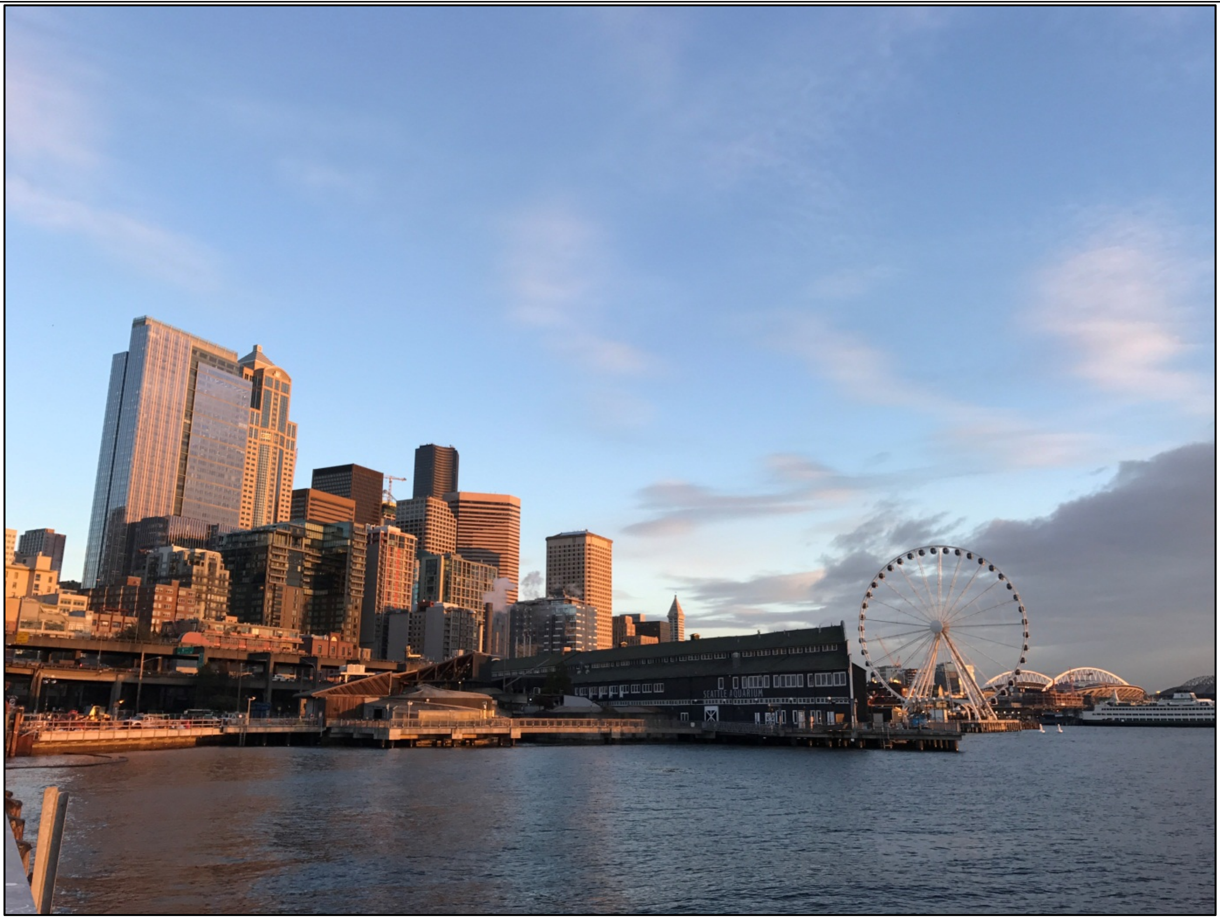

ELLIOTT BAY SEAWALL PROJECT
COMPREHENSIVE ACOUSTIC MONITORING REPORT

August 18, 2017

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City of Seattle Department of Transportation

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1.0 INTRODUCTION

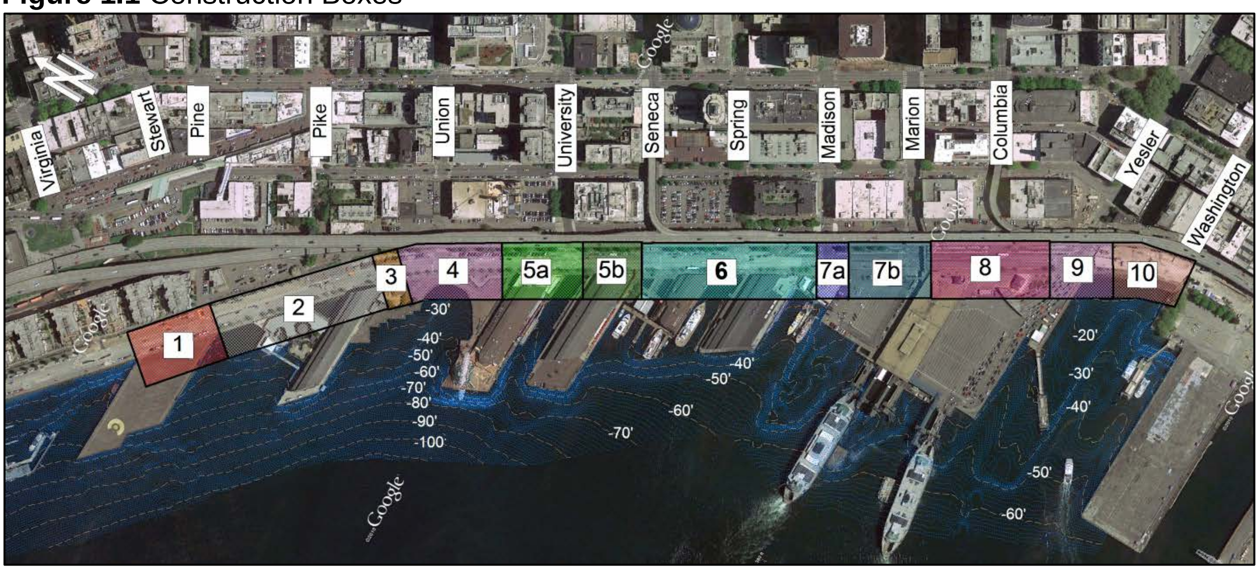
This Comprehensive Acoustic Monitoring Report provides a summary of underwater sound levels measured during in-water pile driving from all four construction seasons of the Elliott Bay Seawall Project ("Project").

Consultation with the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Fish and Wildlife Service (USFWS) under the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA) requires sound level monitoring for the first five unobstructed piles of each pile type and installation method, with some exceptions. This Comprehensive Acoustic Monitoring Technical Report fulfills the requirements of the Project's Biological Opinion issued by NOAA and USFWS, and the MMPA Letters of Authorization (LOA), issued by NOAA.

Consultation with NOAA and USFWS under the MMPA and ESA also requires collection of underwater background sound levels. As a result of the September 22, 2014 coordination with NOAA, USFWS and SDOT, the parties agreed that background sound level data would be collected at two locations: near the construction area and between 500 and 1,000 meters from the construction area in Elliott Bay.

The Project construction area was located west of Alaskan Way between Virginia Street and Washington Street in Seattle, Washington. Airborne and underwater sound levels measurements were made in Boxes 4 and 10 during Season 1; Box 6 during Season 2; Box 2 during Season 3 and Box 1 during Season 4 (see Figure 1.1).

