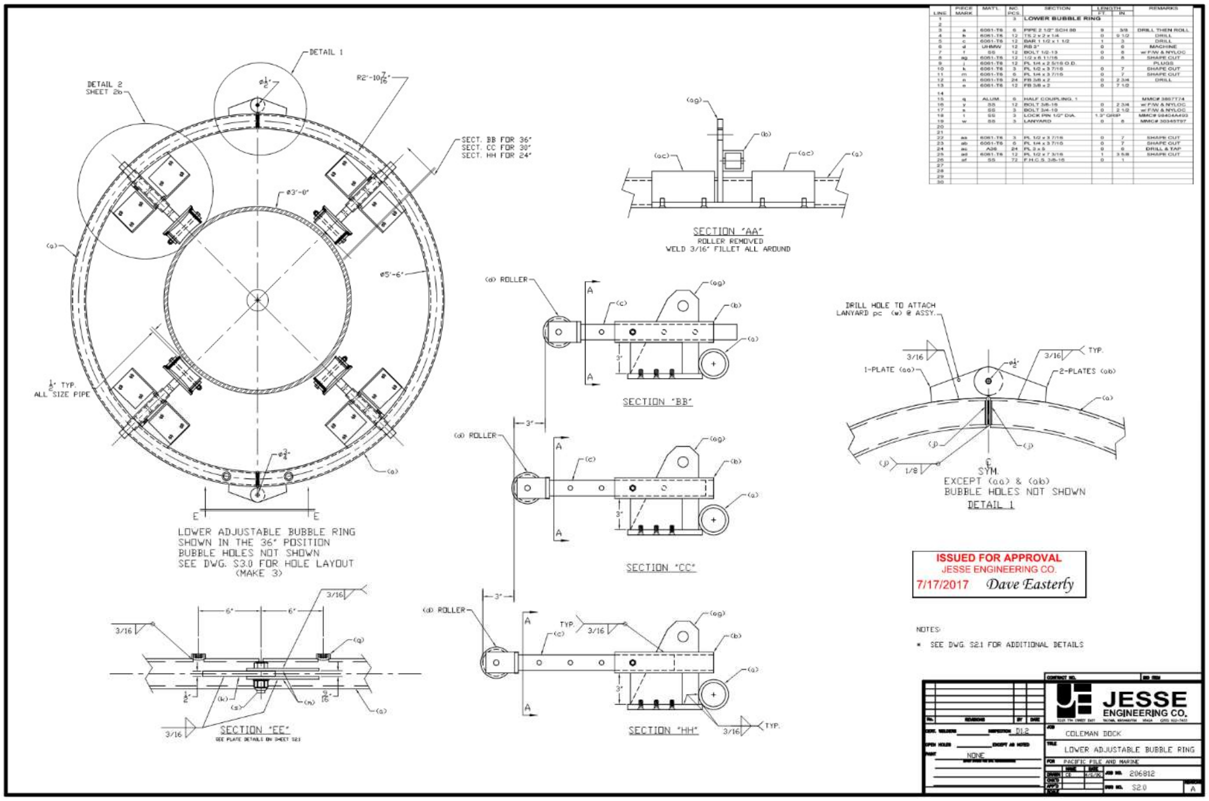
SCHEDULE OF OPENINGS		
TAG	SIZE & RATING	SERVICE / DESCRIPTION
A	3" PLAIN END	INLET FROM AIR RECEIVER/COMPRESSOR
B	1" NPT	OUTLET TO BUBBLER RING
C	1" NPT	OUTLET TO BUBBLER RING
D	1" NPT	OUTLET TO BUBBLER RING
E	1" NPT	OUTLET TO BUBBLER RING
F	3" NPT	SPARE c/w CAP
G	3" NPT	SPARE c/w CAP
H	3" NPT	SPARE c/w CAP
J	1" NPT	DRAIN c/w CAP
K	3/4" 3000# NPT	SPARE c/w PLUG
L	1 1/2" NPT	PSV OUTLET

