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Piling Test Noise and Vibration Measurements

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1 INTRODUCTION

Acoustic Logic has been engaged to carry out noise and vibration measurements of a test pile at the proposed Manildra Ethanol Storage and transfer site at Lot 1 DP1236743, Foreshore Road, Port Kembla.

The existing yard will be levelled and the existing mound of spoil from Barangaroo will be relocated elsewhere. Piling is required under the 6 large storage tanks, 2 small tanks and under a retaining wall that will run parallel to the existing canal. A full description of the future site was given in the main environmental noise and vibration impact assessment (20210641.1/2308A/R6/OB).

Acoustic Logic were present for two test piles to be driven for test purposes. This was identified by Manildra to be the noisiest process expected to occur on site during the construction phase. Noise and vibration monitors were installed around the site to capture the noise and vibration emissions.

The issues which will be addressed in this report are:

- Presentation of the measured noise levels from impact piling
- Prediction of noise levels from the piling process.
- Assessment against Construction noise trigger levels
- Presentation of the measured vibration levels.
- Prediction of vibration levels from the piling process
- Assessment against structural vibration criteria

It is noted that the testing coincided with the Council repaving foreshore road directly outside the site. The road was profiled with a roto-mill, then graded and compacted with a large vibrating roller. The traffic was built up and intermittent with traffic control outside the site. Site remote noise and vibration monitoring was used rather than attended measurements at the nearest receivers.

2 SITE DESCRIPTION

The proposed construction works will occur on a vacant block. The existing mound of spoil (rock) will be relocated elsewhere to reclaim land at the port. The existing flat portion of the yard is half old hard stand concrete paving and the remainder is dirt, bitumen and rubble.

Figure 1 shows the locations of the test pile locations and the noise and vibration monitoring stations on the day. Only roadside vibration monitor was relocated to the second piling location.

The proposed construction site is located on the edge of the port and Figure 2 shows its location relative to the nearest and most affected receivers.

Residential receiver locations as presented in Figure 2 and detailed below.

- **R1**: Residential dwellings along Premier Street immediately to the north;
- **R2**: Residential dwellings along Montpelier Street immediately to the west;
- **R3**: Residential dwellings along Premier Street immediately to the south; and
- **R4**: Residential dwellings across Premier Street to the east.

★ Vibration Monitor location

⧗ Noise monitor location

● Test Pile Location

Figure 1 - Site Map – Piling and Monitor locations for the Tests

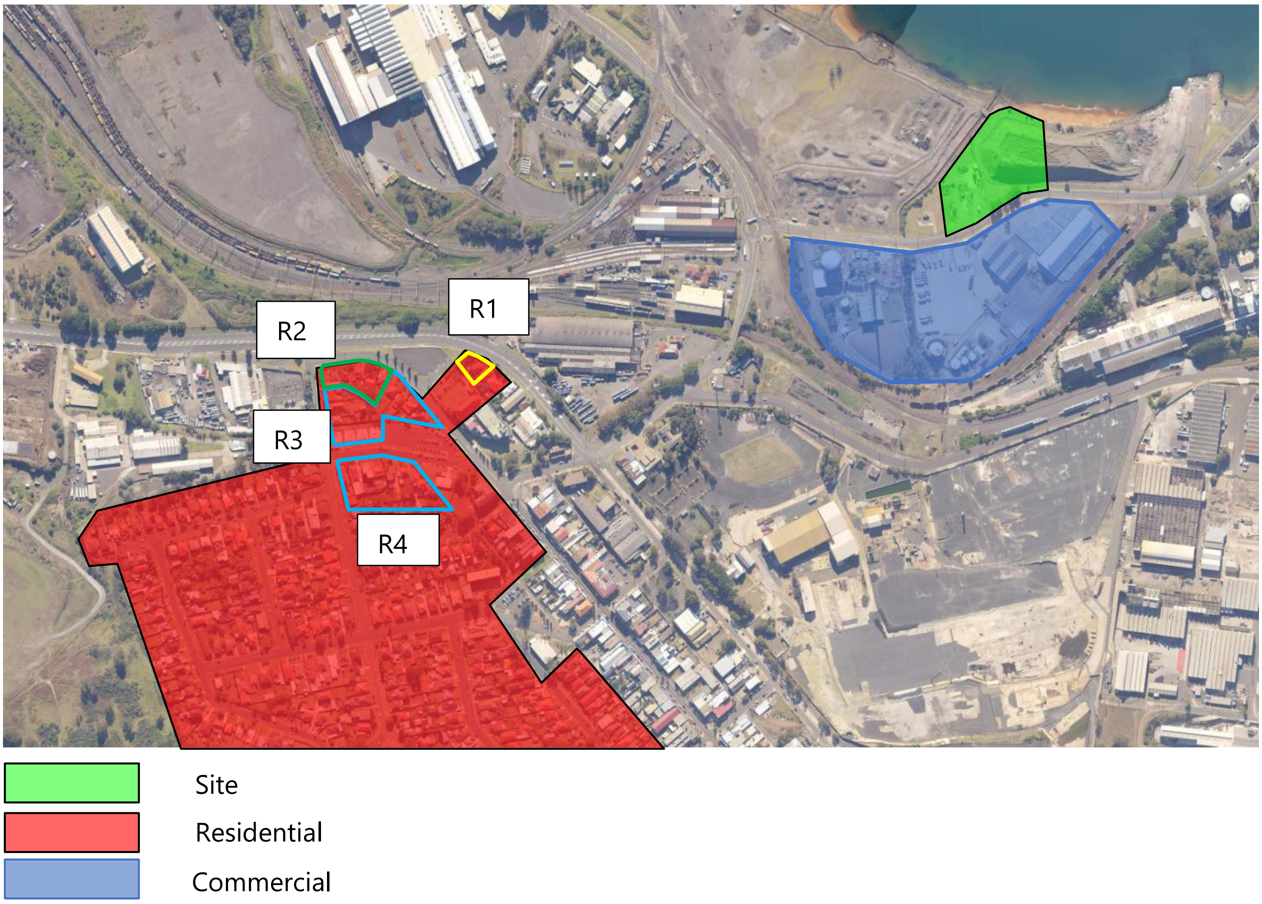


Figure 2: Site relative to Sensitive Receiver Locations

3 PILING PROCESS DESCRIPTION

The piles to be used to support the bunded area and the tank farm are hardwood timber piles. The approximate depth of the rock foundation is 12m below ground level, hence an 8m pile is first driven to the ground then a 4m pile is spliced into the first pile and then driven until it beds into the rock below. Any remaining pile length is cut off with a chainsaw.

The process is as follows:

- Hardwood timber pile is lifted using an excavator then the piling head is placed over the top of the pile
- The pile is struck with a falling weight which is hydraulically lifted
- Piling continues until the pile is at ground level
- A connector made of a large diameter pipe is then driven into the first pile head
- The second pile is located above the connector and driven down to splice to the first pile
- Impact piling continues until the pile hits the rock foundation
- The pile is struck several times to ensure bedding into the rock

The piles will be installed under the 6 large tanks (105 piles per tank) and under the two smaller tanks (10 piles per tank) inside the bund. There will also be about 40 piles behind the retaining wall that runs along the existing canal. The total number of pile locations is 690. It is envisaged that they will be driven at a rate of 20 to 30 per day.

4 PILING MACHINE DESCRIPTION

The piling machine used for the testing is a custom build hydraulic impact driver that is attached to an excavator. The rig is shown in Figure 3.

Figure 3 Impact Piling rig with Pile

The piling head specifications were provided to Acoustic Logic by the owner Adam and are as follows:

- 1.8t drop weight
- 1500mm drop height
- Hit rate is 15 blows/minute up to 21 blows/minute

For prediction purposes the energy per blow is 18.6kJ (assuming a 30% loss for hydraulic drop hammer). We were informed the impact frequency ranges from 0.25-0.35Hz. We measured 0.42Hz on the day.

5 CONSTRUCTION NOISE AND VIBRATION MANAGEMENT LEVELS

The construction noise and vibration management trigger levels have been obtained from the CNVMP previously submitted by this office.

5.1 NOISE

The resultant Noise Management Levels (NMLs) based on long term background noise monitoring have been summarised in Table 1.

Table 1 – Resultant Noise Management Levels (NML's)

Hours of Work	Receiver No.	Receiver Address	Noise Management Trigger Level dB(A)$L_{eq(15\text{-minute})}$
Standard Construction Hours (7am-6pm Monday – Friday 7am-5pm Saturday)	1	7, 11, and 15 Military Road, 91 Five Islands Road	58dB(A)$L_{eq(15\text{-minute})}$ (BG + 10dB(A)) (48dB(A)$L_{90(Period)}$ + 10dB(A)
	2	3, 5, 7, 9, and 11 Wentworth Street	52dB(A)$L_{eq(15\text{-minute})}$ (BG + 10dB(A)) (42dB(A)$L_{90(Period)}$ + 10dB(A)
	3	13-19 Wentworth Street, and the residences on Darcy Road	52dB(A)$L_{eq(15\text{-minute})}$ (BG + 10dB(A)) (42dB(A)$L_{90(Period)}$ + 10dB(A)
	4	Lot 2 on DP1079726, Foreshore Road	75 dB(A)$L_{eq(15\text{-minute})}$
	5	Port Authority of New South Wales	70 dB(A)$L_{eq(15\text{-minute})}$

5.2 VIBRATION

Vibration caused by construction at any residence or structure outside the subject site must be limited to:

- For structural damage vibration, German Standard DIN 4150-3 Structural Vibration: Effects of Vibration on Structures; and
- For human exposure to vibration, British Standard BS 6472 – 'Guide to Evaluate Human Exposure to Vibration Buildings (1Hz to 80Hz.)

The criteria and the application of this standard are discussed in the following separate sections.

5.2.1 Damage Criteria

German Standard DIN 4150-3 (1999-02) provides vibration velocity guideline levels for use in evaluating the effects of vibration on structures. The criteria presented in DIN 4150-3 (1999-02) are presented in Table 2.

It is noted that the peak velocity is the absolute value of the maximum of any of the three orthogonal component particle velocities as measured at the foundation, and the maximum levels measured in the x- and y-horizontal directions in the plane of the floor of the uppermost storey.

Table 2 – DIN 4150-3 (1999-02) Safe Limits for Building Vibration

	Type of Structure	Peak Particle Velocity (mms^{-1})			
		At Foundation at a Frequency of			Plane of Floor of Uppermost Storey
		< 10Hz	10Hz to 50Hz	50Hz to 100Hz	All Frequencies
1	Buildings used in commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Lines 1 or 2 and have intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8

5.2.2 Assessing Amenity

The NSW EPA document "*Assessing Vibration: A Technical Guideline*" provides procedures for assessing tactile vibration and regenerated noise within potentially affected buildings and is used in the assessment of vibration impact on amenity. The relevant criteria are presented in Table 3.

Table 3 – EPA Recommended Vibration Criteria

		RMS acceleration (m/s^2)		RMS velocity (mm/s)		Peak velocity (mm/s)	
Place	Time	Preferred	Maximum	Preferred	Maximum	Preferred	Maximum
Continuous Vibration							
Residences	Daytime	0.01	0.02	0.2	0.4	0.28	0.56
Offices		0.02	0.04	0.4	0.8	0.56	1.1
Workshops		0.04	0.08	0.8	1.6	1.1	2.2
Impulsive Vibration							
Residences	Daytime	0.3	0.6	6.0	12.0	8.6	17.0
Offices		0.64	1.28	13.0	26.0	18.0	36.0
Workshops		0.64	1.28	13.0	26.0	18.0	36.0

5.2.3 Water Board Buried Asset Vibration Criteria

The south western corner of the site is near a sewer line easement and there is a pumping station on the adjacent lot. These assets are approximately 46m and 59m away, respectively.

The most relevant vibration criterion for the buried sewer line is a peak particle velocity (PPV) of 10mm/s for intermittent vibrations and 5mm/s for continuous vibrations based on Sydney Water's Specialist Engineering Assessment (SEA, 19/02/2021) for a brittle pipe such as a concrete pipe.

The most relevant vibration criterion for the pumping station building will be the DIN 4150-3 vibration levels for a domestic house as the building appears to be constructed of blockwork.

6 NOISE MEASUREMENTS

Noise measurements were taken by two remote noise monitors. A Norsonic N118 meter was taken as backup and for spot measurements.

6.1 MONITORING EQUIPMENT

Unattended noise monitoring was conducting using two Rion NL-27 noise loggers. Each logger was programmed to store 5-minute statistical noise levels and 1s L_{Aeq} noise levels throughout the monitoring period. The equipment was calibrated at the beginning and the end of each measurement using a Rion NC-74 calibrator; no significant drift was detected. All measurements were taken on A-weighted fast response mode.

6.2 MONITORING LOCATIONS

An unattended noise monitors were installed on the ground with the microphones 1.5m above ground. The locations are shown on Figure 1.

6.3 MONITORING PERIOD

Unattended noise monitoring was conducted on the 25th of October 2021 between 12:30pm and 2:30pm.

6.4 MONITORING RESULTS

A summary of the monitored noise levels of the piling tests are shown in Table 1. Note that the EPA requires a 15minute L_{Aeq} noise level for the assessment, not the 1s L_{Aeq} noise level. The 1s noise levels were used to clearly see the start/stop and relocation times.

There is a pause between blows on this pile driver hence the short term noise levels are time diluted by the lifting pause and when new piles moved into position. We have used 5 minute measurements to calculate a running L_{Aeq}(15minute) noise level which is required for assessment by the EPA interim construction noise guideline. The highest $L_{Aeq(15min)}$ levels during the piling process are presented in Table 4. The maximum noise level for the blows at the monitor are also presented.

Table 4 - Monitored Impact Piling Noise Levels

Test Pile location	Monitor Location	Distance to Pile (m)	Noise Level $L_{Aeq(15min)}$, dB	Noise Level L_{Amax}, dB
1	Middle of Site	32	87	104
1	Boundary	56	81	99
2	Middle of Site	85	74	92
2	Boundary	99	67	85

6.5 NOISE IMPACT ASSESMENT

As discussed, the impact noise is time diluted. We used the noise level taken at the nearest noise monitor to back calculate a sound power level for the rig. The monitor was suitably placed on the edge of the concrete hard stand area. The boundary logger follows the expected free-field decay but for the distant measurements, air and ground absorption become significant.

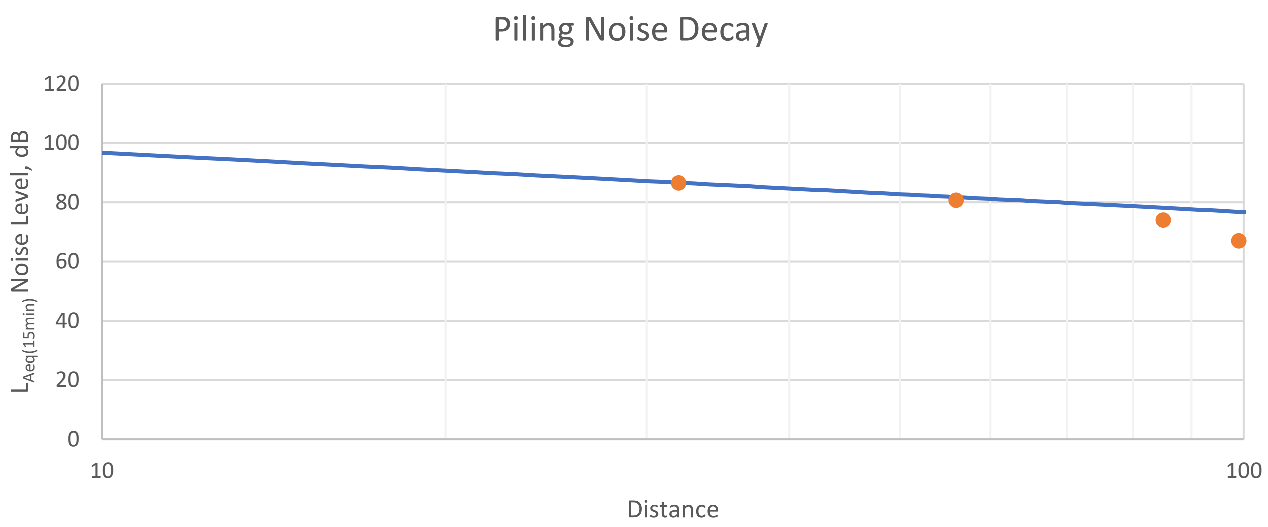


Figure 4, Free Field Attenuation and measured positions

The following table predicts the noise levels at the nearest and most affected receivers using the free- field attenuation rule. To account for the air and ground absorption a quick SoundPLAN model was run using the previously constructed terrain model. The pile was modelled as a 6m tall line source with the calculated sound power level over 15minutes. A pile location on the future retaining wall was chosen to be the closest to the residents and the nearest industrial receivers and a pile location under a small tank chosen to be the closest to the Port Authorities grounds.

