Robert Miner Dynamic Testing of Alaska Inc.

Dynamic Measurements and Analyses for Deep Foundations

September 29, 2018

Joe Lyman
Turnagain Marine
8241 Diamond Hook Drive, Unit A
Anchorage, AK 99507

Re: Sound Source Verification
Down-hole Hammer Operation, August 13 & 15, 2018
Vibratory Hammer Operation, August 15, 2018
Biorka Island Dock Replacement Project, Southeast Alaska

Dear Mr. Lyman,

This letter provides a synopsis of in-water sound measurements be made at the site referenced above. The measurements and work presented herein were completed by Robert Miner Dynamic Testing of Alaska (RMDT) at your request.

The anticipated field measurement program for this project is not complete. However, this present synopsis provides results for measurements completed during August 2018. The anticipated final report will include additional details, measurements, and results.

PROJECT AND TEST DETAILS

Introduction

In-water sounds were monitored as steel piles were installed with a down-hole hammer and a with vibratory hammer. The subject piles were for the support of an replacement dock within Symonds Bay at a US government facility on Biorka Island near Sitka, Alaska. This monitoring was completed as part of a program intended to provide Sound Source Verification for the project.

*Piles and Hammer*s

The steel piles were approximately 50 ft long vertical 18" OD open-end steel pipe piles. These piles advanced by self-weight through a very thin layer of soft or loose soil to contact bedrock. A down-hole hammer then advanced the piles approximately 10 ft into hard bedrock. We understand that the down-hole hammer was a Patriot 125 hammer manufactured by Numa, and that it operated inside the 18" OD pile by the combined action of a down-hole percussive bit acting on the rock plus modest impact forces on the pile shoe which aided in advancing the pile into the drilled hole. Rock “cuttings” were removed from the wetted work-face by means of an airlift.

Final driving on each pile was accomplished by means of a Model 22B vibratory hammer manufactured by International Construction Equipment, Inc. The Model 22 B hammer operated by clamping to the top of the pile and generating a vibratory action combined with modest down-pressure.

Mailing Address: P.O. Box 340, Manchester, WA, 98353, USA **Phone:** 360-871-5480
Location: 2288 Colchester Dr. E., Ste A, Manchester, WA, 98353 **Fax:** 360-871-5483

Test Sequence

On August 13 RMDT collected in-water sounds for the complete session of down-hole hammer operation on Pile F14. Down-hole hammer operation on Pile F14 ended at approximately 1:15 PM. Due to heavy swells at the site all pile driving has halted until August 15. On the morning of August 15 swells remained relatively heavy, but installation of Pile E14 began at approximately 09:15 AM. We monitored in-water sounds for the entire down-hole operation on Pile E14. The Model 22 B vibratory hammer was then briefly used to complete the installation of Piles D14, F14, D12 and E12, each of which had been initially advanced with the down-hole hammer. Use of the Model 22 B was apparently for "proofing" purposes: the hammer operated for approximately 5 to 20 seconds on each of the four piles. We monitored in-water sounds during all use of the Model B22 vibratory hammer on August 15, 2018.

ACOUSTIC MONITORING INSTRUMENTATION

Sound levels were measured with hydrophones placed in water at distances of approximately 10, 200, and 1200 m from the piles. Each hydrophone was suspended (floated) above an anchor which rested on the soil surface at the respective distances. The water depth at the pile, and at the 10 m location was approximately 3 to 4 m, and the hydrophone at that location was approximately 2 m above the resting anchor. At the 200 m and 1200 m locations the water depth was approximately 7 to 9 m, and 15 m, respectively. The hydrophone at the 10 m location was a Reson model TC 4040. Reson Model 4033 hydrophones were used at the 200 and 1200 m locations. Each hydrophone was connected to a Bruel and Kjar Model 2635 Charge Amplifier which fed the conditioned signal to a Model 2270 Class 1 Sound Level Meter which digitized the signal at a rate of 48 kHz, displayed field results, and digitally stored the full signal time-history for reprocessing

The equipment field configuration allowed direct field verification of proper function and calibration by means of a calibrated sound source. The sound source was a GRAS 42AC piston-phone with hydrophone couplers. The signal from that calibrated piston-phone was, in turn, verified with a calibrated Class 1 sound level meter. Such system checks and calibrations were completed twice daily - once as the equipment was deployed for the day and once after the day's measurements were complete. The system at the 1200 m location was likewise checked during the day of August 13 when the instrument configuration was altered. Such alteration involved changing settings on the 2635 charge amplifier so as to avoid over-ranging in the presence of higher than expected background sound levels apparently caused by heavy swells and surges breaking on the nearby back side of Hanus Point.