Figure 1.1 Construction Boxes



2.0 MEASUREMENT METHODOLOGY

Airborne sound levels were collected at 50 feet from pile driving, with the exception of Season 1 when greater distances were needed due to site layout and safety. However, Season 1 data was normalized to 50 feet, as required in the Project's LOA. Measurements were made between five and seven feet above either a pier or ground with line of sight to the pile driving.

Unless otherwise noted, hydroacoustic monitoring was conducted using two hydrophones located approximately 33 feet (10 meters) from pile driving activities. The distances between the piles and hydrophones were measured using a laser distance measurement device. Hydrophone locations were selected based on site access and to achieve an unobstructed acoustical transmission path between the hydrophones and piles where possible.

Generally, one hydrophone was positioned 3.3 feet (1 meter) below the surface and the second hydrophone was positioned 3.3 feet (1 meter) above the sea floor. Water depth was measured at the hydrophone deployment locations. In addition to water depth measurements, tidal information was obtained from NOAA Station #9447130 and was used to track tidal changes during construction and to calculate the resulting distance between the two hydrophones.

During Season 1, one hydrophone located approximately 33 feet (10 meters) from pile driving was used to collect underwater sound levels from impact and vibratory pile driving in Box 10 due to shallow water depths. Hydroacoustic data measured from vibratory pile driving in Box 4 during Season 1 was conducted using four hydrophones. Two hydrophones were located approximately 3.3 feet (1 meter) below the surface, while the other two were deployed 70% to 85% of the total water depth. Far field measurements were not conducted during Season 1.

Underwater sound levels measured from impact pile driving during Season 3 were measured simultaneously at two different monitoring locations, one near the pile and the other near a buoy in Elliott Bay to determine whether underwater sound levels generated by pile driving were above the disturbance and injury thresholds for pinnipeds. Near shore measurements and measurements made near the buoy were made with one hydrophone deployed at mid-water depth, allowing for the estimation of a site-specific attenuation factor for obstructed piles in Box 2. Near shore measurements were made approximately 50 feet (15 meters) from impact pile driving due to limited site access and to maintain an unobstructed acoustical path between the hydrophone and the piles.

Hydroacoustic measurements of impact pile driving during Season 4 were made using four hydrophones. Two hydrophones were deployed approximately 33 feet (10 meters) from impact pile driving at 3.3 feet (1 meter) below the surface and 3.3 feet (1 meter) above the seafloor. Two additional hydrophones were located at mid-water depth at various distances from pile driving to determine a site-specific attenuation factor for obstructed piles in Box 1.

Near shore and far-field background sound levels were measured using one hydrophone deployed at mid-water depth.

3.0 SIGNAL PROCESSING

The Project's LOAs and Biological Opinion require reporting of underwater sound levels generated by the first five unobstructed piles of each pile type and driving method. These reported sound levels must include the frequency spectrum, ranges, means and standard deviation for the peak and RMS sound pressure levels for each marine mammal functional hearing group, as well as the estimated distance required for the RMS values to reach the marine mammal thresholds and background sound levels. During impact pile driving, the pile strike resulting in the absolute highest peak sound pressure level must be used to calculate the cSEL of the pile drive.

The Season 1 LOA did not specify that the sound levels should be measured from unobstructed piles, but did require monitoring of the first five piles of each pile type and driving method. Measurements of unobstructed piles were included in the LOAs for Seasons 2 through 4. Monitoring of obstructed piles was permitted during Season 3 to allow for measurements of sound levels near a buoy to determine whether pile driving was exceeding the relevant marine mammal threshold criteria at the location of the buoy.

As requested by NOAA during a conference call on September 22, 2014, sound levels measured during ramp-up activities are reported separately from sound levels measured during pile driving under full power. In addition, NOAA requested sound level data to include the range of SEL values.

Consultation with NOAA and USFWS under the MMPA and ESA also requires collection of underwater background sound levels. As a result of the September 22, 2014 coordination with NOAA, USFWS and SDOT, the parties agreed that background sound level data would be collected between 500 and 1,000 meters from the construction area to verify that sound levels reported by WSDOT in 2011 had not changed.

3.1 Vibratory Pile Driving

Hydroacoustic data collected during vibratory installation of steel sheet piles and removal of concrete piles from all four construction seasons was analyzed to determine the range, average and standard deviation of 10-second RMS, peak and SEL values for each marine mammal functional hearing group. Periods during the pile drive when pile installation was not occurring under full power are excluded from the analysis.

Data was analyzed for each functional hearing group by applying a band pass filter to remove frequencies from the signal that are not included in the functional hearing group being analyzed. SEL values were calculated using 1-second RMS values.

The reported maximum and minimum values are the maximum or minimum value from either of the two hydrophones located approximately 10 meters from vibratory pile driving. The standard deviation was calculated using decibel values. Average sound levels were calculated using the mean sound pressure from each hydrophone, converted to decibels and taking the logarithmic average of the two values.

Airborne sound data collected during vibratory installation of the steel sheet piles and removal of concrete piles was analyzed to determine the range and average of unweighted 10-second RMS values while piles were installed under full power. These 10-second RMS values were calculated over a frequency range of at least 10 Hz to 20 kHz.

3.2 Impact Pile Driving

Underwater sound data collected during the impact driving of steel sheet piles were analyzed to determine the range, average and standard deviation of peak, RMS_{90}, and SEL values as well as the cSEL of each pile for each marine mammal functional hearing group as required by the ESA and MMPA consultation. Periods when pile driving was not occurring under full power were excluded from this analysis. Ramp-up activities were separated from the full power pile driving analysis and are presented separately.

Standard deviation was calculated using the decibel values and the average sound levels were calculated using the mean sound pressure levels.

Data analysis was conducted for each marine mammal functional hearing group by applying a band pass filter to remove frequencies from the signal that are not included in the functional hearing group being analyzed. This filter provides a roll off of more than -40 dB per decade.

The RMS_{90} was established between the 5^{th} percentile and 95^{th} percentile of each recorded pile strike. SEL values for impact pile driving of steel sheet piles were calculated for each pile strike over the duration of the strike containing 90% of the acoustic energy 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.

cSEL values where calculated using the SEL value corresponding to the maximum peak pile strike using the following formula, which is required by the ESA documents:

$$\mathrm{cSEL} = \mathrm{SEL_{single}} + 10\log_{10}(n)$$

Where $\mathrm{SEL_{single}}$ is the SEL value corresponding to the pile strike which produced the highest peak sound pressure and *n* is the total number of pile strikes included in the analysis.

An unobstructed path between the piles and microphone used to collected airborne sound levels was maintained throughout the duration of all impact pile driving wherever possible. The range and average unweighted RMS values were calculated over periods of full power pile driving using either 100-millisecond or 1-second RMS values calculated over a frequency range of at least 10 Hz to 20 kHz.

3.3 Background Sound Levels

Background sound levels reported from Season 1 were calculated from broadband 1-hour RMS sound levels and background sound levels reported from construction Seasons 2 through 4 were calculated using 10-second RMS background sound data collected during daytime hours. This data was used to calculate the cumulative distribution function (CDF) of each marine mammal functional hearing group in accordance with the NOAA Guidance Document: “Data Collection Methods to Characterize Underwater Background Sound Relevant to Marine Mammals in Coastal Nearshore Waters and Rivers of Washington and Oregon” dated January 31, 2012. The marine mammal functional hearing groups are presented in Table 3.1.

