APPENDIX

Table of Contents

1.0 STEEL PILES INSTALLED WITH APE 200 VIBRATORY HAMMER

PILE #79

September 7, 2018

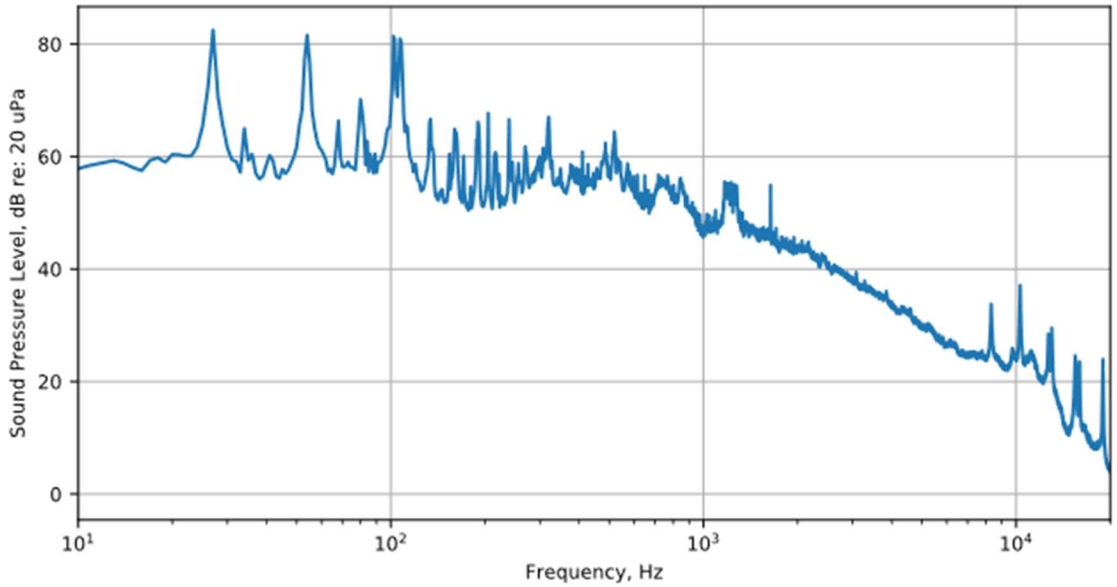
Hydrophone and Pile Information, Feet

Hydro Depth (upper/lower)	Distance			Water Depth	
	Between Hydros	Hydros to Pile	Pile to Water's Edge	Hydros	Pile
3/11	8	31	87	14	13

Airborne Sound Levels, dB re: 20 µPa

Median	Maximum	Minimum
92	98	85

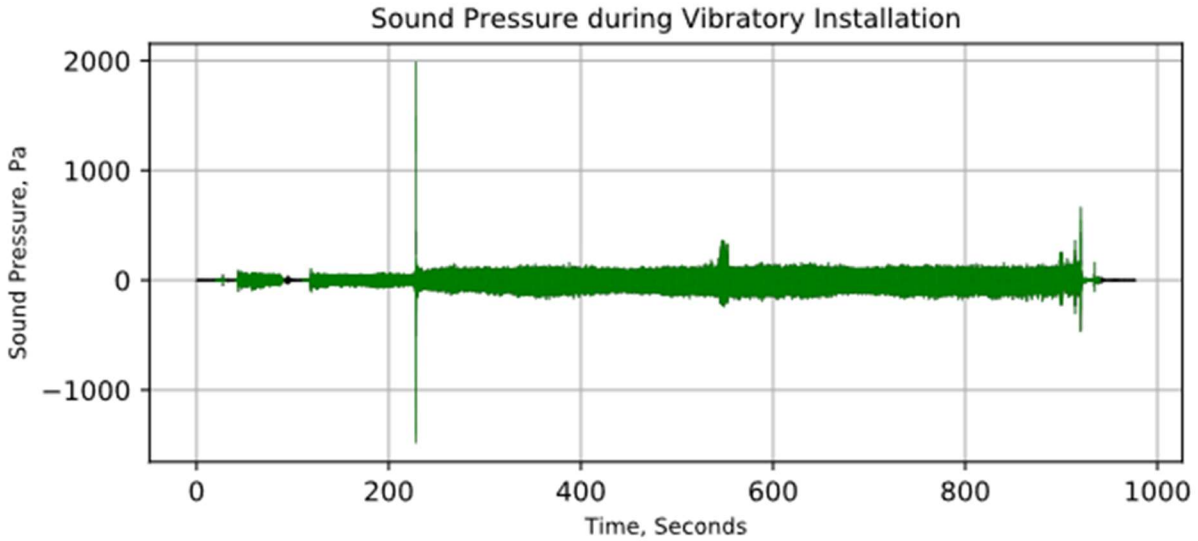
Airborne Frequency Spectra

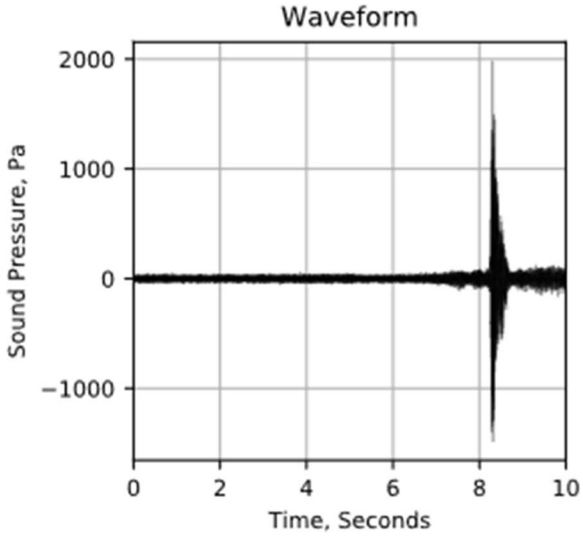


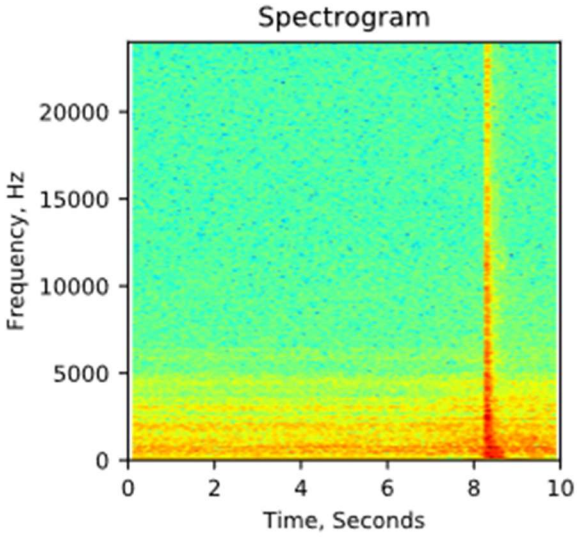
Underwater Sound Levels, dB re: 1 µPa

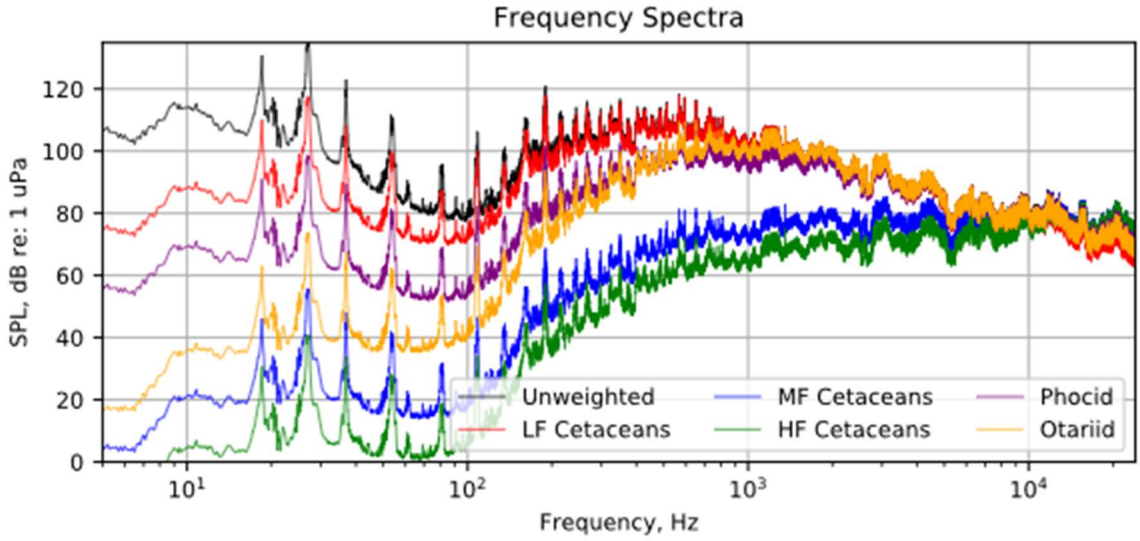
Frequency Range	Peak					RMS_{90}					SEL					cSEL
	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	
Upper Hydrophone																
Unweighted	154	186	4.4	168	163	122	155	4.1	149	150	132	165	4.1	159	160	179
LF Cetacean	154	186	4.5	168	162	116	149	5.1	143	143	126	159	5.1	153	153	172
MF Cetacean	154	186	4.5	168	162	118	149	3.8	143	144	128	159	3.8	153	154	173
HF Cetacean	154	186	4.5	168	162	118	149	3.8	144	144	128	159	3.8	154	154	173
PW	154	186	4.5	168	162	116	147	4.4	140	140	126	157	4.4	150	150	169
OW	154	186	4.5	168	162	116	148	4.6	140	141	126	158	4.6	150	151	170
Lower Hydrophone																
Unweighted	151	182	4.9	165	160	118	152	4.7	146	146	128	162	4.7	156	156	175
LF Cetacean	151	182	4.9	165	159	113	146	5	140	140	123	156	5	150	150	170
MF Cetacean	151	182	4.9	165	159	116	146	4.3	140	140	126	156	4.3	150	150	169
HF Cetacean	151	182	4.9	165	159	117	146	4.3	140	141	127	156	4.3	150	151	170
PW	151	182	4.9	165	159	113	144	4.6	137	137	123	154	4.6	147	147	166
OW	151	182	4.9	165	159	113	145	4.7	138	138	123	155	4.7	148	148	168

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


Sound Pressure during Vibratory Installation
Sound Pressure, Pa
2000
1000
0
−1000
0
200
400
600
800
1000
Time, Seconds


Waveform
Sound Pressure, Pa
2000
1000
0
−1000
0
2
4
6
8
10
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
120
100
80
60
40
20
0
10^1
10^2
10^3
10^4
Frequency, Hz
Unweighted
LF Cetaceans
MF Cetaceans
HF Cetaceans
Phocid
Otariid

PILE #87

September 7, 2018

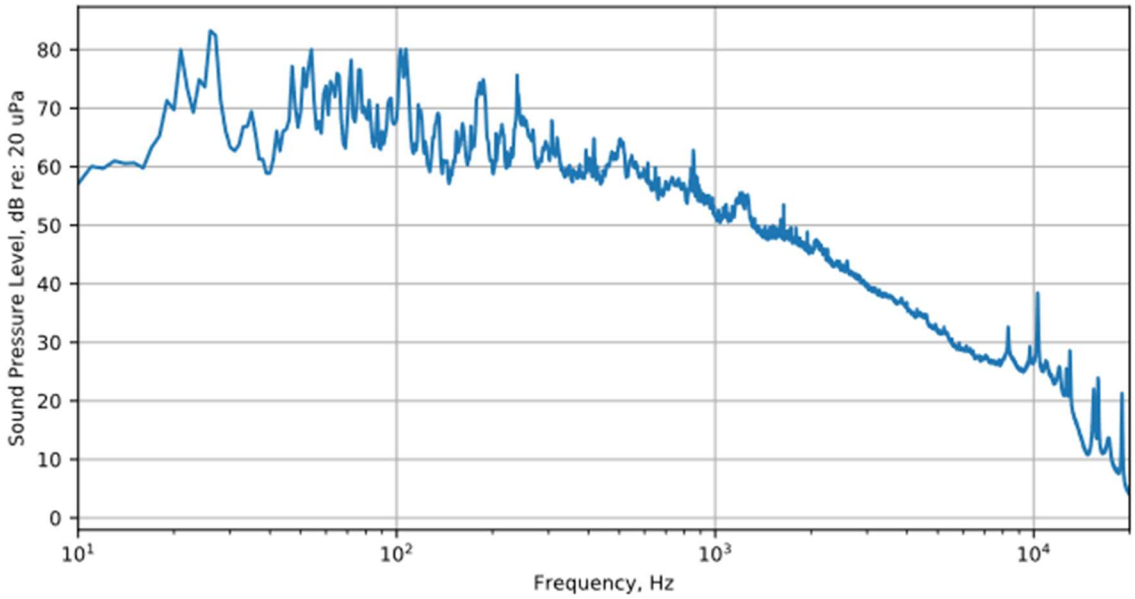
Hydrophone and Pile Information, Feet

Hydro Depth (upper/lower)	Distance			Water Depth	
	Between Hydros	Hydros to Pile	Pile to Water's Edge	Hydros	Pile
3/11	8	40	54	14	10

Airborne Sound Levels, dB re: 20 µPa

Median	Maximum	Minimum
94	104	85

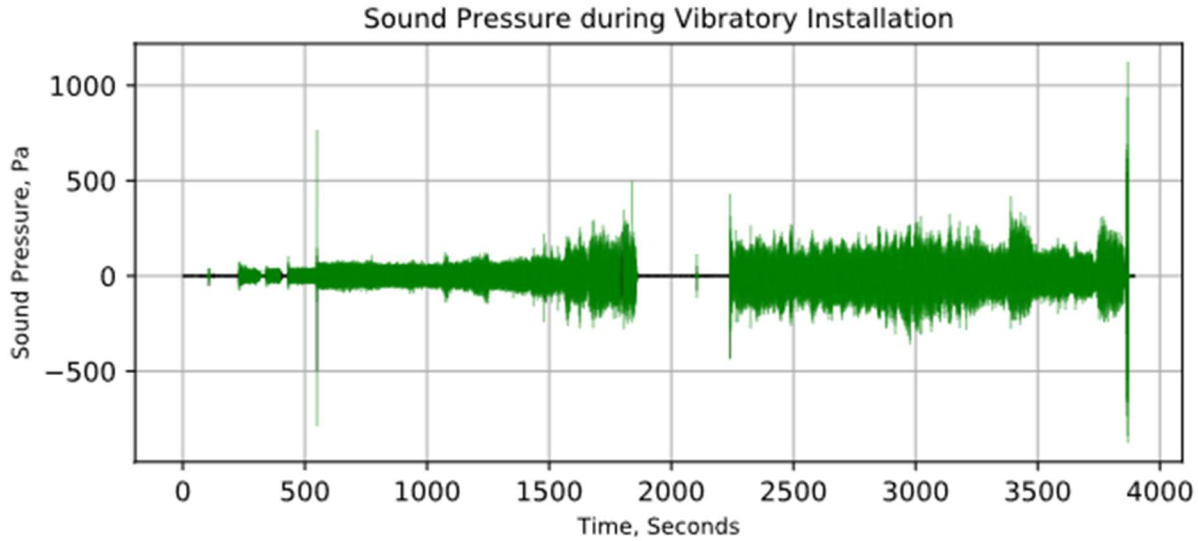
Airborne Frequency Spectra

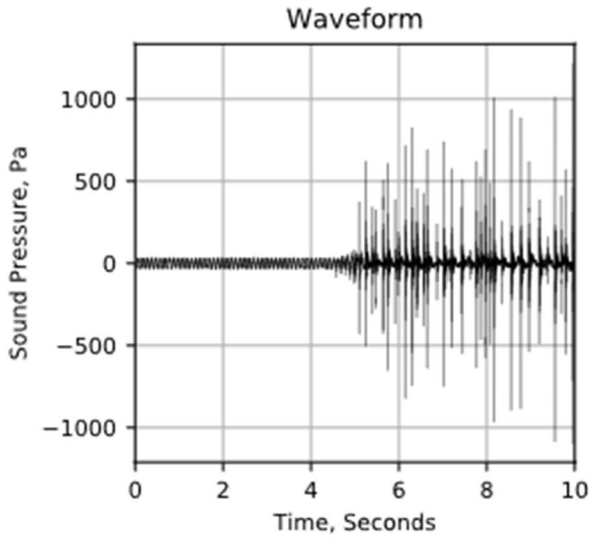


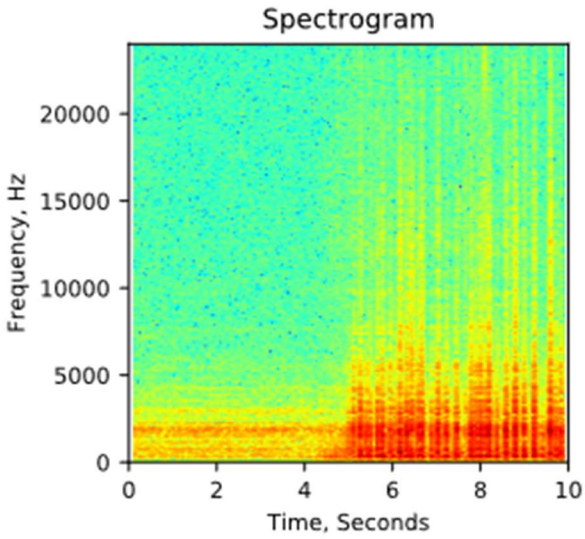
Underwater Sound Levels, dB re: 1 µPa

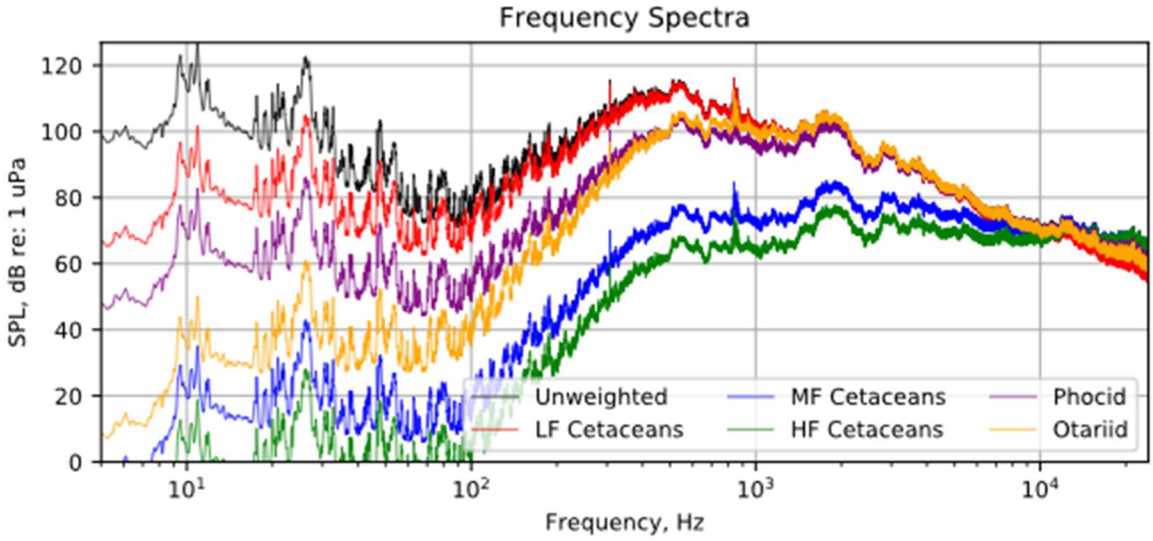
Frequency Range	Peak					RMS_{90}					SEL					cSEL
	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	
Upper Hydrophone																
Unweighted	148	183	5.2	167	165	117	156	4.5	151	150	127	166	4.5	161	160	186
LF Cetacean	151	183	5.2	167	165	109	150	4.7	145	145	119	160	4.7	155	155	180
MF Cetacean	151	183	5.2	167	165	116	150	4.4	145	144	126	160	4.4	155	154	180
HF Cetacean	151	183	5.2	167	165	116	150	4.4	145	145	126	160	4.4	155	155	180
PW	151	183	5.2	167	165	108	148	4.6	142	142	118	158	4.6	152	152	177
OW	151	183	5.2	167	165	108	149	4.6	143	143	118	159	4.6	153	153	178
Lower Hydrophone																
Unweighted	144	182	5.4	166	164	115	154	4.6	149	149	125	164	4.6	159	159	184
LF Cetacean	144	182	5.4	166	164	108	149	4.7	144	143	118	159	4.7	154	153	179
MF Cetacean	144	182	5.4	166	164	117	149	4.4	143	143	127	159	4.4	153	153	178
HF Cetacean	144	182	5.4	166	164	117	149	4.4	144	143	127	159	4.4	154	153	179
PW	144	182	5.4	166	164	109	147	4.4	141	140	119	157	4.4	151	150	176
OW	144	182	5.4	166	164	108	147	4.3	141	141	118	157	4.3	151	151	177

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


Sound Pressure during Vibratory Installation
Sound Pressure, Pa
1000
500
0
−500
0
500
1000
1500
2000
2500
3000
3500
4000
Time, Seconds


Waveform
Sound Pressure, Pa
1000
500
0
−500
−1000
0
2
4
6
8
10
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
120
100
80
60
40
20
0
10^1
10^2
10^3
10^4
Frequency, Hz
Unweighted
LF Cetaceans
MF Cetaceans
HF Cetaceans
Phocid
Otariid

PILE #159

September 25, 2018

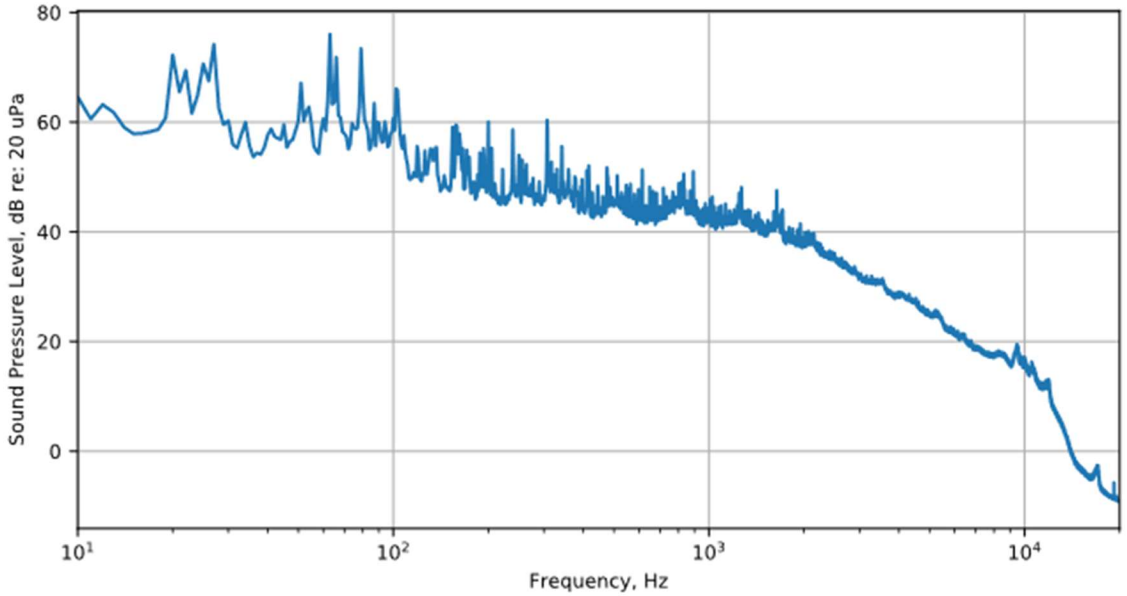
Hydrophone and Pile Information, Feet

Hydro Depth (upper/lower)	Distance			Water Depth	
	Between Hydros	Hydros to Pile	Pile to Water's Edge	Hydros	Pile
4/10	6	178	4	16	2

Airborne Sound Levels, dB re: 20 µPa

Median	Maximum	Minimum
95	100	91

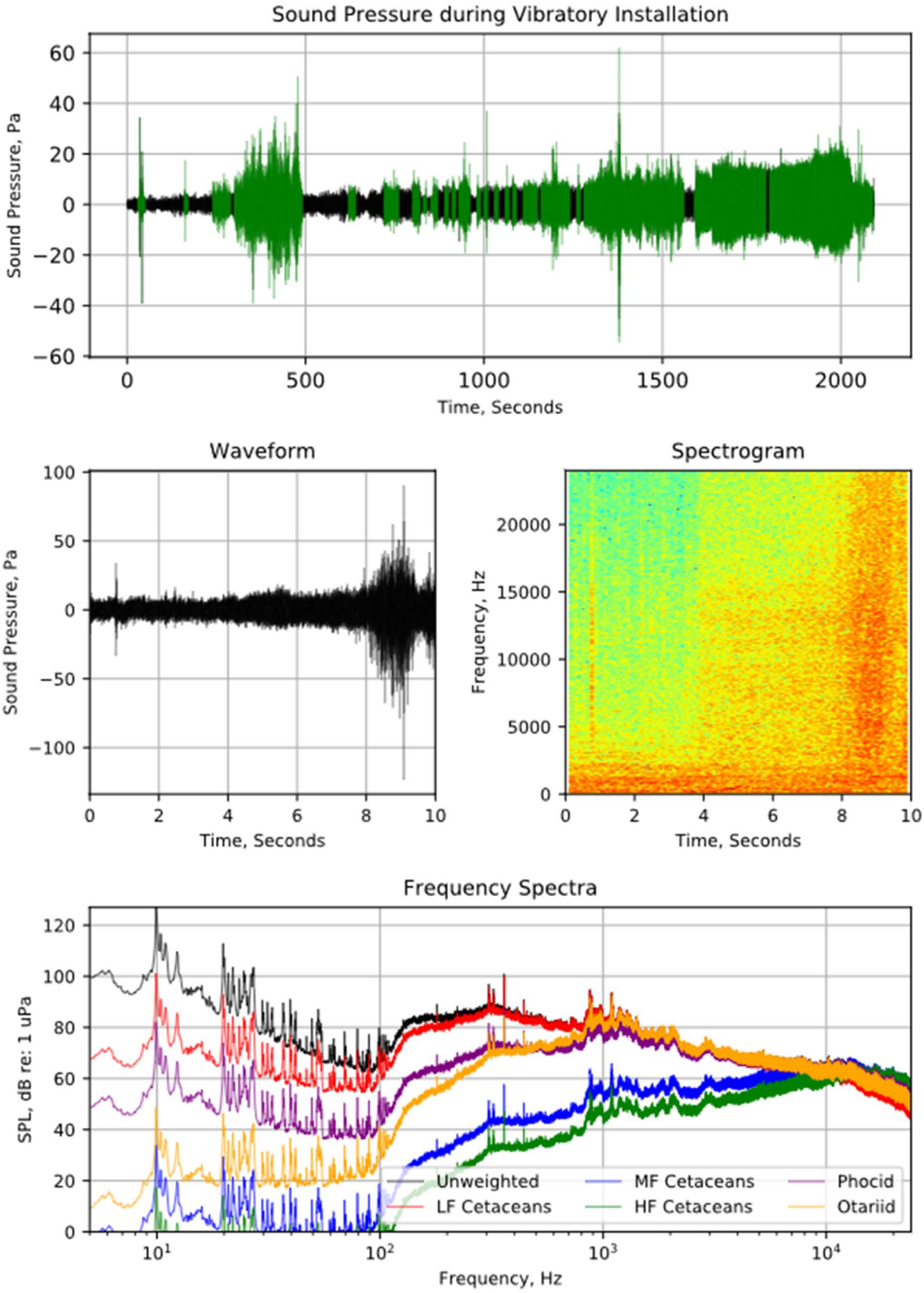
Airborne Frequency Spectra



Underwater Sound Levels, dB re: 1 µPa

Frequency Range	Peak					RMS_{90}					SEL					cSEL
	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	
Upper Hydrophone																
Unweighted	151	170	4	159	156	128	148	5.1	142	138	138	158	5.1	152	148	174
LF Cetacean	151	170	4	159	156	121	138	3	132	132	131	148	3	142	142	164
MF Cetacean	151	170	4	159	156	126	142	4.3	137	133	136	152	4.3	147	143	168
HF Cetacean	151	170	4	159	156	126	143	4.4	137	134	136	153	4.4	147	144	169
PW	151	170	4	159	156	119	138	3.2	131	131	129	148	3.2	141	141	163
OW	151	170	4	159	156	117	138	3.3	131	131	127	148	3.3	141	141	163
Lower Hydrophone																
Unweighted	147	171	4.3	157	153	126	143	3.1	136	135	136	153	3.1	146	145	168
LF Cetacean	147	171	4.3	157	153	118	136	2.8	129	128	128	146	2.8	139	138	161
MF Cetacean	147	171	4.3	157	153	126	152	2.6	135	132	136	162	2.6	145	142	166
HF Cetacean	147	171	4.3	157	153	127	153	2.6	135	133	137	163	2.6	145	143	167
PW	147	171	4.3	157	153	118	142	2.8	129	127	128	152	2.8	139	137	160
OW	147	171	4.3	157	153	116	140	3	129	128	126	150	3	139	138	161

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


Sound Pressure during Vibratory Installation
Sound Pressure, Pa
Time, Seconds
Waveform
Sound Pressure, Pa
Time, Seconds
Spectrogram
Frequency, Hz
Time, Seconds
Frequency Spectra
SPL, dB re: 1 uPa
Frequency, Hz
Unweighted
LF Cetaceans
MF Cetaceans
HF Cetaceans
Phocid
Otariid

PILE #150

September 25, 2018

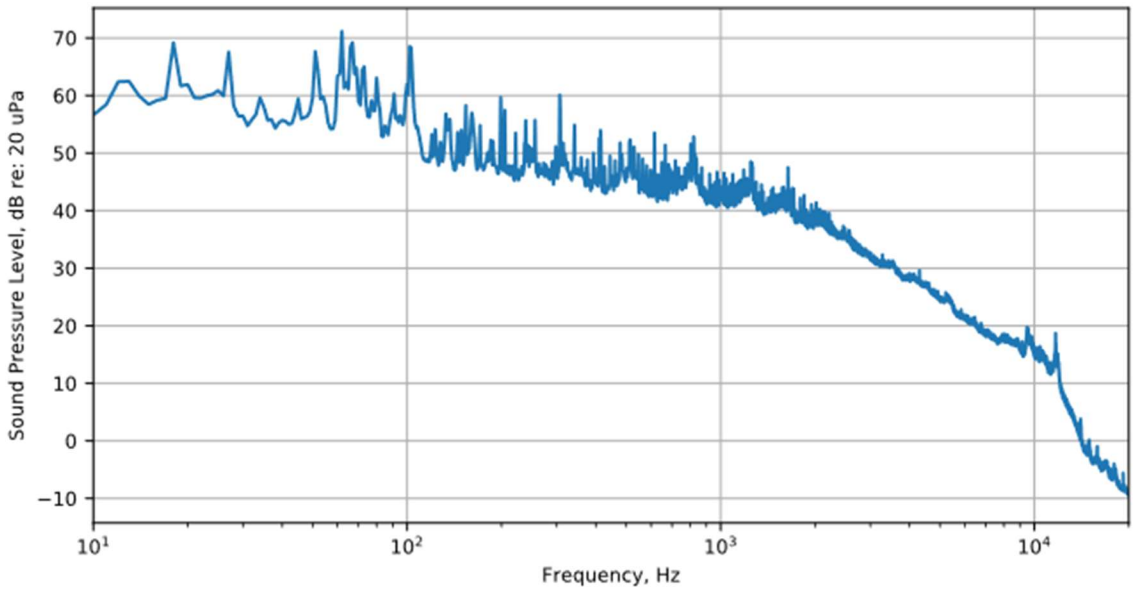
Hydrophone and Pile Information, Feet

Hydro Depth (upper/lower)	Distance			Water Depth	
	Between Hydros	Hydros to Pile	Pile to Water's Edge	Hydros	Pile
4/8	4	170	25	12	7

Airborne Sound Levels, dB re: 20 µPa

Median	Maximum	Minimum
94	99	89

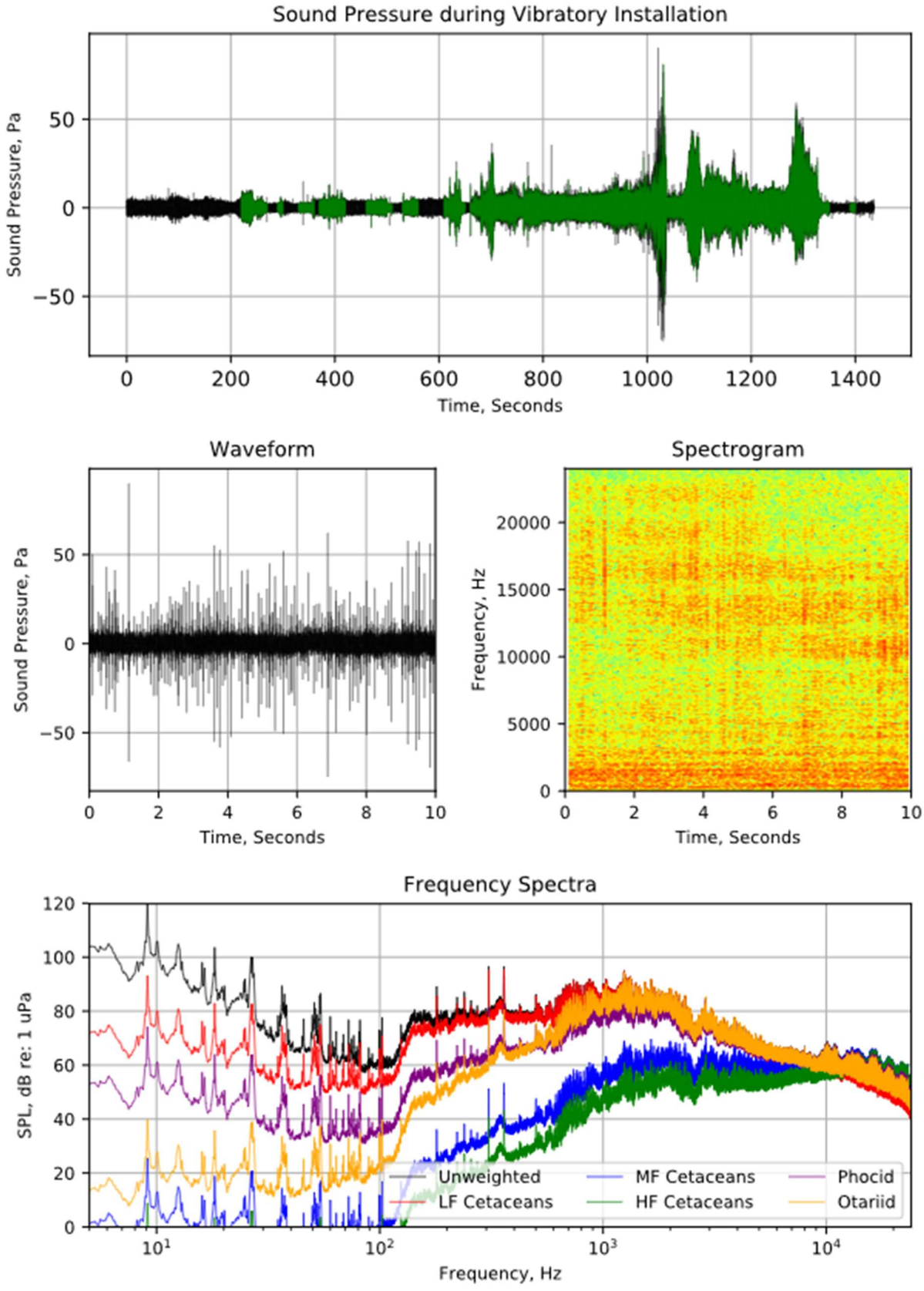
Airborne Frequency Spectra



Underwater Sound Levels, dB re: 1 µPa

Frequency Range	Peak					RMS_{90}					SEL					cSEL
	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	
Upper Hydrophone																
Unweighted	146	170	5.4	158	153	126	147	4.8	139	137	136	157	4.8	149	147	169
LF Cetacean	146	170	5.4	158	153	116	142	5.6	133	131	126	152	5.6	143	141	162
MF Cetacean	146	170	5.4	158	153	122	142	4.3	134	132	132	152	4.3	144	142	163
HF Cetacean	146	170	5.4	158	153	123	142	4.3	134	132	133	152	4.3	144	142	164
PW	146	170	5.4	158	153	115	141	5.4	131	130	125	151	5.4	141	140	161
OW	146	170	5.4	158	153	114	142	6	133	131	124	152	6	143	141	162
Lower Hydrophone																
Unweighted	144	167	5.1	156	152	123	145	4.6	136	135	133	155	4.6	146	145	166
LF Cetacean	144	167	5.1	156	152	115	140	5.4	131	130	125	150	5.4	141	140	160
MF Cetacean	144	167	5.1	156	152	121	140	3.7	131	130	131	150	3.7	141	140	161
HF Cetacean	144	167	5.1	156	152	122	140	3.6	132	131	132	150	3.6	142	141	161
PW	144	167	5.1	156	152	115	140	5.1	130	128	125	150	5.1	140	138	160
OW	144	167	5.1	156	152	114	141	5.7	131	130	124	151	5.7	141	140	161

