Final Interim Report

Underwater and Airborne Acoustic Monitoring for the U.S. Navy Elevated Causeway (ELCAS) Construction at the JEB Little Creek Naval Station: 26–28 April 2016

Submitted to:

Naval Facilities Engineering Command Atlantic under
HDR Environmental, Operations and Construction, Inc.
Contract No. N62470-10-D-3011, Task Order CTO33

NAVFAC
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November 2016

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Interim Summary

This report summarizes underwater and airborne acoustic monitoring results for the installation of piles associated with the training exercise related to the construction of the Elevated Causeway (ELCAS) at Joint Expeditionary Base (JEB) Little Creek, Norfolk, Virginia. On 26, 27, and 28 April 2016, multiple 24-inch (61-centimeter) diameter steel pipe piles were installed. All pile-driving was accomplished using an APE D19-42 Diesel Impact Hammer; which has a maximum rated energy of 47,132 foot-pounds (63.63 kilogram-force-meters) at setting 4. Noise levels were measured for nine piles. The hydroacoustic monitoring took place at three distances from the pile installation; *near* was on the pier 33 feet (10 meters) from the pile, *mid-range* was on a vessel 410 feet (125 meters) from the pile, and *far was located* 1,640 feet (500 meters) from the pile. The *near* and *mid-range* positions were manned, and the *far* position had an autonomous recording system in place. Four different measures of sound were made: root mean square (RMS), the Peak sound pressure level (SPL), sound exposure level (SEL), and cumulative SEL ($\text{SEL}_{\text{cumulative}}$). The compiled hydroacoustic data also allowed estimation of sound attenuation with range (propagation rate). **Table 1** is a summary of the average noise levels and range of noise levels measured during the pile-installation monitoring. The time history and one-third-octave-band spectra for all measurements at the 33 foot (10 meter) location are shown in **Appendix A**. These data were supplied to the Navy under a separate cover in a spreadsheet format.

During the shipment of the equipment on the airline, there was damage to key pieces of equipment. The power supply in the autonomous unit was damaged beyond repair and a decision was made to use the power supply from the *near* location rather than not measure at the *far* position where the autonomous unit was to be deployed. Doing this it was possible to measure at the near location but not recorded the data. The second damage was to the sound level meter (SLM) used at the *near* position, this was repairable and the meter was used to measure, unfortunately the meter did not capture the LZ_{eq} or the 1-second SEL live. The 1-second SEL was calculated using the data from the *mid-range* location. The offset from the peak levels to the 1-second SEL levels from the *mid-range* location was used to calculate the *near* 1-second SEL's. The replacement power supply that was used in the autonomous unit failed, causing recordings from the autonomous recorder to have a high-pitched squealing noise in the recorded data. The data at collected at this location was not usable. Based on the damage to the equipment, most likely due to rough handling by airline baggage personal, it was decided that in the future all equipment will be shipped either by FedEx or UPS. Table 1 shows the dates and locations where measurements were made.

On 26 April, sound measurements were completed on the installation of four piles. The average driving time per pile was approximately 11 minutes. The weather was good with a Beaufort Sea state of 2.

On 27 April, noise monitoring was conducted during the installation of two piles and the re-striking of two piles installed on the previous day. The average driving time for the two pile restrikes was 2 minutes; for the two new piles the driving time was approximately 5 minutes. The difference in the driving times for the restrikes and the new piles is that the restrikes were on piles that were partially installed the previous day and the new piles were driven the full

Table 1 – Data Summary of the Underwater Sound Levels

Start Time	Stop Time	Distance (meters)	Maximum Peak SPL (dB re 1µPa)	RMS SPL (dB re 1µPa)		SEL (dB re 1 µPa)		SEL$_{cumulative}$ (dB re 1µPa^2-sec)
				Average	Range	Average	Range	
26 April 2016								
13:55:39	14:04:33	10	211	193	190-196	180[1]	174-185[1]	208[1]
		125	194	179	173-183	167	159-172	192
		500	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
14:09:46	14:19:23	10	212	196	192-198	183[1]	179-187[1]	209[1]
		125	196	181	179-183	168	160-172	194
		500	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
14:23:11	14:34:16	10	212	195	192-198	183[1]	179-187[1]	210[1]
		125	196	180	175-183	168	160-171	195
		500	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
14:37:43	14:47:20	10	213	196	191-200	182[1]	177-188[1]	209[1]
		125	194	178	175-181	165	161-169	192
		500	--[2]	--[2]	--[2]	--[2]	--[2]	--[2]
27 April 2106								
10:44:07	10:45:17	10	213	198	194-199	186	182-188	203
		125	197	--[2]	--[2]	178	167-180	195
		500	182	167	160-168	154	148-156	171
15:39:17	15:43:53	10	211	196	194-198	183	177-188	207
		125	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
		500	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
15:47:57	15:53:47	10	212	196	194-201	184	173-192	208
		125	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
		500	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
15:57:45	16:01:19	10	211	196	187-201	184	173-197	203
		125	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
		500	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]

Start Time	Stop Time	Distance (meters)	Maximum Peak SPL (dB re 1µPa)	RMS SPL (dB re 1µPa)		SEL (dB re 1 µPa)		SEL$_{cumulative}$ (dB re 1µPa^2-sec)
				Average	**Range**	**Average**	**Range**	
28 April 2016								
07:30:10	07:38:22	10	211	195	191-198	183	177-187	207
		125	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
		500	183	167	164-170	155	143-159	179
07:43:58	07:54:27	10	209	194	192-196	181	174-183	207
		125	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
		500	183	167	165-170	155	147-159	180
07:59:08[4]	09:50:27	10	210	194	191-197	181	168-186	205
		125	--[3]	--[3]	--[3]	--[3]	--[3]	--[3]
		500	[5]	[5]	[5]	[5]	[5]	[5]

1 - Estimated from 125-meter data, not measured

2 - No data due to equipment failure

3 - No data due to rough seas; equipment not deployed

4 - Pile dropped several feet causing a strain on the crane and an approximate 1 hour and 45 minute delay in the driving

5 - Partial days of measurements; unit was retrieved early due to weather conditions.

depth. The weather was significantly worse with a Beaufort sea state of 4. The power supply on the autonomous recorder was replaced and the system was successfully deployed at the *far* location. The boat at the *mid-range* position broke its anchor line and made a retreat to safer water. Data at the mid-range and far position were only collected for the first pile, which was a restrike of the last pile driven on 26 April. Both the autonomous unit (*far*) and the boat (*mid-range*) did not measure the three pile driving events that occurred in the afternoon from approximately 15:39 to approximately 16:01.

On 28 April, noise monitoring was conducted on the installation of three piles. The driving time for the first two piles ranged from 8 to 10 minutes. The third pile dropped several feet after approximately 12 pile strikes. This caused the crane to be put under an unusual strain, and driving was stopped until the crane could be inspected and cleared to continue working. Driving was restarted at 09:45 and was completed without any further complications at 09:50. The weather was slightly worse than what was recorded on 27 April, with a Beaufort sea state of 5. The boat was able to deploy the *far* autonomous unit, but the captain felt it was not safe to attempt to anchor at the *mid-range* position and retreated to a safe harbor. After the first two piles were driven and it appeared that the seas were worsening they retrieved the autonomous unit and returned to port while the monitoring continued at the 10 meter location.

An attempt was made to measure airborne noise at fixed locations on all days at 49 feet (15 meters) from the pile installation. The objective was to place an SLM as close as possible to the pile being installed while remaining safely out of the way of construction. Unfortunately, the weather conditions were not acceptable for measuring airborne noise. There were winds above the recommended XX feet (5 meters) per second (9 knots) wind speed. The tripod used to hold the SLM was blown over, even after weights were added in an attempt to stabilize it. When the SLM blew over on the first day it was slightly damaged, causing not all the noise descriptors to be recorded. This was not noticed until after the pile driving was completed. Typically the LA_{eq}, LZ_{eq} and the LZ_{max} would be recorded; what were recorded were the LA_{eq}, the LZ_{eq} and the LA_{max}. The main difference was the L_{max} is recorded using the A-weighting rather than the Z-weighting (flat).

On 27 and 28 April, measurements were attempted, but the winds were blowing too strong for the tripod holding the SLM in place, and it was decided that rather than risk permanently damaging the SLM, the airborne measurements were canceled.

The airborne noise levels measured are shown in **Appendix B**.

Measurement Equipment

Reson Model TC-4013 and TC-4033 hydrophones were used for the underwater sound measurements. The signal from the hydrophones was fed directly into a Larson Davis Model 831 Precision Sound Level Meter (LDL 831). The LDL 831 captures the signal and stores the measurement data to be downloaded for analysis at the end of each day.