On August 13 and 15 hydrophones were located approximately 10, 200 and 1200 m from the piles being driven. The 200 m location was placed on a raft anchored within Symonds Bay and was unattended. Upon completion of the measurement session on August 15 it was found that no usable data was obtained at 200 m for that day. This failure appeared to have resulted from disturbance to a cable connection during final deployment.

ANALYSIS METHODS

Post-processing is based on the time-series (continuous waveforms) recorded with a sampling rate of 48 kHz. Review of the signals indicated that the down-hole hammer generated signals having a character which resembled those commonly associated with vibratory pile installation. Moreover, the down-hole hammer signals occurred repetitively at a rate of 750 to 850 bursts per minute which rate is similar to signals seen with vibratory driving. By contrast, impact pile driving typically yields repetitive signals at a rate of 36 to 44 blows per minute. In consideration of the signal character from the down-hole hammer we processed the acoustic measurements using methods applied to measurements of vibratory pile driving. All conversions of measured sound pressure to Decibels (dB) were made using the standard reference pressure of 1 microPascals applicable to in-water sound.

Per established practice, analysis of vibratory driving consists of computing the root mean square, RMS, for short sequential intervals of time. In recent years the RMS has typically been computed for sequential periods of 30 second duration, RMS_{30}. For the present work we considered it appropriate to compute the RMS values for sequential period of 5 seconds, RMS_5 rather than the 30 second duration. Generally, use of a longer period such as 30 seconds reduces differences between higher and lower range values and makes it more difficult to avoid averaging data measured when the hammer was inactive with data measured when the hammer was active. Use of a 5 second integration period generally increases the variation in the data and thus is likely a more conservative approach. (If the signal of this nature is constant over time, then a 5 second and 30 second integration limit will yield essentially identical results. However, if the hammer operation is intermittent, as was the case for this work, then a 30 second integration limit yield sound levels which are lower than levels for some of the 5 second intervals within that 30 second limit.) Further review of the results may indeed suggest that the 30 second integration limit is suitable or otherwise applicable for this project; the presently applied 5 second integration limit is now considered a conservative limit.

MEASURED SOUND SOURCE LEVELS

Down-hole Hammer

Attached figures presents RMS_5 values at the various hydrophone locations as the down-hole hammer drove Pile F14 on August 13 and Pile E14 on August 15

For Pile F14 driving occurred within a period of approximately 60 minutes, with intermittent pauses such that actual driving time totaled approximately 45 minutes. Within the figure the 10, 200 and 1200 m locations are indicated as Series 1, 2 and 3, respectively. When driving started at approximately 12:10 PM the levels at 10 m gradually rose from prior (“ambient”) levels of approximately 130 dB to levels of 159 to 167 dB, and then the hammer was halted for approximately 5 minutes. During subsequent driving the levels at 10 m typically ranged from 147 to 164 dB. RMS_5 values at the 200 m location followed a very similar pattern, but with significantly lower levels. The RMS_5 measurements at the 1200 m distance do not appear to rise during hammer operation. The 1200 m location does show a slight trend of increasing levels overall during the 1.5 hours depicted in the figure. We attribute this slight increasing trend to the gradually building sea swells, a condition which was sufficiently severe that it warranted a halt in construction activity on the crane barge within Symonds Bay.

For Pile E14 driving occurred intermittently within a period of approximately 110 minutes, with hammer operation totaling approximately 90 minutes. In the attached figure for Pile E14 the 10 and 1200 m locations are labeled as Series 1 and 2, respectively. At the 10 m location the RMS_5 levels during hammer operation were typically between 142 and 162 dB, with peak values of 165 dB. The RMS_5 levels at 1200 m did not appear to rise during hammer operation. The apparent trend of gradually decreasing average RMS_5 levels at the 1200 m location may be attributed to the gradual decline in the sea state following the severe swells of late August 13 and August 14.