Table 3.1 Marine Mammal Functional Hearing Groups

Functional Hearing Group	Low Frequency	High Frequency
Low-Frequency Cetaceans	7 Hz	20 kHz
Mid-Frequency Cetaceans	150 Hz	20 kHz
High-Frequency Cetaceans	200 Hz	20 kHz
Pinnipeds	75 Hz	20 kHz

Note: Underwater sound levels from pile driving as well as background sound levels measured during Season 1-4 were analyzed using NOAA’s previous Guidance Documents dated January 31, 2012. Data collected from pile driving during Season 4 was also analyzed using the updated technical guidance issued in July, 2016.
Source: NOAA Guidance Document: “Data Collection Methods to Characterize Underwater Background Sound Relevant to Marine Mammals in Coastal Nearshore Waters and Rivers of Washington and Oregon” dated January 31, 2012

The overall broadband background sound levels for each hearing group described in Table 3.1 are reported as the 50th percentile of the CDFs.

4.0 RESULTS

Underwater sound levels measured during all four construction seasons are provided in the Appendix of this Report. It should be noted that underwater data collected during Season 1 was reanalyzed at the request of NOAA to include additional metrics. These data was re-analyzed after the issuance of the Season 1 Report and as a result Season 1 sound levels included in the Appendix of this report differ from those provided in the Season 1 Report.

The range of average peak, RMS and SEL sound levels measured over the duration of the Project are provided in Table 4.1 below.

Table 4.1 Range of Average Underwater Sound Levels, dB re: 1 μPa

Driving Method	Pile Type	Obstructed			Unobstructed		
		Peak	RMS	SEL	Peak	RMS	SEL
Vibratory	Sheet Pile	163 – 171	147 – 164	147 – 164	164 – 186	147 – 168	148 – 168
	Concrete Pile (removal)	148 – 157	129 – 147	129 – 147	-	-	-
Impact	Sheet Pile	184 – 194	171 – 182	157 – 167	192 – 198	180 – 185	166 – 170
	Concrete Pile	159 – 181	145 – 170	134 – 158	172 – 194	155 – 183	146 – 168

Note: Underwater sound levels were measured 32 to 40 feet (10-12 meters) from piles or were normalized to 33 feet (10 meters)

The number of piles and driving methods monitored during all four construction seasons is summarized in Table 4.2.

Table 4.2 Summary of Monitored Pile Types and Driving Methods

Driving Method	Pile Type	Season 1		Season 2	Season 3	Season 4
		Box 4	Box 10			
Vibratory	Sheet Pile	5*	7	5	5	5*
	Concrete Pile (removal)	0	0	0	0	5*
Impact	Sheet Pile	0	0	5	5*	5*
	Concrete Pile	6*	5	0	0	0

Note: "*" indicates obstructed piles

The results of hydroacoustic monitoring conducted over the duration of the Project are discussed in the Sections below.

4.1 Vibratory Pile Driving

Steel sheet piles were installed using an APE Model 250 Variable Moment Vibratory Driver/Extractor during all four construction seasons. Hydroacoustic monitoring took place during the installation of at least five sheet piles during each construction season, totaling 27 steel sheet piles over the duration of the project. The same vibratory hammer was also used to remove concrete piles in Box 1 during Season 4. Hydroacoustic monitoring was conducted during the removal of the first five concrete piles.

Vibratory pile driving was monitored in Box 4 on February 12 and 13, 2014 during Season 1. However, because the sheet piles were obstructed by Waterfront Dock, further measurements were made in Box 10 on February 24, 2014. Reported sound levels from Box 4 have been normalized to 33 feet (10 meters) from the pile using the practical spreading model.

During vibratory pile driving in Box 10, the vibratory hammer operated at a reduced energy setting during the monitoring of sheet piles three through seven, which led to a reduction in underwater sound levels. The reduced energy setting appeared to be most effective in mid and high-frequency cetacean and pinniped marine mammal hearing groups. Noise mitigation was not implemented during any other vibratory pile driving over the duration of the project.

Unobstructed measurements of vibratory pile driving were conducted in Box 6 on October 30 and 31, 2014 and November 7, 2014 during Season 2. During Season 3, unobstructed vibratory pile driving was monitored on January 14 and 15, 2016 in Box 2. Vibratory pile driving was also monitored on December 28, 2016 in Box 1 during Season 4. However, all piles driven during Season 4 were landward of Pier 62/63 and an unobstructed path between the hydrophones and piles was not able to be established during all pile driving.

Additional measurements were made in Elliott Bay while vibratory pile driving was underway during Seasons 3 and 4. The Season 3 measurements were used to determine whether underwater sound produced by pile driving exceeded relevant marine mammal thresholds near a buoy approximately 10,000 feet (3,048 meters) to the southwest of the project area. Measurements in Elliott Bay during Season 4 were made to allow the site specific attenuation factor from obstructed pile driving to be calculated (see Section 4.4). However, due to high background sound levels in Elliott Bay during Seasons 3 and 4 sound levels produced by vibratory pile driving did not appear to significantly increase during periods of vibratory pile driving and it was difficult to attribute contributions in underwater sound levels specifically to pile driving.

The highest underwater sound levels measured during vibratory pile driving occurred during Season 2, likely the result of the water depth and substrate conditions at the pile locations.

4.2 Impact Pile Driving

Concrete piles were driven with an APE Model D62-42 Single Acting Diesel Impact Hammer during Season 1. Hydroacoustic monitoring took place on February 22 through 24, 2014 of five concrete piles installed with the impact hammer in Box 10. Additional monitoring also occurred during the installation of six concrete piles in Box 4 on February 22 and 23, 2014. No additional concrete piles were installed during the project.

In the event that the vibratory hammer was unable to drive piles to the required embedment depth, an impact hammer was used to complete the drive. Impact pile driving of sheet piles occurred during Seasons 2 through 4. Hydroacoustic monitoring of unobstructed sheet piles driven with an APE Model 6-2 Hydraulic Impact Hammer was conducted on November 7 and 8, 2014 in Box 6 during Season 2. During Season 3, obstructed hydroacoustic data was collected on February 8, 2016 during impact pile driving of steel sheet piles with an APE Model D50-42 Single Acting Diesel Impact Hammer. Impact pile driving with an APE Model D50-52 Single Acting Diesel Impact Hammer was monitored in Box 1 on December 28, 2016 during Season 4. However, because Box 1 was obstructed by Pier 62/63 pilings, an unobstructed acoustical transmission path was not able to be achieved during all impact pile driving. Underwater sound levels were measured during the impact pile driving of 15 steel sheet piles during Seasons 2 through 4 of the Project.

During Seasons 3 and 4, hydroacoustic measurements were made at multiple distances from impact pile driving and were used to determine whether underwater sound generated by impact pile driving exceeded relevant marine mammal thresholds. These measurements were also used to estimate the site specific attenuation factors (see Section 4.4).

The loudest underwater sound levels measured from impact pile driving of steel sheet piles were recorded during Season 2, likely due to water depth and substrate conditions. It should be noted that the rated energy of the APE Model 6-2 Hydraulic Impact Hammer used during Season 2 is 24,000 foot-pounds, which is less than either of the diesel impact hammers used to drive sheet piles.

