Appendix F. Baseline Measurements

Introduction

This document presents details on the baseline measurements undertaken for the Melbourne Metro. The types of measurements that have been undertaken and their corresponding sections in this appendix are described below:

- Section F.1: Unattended External Noise Measurements
- Section F.2: Attended External Noise Measurements (For Parkville, CBD North and CBD South)
- Section F.3: Internal Noise Measurements
- Section F.4: External Vibration Measurements
- Section F.5: Internal Vibration Measurements
- Section F.6: Underwater Ambient Noise Measurements.

Current calibration certificates for all the equipment used are presented in Section F.7.

F.1 Unattended External Noise Measurements

F.1.1 Summary

Unattended external noise measurements have been conducted at 22 locations across the Melbourne Metro area. The locations have been strategically selected in order to:

- Measure existing rail noise levels at residences in the vicinity of the portals and determination of Investigation Thresholds in compliance with the Victorian Passenger Rail Infrastructure Noise Policy *(*PRINP*)*.
- Measure existing background noise levels in the vicinity of fixed infrastructure to determine the *Noise Limits* at *Noise Sensitive Areas (*residential locations) in compliance with State Environment Protection Policy (Control of Noise from Commerce, Industry and Trade) No. N-1 (SEPP N-1).
- Measure existing background noise levels in the vicinity of proposed construction work to determine the Noise Limits for construction outside of Normal Working Hours in compliance with EPA Noise Control Guidelines Publication 1254, October 2008 (EPA 1254).

F.1.2 Methodology

F.1.2.1 Noise Monitoring Location

Noise Monitoring has been conducted at 22 locations across the Melbourne Metro. The specific locations are detailed in Table F1 and shown in Figure F1.

Table F1: Noise Monitoring Locations

Location No.	Address	Measurement Dates
Precinct 2: Western Portal		
1	148 Kensington Road, Kensington	21/7/2015 – 30/7/2015
2	138 Kensington Road, Kensington	31/7/2015 – 11/8/2015
3	3 Childers Street, Kensington	21/7/2015 – 11/8/2015
4	1 Altona Street, Kensington	21/7/2015 – 30/7/2015
Precinct 3: Arden		
5	141 Lauren, North Melbourne	13/8/2015 – 24/8/2015
6	724 Queensberry Street, North Melbourne	31/8/2015 – 14/9/2015
7	2/3 Miller Street, West Melbourne	21/7/2015 – 11/8/2015
Precinct 5: CBD North Station		
8	The Verve Apartments, 483 Swanston Street, Melbourne	13/8/2015 – 21/8/2015
9	QV 2 Apartments, 300 Swanston Street, Melbourne	1/10/2015 – 13/10/2015
Precinct 6: CBD South Station		
10	The Westin Hotel, 210 Collins Street, Melbourne	13/8/2015 – 21/8/2015
11	Quay West, 26 Southgate Avenue, Southbank	13/8/2015 – 21/8/2015
Precinct 7: Domain Station		
12	Hallmark Apartments, 2-14 Albert Road, South Melbourne	31/8/2015 – 11/9/2015
13	The, Domain, 1-29 Albert Road, South Melbourne	15/9/2015 – 23/9/2015
14	The Melburnian, 250 St. Kilda Road, Melbourne	11/11/2015 – 18/11/2015
In vicinity of Fawkner Park		
15	68 Toorak Road, South Yarra	31/8/2015 – 11/9/2015
16	2/1 Park Street, South Yarra	26/10/2015 – 4/11/2015
Precinct 8: Eastern Portal		
17	139 Osborne Street, South Yarra	1/10/2015 – 13/10/2015
18	4 William Street, South Yarra	9/10/2015 – 26/10/2015
19	6 William Street, South Yarra	22/9/2015 – 1/10/2015
20	10 William Street, South Yarra	22/9/2015 – 1/10/2015
21	19 William Street, South Yarra	9/10/2015 – 26/10/2015
22	3 Chamber Street, South Yarra	22/9/2015 – 5/10/2015

F.1.2.2 Noise Monitoring Approach

Noise Monitoring has been conducted in general compliance with Australian Standard AS1055.1-1997 Acoustics-Description and measurement of environmental noise, Part 1: General procedures (AS 1055.1) and SEPP N-1. Two locations were used for the microphone of the noise logger:

- At 1 m from the most exposed window of a habitable room. This was the location used in the vicinity of existing rail activity
- At the property boundary (where possible) at 1.2 m to 1.5 m above ground level. This was the location used when ambient noise levels were being measured.

Where measurements were located within 1 to 2 m of a reflecting surface an adjustment of '-2' was applied in accordance with SEPP N-1 where applicable.

F.1.2.3 Acoustic Equipment

Details of the acoustic equipment used to conduct these measurements are provided in Table F2. All acoustic equipment has current calibration certificates and these are provided at the end of this Appendix (Section F.7).

Table F2: Acoustic Equipment

Manufacturer	Type of Instrument	Serial No.	Last Calibration Date
Bruel & Kjaer	Acoustic Calibrator	2542100	23/09/2013
Bruel & Kjaer	Acoustic Calibrator	2542100	04/09/2015
Acoustic Research Laboratories (ARL)	Noise Logger - Ngara	8780E1	25/07/2014
ARL	Noise Logger - Ngara	87811E	03/06/2014
ARL	Noise Logger - Ngara	8780E3	03/07/2014
ARL	Noise Logger - Ngara	8780B6	20/01/2014
ARL	Noise Logger - Ngara	878110	12/08/2014
ARL	Noise Logger - Ngara	87811F	03/06/2014

The sound level meters and noise loggers were checked for calibration before and after each set of measurements. A windshield was fitted to the microphone for all measurements.

F.1.2.4 Meteorology / Anomalous data

Meteorological conditions during the measurement period have been recorded by the Bureau of Meteorology at weather stations in the vicinity of each measurement location. This information, in addition to subjective observations, and review of the noise monitoring results, has been used to assess the impact of weather at all properties. It is likely that the wind speed will be higher at the weather stations than at the monitoring locations which are more shielded in residential backyards. As such, the measurements have been assessed and judgement used to determine if it is affected by a weather event.

Where anomalous or weather effected data is identified it has been excluded in the determination of acoustic parameters.

F.1.3 Results

The results of the acoustic measurements are presented on Figures F2 to F23.

The L_{Amax}, L_{Aeq} and L_{A90} parameters have been provided. The definitions for each of these are provided below.

L_{Amax}: The maximum measured A-weighted sound pressure level over the measurement period.

L_{Aeq}: The A weighted equivalent continuous sound pressure level is the steady level which would, over a given period of time, deliver the same sound energy as the actual time-varying sound over the same period. Hence fluctuating levels can be described in terms of a single figure level.

L_{A90}: The A weighted sound pressure level that is exceeded for 90% of the measurement period. It is usually used to represent the background noise level.

A-weighting The A-weighted sound pressure level in decibels, denoted dB(A) is the unit generally used for the measurement of environmental, transportation or industrial noise. The A-weighting scale approximates the sensitivity of the human ear and correlates well with subjective perception of sounds.

The calculated parameters presented have been calculated from the measured weekday data, excluding periods of inclement weather. These are defined as:

$L_{Aeq,16hr}$: The A-weighed equivalent continuous sound pressure level over the day period, 06:00 to 22:00 hours as defined in the PRINP.

$L_{Aeq,8hr}$: The A-weighed equivalent continuous sound pressure level over the night period, 06:00 to 22:00 hours as defined in the PRINP.

$L_{A90\ Day}$: The hourly A-weighted sound pressure level that is exceeded for 90% of the measurement period averaged over the day period, 07:00 hours to 18:00 hours.

$L_{A90,\ Evening}$: The hourly A-weighted sound pressure level that is exceeded for 90% of the measurement period averaged over the evening period, 18:00 hours to 22:00 hours.

$L_{A90,\ Night}$: The hourly A-weighted sound pressure level that is exceeded for 90% of the measurement period averaged over the evening period, 22:00 hours to 07:00 hours

$L_{Aeq,\ Day}$: The A-weighted equivalent continuous sound pressure level over the day period, 07:00 hours to 18:00 hours

$L_{Aeq,\ Evening}$: The A-weighted equivalent continuous sound pressure level over the evening period, 18:00 hours to 22:00 hours

$L_{Aeq,\ Night}$: The A-weighted equivalent continuous sound pressure level over the night period, 22:00 hours to 07:00 hours

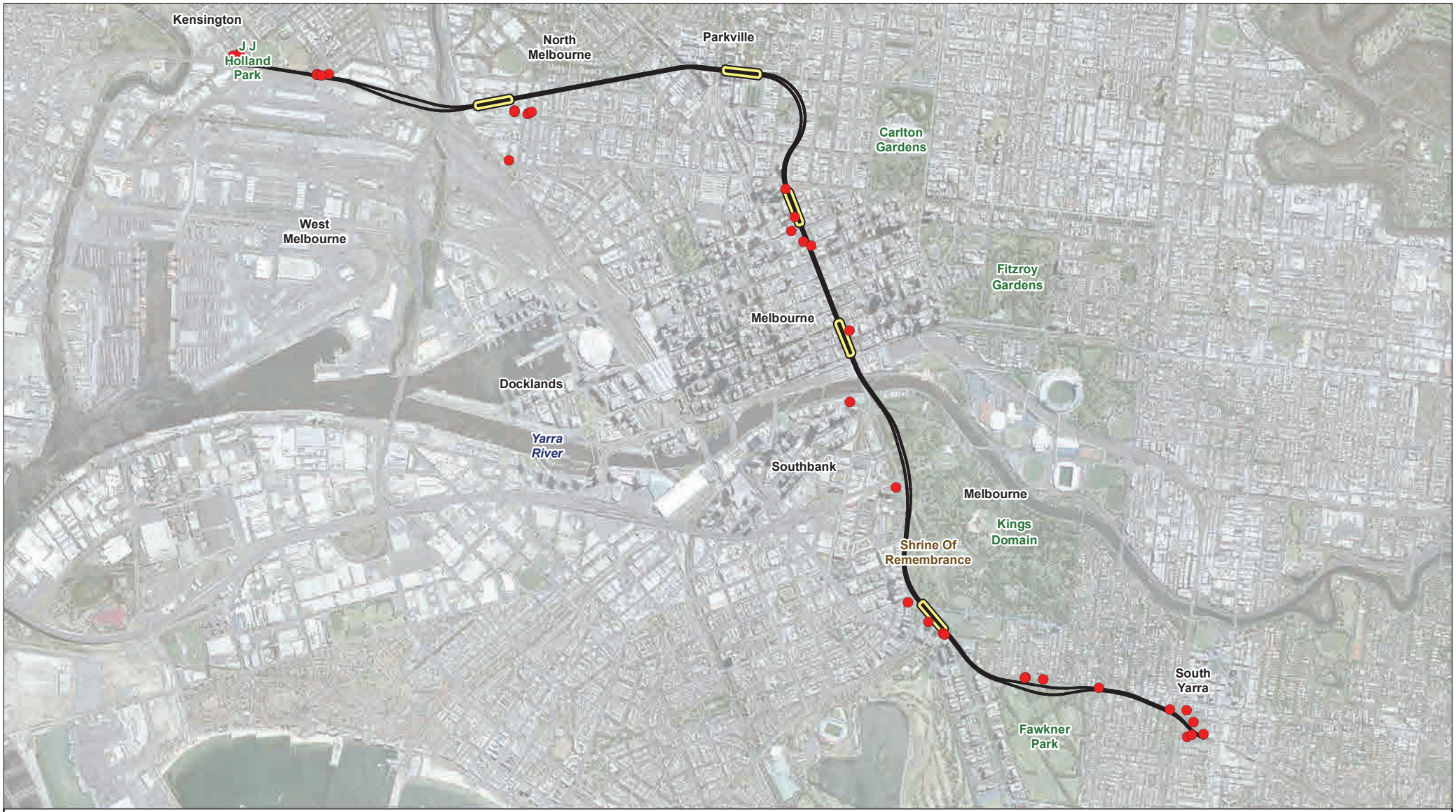


Figure F1: Noise Measurement Locations

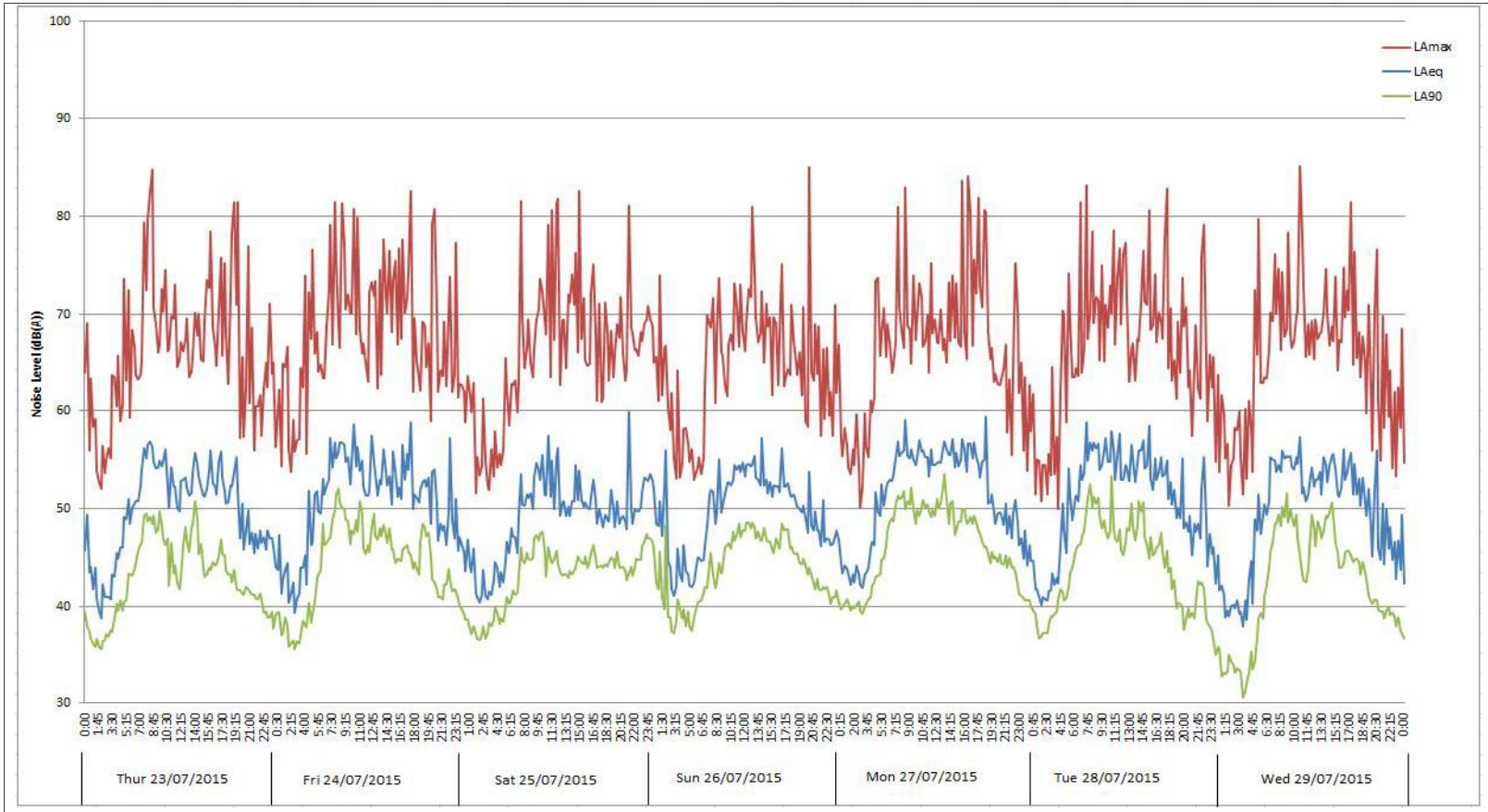


Image 1: View from logger

Image 2: Noise Logger

Image 3: Measurement Location

Parameters:

$L_{Aeq,16hr}$: 54 dB

$L_{Aeq,8hr.}$ 46 dB

$L_{Aeq,\ Day*}$: 53 dB

$L_{Aeq,\ Evening*}$: 49 dB

$L_{Aeq,\ Night*}$: 45 dB

$L_{A90\ Day*}$: 46 dB

$L_{A90,\ Evening*}$: 41 dB

$L_{A90,\ Night*}$: 38 dB

*Adjustment for reflection

Comments: the logger was in the vicinity of the existing railway and was installed at 1 m from the most exposed accessible window.