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


Sound Pressure during Vibratory Installation
Sound Pressure, Pa
Time, Seconds
Waveform
Sound Pressure, Pa
Time, Seconds
Spectrogram
Frequency, Hz
Time, Seconds
Frequency Spectra
SPL, dB re: 1 uPa
Frequency, Hz
Unweighted
LF Cetaceans
MF Cetaceans
HF Cetaceans
Phocid
Otariid

PILE #161

September 25, 2018

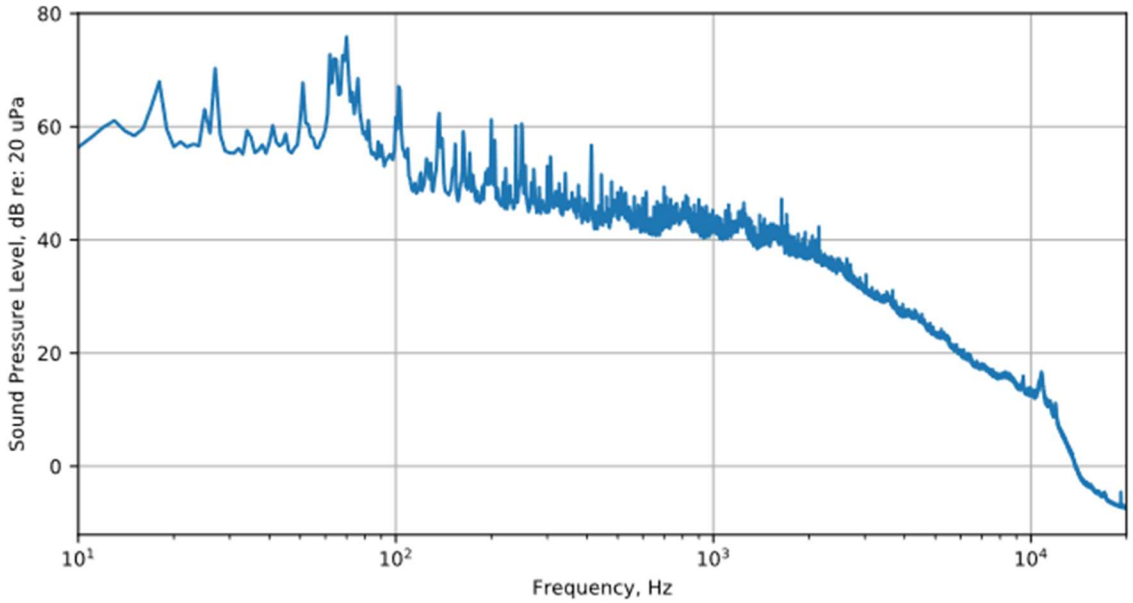
Hydrophone and Pile Information, Feet

Hydro Depth (upper/lower)	Distance			Water Depth	
	Between Hydros	Hydros to Pile	Pile to Water's Edge	Hydros	Pile
4/6	2	185	4	10	2

Airborne Sound Levels, dB re: 20 µPa

Median	Maximum	Minimum
95	102	91

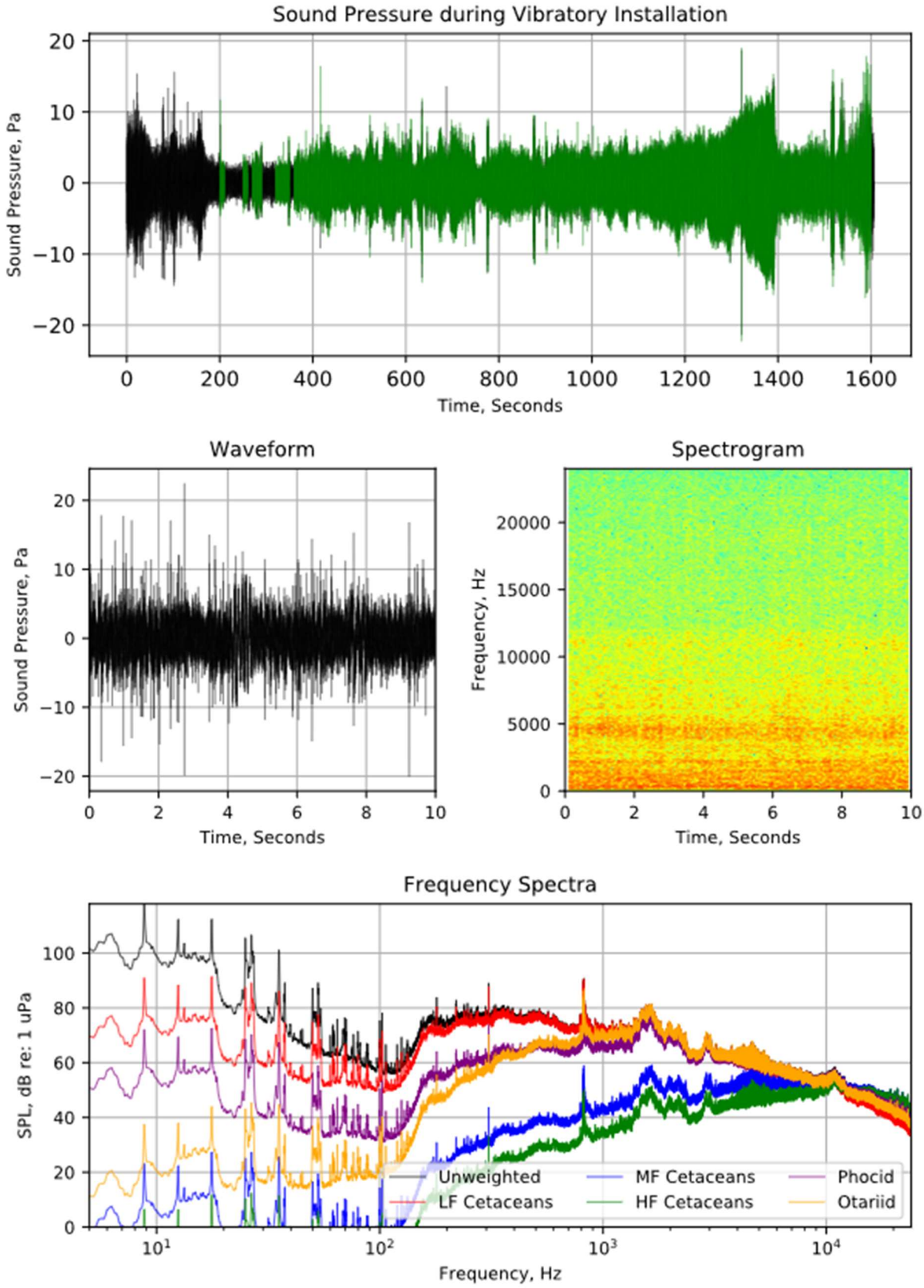
Airborne Frequency Spectra



Underwater Sound Levels, dB re: 1 µPa

Frequency Range	Peak					RMS_{90}					SEL					cSEL
	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	
Upper Hydrophone																
Unweighted	145	158	3	151	149	126	146	3.8	137	134	136	156	3.8	147	144	168
LF Cetacean	145	158	3	151	149	117	130	2.7	125	125	127	140	2.7	135	135	156
MF Cetacean	145	158	3	151	149	122	140	3.3	131	129	132	150	3.3	141	139	162
HF Cetacean	145	158	3	151	149	123	141	3.4	132	129	133	151	3.4	142	139	163
PW	145	158	3	151	149	115	131	3	125	124	125	141	3	135	134	156
OW	145	158	3	151	149	114	130	3.2	125	124	124	140	3.2	135	134	156
Lower Hydrophone																
Unweighted	144	164	3.5	153	151	126	141	2.8	134	132	136	151	2.8	144	142	165
LF Cetacean	144	164	3.5	153	151	121	131	1.6	125	125	131	141	1.6	135	135	156
MF Cetacean	144	164	3.5	153	151	126	147	4.6	136	133	136	157	4.6	146	143	167
HF Cetacean	144	164	3.5	153	151	126	147	4.7	136	134	136	157	4.7	146	144	168
PW	144	164	3.5	153	151	122	137	2.7	127	126	132	147	2.7	137	136	158
OW	144	164	3.5	153	151	121	135	2.1	126	125	131	145	2.1	136	135	157

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


Sound Pressure during Vibratory Installation
Sound Pressure, Pa
Time, Seconds
Waveform
Sound Pressure, Pa
Time, Seconds
Spectrogram
Frequency, Hz
Time, Seconds
Frequency Spectra
SPL, dB re: 1 uPa
Frequency, Hz
Unweighted
LF Cetaceans
MF Cetaceans
HF Cetaceans
Phocid
Otariid

PILE #162

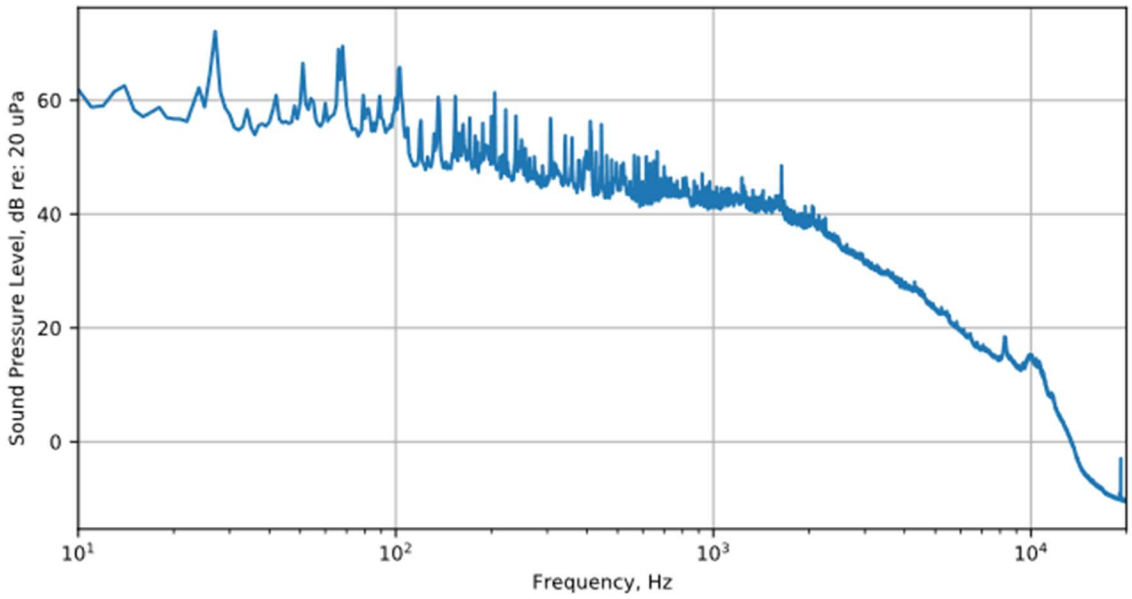
Hydrophone and Pile Information, Feet

Hydro Depth (upper/lower)	Distance			Water Depth	
	Between Hydros	Hydros to Pile	Pile to Water's Edge	Hydros	Pile
6/10	102	203/305	4	10/20	2

Airborne Sound Levels, dB re: 20 µPa

Median	Maximum	Minimum
94	102	90

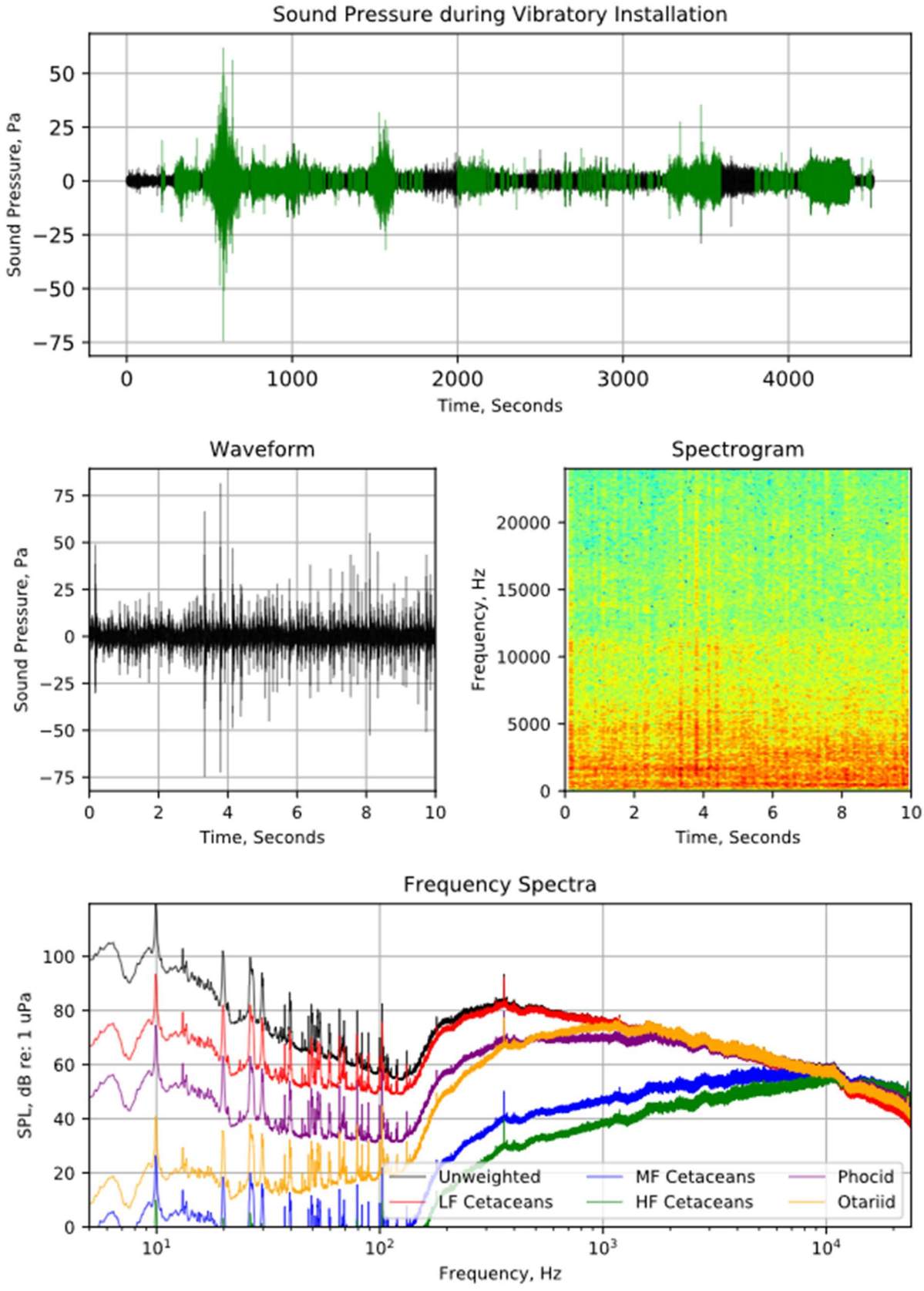
Airborne Frequency Spectra



Underwater Sound Levels, dB re: 1 µPa

Frequency Range	Peak					RMS_{90}					SEL					cSEL
	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	
Upper Hydrophone																
Unweighted	147	170	4.4	156	152	121	146	5.2	137	133	131	156	5.2	147	143	171
LF Cetacean	147	170	4.4	156	152	112	137	4.8	128	125	122	147	4.8	138	135	162
MF Cetacean	147	170	4.4	156	152	125	141	3.4	133	131	135	151	3.4	143	141	167
HF Cetacean	147	170	4.4	156	152	126	141	3.4	133	131	136	151	3.4	143	141	168
PW	147	170	4.4	156	152	117	136	3.9	127	124	127	146	3.9	137	134	161
OW	147	170	4.4	156	152	114	137	4.2	126	124	124	147	4.2	136	134	161
Lower Hydrophone																
Unweighted	141	171	5	159	155	124	150	3.9	141	140	134	160	3.9	151	150	176
LF Cetacean	141	171	5	159	155	114	144	4.5	135	132	124	154	4.5	145	142	169
MF Cetacean	141	171	5	159	155	122	144	3.6	136	134	132	154	3.6	146	144	170
HF Cetacean	141	171	5	159	155	123	144	3.6	136	135	133	154	3.6	146	145	171
PW	141	171	5	159	155	115	139	4.1	131	129	125	149	4.1	141	139	166
OW	141	171	5	159	155	114	139	4.3	131	128	124	149	4.3	141	138	165

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


Sound Pressure during Vibratory Installation
Sound Pressure, Pa
Time, Seconds
Waveform
Sound Pressure, Pa
Time, Seconds
Spectrogram
Frequency, Hz
Time, Seconds
Frequency Spectra
SPL, dB re: 1 uPa
Frequency, Hz
Unweighted
LF Cetaceans
MF Cetaceans
HF Cetaceans
Phocid
Otariid

PILE #151

September 25, 2018

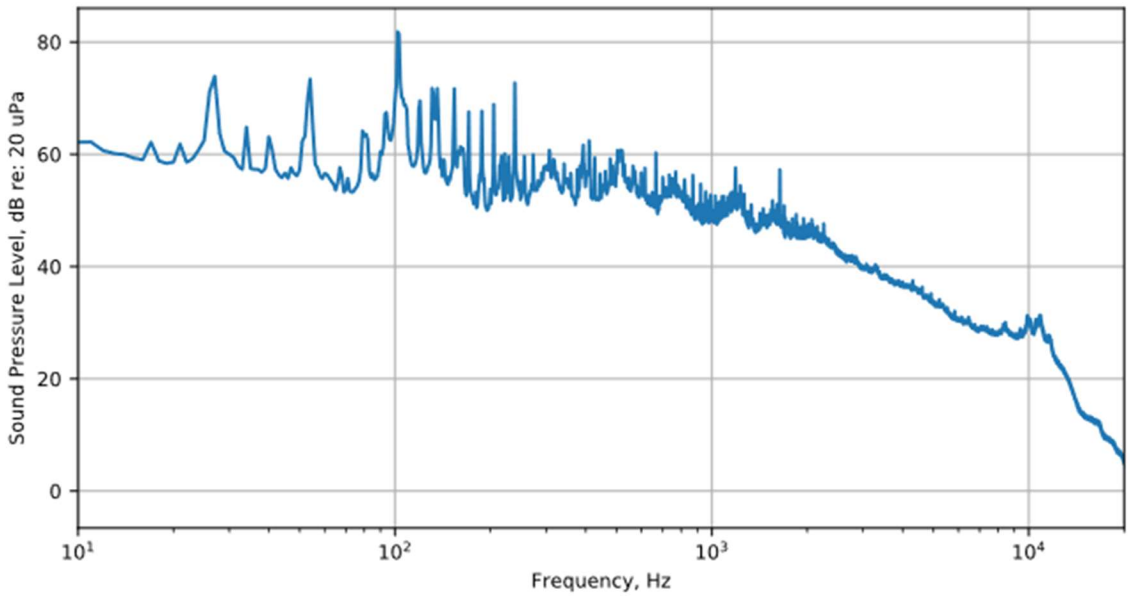
Hydrophone and Pile Information, Feet

Hydro Depth (upper/lower)	Distance			Water Depth	
	Between Hydros	Hydros to Pile	Pile to Water's Edge	Hydros	Pile
3/10	7	49	23	12	2

Airborne Sound Levels, dB re: 20 µPa

Median	Maximum	Minimum
94	97	89

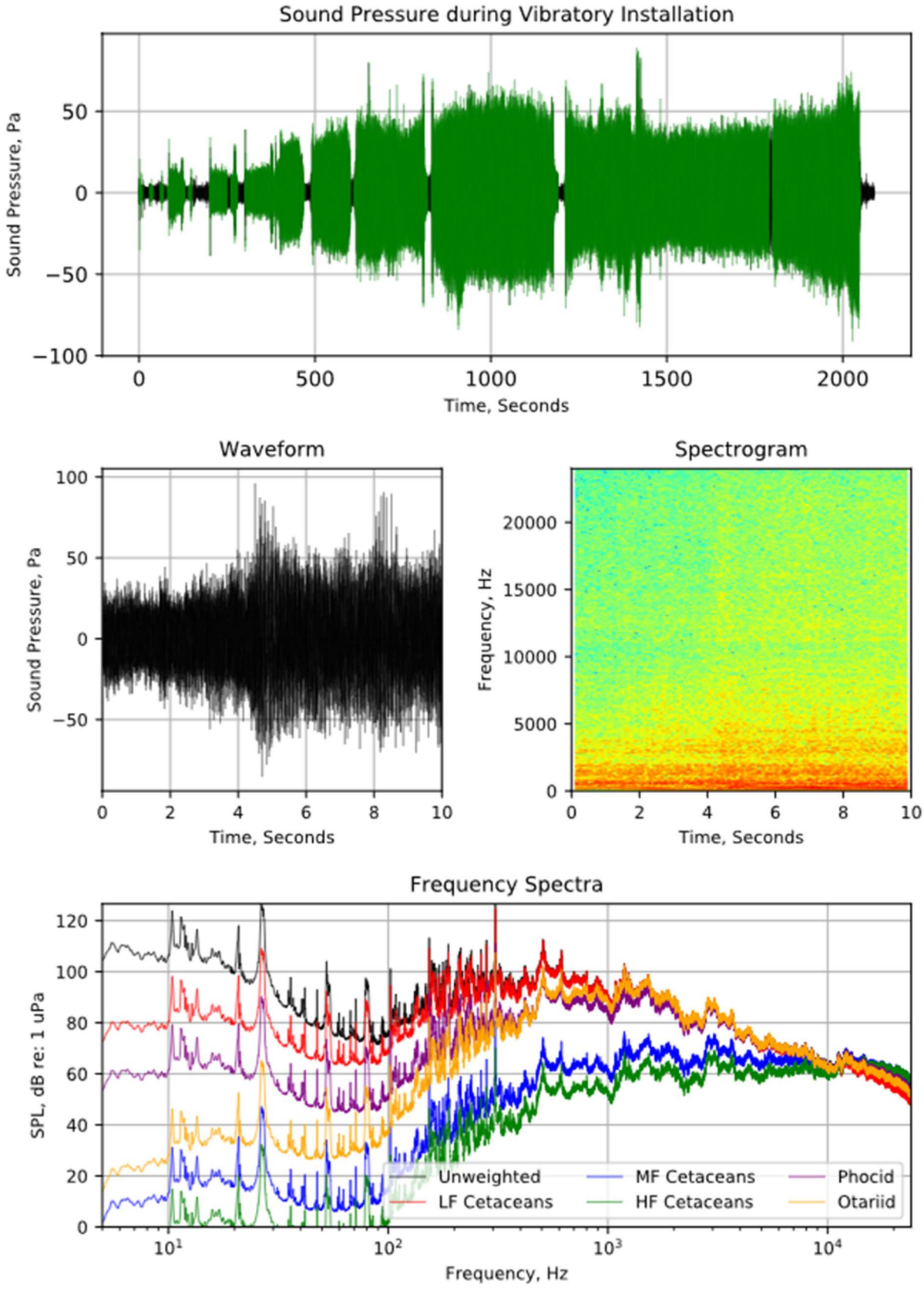
Airborne Frequency Spectra



Underwater Sound Levels, dB re: 1 µPa

Frequency Range	Peak					RMS_{90}					SEL					cSEL
	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	
Upper Hydrophone																
Unweighted	146	162	3.3	157	157	123	150	4.7	144	144	133	160	4.7	154	154	177
LF Cetacean	146	162	3.3	157	157	113	140	5.1	137	137	123	150	5.1	147	147	170
MF Cetacean	146	162	3.3	157	157	121	144	4.3	138	138	131	154	4.3	148	148	171
HF Cetacean	146	162	3.3	157	157	122	145	4.3	139	138	132	155	4.3	149	148	171
PW	146	162	3.3	157	157	113	137	4.5	134	134	123	147	4.5	144	144	167
OW	146	162	3.3	157	157	111	138	4.6	134	134	121	148	4.6	144	144	167
Lower Hydrophone																
Unweighted	143	161	3.2	153	152	118	143	4.1	138	138	128	153	4.1	148	148	170
LF Cetacean	143	161	3.2	153	152	113	135	4.2	132	131	123	145	4.2	142	141	164
MF Cetacean	143	161	3.2	153	152	124	142	3.4	134	132	134	152	3.4	144	142	166
HF Cetacean	143	161	3.2	153	152	125	142	3.4	134	133	135	152	3.4	144	143	167
PW	143	161	3.2	153	152	116	134	3.5	129	129	126	144	3.5	139	139	162
OW	143	161	3.2	153	152	115	134	3.7	130	130	125	144	3.7	140	140	162

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


Sound Pressure during Vibratory Installation
Sound Pressure, Pa
Time, Seconds
Waveform
Sound Pressure, Pa
Time, Seconds
Spectrogram
Frequency, Hz
Time, Seconds
Frequency Spectra
SPL, dB re: 1 uPa
Frequency, Hz
Unweighted
LF Cetaceans
MF Cetaceans
HF Cetaceans
Phocid
Otariid

2.0 STEEL PILES INSTALLED WITH APE 400 KING KONG VIBRATORY HAMMER

PILE #152

September 12, 2018

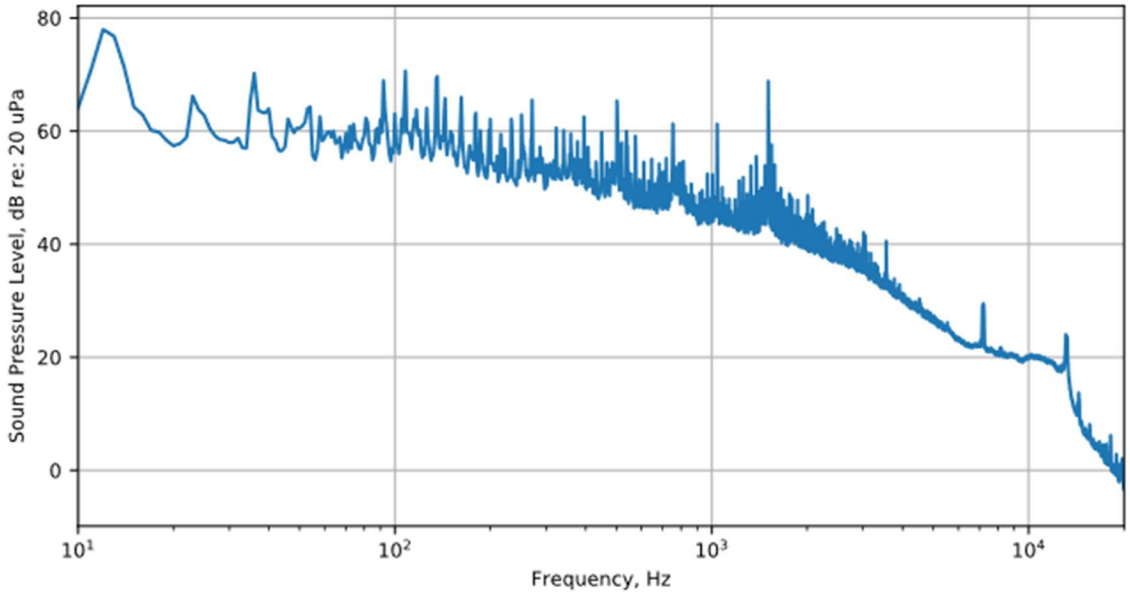
Hydrophone and Pile Information, Feet

Hydro Depth (upper/lower)	Distance			Water Depth	
	Between Hydros	Hydros to Pile	Pile to Water's Edge	Hydros	Pile
3/15	12	80	23	18	2

Airborne Sound Levels, dB re: 20 µPa

Median	Maximum	Minimum
92	96	86

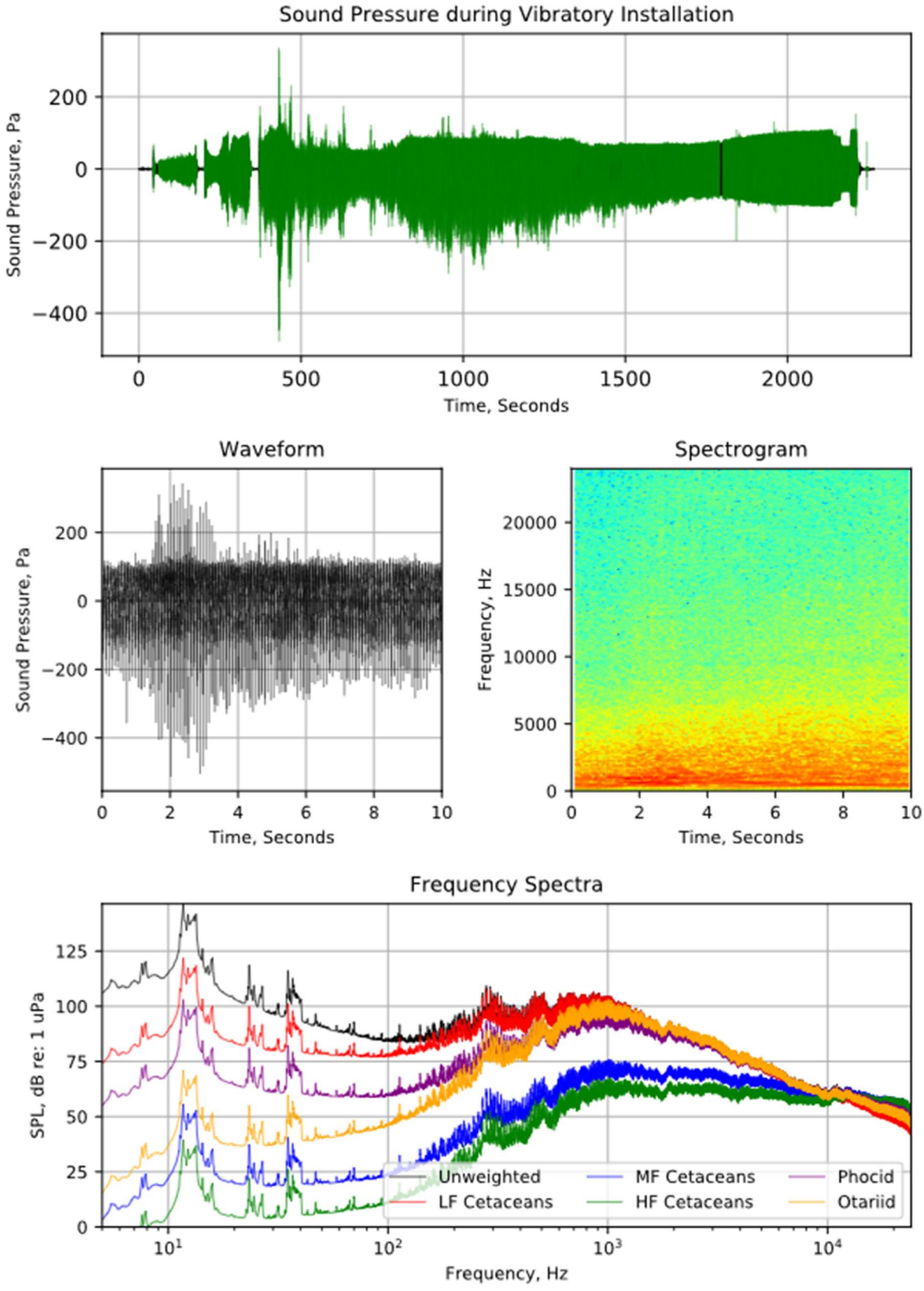
Airborne Frequency Spectra



Underwater Sound Levels, dB re: 1 µPa

Frequency Range	Peak					RMS_{90}					SEL					cSEL
	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	
Upper Hydrophone																
Unweighted	156	176	8.8	166	165	131	163	9.7	159	159	141	173	9.7	169	169	192
LF Cetacean	156	176	8.8	166	165	124	151	9.6	143	143	134	161	9.6	153	153	176
MF Cetacean	156	176	8.8	166	165	126	157	9.6	153	153	136	167	9.6	163	163	186
HF Cetacean	156	176	8.8	166	165	127	157	9.6	154	154	137	167	9.6	164	164	187
PW	156	176	8.8	166	165	122	150	9.4	144	144	132	160	9.4	154	154	177
OW	156	176	8.8	166	165	122	150	9.4	143	143	132	160	9.4	153	153	176
Lower Hydrophone																
Unweighted	149	174	10.1	162	158	131	156	9.2	150	150	141	166	9.2	160	160	183
LF Cetacean	149	174	10.1	162	158	120	147	10.1	139	137	130	157	10.1	149	147	172
MF Cetacean	149	174	10.1	162	158	126	150	9	144	143	136	160	9	154	153	177
HF Cetacean	149	174	10.1	162	158	127	150	9	145	144	137	160	9	155	154	178
PW	149	174	10.1	162	158	122	146	9.3	137	136	132	156	9.3	147	146	171
OW	149	174	10.1	162	158	121	147	9.8	138	136	131	157	9.8	148	146	171

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


Sound Pressure during Vibratory Installation
Sound Pressure, Pa
Time, Seconds
Waveform
Sound Pressure, Pa
Time, Seconds
Spectrogram
Frequency, Hz
Time, Seconds
Frequency Spectra
SPL, dB re: 1 uPa
Frequency, Hz
Unweighted
LF Cetaceans
MF Cetaceans
HF Cetaceans
Phocid
Otariid

PILE #19

September 12, 2018

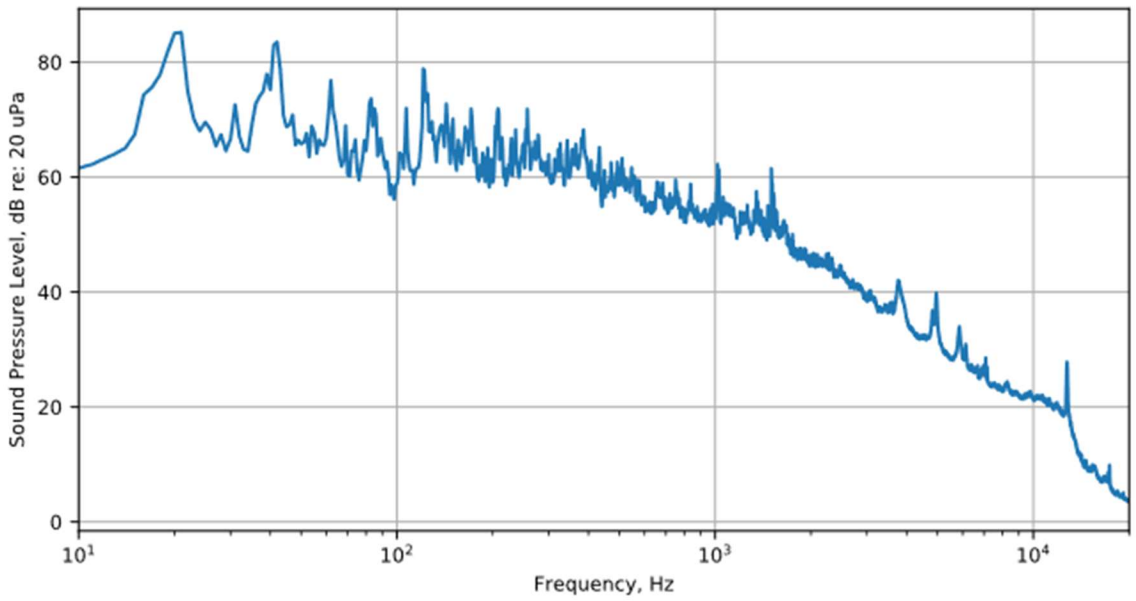
Hydrophone and Pile Information, Feet

Hydro Depth (upper/lower)	Distance			Water Depth	
	Between Hydros	Hydros to Pile	Pile to Water's Edge	Hydros	Pile
3/38	35	33	193	41	32