The results are presented in Table 5 and the noise contour figures are attached the appendix. Note construction noise criteria only apply to the receivers at 1.5m above ground level.

Table 5 – Assessment of Noise Levels

Location	Approx. Distance to Pile (m)	Predicted Noise Level $L_{Aeq(15min)}$, dB	Trigger Noise Level $L_{Aeq(15min)}$, dB	Complies
Residents	600	52-54	52	*Marginal
Commercial Receiver on other side of road	80	75	75	Yes
Port Facility	300	62	70	Yes

*The NSW EPA road traffic noise policy states a difference in noise level of 1-2dB is not perceivable

7 VIBRATION MEASUREMENTS

Vibration measurements were taken by five remote vibration monitors that were scattered around the site, on the site boundaries and at the nearest commercial receiver building.

The ground at the site was soft dirt at the boundaries near the road. The remainder of the site was either concrete hardstand slabs, or ground made up of rubble consisting of broken bitumen paving, rocks and dirt. In many locations it was not possible to drive the geophone spikes into the ground, or the installation was loose as there were too many rocks so the geophones had to be buried.

7.1 VIBRATION EQUIPMENT

Unattended vibration monitoring was conducting using five Texcel blast monitors. Each monitor was programmed to store 1-minute vibration levels and record vibration levels that exceeded a preset trigger level throughout the monitoring period.

7.2 MONITORING LOCATIONS

The unattended vibration monitors were installed on the ground at the locations shown in Figure 1. The geophone for the monitor stationed at the commercial premises on the other side of foreshore drive was adhered to the building's foundation slab, the preferred monitoring position for the nominated standard.

To ensure good ground coupling, where possible the geophones were buried with ground spikes attached and the surrounding soil was hand compacted.

7.3 MONITORING PERIOD

Unattended noise monitoring was conducted on the 25th of October 2021 between 12:30pm and 2:30pm.

7.4 MONITORING RESULTS

Charts of the measured vibration levels are attached to the appendix and also the measured excitation frequencies. Table 6 summarises the maximum vibration levels measured by the vibration monitors for the first 8m pile that was driven. Note the residential vibration criteria is used as a reference since the commercial building on the other side of the road is of domestic brick and sheet metal roof construction.

It is noted that road work was in progress during the testing and this is visible in the results on the boundaries of the site to Foreshore Drive, the Waterboard property and the (Commercial) house nearest to the roadworks.

Table 6 - Monitored Impact Piling Vibration Levels

Location	Approx. Distance (m)	Vertical PPV (mm/s)	Transverse PPV (mm/s)	Radial PPV (mm/s)
Close In	19	5.59	2.11	3.47
Middle Yard	34	2.24	0.59	0.41
Foreshore Fence	45	1.9	1.63	2.1
Commercial House	72	0.46	0.28	0.16
Waterboard Fence	78	1.14	1.17	0.36

7.4.1 ANALYSES OF RESULTS

On the test day there was sufficient time for setting up the noise and vibration monitors for the first pile location, however for the second pile location the measurements were rushed due to time constraints. Hence our focus is on the first pile location results as testing was nearest to potentially affected receivers.

Important test observation made on the day are as follows:

- The dominant frequencies measured during the pile driving were between 16Hz to 35Hz.
- The dominant frequency increased as the pile was driven deeper and into the harder soil and rock. This is most visible on the plots for Monitor 7688, which was nearest to the pile.
- At the Waterboard fence boundary the transverse vibration level was greater than the vertical vibration level and at the Foreshore road boundary both the radial and transverse vibration levels were greater than the vertical vibration. This typically indicates that shear waves were amplified so it’s likely that there is hard ground beneath a shallow and soft surface soil layer.
- The raw data points from the five monitors for the time slice (1:04pm to 1:05pm) are plotted in Figure 5. It was observed that the different ground conditions around the site have influenced the results. Superimposed over the chart are Rayleigh and Body wave geometrical attenuation curves that ignore soil attenuation.
- A curve was fitted to each vibration component to give a pseudo power law of vibration attenuation specific to this site for the dominant vibration frequencies as shown in Figure 6.

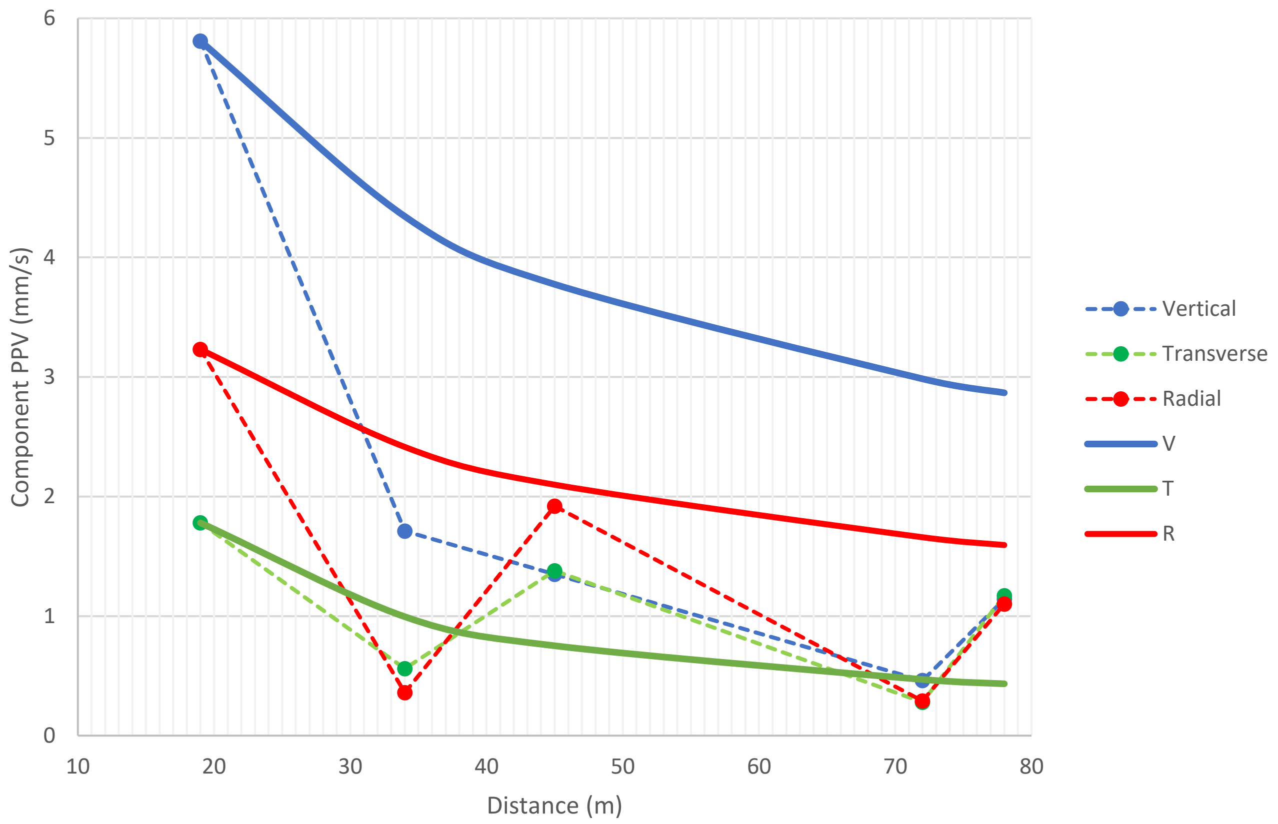


Figure 5, Vibration Attenuation with Distance from Impact Piling

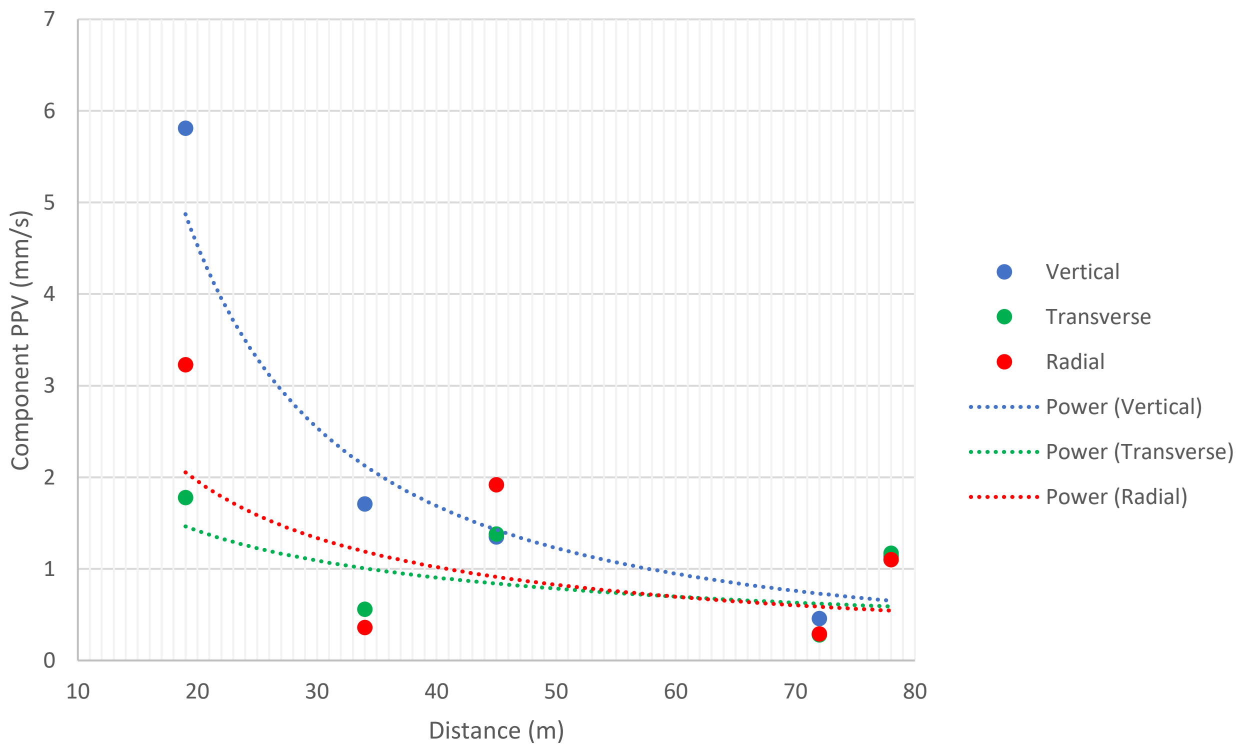


Figure 6, Site specific vibration (20-35Hz) Attenuation with Distance

- The vibration levels from impact piling can be considered to be intermittent and transient vibrations as shown in Figure T for most building structures. However as there is a very tall chimney in an adjacent property so the low frequency vibrations at the impact frequency could be considered to be continuous vibrations. A quick natural frequency analyses assuming the concrete stack was 70m tall, 6m diameter at the base, 3m diameter at top and was 200mm thick on a rigid foundation found the first 3 bending modes are in the frequency ranges of 0.8 to 1.1Hz, 4.4 to 5.5Hz and 10 to 12.6Hz and a column mode at 14 to 17.8 Hz.

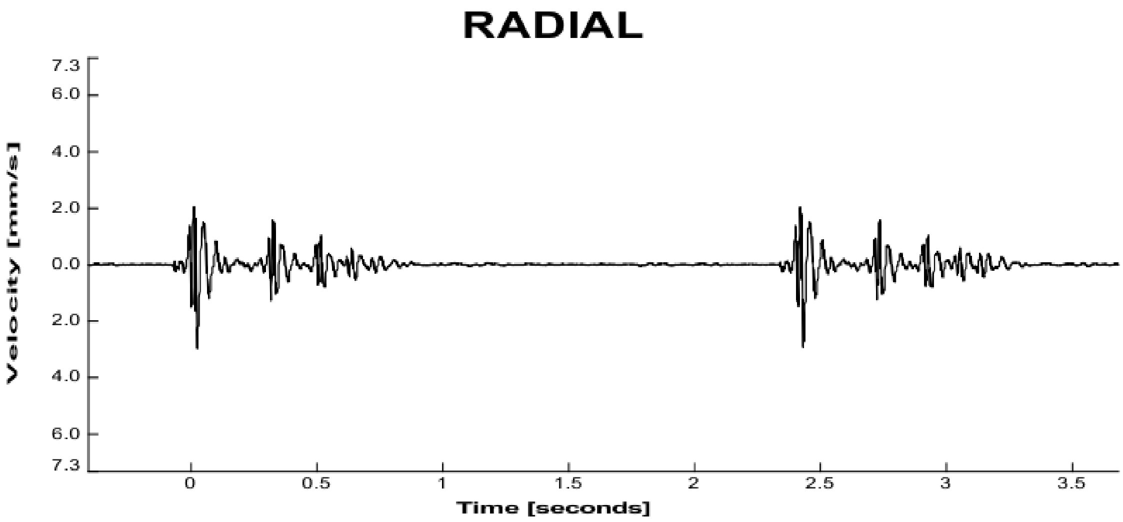


Figure 7, Vibration vs Time waveform from Impact Piling

7.5 VIBRATION IMPACT ASSESSMENT

7.5.1 Structural

The vibration levels from driving the test pile at the nearest building foundation, approximately 72m away were below 1mm/s. This vibration level complies with the limiting vibration level of 5mm/s for a structure of domestic construction. The proposed tank pile locations are further away from the building compared to the test pile. Other industrial buildings in the vicinity have higher vibration limits under DIN 4150-3.

The nearest pile to the pumping station is approximately 46m away at the end of the retaining wall. The predicted vibration level at the building based on the site vibration attenuation curve is 1.3mm/s, which is below the 5mm/s frequency independent limit. Vibrations at a buried sewer line near the building would also comply with the transient vibration level of 10mm/s for a brittle pipe asset.

A spectrum analyses was carried out on a typical vibration waveform at the nearest vibration monitor to the pile which had a low frequency (2Hz) geophone. The majority of energy from impact piling is between 10Hz and 35Hz. The geophone is less sensitive to low frequency vibration, at 0.4Hz impact frequency it is 96% less sensitive based on generic sensitivity curves for 2Hz geophones. The chimney is sensitive to low frequency vibrations in the ground plane. To predict the vibration level at the base we use Rayleigh attenuation and the maximum radial vibration level and the scaling factor to account for the geophone sensitivity at that frequency. The predicted in-plane ground vibration level at the chimney from piling at the retaining wall 193m away is 0.015mm/s x (100/4) x $\sqrt{\frac{19}{193}}$=0.12 mm/s. This resultant vibration is well below the heritage building criteria so it would be reasonable to assume a modern reinforced concrete structure is unlikely to be adversely affected. It is also noted that a canal that divides the properties and this discontinuity will further reduce vibration levels.

7.5.2 Comfort and Amenity

The ground vibration at the nearest building was 0.46mm/s which complies with the preferred continuous vibration limit for an Office of 0.56mm/s.

8 DISCUSSION

The second test pile was driven into the ground close to the sea and near a dilapidated steel girder bridge. Most of the ground was impenetrable with the geophone spikes, except at the chosen locations. An attempt was made to measure near the bridge but there was paving and rocks. The geophone was loose on the embankment leading to spurious results. The first suitable measurement location was in mud/sediment by the shore, the next location near the bridge and finally at the base of the mound. The distance decay of the vibrations is shown in Figure 8. In the near field the radial and transverse vibrations dominate.