Measurement location: measurements were conducted in resident's backyard.

Meteorology: inclement weather on 24 July 2015

Noise sources: vehicles, trains

Figure F2: Measurement at Location 1: 148 Kensington Road, Kensington

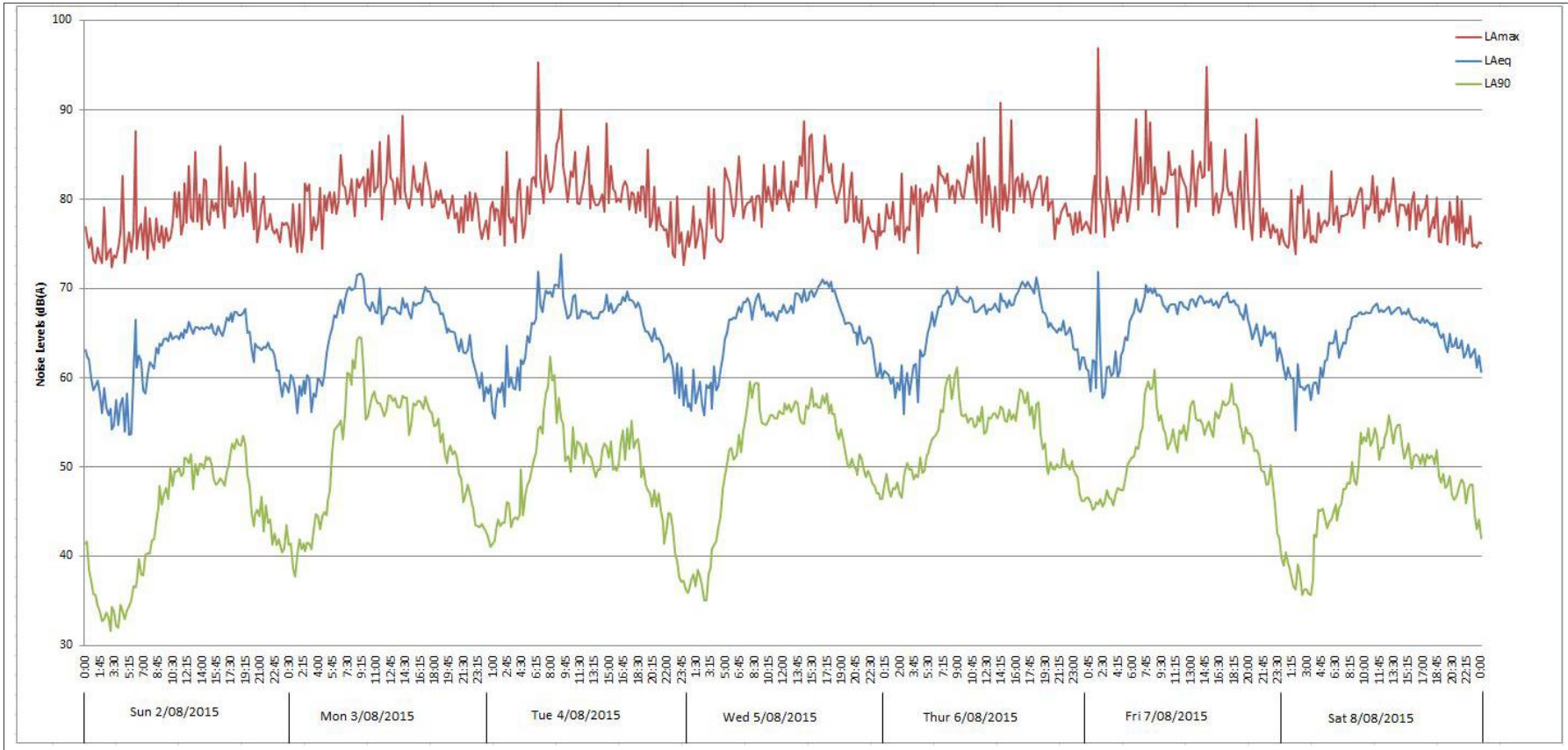


Image 1: Noise Logger

Image 2: View from logger

Image 3: Measurement Location

Parameters:

$L_{Aeq,16hr}$: 68 dB

$L_{Aeq,8hr}$: 62 dB

$L_{Aeq, Day*}$: 67 dB

$L_{Aeq, Evening*}$: 65 dB

$L_{Aeq, Night*}$: 61 dB

$L_{A90\ Day*}$: 54 dB

$L_{A90, Evening*}$: 50 dB

$L_{A90, Night*}$: 45 dB

*Adjustment for reflection

Comments: the logger is in the vicinity of the existing railway and was installed at 1 m from the most exposed accessible window.

Measurement location: measurements were conducted in the frontyard.

Meteorology: inclement weather on 3 August and 6 August.

Noise sources: vehicles, pedestrians, trains

Figure F3: Measurement at Location 2: 138 Kensington Road, Kensington

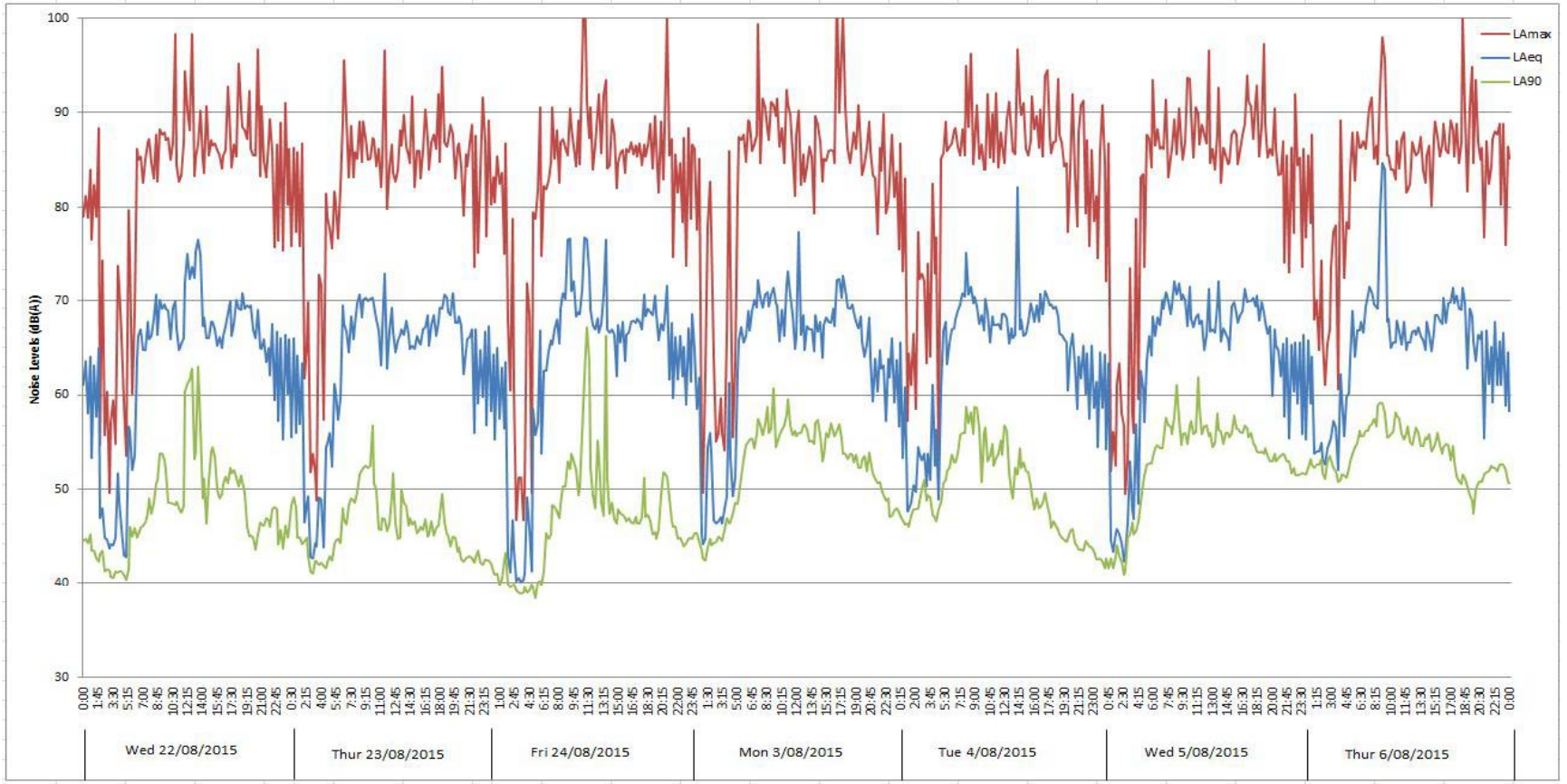


Image 1: Noise Logger

Image 2: View from logger

Image 3: Measurement Location

Parameters:

$L_{Aeq,16hr}$: 69 dB

$L_{Aeq,8hr}$: 61 dB

$L_{Aeq, Day*}$: 67 dB

$L_{Aeq, Evening*}$: 65 dB

$L_{Aeq, Night*}$:60 dB

$L_{A90 Day*}$: 51 dB

$L_{A90, Evening*}$: 46 dB

$L_{A90, Night*}$: 46 dB

*Adjustment for reflection

Comments: the logger is in the vicinity of the existing railway and was installed at 1 m from the most exposed accessible window

Measurement location: measurements were conducted in the front yard

Meteorology: inclement weather on 22 July, 24 July, 3 August and 6 August 2015.

Noise sources: vehicles, trains

Figure F4: Measurement at Location 3: 3 Childers Street, Kensington

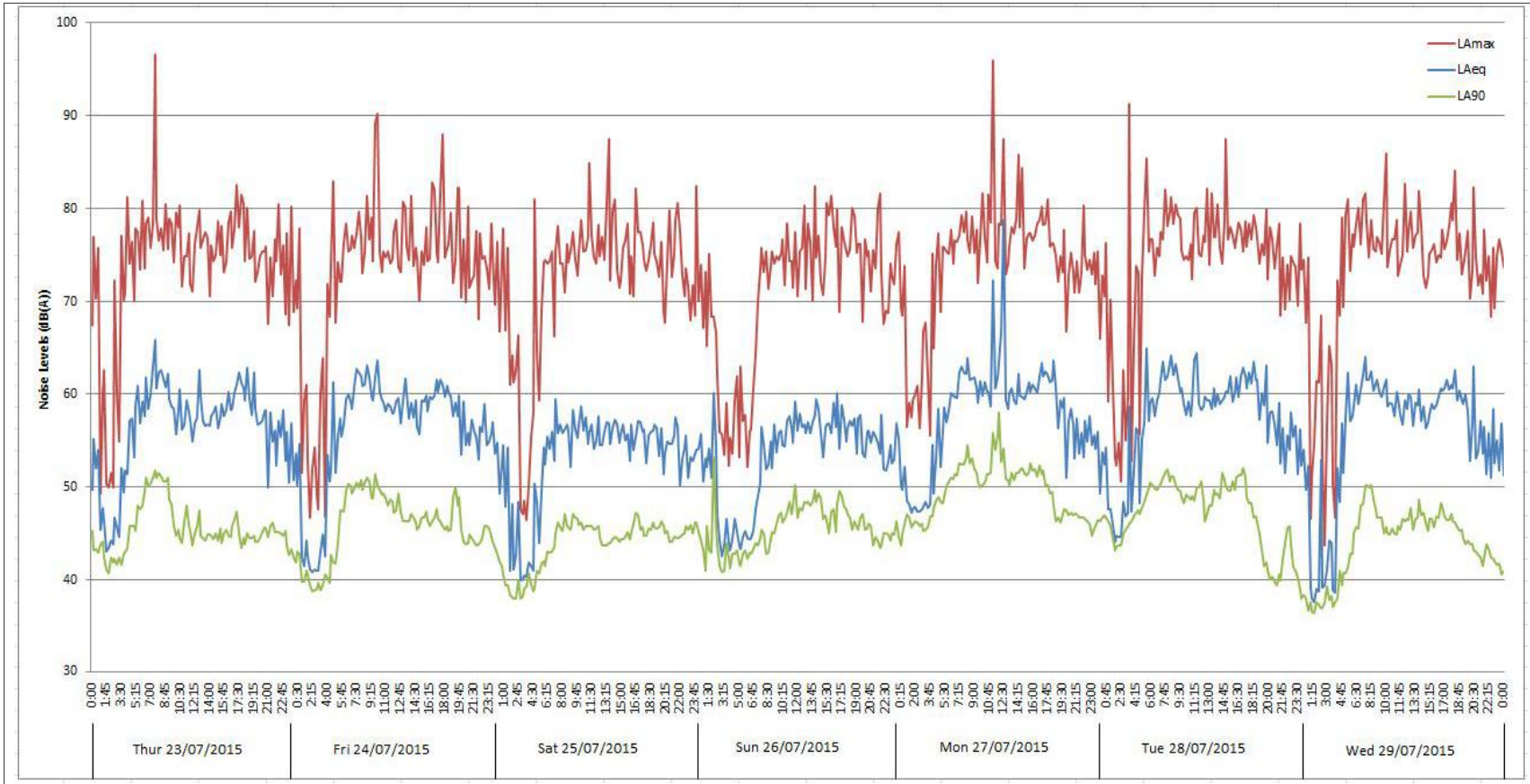


Image 1: Noise Logger

Image 2: View from logger

Image 3: Measurement Location

Parameters:

$L_{Aeq,16hr}$: 60 dB

$L_{Aeq,8hr}$: 54 dB

$L_{Aeq, Day*}$: 59 dB

$L_{Aeq, Evening*}$: 57 dB

$L_{Aeq, Night*}$:53 dB

$L_{A90\ Day*}$: 47 dB

$L_{A90, Evening*}$: 43 dB

$L_{A90, Night*}$: 43 dB

*Adjustment for reflection

Comments: the logger is in the vicinity of the existing railway and was installed at 1 m from the most exposed accessible window.

Measurement location: measurements were conducted in the backyard.