During impact driving, the maximum peak sound pressure (LZ_{peak}), the SEL, and the fast RMS SPL were measured “live” using the LDL 831. The LDL 831 SLM provided measurements of the un-weighted results for each data type, including the 1/3-octave-band spectra for the 1-second

LFZ_{max}. Additional analyses of the acoustical impulses were performed using the LDL 831 SLM as well.

Airborne measurements were made using a 0.5-inch G.R.A.S. Model 40AQ pre-polarized random-incidence microphone. The signal was fed into an LDL 831 SLM. The system was calibrated with a Larson Davis Model CAL200 Acoustic Calibrator. The microphone was calibrated at the beginning and end of each day. Pre-event and post-event calibration levels were within 0.1 dB.

Underwater Sound Descriptors

Acoustic monitoring may report data in several formats, depending on the type of operation generating the noise and the type of acoustic measurement. Impact pile driving produces pulse-type sounds, while vibratory pile installation or removal produces a more continuous type of sound.

For impact pile driving, data reporting included the RMS SPL, the SEL, cumulative SEL, and the L_{max} average 1/3 octave band frequency spectrum over the entire pile-driving event.

Airborne Sound Descriptors

A-weighted airborne data were collected for impact driving of the piles. During data collection, 1-second and 1-minute intervals were used for measuring airborne sounds. The airborne data represent the 1-second "fast" Z-weighted RMS (L_{max}). The tables in **Appendix B** show the data including the L_{eq} and L_{max}. A glossary at the end of the report contains the definition of the technical terms used.

Measurement Data Management

For each day of monitoring, digital data captured by the SLMs were downloaded to a computer. Some of the readings during the monitoring were recorded in field notebooks to track levels and assess the ranges needed for monitoring.

Quality Control

The underwater and airborne measurement systems were calibrated prior to use in the field with a G.R.A.S. Type 42AA pistonphone and hydrophone coupler. For the underwater systems, the pistonphone calibrator produces a continuous 136.4 or 145.3 dB (referenced to 1 microPascal) tone at 250 Hertz (Hz). For the airborne system the pistonphone produces a continuous 114.0 dB (referenced to 20 microPascals) tone at 250 Hz. The SLMs are calibrated to this tone, and it is measured as well as recorded by the SLM at the beginning of all the data files. The system calibration status was checked at the end of the measurement event by both measuring the calibration tone and recording the post-measurement tone on the media files. Signal analysis included the measurement of the calibration tone at the beginning and end of recording events. All systems were found to be within 0.5 dB of the calibration levels. The pistonphone output has been certified at an independent facility.

All field notes were recorded in water-resistant field notebooks. Notebook entries include calibration notes, measurement positions (i.e., distance from the source and depth of the sensor), system gain settings, and the equipment used to make each measurement. Notebook entries were copied after each measurement day and filed for safekeeping. Recorded media were labeled and stored for subsequent analysis.

Propagation Rate

The propagation rate, or acoustic spreading loss, was calculated for the pile extraction. The term “rate” applies to the logarithmic attenuation of noise levels as sound propagates away from the source. Empirically derived propagation rates like these provide a valuable utility in estimating sound harassment areas for future projects. The peak SPL, RMS SPL, and SEL propagation curves are shown in **Figure 1.** These acoustic spreading-loss curves can be used to calculate the overall distances to the various regulatory threshold levels for the peak SPL, RMS SPL, and SEL. The dataset of measurement distances for the piles ranged from 33 to 1,640 feet (10 to 500 meters). The average propagation loss for the piles was 16.28 log$_{10}$ for the peak SPL, 16.01 log$_{10}$ RMS SPL values, and 15.85 log$_{10}$ for the SEL values, which are within the expected ranges for these types of piles.[1]

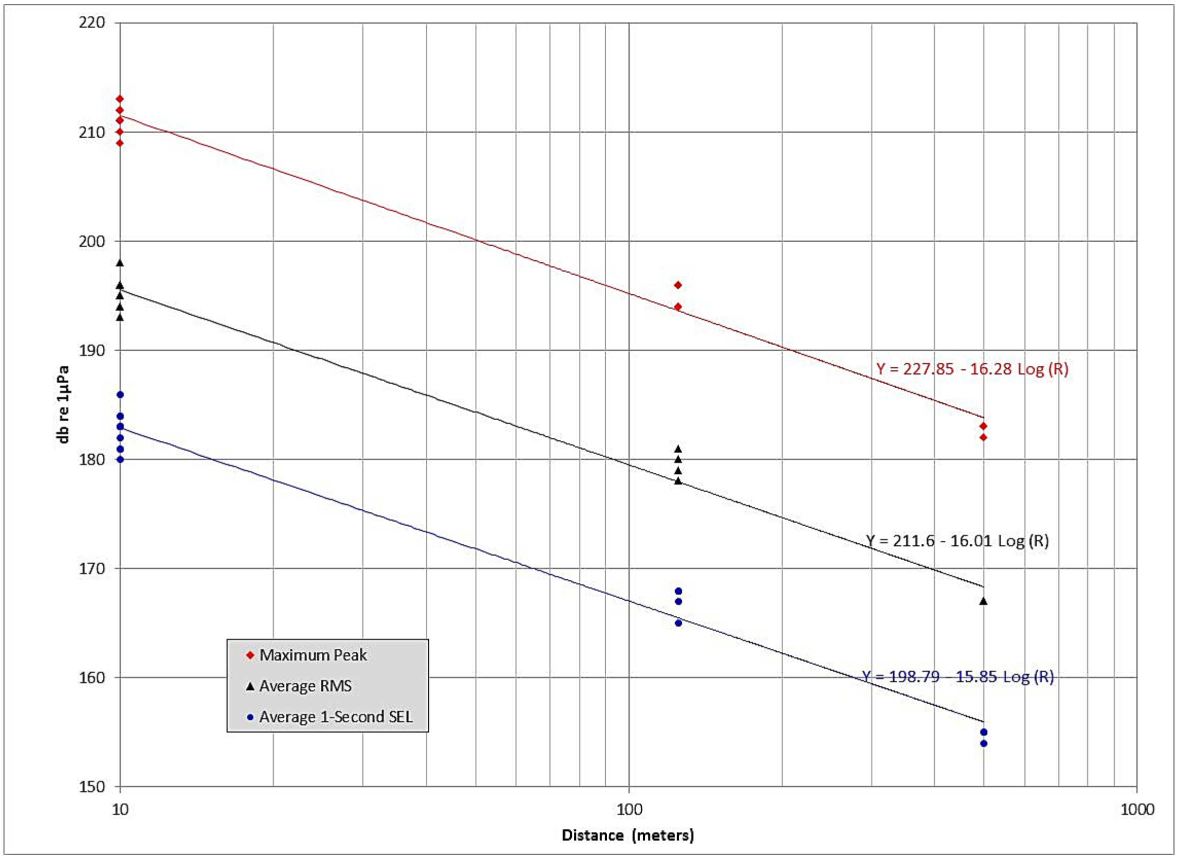

Figure 1 – Acoustic Spreading Loss of Maximum Peak SPL, Average RMS SPL, and Average 1-second SEL.

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[1] Caltrans' *Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish* Nov 2015, **http://www.dot.ca.gov/hq/env/bio/fisheries_bioacoustics.htm**.

Spectrum Analysis

The 1/3-octave-band spectra for the LZI_{max} and the LZ_{eq} for both the background and typical pile driving are shown **Figures 2** and **3**. There is an increase in the energy across the whole spectral range with the largest increase between 200 Hz and 2.5 kilohertz (kHz). The LZI_{max} spectrum was also filtered to show the levels.