Based on the measurements and computed RMS_5 values for Piles F14 and E14 we consider a level of approximately 158 dB RMS (re:1 microPascal) to be a characteristic RMS level at the 10 m location during operation of the down-hole hammer. The maximum RMS_5 was 167 dB and 165 dB for Piles F14 and E14, respectively. Calculations of RMS_{30}, for a 30 second period indicated peak levels of 165.3 and 160.1 dB for piles F14 and E14, respectively, and further support a value of 158 dB as characteristic for the 10 m location during sustained hammer operation. While a level of 158 dB appears reasonable for characterizing sustained operation, we note that in practice hammer operation was quite intermittent; the mean or average values during all driving is likely to be close to 153 dB if the longer periods of hammer stoppage are excluded, and close to 150 dB if the entire period from initial start to final stop is considered.

At the 1200 m location the time series data occasionally contain discernable signals within the marked ambient signal that can be readily identified as those from the down-hole hammer. However, within most of the time series data the hammer signals could not be identified and when the hammer operated the RMS_5 levels did not increase discernibly, as show in the figures for Piles F14 and E14. Because background levels were likely elevated by the heavy swells on August 13 and 15, it is possible, and perhaps likely, that on a calmer day the 1200 m location would show a small but discernable increase in RMS levels during down-hole hammer operation.

Vibratory Hammer

One attached figure presents the computed RMS_5 values for the period of approximately 20 minute length during which Piles D14, F14, D12 and E12 were proofed. Within that figure the 10 m and 1200 locations are labeled as Series 1 and 2, respectively. Hammer operation on each pile was very brief but times of hammer operation may be precisely identified by review of the time series (wave form) data that reveals the characteristic signal. Table 1 contains a summary of the times of driving and the associated results for the 10 m location; the RMS_5 levels range from 139 to 149 dB during vibratory driving. As mentioned above it is customary to characterize source levels for vibratory driving using a 30 second RMS integration limit. However, given the very brief use of the vibratory hammer on this project we used a 5 second limit; use of a 30 second limit would yield significantly lower RMS values.

During the period that the hammer was used the ambient RMS_5 level at the 10 m location was very close to 120 dB. The slightly lower apparent ambient levels just prior to 11:40 AM and just after 11:58 AM probably reflect that fact that the large hydraulic power pack that energized the hammer operated on the deck of the work barge during hammer operation. Isolated high RMS_5 values outside the period of hammer operation likely reflect placement of the hammer onto the various piles.

At the 1200 m location the RMS_5 data do no increase discernibly during hammer operation. These data are consistent with the results for the down-hole hammer, wherein activity that produced higher RMS_5 levels at the 10 m location were not discernable at the 1200 m location.

Table 1. Summary of Results for the ICE 22B Vibratory Hammer

Pile	Start Time HH:MM:SS	End Time HH:MM:SS	Computed RMS_5
D14	11:42:12 AM	11:42:17	142 dB
F14	11:50:11 AM	11:50:15	143 dB
D12	11:53:59	11:54:06	139 dB
E12	11:57:23	11:57:28	144 dB
E12	11:58:14	11:58:22	149 dB

It is anticipated that our final report will include various additional data taken from the measurements reported herein. In particular, we anticipate including sample wave form measurements showing the character of the signal from the down-hole hammer, including narrow band spectra, and support for our consideration that the down-hole hammer is suitably processed using RMS calculations rather those calculations applied to the impulsive sounds of impact pile driving on the top of a pile.

I trust that these results will assist you at this time. Please do not hesitate to contact me if you or others have any questions about our measurements or this letter.