Airborne Sound Levels, dB re: 20 µPa

Median	Maximum	Minimum
95	102	84

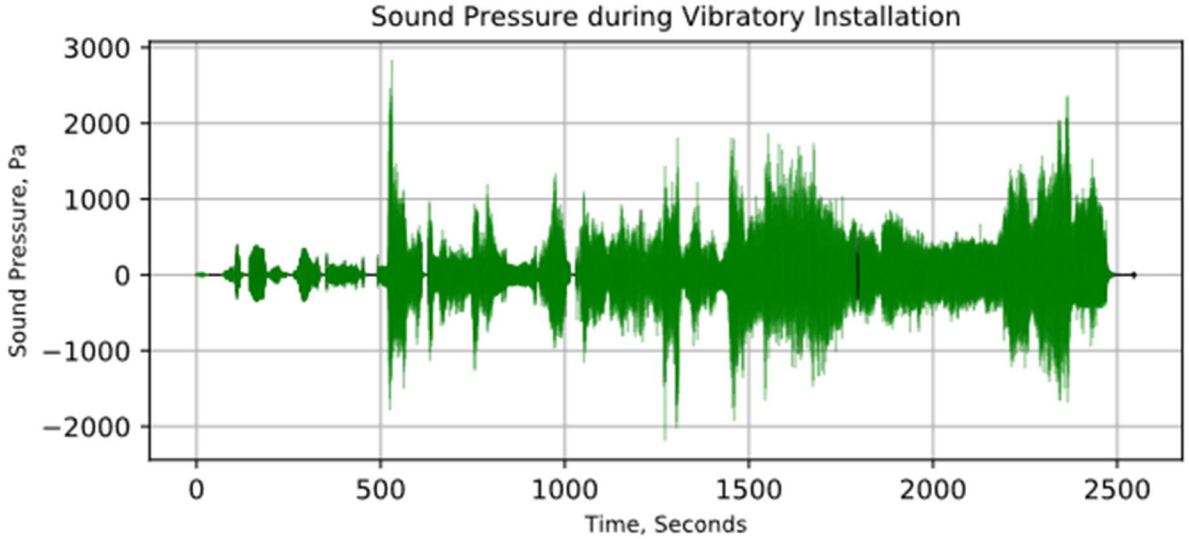
Airborne Frequency Spectra

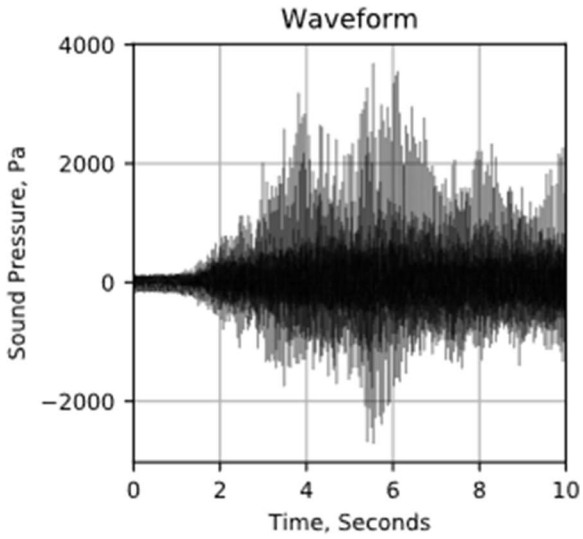


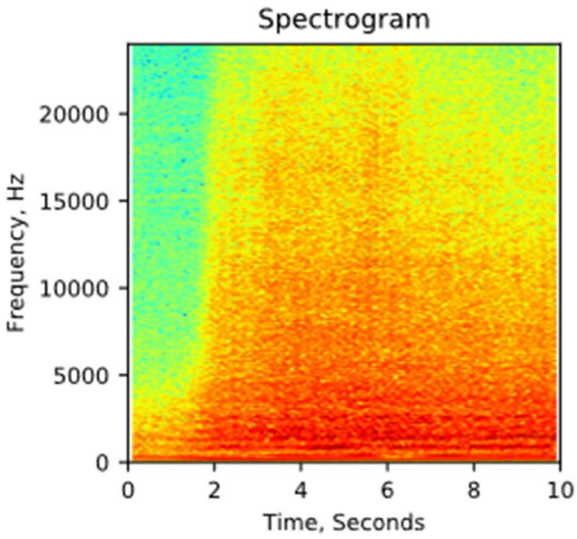
Underwater Sound Levels, dB re: 1 µPa

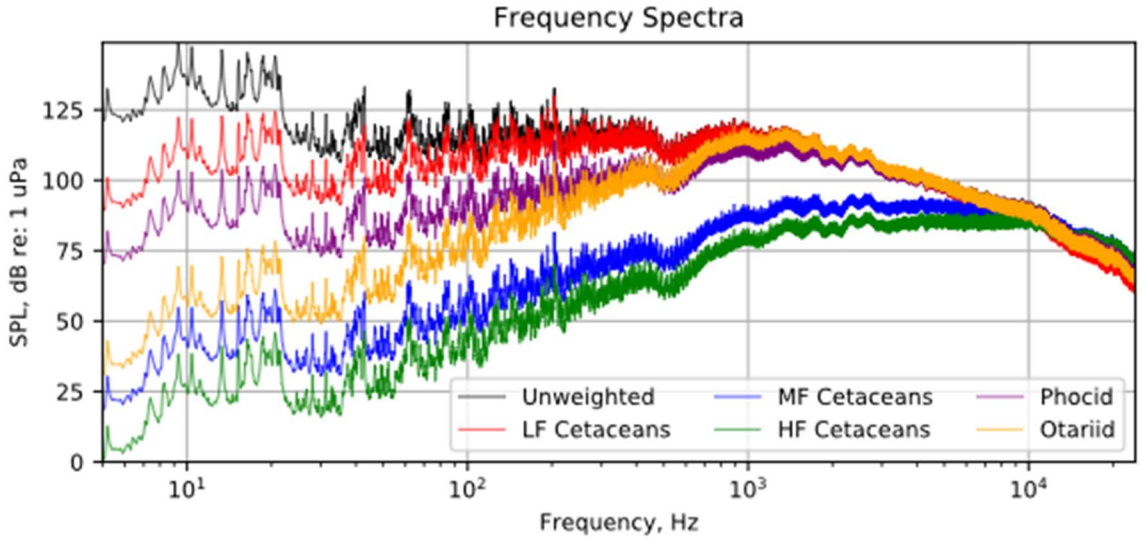
Frequency Range	Peak					RMS_{90}					SEL					cSEL
	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	
Upper Hydrophone																
Unweighted	148	191	8.3	180	176	123	168	7.2	162	160	133	178	7.2	172	170	196
LF Cetacean	148	191	8.3	180	176	115	161	9.0	153	152	125	171	9.0	163	162	187
MF Cetacean	148	191	8.3	180	176	119	162	6.9	156	154	129	172	6.9	166	164	190
HF Cetacean	148	191	8.3	180	176	119	162	6.8	157	155	129	172	6.8	167	165	190
PW	148	191	8.3	180	176	112	160	8.1	152	150	122	170	8.1	162	160	186
OW	148	191	8.3	180	176	112	161	8.9	153	150	122	171	8.9	163	160	186
Lower Hydrophone																
Unweighted	136	192	12.4	182	177	122	167	9.5	159	157	132	177	9.5	169	167	193
LF Cetacean	136	192	12.4	182	177	116	162	10.6	153	151	126	172	10.6	163	161	187
MF Cetacean	136	192	12.4	182	177	117	162	9.6	154	151	127	172	9.6	164	161	187
HF Cetacean	136	192	12.4	182	177	118	162	9.4	154	152	128	172	9.4	164	162	187
PW	136	192	12.4	182	177	111	161	11.0	152	148	121	171	11.0	162	158	186
OW	136	192	12.4	182	177	110	162	11.5	153	149	120	172	11.5	163	159	187

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


Sound Pressure during Vibratory Installation
Sound Pressure, Pa
Time, Seconds


Waveform
Sound Pressure, Pa
Time, Seconds


Spectrogram
Frequency, Hz
Time, Seconds


Frequency Spectra
SPL, dB re: 1 uPa
Frequency, Hz
Unweighted
LF Cetaceans
MF Cetaceans
HF Cetaceans
Phocid
Otariid

3.0 STEEL PILES INSTALLED WITH APE 600 SUPER KONG VIBRATORY HAMMER

PILE #159

September 25, 2018

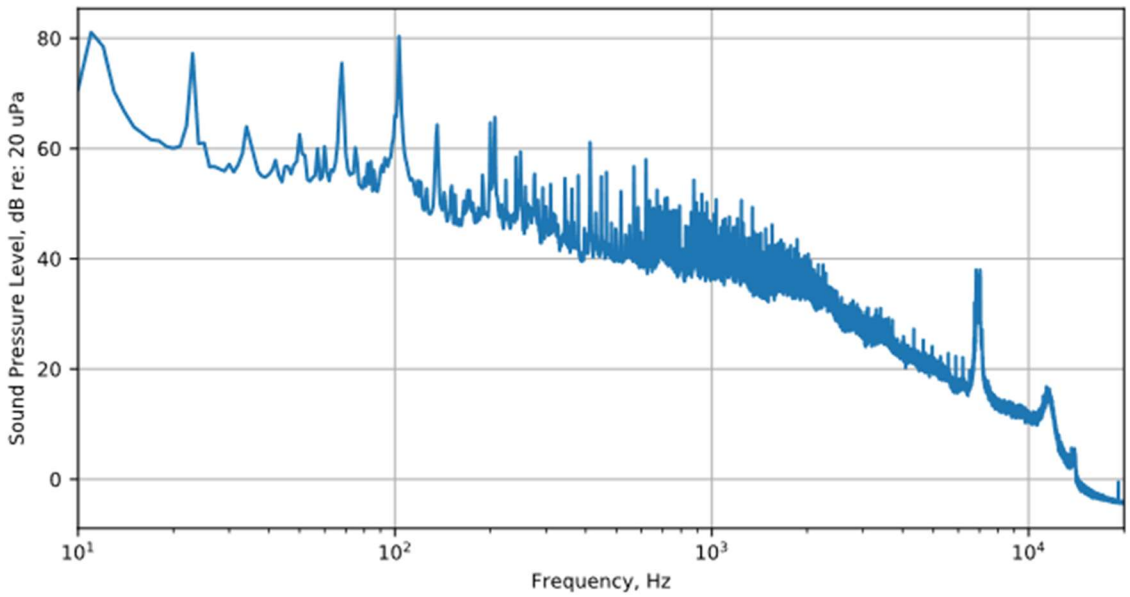
Hydrophone and Pile Information, Feet

Hydro Depth (upper/lower)	Distance			Water Depth	
	Between Hydros	Hydros to Pile	Pile to Water's Edge	Hydros	Pile
6/10	105	178/283	4	10/20	2

Airborne Sound Levels, dB re: 20 µPa

Median	Maximum	Minimum
99	101	91

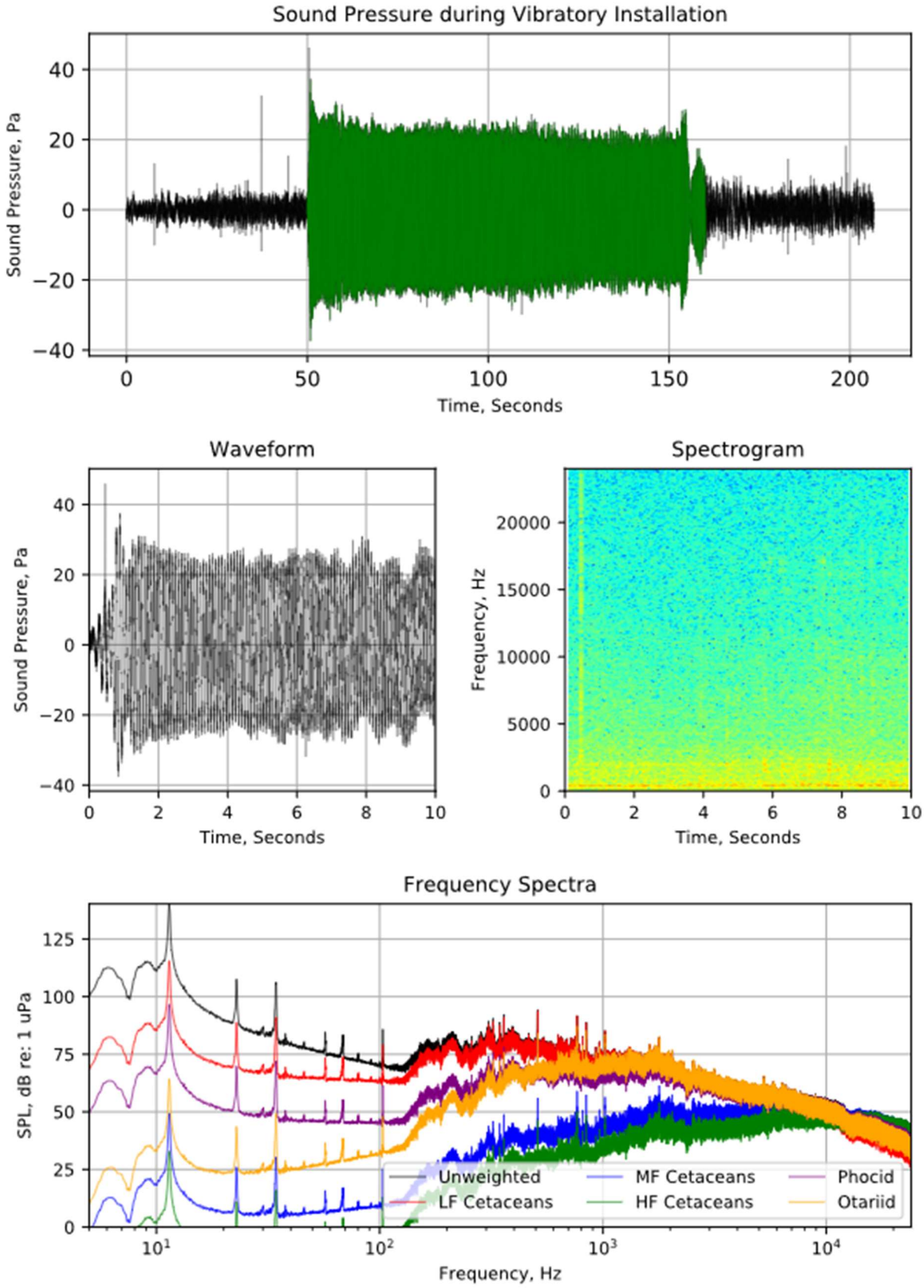
Airborne Frequency Spectra



Underwater Sound Levels, dB re: 1 µPa

Frequency Range	Peak					RMS_{90}					SEL					cSEL
	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	
Upper Hydrophone																
Unweighted	159	164	1.6	160	159	151	155	0.9	154	154	161	165	0.9	164	164	174
LF Cetacean	159	164	1.6	160	159	132	135	0.9	134	134	142	145	0.9	144	144	154
MF Cetacean	159	164	1.6	160	159	146	149	0.8	147	148	156	159	0.8	157	158	168
HF Cetacean	159	164	1.6	160	159	146	149	0.8	148	148	156	159	0.8	158	158	169
PW	159	164	1.6	160	159	136	139	0.8	138	138	146	149	0.8	148	148	158
OW	159	164	1.6	160	159	133	137	0.8	135	135	143	147	0.8	145	145	156
Lower Hydrophone																
Unweighted	160	162	0.5	161	161	152	155	0.8	154	154	162	165	0.8	164	164	175
LF Cetacean	160	162	0.5	161	161	135	137	0.6	136	136	145	147	0.6	146	146	156
MF Cetacean	160	162	0.5	161	161	146	148	0.7	148	148	156	158	0.7	158	158	168
HF Cetacean	160	162	0.5	161	161	147	149	0.7	149	149	157	159	0.7	159	159	169
PW	160	162	0.5	161	161	137	139	0.7	138	139	147	149	0.7	148	149	159
OW	160	162	0.5	161	161	134	136	0.6	136	136	144	146	0.6	146	146	156

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


Sound Pressure during Vibratory Installation
Sound Pressure, Pa
Time, Seconds
Waveform
Sound Pressure, Pa
Time, Seconds
Spectrogram
Frequency, Hz
Time, Seconds
Frequency Spectra
SPL, dB re: 1 uPa
Frequency, Hz
Unweighted
LF Cetaceans
MF Cetaceans
HF Cetaceans
Phocid
Otariid

PILE #150

September 25, 2018

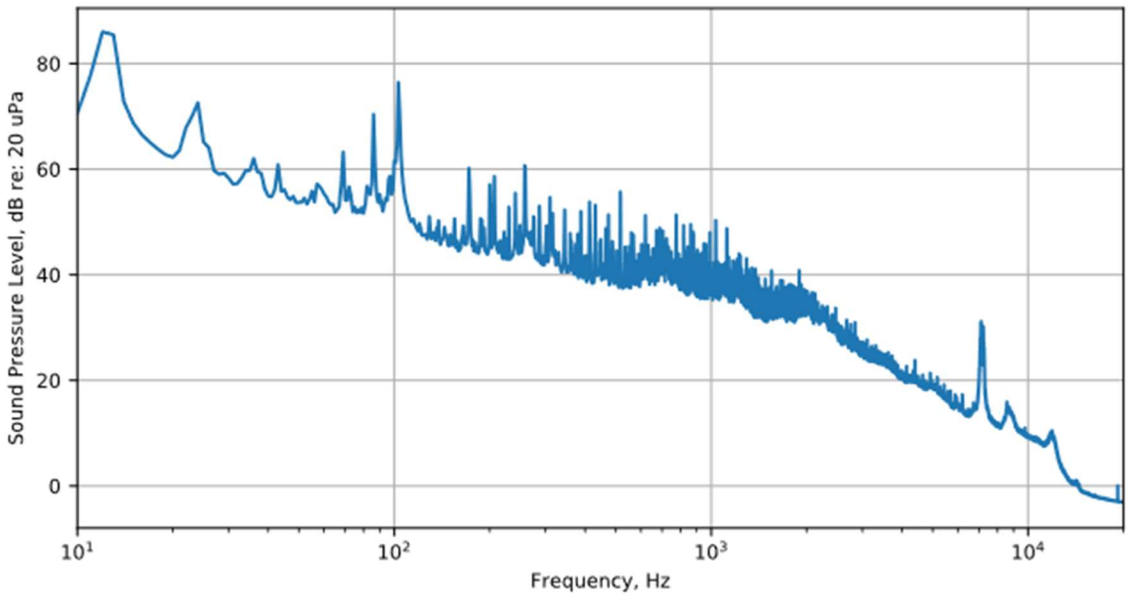
Hydrophone and Pile Hydrophone and Pile Information, Feet

Hydro Depth (upper/lower)	Distance			Water Depth	
	Between Hydros	Hydros to Pile	Pile to Water's Edge	Hydros	Pile
6/10	100	170/270	27	10/20	7

Airborne Sound Levels, dB re: 20 µPa

Median	Maximum	Minimum
102	104	94

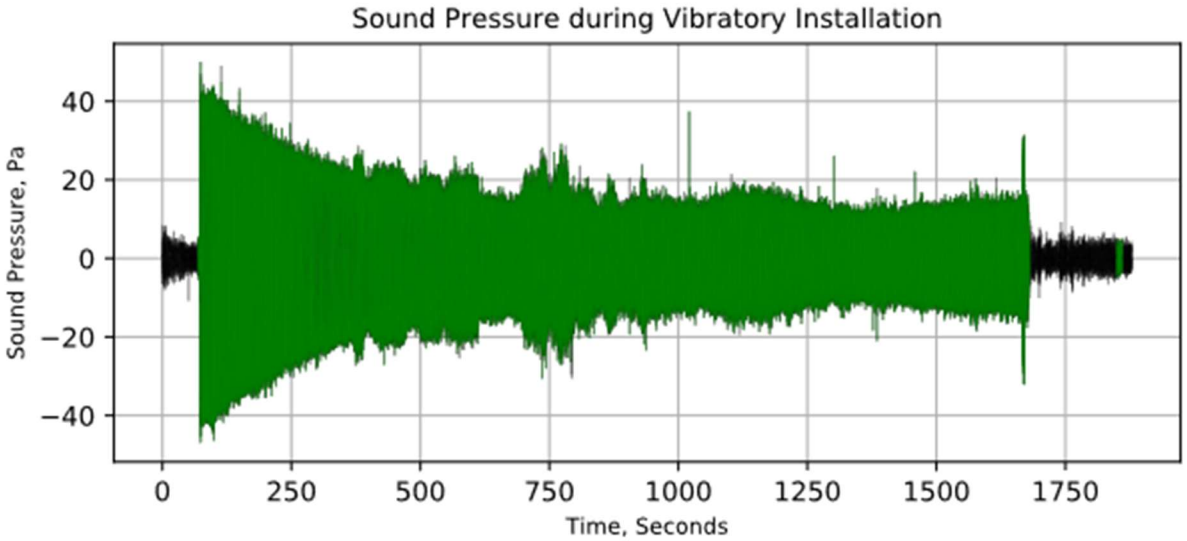
Airborne Frequency Spectra

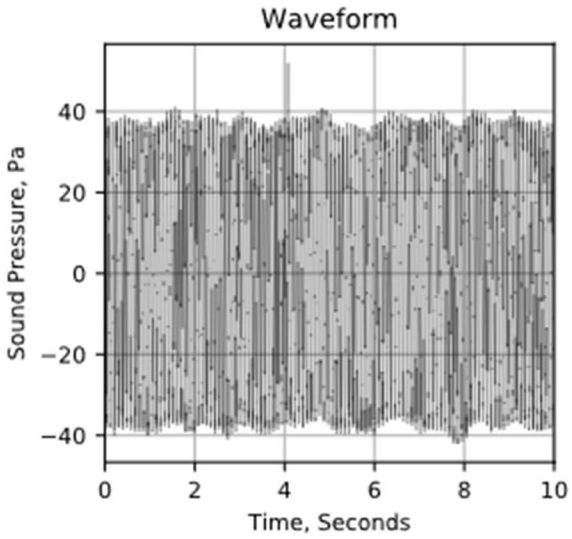


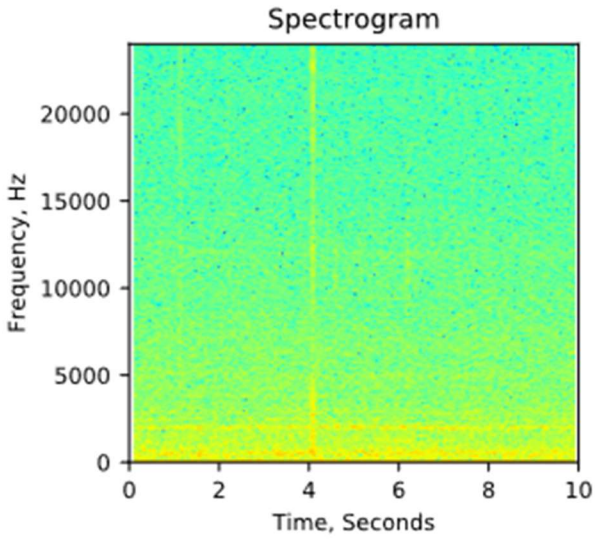
Underwater Sound Levels, dB re: 1 µPa

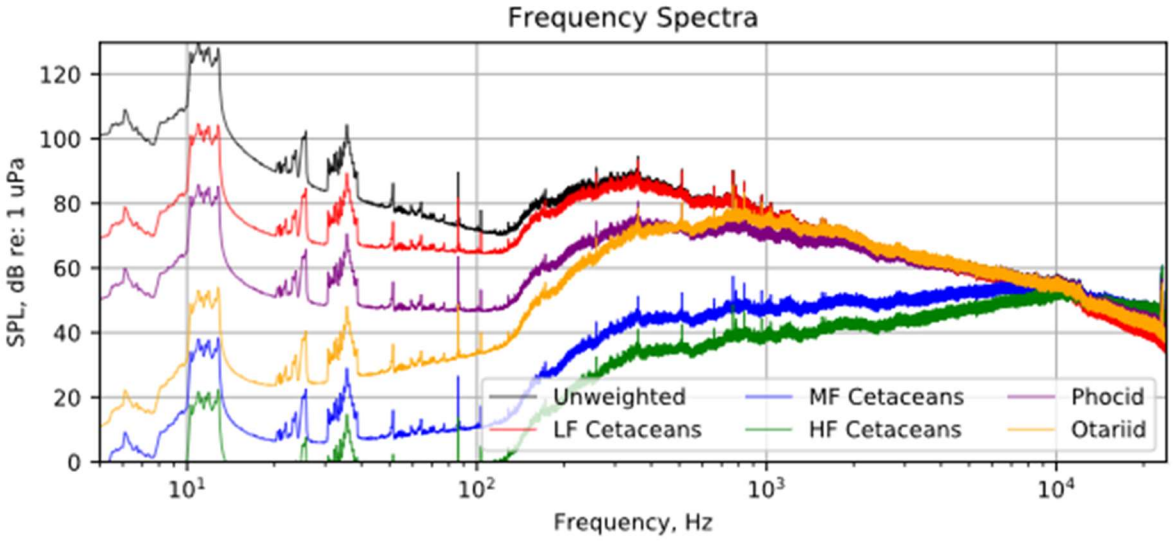
Frequency Range	Peak					RMS$_{90}$					SEL					cSEL
	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	
Upper Hydrophone																
Unweighted	153	165	2.7	158	157	129	159	3.7	151	149	139	169	3.7	161	159	183
LF Cetacean	153	165	2.7	158	157	124	139	3.1	133	131	134	149	3.1	143	141	165
MF Cetacean	153	165	2.7	158	157	127	153	3.6	145	142	137	163	3.6	155	152	177
HF Cetacean	153	165	2.7	158	157	127	154	3.6	146	143	137	164	3.6	156	153	178
PW	153	165	2.7	158	157	121	143	3.3	136	133	131	153	3.3	146	143	168
OW	153	165	2.7	158	157	121	141	3.2	133	131	131	151	3.2	143	141	165
Lower Hydrophone																
Unweighted	150	170	2.4	163	162	136	159	1.9	156	156	146	169	1.9	166	166	188
LF Cetacean	150	170	2.4	163	162	129	147	2.7	139	137	139	157	2.7	149	147	171
MF Cetacean	150	170	2.4	163	162	131	152	1.9	150	150	141	162	1.9	160	160	182
HF Cetacean	150	170	2.4	163	162	131	153	1.9	151	151	141	163	1.9	161	161	183
PW	150	170	2.4	163	162	126	144	1.7	141	141	136	154	1.7	151	151	173
OW	150	170	2.4	163	162	125	143	1.8	138	138	135	153	1.8	148	148	170

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


Sound Pressure during Vibratory Installation
Sound Pressure, Pa
Time, Seconds


Waveform
Sound Pressure, Pa
Time, Seconds


Spectrogram
Frequency, Hz
Time, Seconds


Frequency Spectra
SPL, dB re: 1 uPa
Frequency, Hz
Unweighted
LF Cetaceans
MF Cetaceans
HF Cetaceans
Phocid
Otariid

PILE #161

September 25, 2018

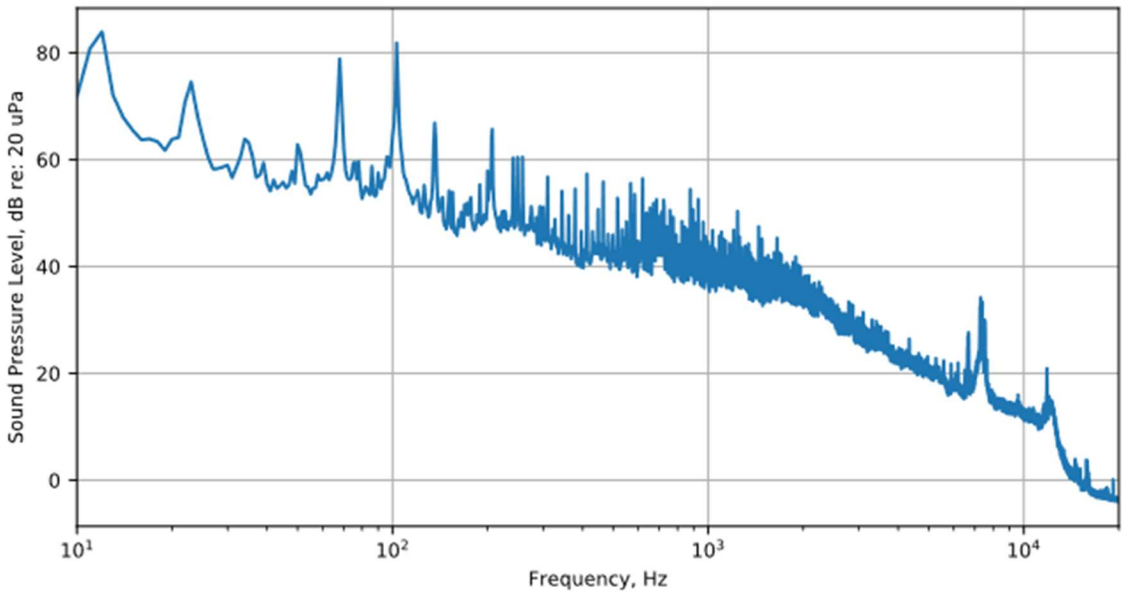
Hydrophone and Pile Information, Feet

Hydro Depth (upper/lower)	Distance			Water Depth	
	Between Hydros	Hydros to Pile	Pile to Water's Edge	Hydros	Pile
6/10	106	185/291	4	10/20	2

Airborne Sound Levels, dB re: 20 µPa

Median	Maximum	Minimum
101	102	98

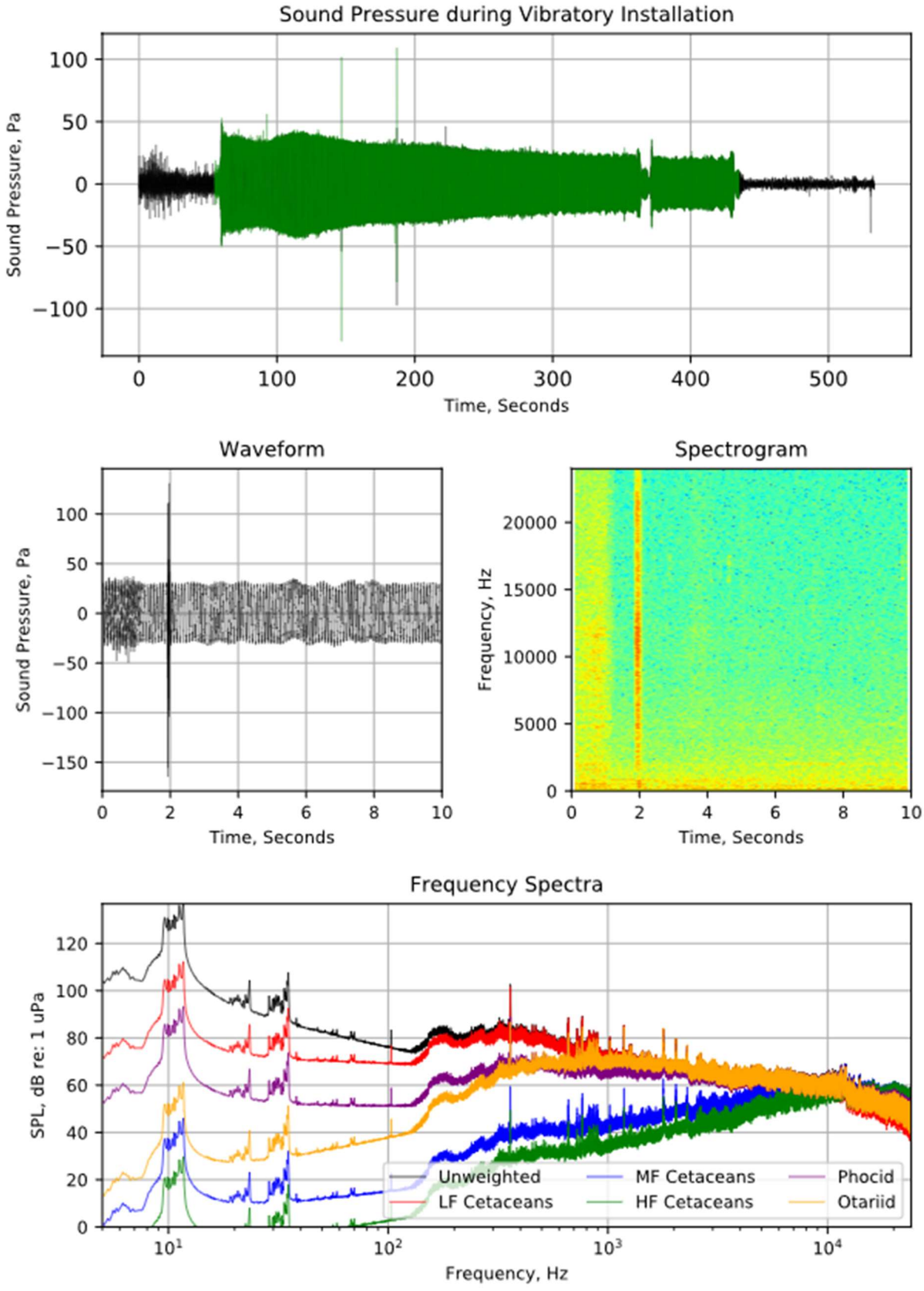
Airborne Frequency Spectra



Underwater Sound Levels, dB re: 1 µPa

Frequency Range	Peak					RMS_{90}					SEL					cSEL
	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	
Upper Hydrophone																
Unweighted	159	174	3.2	164	162	150	159	2.4	156	156	160	169	2.4	166	166	182
LF Cetacean	159	174	3.2	164	162	131	139	2.2	136	136	141	149	2.2	146	146	162
MF Cetacean	159	174	3.2	164	162	144	153	2.4	150	149	154	163	2.4	160	159	176
HF Cetacean	159	174	3.2	164	162	145	154	2.4	151	150	155	164	2.4	161	160	176
PW	159	174	3.2	164	162	135	144	2.4	140	140	145	154	2.4	150	150	166
OW	159	174	3.2	164	162	132	141	2.4	138	137	142	151	2.4	148	147	163
Lower Hydrophone																
Unweighted	160	170	2.5	163	161	151	157	1.1	154	154	161	167	1.1	164	164	180
LF Cetacean	160	170	2.5	163	161	133	141	1.4	137	136	143	151	1.4	147	146	162
MF Cetacean	160	170	2.5	163	161	145	151	1	148	148	155	161	1	158	158	174
HF Cetacean	160	170	2.5	163	161	145	152	1	149	149	155	162	1	159	159	175
PW	160	170	2.5	163	161	135	142	1	139	139	145	152	1	149	149	165
OW	160	170	2.5	163	161	133	140	1.1	136	136	143	150	1.1	146	146	162

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


Sound Pressure during Vibratory Installation
Sound Pressure, Pa
Time, Seconds
Waveform
Sound Pressure, Pa
Time, Seconds
Spectrogram
Frequency, Hz
Time, Seconds
Frequency Spectra
SPL, dB re: 1 uPa
Frequency, Hz
Unweighted
LF Cetaceans
MF Cetaceans
HF Cetaceans
Phocid
Otariid

PILE #162

September 25, 2018

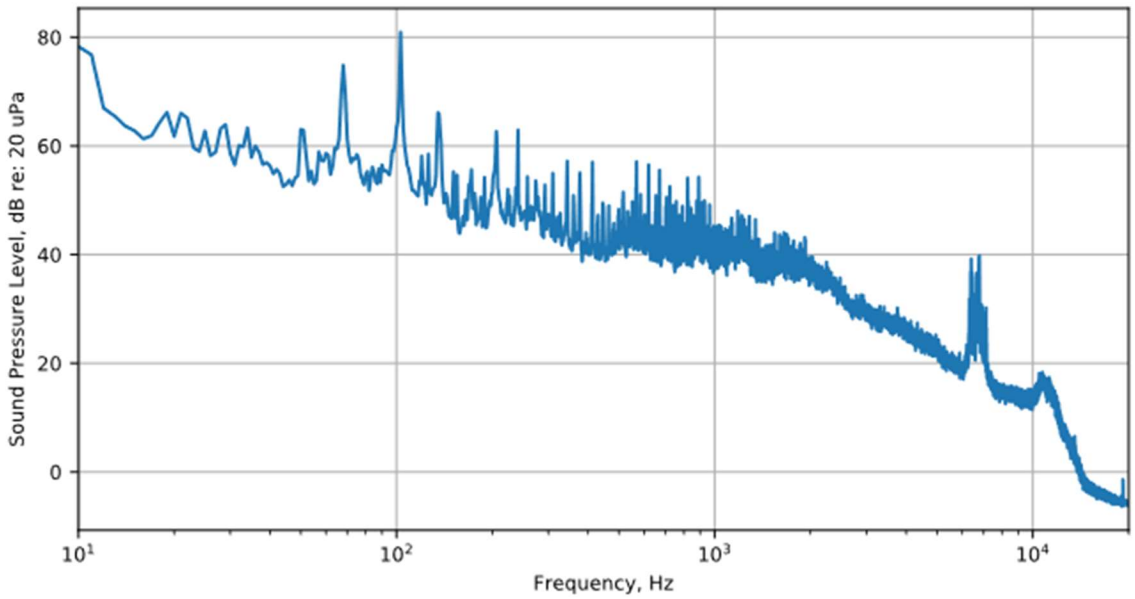
Hydrophone and Pile Information, Feet

Hydro Depth (upper/lower)	Distance			Water Depth	
	Between Hydros	Hydros to Pile	Pile to Water's Edge	Hydros	Pile
6/10	102	203/305	4	10/20	2