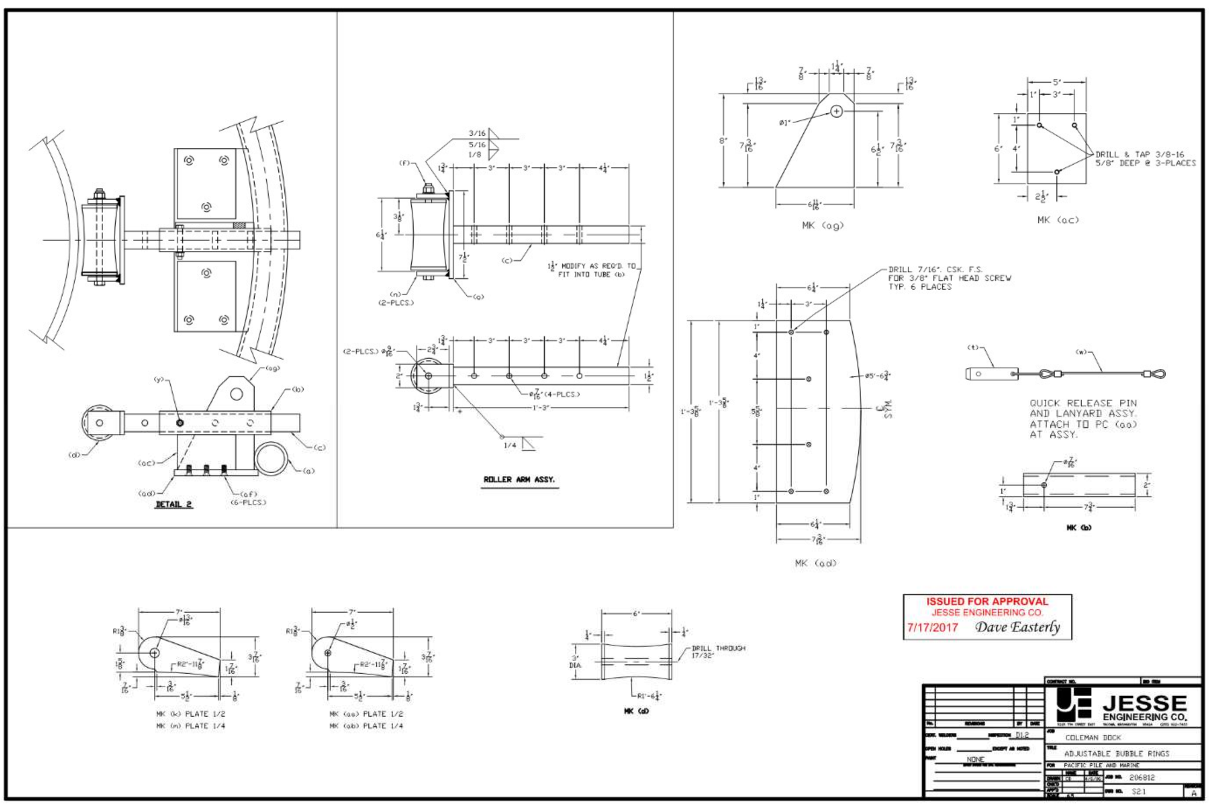

ELEVATION VIEW
END VIEW 'A-A'
BILL OF MATERIAL
SCHEDULE OF OPENINGS
DESIGN DATA
SECTION VIEW 'C-C'
SLIDING SADDLE
NAME PLATE BRACKET DETAIL
SECTION VIEW 'B-B' SADDLE DETAIL
END VIEW
SADDLE PLATE DETAIL
NAME PLATE DATA DETAIL
SEATTLE BOILER WORKS
500 S. MYRTLE STREET
SEATTLE, WA 98108
12 3/4" O.D. x 10'-0" SEAM-SEAM HORIZONTAL DISTRIBUTION MANIFOLD