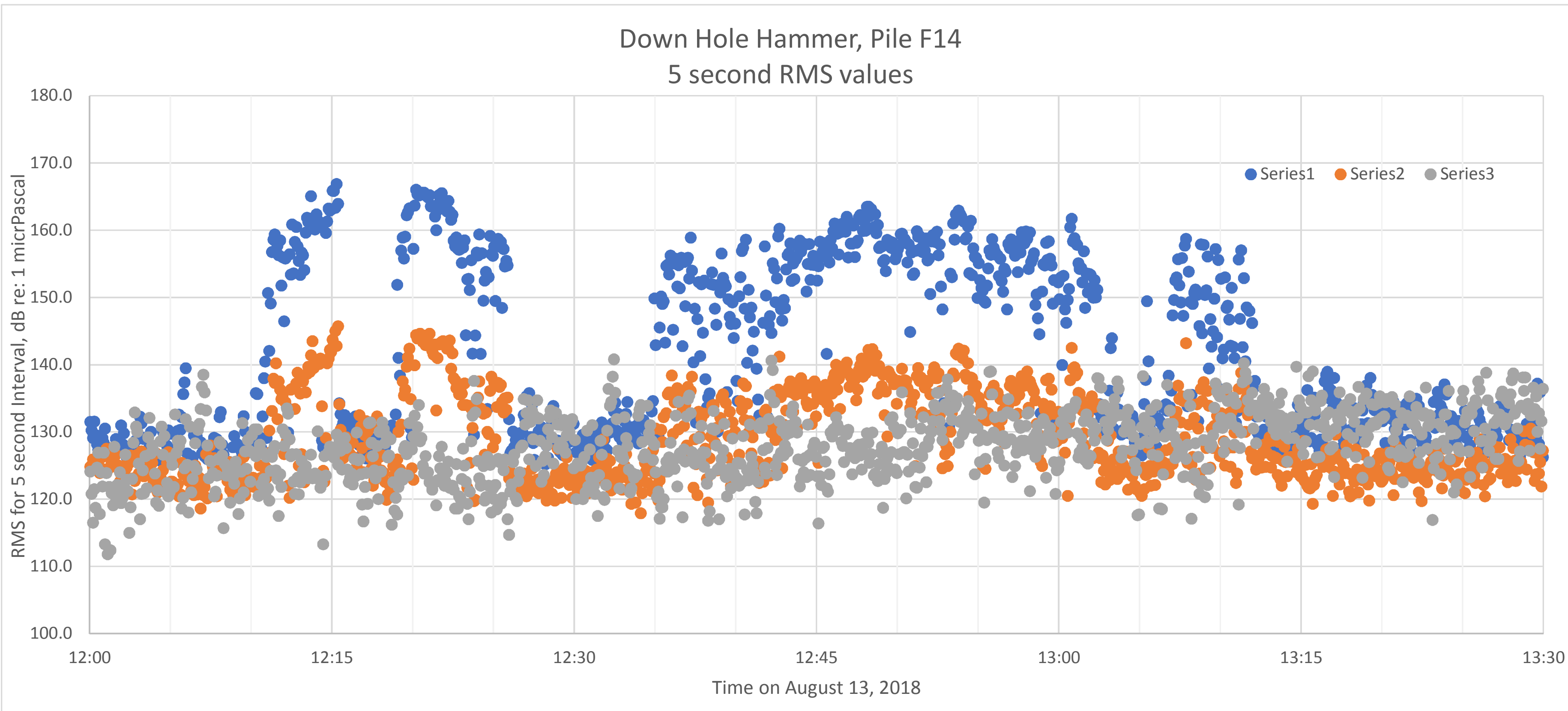
Sincerely,