Meteorology: inclement weather on 24 July 2015

Noise sources: vehicles, trains

Figure F5: Measurement at Location 4: 1 Altona Street, Kensington

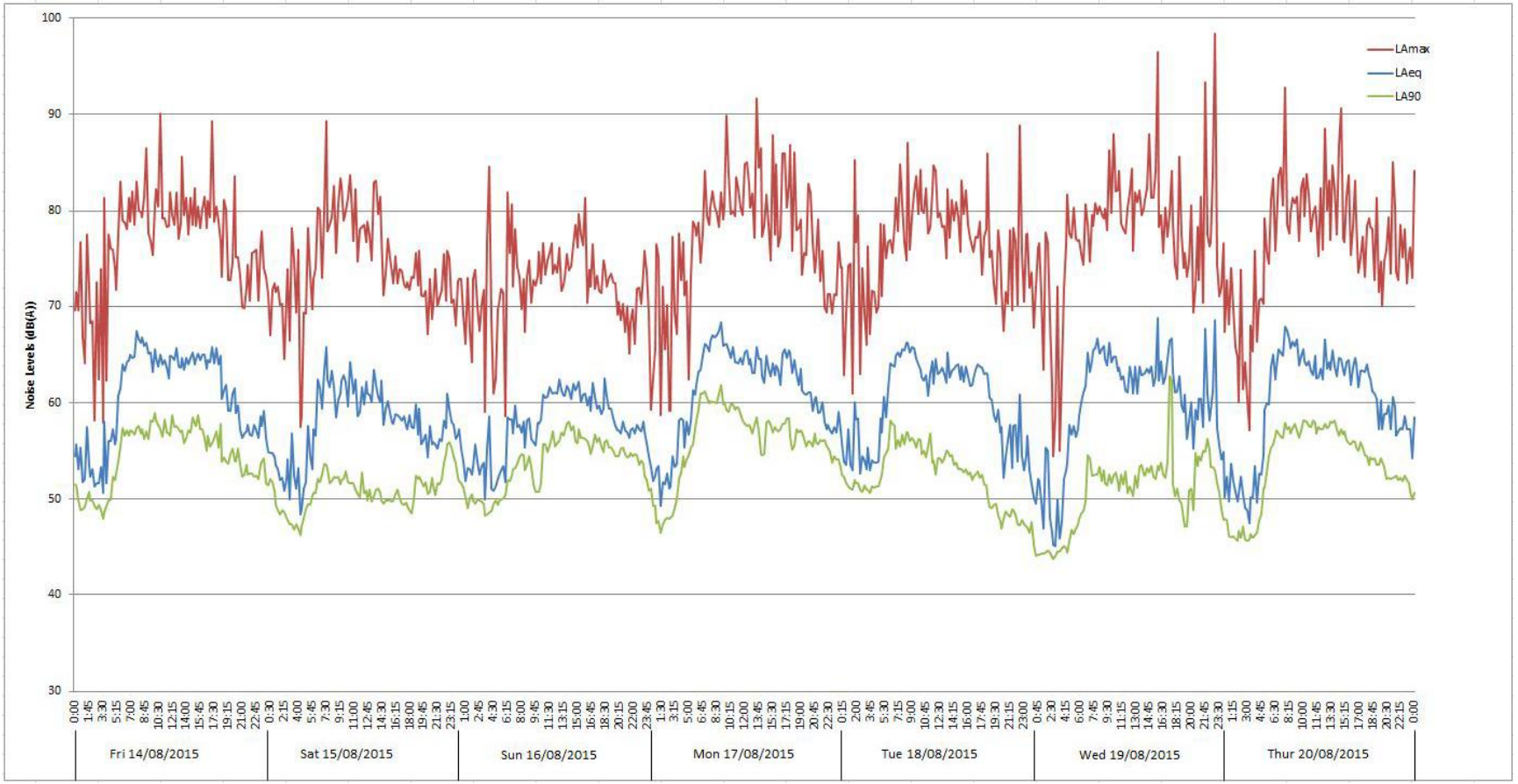


Image 1: Noise Logger

Image 2: View from logger

Image 3: Measurement Location

Parameters:

$L_{Aeq, Day*}$: 62 dB

$L_{Aeq, Evening*}$: 58 dB

$L_{Aeq, Night*}$:56dB

$L_{A90\ Day*}$: 53 dB

$L_{A90, Evening*}$: 50 dB

$L_{A90, Night*}$: 48 dB

*Adjustment for reflection

Measurement location: measurements were conducted on the second floor balcony.

Microphone was approximately 2 m from a reflecting surface.

Meteorology: inclement weather on 17 August and 20 August 2015

Noise sources: vehicles

Figure F6: Measurement at Location 5: 141 Laurens Street, North Melbourne

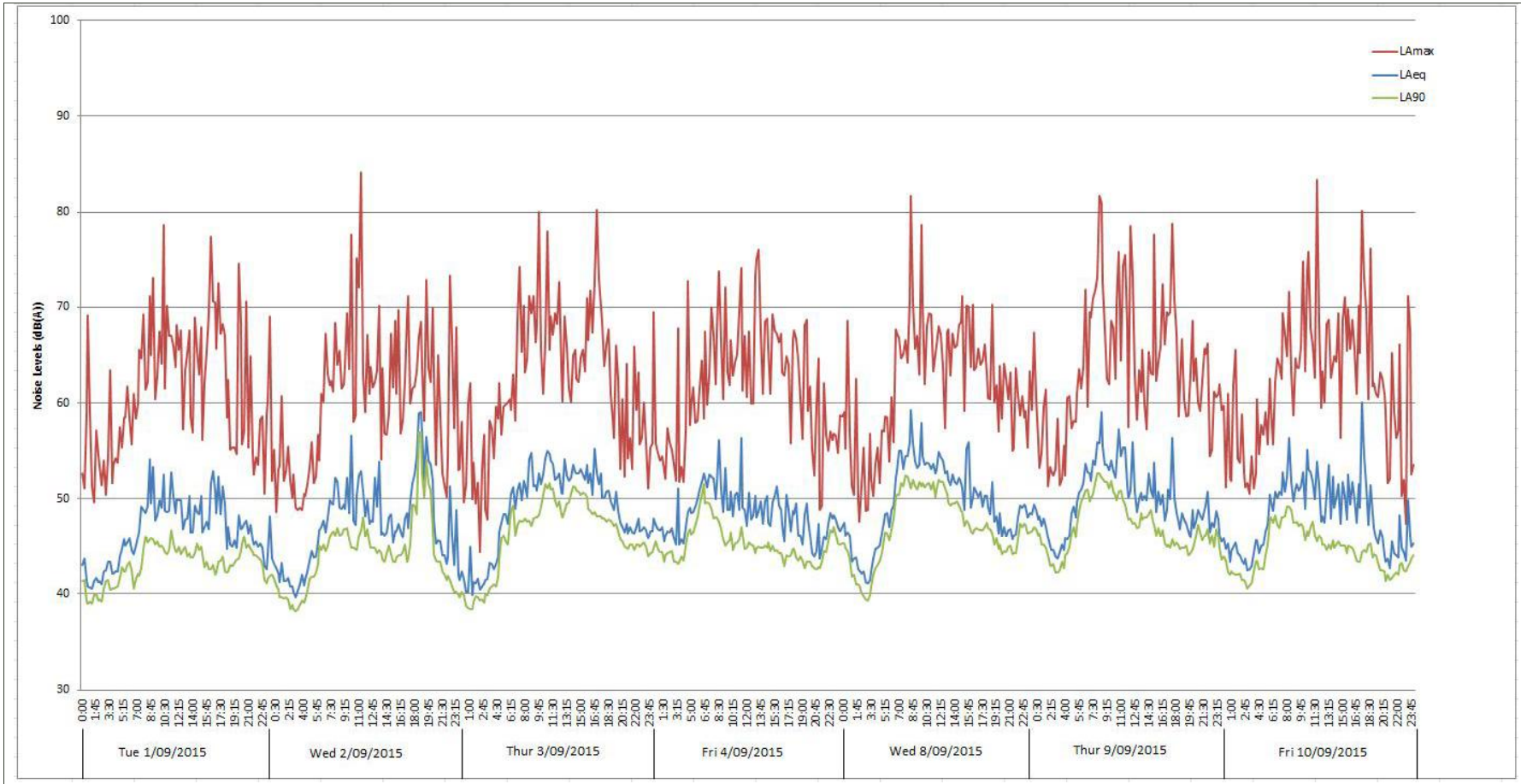


Image 1: Noise Logger

Image 2: View from logger

Image 3: Measurement Location

Parameters:

$L_{Aeq,\ Day*}$: 50 dB

$L_{Aeq,\ Evening*}$: 45 dB

$L_{Aeq,\ Night*}$:46 dB

$L_{A90\ Day*}$: 45 dB

$L_{A90,\ Evening*}$: 42 dB

$L_{A90,\ Night*}$: 43 dB

*Adjustment for reflection

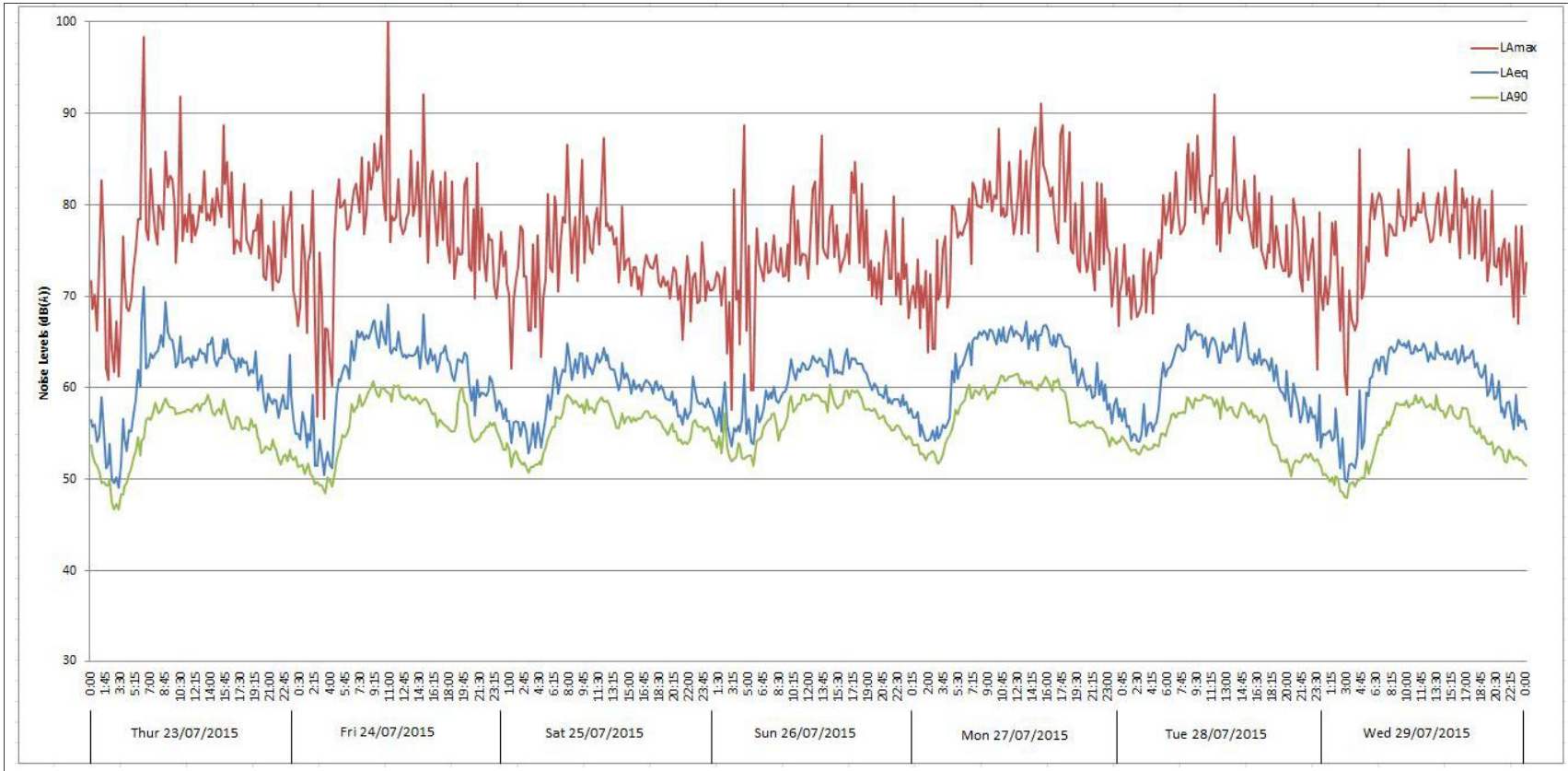
Measurement location: measurements were conducted in the backyard

Microphone was approximately 1 m from a reflecting surface

Meteorology: inclement weather on 2 August, 3 August and 8 August 2015

Noise Sources: vehicles

Figure F7: Measurement at Location 6: 724 Queensberry Street, North Melbourne



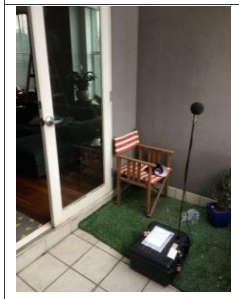


Image 1: Noise Logger

Image 2: View from logger

Image 3: Measurement Location

Parameters:

$L_{Aeq,16hr}$: 62 dB

$L_{Aeq,8hr}$: 57 dB

$L_{Aeq, Day*}$: 63 dB

$L_{Aeq, Evening*}$: 59dB

$L_{Aeq, Night*}$:57 dB

$L_{A90\ Day*}$: 56 dB

$L_{A90, Evening*}$: 52 dB

$L_{A90, Night*}$: 51 dB

*Adjustment for reflection

Comments: the logger is in the vicinity of the existing railway and was installed at 1 m from the most exposed accessible window.

Measurement location: measurements were conducted on the second floor balcony.

Meteorology: inclement weather on 24 July 2015

Noise sources: vehicles, trains

Figure F8: Measurement at Location 7: 2/3 Miller Street, North Melbourne

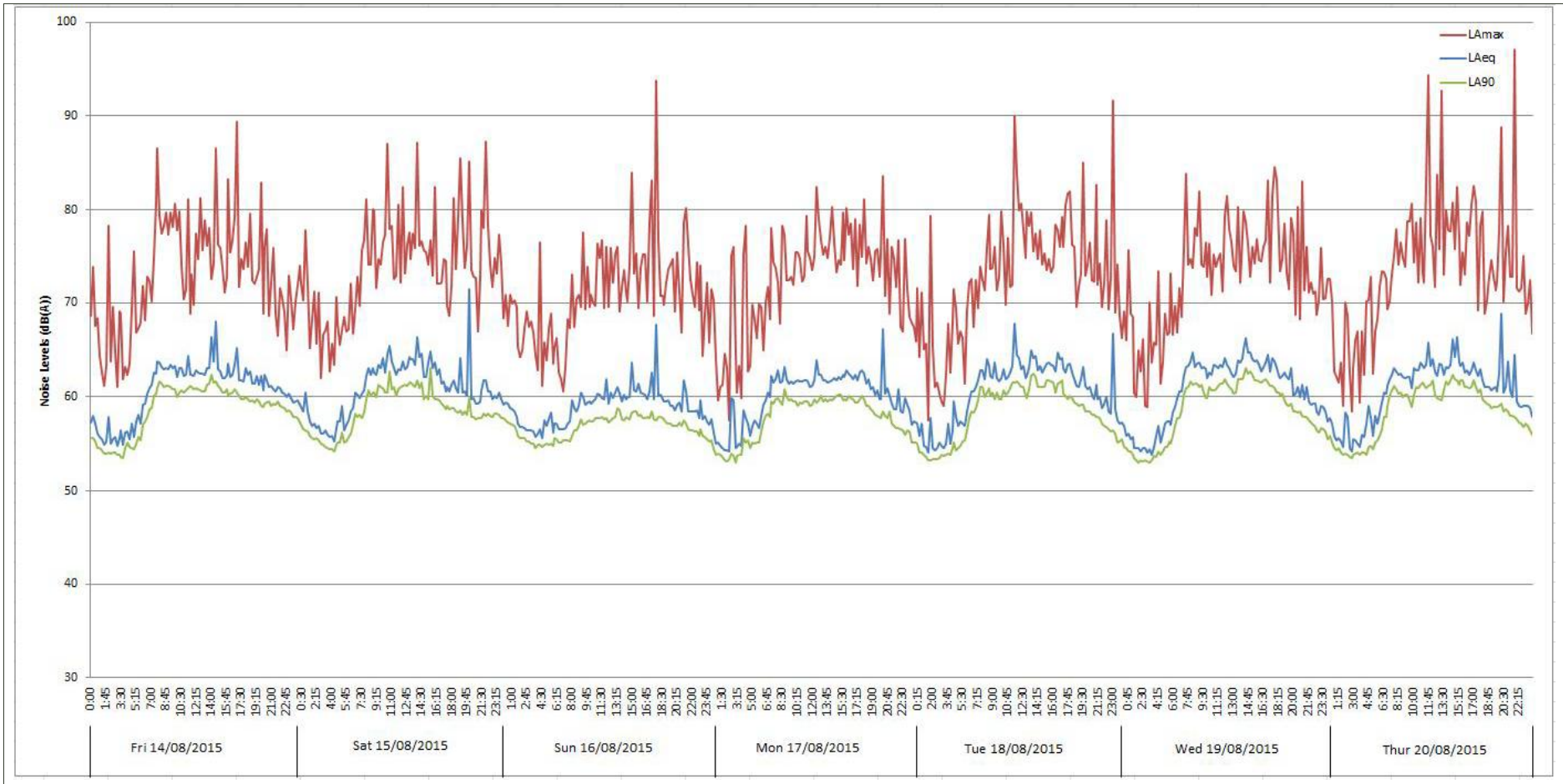


Image 1: Noise Logger

Image 2: View from logger

Image 3: Measurement Location

Parameters:

$L_{Aeq, Day*}$: 61 dB

$L_{Aeq, Evening*}$: 60 dB

$L_{Aeq, Night*}$:56 dB

$L_{A90 Day*}$: 59 dB

$L_{A90, Evening*}$: 57 dB

$L_{A90, Night*}$: 53 dB

*Adjustment for reflection

Measurement location: Verve Apartments, Melbourne. Measurements were conducted on the 28th floor balcony.