At least one 6-inch wooden pile pad was used during all impact pile driving of concrete piles. Multiple sound attenuation measures were tested during impact pile driving in Box 4. The third pile was driven with one 6-inch pile pad at a reduced fuel setting, the fourth and fifth piles were driven with a reduced fuel setting and a new pile pad was inserted part of the way through each pile drive. The sixth pile was driven at a reduced fuel setting with two new 6-inch pile pads.

4.3 Background Sound Levels

Background sound levels were collected in the absence of in-water construction during all four construction seasons. During Season 1 long term background sound levels were measured in Box 10. However, due to the proximity to Coleman Dock it is unlikely the measurements accurately represent background sound levels in Elliott Bay. Additional short term measurements were made in Box 4.

As a result of coordination with NOAA, USFWS and SDOT, short term background sound level measurements were made in Elliott Bay during Seasons 2 through 4 in addition to 72-hour background measurements made near the construction areas.

The results of short term background sound level measurements in Elliott Bay and 72-hour measurements made near the construction areas are summarized in Table 4.3 and Table 4.4.

Table 4.3 Average Daytime Underwater Background Sound Levels in Elliott Bay, dB re: 1 μPa

Functional Hearing Group	Frequency Range	Background Sound Levels[1]											
		Season 2 (2015)				Season 3 (2016)				Season 4 (2017)			
		Min	Max	SD	Avg	Min	Max	SD	Avg	Min	Max	SD	Avg
Low-Frequency Cetaceans	7 Hz–20 kHz	122	170	9	**140**	113	152	8	**126**	112	147	7	**128**
Mid-Frequency Cetaceans	150 Hz–20 kHz	111	141	6	**120**	105	142	6	**119**	109	145	8	**124**
High-Frequency Cetaceans	200 Hz–20 kHz	110	140	6	**120**	105	141	6	**118**	108	145	8	**124**
Pinnipeds	75 Hz–20 kHz	114	142	6	**123**	106	145	6	**120**	110	146	8	**126**

1. The median was used to report the average background sound levels

Table 4.4 Average Daytime Near Shore Underwater Background Sound Levels, dB re: 1 μPa

Functional Hearing Group	Frequency Range	Background Sound Levels[1]											
		Season 2 (2015)				Season 3 (2016)				Season 4 (2017)			
		Min	Max	SD	Avg	Min	Max	SD	Avg	Min	Max	SD	Avg
Low-Frequency Cetaceans	7 Hz–20 kHz	118	157	4	**128**	115	142	5	**127**	119	142	4	**127**
Mid-Frequency Cetaceans	150 Hz–20 kHz	114	144	3	**123**	110	142	5	**125**	117	141	4	**125**
High-Frequency Cetaceans	200 Hz–20 kHz	114	143	3	**123**	109	141	5	**125**	116	140	4	**124**
Pinnipeds	75 Hz–20 kHz	115	150	3	**123**	113	142	5	**126**	117	141	4	**126**

1. The median was used to report the average background sound levels

These data collected from near shore and far field measurements in Elliott Bay during Seasons 2 through 4 suggest that background sound levels in Elliott Bay remained consistent with the background sound levels measured by WSDOT in 2011.

4.4 Calculating Site Specific Attenuation Factors

Far field hydroacoustic measurements were conducted in Elliott Bay during Seasons 3 and 4 in addition to measurements made near vibratory and impact pile driving.

The Season 3 measurements were made near a buoy located approximately 10,000 feet (3,048 meters) southwest of the project area to determine whether underwater sound generated by impact and vibratory pile driving exceeded relevant marine mammal thresholds. This data was also used to calculate the site specific attenuation factor from pile driving in Box 2.

The site specific attenuation factor of Box 1 was calculated from simultaneous hydroacoustic measurements conducted at three different distances during impact pile driving during Season 4. Two hydrophones were located at different depths approximately 33 feet (10 meters) from pile driving as required by the Project's LOA and additional hydrophones were located at mid-water depth approximately 220 feet (67 meters) and 340 feet (104 meters) from impact pile driving. Hydroacoustic data was also collected in Elliott Bay at multiple distances from vibratory pile driving and removal of concrete piles in Box 1 during Season 4.

Due to elevated sound level in Elliott Bay and contributions from sound sources not related to pile driving during far field measurements of vibratory pile driving during Seasons 3 and 4, the site specific attenuation factors were not able to be calculated from vibratory pile driving. However, the site specific attenuation factors were calculated from impact pile driving in Box 1 and Box 2 during Seasons 3 and 4.

The resulting attenuation factors from obstructed impact pile driving were calculated to be 19 for Box 2 and between 36 and 39 for Box 1. These attenuation factors suggest the sound pressure levels could be reduced by 6 dB per doubling of distance in Box 2 and 11 to 12 dB per doubling of distance in Box 1. Sound likely attenuates more rapidly beneath piers due to obstructions caused by piles supporting the pier than unobstructed acoustical paths found further away from shore. The attenuation factor in Box 1 was calculated using only obstructed data collected under Pier 62/63, whereas the attenuation factor calculated for Box 2 included obstructed data as well as the unobstructed acoustical path between the west side of the pier and buoy resulting in a composite of obstructed and unobstructed attenuation.

These site specific attenuation factors suggest that underwater sound produced by obstructed pile driving attenuates more rapidly than predicted by the practical spreading model currently used by WSDOT and NOAA.

5.0 APPENDIX

5.1 Vibratory Pile Driving Underwater Sound Levels

5.1.1 Steel Sheet Piles

Table 5.1 Season 1 – Box 10 Vibratory Pile Driving Underwater Sound Levels, dB re: 1 μPa