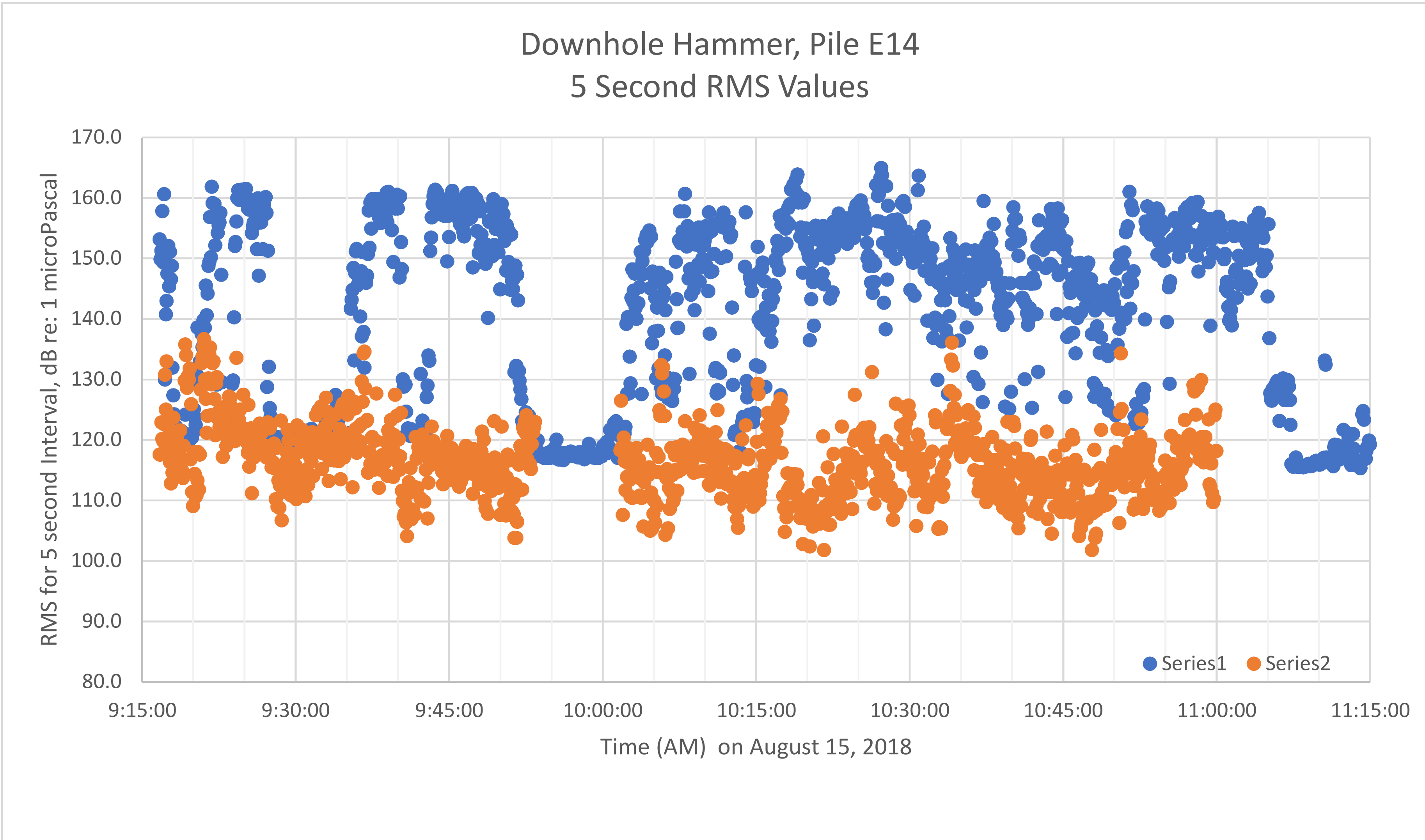
Robert Miner, P.E.