Microphone was approximately 1 m from a reflecting surface.

Meteorology: inclement weather on 17 August and 20 August 2015

Noise sources: vehicles, trams

Figure F9: Measurement at Location 8: Verve Apartments, 483 Swanston Street, Melbourne

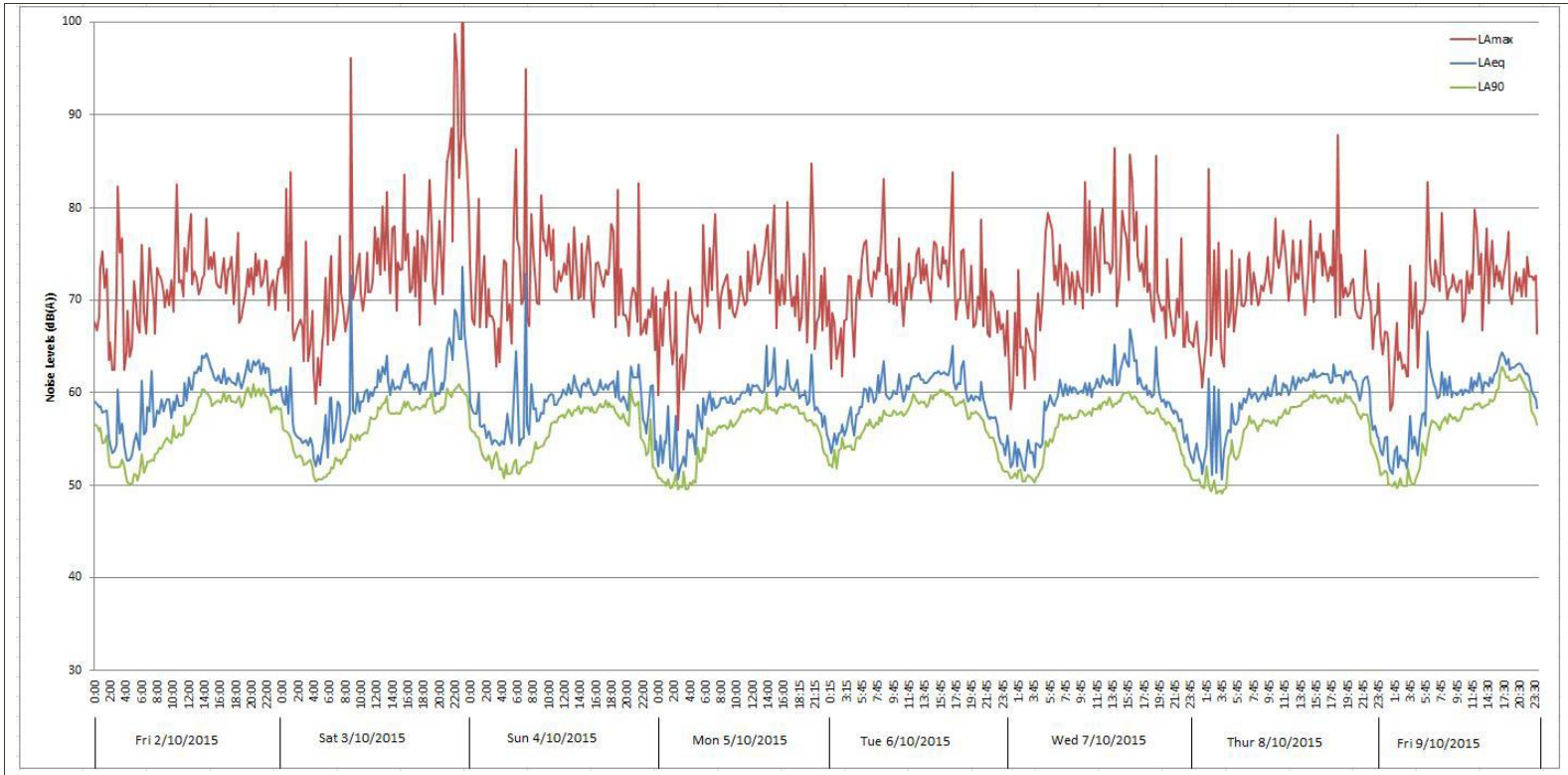


Image 1: Noise Logger

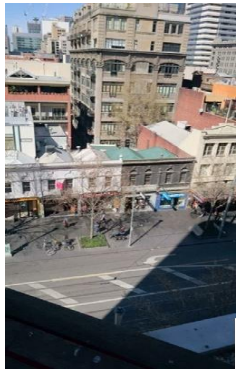


Image 2: View from Logger

Image 3: Measurement Location

Parameters:

$L_{Aeq, Day}$: 61 dB

$L_{Aeq, Evening}$: 62 dB

$L_{Aeq, Night}$: 58 dB

$L_{A90, Day}$: 58 dB

$L_{A90, Evening}$: 60 dB

$L_{A90, Night}$: 54 dB

Measurement location: QV2, Melbourne. Measurements were conducted on the 1st floor balcony.

Meteorology: Inclement weather on 5 October, 6 October and 7 October 2015

Noise sources: vehicles, trams

Figure F10: Measurement at Location 9: QV2 Apartments, 300 Swanston Street, Melbourne

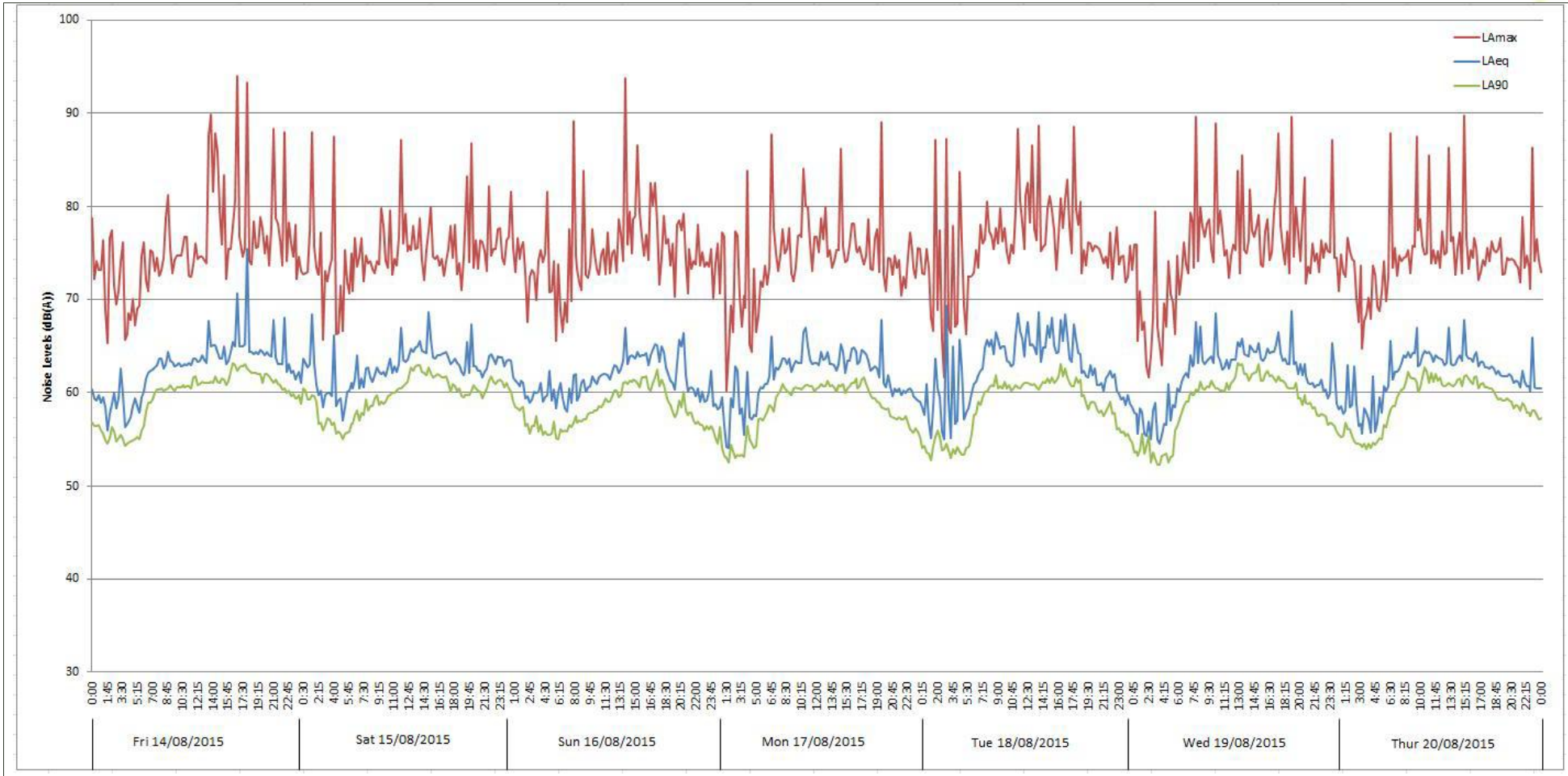


Image 1: Noise Logger

Image 2: View from logger

Image 3: Measurement Location

Parameters:

$L_{Aeq, Day}$: 65 dB

$L_{Aeq, Evening}$: 64 dB

$L_{Aeq, Night}$: 60 dB

$L_{A90, Day}$: 61 dB

$L_{A90, Evening}$: 60 dB

$L_{A90, Night}$: 56 dB

Measurement location: the Westin Melbourne, Melbourne. Measurements were conducted on the 10th balcony.

Meteorology: inclement weather on 17 August and 20 August 2015.

Noise sources: vehicles, trams

Figure F11: Measurement at Location 10: The Westin Hotel, 210 Collins St, Melbourne

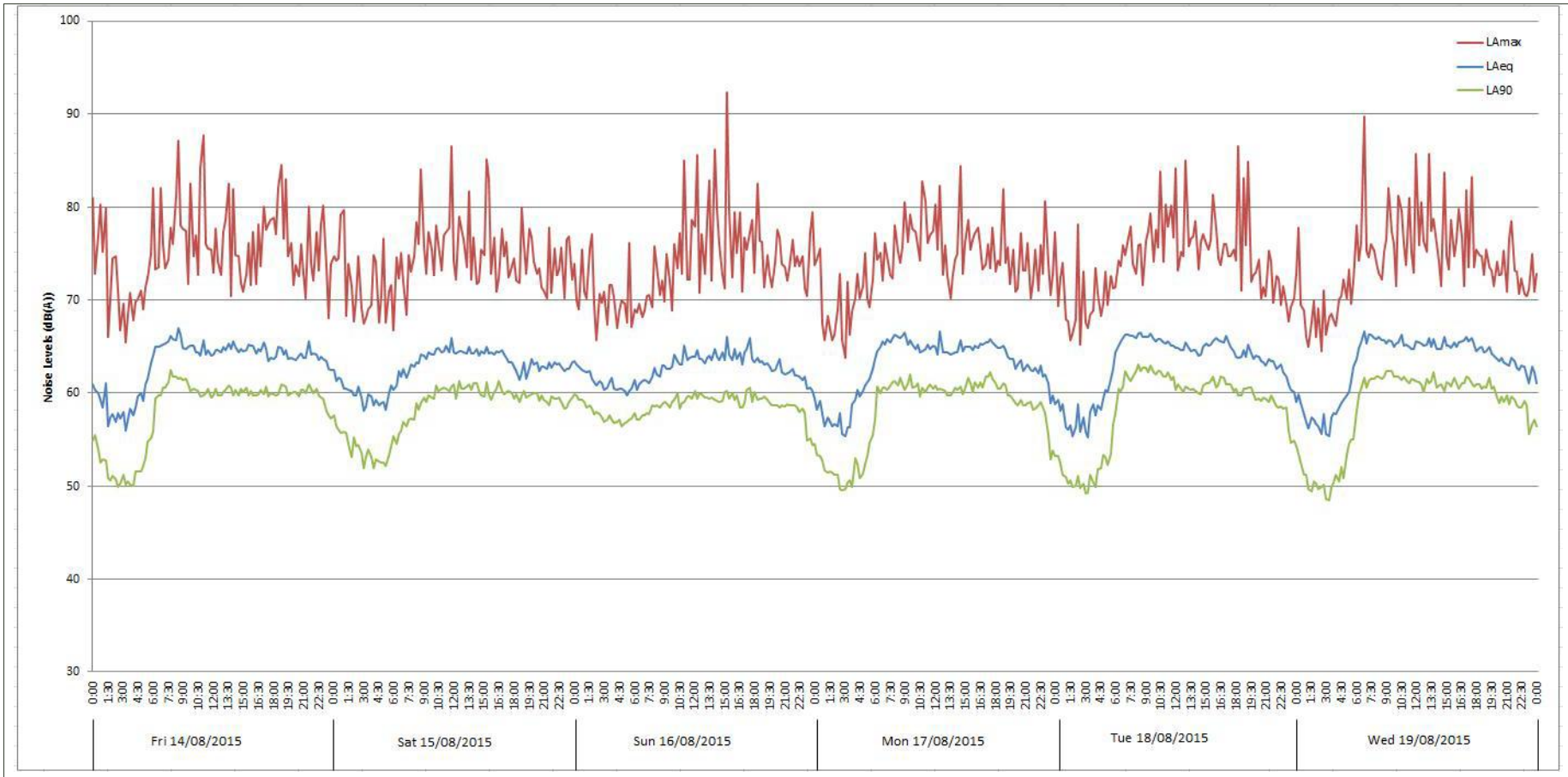


Image 1: Noise Logger

Image 2: View from logger

Image 3: Measurement Location

Parameters:

$L_{Aeq,\ Day*}$: 63 dB

$L_{Aeq,\ Evening*}$: 62 dB

$L_{Aeq,\ Night*}$: 59 dB

$L_{A90\ Day*}$: 59 dB

$L_{A90,\ Evening*}$: 58 dB

$L_{A90,\ Night*}$: 52 dB

*Adjustment for reflection

Measurement location: Quay West, Melbourne. Measurements were conducted on the 24th floor balcony.

Microphone was approximately 1 m from a reflecting surface.