Pile ID	Frequency Range	Peak				RMS				SEL			
		Min	Max	SD	Avg	Min	Max	SD	Avg	Min	Max	SD	Avg
VIB-1	7 Hz-20 kHz	173	189	3	**177**	156	166	2	**161**	154	168	2	**161**
	75 Hz-20 kHz	173	189	3	**177**	156	166	2	**160**	154	168	2	**161**
	150 Hz-20 kHz	173	189	3	**177**	156	166	2	**160**	154	168	2	**161**
	200 Hz-20 kHz	173	189	3	**177**	156	166	2	**160**	154	168	2	**161**
VIB-2	7 Hz-20 kHz	173	186	3	**179**	149	165	3	**162**	146	165	2	**162**
	75 Hz-20 kHz	173	187	3	**179**	149	164	3	**162**	154	165	2	**162**
	150 Hz-20 kHz	173	187	3	**179**	149	164	3	**162**	152	165	2	**162**
	200 Hz-20 kHz	173	187	3	**179**	148	164	3	**162**	151	165	2	**162**
VIB-3	7 Hz-20 kHz	169	183	3	**177**	147	167	4	**161**	152	167	3	**161**
	75 Hz-20 kHz	168	183	3	**176**	146	167	4	**160**	150	167	3	**161**
	150 Hz-20 kHz	167	183	3	**176**	146	167	4	**160**	150	167	3	**161**
	200 Hz-20 kHz	167	183	3	**176**	146	167	4	**160**	150	167	3	**161**
VIB-4	7 Hz-20 kHz	165	177	3	**173**	145	165	4	**160**	148	166	3	**160**
	75 Hz-20 kHz	162	176	3	**170**	142	161	4	**155**	148	162	3	**155**
	150 Hz-20 kHz	163	176	3	**170**	141	160	3	**154**	147	161	3	**155**
	200 Hz-20 kHz	164	176	3	**170**	141	160	3	**154**	147	161	3	**154**
VIB-5	7 Hz-20 kHz	162	177	3	**169**	143	163	4	**157**	144	164	4	**157**
	75 Hz-20 kHz	160	176	3	**167**	146	157	3	**151**	143	157	3	**151**
	150 Hz-20 kHz	159	176	4	**167**	145	156	3	**150**	142	157	3	**150**
	200 Hz-20 kHz	158	176	4	**167**	144	156	3	**150**	142	157	3	**150**
VIB-6	7 Hz-20 kHz	167	178	2	**172**	152	166	3	**159**	151	168	3	**159**
	75 Hz-20 kHz	161	178	3	**170**	146	161	2	**155**	144	162	2	**155**
	150 Hz-20 kHz	161	178	3	**170**	144	161	2	**154**	143	162	3	**154**
	200 Hz-20 kHz	161	178	3	**170**	144	161	3	**154**	143	162	3	**154**
VIB-7	7 Hz-20 kHz	165	177	3	**171**	149	167	4	**162**	154	168	3	**162**
	75 Hz-20 kHz	159	177	4	**165**	138	155	3	**151**	144	156	2	**151**
	150 Hz-20 kHz	156	177	5	**164**	131	153	4	**147**	154	138	4	**148**
	200 Hz-20 kHz	156	177	5	**164**	130	153	5	**147**	137	154	4	**148**

Table 5.2 Season 1 – Box 4 Vibratory Pile Driving Underwater Sound Levels, dB re: 1 μPa

Pile ID	Frequency Range	Peak				RMS				SEL			
		Min	Max	SD	Avg	Min	Max	SD	Avg	Min	Max	SD	Avg
VIB-1	7 Hz-20 kHz	151	192	6	**171**	134	172	6	**154**	135	174	6	**155**
	75 Hz-20 kHz	151	192	6	**171**	133	172	6	**154**	136	174	6	**155**
	150 Hz-20 kHz	151	192	6	**171**	132	171	6	**154**	136	173	6	**155**
	200 Hz-20 kHz	151	191	6	**171**	132	171	6	**154**	136	173	6	**154**
VIB-2	7 Hz-20 kHz	152	186	6	**168**	135	166	5	**151**	138	169	5	**152**
	75 Hz-20 kHz	153	185	6	**168**	134	166	5	**151**	137	169	5	**152**
	150 Hz-20 kHz	153	185	5	**168**	136	166	5	**150**	138	169	5	**152**
	200 Hz-20 kHz	153	185	5	**168**	135	166	6	**151**	138	169	5	**152**
VIB-3	7 Hz-20 kHz	154	184	5	**169**	136	164	5	**150**	138	167	5	**152**
	75 Hz-20 kHz	153	184	5	**170**	137	164	5	**150**	137	167	5	**152**
	150 Hz-20 kHz	155	185	5	**170**	138	163	5	**150**	137	167	5	**152**
	200 Hz-20 kHz	155	185	5	**170**	138	163	5	**150**	136	167	5	**152**
VIB-4	7 Hz-20 kHz	155	180	5	**170**	139	164	6	**154**	139	165	5	**156**
	75 Hz-20 kHz	155	180	5	**171**	138	164	6	**154**	139	165	5	**156**
	150 Hz-20 kHz	155	180	5	**170**	138	164	6	**154**	139	165	5	**156**
	200 Hz-20 kHz	156	180	5	**170**	138	163	6	**154**	139	165	5	**156**
VIB-5	7 Hz-20 kHz	160	189	4	**181**	139	169	4	**164**	139	170	3	**164**
	75 Hz-20 kHz	159	189	4	**181**	135	169	4	**164**	138	170	3	**164**
	150 Hz-20 kHz	159	190	4	**181**	135	169	4	**164**	138	170	3	**164**
	200 Hz-20 kHz	159	190	4	**181**	135	169	4	**164**	138	170	3	**164**

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

Table 5.3 Season 2 - Vibratory Pile Driving Underwater Sound Levels, dB re: 1 μPa

Pile ID	Frequency Range	Peak				RMS				SEL			
		Min	Max	SD	Avg	Min	Max	SD	Avg	Min	Max	SD	Avg
VIB-1	7 Hz-20 kHz	171	190	5	**181**	155	169	4	**163**	148	169	4	**164**
	75 Hz-20 kHz	171	190	4	**181**	155	169	4	**163**	147	169	4	**164**
	150 Hz-20 kHz	170	190	4	**181**	155	168	4	**163**	147	169	4	**163**
	200 Hz-20 kHz	171	190	4	**181**	155	168	4	**163**	147	168	4	**163**
VIB-2	7 Hz-20 kHz	166	182	4	**174**	144	164	3	**156**	148	166	3	**157**
	75 Hz-20 kHz	166	182	4	**173**	144	164	4	**156**	146	165	3	**156**
	150 Hz-20 kHz	166	182	4	**173**	143	163	4	**156**	146	164	3	**156**
	200 Hz-20 kHz	166	182	4	**173**	143	163	4	**155**	146	164	3	**156**
VIB-3	7 Hz-20 kHz	177	185	2	**182**	159	168	2	**166**	153	168	2	**166**
	75 Hz-20 kHz	177	185	2	**182**	159	168	2	**165**	153	168	2	**166**
	150 Hz-20 kHz	176	185	2	**182**	159	168	2	**165**	150	168	3	**165**
	200 Hz-20 kHz	175	185	2	**182**	158	168	2	**165**	150	168	3	**165**
VIB-4	7 Hz-20 kHz	180	195	3	**186**	163	174	2	**168**	146	175	3	**168**
	75 Hz-20 kHz	180	194	3	**186**	163	174	2	**168**	146	175	3	**168**
	150 Hz-20 kHz	181	193	3	**186**	163	174	2	**168**	146	175	3	**168**
	200 Hz-20 kHz	180	193	3	**186**	163	174	2	**168**	146	175	3	**168**
VIB-5	7 Hz-20 kHz	166	190	3	**183**	142	171	3	**167**	149	172	3	**167**
	75 Hz-20 kHz	167	190	3	**183**	142	171	4	**167**	149	172	3	**167**
	150 Hz-20 kHz	167	190	3	**183**	142	171	3	**167**	149	172	3	**167**
	200 Hz-20 kHz	167	190	3	**183**	142	171	3	**167**	148	172	3	**167**

Table 5.4 Season 3 - Vibratory Pile Driving Underwater Sound Levels, dB re: 1 μPa