Airborne Sound Levels, dB re: 20 µPa

Median	Maximum	Minimum
99	103	95

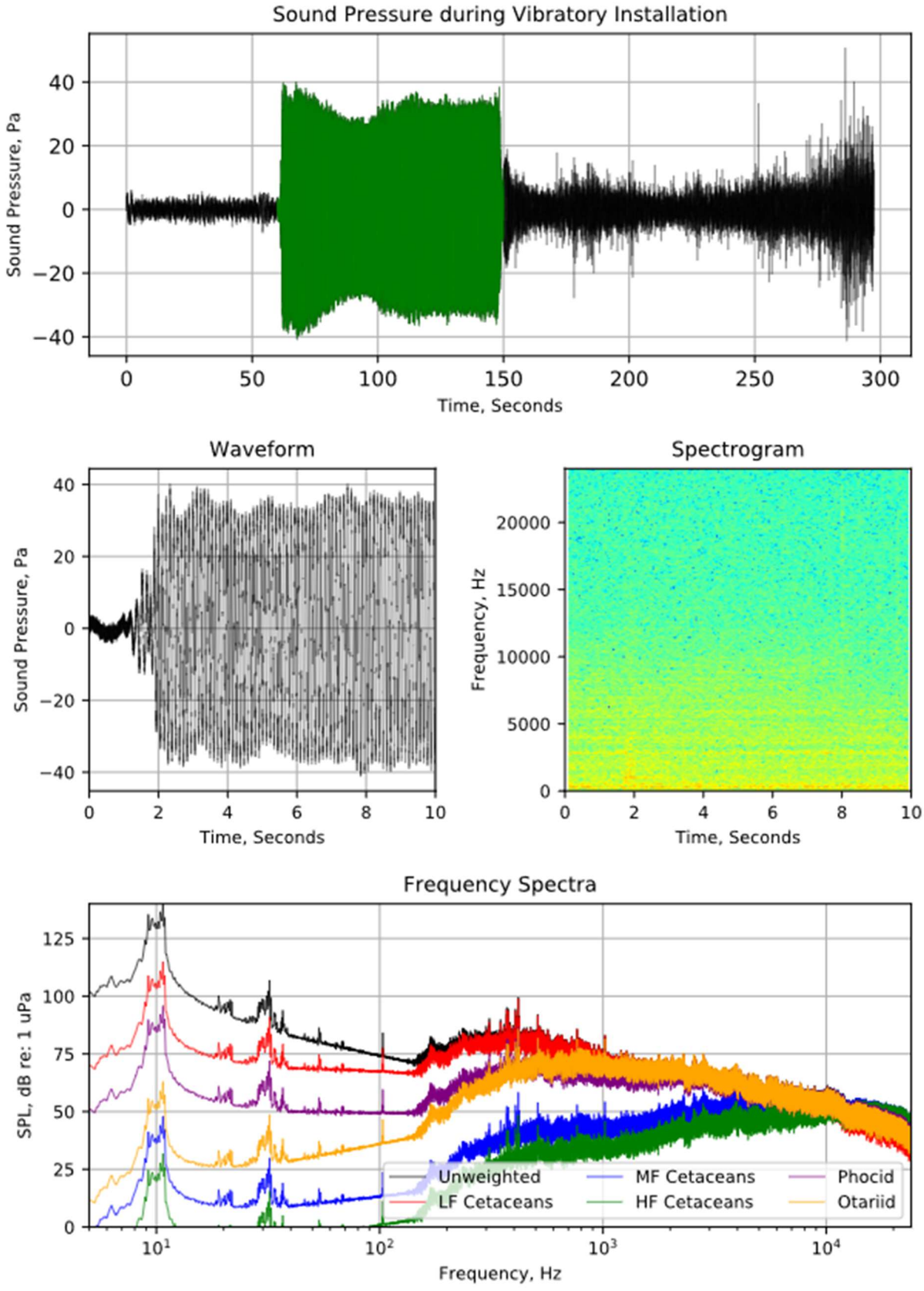
Airborne Frequency Spectra



Underwater Sound Levels, dB re: 1 µPa

Frequency Range	Peak					RMS_{90}					SEL					cSEL
	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	
Upper Hydrophone																
Unweighted	161	164	0.8	163	163	157	159	0.7	158	158	167	169	0.7	168	168	177
LF Cetacean	161	164	0.8	163	163	137	138	0.7	138	138	147	148	0.7	148	148	157
MF Cetacean	161	164	0.8	163	163	151	153	0.7	152	152	161	163	0.7	162	162	171
HF Cetacean	161	164	0.8	163	163	151	153	0.7	152	153	161	163	0.7	162	163	172
PW	161	164	0.8	163	163	141	143	0.7	142	142	151	153	0.7	152	152	162
OW	161	164	0.8	163	163	138	140	0.7	139	140	148	150	0.7	149	150	159
Lower Hydrophone																
Unweighted	157	163	1.8	160	159	148	155	2.4	152	150	158	165	2.4	162	160	171
LF Cetacean	157	163	1.8	160	159	133	138	1.7	135	135	143	148	1.7	145	145	155
MF Cetacean	157	163	1.8	160	159	142	149	2.4	146	144	152	159	2.4	156	154	165
HF Cetacean	157	163	1.8	160	159	143	150	2.4	146	144	153	160	2.4	156	154	166
PW	157	163	1.8	160	159	134	140	2	136	135	144	150	2	146	145	156
OW	157	163	1.8	160	159	132	137	1.8	134	134	142	147	1.8	144	144	154

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


Sound Pressure during Vibratory Installation
Sound Pressure, Pa
Time, Seconds
Waveform
Sound Pressure, Pa
Time, Seconds
Spectrogram
Frequency, Hz
Time, Seconds
Frequency Spectra
SPL, dB re: 1 uPa
Frequency, Hz
Unweighted
LF Cetaceans
MF Cetaceans
HF Cetaceans
Phocid
Otariid

PILE #149

September 25, 2018

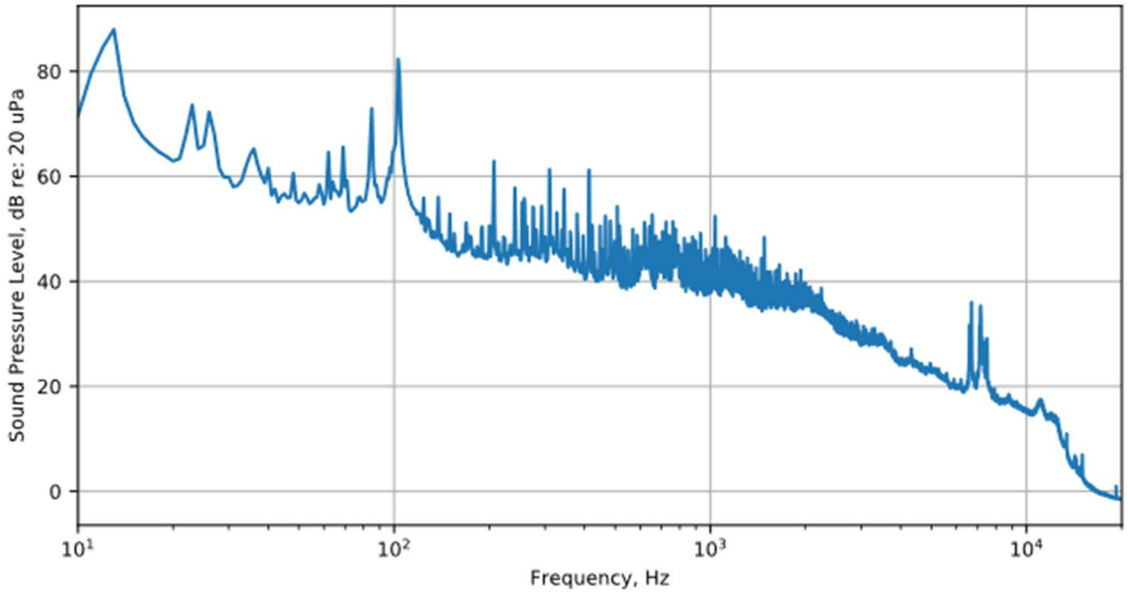
Hydrophone and Pile Information, Feet

Hydro Depth (upper/lower)	Distance			Water Depth	
	Between Hydros	Hydros to Pile	Pile to Water's Edge	Hydros	Pile
6/10	104	162/266	16	10/20	4

Airborne Sound Levels, dB re: 20 µPa

Median	Maximum	Minimum
103	105	100

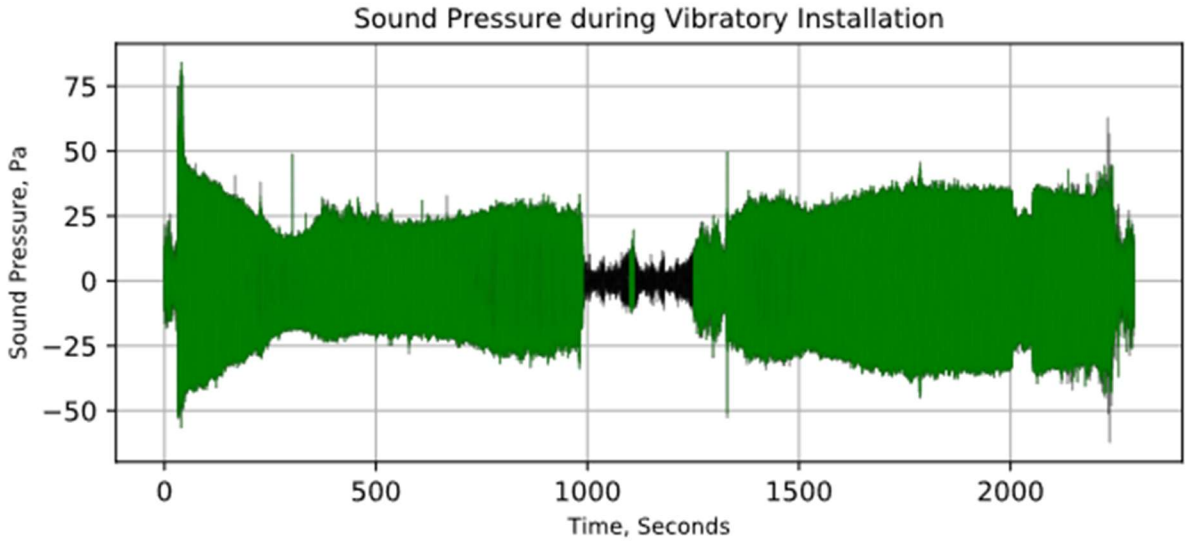
Airborne Frequency Spectra

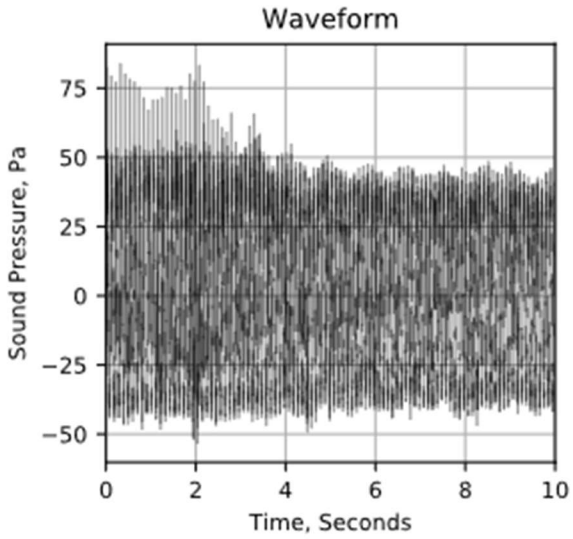


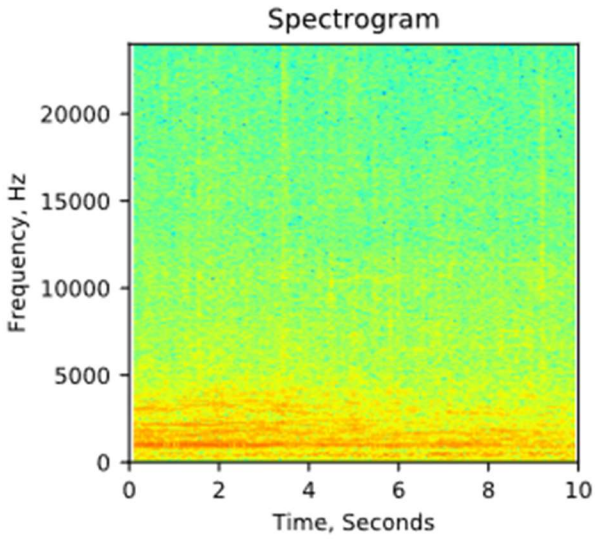
Underwater Sound Levels, dB re: 1 µPa

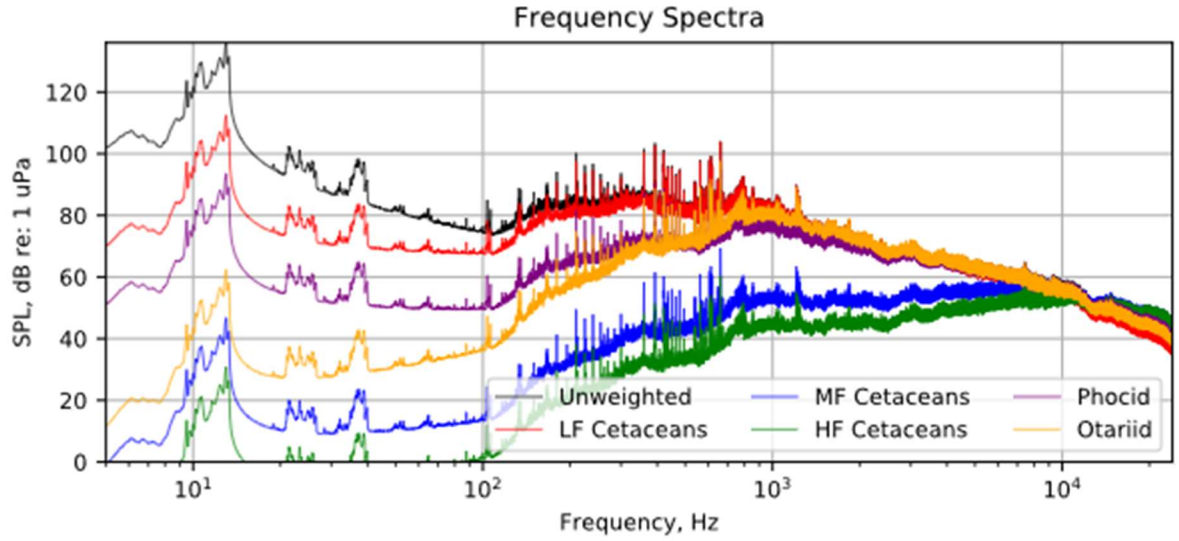
Frequency Range	Peak					RMS_{90}					SEL					cSEL
	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	
Upper Hydrophone																
Unweighted	155	169	2.1	161	161	134	159	4.5	155	154	144	169	4.5	165	164	188
LF Cetacean	155	169	2.1	161	161	128	141	2.2	136	136	138	151	2.2	146	146	169
MF Cetacean	155	169	2.1	161	161	131	153	4.1	148	148	141	163	4.1	158	158	181
HF Cetacean	155	169	2.1	161	161	131	154	4.2	149	149	141	164	4.2	159	159	182
PW	155	169	2.1	161	161	127	144	2.9	139	138	137	154	2.9	149	148	172
OW	155	169	2.1	161	161	125	142	2.4	136	136	135	152	2.4	146	146	170
Lower Hydrophone																
Unweighted	155	168	2.3	163	163	140	158	3.8	156	157	150	168	3.8	166	167	189
LF Cetacean	155	168	2.3	163	163	131	145	2.7	139	138	141	155	2.7	149	148	172
MF Cetacean	155	168	2.3	163	163	135	152	3.7	150	151	145	162	3.7	160	161	183
HF Cetacean	155	168	2.3	163	163	135	152	3.7	150	151	145	162	3.7	160	161	183
PW	155	168	2.3	163	163	132	143	2.8	140	141	142	153	2.8	150	151	173
OW	155	168	2.3	163	163	131	141	2.5	138	138	141	151	2.5	148	148	171

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


Sound Pressure during Vibratory Installation
Sound Pressure, Pa
75
50
25
0
−25
−50
0
500
1000
1500
2000
Time, Seconds


Waveform
Sound Pressure, Pa
75
50
25
0
−25
−50
0
2
4
6
8
10
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
120
100
80
60
40
20
0
10^1
10^2
10^3
10^4
Frequency, Hz
Unweighted
LF Cetaceans
MF Cetaceans
HF Cetaceans
Phocid
Otariid

PILE #151

September 25, 2018

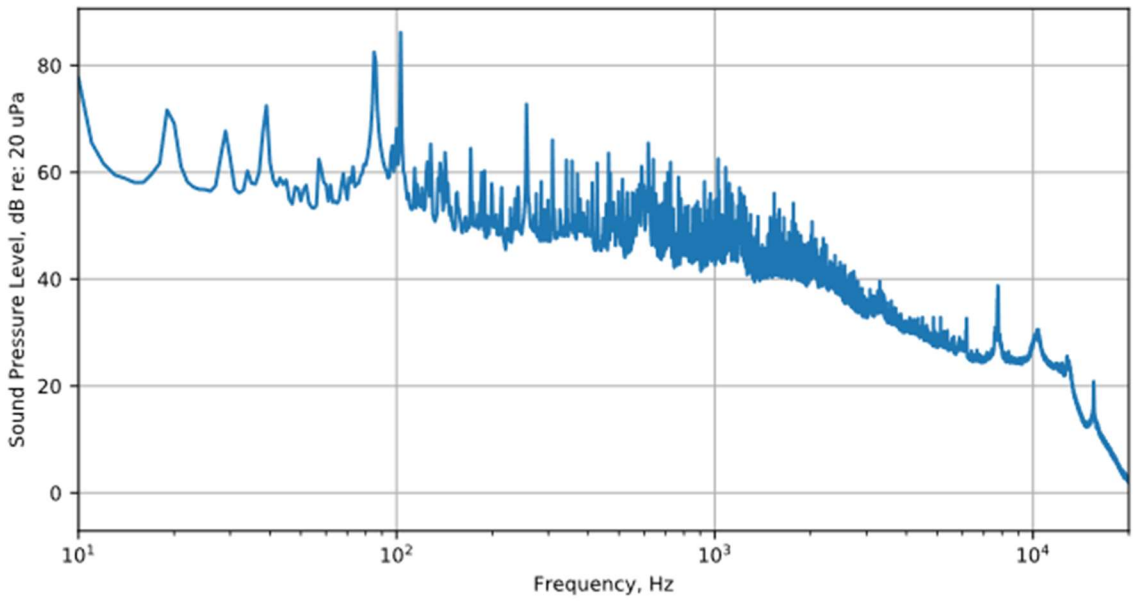
Hydrophone and Pile Information, Feet

Hydro Depth (upper/lower)	Distance			Water Depth	
	Between Hydros	Hydros to Pile	Pile to Water's Edge	Hydros	Pile
3/12	9	49	23	15	2

Airborne Sound Levels, dB re: 20 µPa

Median	Maximum	Minimum
93	97	87

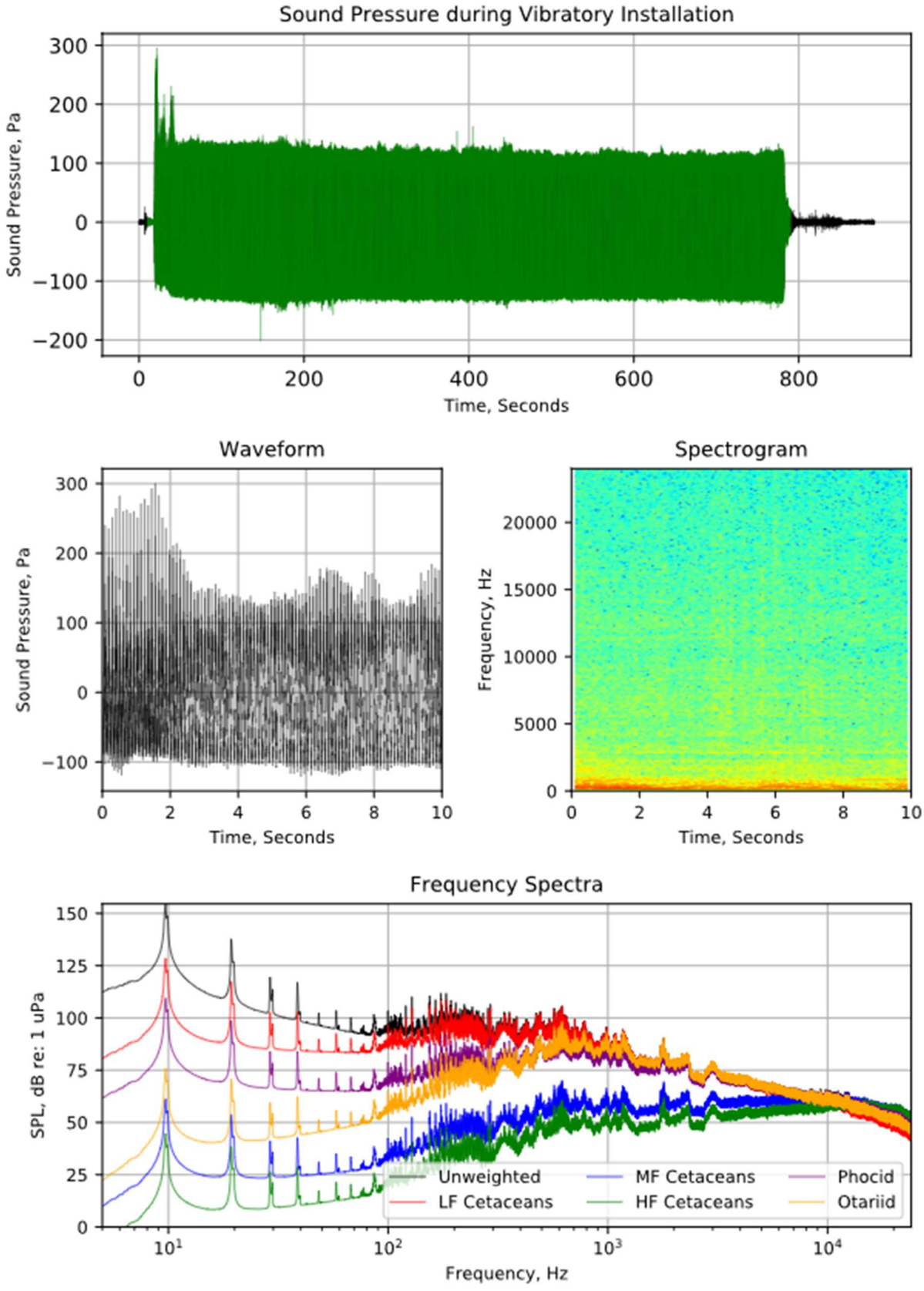
Airborne Frequency Spectra



Underwater Sound Levels, dB re: 1 µPa

Frequency Range	Peak					RMS_{90}					SEL					cSEL
	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	
Upper Hydrophone																
Unweighted	164	172	1.4	166	165	148	161	1.6	160	160	158	171	1.6	170	170	189
LF Cetacean	164	172	1.4	166	165	133	143	1.2	141	140	143	153	1.2	151	150	169
MF Cetacean	164	172	1.4	166	165	142	155	1.6	154	154	152	165	1.6	164	164	183
HF Cetacean	164	172	1.4	166	165	143	155	1.6	155	155	153	165	1.6	165	165	184
PW	164	172	1.4	166	165	133	145	1.5	144	144	143	155	1.5	154	154	173
OW	164	172	1.4	166	165	130	142	1.5	142	142	140	152	1.5	152	152	171
Lower Hydrophone																
Unweighted	155	169	2.4	159	157	140	151	1.4	150	150	150	161	1.4	160	160	179
LF Cetacean	155	169	2.4	159	157	128	141	1.3	133	132	138	151	1.3	143	142	162
MF Cetacean	155	169	2.4	159	157	134	145	1.4	144	144	144	155	1.4	154	154	173
HF Cetacean	155	169	2.4	159	157	134	146	1.4	145	145	144	156	1.4	155	155	174
PW	155	169	2.4	159	157	126	137	1.2	135	135	136	147	1.2	145	145	164
OW	155	169	2.4	159	157	123	134	1.2	132	132	133	144	1.2	142	142	161

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


Sound Pressure during Vibratory Installation
Sound Pressure, Pa
Time, Seconds
Waveform
Sound Pressure, Pa
Time, Seconds
Spectrogram
Frequency, Hz
Time, Seconds
Frequency Spectra
SPL, dB re: 1 uPa
Frequency, Hz
Unweighted
LF Cetaceans
MF Cetaceans
HF Cetaceans
Phocid
Otariid

PILE #164

September 25, 2018

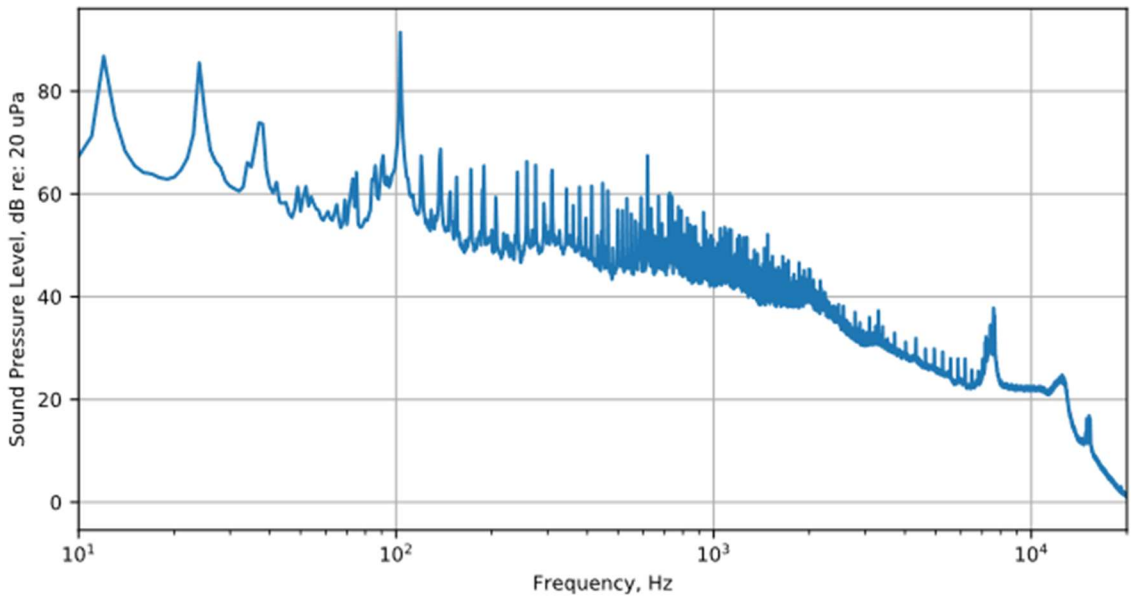
Hydrophone and Pile Information, Feet

Hydro Depth (upper/lower)	Distance			Water Depth	
	Between Hydros	Hydros to Pile	Pile to Water's Edge	Hydros	Pile
3/12	9	92	4	15	2

Airborne Sound Levels, dB re: 20 µPa

Median	Maximum	Minimum
101	102	96

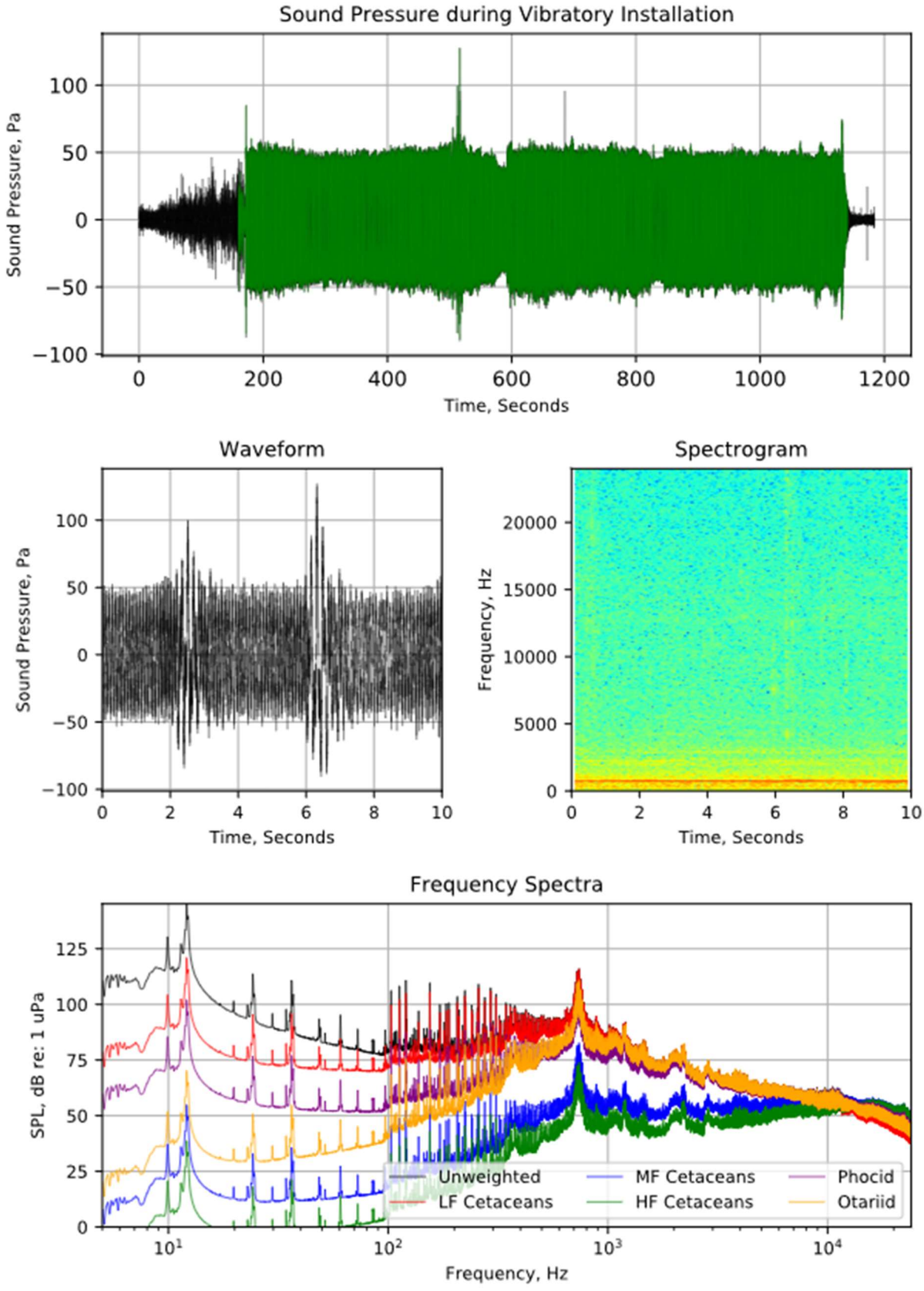
Airborne Frequency Spectra



Underwater Sound Levels, dB re: 1 µPa

Frequency Range	Peak					RMS_{90}					SEL					cSEL
	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	
Upper Hydrophone																
Unweighted	159	169	1.2	162	161	135	156	2	155	155	145	166	2	165	165	185
LF Cetacean	159	169	1.2	162	161	129	141	1.5	139	139	139	151	1.5	149	149	169
MF Cetacean	159	169	1.2	162	161	131	150	1.8	148	148	141	160	1.8	158	158	178
HF Cetacean	159	169	1.2	162	161	131	150	1.9	149	149	141	160	1.9	159	159	179
PW	159	169	1.2	162	161	129	141	1.1	139	139	139	151	1.1	149	149	169
OW	159	169	1.2	162	161	129	139	1.1	138	138	139	149	1.1	148	148	168
Lower Hydrophone																
Unweighted	152	162	1.2	156	155	134	148	1.5	147	147	144	158	1.5	157	157	177
LF Cetacean	152	162	1.2	156	155	125	137	2	133	133	135	147	2	143	143	163
MF Cetacean	152	162	1.2	156	155	130	142	1.2	141	141	140	152	1.2	151	151	171
HF Cetacean	152	162	1.2	156	155	130	143	1.3	142	142	140	153	1.3	152	152	172
PW	152	162	1.2	156	155	128	135	1.1	133	133	138	145	1.1	143	143	163
OW	152	162	1.2	156	155	126	135	1.4	132	132	136	145	1.4	142	142	162

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


Sound Pressure during Vibratory Installation
Sound Pressure, Pa
Time, Seconds
Waveform
Sound Pressure, Pa
Time, Seconds
Spectrogram
Frequency, Hz
Time, Seconds
Frequency Spectra
SPL, dB re: 1 uPa
Frequency, Hz
Unweighted
LF Cetaceans
MF Cetaceans
HF Cetaceans
Phocid
Otariid

PILE #163

September 25, 2018

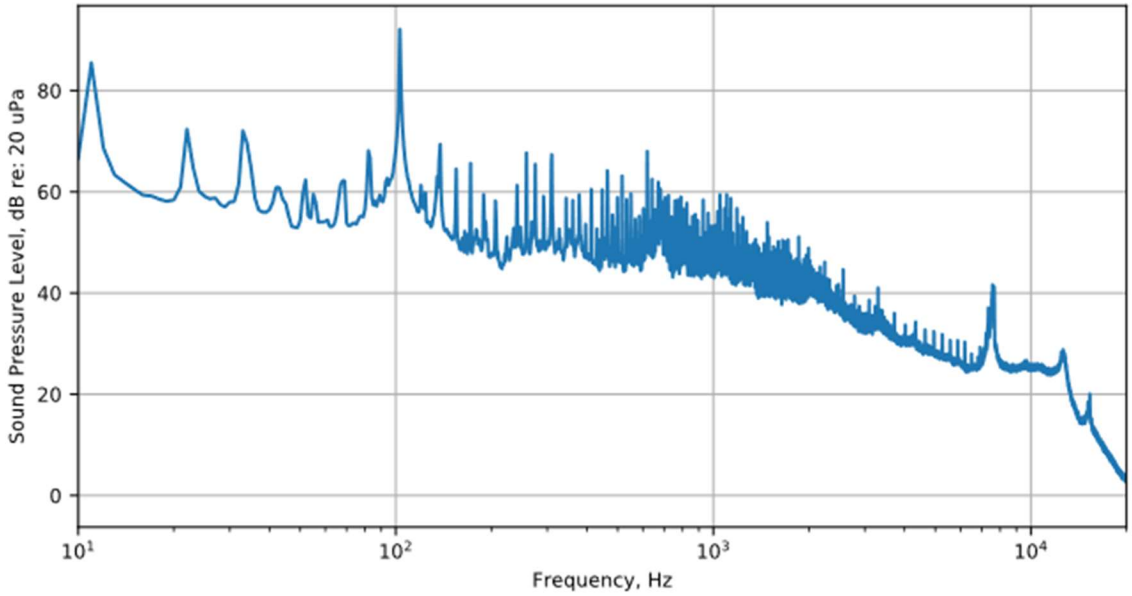
Hydrophone and Pile Information, Feet

Hydro Depth (upper/lower)	Distance			Water Depth	
	Between Hydros	Hydros to Pile	Pile to Water's Edge	Hydros	Pile
3/12	9	75	4	15	2