Meteorology: inclement weather on 17 August and 20 August. 2015

Noise sources: vehicles, trams

Figure F12: Measurement at Location 11: Quay West, 26 Southgate Avenue, Melbourne

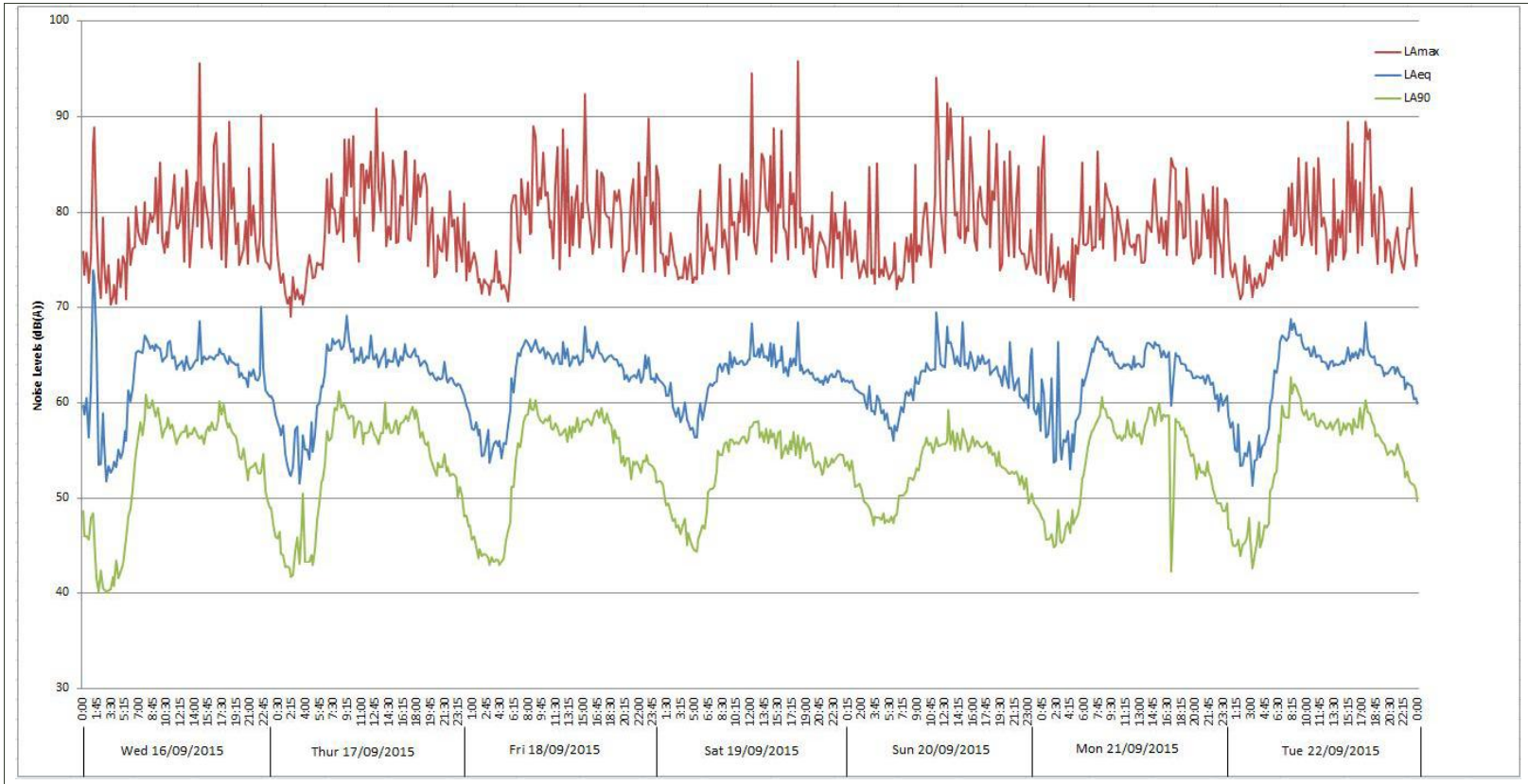


Image 1: Noise Logger

Image 2: View from logger

Image 3: Measurement Location

Parameters:

$L_{Aeq,\ Day*}$: 63 dB

$L_{Aeq,\ Evening*}$: 62 dB

$L_{Aeq,\ Night*}$:59 dB

$L_{A90\ Day*}$: 56 dB

$L_{A90,\ Evening*}$: 53 dB

$L_{A90,\ Night*}$: 45 dB

*Adjustment for reflection

Measurement location: Hallmark Apartments, Melbourne. Measurements were conducted on the 2nd floor balcony.

Microphone was approximately 1 m from a reflecting surface.

Meteorology: inclement weather on 21 September and 22 September 2015

Noise sources: vehicles, trams

Figure F13: Measurement at Location 12: Hallmark Apartments, 2-14 Albert Road, Melbourne

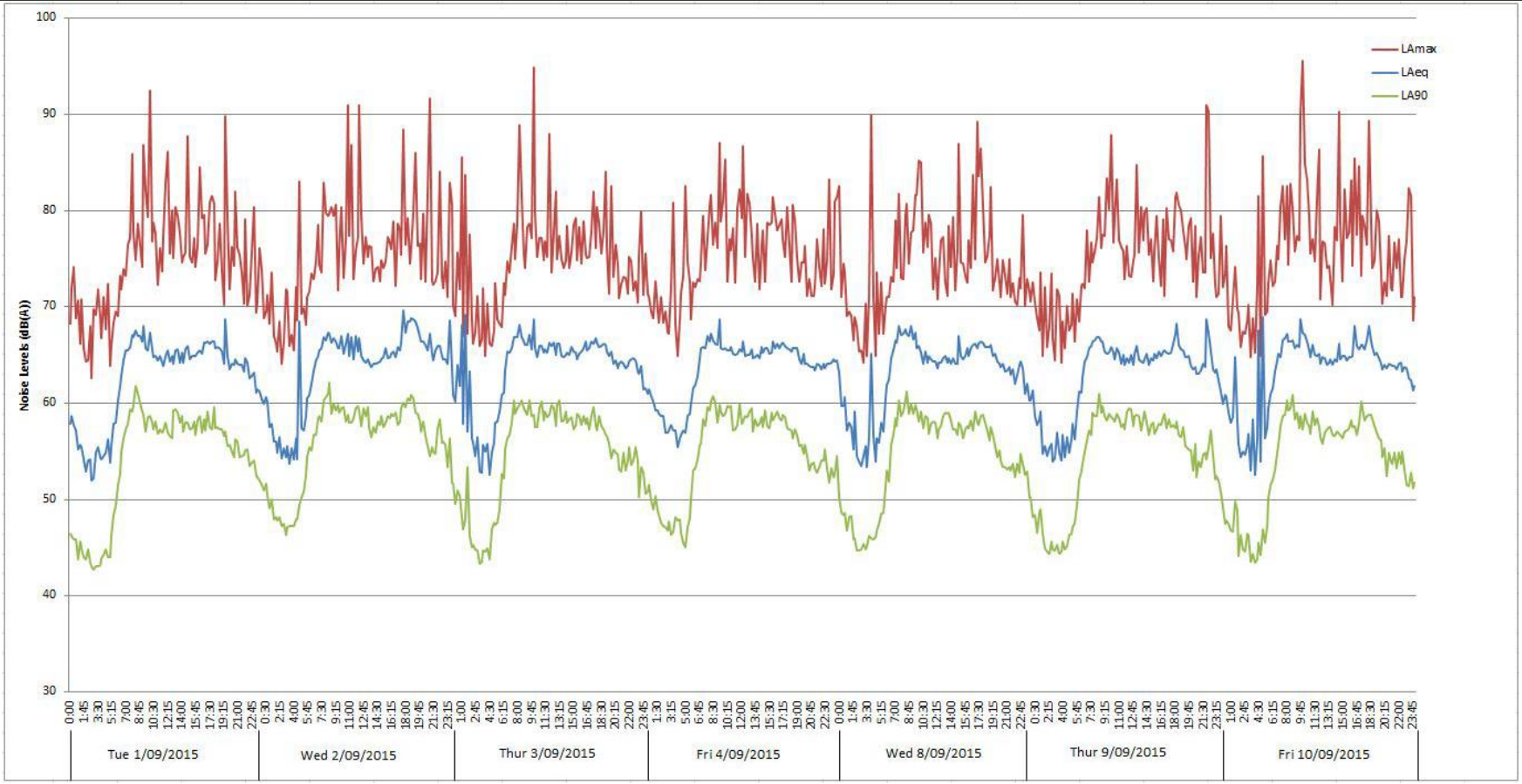


Image 1: Noise Logger

Image 2: View from logger

Image 3: Measurement Location

Parameters:

$L_{Aeq, Day*}$: 64 dB

$L_{Aeq, Evening*}$: 63 dB

$L_{Aeq, Night*}$:59 dB

$L_{A90 Day*}$: 56 dB

$L_{A90, Evening*}$: 53 dB

$L_{A90, Night*}$: 47 dB

*Adjustment for reflection

Measurement location: The Domain, Melbourne. Measurements were conducted on the 10th balcony.

Microphone was approximately 1 m from a reflecting surface.

Meteorology: inclement weather on 2 August, 3 August and 8 August 215

Noise sources: vehicles and trams.

Figure F14: Measurement at Location 13: The Domain, 1-29 Albert Road, Melbourne

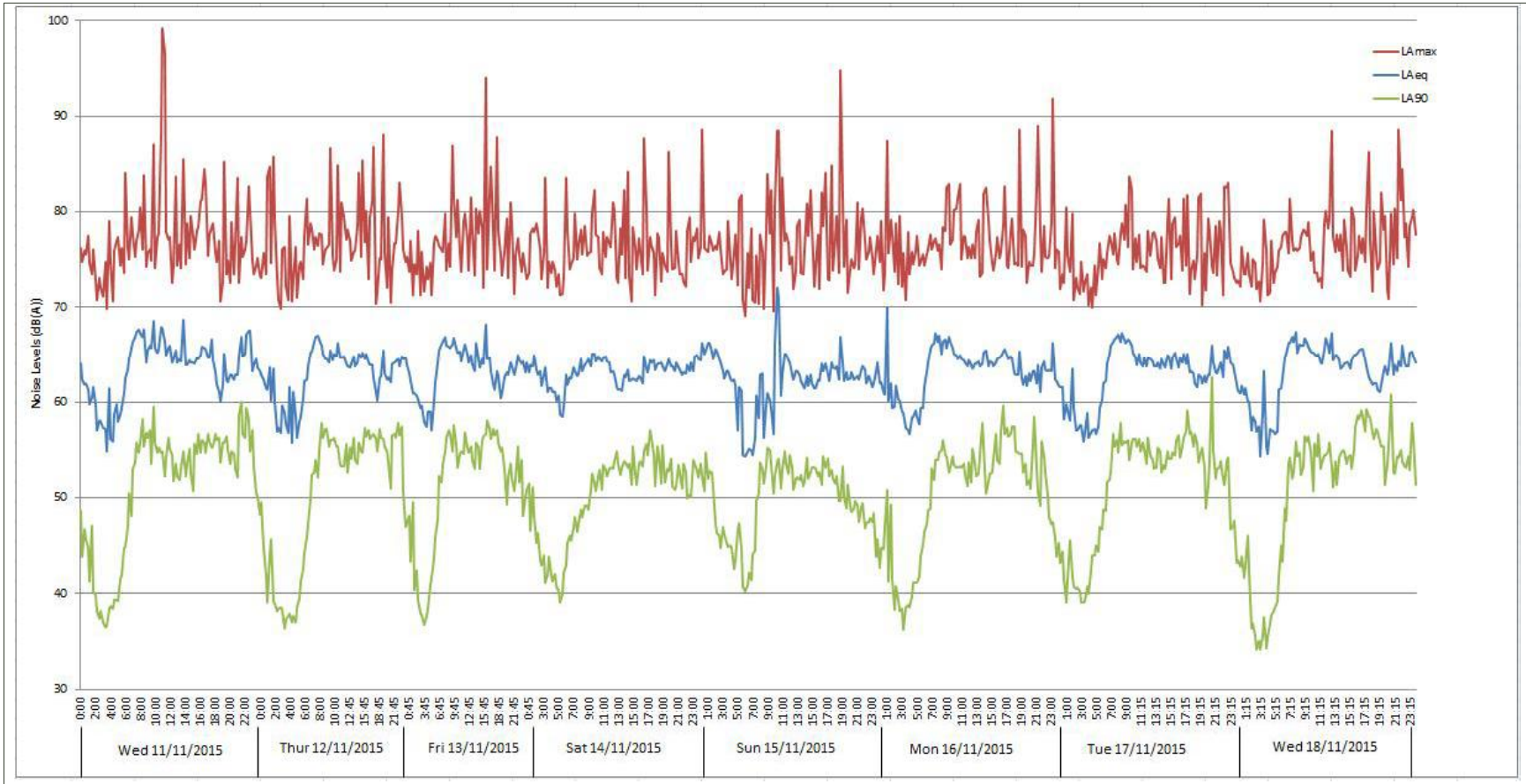


Image 1: Noise Logger

Image 2: View from logger

Image 3: Measurement Location

Parameters:

$L_{Aeq,\ Day*}$: 63 dB

$L_{Aeq,\ Evening*}$: 62 dB

$L_{Aeq,\ Night*}$:59 dB

$L_{A90\ Day*}$: 53 dB

$L_{A90,\ Evening*}$: 54 dB

$L_{A90,\ Night*}$: 43 dB

*Adjustment for reflection

Measurement location: the Melburnian, Melbourne. Measurements were conducted on the 1st floor balcony.

Meteorology: inclement weather on 13 November and 17 November

Noise sources: vehicles and trams.

Figure F15: Measurement at Location 14: The Melburnian, 250 St. Kilda Road, Melbourne

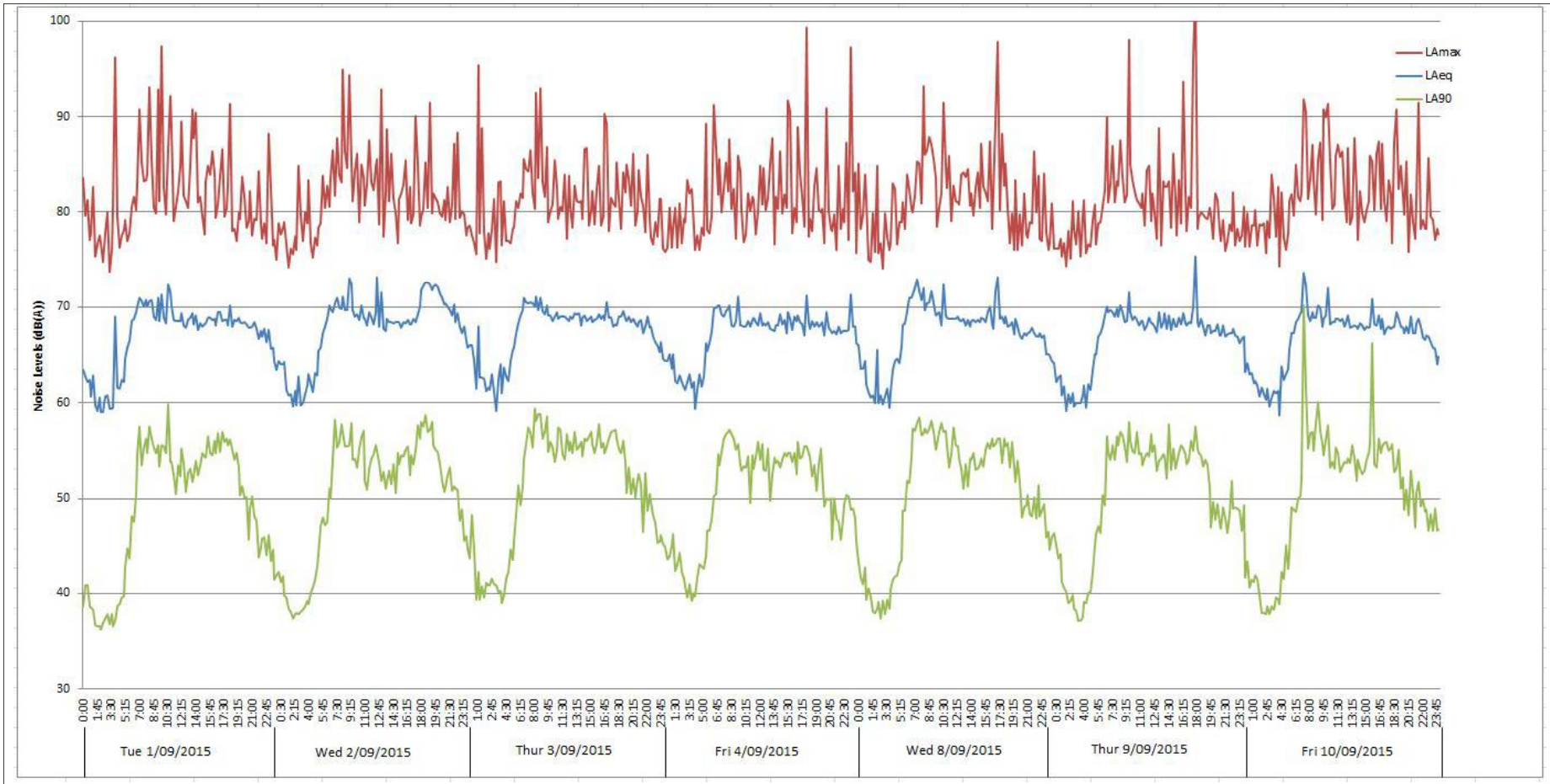


Image 1: Noise Logger

Image 2: View from logger

Image 3: Measurement Location

Parameters:

$L_{Aeq, Day}$: 69 dB

$L_{Aeq, Evening}$: 68 dB

$L_{Aeq, Night}$: 65 dB

$L_{A90, Day}$: 55 dB

$L_{A90, Evening}$: 51 dB

$L_{A90, Night}$: 44 dB

Measurement location: measurements were conducted in the resident's frontyard.