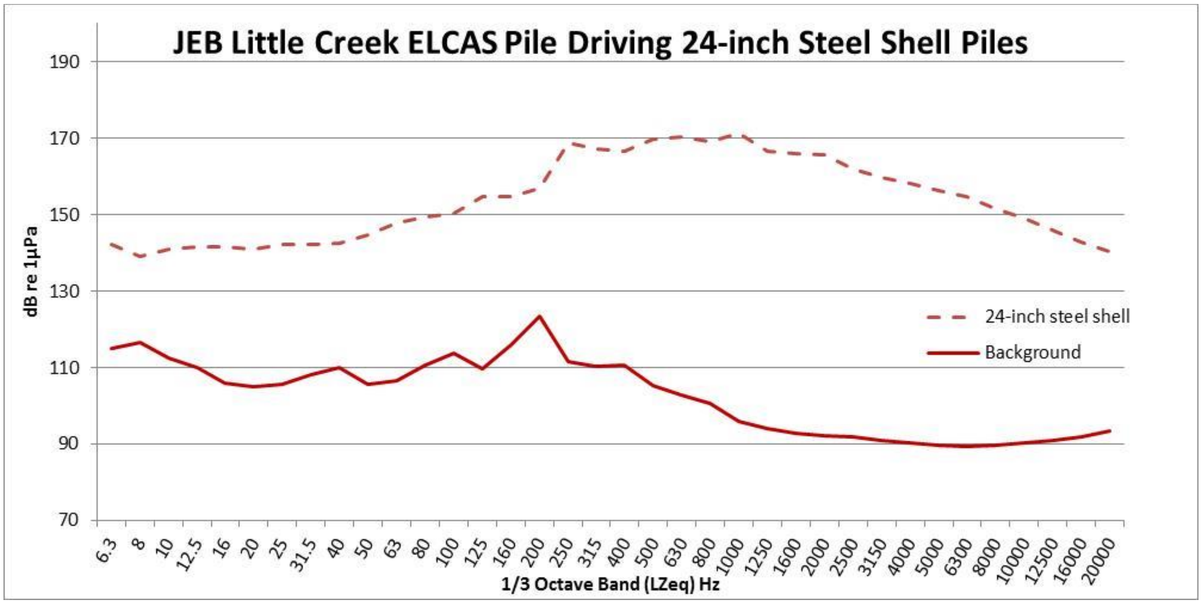

Figure 2 – Comparison of 1/3-Octave Band (LZ_{eq}) Pile-Driving Spectra and Background Spectra Measured at 33 feet (10 meters).

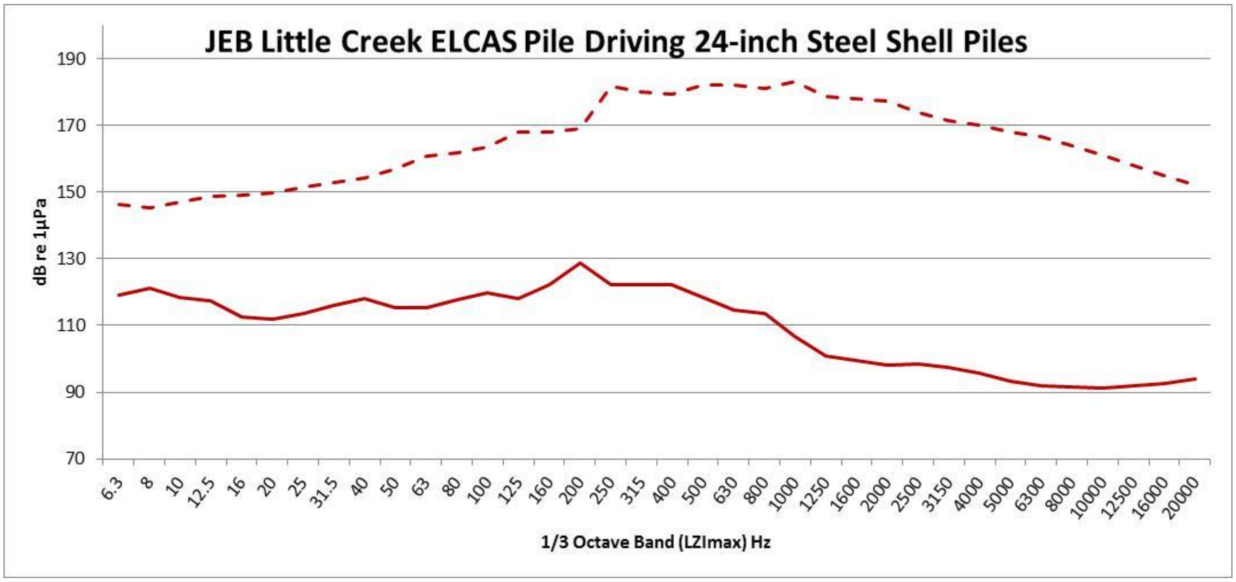

Figure 3 – Comparison of 1/3-Octave Band (LZI_{max}) Pile-Driving Spectra and Background Spectra Measured at 33 feet (10 meters).

Results

The times to drive a pile ranged from just under 4 minutes to a little over 11 minutes, excluding the re-tap of the first pile on 27, April. The average underwater Peak SPL from the pile driving was 212 dB at 10 meters. The average RMS SPL at 10 meters was 196 dB, and the average SEL was 183 dB. The cumulative SEL per pile at 10 meters ranged from 203 dB to 210 dB, the daily cumulative SEL at 10 meters was 215 and 217 dB for the two days of measurements. The distance to the 187 dB cumulative criteria based on the calculated attenuation rate would be approximately 576 and 768 meters, respectively.

Discussion

The measured noise levels were higher than typically measured for 24-inch steel piles; typically the peak SPL for a 24-inch steel pile would be approximately 208 dB. The difference between the different metrics, the peak and RMS and the RMS and the SEL, were in the range that would be measured. The calculated propagation rate is similar to that measured for this type pile in other locations. Overall, other than the slightly higher levels measured, these results are what would be typically expected when driving an unattenuated 24-inch steel shell pile. One recommendation to reduce the underwater noise levels from future ELCAS operations would be with the use of a bubble ring around the piles being driven. If properly designed it has been shown that the addition of a bubble ring has little effect on the number of piles that can be driven in a day. For the Ten Mile River Replacement Project north of Fort Bragg, California they were driving up to sixteen 30-inch steel piles per day with the use of a bubble ring. The SPLs can be reasonably expected to be reduced by 10 dB which on this project would reduce the cumulative SEL impact zone from approximately 576 and 768 meters to 182 and 137 meters. This would reduce the acres of impact from approximately 229 and 128 acres to 13 and 7 acres.

There were a few problems, some that can be corrected and others that could not be corrected. The weather, which caused numerous issues, is a primary factor that could not be controlled. Because of the scheduling for the construction project the measurements could not be postponed until the weather cleared up. Factors that can be corrected and have already been addressed for future work include changing the method in which the equipment is shipped and realizing that the equipment is sensitive and while typically there are no issues with tits stability, adding a complete set of spare parts is now part of the preparation for al projects. This will allow full operation of all systems regardless of a component failure. Below is a description of the problems that occurred for this project and how they were dealt with.

Prior to pile driving, it was noted that some of the equipment shipped out had been damaged in transit. Using the spare parts and removing part of the equipment from the equipment scheduled for the 33-foot (10-meter) location, we were able to set up the equipment at all locations, unfortunately the autonomous unit failed before the measurements began. On the second day, all systems were operational. However, due to weather conditions, measurements were not made at the 410-foot (125-meter) location on days two and three. During the first day, the weather was fine and measurements were made at the various locations without too much of a problem. On the second day the winds picked up and made it impossible to keep the boat on station. On the third day, after setting the autonomous unit at 1,640 feet (500 meters), they made an attempt to set anchor with no success; the wind and waves were too great. A similar condition was true for the airborne measurements; the winds were so great that the tripod holding the SLM would not stand up and with the wind as high as it was the measurements would have been contaminated and not valid.

Glossary

Ambient sound – Normal background noise in the environment that has no distinguishable sources.

Ambient sound level – The background sound pressure level at a given location, normally specified as a reference level to study a new intrusive sound source.

Amplitude – The maximum deviation between the sound pressure and the ambient pressure.

Background level – Similar to ambient sound level with the exception that is a composite of all sound measured during the construction period minus the pile removal.

Cumulative sound exposure level ($SEL_{cumulative}$) – In an evaluation of pile-driving impacts, it may be necessary to estimate the cumulative SEL associated with a series of pile-strike events. $SEL_{cumulative}$ can be estimated from the single-strike SEL and the number of strikes that likely would be required to place the pile at its final depth by using the following equation:

$$SEL_{cumulative} = SEL_{single\ strike} + 10*\log(\#\ of\ pile\ strikes)$$

Decibel (dB) – A customary scale most commonly used for reporting levels of sound. A difference of 10 dB corresponds to a factor of 10 in sound power. A unit describing the amplitude of sound, equal to 20 times the logarithm to the base 10 of the ratio of the pressure of the sound measured to the reference pressure. The reference pressure for water is 1 microPascal, and for air it is 20 microPascals (the threshold of healthy human auditory sensitivity).

ELCAS – Elevated Causeway

Fast, Slow, and Impulse – Most sound level meters have two conventional time weightings, F = Fast and S = Slow with time constants of 125 milliseconds (ms) and 1,000 ms, respectively. Some also have I = Impulse time weighting, which is a quasi-peak detection characteristic with rapid rise time (35 ms) and a much slower 1.5-second decay.

- F = 125 ms up and down
- S = 1 second up and down
- I = 35 ms while the signal level is increasing or 1,500 ms while the signal level is decreasing.