Pile ID	Frequency Range	Peak				RMS				SEL			
		Min	Max	SD	Avg	Min	Max	SD	Avg	Min	Max	SD	Avg
January 14, 2016													
VIB-1	7 Hz-20 kHz	169	182	2	**176**	150	161	2	**157**	147	163	2	**157**
	75 Hz-20 kHz	169	182	3	**176**	150	161	2	**156**	147	163	2	**156**
	150 Hz-20 kHz	169	182	3	**176**	150	161	2	**156**	146	163	2	**156**
	200 Hz-20 kHz	169	182	3	**176**	150	161	2	**156**	146	163	2	**156**
January 15, 2016													
VIB-1	7 Hz-20 kHz	173	190	4	**181**	148	166	4	**160**	148	172	2	**161**
	75 Hz-20 kHz	174	190	4	**181**	147	166	4	**159**	147	172	3	**160**
	150 Hz-20 kHz	174	190	4	**181**	147	166	4	**159**	146	172	3	**160**
	200 Hz-20 kHz	174	190	4	**181**	147	166	4	**159**	143	172	3	**160**
VIB-2	7 Hz-20 kHz	175	186	2	**182**	153	168	2	**164**	150	168	2	**164**
	75 Hz-20 kHz	175	185	2	**181**	151	166	3	**162**	146	167	2	**162**
	150 Hz-20 kHz	175	185	2	**181**	150	166	3	**162**	146	167	2	**162**
	200 Hz-20 kHz	175	185	2	**181**	150	166	3	**162**	146	167	2	**162**
VIB-3	7 Hz-20 kHz	165	183	4	**175**	147	167	4	**158**	149	167	4	**159**
	75 Hz-20 kHz	165	183	4	**174**	143	163	4	**156**	145	164	4	**157**
	150 Hz-20 kHz	166	183	4	**174**	143	163	4	**156**	145	164	4	**157**
	200 Hz-20 kHz	166	183	4	**174**	143	163	4	**156**	145	164	4	**157**
VIB-4	7 Hz-20 kHz	166	188	2	**175**	141	167	2	**161**	147	167	2	**161**
	75 Hz-20 kHz	167	187	3	**174**	145	162	3	**155**	146	163	3	**156**
	150 Hz-20 kHz	166	185	3	**174**	145	162	3	**155**	146	163	3	**156**
	200 Hz-20 kHz	166	184	3	**174**	145	162	3	**155**	146	163	3	**156**
VIB-5	7 Hz-20 kHz	166	174	2	**171**	144	164	4	**157**	148	164	3	**158**
	75 Hz-20 kHz	165	174	2	**169**	143	157	3	**153**	145	159	2	**153**
	150 Hz-20 kHz	165	174	2	**169**	143	157	3	**153**	145	159	2	**153**
	200 Hz-20 kHz	165	173	2	**169**	143	157	3	**153**	145	159	2	**153**

Note: Underwater sound levels were measured 32 to 38 feet (10 to 12 meters) from the piles.

Table 5.5 Season 4 - Vibratory Pile Driving Underwater Sound Levels, dB re: 1 μPa

Pile ID	Frequency Range	Peak				RMS				SEL			
		Min	Max	SD	Avg	Min	Max	SD	Avg	Min	Max	SD	Avg
VIB-1	7 Hz-20 kHz	155	180	5	**169**	135	161	5	**153**	135	162	4	**154**
	75 Hz-20 kHz	155	180	5	**169**	135	161	5	**153**	135	162	4	**154**
	150 Hz-20 kHz	155	180	5	**169**	135	161	5	**153**	135	162	4	**154**
	200 Hz-20 kHz	155	180	5	**169**	135	161	5	**153**	135	162	4	**154**
VIB-2	7 Hz-20 kHz	151	174	5	**164**	135	155	5	**148**	133	155	5	**148**
	75 Hz-20 kHz	151	174	5	**163**	134	153	5	**147**	127	155	5	**147**
	150 Hz-20 kHz	150	174	5	**163**	134	153	5	**147**	127	155	5	**147**
	200 Hz-20 kHz	150	174	5	**163**	134	153	5	**147**	127	155	5	**147**
VIB-3	7 Hz-20 kHz	154	174	3	**166**	129	159	4	**151**	139	159	3	**152**
	75 Hz-20 kHz	153	174	3	**165**	126	155	4	**149**	127	157	3	**150**
	150 Hz-20 kHz	153	174	3	**165**	126	155	4	**149**	127	157	3	**149**
	200 Hz-20 kHz	153	174	3	**165**	126	155	4	**149**	127	157	3	**149**
VIB-4	7 Hz-20 kHz	154	170	4	**164**	131	154	5	**148**	137	156	3	**149**
	75 Hz-20 kHz	154	170	4	**164**	130	154	5	**148**	133	156	3	**148**
	150 Hz-20 kHz	154	170	4	**164**	130	154	5	**147**	133	156	3	**148**
	200 Hz-20 kHz	154	171	4	**164**	130	154	5	**147**	133	156	3	**148**
VIB-5	7 Hz-20 kHz	155	180	4	**170**	137	159	3	**153**	137	161	3	**153**
	75 Hz-20 kHz	154	180	4	**170**	137	158	3	**152**	135	161	3	**153**
	150 Hz-20 kHz	155	180	4	**170**	137	158	3	**152**	135	161	3	**153**
	200 Hz-20 kHz	154	179	4	**170**	137	158	3	**152**	135	161	3	**153**

Note: Underwater sound levels were measured 37 to 39 feet (11.3 to 11.9 meters) from the piles.

5.1.2 Concrete Pile Removal

Table 5.6 Season 4 - Vibratory Pile Removal Underwater Sound Levels, dB re: 1 μPa

Pile ID	Frequency Range	Peak				RMS				SEL			
		Min	Max	SD	Avg	Min	Max	SD	Avg	Min	Max	SD	Avg
REM-1	7 Hz-20 kHz	147	162	3	**154**	122	149	3	**143**	127	151	2	**144**
	75 Hz-20 kHz	144	162	3	**152**	119	141	3	**134**	123	143	2	**135**
	150 Hz-20 kHz	144	158	3	**151**	119	141	3	**134**	123	143	2	**135**
	200 Hz-20 kHz	143	161	3	**151**	118	140	3	**134**	122	142	2	**135**
REM-2	7 Hz-20 kHz	147	161	3	**156**	124	154	4	**147**	121	155	3	**147**
	75 Hz-20 kHz	143	161	4	**152**	119	139	2	**133**	119	140	2	**133**
	150 Hz-20 kHz	144	161	4	**151**	118	138	3	**133**	119	140	2	**133**
	200 Hz-20 kHz	143	161	4	**151**	118	138	3	**132**	119	139	2	**133**
REM-3	7 Hz-20 kHz	142	164	4	**155**	126	154	4	**145**	123	155	3	**145**
	75 Hz-20 kHz	141	164	5	**152**	116	141	5	**135**	115	144	3	**133**
	150 Hz-20 kHz	138	164	5	**151**	115	141	4	**132**	114	143	4	**132**
	200 Hz-20 kHz	138	164	5	**151**	115	141	4	**132**	121	153	4	**135**
REM-4	7 Hz-20 kHz	146	161	3	**151**	117	149	3	**140**	133	153	3	**141**
	75 Hz-20 kHz	142	159	4	**148**	119	132	2	**130**	123	135	2	**130**
	150 Hz-20 kHz	142	159	4	**148**	118	131	3	**129**	119	134	3	**130**
	200 Hz-20 kHz	142	159	4	**148**	118	131	3	**129**	119	134	3	**129**
REM-5	7 Hz-20 kHz	153	168	3	**157**	139	150	3	**147**	137	151	2	**147**
	75 Hz-20 kHz	147	168	5	**153**	130	139	2	**135**	128	141	2	**135**
	150 Hz-20 kHz	146	165	4	**152**	128	139	2	**135**	125	141	2	**135**
	200 Hz-20 kHz	146	165	4	**152**	128	139	2	**135**	124	141	2	**135**

Note: Underwater sound levels were measured 35 to 40 feet (11 to 12 meters) from the piles.