Airborne Sound Levels, dB re: 20 µPa

Median	Maximum	Minimum
100	102	92

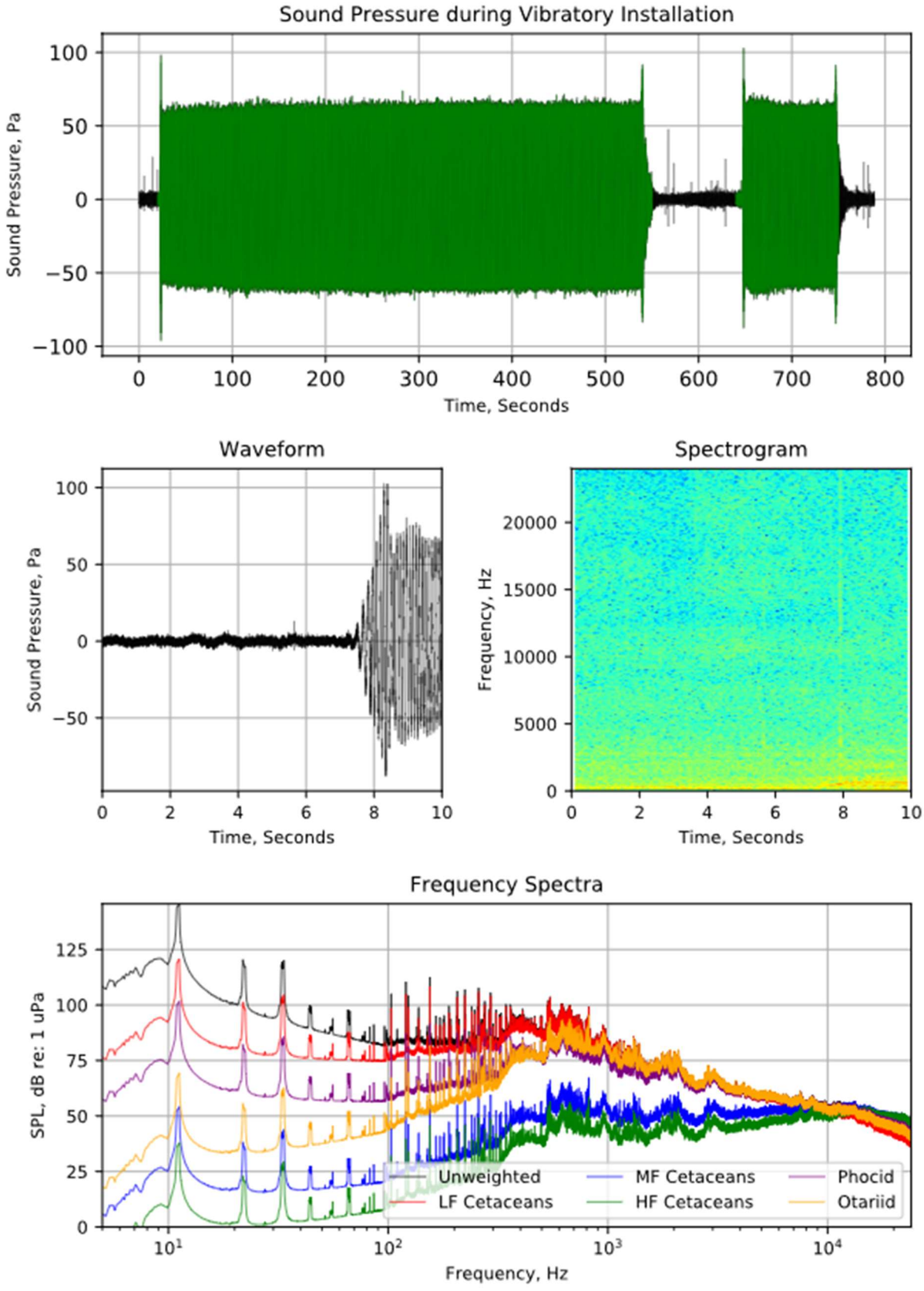
Airborne Frequency Spectra



Underwater Sound Levels, dB re: 1 µPa

Frequency Range	Peak					RMS_{90}					SEL					cSEL
	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	
Upper Hydrophone																
Unweighted	162	166	0.8	162	162	150	157	1.1	156	157	160	167	1.1	166	167	184
LF Cetacean	162	166	0.8	162	162	130	138	1.1	137	137	140	148	1.1	147	147	165
MF Cetacean	162	166	0.8	162	162	145	151	1	150	150	155	161	1	160	160	178
HF Cetacean	162	166	0.8	162	162	145	152	1	151	151	155	162	1	161	161	179
PW	162	166	0.8	162	162	135	141	1	141	141	145	151	1	151	151	169
OW	162	166	0.8	162	162	133	139	1	138	138	143	149	1	148	148	166
Lower Hydrophone																
Unweighted	153	156	0.6	155	155	139	148	1.3	147	147	149	158	1.3	157	157	175
LF Cetacean	153	156	0.6	155	155	123	130	1.2	129	129	133	140	1.2	139	139	157
MF Cetacean	153	156	0.6	155	155	134	142	1.2	141	141	144	152	1.2	151	151	169
HF Cetacean	153	156	0.6	155	155	134	142	1.2	142	142	144	152	1.2	152	152	170
PW	153	156	0.6	155	155	125	132	1.2	132	132	135	142	1.2	142	142	160
OW	153	156	0.6	155	155	122	130	1.1	129	130	132	140	1.1	139	140	157

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


Sound Pressure during Vibratory Installation
Sound Pressure, Pa
Time, Seconds
Waveform
Sound Pressure, Pa
Time, Seconds
Spectrogram
Frequency, Hz
Time, Seconds
Frequency Spectra
SPL, dB re: 1 uPa
Frequency, Hz
Unweighted
LF Cetaceans
MF Cetaceans
HF Cetaceans
Phocid
Otariid

PILE #152

September 25, 2018

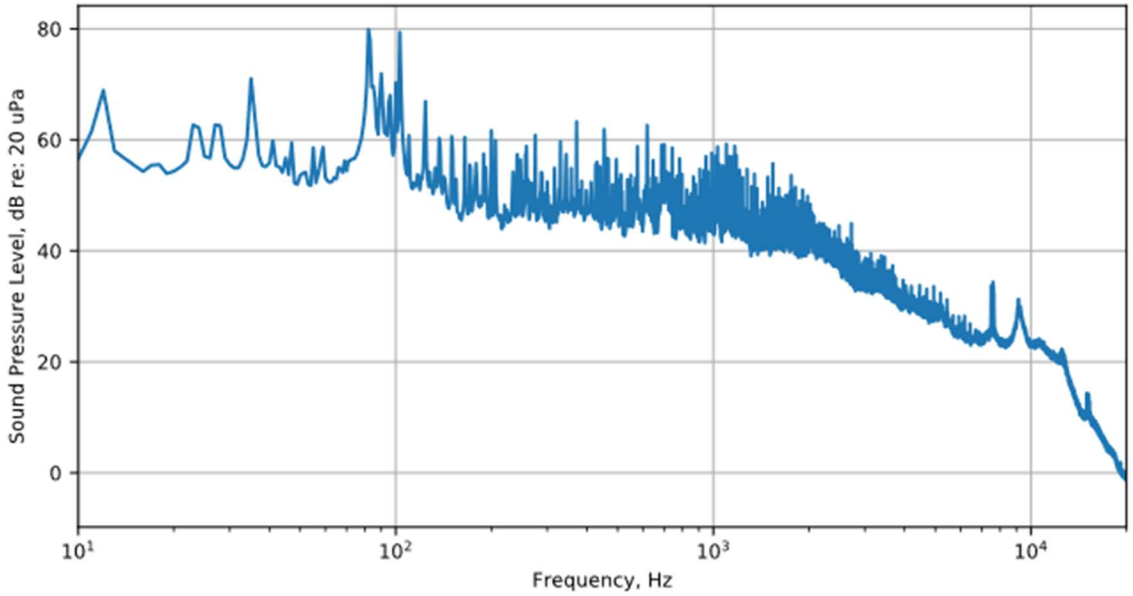
Hydrophone and Pile Hydrophone and Pile Information, Feet

Hydro Depth (upper/lower)	Distance			Water Depth	
	Between Hydros	Hydros to Pile	Pile to Water's Edge	Hydros	Pile
3/12	9	67	23	15	2

Airborne Sound Levels, dB re: 20 µPa

Median	Maximum	Minimum
92	101	89

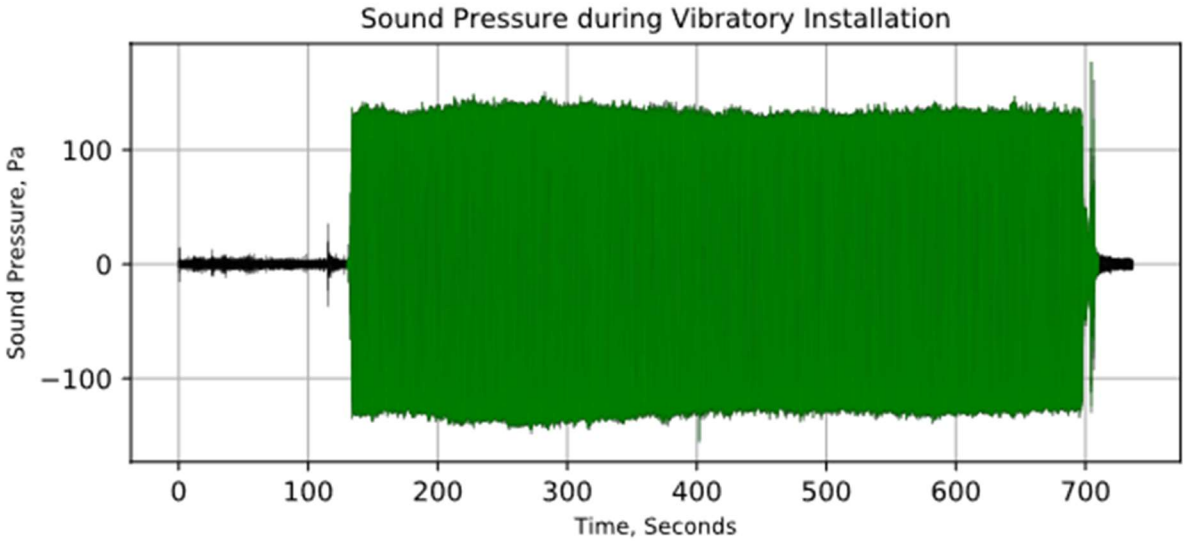
Airborne Frequency Spectra

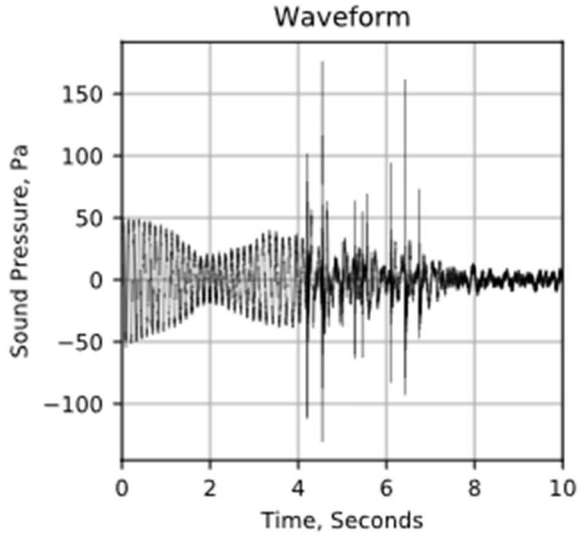


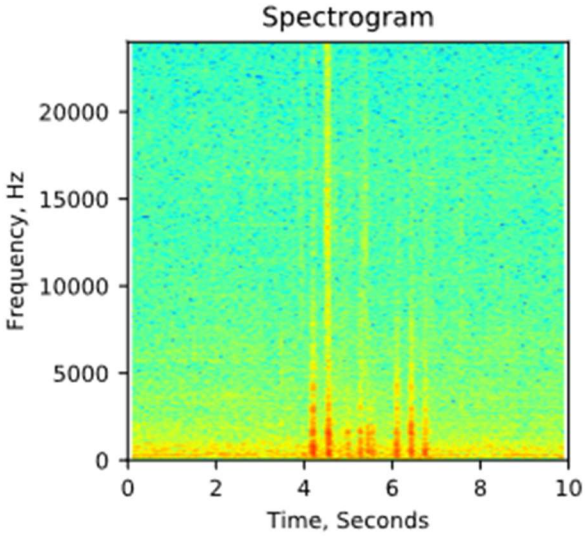
Underwater Sound Levels, dB re: 1 µPa

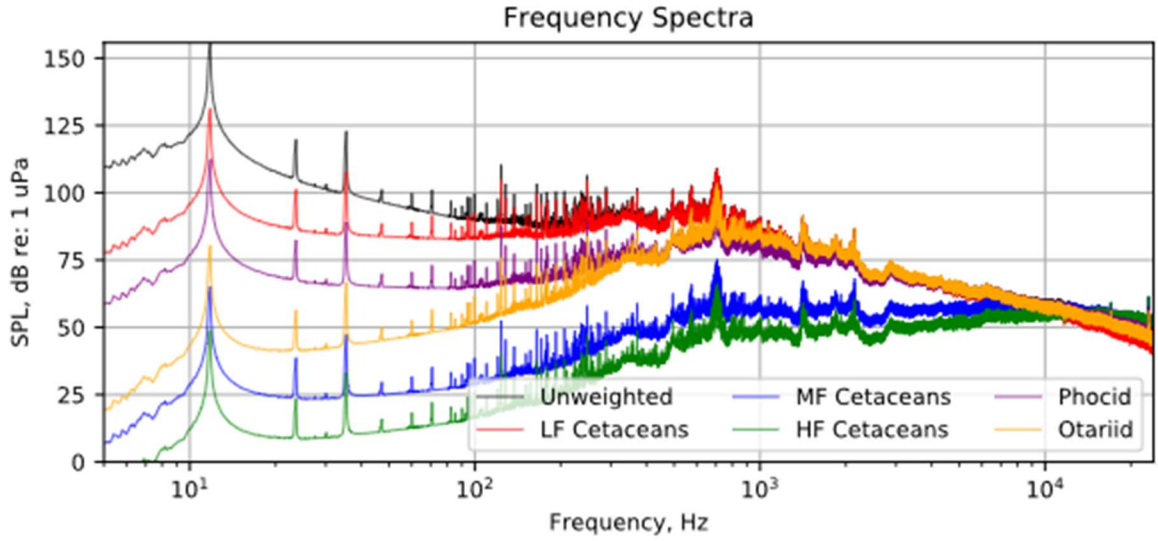
Frequency Range	Peak					RMS_{90}					SEL					cSEL
	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	
Upper Hydrophone																
Unweighted	167	170	0.4	168	168	148	164	2	163	163	158	174	2.0	173	173	191
LF Cetacean	167	170	0.4	168	168	133	144	1.5	143	143	143	154	1.5	153	153	171
MF Cetacean	167	170	0.4	168	168	143	158	1.9	157	157	153	168	1.9	167	167	184
HF Cetacean	167	170	0.4	168	168	144	158	1.9	158	158	154	168	1.9	168	168	185
PW	167	170	0.4	168	168	134	148	1.8	147	147	144	158	1.8	157	157	175
OW	167	170	0.4	168	168	133	145	1.6	145	145	143	155	1.6	155	155	172
Lower Hydrophone																
Unweighted	159	166	1	160	159	141	155	1.7	154	154	151	165	1.7	164	164	181
LF Cetacean	159	166	1	160	159	128	137	1.1	135	135	138	147	1.1	145	145	163
MF Cetacean	159	166	1	160	159	136	148	1.6	148	148	146	158	1.6	158	158	175
HF Cetacean	159	166	1	160	159	137	149	1.6	148	148	147	159	1.6	158	158	176
PW	159	166	1	160	159	128	139	1.4	138	138	138	149	1.4	148	148	166
OW	159	166	1	160	159	127	136	1.2	136	136	137	146	1.2	146	146	163

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


Sound Pressure during Vibratory Installation
Sound Pressure, Pa
100
0
−100
0
100
200
300
400
500
600
700
Time, Seconds


Waveform
Sound Pressure, Pa
150
100
50
0
−50
−100
0
2
4
6
8
10
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
125
100
75
50
25
0
10^1
10^2
10^3
10^4
Frequency, Hz
Unweighted
LF Cetaceans
MF Cetaceans
HF Cetaceans
Phocid
Otariid

4.0 STEEL PILES INSTALLED WITH DIESEL IMPACT HAMMER

PILE #19

September 13, 2018

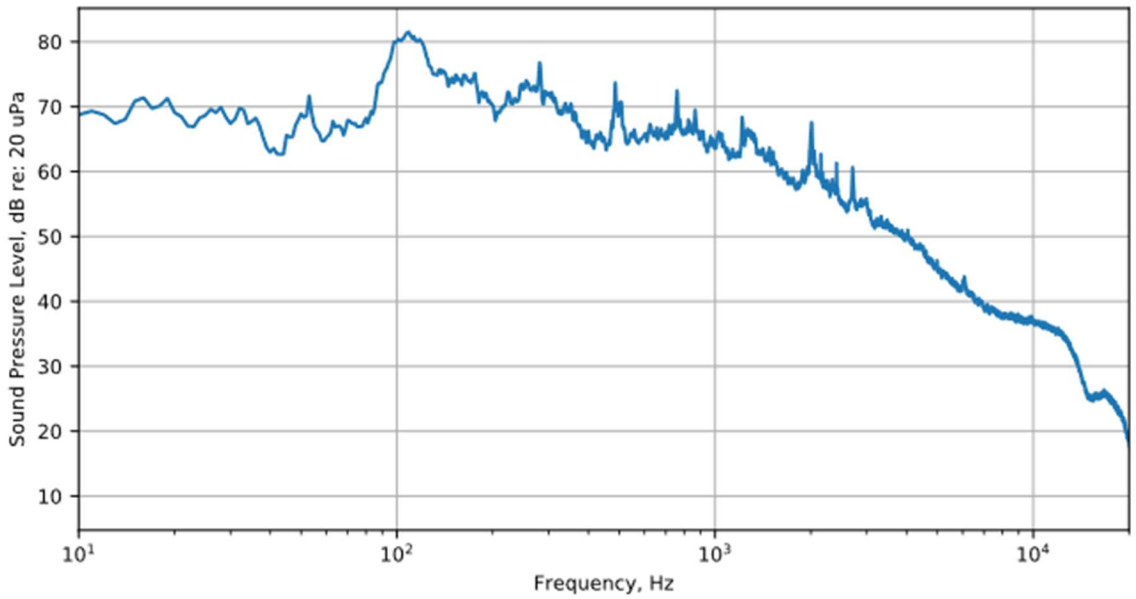
Hydrophone and Pile Hydrophone and Pile Information, Feet

Hydro Depth (upper/lower)	Distance			Water Depth	
	Between Hydros	Hydros to Pile	Pile to Water's Edge	Hydros	Pile
3/43	40	33	193	46	32

Airborne Sound Levels, dB re: 20 µPa

Median	Maximum	Minimum
102	104	88

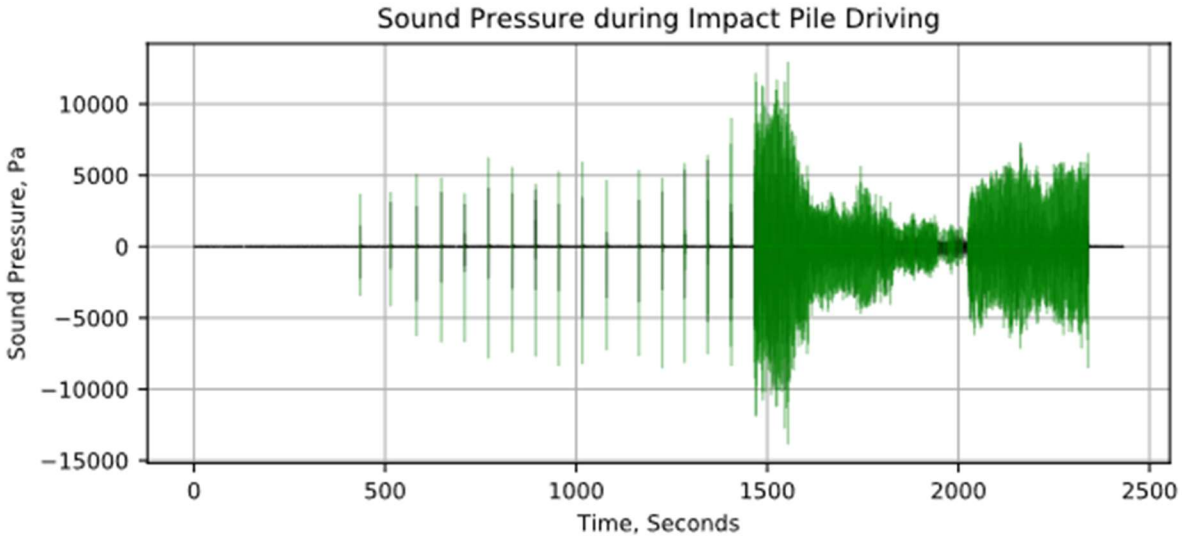
Airborne Frequency Spectra

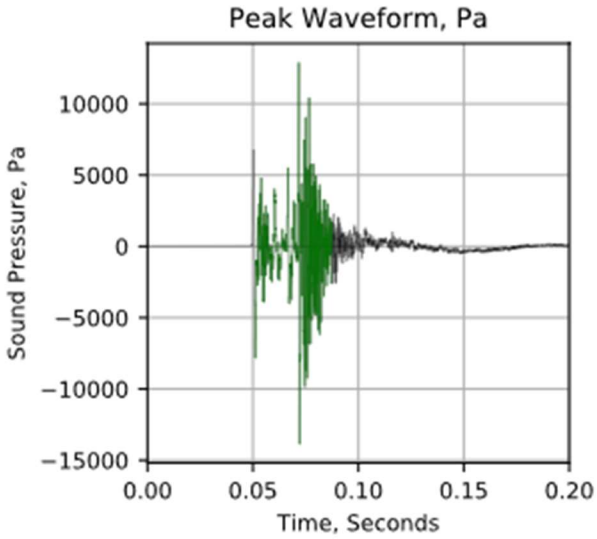


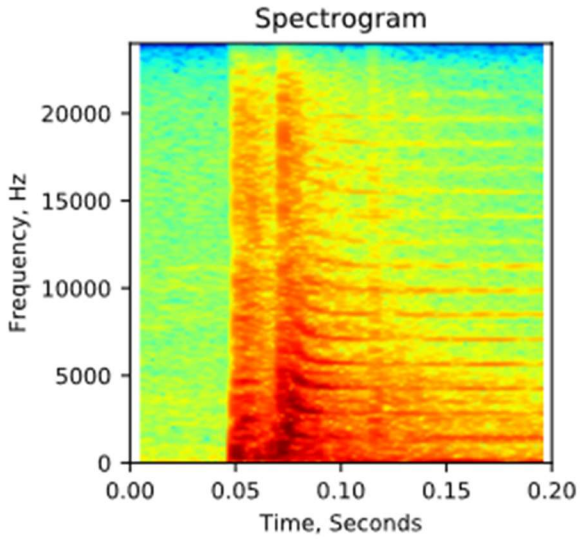
Underwater Sound Levels, dB re: 1 µPa

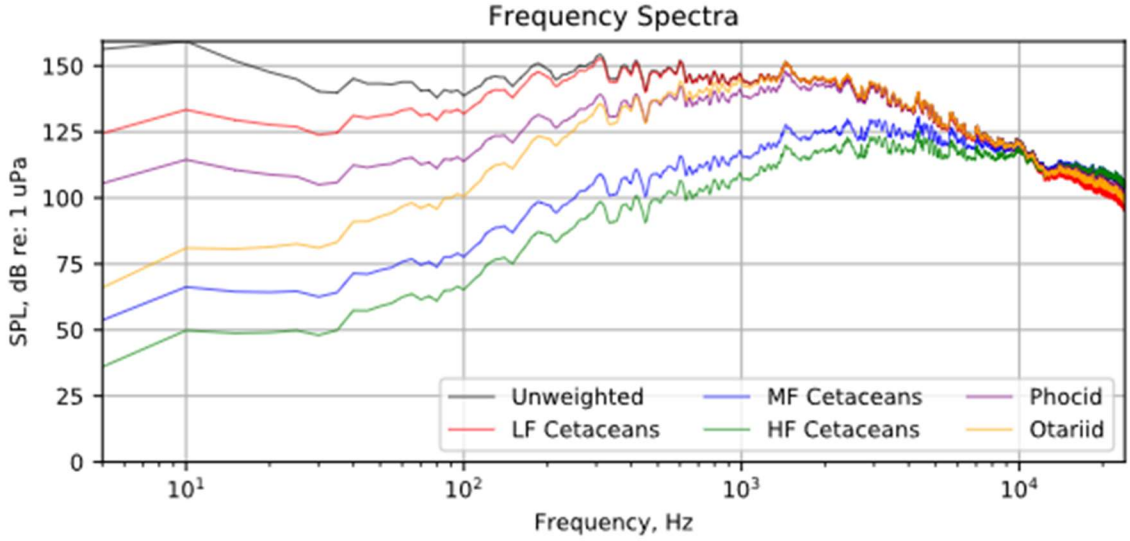
Frequency Range	Peak					RMS_{90}					SEL					cSEL
	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	
Upper Hydrophone																
Unweighted	180	202	5.1	193	191	164	189	5.8	180	177	154	175	4.4	167	164	195
LF Cetacean	180	202	5.1	193	191	159	184	5.0	176	174	147	170	4.7	161	159	190
MF Cetacean	180	202	5.1	193	191	158	184	5.8	175	171	150	169	4.3	161	159	190
HF Cetacean	180	202	5.1	193	191	159	184	5.8	175	171	150	170	4.3	162	159	190
PW	180	202	5.1	193	191	157	183	5.1	174	172	146	168	4.6	160	157	188
OW	180	202	5.1	193	191	160	184	4.8	176	174	147	169	4.5	161	159	189
Lower Hydrophone																
Unweighted	169	192	4.1	185	184	158	181	4.4	174	173	146	167	3.8	160	158	188
LF Cetacean	169	192	4.1	185	184	153	176	4.0	169	168	140	161	3.8	154	153	182
MF Cetacean	169	192	4.1	185	184	152	175	4.4	168	167	140	161	3.7	154	152	182
HF Cetacean	169	192	4.1	185	184	153	176	4.4	169	167	141	161	3.8	154	153	182
PW	169	192	4.1	185	184	151	173	3.9	167	166	137	158	3.8	152	151	180
OW	169	192	4.1	185	184	153	175	3.9	168	168	138	160	3.8	153	153	182

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


Sound Pressure during Impact 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
Unweighted
LF Cetaceans
MF Cetaceans
HF Cetaceans
Phocid
Otariid

PILE #47

September 13, 2018

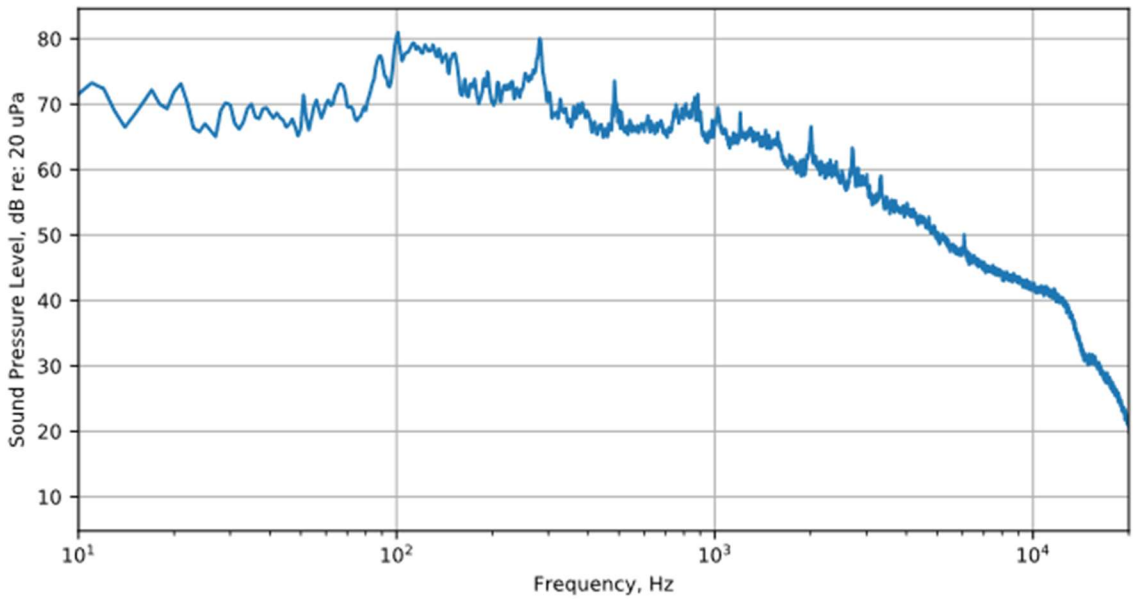
Hydrophone and Pile Hydrophone and Pile Information, Feet

Hydro Depth (upper/lower)	Distance			Water Depth	
	Between Hydros	Hydros to Pile	Pile to Water's Edge	Hydros	Pile
3/28	25	33	144	32	24

Airborne Sound Levels, dB re: 20 µPa

Median	Maximum	Minimum
102	105	88

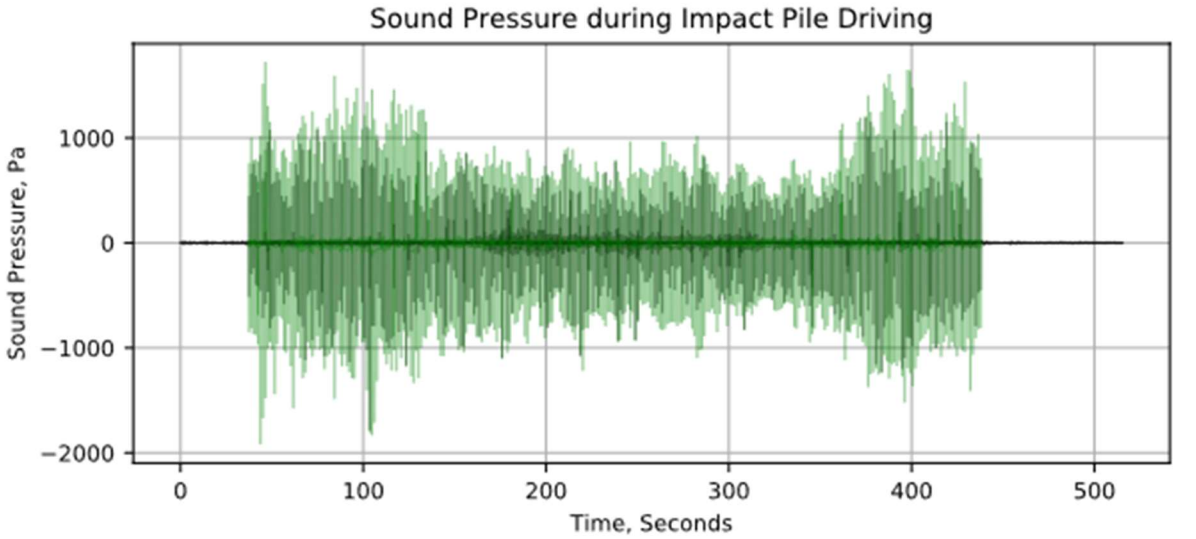
Airborne Frequency Spectra

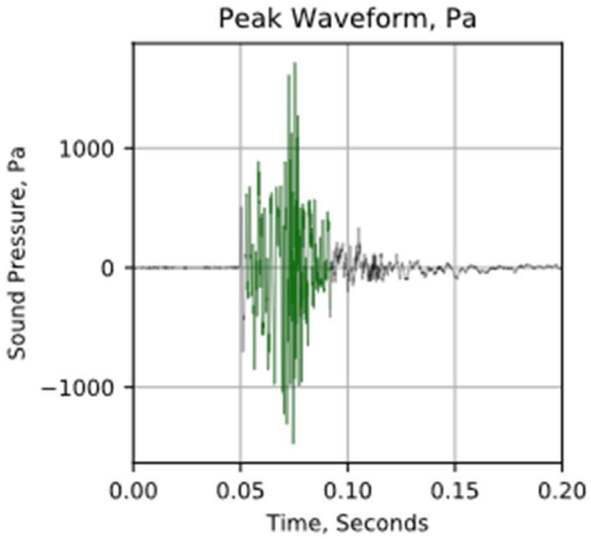


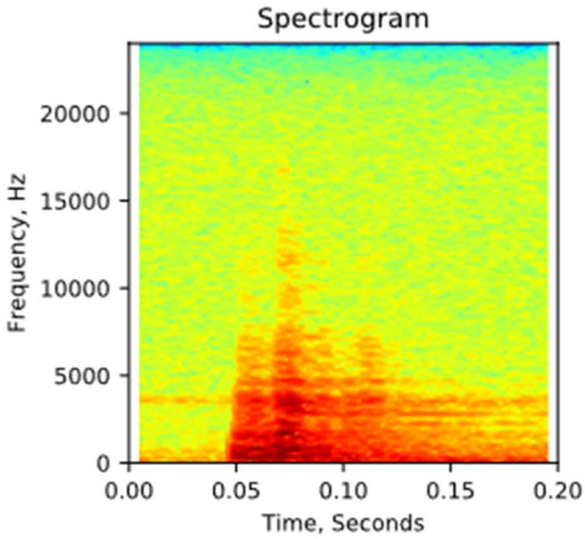
Underwater Sound Levels, dB re: 1 µPa

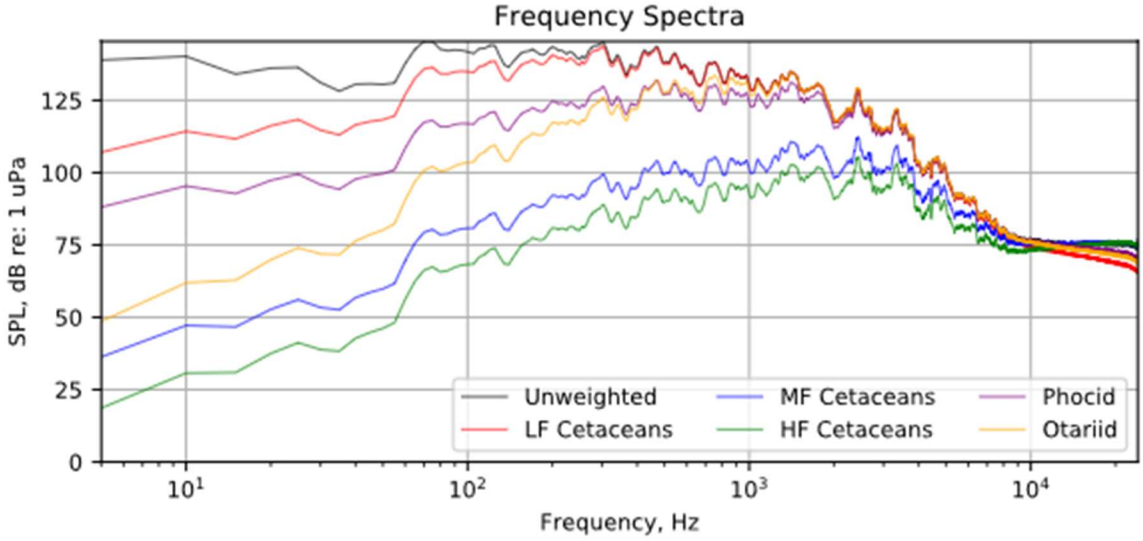
Frequency Range	Peak					RMS_{90}					SEL					cSEL
	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	
Upper Hydrophone																
Unweighted	184	194	2.0	187	186	169	192	4.7	179	172	161	183	4.3	169	164	193
LF Cetacean	184	194	2.0	187	186	163	179	3.5	170	167	153	170	3.7	159	155	183
MF Cetacean	184	194	2.0	187	186	163	186	4.6	173	166	154	176	4.3	163	157	187
HF Cetacean	184	194	2.0	187	186	164	186	4.6	173	167	155	177	4.3	163	158	188
PW	184	194	2.0	187	186	159	177	4.3	166	161	149	168	4.0	156	152	181
OW	184	194	2.0	187	186	159	175	4.4	168	164	149	166	3.8	156	152	180
Lower Hydrophone																
Unweighted	172	184	2.7	179	178	163	173	2.2	168	167	151	159	2.1	155	155	180
LF Cetacean	172	184	2.7	179	178	157	168	2.5	163	162	144	154	2.3	149	148	174
MF Cetacean	172	184	2.7	179	178	157	167	2.3	162	161	145	153	2.1	149	149	174
HF Cetacean	172	184	2.7	179	178	157	168	2.2	163	162	145	154	2.1	150	149	175
PW	172	184	2.7	179	178	152	165	2.9	159	157	139	150	2.6	145	144	170
OW	172	184	2.7	179	178	152	166	3.4	160	158	139	151	2.9	145	144	170

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


Sound Pressure during Impact Pile Driving
Sound Pressure, Pa
1000
0
−1000
−2000
0
100
200
300
400
500
Time, Seconds


Peak Waveform, Pa
Sound Pressure, Pa
1000
0
−1000
0.00
0.05
0.10
0.15
0.20
Time, Seconds


Spectrogram
Frequency, Hz
20000
15000
10000
5000
0
0.00
0.05
0.10
0.15
0.20
Time, Seconds