Frequency – The number of complete pressure fluctuations per second above and below atmospheric pressure, measured in cycles per second (Hertz [Hz]). Normal human hearing is between 20 and 20,000 Hz. Infrasonic sounds are below 20 Hz and ultrasonic sounds are above 20,000 Hz.

Frequency spectrum – The distribution of frequencies that comprise a sound.

Hertz (Hz) – The units of frequency where 1 Hz equals 1 cycle per second.

JEB – Joint Expeditionary Base

Kilohertz (kHz) – 1,000 Hz

L_{eq} – *Equivalent Average Sound Pressure Level (or Energy-Averaged Sound Level).* The decibel level of a constant noise source that would have the same total acoustical energy over the same time interval as the actual time-varying noise condition being measured or estimated. Leq values must be associated with an explicit or implicit averaging time in order to have practical meaning. The use of A-weighted, C-weighted, or Z-weighted (flat) decibel units sometimes is indicated by LA_{eq}, LC_{eq}, or LZ_{eq}, respectively

LZ_{eq} – Z-weighted, Leq, sound pressure level

LZF – Z-weighted Fast RMS Sound Pressure Level

LZF_{max} – Maximum Z-weighted Fast RMS Sound Pressure Level

LZI_{max} – Maximum Z-weighted Impulse RMS Sound Pressure Level

LZ_{max} – Maximum Sound Pressure level during a measurement period or a noise event.

LZ_{peak} – Z-weighted peak sound pressure level

microPascal (µPa) – The Pascal (symbol Pa) is the SI unit of pressure. It is equivalent to one Newton per square meter. There are 1,000,000 microPascals in one Pascal.

Peak sound pressure level (L_{PEAK}) – The largest absolute value of the instantaneous sound pressure. This pressure is expressed in decibels (referenced to a pressure of 1 µPa for water and 20 µPa for air) or in units of pressure, such as µPa or Pounds per Square Inch.

Root mean square (RMS) sound pressure level – Decibel measure of the square root of mean square (RMS) pressure. For impulses, the average of the squared pressures over the time that comprise that portion of the waveform containing 90 percent of the sound energy of the impulse.

SLM – Sound level meter

Sound – Small disturbances in a fluid from ambient conditions through which energy is transferred away from a source by progressive fluctuations of pressure (or sound waves).

Sound exposure – The integral over all time of the square of the sound pressure of a transient waveform.

Sound exposure level (SEL) – The time integral of frequency-weighted squared instantaneous sound pressures. Proportionally equivalent to the time integral of the pressure squared. Sound energy associated with a pile driving pulse, or series of pulses, is characterized by the SEL. SEL is the constant sound level in one second, which has the same amount of acoustic energy as the original time-varying sound (i.e., the total energy of an event). SEL is calculated by summing the cumulative pressure squared over the time of the event ($1\mu Pa^2$-sec**)**.

Sound pressure level (SPL) – An expression of the sound pressure using the decibel (dB) scale and the standard reference pressures of 1 μPa for water, and 20 μPa for air and other gases. Sound pressure is the sound force per unit area, usually expressed in microPascals (or microNewtons per square meter), where 1 Pascal is the pressure resulting from a force of 1 Newton exerted over an area of 1 square meter. The SPL is expressed in dB as 20 times the logarithm to the base 10 of the ratio between the pressure exerted by the sound to a reference sound pressure. SPL is the quantity directly measured by a sound level meter.

Z-weighted – Z-weighting is a flat frequency response of 10 Hz to 20 kHz ±1.5 dB. This response replaces the older "Linear" or "Unweighted" responses as these did not define the frequency range over which the meter would be linear

A-Weighted - The sound pressure level in decibels as measured on a sound level meter using the A-weighting filter network. The A-weighting filter de-emphasizes the very low and very high frequency components of the sound in a manner similar to the frequency response of the human ear and correlates well with subjective reactions to noise

C-Weighted - C- Weighting is a standard weighting of the audible frequencies commonly used for the measurement of Peak Sound Pressure level. Measurements made using C-weighting are usually shown with dB(C) to show that the information is C-weighted decibels.

The sound pressure level in decibels as measured on a sound level meter using the A-weighting filter network. The A-weighting filter de-emphasizes the very low and very high frequency components of the sound in a manner similar to the frequency response of the human ear and correlates well with subjective reactions to noise

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A

Time History of Pile Removals and 1/3 Octave Band Spectra

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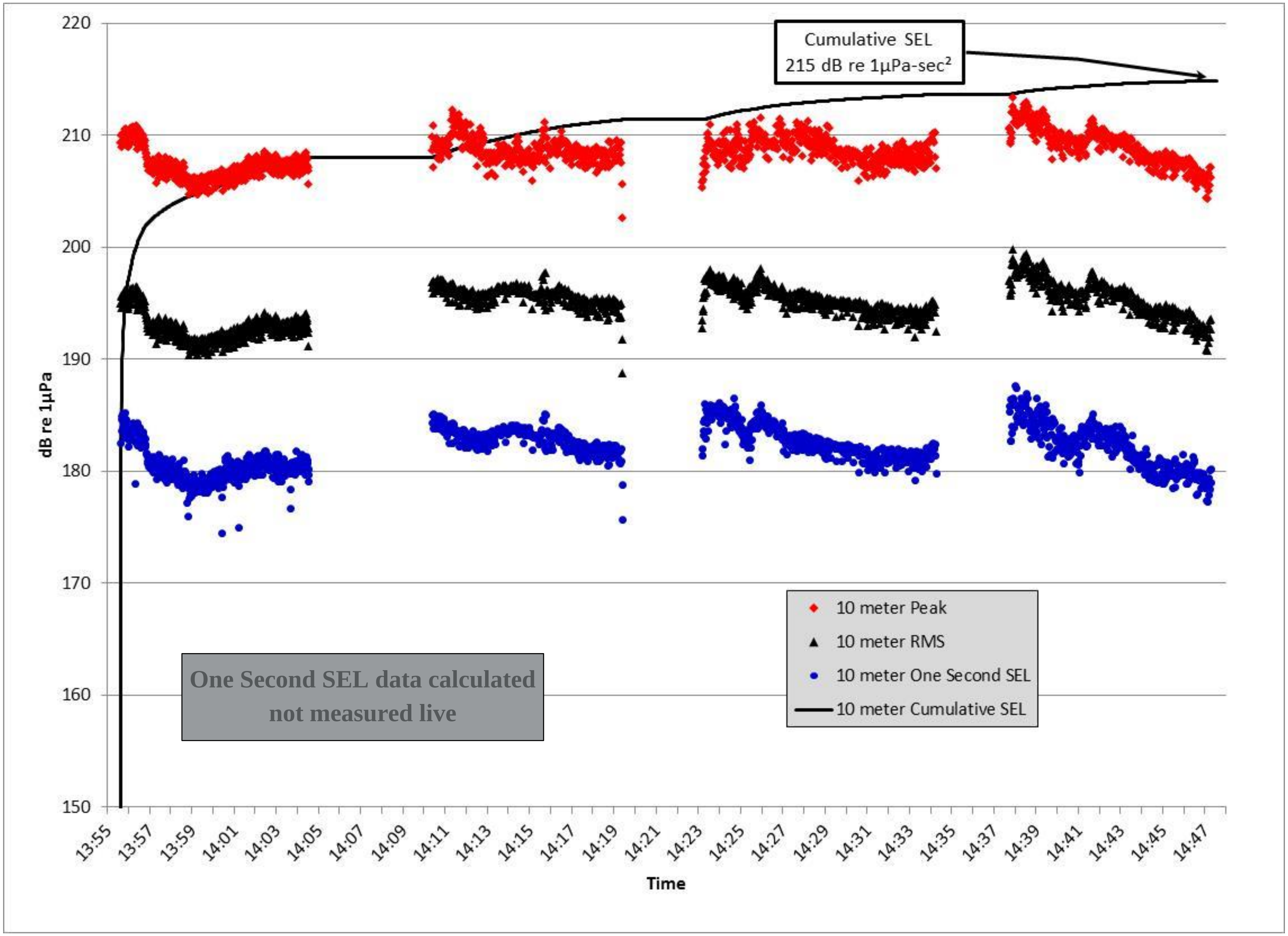

Figure A-1 – Underwater Noise Recorded at 33 feet (10 meters) ELCAS Pile #1 at 10 meters at JEB Little Creek, 26 April 2016.