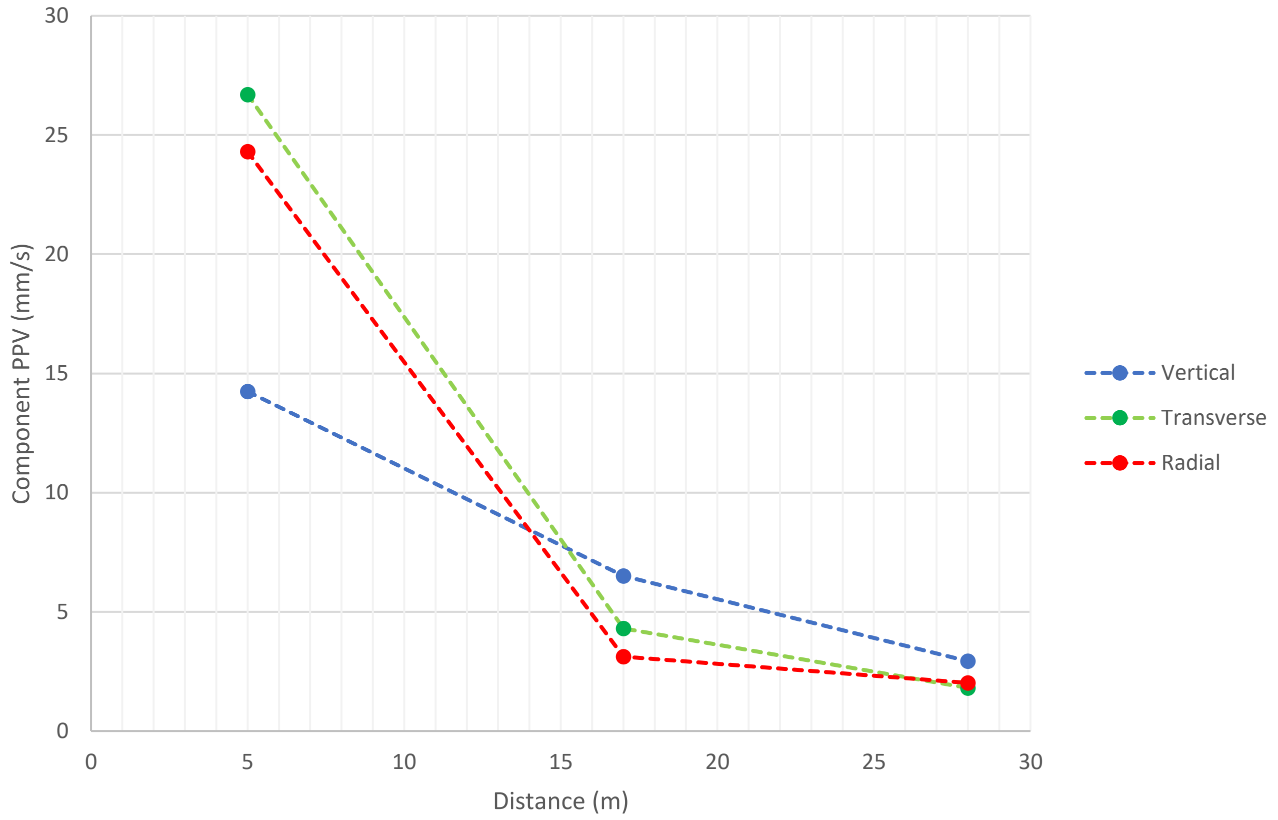


Figure 8, Near field vibration levels from Impact Piling

9 CONCLUSION

An assessment of noise and vibration from the proposed piling works associated with Manildra ethanol storage and transfer facility at Port Kembla has been presented within this report. Test impact piling was caried out on the future site and noise and vibration sensors were installed to capture noise and vibration levels.

The acoustic assessment of the proposed works has been made with reference to the Construction Noise and Vibration Management Plan that was previously developed by Acoustic Logic (Report 20210641.1/2308A/R6/OB) and relevant policies & guidelines for construction noise and vibration– namely the *Interim Construction Noise Guideline* and DIN Standard 4150-3

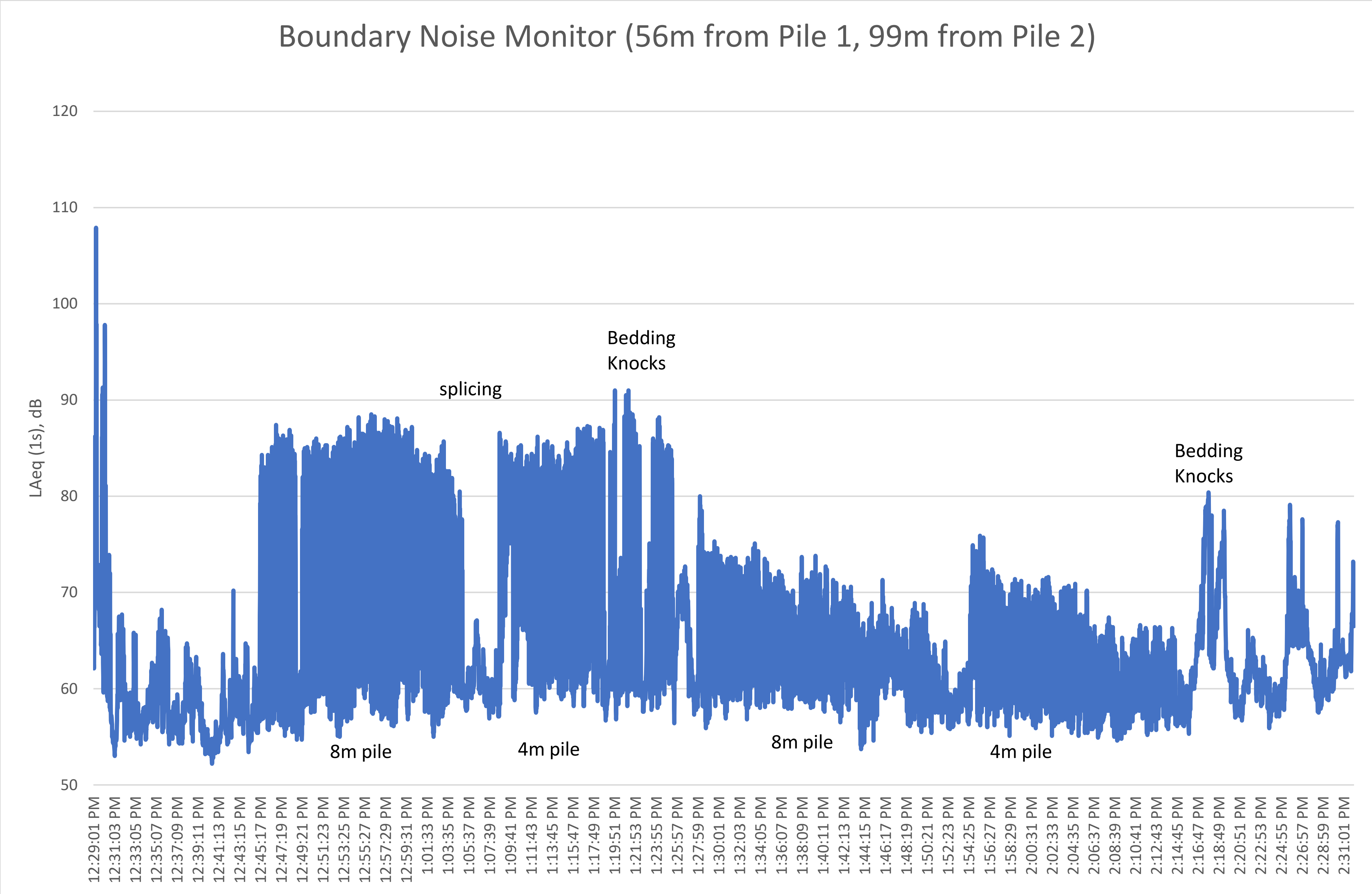
Based on this assessment, noise emission from impact piling activities can generally meet the relevant noise emission levels at the nearest and most affected receivers. Vibration emissions from the site have been found to meet the nominated guidelines and standards.

Please contact us should you have any further queries.

Yours faithfully,

Acoustic Logic Pty Ltd
Tomas Bohdan

APPENDIX 1 – NOISE LEVEL MAPS


Boundary Noise Monitor (56m from Pile 1, 99m from Pile 2)
LAeq (1s), dB
120
110
100
90
80
70
60
50
Bedding Knocks
splicing
Bedding Knocks
8m pile
4m pile
8m pile
4m pile
12:29:01 PM
12:31:03 PM
12:33:05 PM
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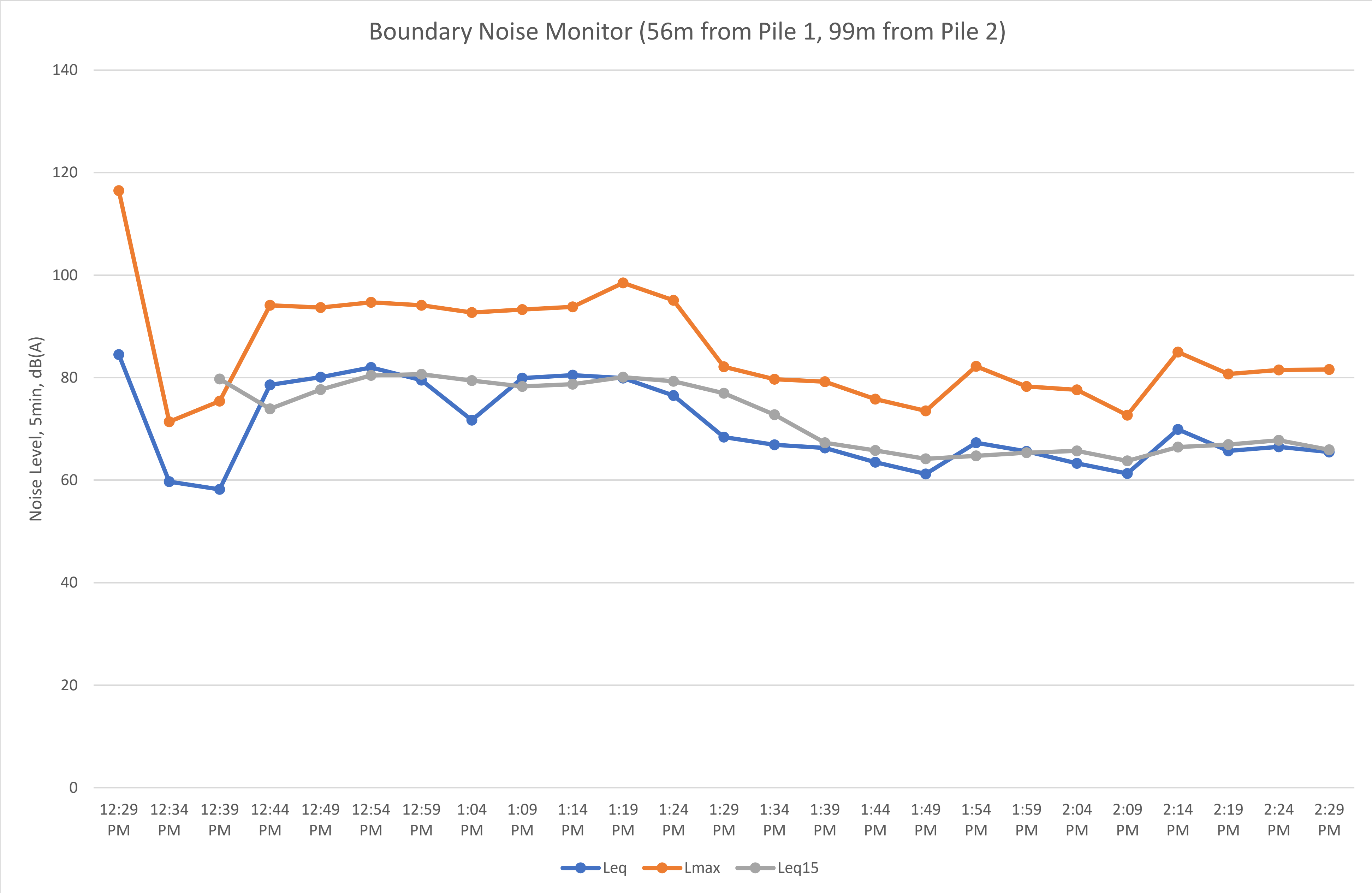
Boundary Noise Monitor (56m from Pile 1, 99m from Pile 2)
Noise Level, 5min, dB(A)
140
120
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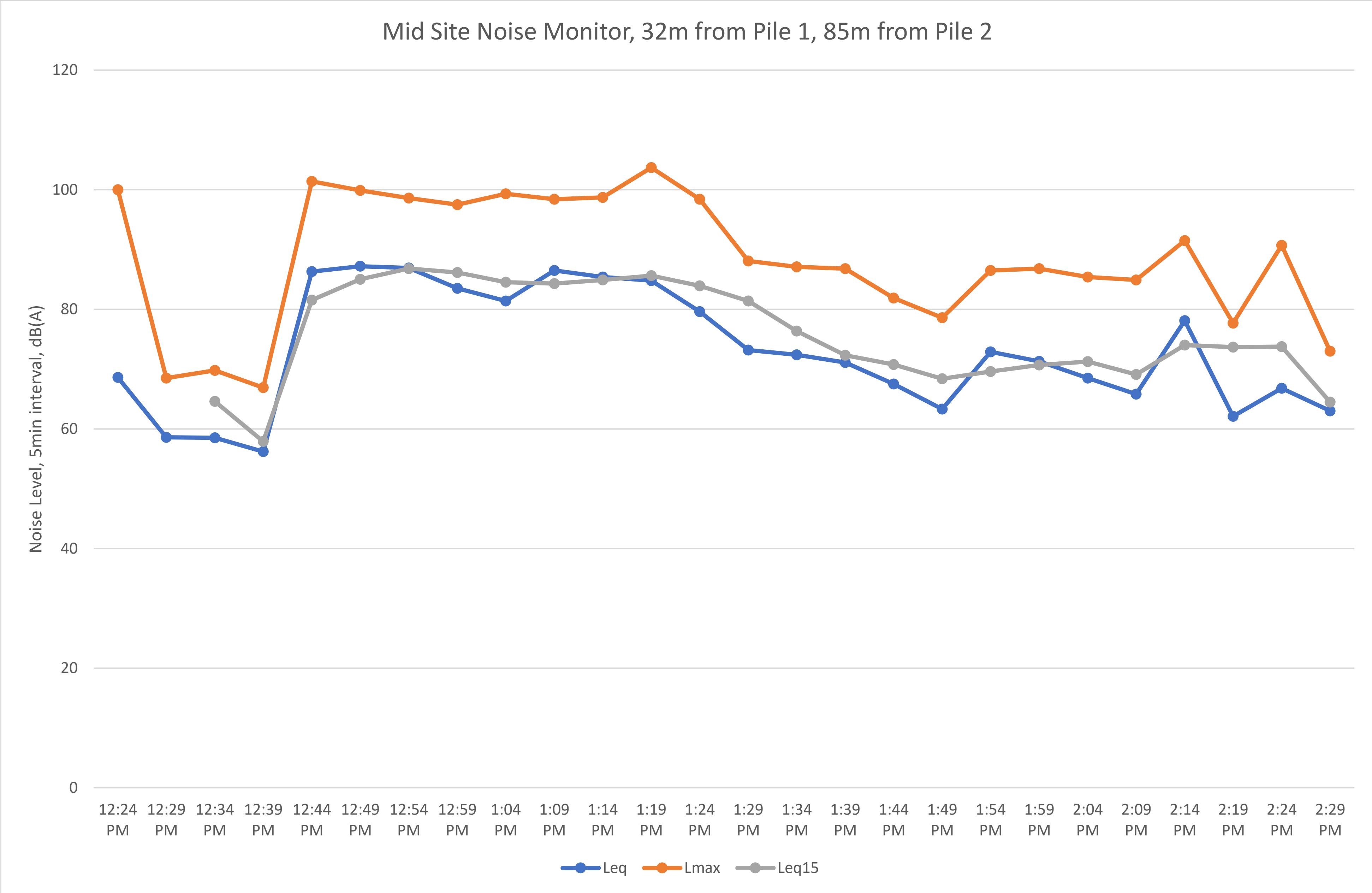
Mid Site Noise Monitor, 32m from Pile 1, 85m from Pile 2
Noise Level, 5min interval, dB(A)
120
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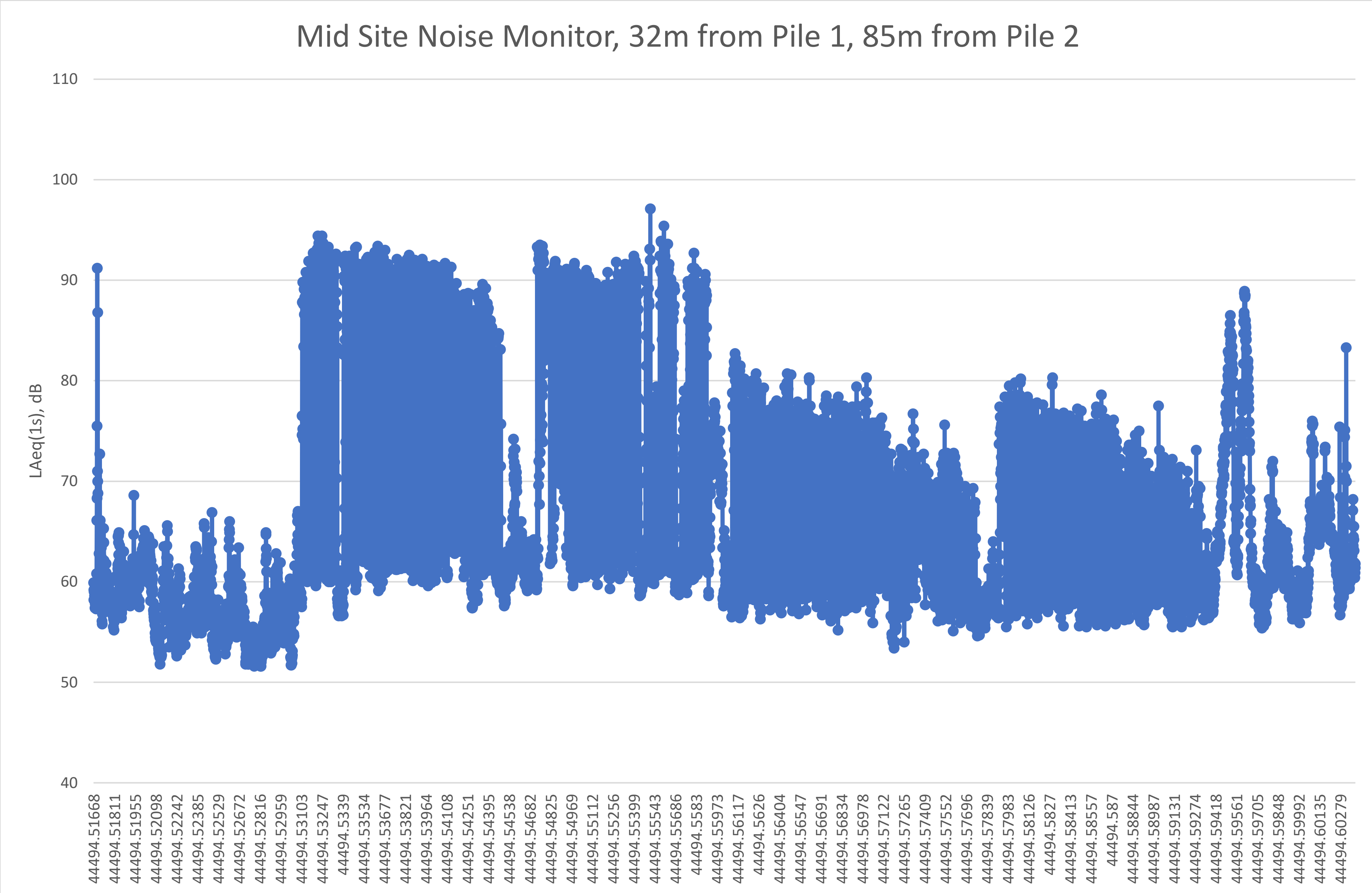
Leq
Lmax
Leq15