Frequency Spectra
SPL, dB re: 1 uPa
125
100
75
50
25
0
Unweighted
LF Cetaceans
MF Cetaceans
HF Cetaceans
Phocid
Otariid
10¹
10²
10³
10⁴
Frequency, Hz

PILE #63

September 13, 2018

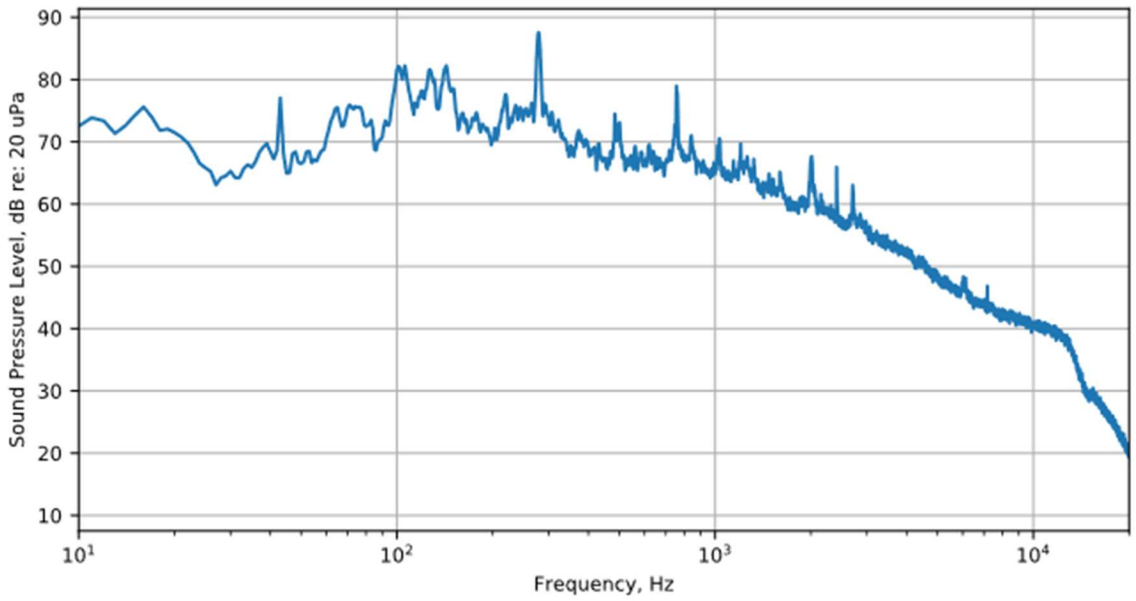
Hydrophone and Pile Hydrophone and Pile Information, Feet

Hydro Depth (upper/lower)	Distance			Water Depth	
	Between Hydros	Hydros to Pile	Pile to Water's Edge	Hydros	Pile
3/25	22	33	117	28	17

Airborne Sound Levels, dB re: 20 µPa

Median	Maximum	Minimum
104	106	89

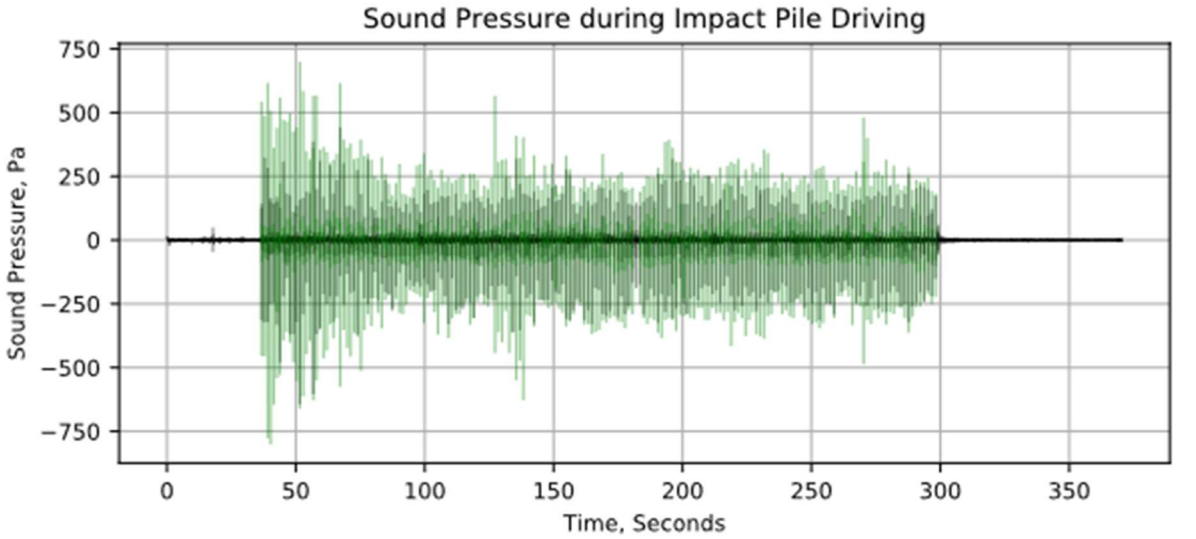
Airborne Frequency Spectra

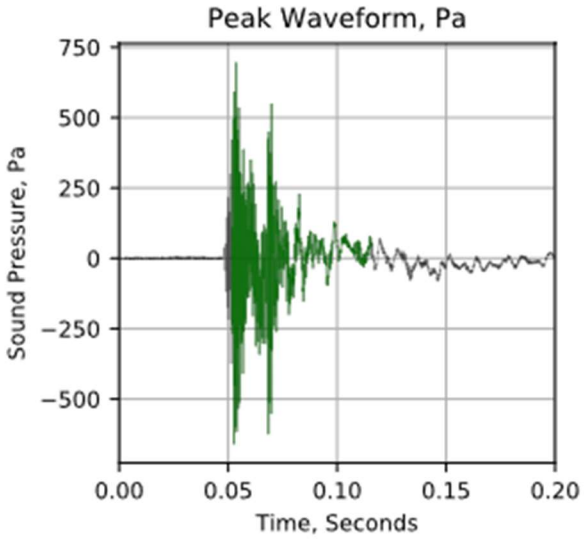


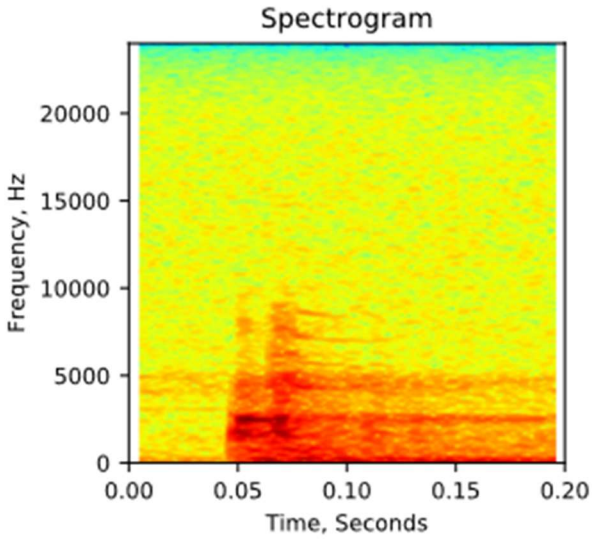
Underwater Sound Levels, dB re: 1 µPa

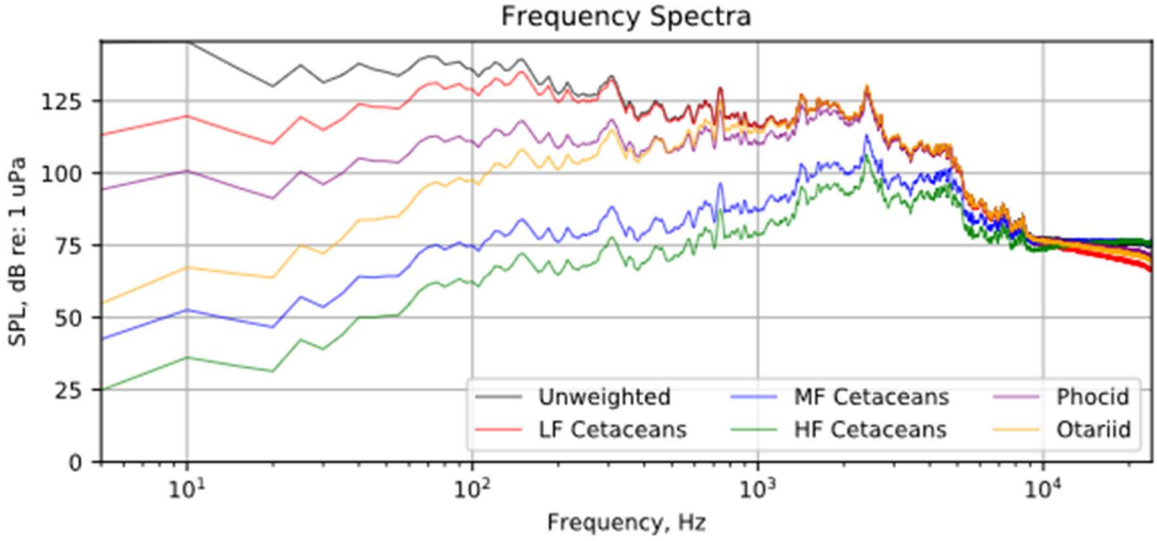
Frequency Range	Peak					RMS_{90}					SEL					cSEL
	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	
Upper Hydrophone																
Unweighted	168	186	3.6	176	175	161	170	1.8	164	164	152	162	2.0	155	154	178
LF Cetacean	168	186	3.6	176	175	148	166	4.1	157	155	140	153	2.7	145	144	168
MF Cetacean	168	186	3.6	176	175	155	165	1.9	159	158	147	157	1.9	150	149	173
HF Cetacean	168	186	3.6	176	175	156	166	1.9	159	158	147	158	1.9	151	150	174
PW	168	186	3.6	176	175	148	162	3.4	155	153	140	153	2.6	145	144	168
OW	168	186	3.6	176	175	147	167	4.9	158	155	138	154	3.1	146	144	168
Lower Hydrophone																
Unweighted	164	177	2.6	169	168	155	163	1.3	158	157	145	151	1.0	148	147	170
LF Cetacean	164	177	2.6	169	168	146	161	2.7	152	150	135	145	1.8	139	139	162
MF Cetacean	164	177	2.6	169	168	149	157	1.6	151	151	140	146	1.0	142	142	165
HF Cetacean	164	177	2.6	169	168	149	157	1.4	152	151	141	146	1.0	142	142	165
PW	164	177	2.6	169	168	142	162	4.3	151	146	133	145	2.6	138	136	160
OW	164	177	2.6	169	168	141	163	5.2	152	147	131	146	3.3	138	136	161

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


Sound Pressure during Impact 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
Unweighted
LF Cetaceans
MF Cetaceans
HF Cetaceans
Phocid
Otariid

PILE #79

September 14, 2018

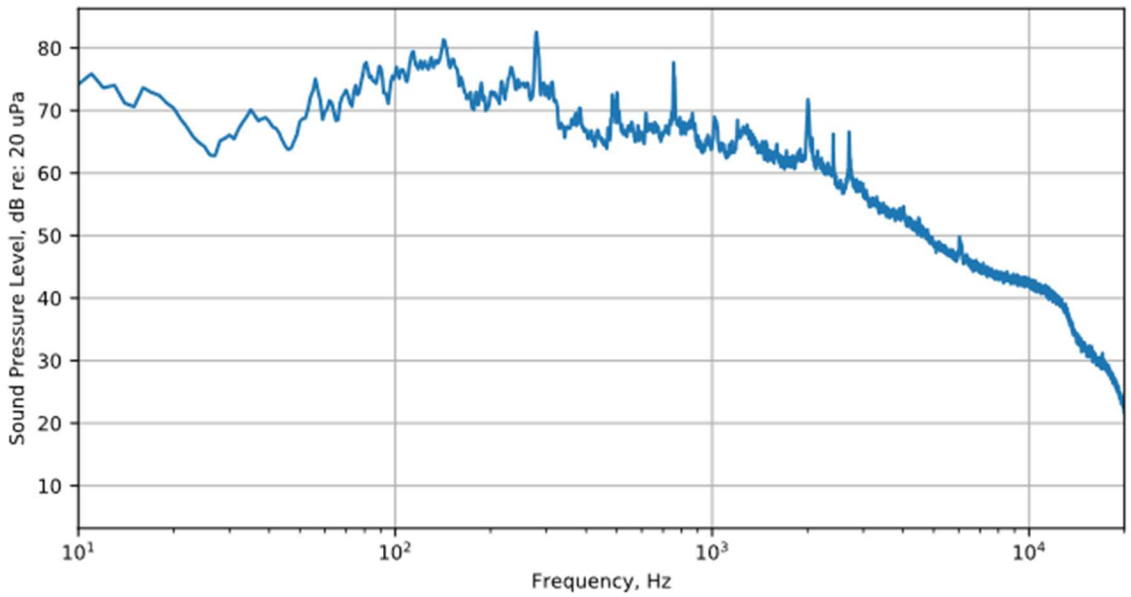
Hydrophone and Pile Hydrophone and Pile Information, Feet

Hydro Depth (upper/lower)	Distance			Water Depth	
	Between Hydros	Hydros to Pile	Pile to Water's Edge	Hydros	Pile
3/20	17	33	91	23	13

Airborne Sound Levels, dB re: 20 µPa

Median	Maximum	Minimum
103	105	88

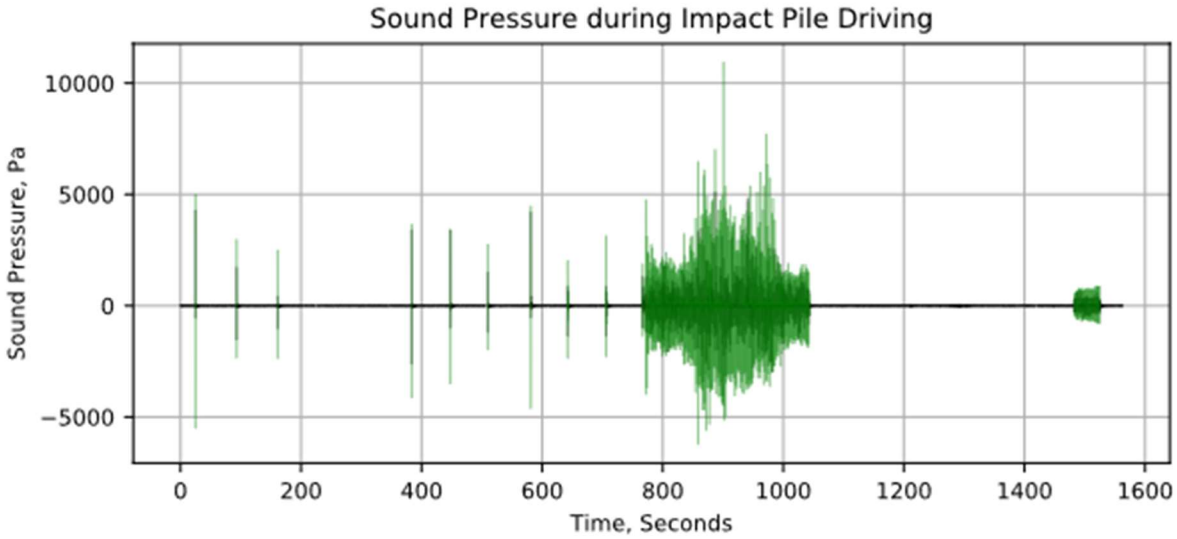
Airborne Frequency Spectra

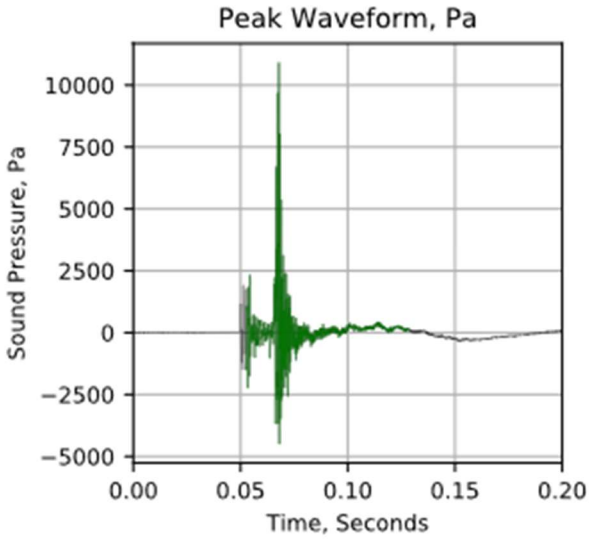


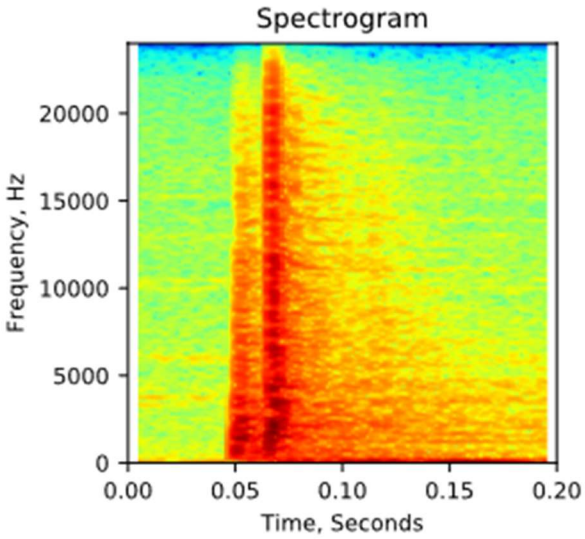
Underwater Sound Levels, dB re: 1 µPa

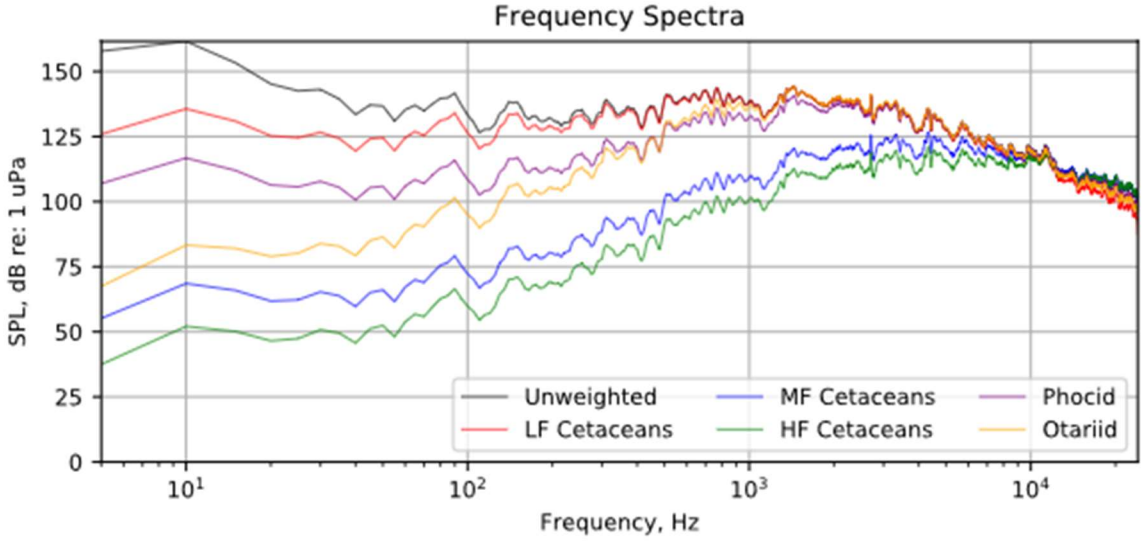
Frequency Range	Peak					RMS_{90}					SEL					cSEL
	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	
Upper Hydrophone																
Unweighted	174	202	5.3	190	186	160	177	2.8	171	170	151	166	2.5	161	161	185
LF Cetacean	174	202	5.3	190	186	151	177	6.1	171	170	141	160	4.2	155	154	179
MF Cetacean	174	202	5.3	190	186	155	174	3.1	166	165	146	162	2.5	156	156	180
HF Cetacean	174	202	5.3	190	186	155	173	2.9	166	165	147	162	2.4	156	156	180
PW	174	202	5.3	190	186	149	178	6.5	170	168	140	161	4.0	154	154	178
OW	174	202	5.3	190	186	150	178	6.5	171	170	141	161	4.3	155	155	179
Lower Hydrophone																
Unweighted	159	187	3.8	180	178	150	174	3.8	167	166	141	165	3.0	155	154	179
LF Cetacean	159	187	3.8	180	178	142	171	4.6	163	162	132	154	3.1	149	148	172
MF Cetacean	159	187	3.8	180	178	144	168	3.7	161	160	135	161	3.2	150	148	173
HF Cetacean	159	187	3.8	180	178	145	169	3.7	161	160	136	161	3.2	150	149	174
PW	159	187	3.8	180	178	138	168	4.8	161	159	129	152	3.3	146	145	170
OW	159	187	3.8	180	178	138	169	4.9	163	162	129	153	3.5	147	146	171

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


Sound Pressure during Impact 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
Unweighted
LF Cetaceans
MF Cetaceans
HF Cetaceans
Phocid
Otariid

PILE #87

September 14, 2018

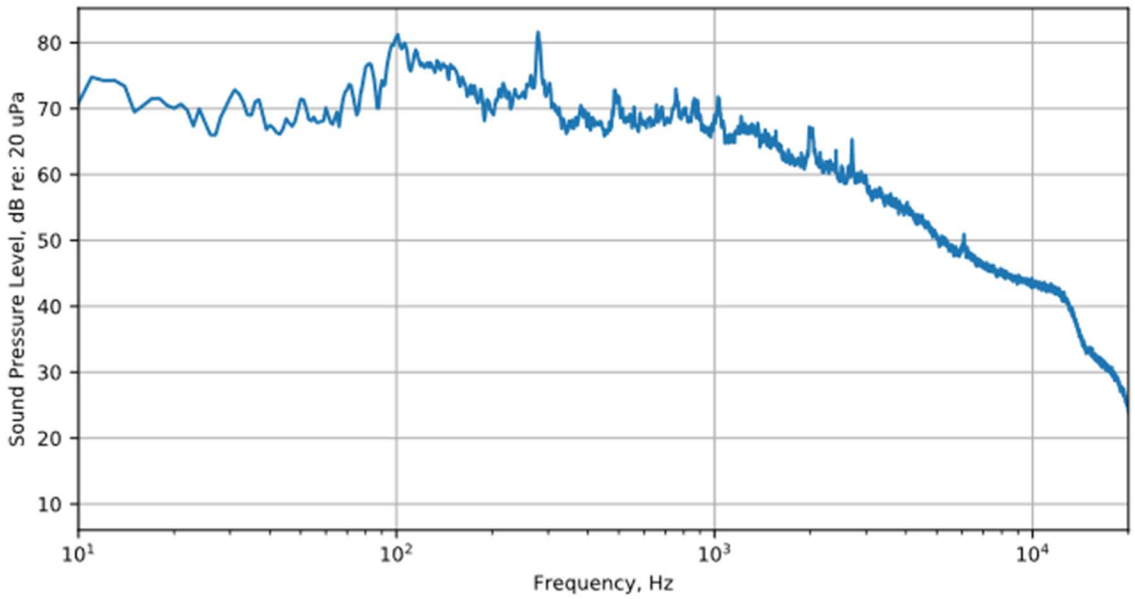
Hydrophone and Pile Hydrophone and Pile Information, Feet

Hydro Depth (upper/lower)	Distance			Water Depth	
	Between Hydros	Hydros to Pile	Pile to Water's Edge	Hydros	Pile
3/17	14	33	78	20	11

Airborne Sound Levels, dB re: 20 µPa

Median	Maximum	Minimum
103	105	88

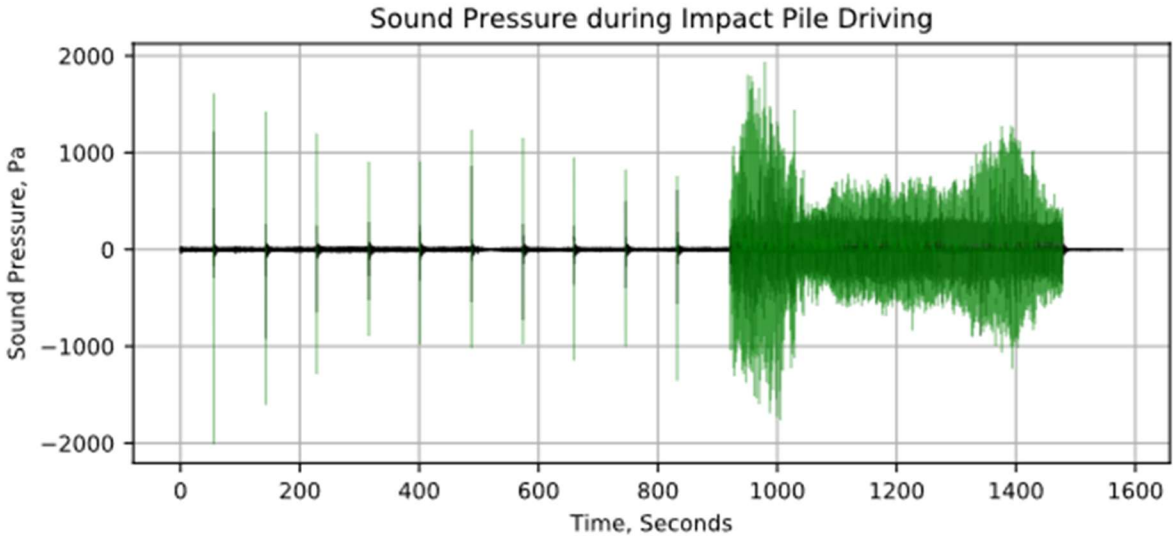
Airborne Frequency Spectra

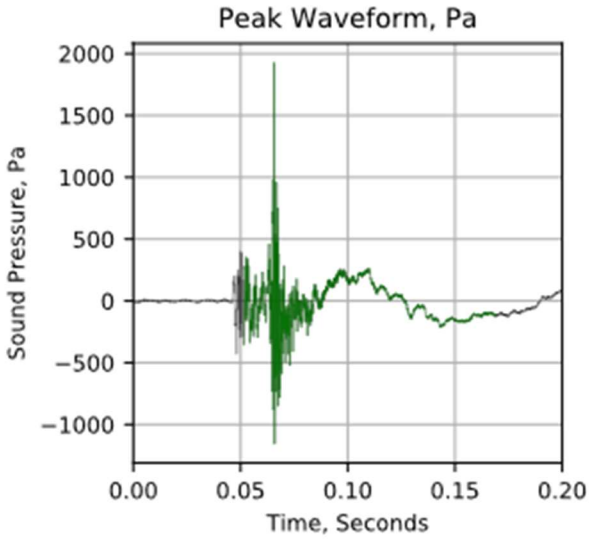


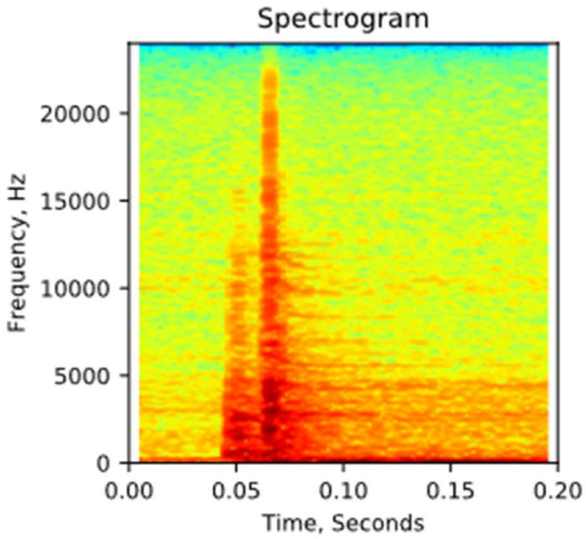
Underwater Sound Levels, dB re: 1 µPa

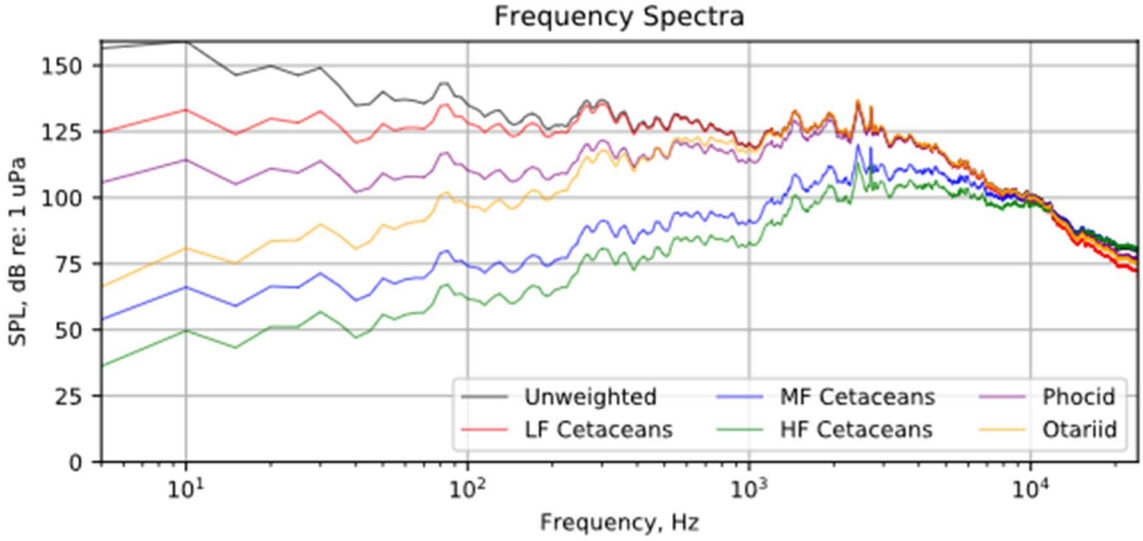
Frequency Range	Peak					RMS_{90}					SEL					cSEL
	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	Min	Max	SD	Mean	Med	
Upper Hydrophone																
Unweighted	169	186	3.3	178	176	162	166	0.7	164	164	153	157	0.7	155	155	181
LF Cetacean	169	186	3.3	178	176	149	166	3.6	157	155	140	150	2.0	145	144	171
MF Cetacean	169	186	3.3	178	176	156	163	0.7	158	158	148	151	0.7	150	150	176
HF Cetacean	169	186	3.3	178	176	157	163	0.7	159	159	148	152	0.7	150	150	176
PW	169	186	3.3	178	176	149	167	2.9	155	153	140	151	1.9	145	144	171
OW	169	186	3.3	178	176	148	167	3.9	157	153	139	151	2.2	145	144	171
Lower Hydrophone																
Unweighted	163	178	2.5	171	170	156	164	1.3	160	160	147	154	1.2	150	150	176
LF Cetacean	163	178	2.5	171	170	147	161	2.6	153	152	136	145	1.8	142	141	168
MF Cetacean	163	178	2.5	171	170	150	157	1.2	154	154	141	148	1.1	145	145	171
HF Cetacean	163	178	2.5	171	170	151	158	1.1	154	154	142	149	1.1	145	145	171
PW	163	178	2.5	171	170	143	161	2.5	149	147	134	145	1.6	138	138	164
OW	163	178	2.5	171	170	141	162	3.6	150	147	132	146	2.1	138	137	164

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


Sound Pressure during Impact 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
Unweighted
LF Cetaceans
MF Cetaceans
HF Cetaceans
Phocid
Otariid

5.0 PILE DRIVER INFORMATION

APE MODEL 200 VIBRATORY DIVER/EXTRACTOR

APE Model 200 Vibratory Driver Extractor

The Worlds Largest Provider of Foundation Construction Equipment

SPECIFICATIONS	DATA
Eccentric Moment	4,400 in-lbs (50.69 kgm)
Drive Force	170 tons (1,513 kN)
Frequency Maximum (VPM)	0 - 1,650 vpm
Max Line Pull	133 tons (1,183 kN)
Bare Hammer Weight w/o Clamp	12,760 lbs (5,788 kg)
Throat Width	14.75 in (37 cm)
Length	104.00 in (264 cm)
Height w/o Clamp	65.50 in (166 cm)

APE Model 595 Power Unit

SPECIFICATIONS	DATA
Engine Type	Caterpillar C15 Tier III
Horse Power	595 HP (438 kW)
Drive Pressure	0 - 4,500 psi (310 bar)
Drive Flow	188 gpm (712 lpm)
Clamp Pressure	4,800 psi (69,618 bar)
Clamp Flow	10 gpm (3 lpm)
Engine Speed	2,100 rpm
Weight	19,500 lbs (8,845 kg)
Length	152 in (385 cm)
Width	82 in (208 cm)
Height	94 in (239 cm)
Hydraulic Reservoir	575 gal (2,177 L)
Fuel Capacity	160 gal (606 L)

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.APEVIBRO.COM
(800) 248-8498
webmaster@apevibro.com

APE MODEL 400 "KING KONG" VIBRATORY DRIVER/EXTRACTOR

APE Model 400 Vibratory Driver Extractor

The Worlds Largest Provider of Foundation Construction Equipment

SPECIFICATIONS	DATA
Eccentric Moment	11,500 in-lbs (132.49 kgm)
Drive Force	298 tons (2,648 kN)
Frequency Maximum (VPM)	0 - 1,350 vpm
Max Line Pull	234 tons (2,082 kN)
Bare Hammer Weight w/o Clamp	31,570 lbs (14,320 kg)
Throat Width	33.00 in (84 cm)
Length	141.00 in (358 cm)
Height w/o Clamp	88.50 in (225 cm)

APE Model 1050 Power Unit

SPECIFICATIONS	DATA
Engine Type	Caterpillar C27 Tier II
Horse Power	1,050 HP (772 kW)
Drive Pressure	0 - 4,500 psi (310 bar)
Drive Flow	278 gpm (1,052 lpm)
Clamp Pressure	4,800 psi (69,618 bar)
Clamp Flow	10 gpm (3 lpm)
Engine Speed	2,100 rpm
Weight	22,500 lbs (10,206 kg)
Length	186 in (472 cm)
Width	87 in (221 cm)
Height	103 in (260 cm)
Hydraulic Reservoir	485 gal (1,836 L)
Fuel Capacity	175 gal (662 L)

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.

APE MODEL 600 "SUPER KONG" VIBRATORY DRIVER/EXTRACTOR

APE Model 600

SPECIFICATIONS	DATA
Eccentric moment	20,000 in-lbs (230.42 kgm)
Frequency (variable)	400-1400 vpm
Driving Force	3203 kN / 556 tons
Amplitude with 15' Dual Clamps	(dynamic wt: 30,000 lbs.) 34 mm / 1.34 in
Amplitude with 15' Quad Clamps	(dynamic wt: 36,000 lbs.) 29 mm / 1.12 in
Maximum line pull	379.2 mt / 418 US tons
Suspended Weight with 15' Wood Clamp System and 150' Hoses	30,385 kg / 67,000 lbs
Length	430 cm / 170 in
Width throat	90 cm / 36 in
Width at widest point	90 cm / 36 in
Height with 11' beam and clamps	244 cm / 96 in
Height with 15' Quad Clamp system	280 cm / 110 in
Hydraulic Hose Length (Standard)	45 m / 150 ft

APE Model 1050 Power Unit

SPECIFICATIONS	DATA
Power Unit Engine	Caterpillar E-series C27 ACERT
Maximum Power	1050 hp (745kW)
Operating Speed	800 to 2100 rpm
Maximum Drive Pressure	5,000 psi (340 bar)
Drive Flow	0 to 321 gpm (1,219 lpm)
Clamp Pressure	4,800 psi (326 bar)
Clamp Pump Flow @ 2200 rpm	6.5 gpm (27 lpm)
Weight	27,000 lbs (12,247 kg)
Length	169 in (442 cm)
Width	82 in (208 cm)
Height	96 in (244 cm)

DELMAG D100-52 SINGLE ACTING DIESEL IMPACT HAMMER

APE D100-52 Single Acting Diesel Impact Hammer

D100-52 in a bottom drive.

Optional Variable Throttle Control.

Cushion material.

Typical 54" offshore.

MODEL D100-52 (10.0 metric ton ram)

SPECIFICATIONS

Stroke at maximum rated energy	135 in (343 cm)
Maximum rated energy (Setting 4)	248,063 ft-lbs (334.88 kNm)
Setting 3	220,776 ft-lbs (298.05 kNm)
Setting 2	191,008 ft-lbs (257.86 kNm)
Minimum rated energy (Setting 1)	158,760 ft-lbs (214.33 kNm)
(Variable throttle allows for infinite fuel settings)	
Maximum obtainable stroke	150 in (381 cm)
Maximum obtainable energy	288,488 ft-lbs (391 kNm)
Speed (blows per minute)	34-53

WEIGHTS (Approximate)

Piston	22,050 lbs (10,000 kg)
Anvil	4,670 lbs (2,118 kg)
Anvil cross sectional area	482.8 in² (3114.83 cm²)
Hammer weight (includes hydraulic trip device)	47,000 lbs (21,318 kg)
Typical operating (weight with offshore leader)	77,000 lbs (34,920 kg)

CAPACITIES

Fuel tank (runs on diesel or bio-diesel)	40.3 gal (153 liters)
Oil tank	8.3 gal (31.5 liters)

CONSUMPTION

Diesel or Bio-diesel fuel	7.8gal/hr (30 liters/hr)
Lubrication	0.67 gal/hr (2.5 liters/hr)
Grease	8 to 10 pumps every 20 minutes of operation time.