5.2 Impact Pile Driving Underwater Sound Levels

5.2.1 Concrete Piles

Table 5.7 Season 1 – Box 10 Impact Pile Driving Underwater Sound Levels, dB re: 1 μPa

Pile ID	Frequency Range	Peak				RMS_{90}				SEL				cSEL
		Min	Max	SD	Avg	Min	Max	SD	Avg	Min	Max	SD	Avg	
IMP-1	7 Hz-20 kHz	174	190	3	**185**	162	179	3	**172**	154	164	2	**161**	**190**
	75 Hz-20 kHz	173	187	2	**182**	165	178	3	**174**	149	161	2	**158**	**187**
	150 Hz-20 kHz	174	187	3	**182**	164	177	3	**173**	149	160	2	**157**	**186**
	200 Hz-20 kHz	172	187	3	**182**	162	177	3	**173**	146	160	2	**156**	**185**
IMP-2	7 Hz-20 kHz	180	193	2	**189**	165	182	2	**176**	157	170	1	**164**	**193**
	75 Hz-20 kHz	180	192	2	**188**	170	184	2	**178**	154	166	2	**161**	**192**
	150 Hz-20 kHz	180	191	2	**187**	168	184	2	**178**	153	166	2	**161**	**192**
	200 Hz-20 kHz	180	192	2	**187**	168	183	2	**177**	153	166	2	**160**	**193**
IMP-3	7 Hz-20 kHz	175	202	5	**194**	160	189	5	**181**	151	172	3	**167**	**200**
	75 Hz-20 kHz	174	202	5	**193**	164	189	4	**183**	148	172	4	**167**	**200**
	150 Hz-20 kHz	174	202	6	**193**	164	189	4	**183**	148	172	4	**167**	**200**
	200 Hz-20 kHz	174	202	6	**193**	164	189	4	**183**	147	172	4	**166**	**200**
IMP-4	7 Hz-20 kHz	187	199	3	**192**	173	188	3	**178**	162	171	2	**166**	**197**
	75 Hz-20 kHz	188	199	3	**192**	177	188	2	**182**	161	171	2	**165**	**197**
	150 Hz-20 kHz	187	199	3	**192**	177	188	2	**182**	161	171	2	**165**	**197**
	200 Hz-20 kHz	187	199	3	**192**	177	188	2	**182**	160	171	2	**165**	**198**
IMP-5	7 Hz-20 kHz	164	190	4	**185**	141	183	4	**179**	134	172	4	**168**	**200**
	75 Hz-20 kHz	164	189	3	**174**	145	173	3	**161**	131	160	3	**153**	**188**
	150 Hz-20 kHz	164	187	3	**172**	145	181	2	**156**	131	158	2	**147**	**186**
	200 Hz-20 kHz	164	187	3	**172**	145	180	3	**155**	131	158	3	**146**	**186**

Table 5.8 Season 1 – Box 4 Impact Pile Driving Underwater Sound Levels, dB re: 1 μPa

Pile ID	Frequency Range	Peak				RMS_{90}				SEL				cSEL
		Min	Max	SD	Avg	Min	Max	SD	Avg	Min	Max	SD	Avg	
IMP-1	7 Hz-20 kHz	165	193	4	**181**	155	179	4	**170**	147	163	2	**158**	**188**
	75 Hz-20 kHz	164	193	5	**181**	154	179	4	**169**	139	163	3	**155**	**188**
	150 Hz-20 kHz	164	193	5	**181**	154	179	4	**170**	139	162	3	**154**	**188**
	200 Hz-20 kHz	164	193	5	**181**	154	179	4	**170**	139	162	3	**154**	**188**
IMP-2	7 Hz-20 kHz	169	187	3	**181**	158	173	2	**168**	147	163	3	**158**	**189**
	75 Hz-20 kHz	170	186	3	**181**	159	176	3	**170**	145	161	2	**156**	**188**
	150 Hz-20 kHz	168	185	3	**180**	158	176	3	**170**	143	160	2	**155**	**187**
	200 Hz-20 kHz	167	185	3	**180**	157	176	3	**170**	142	160	2	**154**	**187**
IMP-3	7 Hz-20 kHz	171	190	3	**180**	156	175	3	**168**	147	163	3	**158**	**189**
	75 Hz-20 kHz	171	189	3	**180**	158	176	3	**169**	145	162	3	**155**	**189**
	150 Hz-20 kHz	170	187	3	**179**	159	176	3	**169**	144	161	3	**154**	**188**
	200 Hz-20 kHz	170	187	3	**179**	159	175	3	**168**	144	160	3	**154**	**187**
IMP-4	7 Hz-20 kHz	165	191	2	**177**	152	180	3	**166**	140	165	3	**157**	**191**
	75 Hz-20 kHz	164	190	2	**177**	152	180	2	**167**	140	165	2	**152**	**191**
	150 Hz-20 kHz	163	189	2	**177**	153	180	2	**167**	139	165	2	**152**	**191**
	200 Hz-20 kHz	164	189	2	**177**	153	180	2	**167**	139	165	2	**152**	**191**
IMP-5	7 Hz-20 kHz	145	179	4	**170**	132	172	7	**163**	124	163	6	**155**	**180**
	75 Hz-20 kHz	143	178	3	**169**	127	167	3	**159**	119	153	2	**145**	**179**
	150 Hz-20 kHz	143	178	3	**168**	126	167	3	**159**	118	153	2	**145**	**179**
	200 Hz-20 kHz	143	178	3	**168**	126	167	3	**159**	117	153	2	**144**	**179**
IMP-6	7 Hz-20 kHz	141	179	6	**169**	133	175	8	**162**	125	165	7	**156**	**191**
	75 Hz-20 kHz	146	167	3	**160**	132	151	3	**146**	123	142	3	**137**	**167**
	150 Hz-20 kHz	147	166	3	**160**	132	153	3	**145**	123	139	2	**134**	**164**
	200 Hz-20 kHz	147	166	3	**159**	131	154	4	**145**	123	139	2	**134**	**165**