Mid Site Noise Monitor, 32m from Pile 1, 85m from Pile 2
LAeq(1s), dB
110
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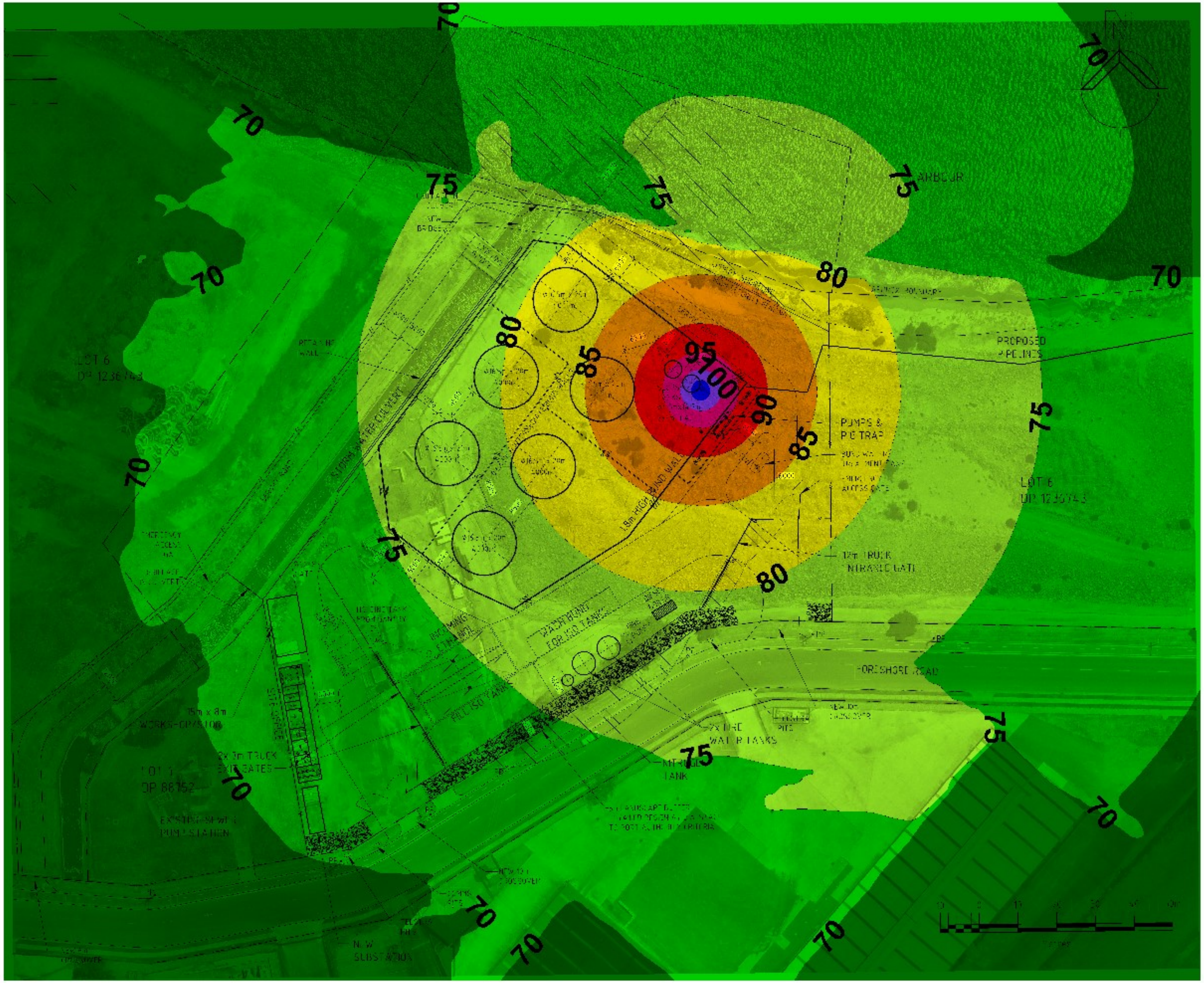
44494.57122
44494.57265
44494.57409
44494.57552
44494.57696
44494.57839
44494.57983
44494.58126
44494.5827
44494.58413
44494.58557
44494.587
44494.58844
44494.58987
44494.59131
44494.59274
44494.59418
44494.59561
44494.59705
44494.59848
44494.59992
44494.60135
44494.60279

Port Kembla

<u>Ground Level Noise Contours</u>
<u>Height above ground: 1800mm</u>



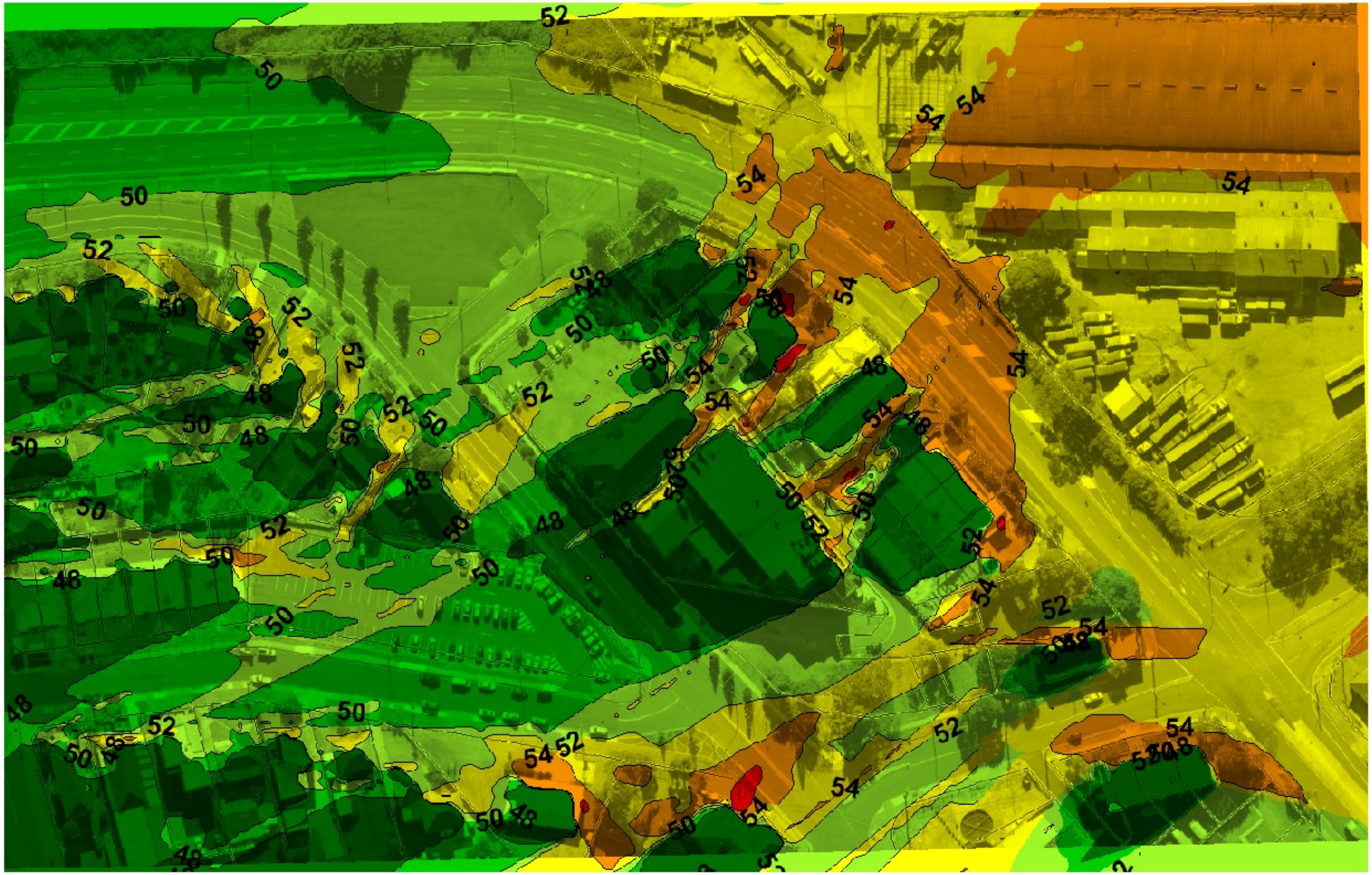
Prepared by: OB
Date: 19/11/2021

Noise Level
LAeq
in dB(A)

Noise Level
< 70
70 - 75
75 - 80
80 - 85
85 - 90
90 - 95
95 - 10
10 - 10
10 - 11
11 - 11
11 - 12
>= 12

ACOUSTIC LOGIC

Port Kembla



Ground Level Noise Contours
Height above ground: 1800mm

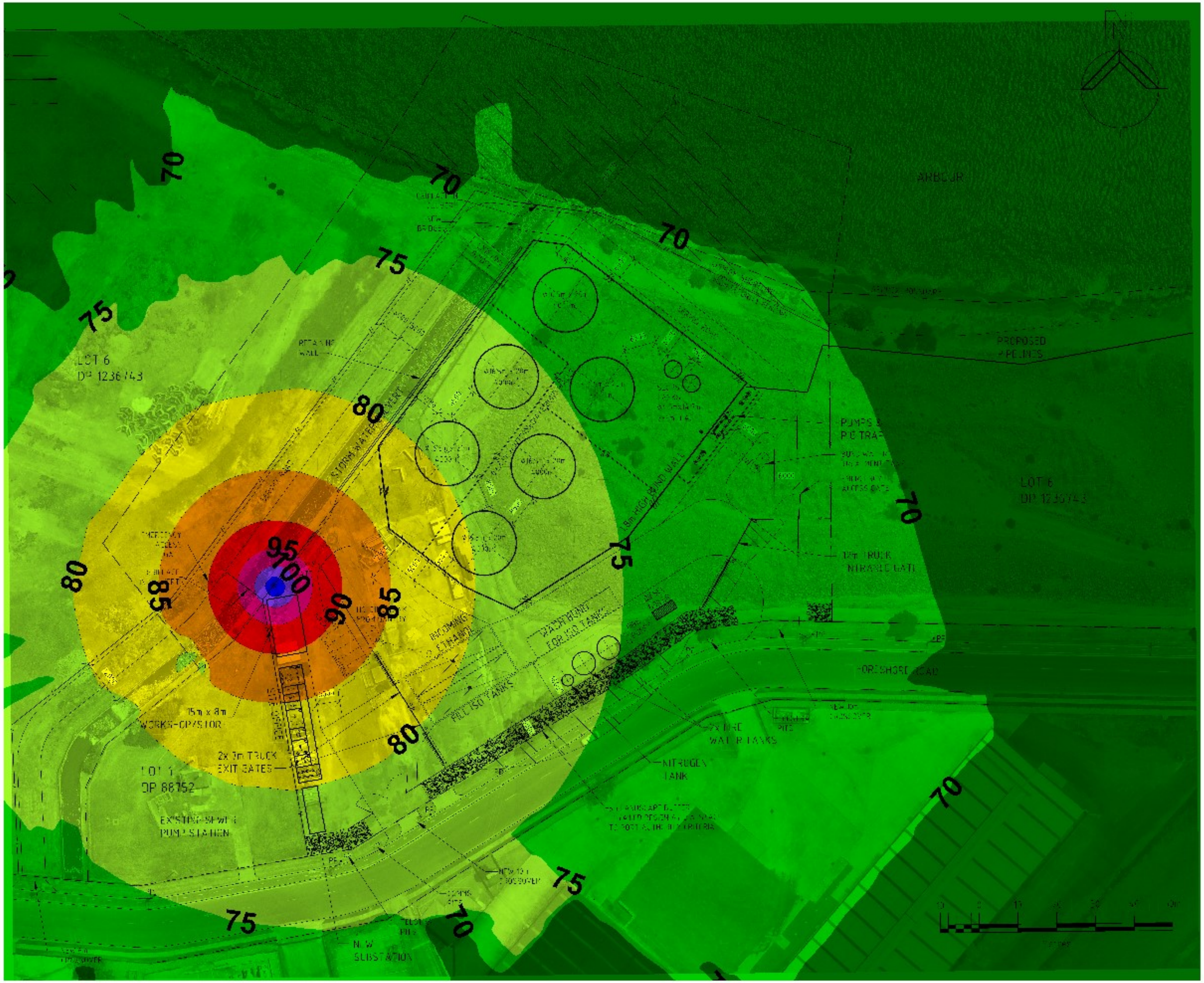
Prepared by: OB
Date: 19/11/2021

Noise Level
LAeq
in dB(A)

	< 48
	48 - 50
	50 - 52
	52 - 54
	54 - 56
	56 - 58
	58 - 60
	60 - 62
	62 - 64
	64 - 66
	66 - 68
	>=68