Meteorology: inclement weather on 2 August, 3 August and 8 August 2015

Noise sources: vehicles, pedestrians and trams.

Figure F16: Measurement at Location 15: 68 Toorak Road, South Yarra

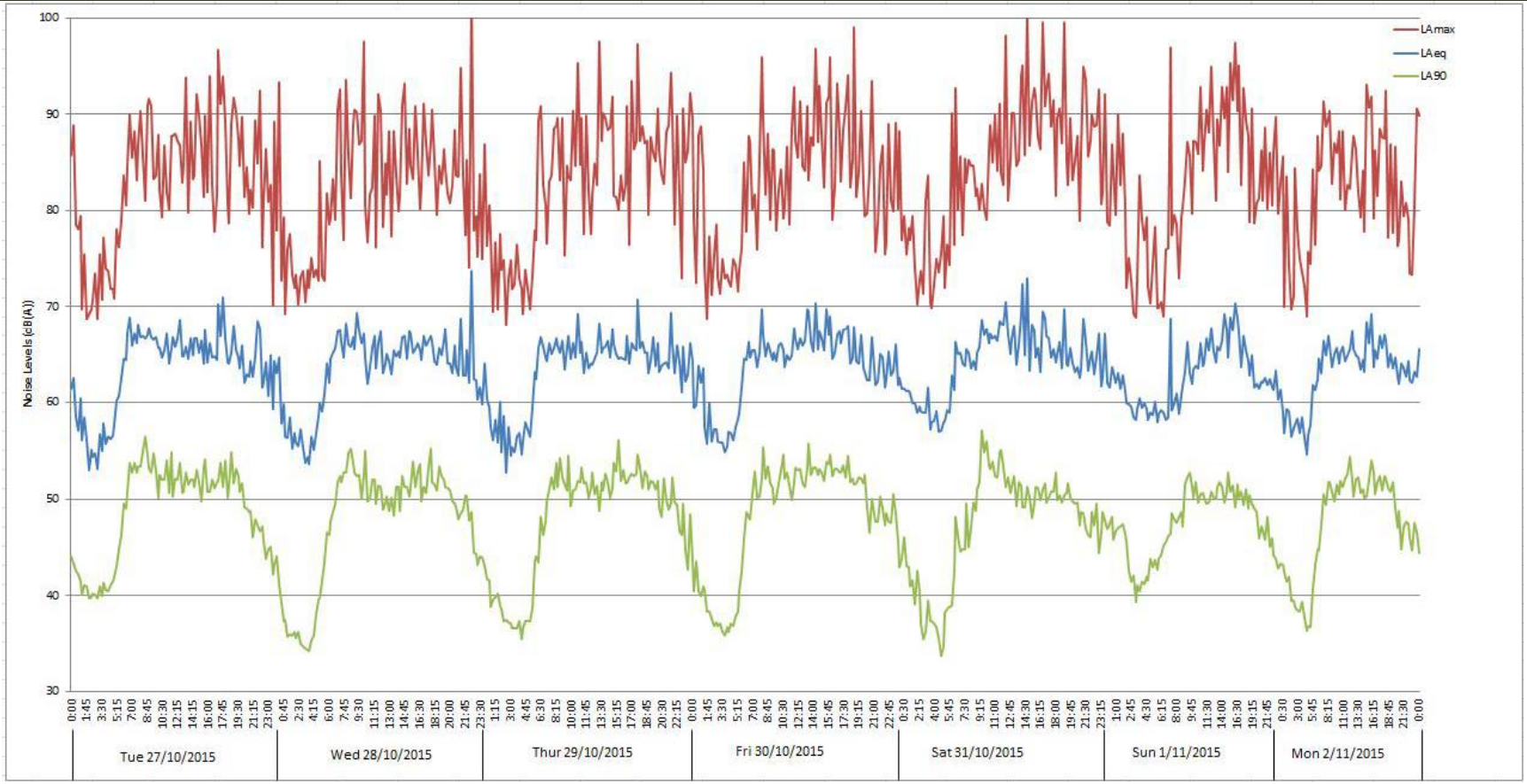


Image 1: Noise Logger

Image 2: View from logger

Image 3: Measurement Location

Parameters:

$L_{Aeq, Day}$: 64 dB

$L_{Aeq, Evening}$: 63 dB

$L_{Aeq, Night}$: 58 dB

$L_{A90, Day}$: 50 dB

$L_{A90, Evening}$: 49 dB

$L_{A90, Night}$: 40 dB

Measurement location: measurements were conducted in the front porch.

Microphone was approximately 1 m from a reflecting surface.

Meteorology: inclement on 28 October 2015

Noise sources: vehicles, pedestrians, trams

Figure F17: Measurement at Location 16: 2/1 Park Street, South Yarra

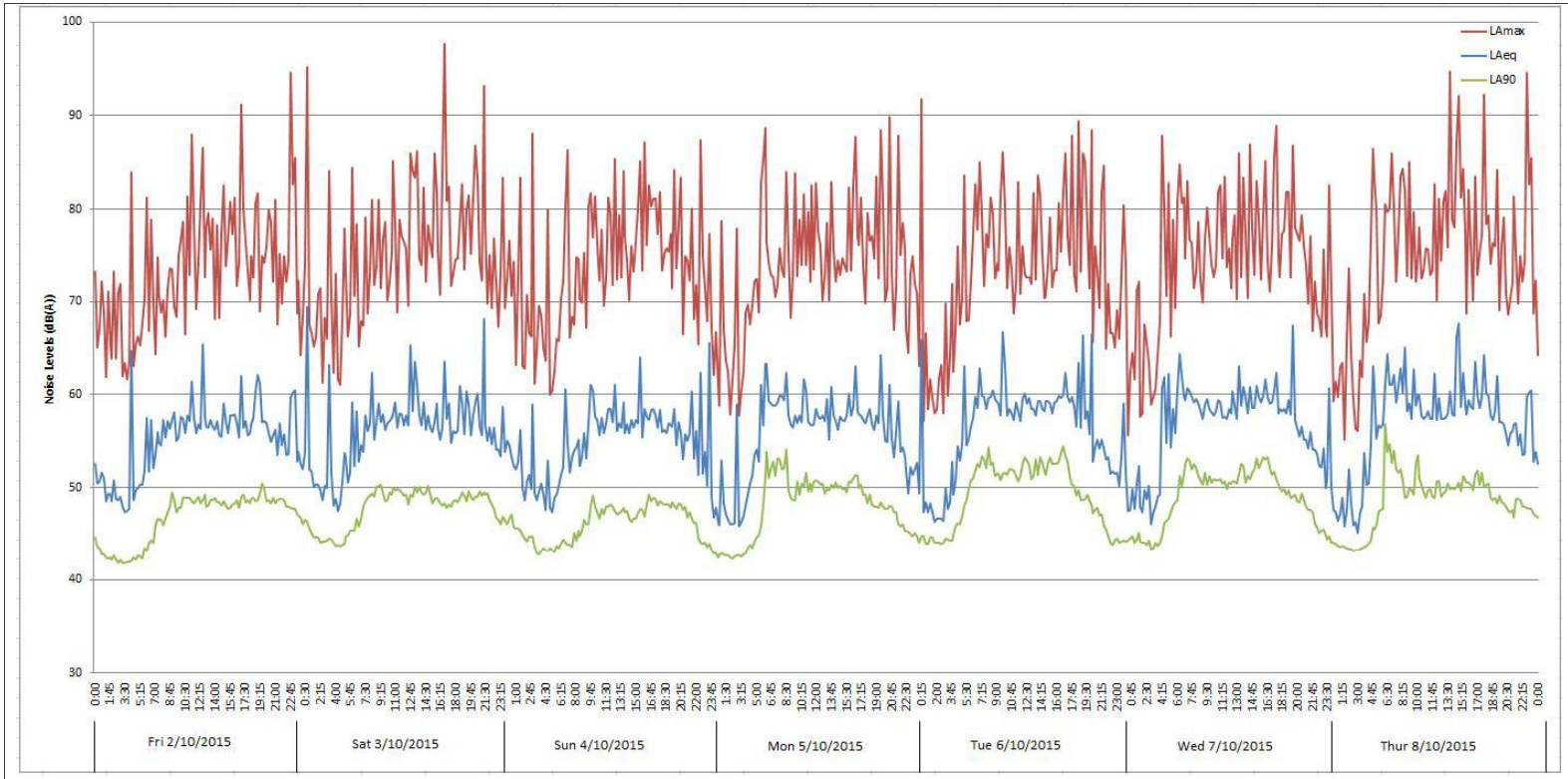


Image 1: Noise Logger

Image 2: View from logger

Image 3: Measurement Location

Parameters:

$L_{Aeq,16hr}$: 59 dB

$L_{Aeq,8hr}$: 54 dB

$L_{Aeq,\ Day*}$: 57 dB

$L_{Aeq,\ Evening*}$: 56 dB

$L_{Aeq,\ Night*}$: 54 dB

$L_{A90\ Day*}$: 48 dB

$L_{A90,\ Evening*}$:46 dB

$L_{A90,\ Night*}$: 44 dB

*Adjustment for reflection

Measurement location: measurements were conducted in the frontyard

Microphone was approximately 1 m from a reflecting surface.

Meteorology: inclement weather on 4 October, 6 October and 7 October, 2015

Noise sources: vehicles, trains

Figure F18: Measurement at Location 17: 139 Osborne Street, South Yarra

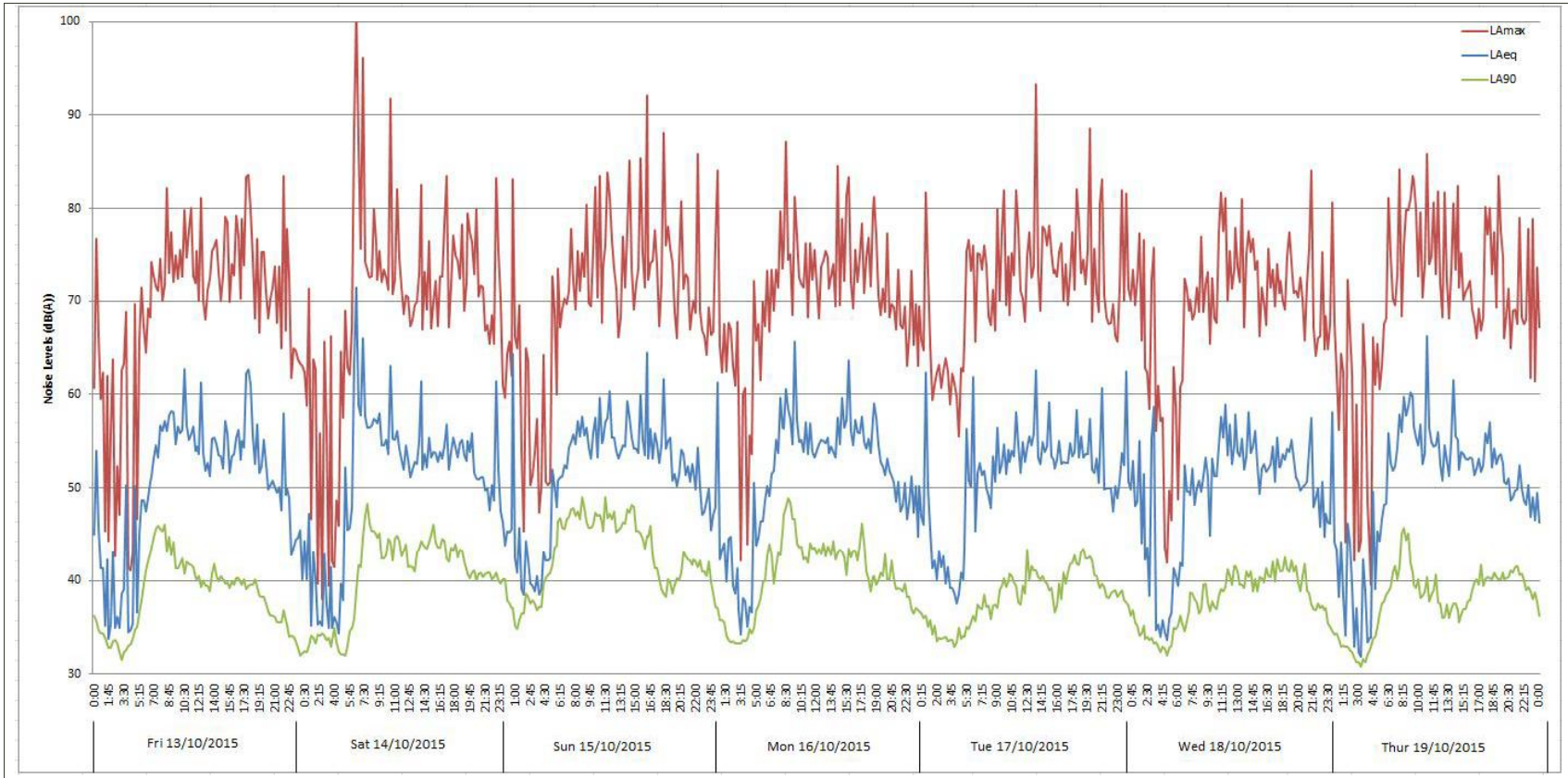


Image 1: Noise Logger

Image 2: View from logger

Image 3: Measurement Location

Parameters:

$L_{Aeq,16hr}$: 55 dB

$L_{Aeq,8hr}$: 50 dB

$L_{Aeq,\ Day*}$: 53 dB

$L_{Aeq,\ Evening*}$: 51 dB

$L_{Aeq,\ Night*}$: 45 dB

$L_{A90\ Day*}$: 39 dB

$L_{A90,\ Evening*}$:39 dB

$L_{A90,\ Night*}$: 34 dB

*Adjustment for reflection

Measurement location: measurements were conducted in the frontyard.

Microphone was approximately 1 m from a reflecting surface.