5.2.2 Steel Sheet Piles

Table 5.9 Season 2 - Impact Pile Driving Underwater Sound Levels, dB re: 1 μPa

Pile ID	Frequency Range	Peak				RMS_{90}				SEL				cSEL
		Min	Max	SD	Avg	Min	Max	SD	Avg	Min	Max	SD	Avg	
IMP-1	7 Hz-20 kHz	175	200	5	**192**	163	186	5	**180**	150	172	4	**166**	**190**
	75 Hz-20 kHz	175	200	5	**192**	162	186	5	**180**	150	172	4	**166**	**190**
	150 Hz-20 kHz	175	200	5	**192**	162	186	5	**180**	150	172	4	**166**	**190**
	200 Hz-20 kHz	175	200	5	**192**	162	186	5	**180**	150	172	5	**166**	**190**
IMP-2	7 Hz-20 kHz	189	204	1	**198**	176	189	1	**185**	162	173	1	**170**	**198**
	75 Hz-20 kHz	189	203	1	**198**	175	189	1	**185**	164	173	1	**170**	**198**
	150 Hz-20 kHz	189	203	1	**198**	175	189	1	**185**	162	173	1	**169**	**198**
	200 Hz-20 kHz	189	203	1	**198**	173	189	1	**185**	162	173	1	**169**	**198**
IMP-3	7 Hz-20 kHz	189	204	2	**198**	174	189	1	**185**	162	173	1	**170**	**202**
	75 Hz-20 kHz	189	204	2	**198**	174	189	1	**185**	162	173	1	**170**	**202**
	150 Hz-20 kHz	189	204	2	**198**	174	189	1	**185**	162	173	1	**170**	**202**
	200 Hz-20 kHz	189	204	2	**198**	174	189	1	**185**	162	173	1	**170**	**202**
IMP-4	7 Hz-20 kHz	191	202	1	**197**	178	187	1	**184**	165	172	1	**169**	**199**
	75 Hz-20 kHz	191	202	1	**197**	179	187	1	**184**	164	172	1	**169**	**198**
	150 Hz-20 kHz	192	202	1	**197**	179	187	1	**184**	164	172	1	**169**	**198**
	200 Hz-20 kHz	192	202	1	**197**	179	187	1	**184**	164	172	1	**169**	**198**
IMP-5	7 Hz-20 kHz	190	204	1	**197**	177	188	1	**184**	163	173	1	**170**	**201**
	75 Hz-20 kHz	190	203	1	**197**	177	188	1	**184**	165	173	1	**170**	**201**
	150 Hz-20 kHz	191	202	1	**197**	177	188	1	**184**	163	173	1	**170**	**201**
	200 Hz-20 kHz	190	203	1	**197**	177	188	1	**184**	163	173	1	**170**	**201**

Table 5.10 Season 3 - Impact Pile Driving Underwater Sound Levels, dB re: 1 μPa

Pile ID	Frequency Range	Peak				RMS_{90}				SEL				cSEL
		Min	Max	SD	Avg	Min	Max	SD	Avg	Min	Max	SD	Avg	
IMP-1	7 Hz-20 kHz	189	199	2	**193**	175	183	1	**179**	161	168	1	**165**	**188**
	75 Hz-20 kHz	189	199	2	**193**	175	183	1	**179**	161	168	1	**165**	**188**
	150 Hz-20 kHz	189	199	2	**193**	175	183	1	**179**	161	168	1	**165**	**188**
	200 Hz-20 kHz	189	199	2	**193**	175	183	1	**179**	161	168	1	**165**	**188**
IMP-2	7 Hz-20 kHz	187	194	2	**190**	175	181	1	**177**	161	167	1	**164**	**180**
	75 Hz-20 kHz	187	194	2	**190**	175	181	1	**177**	161	167	1	**164**	**180**
	150 Hz-20 kHz	187	194	2	**190**	175	181	1	**177**	161	167	1	**164**	**180**
	200 Hz-20 kHz	187	195	2	**190**	175	181	1	**177**	161	167	1	**164**	**180**
IMP-3	7 Hz-20 kHz	186	192	2	**190**	175	180	2	**177**	162	166	1	**164**	**173**
	75 Hz-20 kHz	186	192	2	**190**	175	180	2	**177**	162	166	1	**164**	**173**
	150 Hz-20 kHz	186	192	2	**190**	175	180	2	**177**	162	166	1	**164**	**173**
	200 Hz-20 kHz	187	192	2	**190**	175	180	2	**177**	162	166	1	**164**	**173**
IMP-4	7 Hz-20 kHz	182	193	2	**190**	169	178	1	**177**	156	164	1	**163**	**180**
	75 Hz-20 kHz	182	193	2	**190**	170	178	1	**177**	156	164	1	**163**	**180**
	150 Hz-20 kHz	181	193	2	**190**	170	178	1	**177**	156	164	1	**163**	**180**
	200 Hz-20 kHz	181	193	2	**190**	170	178	1	**177**	156	164	1	**163**	**180**
IMP-5	7 Hz-20 kHz	187	194	2	**191**	176	182	2	**178**	162	167	1	**165**	**180**
	75 Hz-20 kHz	187	194	2	**191**	176	182	2	**178**	162	167	1	**165**	**180**
	150 Hz-20 kHz	187	194	1	**191**	176	182	2	**178**	162	167	1	**165**	**180**
	200 Hz-20 kHz	187	194	2	**191**	182	176	2	**178**	162	167	1	**165**	**180**

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

Table 5.11 Season 4 - Impact Pile Driving Underwater Sound Levels, dB re: 1 μPa

Pile ID	Frequency Range	Peak				RMS_{90}				SEL				cSEL
		Min	Max	SD	Avg	Min	Max	SD	Avg	Min	Max	SD	Avg	
IMP-1	7 Hz-20 kHz	174	189	3	**184**	160	176	3	**171**	147	162	2	**157**	**177**
	75 Hz-20 kHz	174	189	3	**184**	160	176	3	**171**	147	162	2	**157**	**177**
	150 Hz-20 kHz	175	189	3	**184**	160	176	3	**171**	147	162	2	**157**	**177**
	200 Hz-20 kHz	175	189	3	**184**	160	176	3	**171**	147	162	2	**157**	**177**
IMP-2	7 Hz-20 kHz	182	191	1	**187**	166	179	1	**175**	155	164	1	**161**	**182**
	75 Hz-20 kHz	182	191	1	**187**	170	179	1	**175**	155	164	1	**161**	**182**
	150 Hz-20 kHz	182	191	1	**187**	170	179	1	**175**	155	164	1	**161**	**182**
	200 Hz-20 kHz	182	191	1	**187**	170	179	1	**175**	155	164	1	**161**	**182**
IMP-3	7 Hz-20 kHz	184	197	2	**192**	169	182	1	**179**	157	167	1	**164**	**187**
	75 Hz-20 kHz	184	197	2	**192**	171	182	1	**179**	157	167	1	**164**	**187**
	150 Hz-20 kHz	184	197	2	**192**	171	182	1	**179**	157	167	1	**164**	**187**
	200 Hz-20 kHz	183	197	2	**192**	171	182	1	**179**	157	167	1	**164**	**187**
IMP-4	7 Hz-20 kHz	183	199	2	**194**	168	185	2	**182**	156	170	2	**167**	**188**
	75 Hz-20 kHz	183	199	2	**194**	171	186	2	**182**	156	170	2	**167**	**188**
	150 Hz-20 kHz	183	199	2	**194**	171	186	2	**182**	156	170	2	**167**	**188**
	200 Hz-20 kHz	183	199	2	**194**	171	186	2	**182**	156	170	2	**167**	**188**
IMP-5	7 Hz-20 kHz	180	198	2	**194**	166	183	2	**181**	151	168	2	**166**	**188**
	75 Hz-20 kHz	180	198	2	**194**	166	183	2	**181**	151	168	2	**166**	**188**
	150 Hz-20 kHz	180	198	2	**194**	166	183	2	**181**	151	168	2	**166**	**188**
	200 Hz-20 kHz	180	198	2	**194**	166	183	2	**181**	151	168	2	**166**	**188**

Note: Underwater sound levels were measured 32 to 40 feet (10 to 12 meters) from the piles.