ACOUSTIC LOGIC

Port Kembla



Ground Level Noise Contours
Height above ground: 1800mm

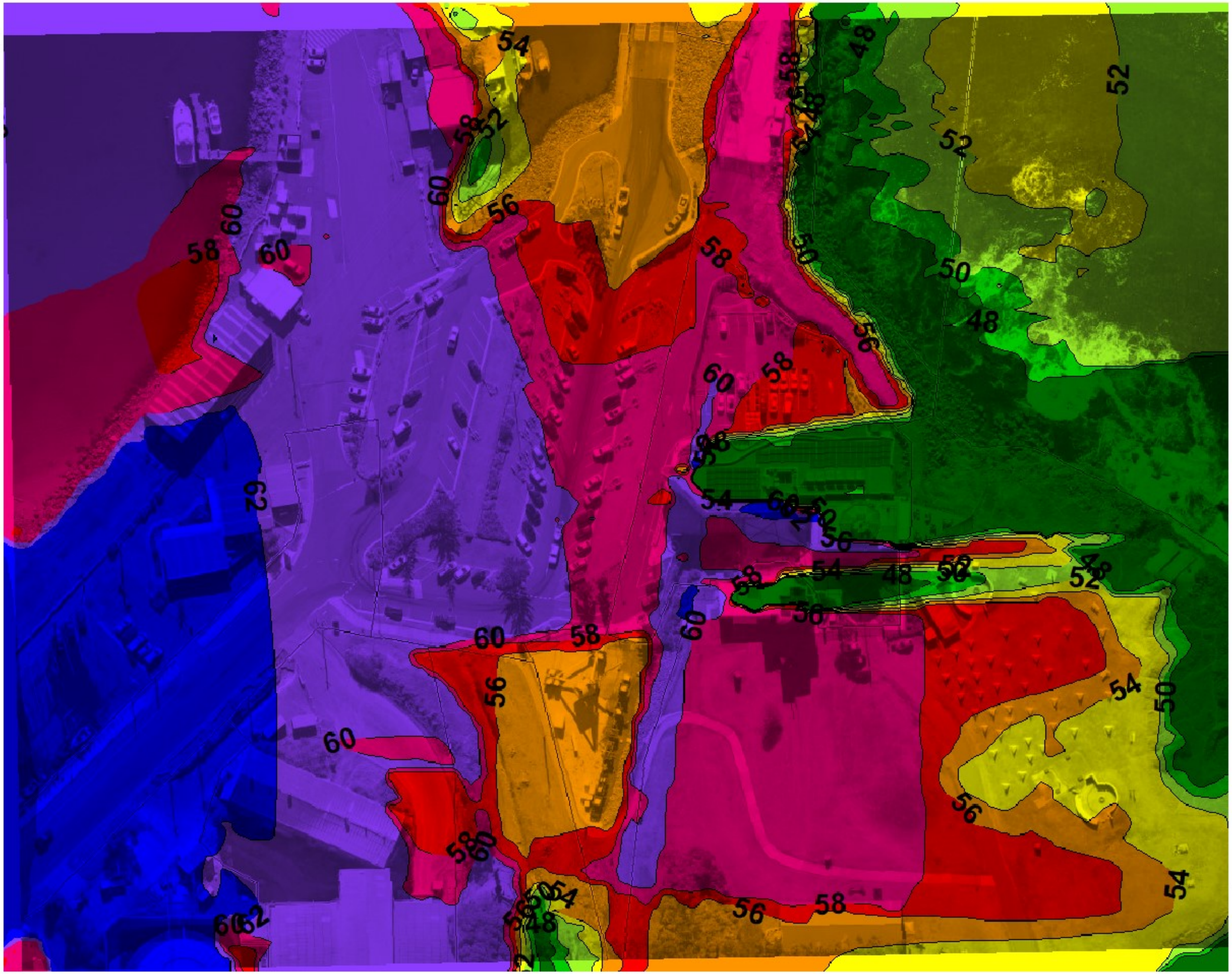
Prepared by: OB
Date: 19/11/2021

Noise Level
LAeq
in dB(A)

dark green	< 70
green	70 - 75
light green	75 - 80
yellow	80 - 85
orange	85 - 90
red	90 - 95
pink	95 - 10(
purple	10(- 10!
blue	10! - 11(
dark blue	11(- 11!
dark grey	11! - 12(
black	>= 12(

ACOUSTIC LOGIC

Port Kembla



Ground Level Noise Contours
Height above ground: 1800mm

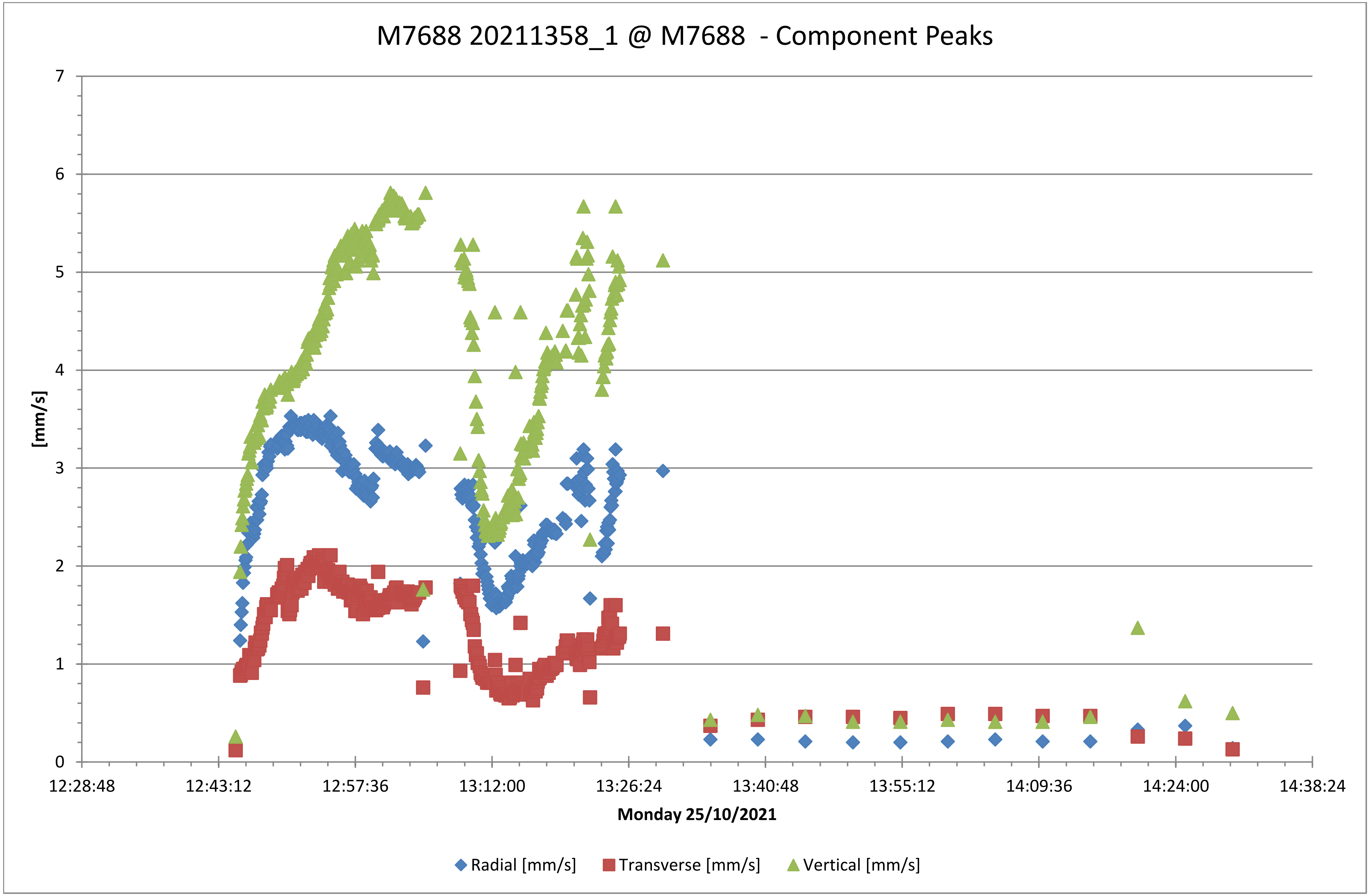
Prepared by: OB
Date: 19/11/2021

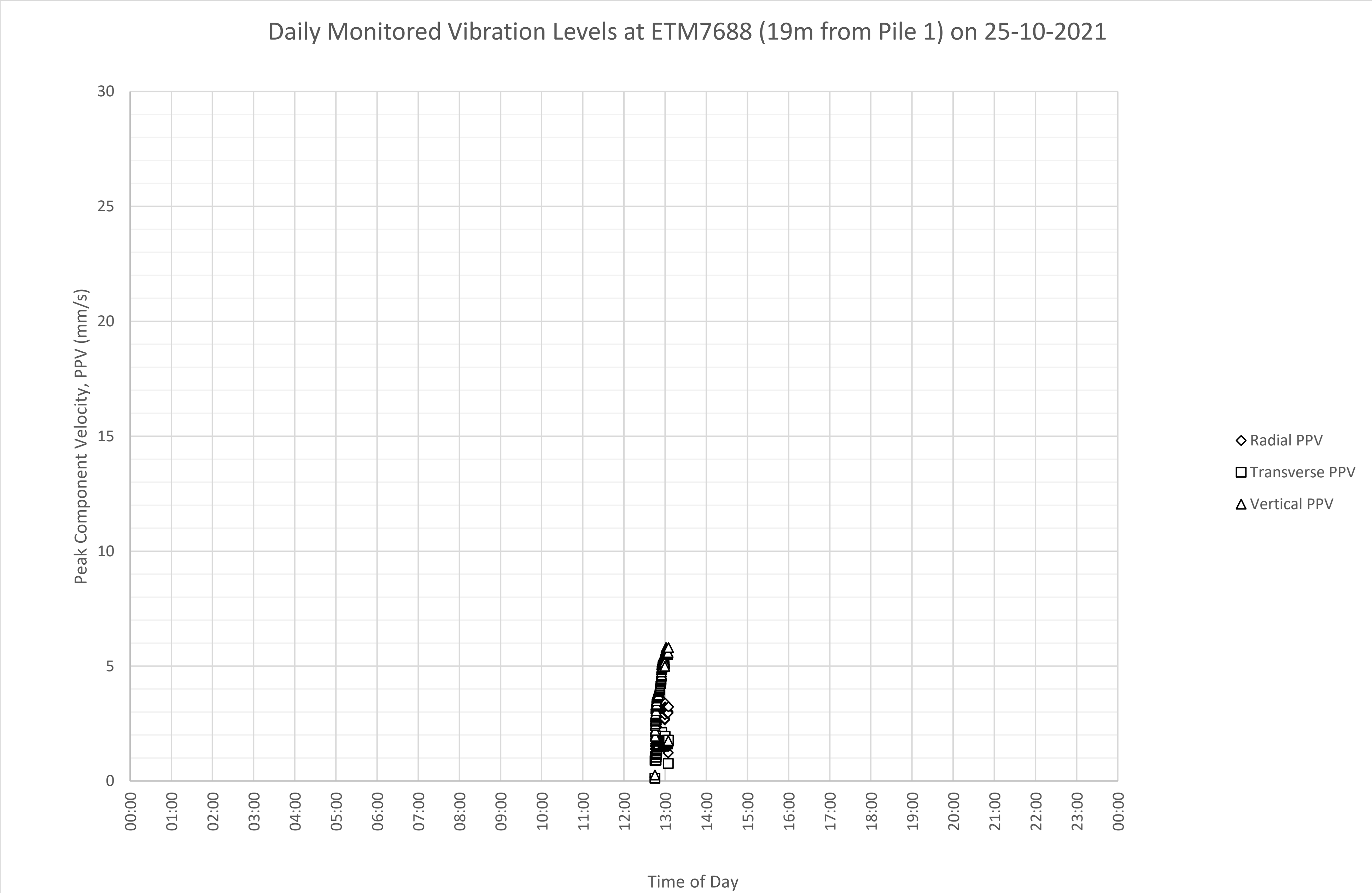
Noise Level
LAeq
in dB(A)

	< 48
	48 - 50
	50 - 52
	52 - 54
	54 - 56
	56 - 58
	58 - 60
	60 - 62
	62 - 64
	64 - 66
	66 - 68
	>=68