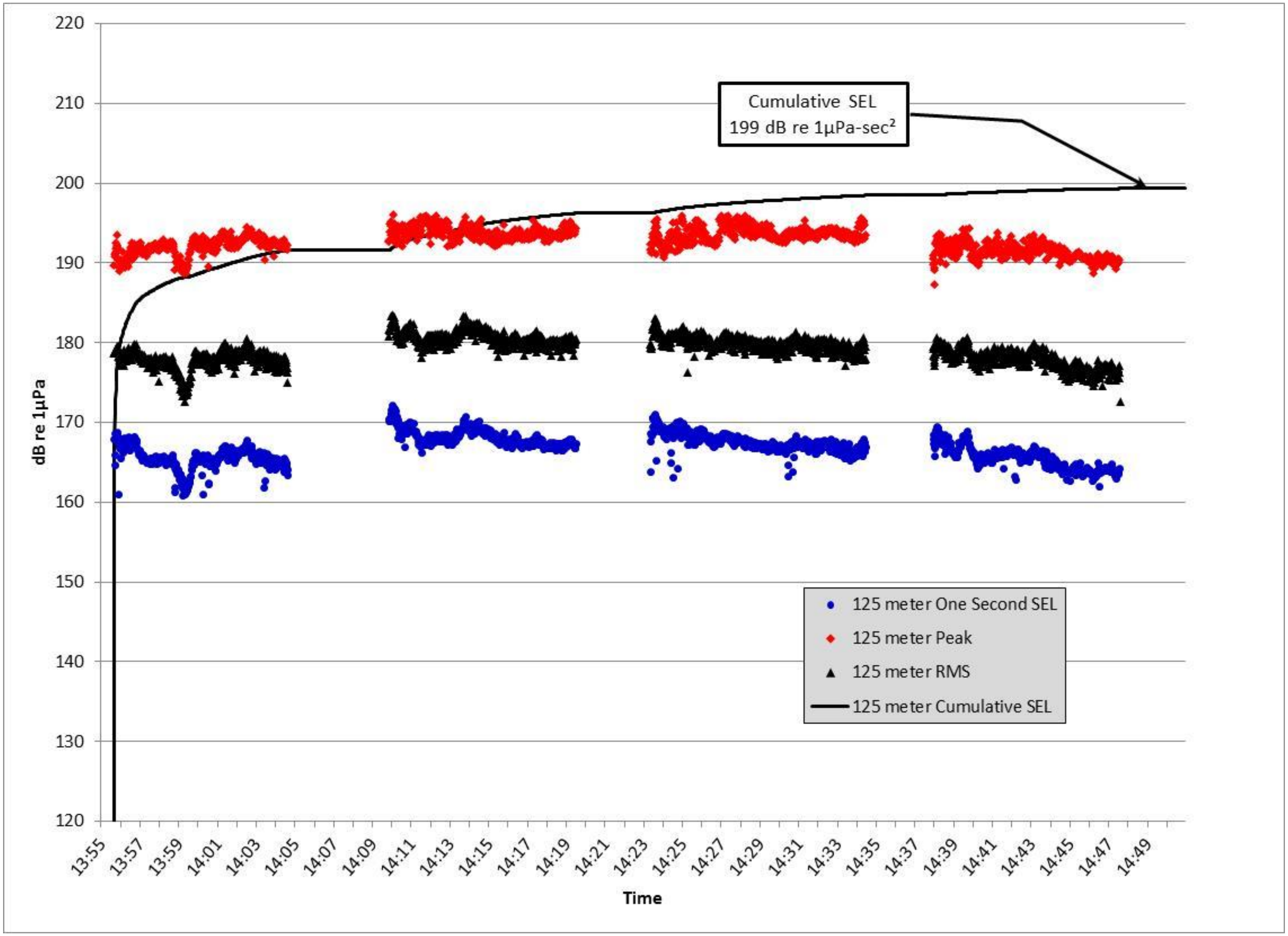

Figure A-2 – Underwater Noise Recorded at 410 feet (125 meters) ELCAS Piles at JEB Little Creek, 26 April 2016.

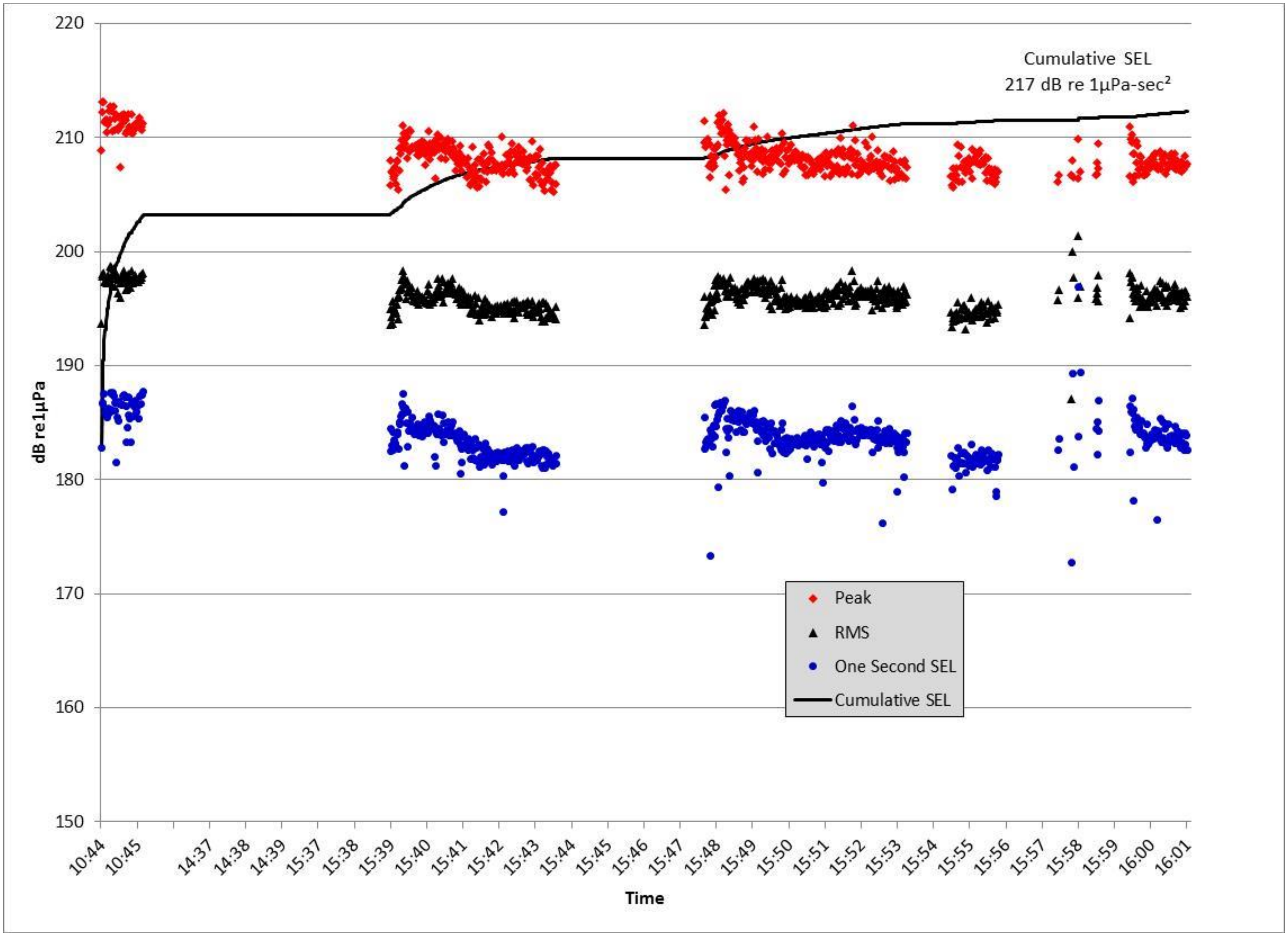

Figure A-3 – Underwater Noise Recorded at 33 feet (10 meters) ELCAS Piles at JEB Little Creek, 27 April 2016.