Meteorology: inclement weather on 13 October 2015

Noise sources: vehicles, trains

Figure F19: Measurement at Location 18: 4 William Street, South Yarra

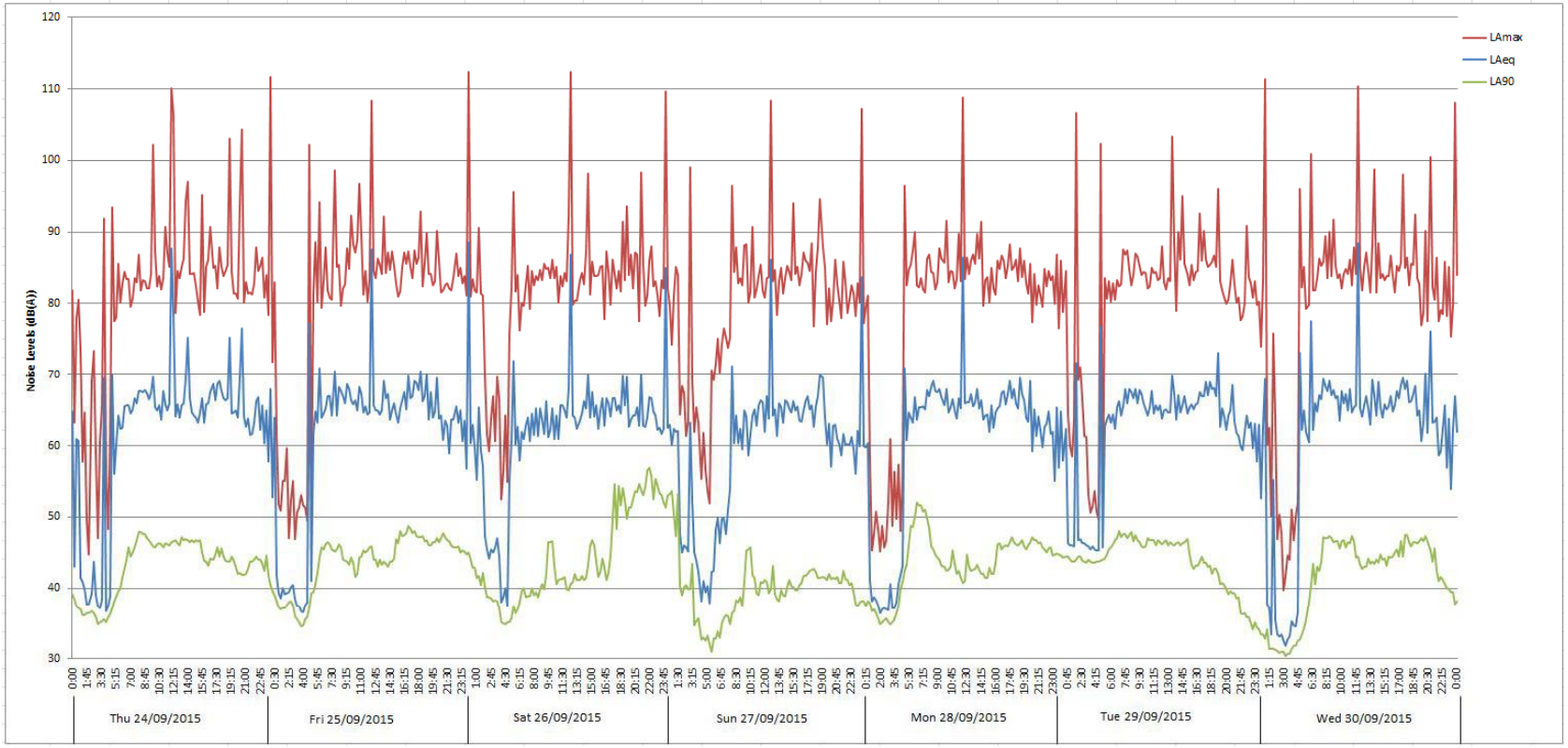


Image 1: Noise Logger

Image 2: View from Logger

Image 3: Measurement Location

Parameters:

$L_{Aeq,16hr}$: 72 dB

$L_{Aeq,8hr}$: 63 dB

$L_{Aeq,\ Day*}$: 69 dB

$L_{Aeq,\ Evening*}$: 65 dB

$L_{Aeq,\ Night*}$: 62 dB

$L_{A90\ Day*}$: 44 dB

$L_{A90,\ Evening*}$: 41 dB

$L_{A90,\ Night*}$: 40 dB

*Adjustment for reflection

Measurement location: measurements were conducted in the backyard

Microphone was approximately 1 m from a reflecting surface.

Meteorology: no inclement weather

Noise sources: vehicles, trains

Figure F20: Measurement at Location 19: 6 William Street, South Yarra

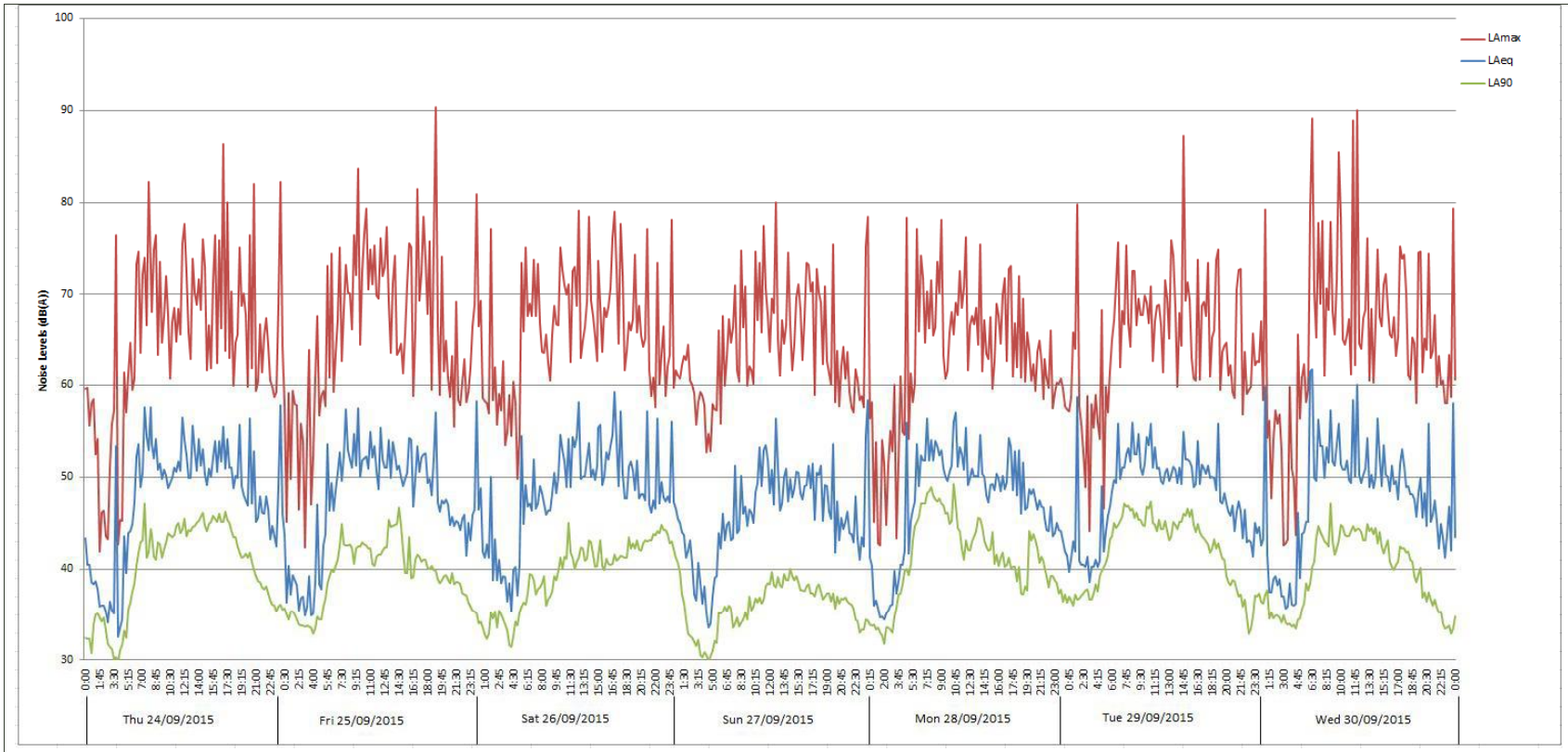


Image 1: Noise Logger

Image 2: View from Logger

Image 3: Measurement Location

Parameters:

$L_{Aeq,16hr}$: 52 dB

$L_{Aeq,8hr}$: 47 dB

$L_{Aeq,\ Day*}$: 50 dB

$L_{Aeq,\ Evening*}$: 47 dB

$L_{Aeq,\ Night*}$: 46 dB

$L_{A90\ Day*}$: 42 dB

$L_{A90,\ Evening*}$:38 dB

$L_{A90,\ Night*}$: 36 dB

*Adjustment for reflection

Measurement location: measurements were conducted in the frontyard

Microphone was approximately 1 m from a reflecting surface.

Meteorology: no inclement weather

Noise sources: vehicles, trains

Figure F21: Measurement at Location 20: 10 William Street, South Yarra

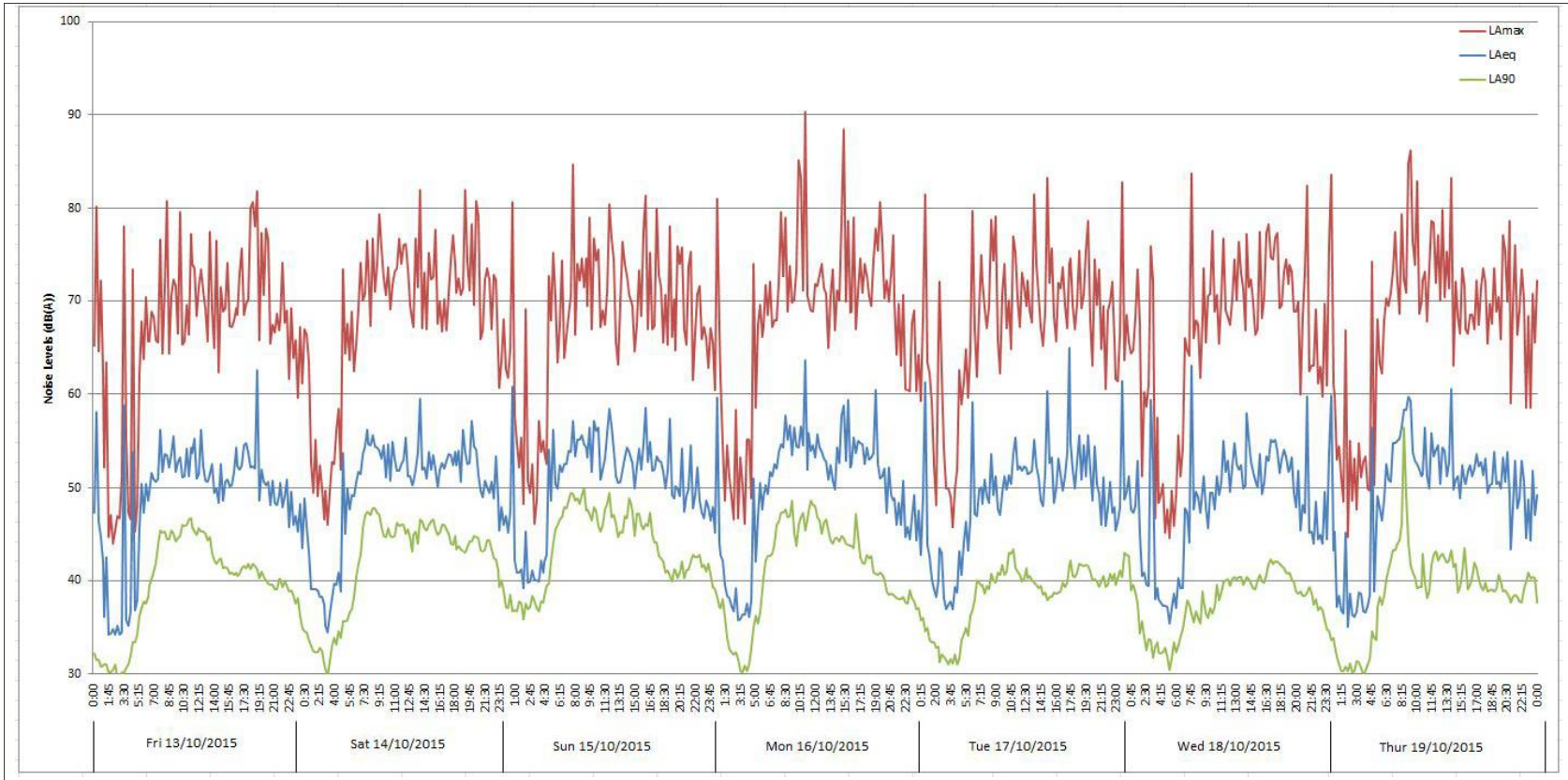


Image 1: Noise Logger

Image 2: View from logger

Image 3: Measurement Location

Parameters:

$L_{Aeq,16hr}$: 54 dB

$L_{Aeq,8hr}$: 49 dB

$L_{Aeq,\ Day*}$: 51 dB

$L_{Aeq,\ Evening*}$: 50 dB

$L_{Aeq,\ Night*}$: 44 dB

$L_{A90\ Day*}$: 40 dB

$L_{A90,\ Evening*}$:38 dB

$L_{A90,\ Night*}$: 33 dB

*Adjustment for reflection

Measurement location: measurements were conducted in the frontyard

Microphone was approximately 1 m from a reflecting surface.

Meteorology: inclement weather on 13 October 2015

Noise sources: trains

Figure F22: Measurement at Location 21: 19 William Street, South Yarra

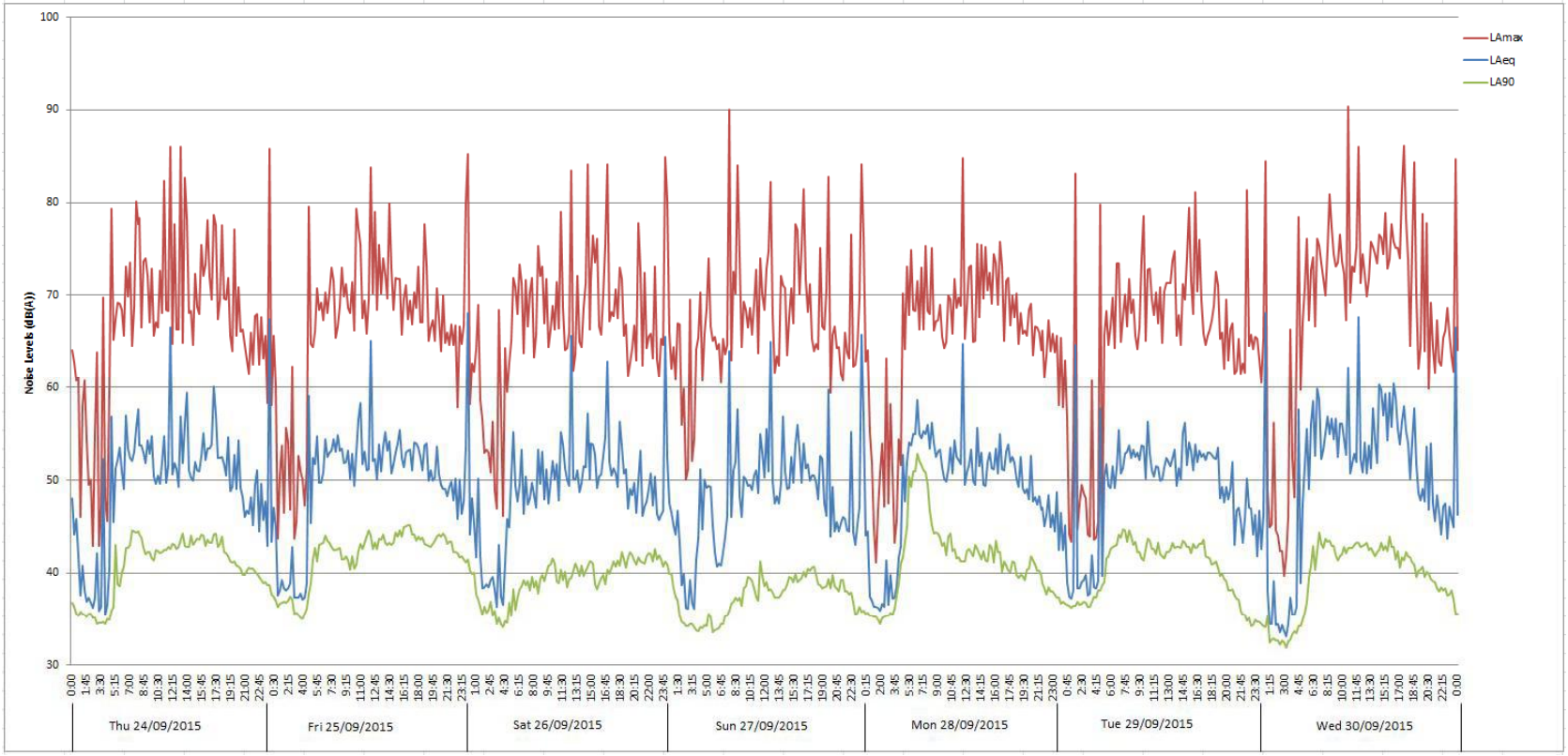


Image 1: Noise Logger

Image 2: Vicinity to track

Image 3: Measurement Location

Parameters:

$L_{Aeq,16hr}$: 55 dB

$L_{Aeq,8hr}$: 52 dB

$L_{Aeq,\ Day*}$: 53 dB

$L_{Aeq,\ Evening*}$: 49 dB

$L_{Aeq,\ Night*}$: 50 dB

$L_{A90\ Day*}$: 41 dB

$L_{A90,\ Evening*}$: 39 dB

$L_{A90,\ Night*}$: 37 dB

*Adjustment for reflection

Measurement location: measurements were conducted in the frontyard.