STRIKER PLATE

Weight	1,036 lbs (470 kg)
Diameter	25 in (57.15 cm)
Area	491 in² (3167.74 cm²)
Thickness	8 in (20.32 cm)

CUSHION MATERIAL

Type/Qty	Micarta / 2 each
Diameter	25 in (57.15 cm)
Thickness	1 in (25.4 mm)
Type/Qty	Aluminum / 3 each
Thickness	1/2 in (12.7 mm)
Diameter	25 in (57.15 cm)
Total Combined Thickness	3.5 in (8.89 cm)
Area	491 in² (3167.74 cm²)
Elastic-modulus	285 ksi (1,965 mpa)
Coeff. of restitution	0.8

STANDARD OFFSHORE LEADER

8"x54" for 48" piles and under	Consult Factory

MINIMUM BOX LEAD SIZE/OPERATING LENGTH

Minimum box leader size	8 in x 37 in (20.32 cm x 94 cm)
Operating length for offshore leader	396 in (1005.84 cm)

AMERICAN PILEDRIVING EQUIPMENT INC. APE

Corporate Offices
7032 South 196th
Kent, Washington 98032 USA
(800) 248-8498 & (253) 872-0141
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6.0 BUBBLE CURTAIN INFORMATION

System Design Calculations:

Compressed Air Bubble Curtain

Design:	**Washington State DOT** **Colman Dock Project**
For:	**Pacific Pile & Marine, LLC** **Seattle, Washington**
System:	**Bubble Curtain Performance Calculations**
System Number:	**2017-47-72-1B**
Date:	**14-Sep-17**
By:	**jwk**

Rev B

VANGUARD MARINE, PLLC
P.O. Box 505 Quilcene WA 98376
Phone (206) 595-9203 email: jmkreuter@vanguardmarinepllc.com

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A. REVISIONS

REV A

Date	Item	Description
9-14-2017	1)	Corrected quantity of air bubbler rings used for "confined bubbler ring" needed when driving batter piles. The original quantity used WAS (7), and now IS (1). HDPE Ring only needs to protrude a minimum distance of 0.50-FT (6-IN) above water level in order to function as required. See sheets 19-22.

REV B

Date	Item	Description
9-14-2017	1)	Modified calculations to consider and include air manifold and pertinence of it in system performance (including available air flow rate). Added sheet 12. Modified calculation CONCLUSION to suit.

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C. DISCUSSION

The following calculations are provided to demonstrate the performance of a Bubble Curtain Assembly design that will be used to generate a noise attenuating curtain of bubbles during pile driving associated with work being conducted as part of the rebuilding of the Washington State DOT Colman Dock in Seattle, WA. A previously constructed bubble curtain system will be used (and modified) to satisfy the contractual requirements associated with the noise attentuation portion of the project specification. The bubble curtain system is to engulf in bubbles over the full depth of the water column at all times that the impact pile driver is in use.

The bubble curtain equipment will take two general forms: 1) Unconfined bubble curtain arrangement, and 2) Confined bubble curtain arrangement. The unconfined arrangement will be used to provide noise attenuation for vertical piles that are being driven into the mud. The confined arrangement will be used while driving batter piling.

The unconfined bubble curtain assembly equipment consists of air compressors that will deliver supply air to a fabricated air system manifold. The manifold splits the supply air into (up to) fourteen supply hoses that provide supply air to (up to) seven air bubbler rings that are positioned around the pile being driven. The air bubbler rings are positioned at regular 7-FT intervals beginning at the mud line and spaced vertically up to the water surface. The confined bubble curtain system includes ONLY one ring at the mud line.

This set of calculations will establish the number of air compressors required (including rated output) to satisfy the WSDOT specified air bubble flux density of 32.91-CFM per foot of bubbler ring. This installation will consist of three bubbler rings used in water depths of up to 50-FT deep.

It is assumed that the existing equipment has been fabricated in accordance the the intent of the project specificaions and that the equipment performs as described in the specifications. The purpose of this set of caclulations is to serve as a check on equipment performance and to establish, using the characteristics of compressible gas (ie. Compressed air) the flowrate and pressure of air delivered to the equipment to achieve the specified bubble flux for the water depths required and the as-built bubbler rings (with the established air orifice size and count).

Assumptions made to support this set of calculations are shown on next sheet.

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D. ASSUMPTIONS & CRITERIA

1) The following industry accepted nomenclature is used throughout this analysis:

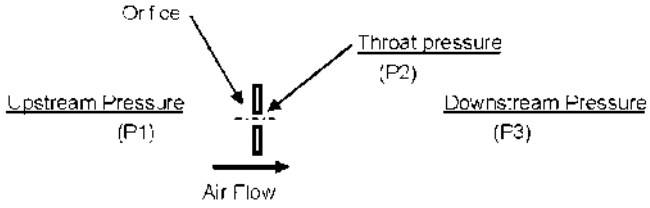
   SCFM = Air as measured at "standard" conditions (Temp = 60-F, 14.7-PSIA)

   ACFM = Air as measured at "actual" conditions (Temp = xx-F, xx-PSIA)

2) The pressure drop calculations made to estimate the frictional losses in the system air piping consider the "longest run" in the system. If the system will perform as required through the longest run, performance through all shorter runs of piping will be at least as good as determined for the longest run.

3) The bubble curtain is created by delivering compressed air to a pipe formed into a ring that has several holes drilled through the pipe ring that allow air bubbles to discharge. The drilled holes act as "orifices" through which the compressed air passes. Any reference to orifices in this set of calculations indicates these holes.

4) Compressed gases, when passing through an orifice, will demonstrate different behaviors depending upon flow and pressure parameters. If the upstream pressure (upstream of the orifice) is high enough, and the downstream pressure is low enough, the upstream pressure will cause enough flow through the orifice to create what is known as a "critical flow" condition. For fully developed "critical flow", the velocity of the gas through the throat of the orifice reaches a sonic velocity. If this occurs, it can be shown that the behavior of the gas can be predicted using certain formulae. If the downstream pressure is higher, the relative pressures cannot reach "critical flow" and instead achieve what is referred to as "subcritical flow". In this case, different formulae are used to predict the behavior of the gas. In these calculations, it is shown that the submergence of the bubbler ring under the static head of the water column prevents full "critical" flow from developing. Instead, the air flow calculations are based on "subcritical" flow, as shown in the calculations.



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D. ASSUMPTIONS & CRITERIA

5) An orifice is a round sharp edged hole in a thin plate. The holes in the fish ring pipe are assumed to behave as do orifices - rather than like any form of nozzle. Critical ratios for compressed (perfect) gases apply accurately to rounded entrance nozzles. Their application to sharp edge orifices is rather approximate. In practice, the critical ratio is applied to either nozzle or orifice.

   For air between 0-DEG F and 250-DEG F, the critical ratio for air is: $r_c = 0.528$.

6) The air system schematic and details are shown in the Washington State Department of Transportation guidance drawing set, Drawing Numbers "S03.70" thru "S03.75" dated with "Submittal Date" of 2-28-2017 in all cases. These drawings developed for the Multimodal Terminal at Colman Dock.

7) The Bubble Curtain performance specification is provided in Washington Department of Transportation - Ferries Division project specification for the Seattle Multimodal Terminal at Colman Dock. See pages 255 through 258 (dated 2-28-2017).

8) The assumed hose size between the air compressors and the air system supply manifold assembly is 3"-Nom and the hose length is assumed to be 100-FT long. The hose is rubber-lined and assumed to be equivalent to steel pipe.

9) The assumed hose size between the air system supply manifold assembly and the (furthest) air bubbler ring is assumed to be 1"-Nom and the hose length is assumed to be 200-FT long. Rubber-lined hose assumed to be equivalent to steel pipe.

10) The compressor air will be filtered for oil mist prior to delivery to the system. The sizing and selection of the fillter will be provided elsewhere, by others.

11) For the unconfined bubble curtain arrangement, there will be up to (7) bubbler rings spaced at 7-FT intervals (first ring being positioned on mud) suitable for depths of up to 50-FT deep (water depth). The confined bubble curtain arrangement will be fabricated from a combination of steel with HDPE tube, also sized for 50-FT depths.

12) The seawater temperature (avg.) is assumed to be: **50** F

13) The specific gravity of seawater assumed is: **1.03** - -

14) The assumed atmospheric pressure is: **14.696** PSI

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D. ASSUMPTIONS & CRITERIA

15) The assumed air temperature of the compressed air: **60** F

16) Criteria for the unconfined ring as follows:
The bubbler ring diameter is assumed to be: **68.875** IN
The number of holes in each ring (per WSDOT dwg): 1,134 holes
(assumes 1"-deducted from length of each half, each end)

17) Criteria for the confined ring as follows:
The bubbler ring diameter is assumed to be: **62.875** IN
The number of holes in each ring (per WSDOT dwg): 1,053 holes
(assumes 1"-deducted from length of each half, each end)

18) Bubbler ring hole (orifice) diameter: **0.0625** IN

19) Air flux density required per foot of ring: **32.91** SCFM per FT

20) Max. water depth of rings: **50** FT

21) While the calculations provided in this report are accurate and reflect current industry calculation methods. It must be noted that due to variations in air and water temperatures, variations in barometric pressure and variations of piping and system components used (final dimensions and equipment arrangement), there will be variations in the system performance. On the other hand, these variations should be fairly small and while the actual performance will change based on these variables, the purpose of these calculations is maintained and the system performance will, from a practical point of view, match what is shown in this report.

22) It is assumed that the air flow meters that are installed in each bubbler ring air supply line (located at the manifold) will provide air flow rate information in Standard Cubic Feet per Minute (SCFM) to the system operators. This is per flow meter information provided by WSDOT. As a result, it is further assumed that the operators will adjust air flow throttling valves to achieve the target air flow rates to each air bubble ring as calculated in this set of calculations.

23) It is assumed that all compressed air piping has been selected and fabricated for system pressures up to 300-PSIG.

24) Other assumptions as noted in the body of this set of calculations.

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E. CONCLUSION

The performance of the Washington State Colman Dock Bubble Curtain equipment when used as described by this set of calculations should provide the specified air bubble flux required to attenuate pile driving noise.

One air compressor described in the body of the calculations will provide the specified, required flowrate of air required to satisfy the contract specification for water depths to 30-FT deep. Two compressors (operated in parallel with one manifold) will provide the required air for depths to 50-FT deep.

The following detailed calculations indicate that a total air flow rate of 4,186-SCFM is required to supply a depth of 50-FT. The air compressors, set to operate at a discharge pressure of 200-PSIG, will deliver approximately 4,643-SCFM to the bubbler rings.

When used as described here, the expected air bubble flux will be approximately 33-CFM per foot of bubbler ring. The required flux is 33-CFM per foot of ring. ASSUMPTION No. (21) explains some of the unknowns and variables that will affect system performance. It should also be noted that the required air flow rates necessary to achieve this air flux density exceed the compressor ratings by approximately 1%. However, given the variables described, it is nearly impossible to expect the system to perform exactly as described by this set of calculations. It is still expected that the system described in this report will satisfy the intent of the Washington State performance specification.

The final performance of the system will be controlled by the air flow meters and throttling valves provided as part of the system. Operators should adjust the throttling valves to supply 600-SCFM to each bubbler ring - for all depths.

Using the approach described above (with the valves throttled accordingly), the total pressure required in the system is approximately 100-PSIG. The compressors are rated to deliver a maximum output pressure of 200-PSIG.

This flux density and the associated calculations are valid for both the unconfined bubble curtain assembly AND the confined bubble curtain assembly.

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E. CONCLUSION

Calculations show that, for the confined bubble curtain arrangement, the 72-IN Dia. HDPE tube must protrude at least 6-IN above the surface of the water so that there will be enough head in the column of water to prevent water from being pumped out of the top of the HDPE tube. This assumes one bubbler ring being used at depth.

Specific attention should be paid to the pipe branch sizes identified in this set of calculations, the hose sizes and the hose lengths. While there is SOME margin in the system (ie. Capacity of equipment vs. system design requirements), longer hoses and smaller piping could quickly result in elimination of this margin.
The sizes shown for hose, valves, pipe and fittings in this set of calculations must be adhered to in order to meet the WSDOT system performance requirements.

It is assumed that the Contractor who will be using this equipment will satisfy the requirements of the specification and any and all safety regulatory requirements for the maintenance and use of this type of equipment.

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F. AIR FLOWRATE REQUIRED FOR BUBBLE CURTAIN

1) Criteria

Required flux density per foot of ring:	32.91	SCFM per FOOT
Total number of bubble curtain rings is:	**7**	- -
Each ring has a nominal diameter of:	68.875	IN
Length of each bubbler pipe is:	18	FT

Using Boyles Law and the depth at each ring, the total free air required is:

Ring No.	Ring Depth (Ft)	Free Air Req'd (SCFM)	Actual Air at depth (ACFM)
1	50.00	593	236
2	43.00	593	257
3	36.00	593	284
4	29.00	593	316
5	22.00	593	356
6	15.00	593	408
7	8.00	593	478
		4,154	2,334

2) Compressor selection -

Manufacturer =	**Doosan**	
Model =	**XHP1170WCAT**	
F.A.D. =	**1,170**	CFM
Rated Operating Pressure =	**200**	PSIG (pressure relief valve set to this)
BHP output =	**540**	HP
Quantity required =	**4**	- -

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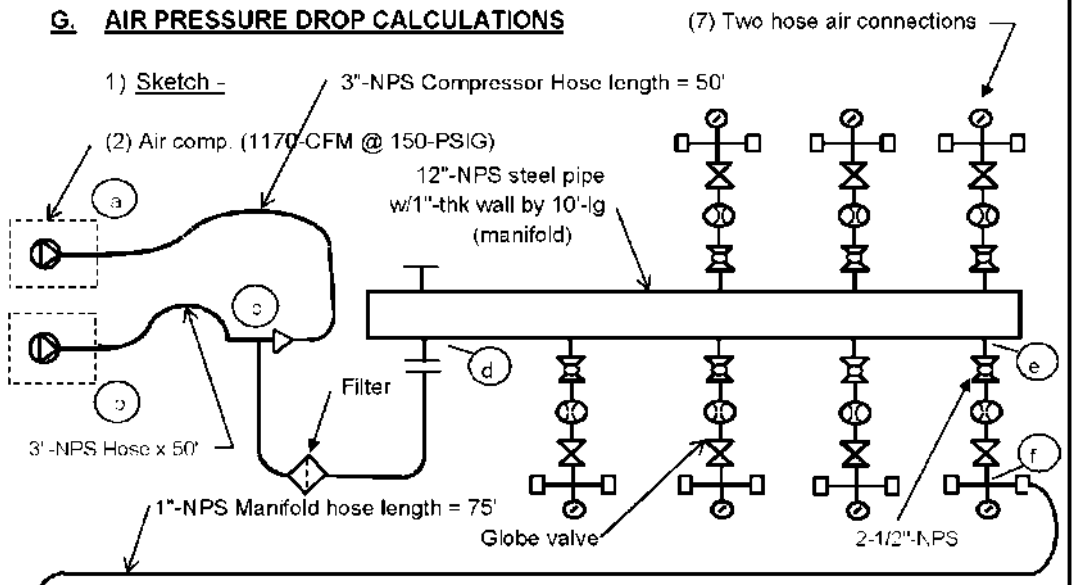
G. AIR PRESSURE DROP CALCULATIONS



Branch	Flow Rate	Qty	Description	Unit Eq. Lgth (FT)	Total Eq. Lgth (FT)	Delta P (PSI)
a - c	1,170	50	LF 3"-NPS Rubber hose		50.0	
		1	3"-NPS Tee - branch	15.3	15.3	
b - c	1,170	50	LF 3"-NPS Rubber hose		50.0	
		1	3"-NPS Tee - branch	15.3	15.3	
c - d	1,170	20	LF 3"-NPS Rubber hose		20.0	
		1	Oil Filter (1-1/4"-NPS)			0.7
d - e	2,340	10	LF 12-NPS pipe	10.0	10.0	
e - f	1,170	1	2-1/2"-NPS Ball valve	0.6	0.6	
		1	Flow Meter (2"-NPS RCM, bronze)			5.0
		1	2-1/2"-NPS Globe valve	65.8	65.8	
		1	2-1/2" Tee - branch	11.6	11.6	
	585	1	Reducer 2-1/2" x 1"	15.0	15.0	
f - g	585	75	LF 1"-NPS Hose		75.0	

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G. AIR PRESSURE DROP CALCULATIONS

3) Pressure Drop Calculation Summary -

Flowrate out of each compressor = 1170 SCFM
Rated pressure at compressor = 200 PSI

Branch	Size (IN)	Inlet Air Pressure (PSI)	Pipe & Ftg Pressure Loss (PSI)	Other Pressure Loss (PSI)	Total Pressure Loss (PSI)
a - c	**3**	200.00	0.377		0.377
b - c	**3**	200.00	0.377		0.377
c - d	**3**	199.62	0.116		0.116
d - e	**12**	199.51	0.000	**0.700** (Filter)	0.700
e - f	**2-1/2**	198.81	1.628	**5.000** (Flowmeter) **26.000** (valve)	32.628
f - g	**1**	166.18	14.097		14.097
Ring	**2-1/2**	152.08	**0.700** (estimated)		0.700
Delta Z =			50 FT =		21.65 PSIG

NOTE: Adjust throttling valve at manifold until pressure in gauge is: **45** PSIG
This will provide a "ring inlet pressure" at the ring inlet as shown next sheet.
Performance of the bubbler ring with this air pressure shown next sheet.

The total pressure required in the system is: 93.5 PSIG

The compressor output pressure is: 200.0 PSIG

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H. AIR RECEIVER STORAGE vs. SYSTEM AIR REQUIREMENTS

1) Discussion -

The manifold shown on the previous sheet acts as an air receiver and, while it doesn't provide a meaningful amount of air storage, it does serve an important function in the system. If it is assumed that the compressor keeps the receiver full as it is operating, this reservoir of pressurized air provides the needed air supply to the hoses that supply pressurized air to the bubbler rings at the required water depths.

The air supply in the receiver is stored at 150-PSIG and is supplied by a constant air flow rate of 1,170-SCFM from the air compressor. The air pressure that is required in the system (supply to the bubbler rings) is required at a lower supply pressure and, as a result, the actual available air in the system is calculated as shown below.

Air supply rate to Receiver	=	1,170	CFM
Air pressure delivered to receiver	=	200	PSIG
Air supply rate required per ring	=	593	CFM
Max Air pressure required to ring	=	93	PSIG (at 50-FT depth)
Available flow rate at required pressure (using Boyle's Law)	=	2,322	CFM per compressor
Available air flowrate (2) compressors	=	4,643	CFM
Total required air flow rate required for seven rings (down to 50-FT)	=	4,154	CFM

Therefore, ONE compressor per pile driving set-up will provide the required air necessary to supply the air bubbler rings at the specified flow rate down to depths of thirty feet of water.

Therefore, TWO compressors per pile driving set-up will provide the required air necessary to supply the air bubbler rings at the specified flow rate down to depths of fifty feet of water.

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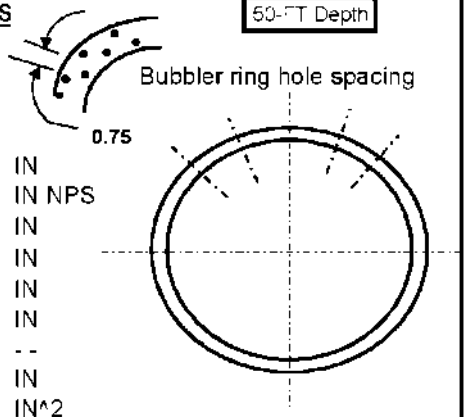
I. UNCONFINED RING AIR FLOWRATE CALCS

50-FT Depth



1) Sketch:

Ring Nom Diameter	=	68.875	IN
Ring Pipe Size	=	**2-1/2**	IN NPS
Pipe OD	=	**2.875**	IN
Pipe ID (Sch 80)	=	**2.323**	IN
Ring OD	=	70.313	IN
Ring OD	=	67.438	IN
No. of Holes in ring	=	1,134	- -
Hole Diameter	=	0.063	IN
Hole Area	=	0.003068	IN^2
Total bubble area in ring	=	3.48	IN^2
	=	0.02	FT^2
Air Temperature	=	60	DEG F
Air Density (atm. pressure)	=	**0.0757**	LBm/FT^3
Air density at (P1), below	=	**0.1919**	LBm/FT^3

2) Flowrate through orifice calculations:

Pressure at ring inlet	=	**22.86**	PSIG
Frictional losses in ring	=	0.69	PSIG (estimated value)
Pressure (P1) at orifice	=	22.2	PSIG
Pressure (P2) at throat	=	21.6	PSIG
Pressure (P3) at outlet	=	21.6	PSIG (water column pressure)
Ratio (P3/P1)	=	0.97	> 0.528
Flow type	=	**Subcritical**	(Greater than critical ratio)
Orifice Discharge Coeff. (C)	=	**0.61**	- - (Sharp edged)
Mass Flow rate thru orifice (W)	=	0.00067	LB / SEC
Volume. flowrate thru orifice	=	0.208	ACFM through each orifice
	=	0.523	SCFM through each orifice

Flow rate through ring	=	593	SCFM
Flow rate per foot of ring	=	32.9	SCFM > 32.91-SCFM

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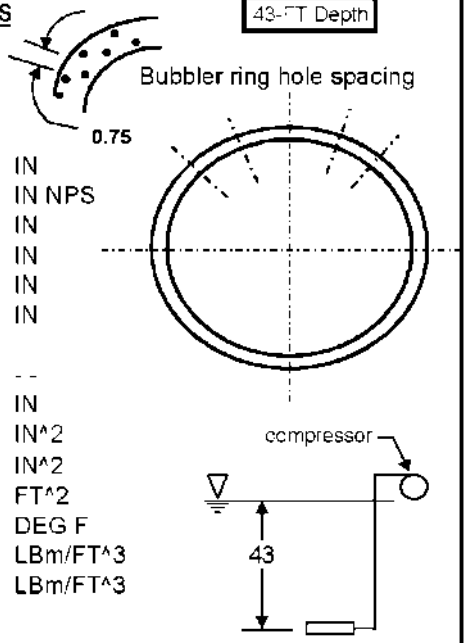
I. UNCONFINED RING AIR FLOWRATE CALCS

43-FT Depth



1) Sketch:

Ring Nom Diameter	=	68.875	IN
Ring Pipe Size	=	2-1/2	IN NPS
Pipe OD	=	2.875	IN
Pipe ID (Sch 80)	=	2.323	IN
Ring OD	=	70.313	IN
Ring OD	=	67.438	IN
No. of Holes in ring	=	1,134	- -
Hole Diameter	=	0.063	IN
Hole Area	=	0.003068	IN^2
Total bubble area in ring	=	3.48	IN^2
	=	0.02	FT^2
Air Temperature	=	60	DEG F
Air Density (atm. pressure)	=	0.0757	LBm/FT^3
Air density at (P1), below	=	**0.1767**	LBm/FT^3

2) Flowrate through orifice calculations:

Pressure at ring inlet	=	**19.76**	PSIG
Frictional losses in ring	=	0.59	PSIG (estimated value)
Pressure (P1) at orifice	=	19.2	PSIG
Pressure (P2) at throat	=	18.6	PSIG
Pressure (P3) at outlet	=	18.6	PSIG (water column pressure)
Ratio (P3/P1)	=	0.97	> 0.528
Flow type	=	**Subcritical**	(Greater than critical ratio)
Orifice Discharge Coeff. (C)	=	**0.61**	- - (Sharp edged)
Mass Flow rate thru orifice (W)	=	0.00067	LB / SEC
Volume. flowrate thru orifice	=	0.227	ACFM through each orifice
	=	0.524	SCFM through each orifice

Flow rate through ring	=	594	SCFM
Flow rate per foot of ring	=	32.9	SCFM > 32.91-SCFM

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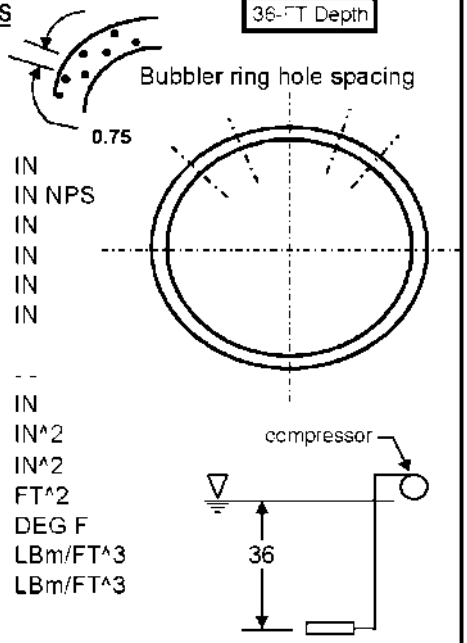
I. UNCONFINED RING AIR FLOWRATE CALCS

36-FT Depth



1) Sketch:

Ring Nom Diameter	=	68.875	IN
Ring Pipe Size	=	2-1/2	IN NPS
Pipe OD	=	2.875	IN
Pipe ID (Sch 80)	=	2.323	IN
Ring OD	=	70.313	IN
Ring OD	=	67.438	IN
No. of Holes in ring	=	1,134	- -
Hole Diameter	=	0.06250	IN
Hole Area	=	0.00307	IN^2
Total bubble area in ring	=	3.47808	IN^2
	=	0.02415	FT^2
Air Temperature	=	60	DEG F
Air Density (atm. pressure)	=	0.07570	LBm/FT^3
Air density at (P1), below	=	**0.15390**	LBm/FT^3

2) Flowrate through orifice calculations:

Pressure at ring inlet	=	**16.65**	PSIG
Frictional losses in ring	=	0.50	PSIG (estimated value)
Pressure (P1) at orifice	=	16.2	PSIG
Pressure (P2) at throat	=	15.6	PSIG
Pressure (P3) at outlet	=	15.6	PSIG (water column pressure)
Ratio (P3/P1)	=	0.97	> 0.528
Flow type	=	**Subcritical**	(Greater than critical ratio)
Orifice Discharge Coeff. (C)	=	**0.61**	- - (Sharp edged)
Mass Flow rate thru orifice (W)	=	0.00064	LB / SEC
Volume. flowrate thru orifice	=	0.251	ACFM through each orifice
	=	0.527	SCFM through each orifice

Flow rate through ring	=	597	SCFM
Flow rate per foot of ring	=	33.1	SCFM > 32.91-SCFM

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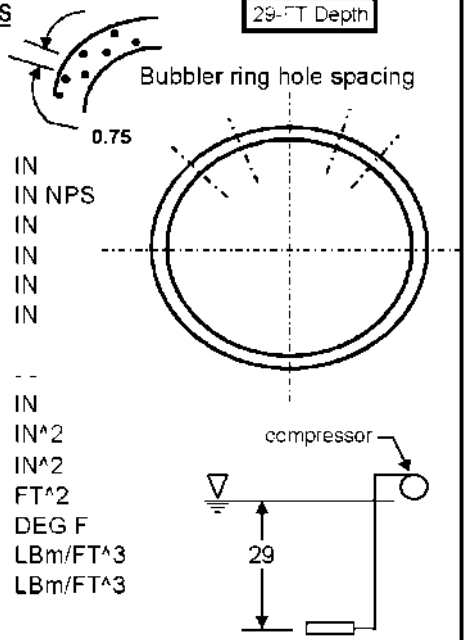
I. UNCONFINED RING AIR FLOWRATE CALCS

29-FT Depth



1) Sketch:

Ring Nom Diameter	=	68.875	IN
Ring Pipe Size	=	2-1/2	IN NPS
Pipe OD	=	2.875	IN
Pipe ID (Sch 80)	=	2.323	IN
Ring OD	=	70.313	IN
Ring OD	=	67.438	IN
No. of Holes in ring	=	1,134	- -
Hole Diameter	=	0.06250	IN
Hole Area	=	0.00307	IN^2
Total bubble area in ring	=	3.47808	IN^2
	=	0.02415	FT^2
Air Temperature	=	60	DEG F
Air Density (atm. pressure)	=	0.07570	LBm/FT^3
Air density at (P1), below	=	**0.14200**	LBm/FT^3

2) Flowrate through orifice calculations:

Pressure at ring inlet	=	**13.53**	PSIG
Frictional losses in ring	=	0.41	PSIG (estimated value)
Pressure (P1) at orifice	=	13.1	PSIG
Pressure (P2) at throat	=	12.6	PSIG
Pressure (P3) at outlet	=	12.6	PSIG (water column pressure)
Ratio (P3/P1)	=	0.97	> 0.528
Flow type	=	**Subcritical**	(Greater than critical ratio)
Orifice Discharge Coeff. (C)	=	**0.61**	- - (Sharp edged)
Mass Flow rate thru orifice (W)	=	0.00066	LB / SEC
Volume. flowrate thru orifice	=	0.277	ACFM through each orifice
	=	0.524	SCFM through each orifice

Flow rate through ring	=	594	SCFM

Flow rate per foot of ring	=	33.0	SCFM > 32.91-SCFM

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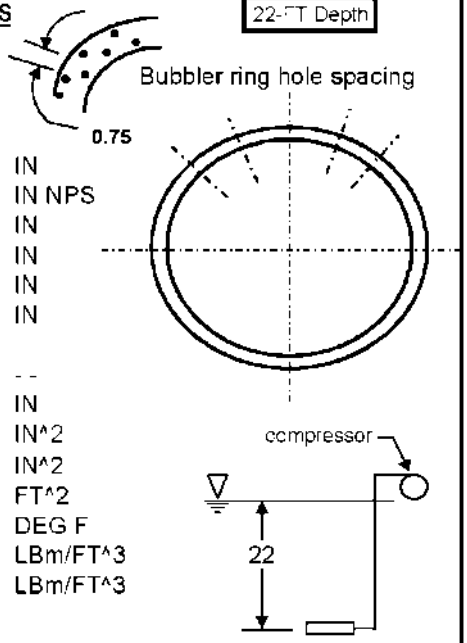
I. UNCONFINED RING AIR FLOWRATE CALCS

22-FT Depth



1) Sketch:

Ring Nom Diameter	=	68.875	IN
Ring Pipe Size	=	2-1/2	IN NPS
Pipe OD	=	2.875	IN
Pipe ID (Sch 80)	=	2.323	IN
Ring OD	=	70.313	IN
Ring OD	=	67.438	IN
No. of Holes in ring	=	1,134	- -
Hole Diameter	=	0.06250	IN
Hole Area	=	0.00307	IN^2
Total bubble area in ring	=	3.47808	IN^2
	=	0.02415	FT^2
Air Temperature	=	60	DEG F
Air Density (atm. pressure)	=	0.07570	LBm/FT^3
Air density at (P1), below	=	**0.12830**	LBm/FT^3

2) Flowrate through orifice calculations:

Pressure at ring inlet	=	**10.40**	PSIG
Frictional losses in ring	=	0.31	PSIG (estimated value)
Pressure (P1) at orifice	=	10.1	PSIG
Pressure (P2) at throat	=	9.5	PSIG
Pressure (P3) at outlet	=	9.5	PSIG (water column pressure)
Ratio (P3/P1)	=	0.97	> 0.528
Flow type	=	**Subcritical**	(Greater than critical ratio)
Orifice Discharge Coeff. (C)	=	**0.61**	- - (Sharp edged)
Mass Flow rate thru orifice (W)	=	0.00067	LB / SEC
Volume. flowrate thru orifice	=	0.313	ACFM through each orifice
	=	0.528	SCFM through each orifice

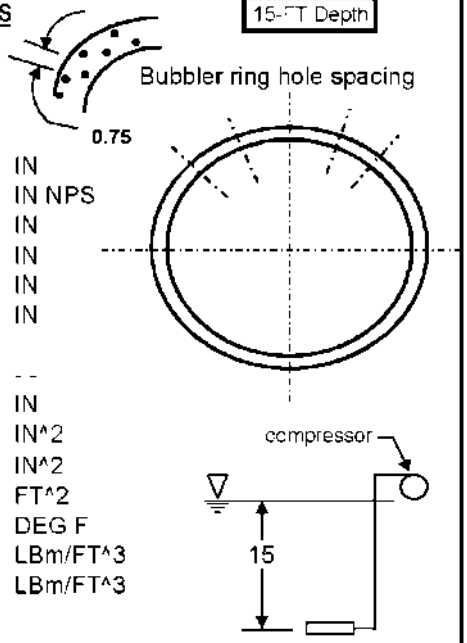
Flow rate through ring	=	599	SCFM
Flow rate per foot of ring	=	33.2	SCFM > 32.91-SCFM

Project: **Colman Dock Project**	By: jwk	Date: 14-Sep-17 **REV B**

Bubble Curtain Performance Calculations	Sheet: 18 of: 23

I. UNCONFINED RING AIR FLOWRATE CALCS

15-FT Depth



1) Sketch:

Ring Nom Diameter	=	68.875	IN
Ring Pipe Size	=	2-1/2	IN NPS
Pipe OD	=	2.875	IN
Pipe ID (Sch 80)	=	2.323	IN
Ring OD	=	70.313	IN
Ring OD	=	67.438	IN
No. of Holes in ring	=	1,134	- -
Hole Diameter	=	0.06250	IN
Hole Area	=	0.00307	IN^2
Total bubble area in ring	=	3.47808	IN^2
	=	0.02415	FT^2
Air Temperature	=	60	DEG F
Air Density (atm. pressure)	=	0.07570	LBm/FT^3
Air density at (P1), below	=	**0.15390**	LBm/FT^3

2) Flowrate through orifice calculations:

Pressure at ring inlet	=	**7.23**	PSIG
Frictional losses in ring	=	0.22	PSIG (estimated value)
Pressure (P1) at orifice	=	7.0	PSIG
Pressure (P2) at throat	=	6.5	PSIG
Pressure (P3) at outlet	=	6.5	PSIG (water column pressure)
Ratio (P3/P1)	=	0.97	> 0.528
Flow type	=	**Subcritical**	(Greater than critical ratio)
Orifice Discharge Coeff. (C)	=	**0.61**	- - (Sharp edged)
Mass Flow rate thru orifice (W)	=	0.00092	LB / SEC
Volume. flowrate thru orifice	=	0.357	ACFM through each orifice
	=	0.527	SCFM through each orifice

Flow rate through ring	=	598	SCFM

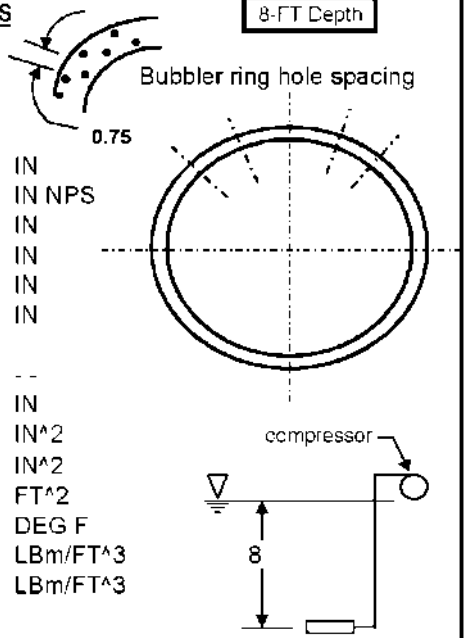
Flow rate per foot of ring	=	33.1	SCFM > 32.91-SCFM

Project: **Colman Dock Project**	By: jwk	Date: 14-Sep-17 **REV B**

Bubble Curtain Performance Calculations	Sheet: 19 of: 23

I. UNCONFINED RING AIR FLOWRATE CALCS

8-FT Depth



1) Sketch:

Ring Nom Diameter	=	68.875	IN
Ring Pipe Size	=	2-1/2	IN NPS
Pipe OD	=	2.875	IN
Pipe ID (Sch 80)	=	2.323	IN
Ring OD	=	70.313	IN
Ring OD	=	67.438	IN
No. of Holes in ring	=	1,134	- -
Hole Diameter	=	0.06250	IN
Hole Area	=	0.00307	IN^2
Total bubble area in ring	=	3.47808	IN^2
	=	0.02415	FT^2
Air Temperature	=	60	DEG F
Air Density (atm. pressure)	=	0.07570	LBm/FT^3
Air density at (P1), below	=	0.15390	LBm/FT^3

2) Flowrate through orifice calculations:

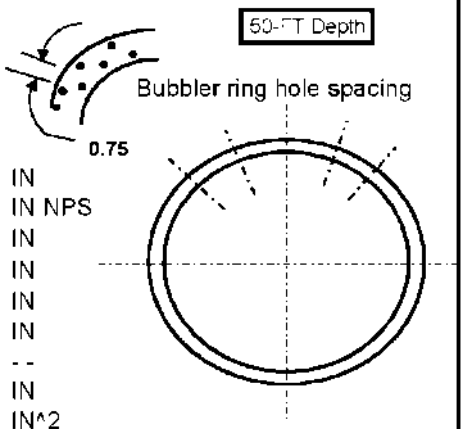
Pressure at ring inlet	=	**3.99**	PSIG
Frictional losses in ring	=	0.12	PSIG (estimated value)
Pressure (P1) at orifice	=	3.9	PSIG
Pressure (P2) at throat	=	3.5	PSIG
Pressure (P3) at outlet	=	3.5	PSIG (water column pressure)
Ratio (P3/P1)	=	0.97	> 0.528
Flow type	=	**Subcritical**	(Greater than critical ratio)
Orifice Discharge Coeff. (C)	=	**0.61**	- - (Sharp edged)
Mass Flow rate thru orifice (W)	=	0.00107	LB / SEC
Volume. flowrate thru orifice	=	0.417	ACFM through each orifice
	=	0.527	SCFM through each orifice

Flow rate through ring	=	598	SCFM
Flow rate per foot of ring	=	33.2	SCFM > 32.91-SCFM

Project: **Colman Dock Project**	By: jwk	Date: 14-Sep-17 **REV B**

Bubble Curtain Performance Calculations	Sheet: 20 of: 23

J. CONFINED RING AIR FLOWRATE CALCS



1) Sketch:

Ring Nom Diameter	=	62.875	IN
Ring Pipe Size	=	**2-1/2**	IN NPS
Pipe OD	=	**2.875**	IN
Pipe ID (Sch 80)	=	**2.323**	IN
Ring OD	=	64.313	IN
Ring OD	=	61.438	IN
No. of Holes in ring	=	1,053	- -
Hole Diameter	=	0.063	IN
Hole Area	=	0.003068	IN^2
Total bubble area in ring	=	3.23	IN^2
	=	0.02	FT^2
Air Temperature	=	60	DEG F
Air Density (atm. pressure)	=	**0.0757**	LBm/FT^3
Air density at (P1), below	=	**0.1919**	LBm/FT^3

2) Flowrate through orifice calculations:

Pressure at ring inlet	=	**22.86**	PSIG
Frictional losses in ring	=	0.69	PSIG (estimated value)
Pressure (P1) at orifice	=	22.2	PSIG
Pressure (P2) at throat	=	21.6	PSIG
Pressure (P3) at outlet	=	21.6	PSIG (water column pressure)
Ratio (P3/P1)	=	1.59	> 0.528
Flow type	=	**Subcritical**	(Greater than critical ratio)
Orifice Discharge Coeff. (C)	=	**0.61**	- - (Sharp edged)
Mass Flow rate thru orifice (W)	=	0.00067	LB / SEC
Volume. flowrate thru orifice	=	0.208	ACFM through each orifice
	=	0.523	SCFM through each orifice

Flow rate through ring	=	551	SCFM
Flow rate per foot of ring	=	33.5	SCFM > 32.91-SCFM

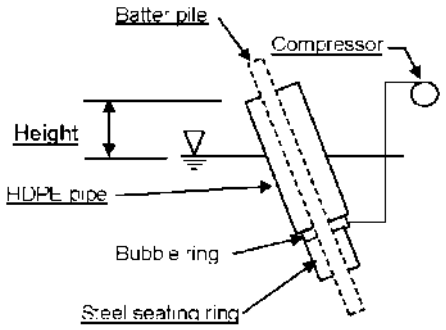
Project: **Colman Dock Project**	By: jwk	Date: 14-Sep-17 **REV B**

Bubble Curtain Performance Calculations	Sheet: 21 of: 23

J. CONFINED RING AIR PUMP EFFECT (HDPE TUBE LENGTH CALC)

1) Discussion

The confined bubble curtain arrangement is shown in simplified sketch below.