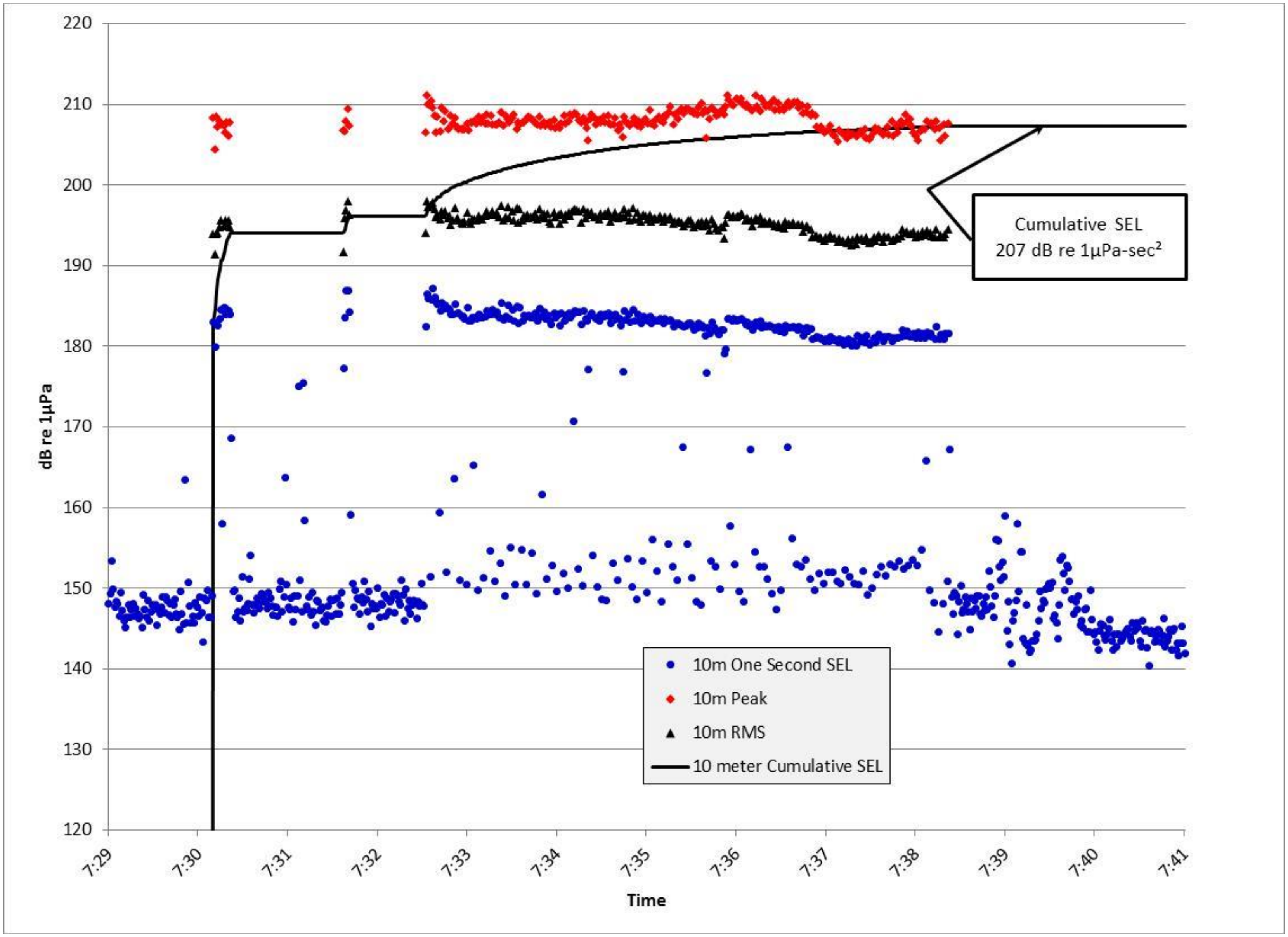

Figure A-4 – Underwater Noise Recorded at 33 feet (10 meters) ELCAS Pile #1 at JEB Little Creek, 28 April 2016.

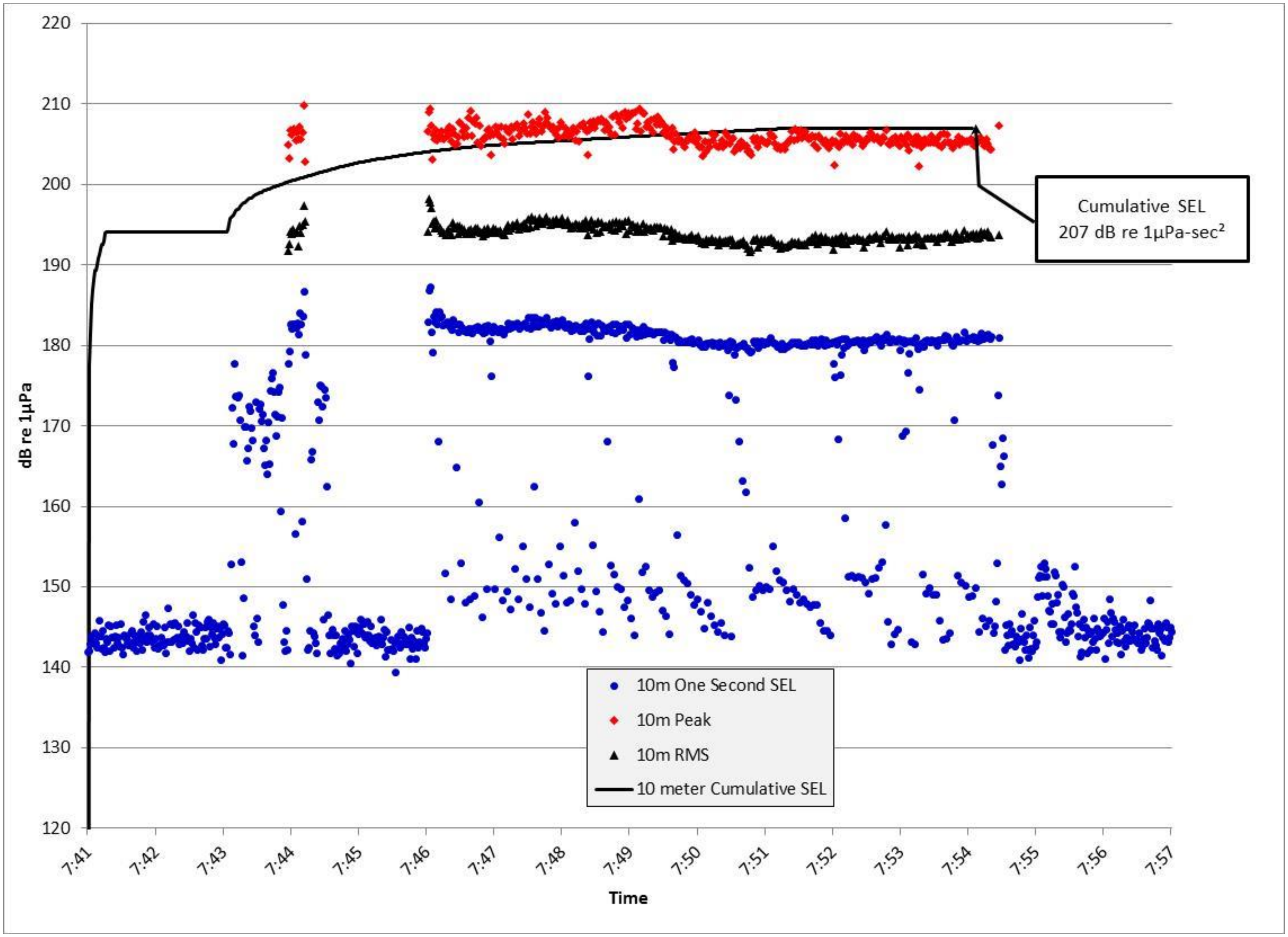

Figure A-5 – Underwater Noise Recorded at 33 feet (10 meters) ELCAS Pile #2 at JEB Little Creek, 28 April 2016.