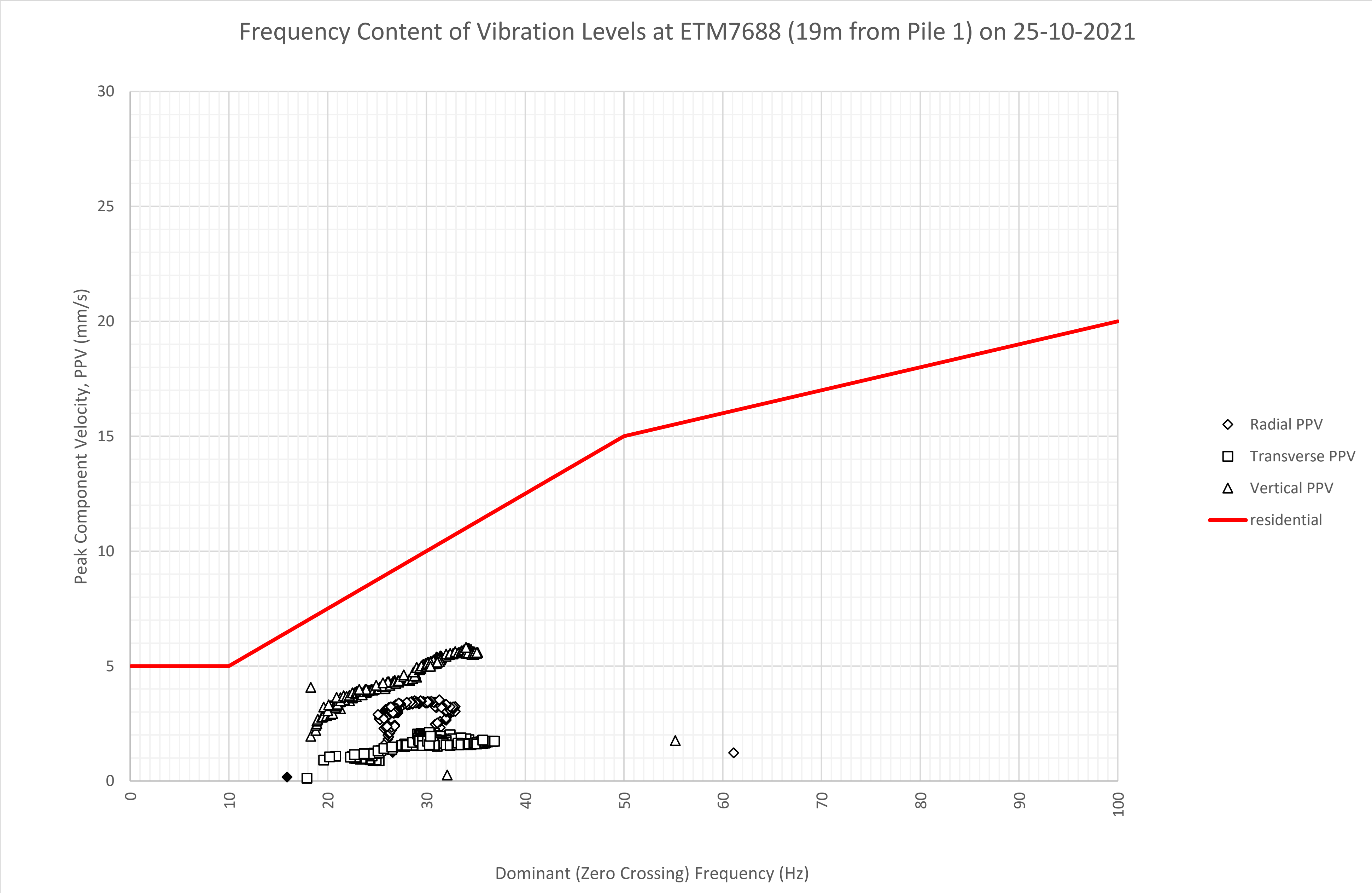
ACOUSTIC LOGIC

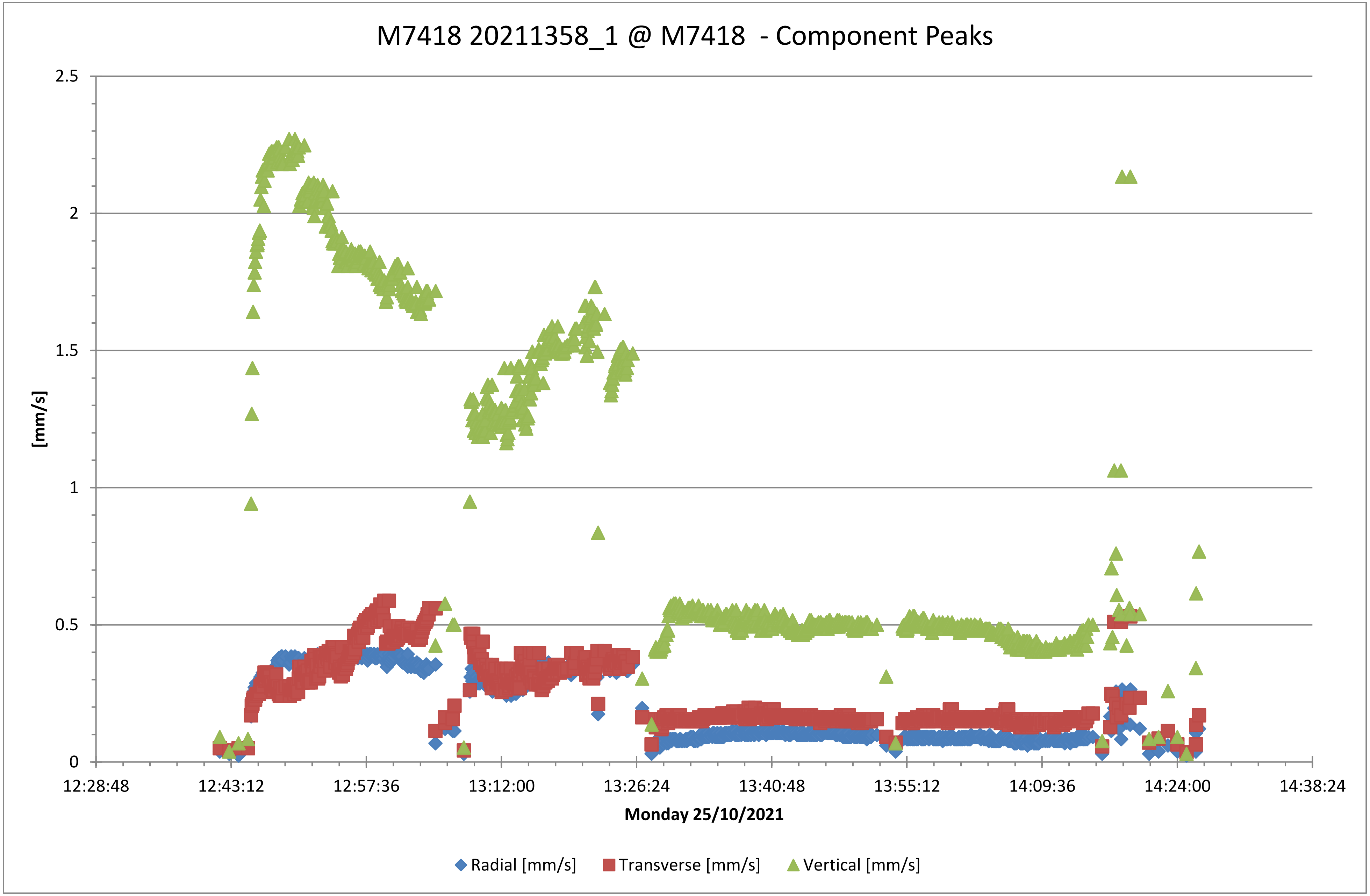
APPENDIX 2 – MONITOR VIBRATION LEVELS

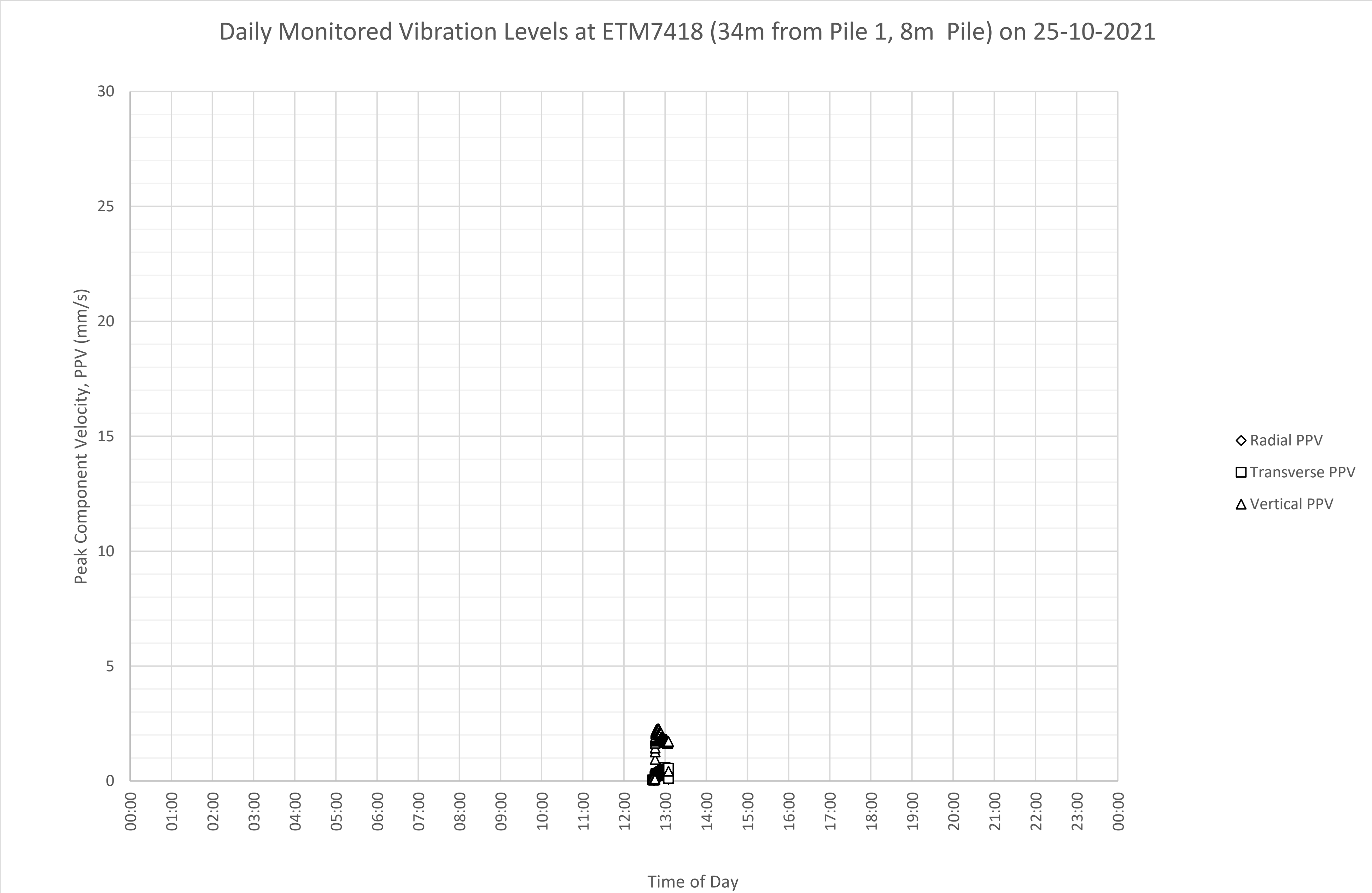

M7688 20211358_1 @ M7688 - Component Peaks
7
6
5
4
3
2
1
0
[mm/s]
12:28:48
12:43:12
12:57:36
13:12:00
13:26:24
13:40:48
13:55:12
14:09:36
14:24:00
14:38:24
Monday 25/10/2021
Radial [mm/s]
Transverse [mm/s]
Vertical [mm/s]



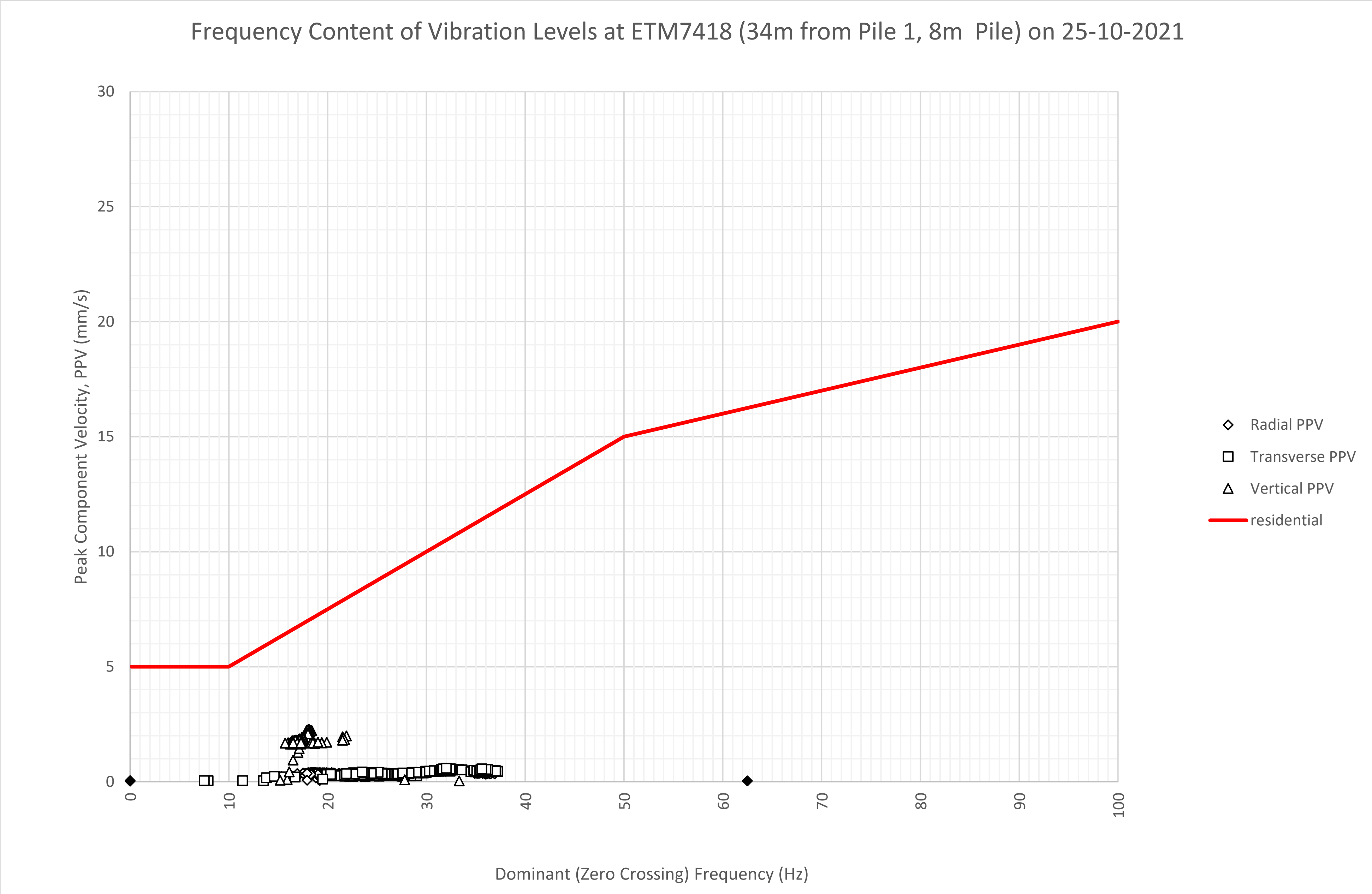
Daily Monitored Vibration Levels at ETM7688 (19m from Pile 1) on 25-10-2021
Peak Component Velocity, PPV (mm/s)
30
25
20
15
10
5
0
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Time of Day
Radial PPV
Transverse PPV
Vertical PPV


Frequency Content of Vibration Levels at ETM7688 (19m from Pile 1) on 25-10-2021
Peak Component Velocity, PPV (mm/s)
30
25
20
15
10
5
0
0
10
20
30
40
50
60
70
80
90
100
Dominant (Zero Crossing) Frequency (Hz)
Radial PPV
Transverse PPV
Vertical PPV
residential

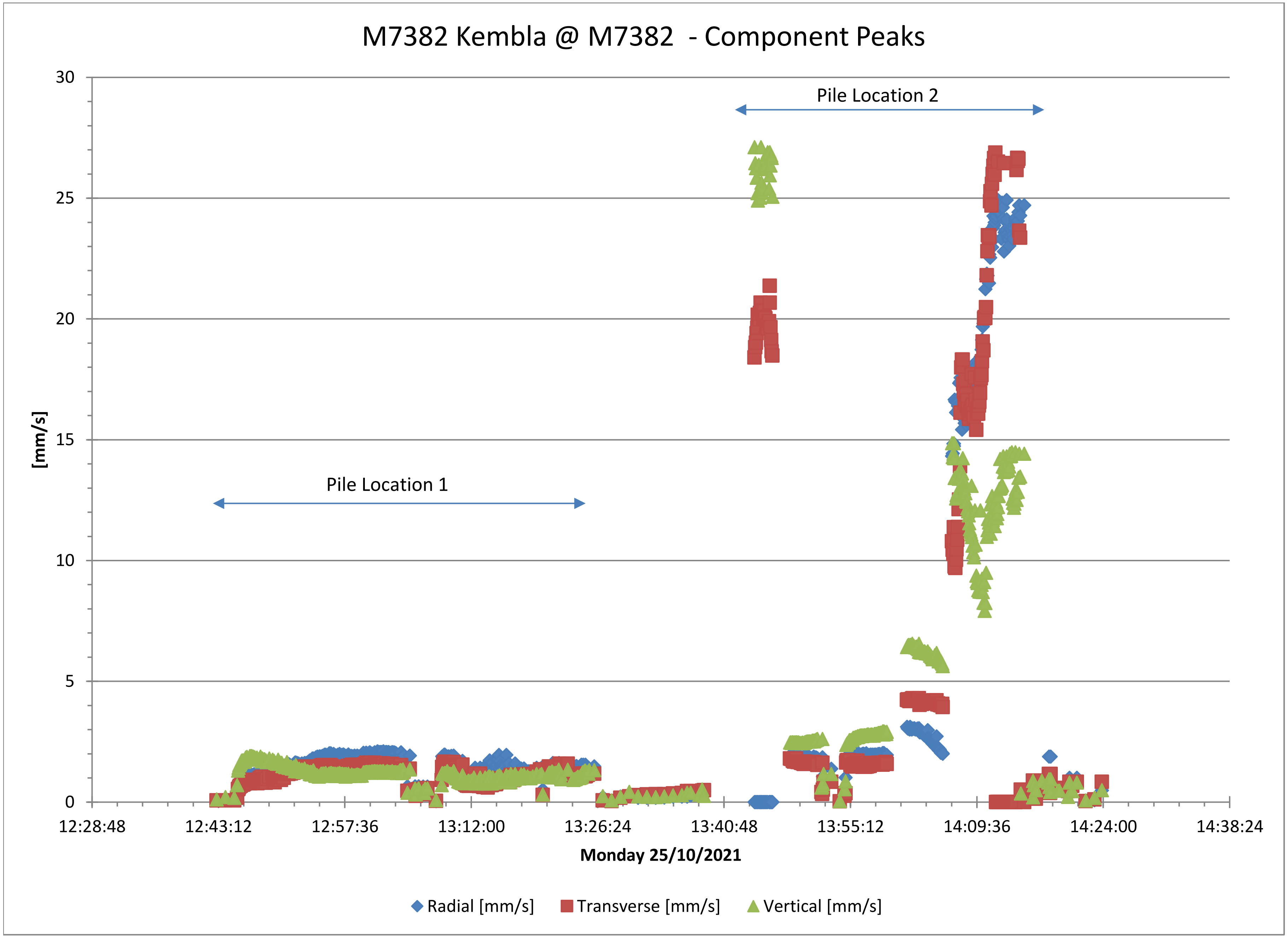

M7418 20211358_1 @ M7418 - Component Peaks
2.5
2
1.5
1
0.5
0
[mm/s]
12:28:48
12:43:12
12:57:36
13:12:00
13:26:24
13:40:48
13:55:12
14:09:36
14:24:00
14:38:24
Monday 25/10/2021
Radial [mm/s]
Transverse [mm/s]
Vertical [mm/s]