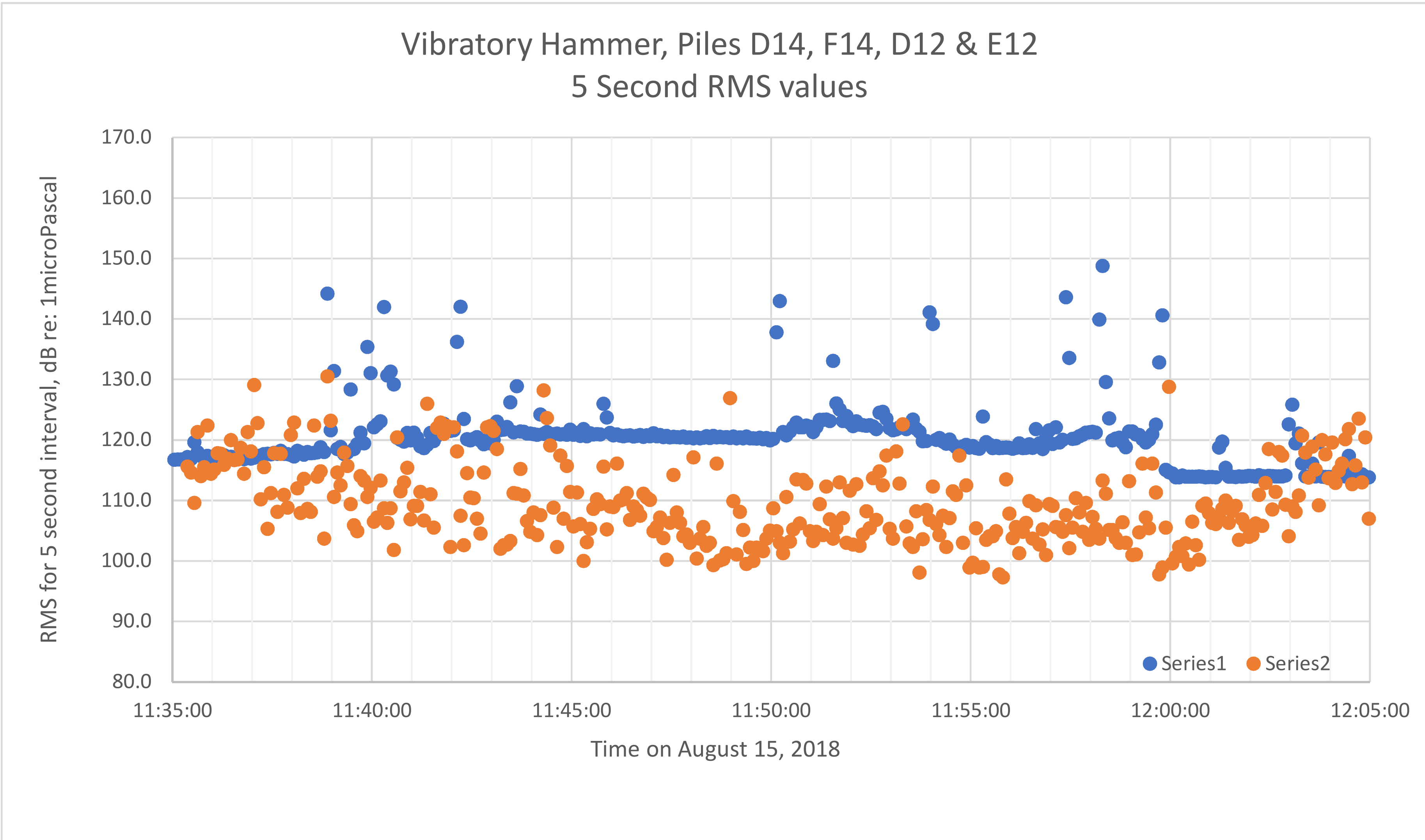
Robert Miner Dynamic Testing, Inc.

STATE OF ALASKA
49TH
ROBERT F. MINER
No. CE 11584
REGISTERED PROFESSIONAL ENGINEER

September 29, 2018


Down Hole Hammer, Pile F14
5 second RMS values
RMS for 5 second Interval, dB re: 1 micrPascal
180.0
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
12:00
12:15
12:30
12:45
13:00
13:15
13:30
Time on August 13, 2018
Series1
Series2
Series3


Downhole Hammer, Pile E14
5 Second RMS Values
RMS for 5 second Interval, dB re: 1 microPascal
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
9:15:00
9:30:00
9:45:00
10:00:00
10:15:00
10:30:00
10:45:00
11:00:00
11:15:00
Time (AM) on August 15, 2018
Series1
Series2



Vibratory Hammer, Piles D14, F14, D12 & E12
5 Second RMS values
RMS for 5 second interval, dB re: 1microPascal
170.0
160.0
150.0
140.0
130.0
120.0
110.0
100.0
90.0
80.0
11:35:00
11:40:00
11:45:00
11:50:00
11:55:00
12:00:00
12:05:00
Time on August 15, 2018
Series1
Series2