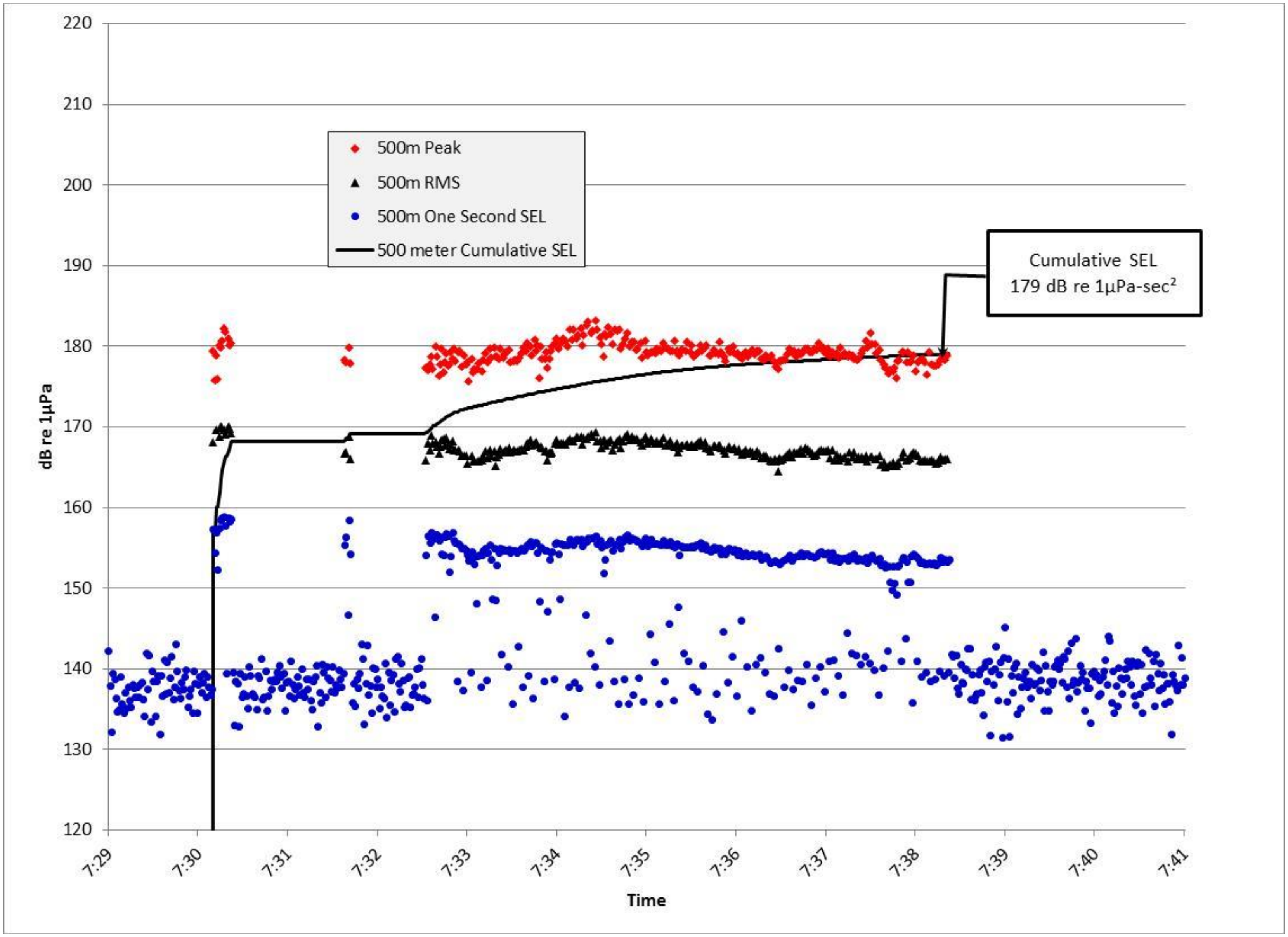

Figure A-6 – Underwater Noise Recorded at 1,640 feet (500 meters) ELCAS Pile #1 at JEB Little Creek, 28 April 2016.

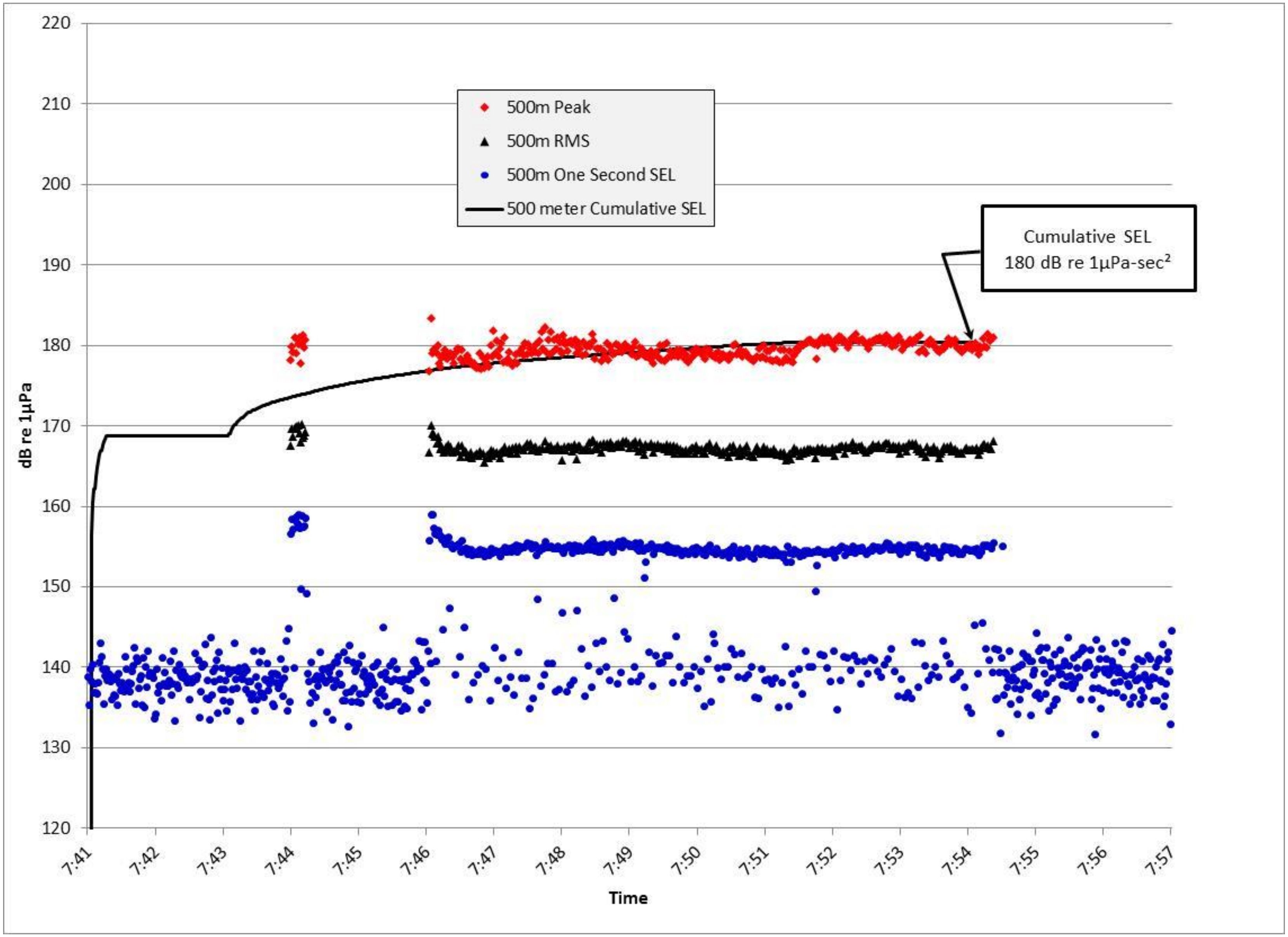

Figure A-7 – Underwater Noise Recorded at 1,640 feet (500 meters) ELCAS Pile #2 at JEB Little Creek, 28 April 2016.