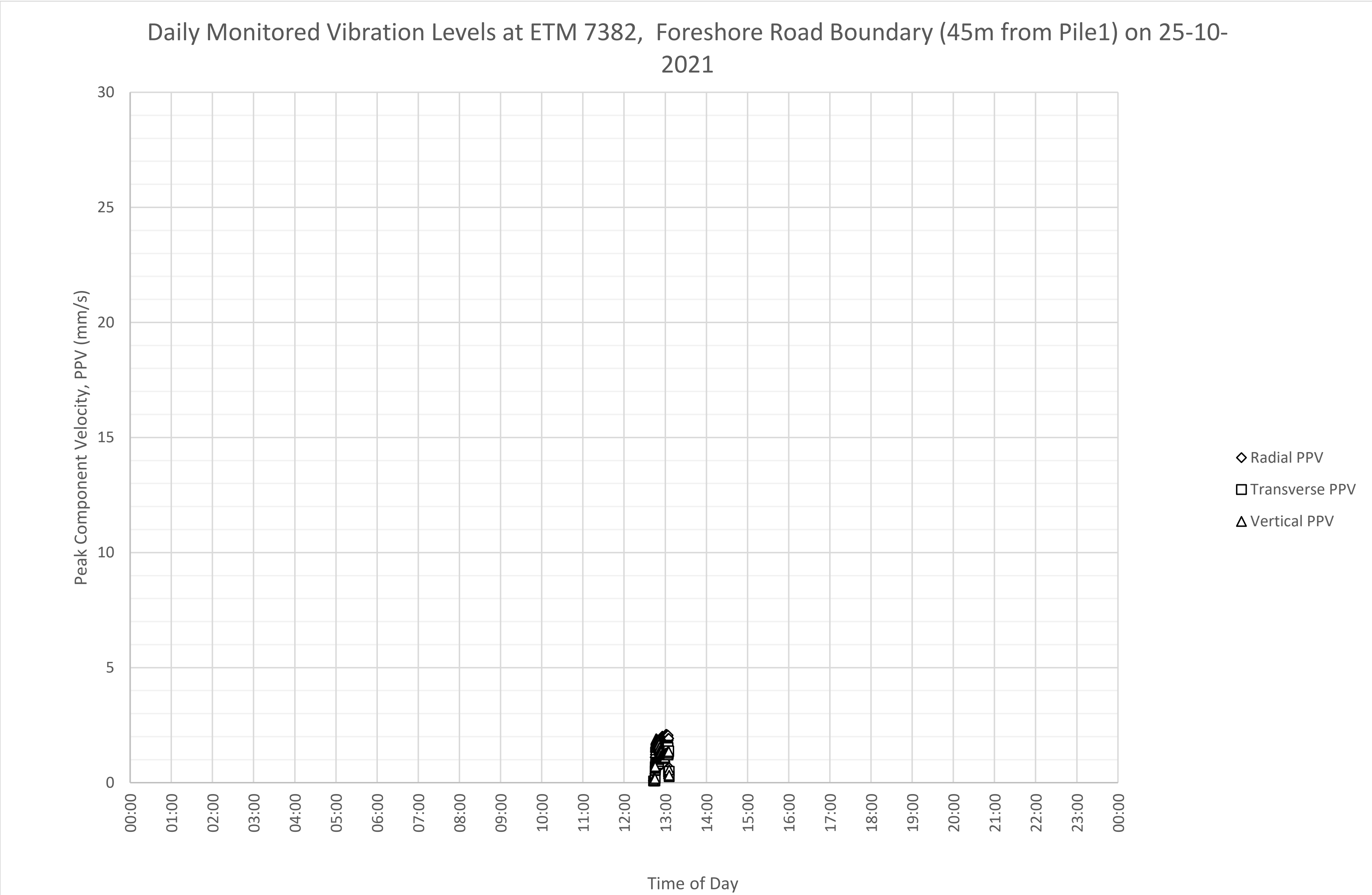
Daily Monitored Vibration Levels at ETM7418 (34m from Pile 1, 8m Pile) on 25-10-2021
Peak Component Velocity, PPV (mm/s)
30
25
20
15
10
5
0
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Time of Day
Radial PPV
Transverse PPV
Vertical PPV

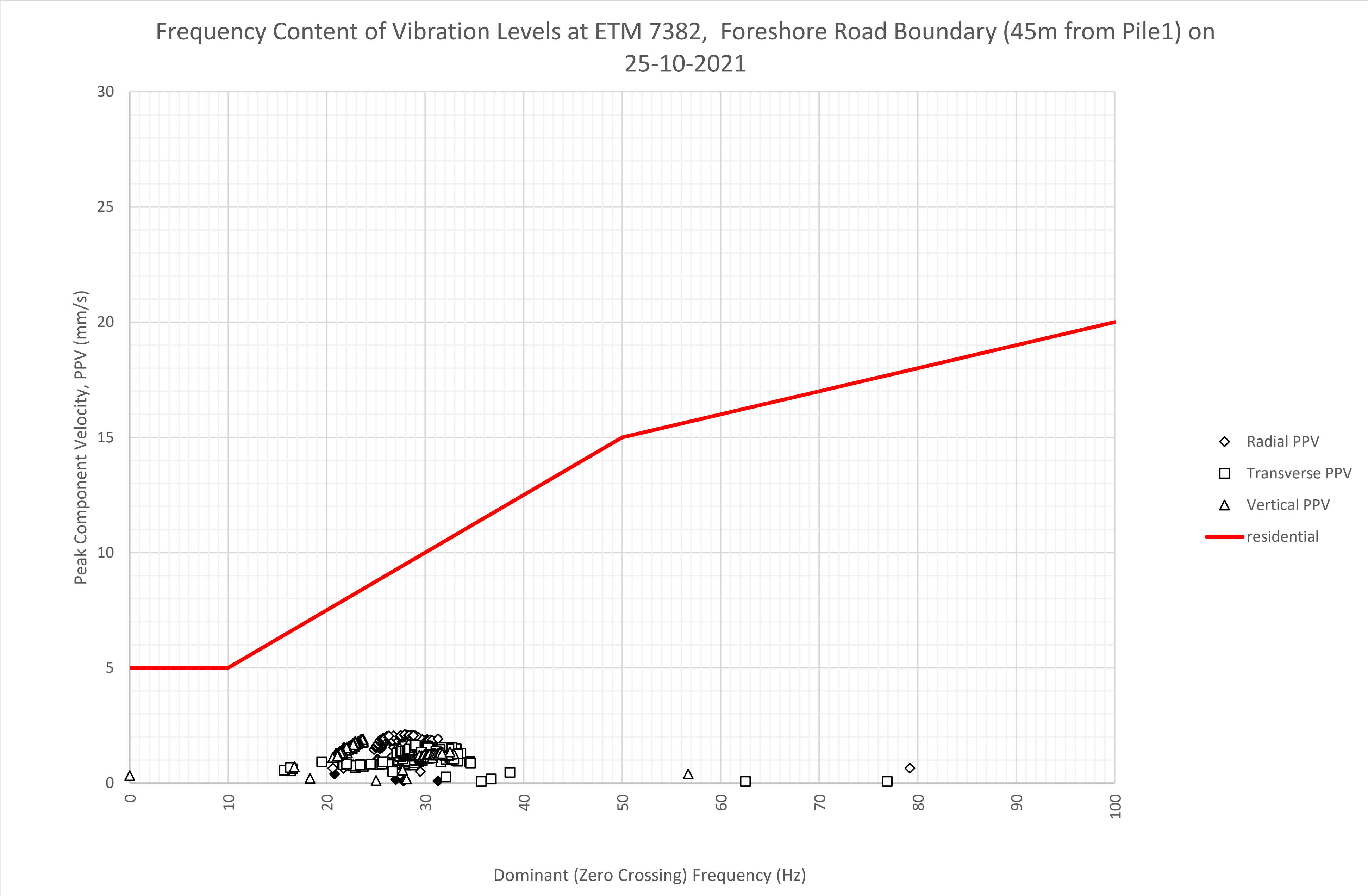


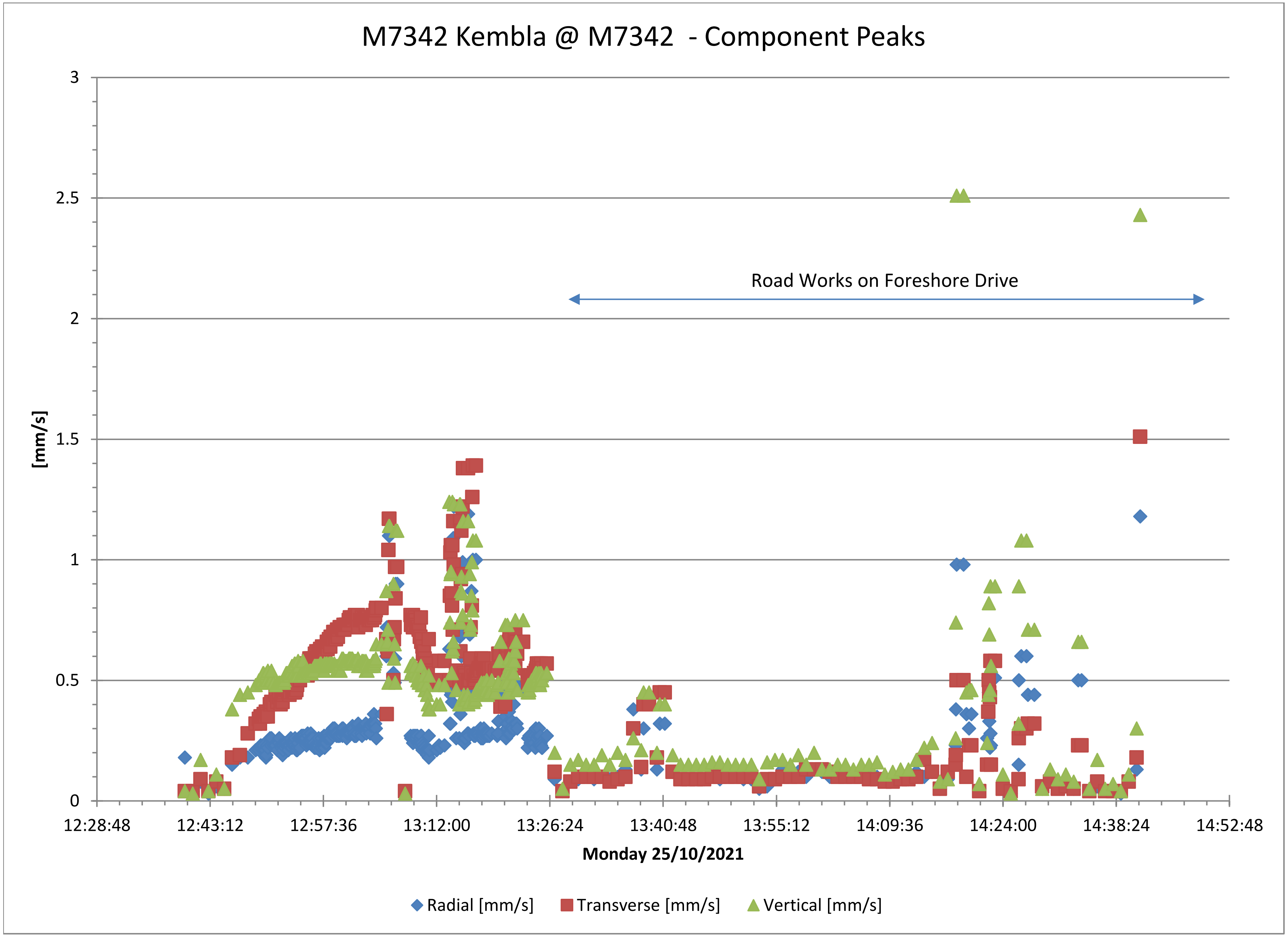
Frequency Content of Vibration Levels at ETM7418 (34m from Pile 1, 8m Pile) on 25-10-2021
Peak Component Velocity, PPV (mm/s)
Dominant (Zero Crossing) Frequency (Hz)
Radial PPV
Transverse PPV
Vertical PPV
residential

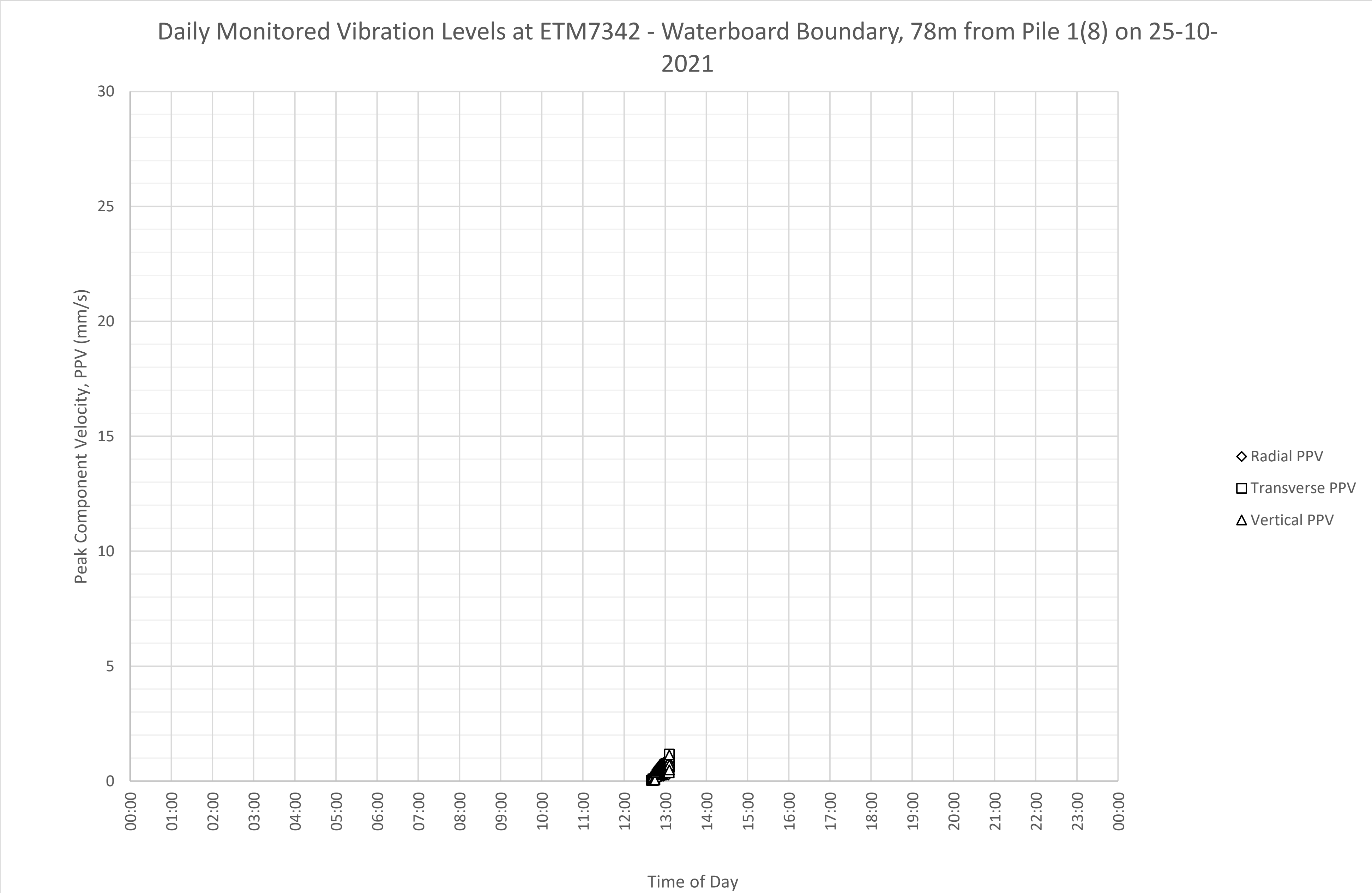


M7382 Kembla @ M7382 - Component Peaks
Pile Location 2
Pile Location 1
[mm/s]
30
25
20
15
10
5
0
12:28:48
12:43:12
12:57:36
13:12:00
13:26:24
13:40:48
13:55:12
14:09:36
14:24:00
14:38:24
Monday 25/10/2021
Radial [mm/s]
Transverse [mm/s]
Vertical [mm/s]