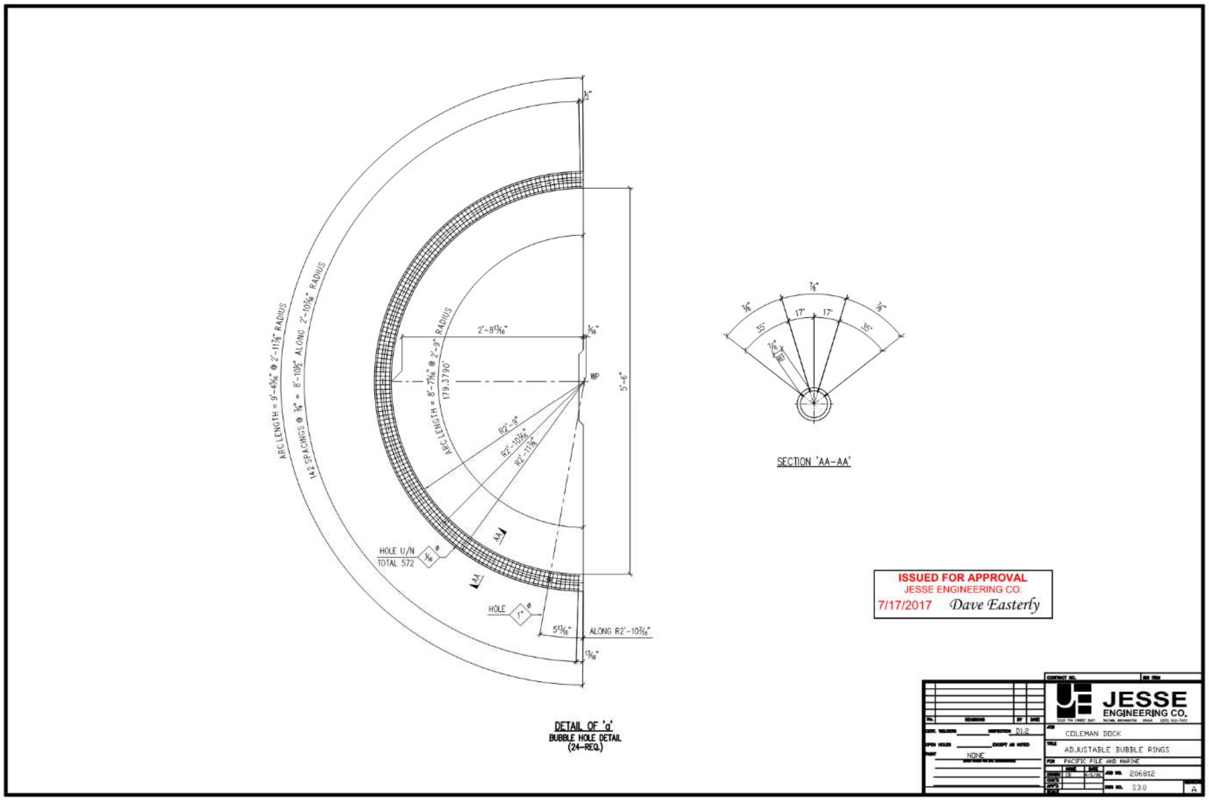

TOP VIEW
FRONT VIEW
SEATTLE BOILER WORKS
500 S. MYRTLE STREET
SEATTLE, WA 98108
12 3/4" O.D. x 10'-0" SEAM-SEAM HORIZONTAL DISTRIBUTION MANIFOLD
WELD MAP


UPPER ADJUSTABLE BUBBLE RING
SHOWN IN THE 36" POSITION
BUBBLE HOLES NOT SHOWN
SEE DWG. S3.0 FOR HOLE LAYOUT
(MAKE 9)
SECTION "AA"
ROLLER REMOVED
WELD 3/16" FILLET ALL AROUND
SECTION "BB"
SECTION "CC"
SECTION "HH"
SECTION "EE"
DETAIL 1
DETAIL 2
ISSUED FOR APPROVAL
JESSE ENGINEERING CO.
7/17/2017 Dave Easterly
NOTES:
SEE DWG. S11 FOR ADDITIONAL DETAILS
JESSE ENGINEERING CO.
COLEMAN DOCK
UPPER ADJUSTABLE BUBBLE RING
PACIFIC PILE AND MARINE
206812
S10


DETAIL 2
ROLLER ARM ASSY.
QUICK RELEASE PIN
AND LANYARD ASSY.
ATTACH TO PC (aa)
AT ASSY.
ISSUED FOR APPROVAL
JESSE ENGINEERING CO.
7/17/2017 Dave Easterly
JESSE ENGINEERING CO.
COLEMAN DOCK
ADJUSTABLE BUBBLE RINGS
PACIFIC PILE AND MARINE
206812
S11


SECTION "AA"
ROLLER REMOVED
WELD 3/16" FILLET ALL AROUND
SECTION "BB"
SECTION "CC"
SECTION "HH"
SECTION "EE"
DETAIL 1
LOWER ADJUSTABLE BUBBLE RING
SHOWN IN THE 36" POSITION
BUBBLE HOLES NOT SHOWN
SEE DWG. S3.0 FOR HOLE LAYOUT
(MAKE 3)
DRILL HOLE TO ATTACH
LANYARD pc (w) @ ASSY.
EXCEPT (aa) & (ab)
BUBBLE HOLES NOT SHOWN
ISSUED FOR APPROVAL
JESSE ENGINEERING CO.
7/17/2017 Dave Easterly
NOTES:
* SEE DWG. S2.1 FOR ADDITIONAL DETAILS
JESSE ENGINEERING CO.
COLEMAN DOCK
LOWER ADJUSTABLE BUBBLE RING
PACIFIC PILE AND MARINE
206812
S2.0


DETAIL 2
ROLLER ARM ASSY.
MK (ag)
MK (ac)
DRILL & TAP 3/8-16
5/8" DEEP @ 3-PLACES
DRILL 7/16", CSK. F.S.
FOR 3/8" FLAT HEAD SCREW
TYP. 6 PLACES
MK (ad)
QUICK RELEASE PIN
AND LANYARD ASSY.
ATTACH TO PC (aa)
AT ASSY.
MK (b)
MK (k) PLATE 1/2
MK (m) PLATE 1/4
MK (aa) PLATE 1/2
MK (ab) PLATE 1/4
DRILL THROUGH
17/32"
MK (d)
ISSUED FOR APPROVAL
JESSE ENGINEERING CO.
7/17/2017 Dave Easterly
JESSE ENGINEERING CO.
COLEMAN DOCK
ADJUSTABLE BUBBLE RINGS
PACIFIC PILE AND MARINE
206812
S2.1


DETAIL OF 'a'
BUBBLE HOLE DETAIL
(24-REQ.)
SECTION 'AA-AA'
ISSUED FOR APPROVAL
JESSE ENGINEERING CO.
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