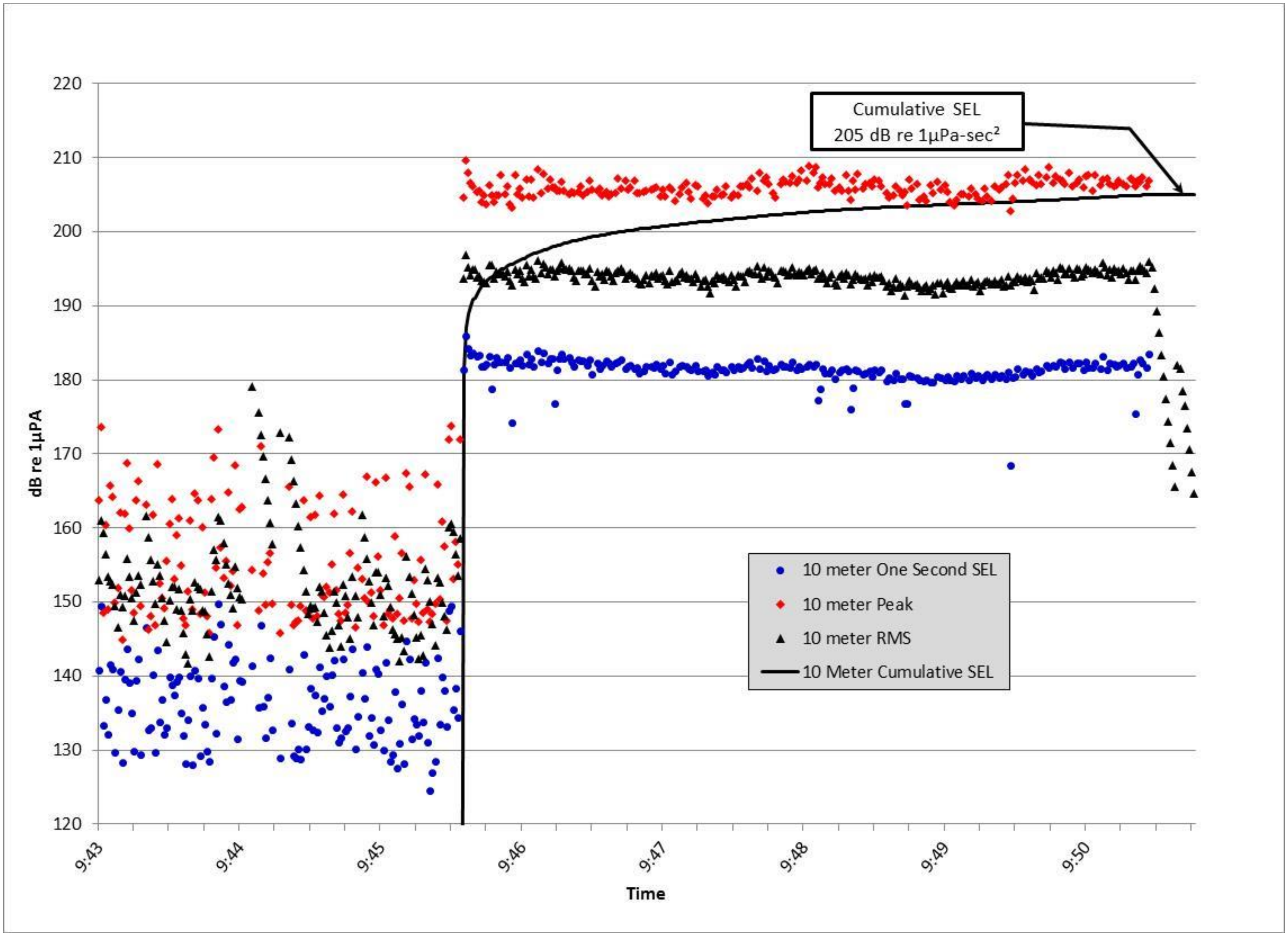

Figure A-8 – Underwater Noise Recorded at 33 feet (10 meters) ELCAS Pile #3 at JEB Little Creek, 28 April 2016.

B

Time History and 1-Minute Airborne Data

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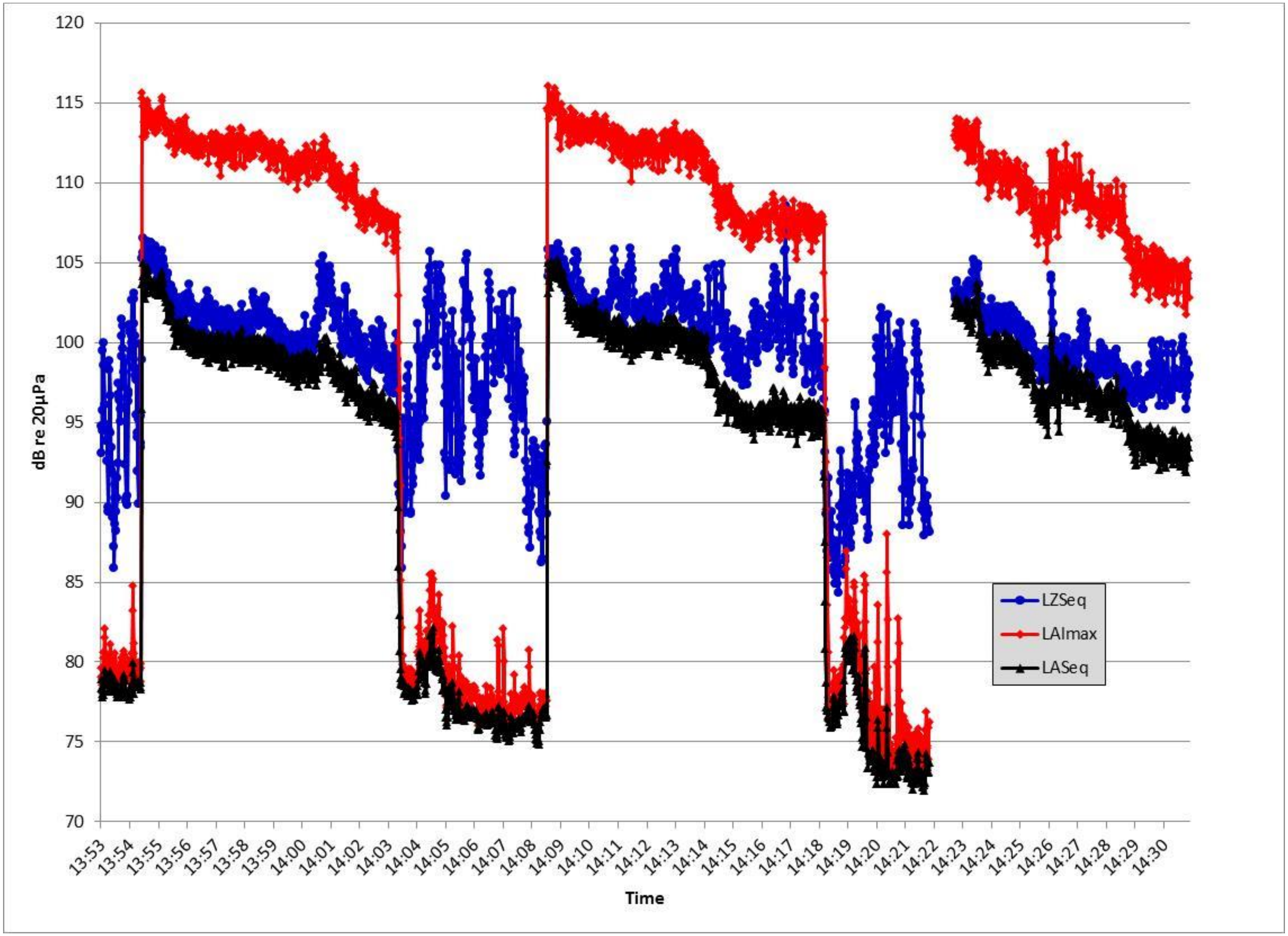

Figure B-1 – Airborne Noise SPLs Recorded During Installation of ELCAS Piles at JEB Little Creek, 26 April 2016.

Table B-1 – Airborne Data for Piles (dBA)

Date	Pile ID	Start Time	End Time	LZ_{eq} [1]	LA_{max} [1]	LA_{eq} [1]	Notes
4/26/2016	1	13:55:39	14:03:33	102	115	100	The high winds had an effect on the measured levels
	2	14:09:46	14:19:33	102	116	100	
	3	14:23:11	14:30:53	100	114	97	
	4	N/D	N/D	N/D	N/D	N/D	
4/27/2016	1	N/D	N/D	N/D	N/D	N/D	No airborne data due to high winds
	2	N/D	N/D	N/D	N/D	N/D	
	3	N/D	N/D	N/D	N/D	N/D	
	4	N/D	N/D	N/D	N/D	N/D	
4/28/2016	1	N/D	N/D	N/D	N/D	N/D	No airborne data due to high winds
	2	N/D	N/D	N/D	N/D	N/D	
	3	N/D	N/D	N/D	N/D	N/D	

1 LZeq and LAeq are the averages over the whole event and LAmax is the maximum level during the event.
N/D = no data; SLM removed due to high winds.

Table B-2 – One-Minute Airborne Noise Data (db re 20 μPa). The Areas Shaded Gray Are When Pile Installations Occurred.

Time	LA_{eq}	LA_{max}	LA_{eq}
26 April 2016			
13:53:00	78.4	79.7	78.9
13:54:00	101.3	106.4	110.1
13:55:00	101.9	106.0	111.7
13:56:00	99.9	102.6	110.6
13:57:00	99.7	102.5	110.5
13:58:00	99.6	102.1	110.5
13:59:00	98.7	101.5	109.6
14:00:00	98.8	102.1	109.7
14:01:00	97.8	101.1	108.3
14:02:00	96.2	98.9	106.3
14:03:00	91.1	98.0	101.1
14:04:00	79.8	82.6	81.0
14:05:00	77.0	79.0	77.6
14:06:00	76.3	77.3	76.7
14:07:00	76.2	77.6	76.8
14:08:00	101.0	106.6	109.7
14:09:00	102.3	105.5	111.9
14:10:00	101.1	104.2	111.5
14:11:00	100.3	103.2	110.5
14:12:00	100.5	103.2	110.7
14:13:00	100.0	103.1	110.4
14:14:00	97.4	101.8	107.9
14:15:00	95.4	98.4	105.7
14:16:00	95.7	99.0	106.1
14:17:00	95.4	98.1	105.7
14:18:00	88.1	97.7	98.4
14:19:00	78.2	82.2	79.7
14:20:00	73.6	78.3	76.7
14:21:00	73.1	74.6	73.8
14:22:00	102.0	104.3	111.5
14:23:00	101.2	105.3	110.4
14:24:00	99.5	102.5	108.8
14:25:00	97.5	101.1	107.0
14:26:00	97.6	102.0	108.1
14:27:00	96.7	100.4	107.1
14:28:00	95.9	99.7	106.0
14:29:00	93.6	96.5	102.9
14:30:00	93.3	96.0	102.4

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