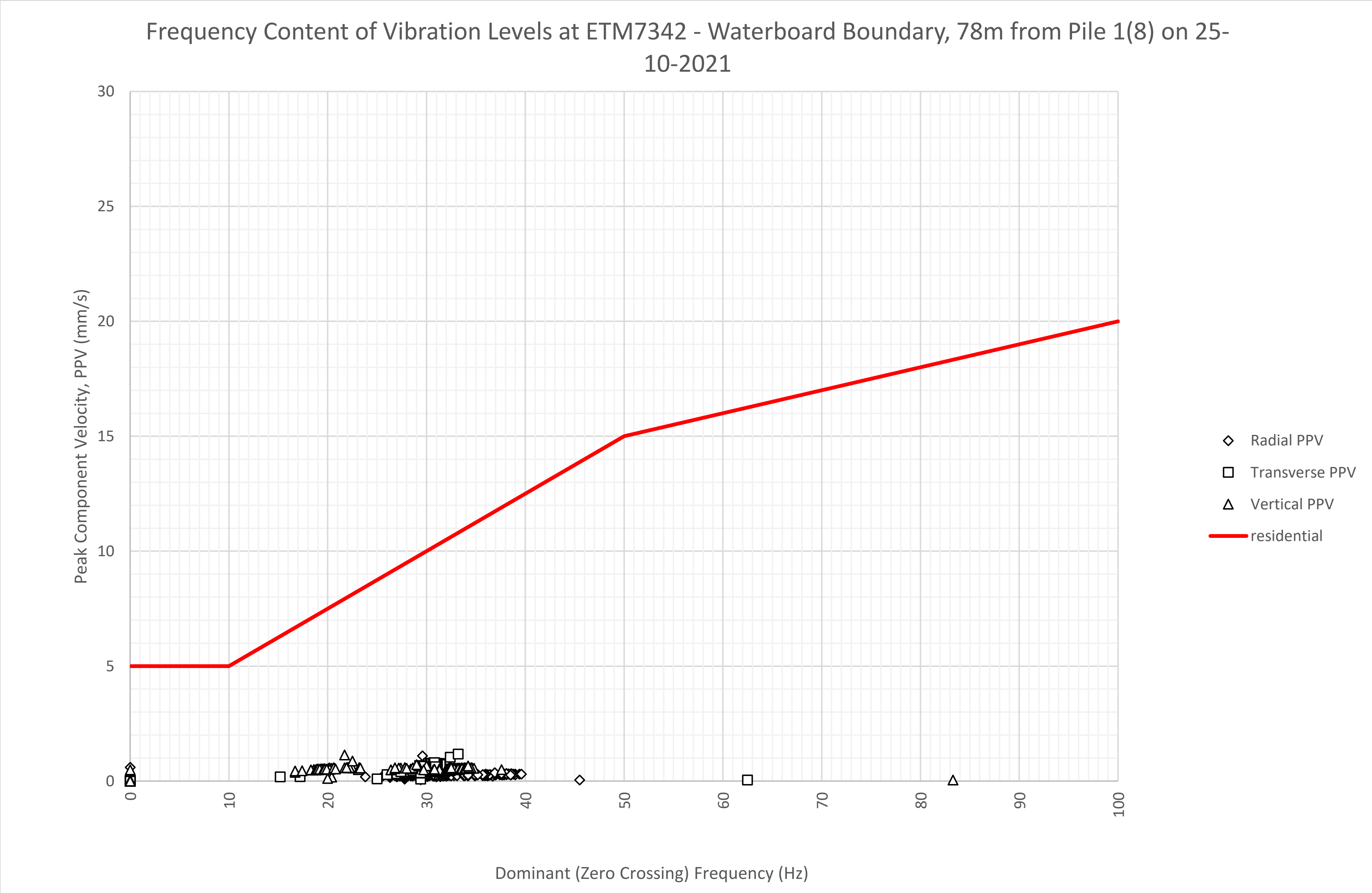

Daily Monitored Vibration Levels at ETM 7382, Foreshore Road Boundary (45m from Pile1) on 25-10-2021
Peak Component Velocity, PPV (mm/s)
30
25
20
15
10
5
0
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Time of Day
Radial PPV
Transverse PPV
Vertical PPV


Frequency Content of Vibration Levels at ETM 7382, Foreshore Road Boundary (45m from Pile1) on 25-10-2021
Peak Component Velocity, PPV (mm/s)
0
5
10
15
20
25
30
0
10
20
30
40
50
60
70
80
90
100
Dominant (Zero Crossing) Frequency (Hz)
Radial PPV
Transverse PPV
Vertical PPV
residential

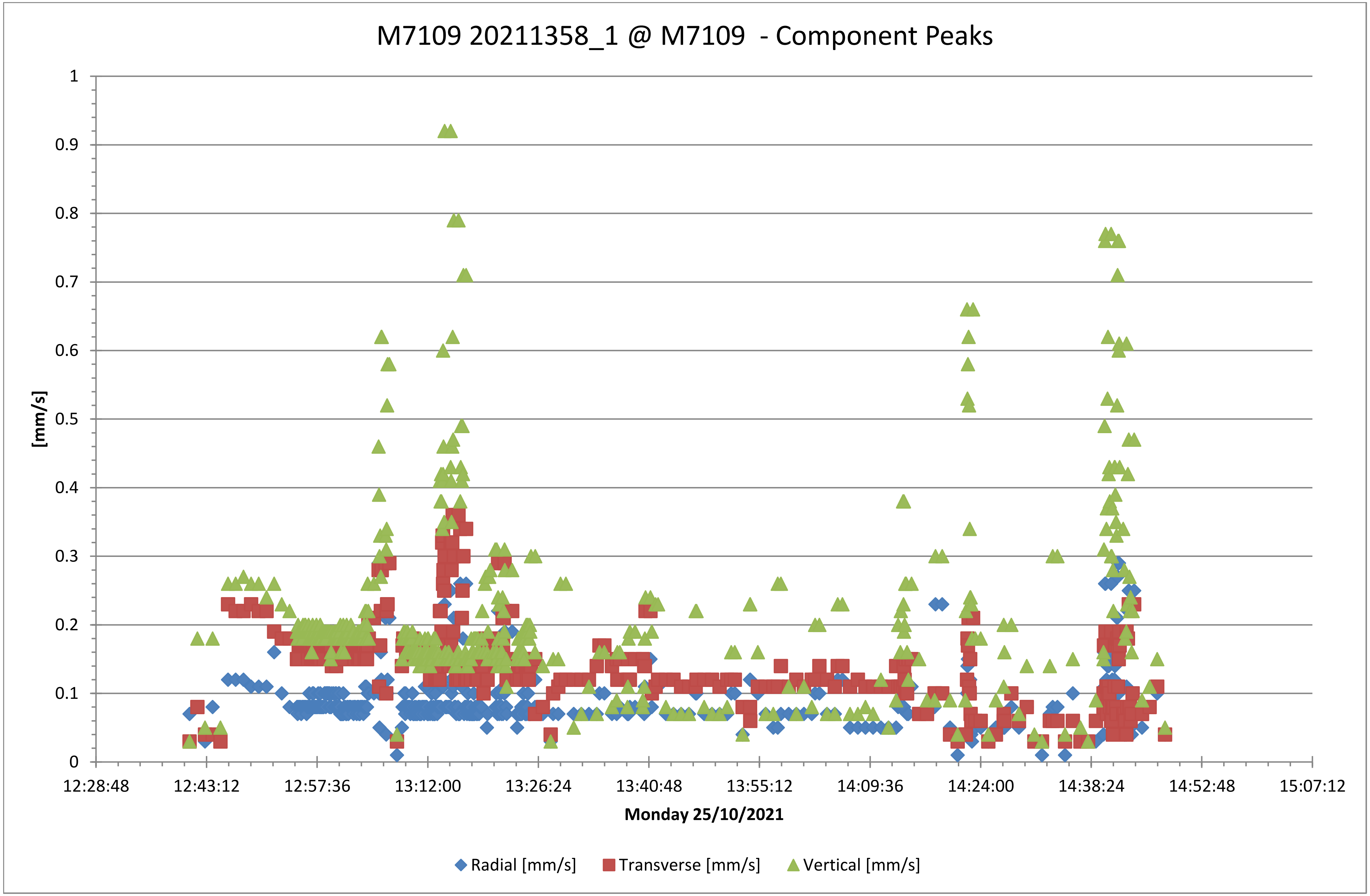

M7342 Kembla @ M7342 - Component Peaks
3
2.5
2
1.5
1
0.5
0
[mm/s]
Road Works on Foreshore Drive
12:28:48
12:43:12
12:57:36
13:12:00
13:26:24
13:40:48
13:55:12
14:09:36
14:24:00
14:38:24
14:52:48
Monday 25/10/2021
Radial [mm/s]
Transverse [mm/s]
Vertical [mm/s]



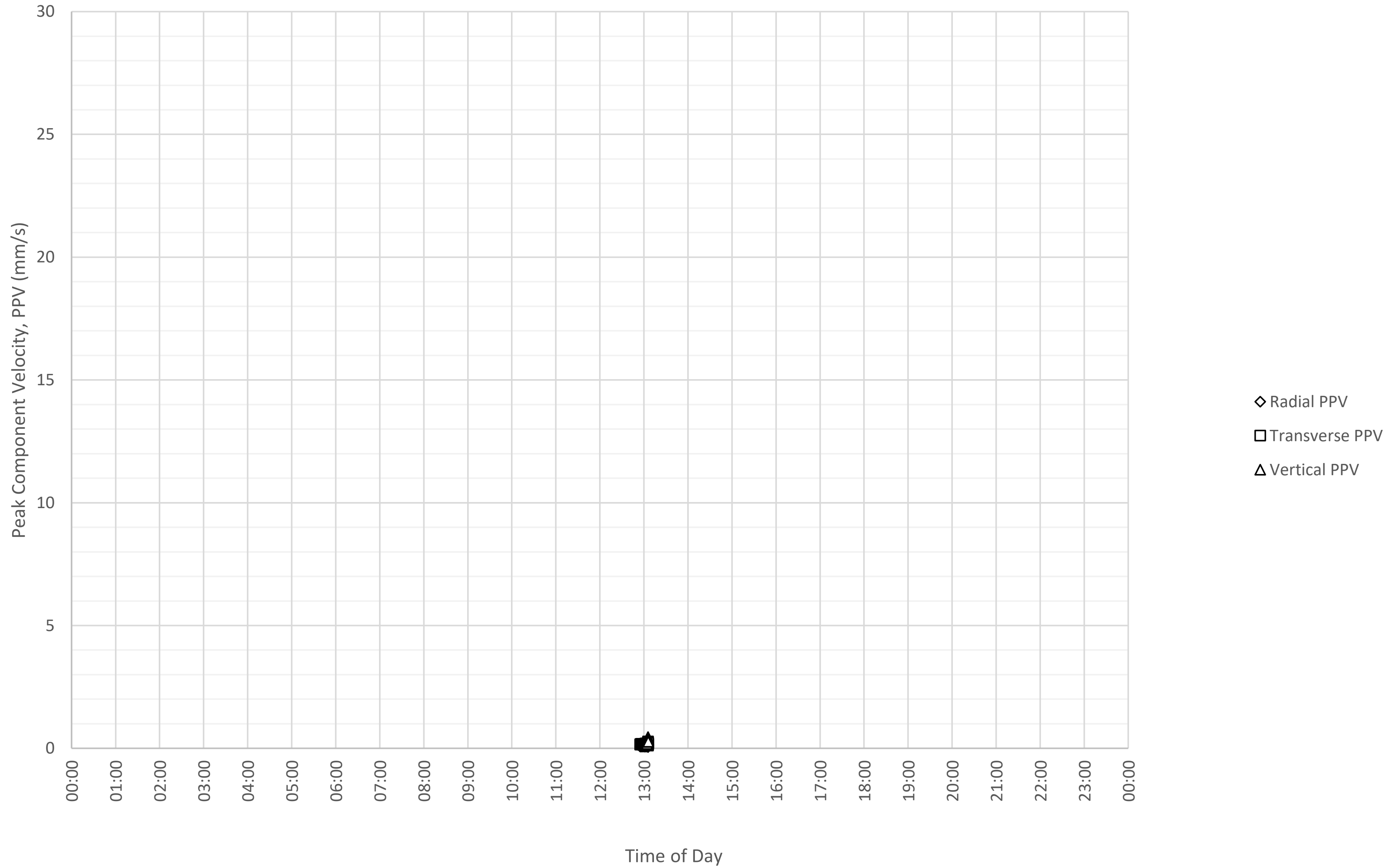
Daily Monitored Vibration Levels at ETM7342 - Waterboard Boundary, 78m from Pile 1(8) on 25-10-2021
Peak Component Velocity, PPV (mm/s)
30
25
20
15
10
5
0
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Time of Day
Radial PPV
Transverse PPV
Vertical PPV

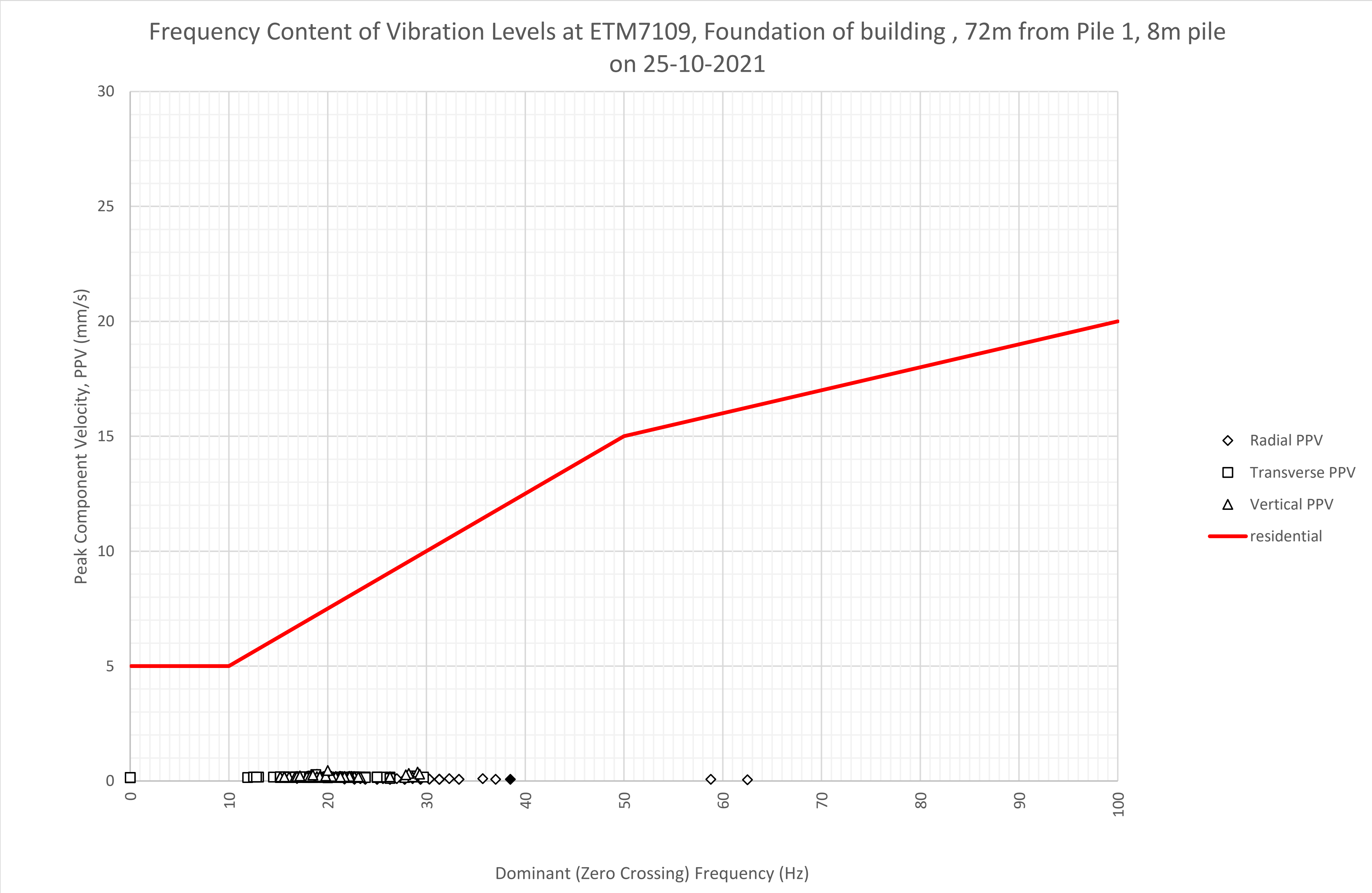


Frequency Content of Vibration Levels at ETM7342 - Waterboard Boundary, 78m from Pile 1(8) on 25-10-2021
Peak Component Velocity, PPV (mm/s)
30
25
20
15
10
5
0
0
10
20
30
40
50
60
70
80
90
100
Dominant (Zero Crossing) Frequency (Hz)
Radial PPV
Transverse PPV
Vertical PPV
residential


M7109 20211358_1 @ M7109 - Component Peaks
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
[mm/s]
12:28:48
12:43:12
12:57:36
13:12:00
13:26:24
13:40:48
13:55:12
14:09:36
14:24:00
14:38:24
14:52:48
15:07:12
Monday 25/10/2021
Radial [mm/s]
Transverse [mm/s]
Vertical [mm/s]

Daily Monitored Vibration Levels at ETM7109, Foundation of building , 72m from Pile 1, 8m pile on 25-10-2021




Frequency Content of Vibration Levels at ETM7109, Foundation of building , 72m from Pile 1, 8m pile on 25-10-2021
Peak Component Velocity, PPV (mm/s)
30
25
20
15
10
5
0
0
10
20
30
40
50
60
70
80
90
100
Dominant (Zero Crossing) Frequency (Hz)
Radial PPV
Transverse PPV
Vertical PPV
residential