The confined bubble curtain arrangement will differ from the unconfined assembly in two ways: 1) The ring diameter is slightly smaller, and 2) There will only be (1) bubbler ring used in the assembly rather than (7). The (1) ring will be placed at the bottom of an external HDPE tube (shown above) that will be positioned over the batter pile (driven at an angle as shown). The air will be supplied to the ring and the result will be that the air and water will mix within the HDPE tube to create the air barrier needed to attenuate the noise during pile driving.

The calculation that follows, however, is necessary to verify that the confined arrangement will not result in a "pumping action" of the water inside of the HDPE tube that is positioned around the batter pile to the extent that the water in the confinement tube is displaced by the air bubbles emitting from the ring.
The tube height above the water surface will be determined by using the required air volume (in the bubble curtain rings) and from this, will determine the static head that the air can "lift". This "lift" height will define the height above water surface that the HDPE pipe must extend.

If the height of the tube above the waterline is adequate to limit the flow of water out of the tube, the arrangement will be considered acceptable.

Project: Colman Dock Project	By: jwk	Date: 14-Sep-17 REV B

Bubble Curtain Performance Calculations	Sheet: 22 of: 23

J. CONFINED RING AIR PUMP EFFECT (HDPE TUBE LENGTH CALC)

2) Behavior of air & water in confinement tube

a) Assume, in the worst case, that the water depth for the batter being driven is 50-FT of water. This means that the amount of air in the HDPE confinement tube will be at a maximum due to the requirement at this depth for the (1) bubbler ring that delivering the required amount of air.

b) Also assume that this set of calculations is based on air having a density at the midpoint depth (ie. 25-FT deep). This means that the air between 25-FT and 50-FT will be more compressed due to the water column (ie. air more dense) and that the air between 25-FT and the surface will have a lower density (due to less static head acting on the air. The two should average out to be close to the actual conditions over the entire water column height of 50-FT. Assumed air density is: **0.1326** LB/FT^3

c) The assumed density of the seawater over the range of the 50-FT depth is assumed to be 64.2-LB/FT^3.

d) Steady state volume of air in tube

Air out of each orifice at 25-FT depth	=	**0.296** ACFM	(use this value)
		0.526 SCFM	
Orifice count per ring	=	1,053	- -
Total ring count	=	1	- -
Total air flow into confined pipe	=	551	CFM
Assumed OD of HDPE tube	=	**72**	IN
HDPE wall thickness	=	**1.375**	IN
Assumed HDPE tube ID	=	69.25	IN
Assumed length of HDPE tube	=	**55**	FT
Total volume of HDPE tube	=	1,439	FT^3

Project: **Colman Dock Project**	By: jwk	Date: 14-Sep-17 **REV B**

Bubble Curtain Performance Calculations	Sheet: 23 of: 23

J. CONFINED RING AIR PUMP EFFECT (HDPE TUBE LENGTH CALC)

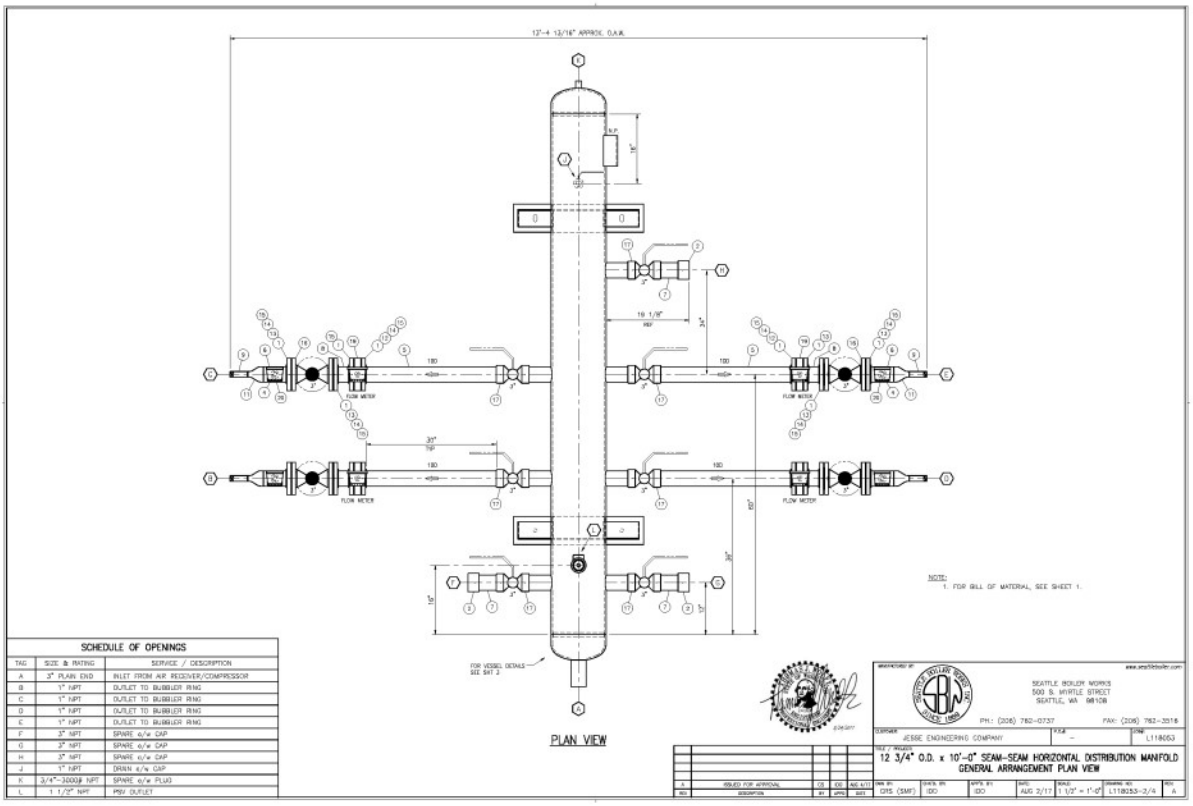
3) Behavior of air & water in confinement tube — 72"-DIA.

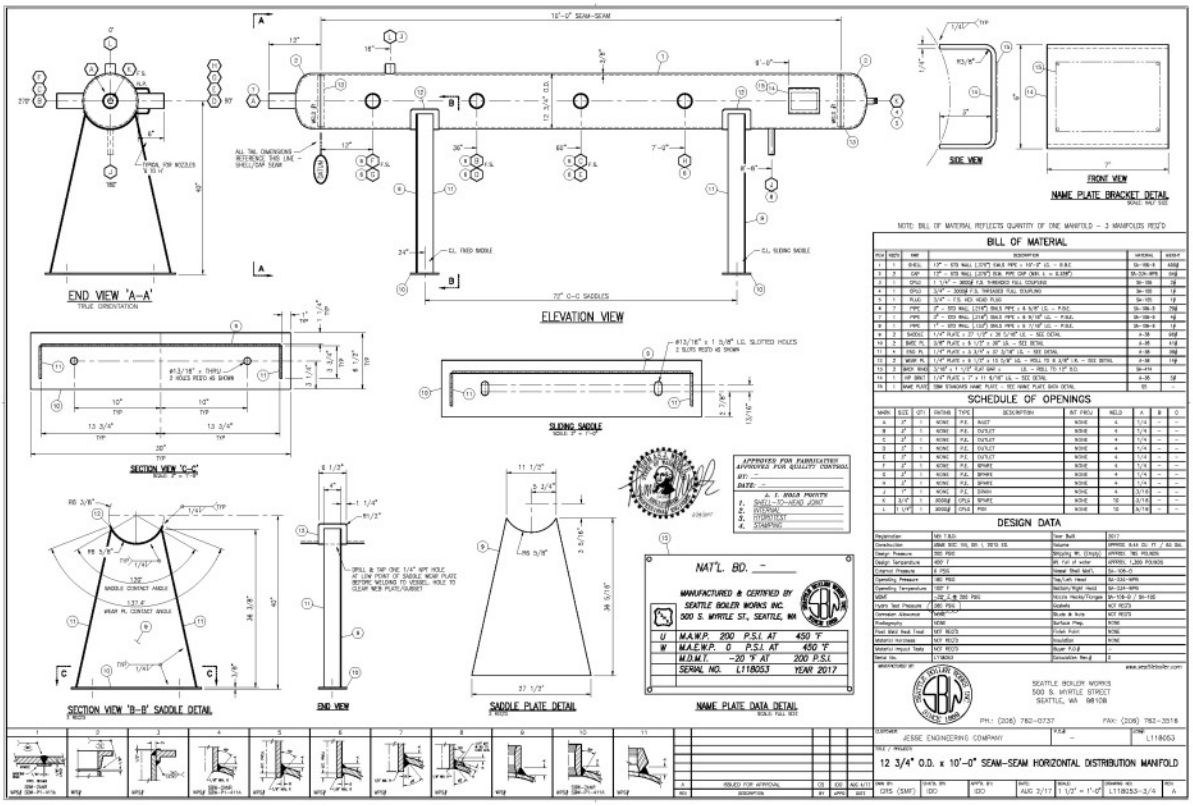
Pumping rate	=	**0.01**	GAL/DAY
Pipe diameter	=	**72.00**	IN
Submergence	=	**50.0**	FT
Lift	=	**0.5**	FT
cross-sectional area of pipe	=	28.274	FT^2
Pipe volume	=	1,427.85	FT^3
Pipe volume	=	7.48	GAL/FT^3
Vl (Flow rate)	=	0	GPM
A (Pipe area)	=	28.274	FT^2
L (Lift)	=	0.5	FT
D (Pipe diameter)	=	72	IN
Lf (density of fluid)	=	**64.2**	LBm/FT^3
S (submergence)	=	50.00	FT
Lg (Gas density)	=	**0.0765**	LBm/FT^3
Vg (Gas flow)	=	709	CFM
Actual flowrate out of (1) ring	=	551	CFM
Pressure	=	21.89	PSI

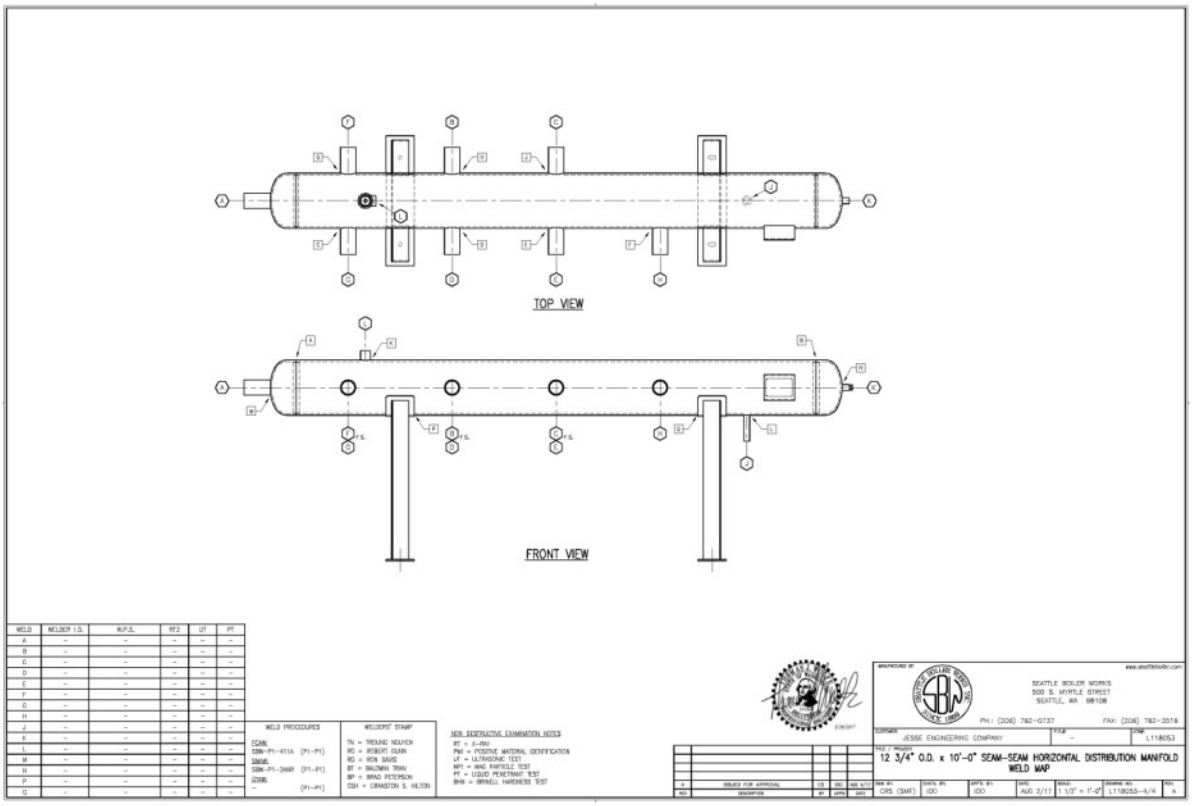
NOTE: This calculation shows that at a flowrate of 709-CFM and a tube length extending 0.5-FT (6-IN) MINIMUM above the surface, water will begin pumping out of the top of the HDPE tube.

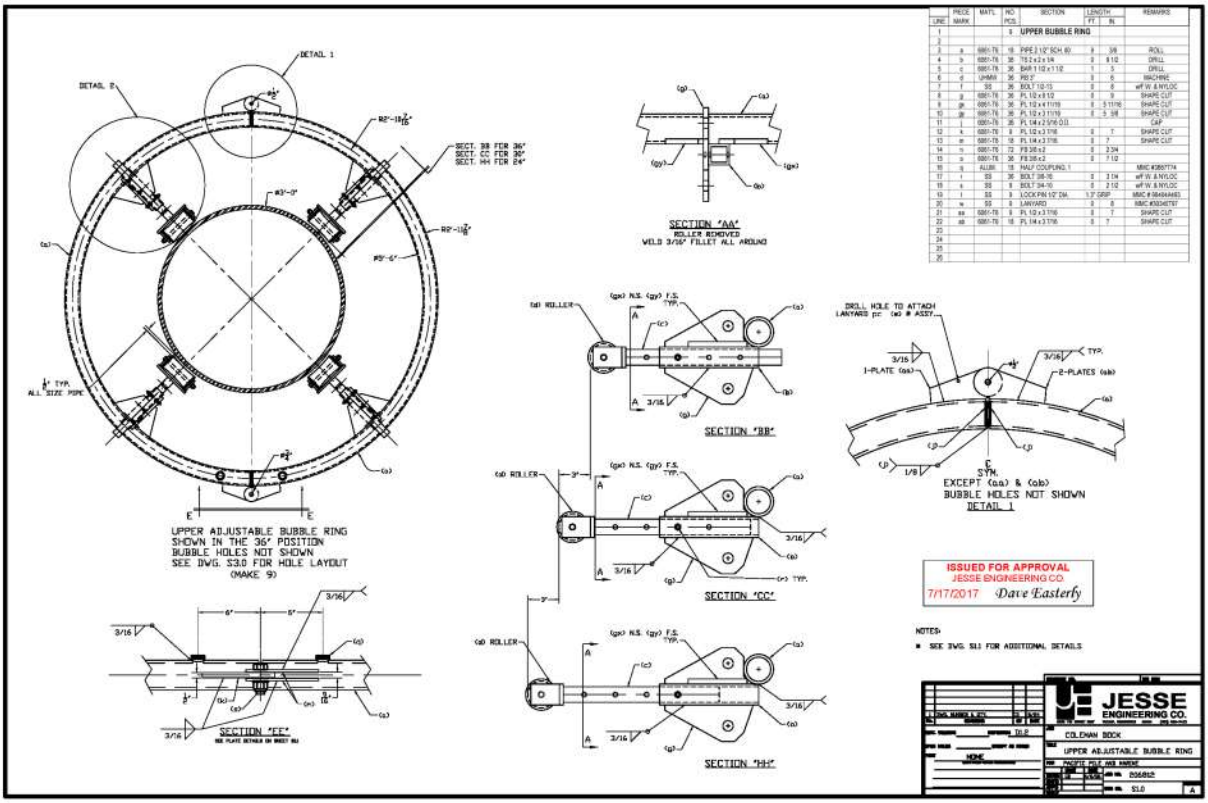
For the required air flowrate of 551-CFM (calculated in earlier calc.) the water will stay in the tube.

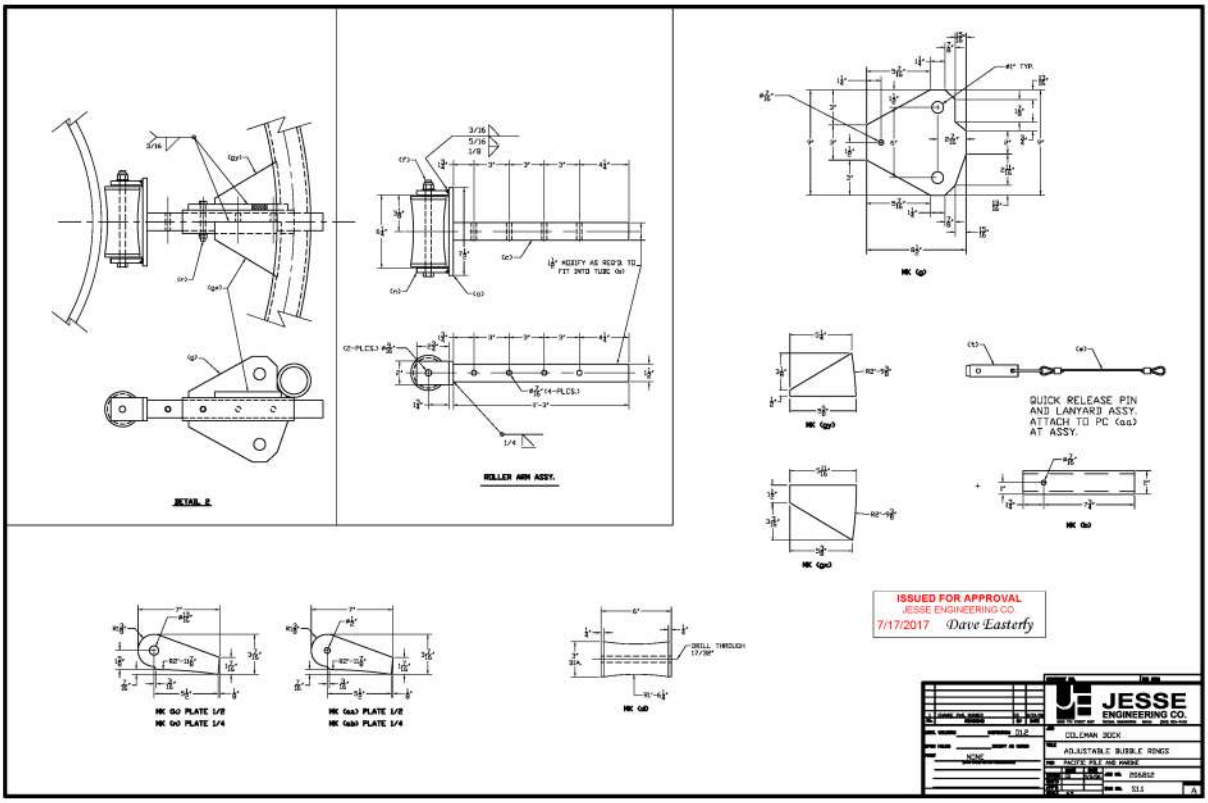
Project: **Colman Dock Project**	By: jwk	Date: 14-Sep-17 **REV B**

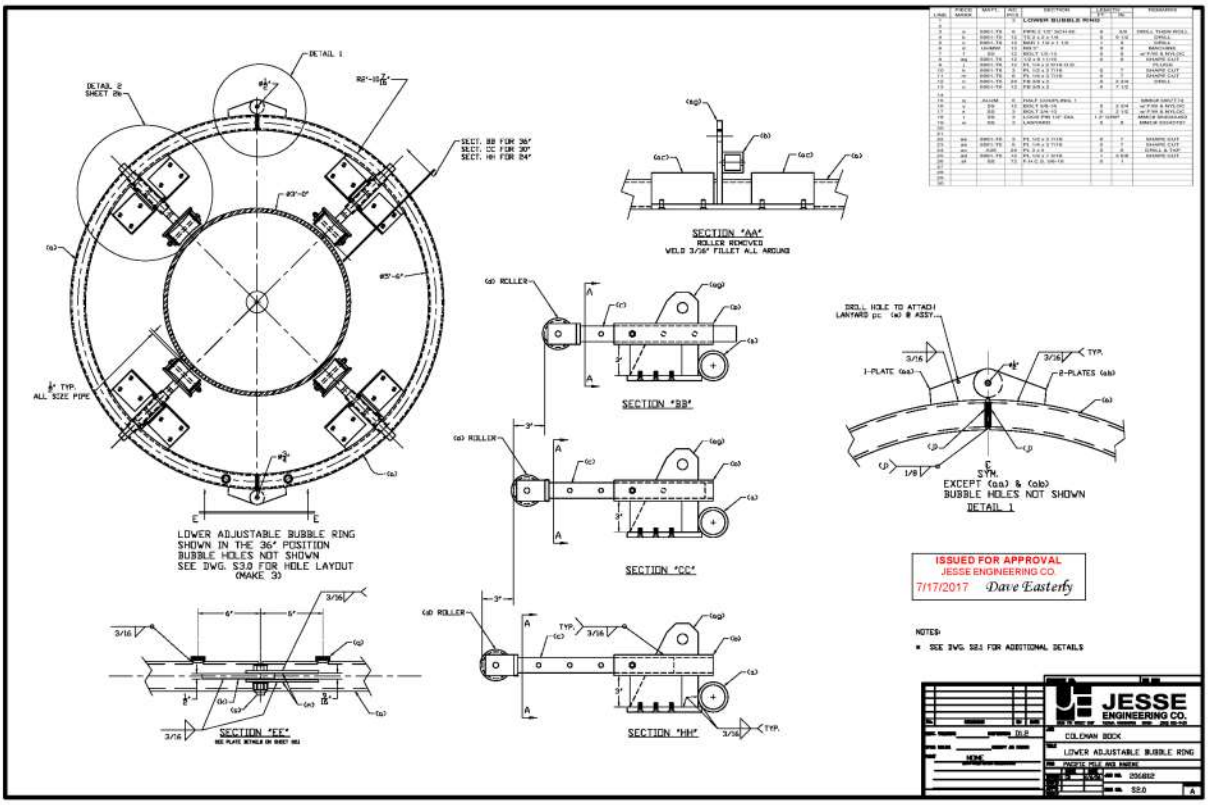

12'-4 13/16" APPROX. O.A.W.
PLAN VIEW
SCHEDULE OF OPENINGS
NOTE:
1. FOR BILL OF MATERIAL SEE SHEET 1.
SEATTLE BOILER WORKS
500 S. MYRTLE STREET
SEATTLE, WA 98108
PH: (206) 782-0737
FAX: (206) 782-3516
JESSE ENGINEERING COMPANY
L118053
12 3/4" O.D. x 10'-0" SEAM-SEAM HORIZONTAL DISTRIBUTION MANIFOLD
GENERAL ARRANGEMENT PLAN VIEW


END VIEW 'A-A'
ELEVATION VIEW
SECTION VIEW 'C-C'
SLIDING SADDLE
SECTION VIEW 'B-B' SADDLE DETAIL
END VIEW
SADDLE PLATE DETAIL
NAME PLATE DATA DETAIL
SIDE VIEW
FRONT VIEW
NAME PLATE BRACKET DETAIL
BILL OF MATERIAL
SCHEDULE OF OPENINGS
DESIGN DATA
NAT'L. BD. —
MANUFACTURED & CERTIFIED BY
SEATTLE BOILER WORKS INC.
500 S. MYRTLE ST., SEATTLE, WA
U M.A.W.P. 200 P.S.I. AT 450 °F
W M.A.E.W.P. 0 P.S.I. AT 450 °F
M.D.M.T. -20 °F AT 200 P.S.I.
SERIAL NO. L118053 YEAR 2017
SEATTLE BOILER WORKS
500 S. MYRTLE STREET
SEATTLE, WA 98108
PH: (206) 782-0737
FAX: (206) 782-3516
JESSE ENGINEERING COMPANY
L118053
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
JESSE ENGINEERING COMPANY
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 "EE"
SECTION "HH"
DETAIL 1
EXCEPT (aa) & (ab)
BUBBLE HOLES NOT SHOWN
ISSUED FOR APPROVAL
JESSE ENGINEERING CO.
7/17/2017 Dave Easterly
NOTES:
SEE DWG. S3.1 FOR ADDITIONAL DETAILS
JESSE ENGINEERING CO.
COLEMAN DOCK
UPPER ADJUSTABLE BUBBLE RING


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


DETAIL 1
DETAIL 2
SECT. BB FOR 36"
SECT. CC FOR 30"
SECT. HH FOR 24"
LOWER ADJUSTABLE BUBBLE RING
SHOWN IN THE 36" POSITION
BUBBLE HOLES NOT SHOWN
SEE DWG. S3.0 FOR HOLE LAYOUT
(MAKE 3)
SECTION "AA"
ROLLER REMOVED
WELD 3/16" FILLET ALL AROUND
SECTION "BB"
SECTION "CC"
SECTION "EE"
SECTION "HH"
DETAIL 1
EXCEPT (aa) & (ab)
BUBBLE HOLES NOT SHOWN
ISSUED FOR APPROVAL
JESSE ENGINEERING CO.
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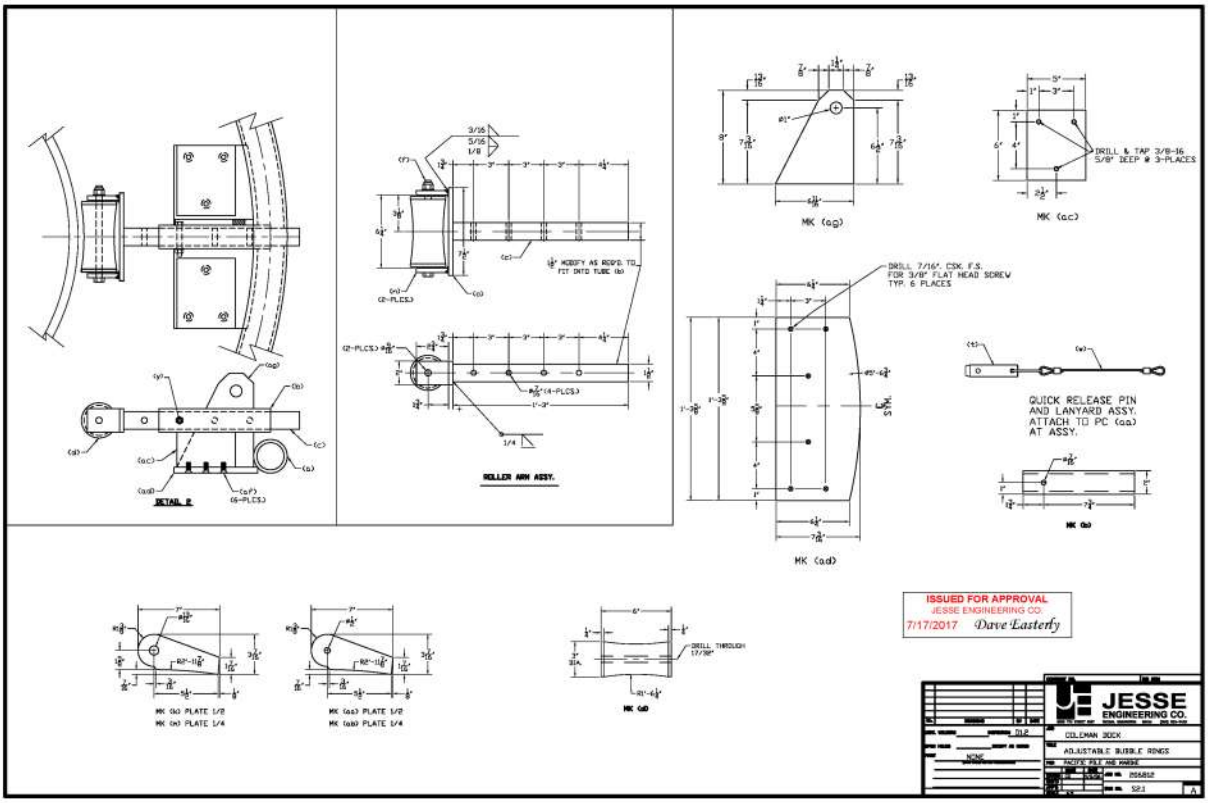
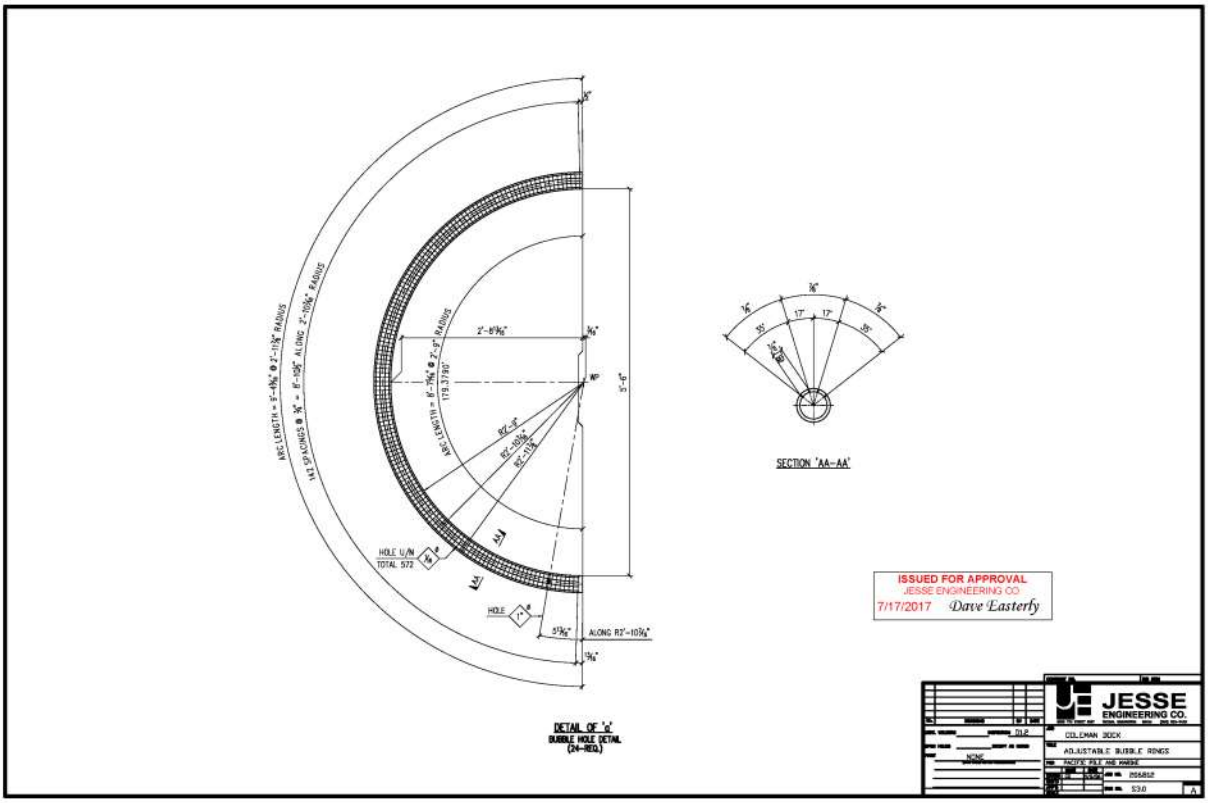
JESSE ENGINEERING CO.
COLEMAN DOCK
LOWER ADJUSTABLE BUBBLE RING


DETAIL B
ROLLER ARM ASSY.
MK (a,g)
MK (a,c)
DRILL & TAP 3/8-16 5/8" DEEP @ 3-PLACES
MK (a,d)
QUICK RELEASE PIN AND LANYARD ASSY. ATTACH TO PC (a,a) AT ASSY.
ISSUED FOR APPROVAL
JESSE ENGINEERING CO.
7/17/2017 Dave Easterly
JESSE ENGINEERING CO.
COLEMAN DOCK
ADJUSTABLE BUBBLE RINGS


SECTION 'AA-AA'
DETAIL OF 'A' BUBBLE HOLE DETAIL (24-REQ.)
ISSUED FOR APPROVAL
JESSE ENGINEERING CO.
7/17/2017 Dave Easterly
JESSE ENGINEERING CO.
COLEMAN DOCK
ADJUSTABLE BUBBLE RINGS