Microphone was approximately 1 m from a reflecting surface.

Meteorology: no inclement weather

Noise sources: pedestrians, trains

Figure F23: Measurement at Location 22: 3 Chambers Street, South Yarra

F.2 Attended External Noise Measurements

F.2.1 Summary

Attended External noise measurements have been undertaken in the vicinity of the noise sensitive locations in the Parkville and CBD North and South Area and are provided in Table F3.

Table F3: Attended external measurement locations

No.	Location
Precinct 4: Parkville Station	
1	The Royal Women's Hospital - Grattan Street
2	The Victorian Cancer Care Centre - Corner of Grattan Street and Flemington Road
3	The Royal Melbourne Hospital - Corner of Grattan Street and Royal Parade
4	The Victorian Cancer Care Centre - Corner of Grattan Street and Royal Parade
5	The University of Melbourne - Corner of Grattan Street and Royal Parade
6	The Peter Doherty Institute - Corner of Grattan Street and Royal Parade
7	Corner of Pelham and Elizabeth Streets
8	University Square – corner of Barry and Pelham Streets
9	University Square – corner of Pelham and Leicester Streets
10	University Square – corner of Grattan and Leicester Streets
11	University Square – corner of Barry and Grattan Streets
12	Howard Florey Laboratories – Royal Parade
13	Melbourne Private Hospital – Royal Parade
14	University High School – Royal Parade
Precinct 5: CBD North Station	
15	Latrobe House, 200 Latrobe Street, Melbourne
16	31 Abeckett Street, Melbourne
17	81 Franklin Street, Melbourne
Precinct 6: CBD South Station	
18	Uni Lodge, 238 Flinders Street, Melbourne
Tunnels Precinct	
19	Fawkner Park – Toorak Road
Precinct 9: West Footscray	
20	142 Cross Street, Footscray
21	70 Cross Street, Footscray

These measurements were attended as this was more practical than unattended noise monitoring in these busy areas. Noise measurements have been undertaken during the day, evening and night periods as defined in SEPP N-1.

F.2.2 Methodology

F.2.2.1 Noise Monitoring Approach

Noise Monitoring has been conducted in compliance with AS 1055.1-1997. Measurements have been located a minimum of 3 m from a vertical reflecting surface where possible. If this has not been achievable it has been stated in the measurements results.

Measurements have been for a period of 10 minutes. Two measurements have been undertaken during each time period.

F.2.2.2 Acoustic Equipment

Details of the acoustic equipment used to conduct these measurements are provided in Table F4. All acoustic equipment has current calibration certificates and these are provided in Section F.7.

Table F4: Noise Measurement Equipment

Manufacturer	Type of Instrument	Serial No.	Calibration Date
Bruel & Kjaer	Sound Level Analyser 2250	2506886	11/09/2013
Bruel & Kjaer	Sound Level Analyser 2250	2602771	23/09/2013
Bruel & Kjaer	Sound Level Analyser 2250	2506886	28/09/2015
Bruel & Kjaer	Acoustic Calibrator	2542100	23/09/2013
Bruel & Kjaer	Acoustic Calibrator	2583258	28/09/2015

The Sound Level Meters was checked for calibration before and after each set of measurements. A windshield was fitted to the microphone for all measurements.

F.2.2.3 Meteorological Conditions

Meteorological conditions were calm for all measurements.

F.2.2.4 Noise Monitoring Location

Noise Monitoring has been conducted at 14 locations in the vicinity of the Melbourne Metro alignment in the Parkville Precinct. The specific locations are shown in Figure F24.

F.2.3 Results

The results of the acoustic measurements are presented in Table F5 to Table F25. The acoustic parameters presented are defined as:

L_{Amax}: The maximum measured A-weighted sound pressure level over the measurement period.

$L_{Aeq,10mins}$: The A weighted equivalent continuous sound pressure level is the steady level which would, over a given period of time, deliver the same sound energy as the actual time-varying sound over the same period. Hence fluctuating levels can be described in terms of a single figure level. These measurements are over a 10 minute period

L_{A90}: The A weighted sound pressure level that is exceeded for 90% of the measurement period. It is usually used to represent the background noise level.

A-weighting: The A-weighted sound pressure level in decibels, denoted dB(A) is the unit generally used for the measurement of environmental, transportation or industrial noise. The A-weighting scale approximates the sensitivity of the human ear and correlates well with subjective perception of sounds

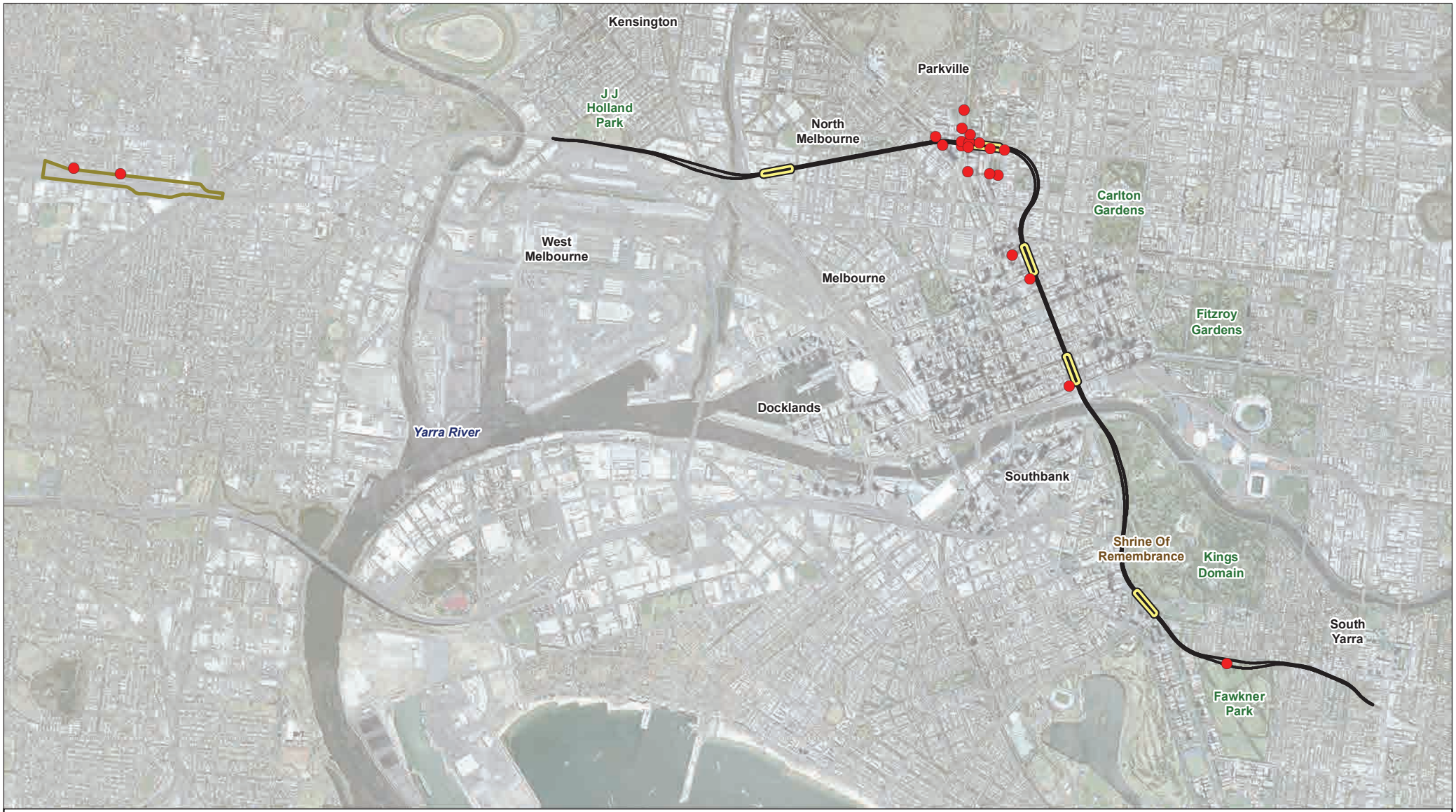


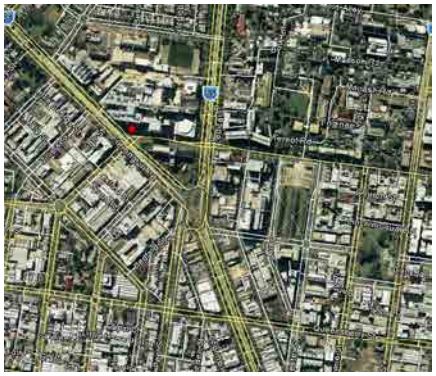
Figure F24: Noise Monitoring Locations

F.2.4 Results

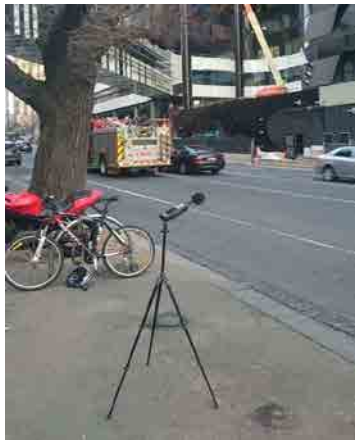
The results of the acoustic measurements are presented in Table F5 to Table F23.

Table F5: Attended Noise Measurements at Location 1, the Royal Women's Hospital

Period	Date / Time (hours)	Noise Level, dB(A)			Comments
		L_{Amax}	$L_{Aeq,10mins}$	L_{A90}	
Day	15/7/2015 16:25	77	66	61	Predominantly traffic noise
	15/7/2015 17:10	80	68	62	Predominantly traffic noise
Evening	20/7/2015 20:00	85	68	56	Predominantly traffic noise Occasional trams
	20/7/2015 21:00	85	67	54	Predominantly traffic noise Occasional trams
Night	21/7/2015 2:20	76	58	51	Light traffic
	21/7/2015 3:10	73	56	51	Light traffic



Measurement Location



Noise Logger

Table F6: Attended Noise Measurements at Location 2, the Victorian Cancer Care Centre

Period	Date / Time (hours)	Noise Level, dB(A)			Comments
		L_{Amax}	$L_{Aeq,10mins}$	L_{A90}	
Day	15/7/2015 16:25	83	69	61	Predominantly traffic noise Occasional trams
	15/7/2015 17:10	84	70	61	Predominantly traffic noise Occasional trams
Evening	20/7/15 20:05	85	67	59	Predominantly traffic noise Occasional trams Constant crossing signal
	20/7/15 21:00	86	67	57	Predominantly traffic noise Occasional trams Constant crossing signal
Night	21/7/2015 2:40	71	58	51	Light traffic
	21/7/2015 3:10	73	59	52	Light traffic

Measurement Location

Noise Logger

Table F7: Attended Noise Measurements at Location 3, the Royal Melbourne Hospital

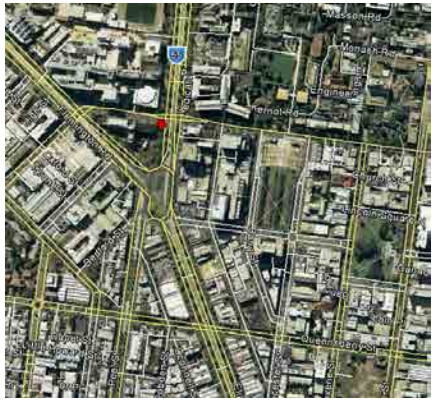
Period	Date / Time (hours)	Noise Level, dB(A)			Comments
		L_{Amax}	$L_{Aeq,10mins}$	L_{A90}	
Day	15/7/2015 16:10	85	69	61	Predominantly traffic noise Occasional trams
	15/7/2015 16:55	96	71	61	Predominantly traffic noise Occasional trams L_{Amax} due to motorcycle
Evening	20/7/2015 19:45	82	67	59	Predominantly traffic noise Occasional trams
	20/7/2015 20:40	84	66	58	Predominantly traffic noise Occasional trams
Night	21/7/2015 2:05	73	61	54	Light traffic
	21/7/2015 2:55	73	61	55	Light traffic

Measurement Location

Noise Logger

Table F8: Attended Noise Measurements at Location 4, the Victorian Cancer Care Centre

Period	Date / Time (hours)	Noise Level, dB (A)			Comments
		L_{Amax}	$L_{Aeq,10mins}$	L_{A90}	
Day	15/7/2015 16:10	80	69	61	Predominantly traffic noise Occasional trams
	15/7/2015 16:55	92	71	61	Predominantly traffic noise Occasional trams L_{Amax} due to motorcycle
Evening	20/7/15 19:50	80	67	59	Predominantly traffic noise Occasional trams
	20/7/15 20:40	80	66	58	Predominantly traffic noise Occasional trams
Night	21/7/2015 2:20	71	60	53	Light traffic
	21/7/2015 2:55	80	63	53	Light traffic

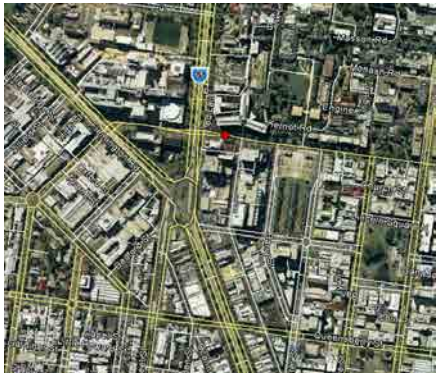


Measurement Location

Noise Logger

Table F9: Attended Noise Measurements at Location 5, the University of Melbourne

Period	Date / Time (hours)	Noise Level, dB (A)			Comments
		L_{Amax}	$L_{Aeq,10mins}$	L_{A90}	
Day	15/7/2015 15:50	89	72	64	Predominantly traffic noise
	15/7/2015 16:40	83	72	64	Predominantly traffic noise Occasional hammering and drilling
Evening	20/7/15 19:15	86	66	58	Predominantly traffic noise
	20/7/15 20:25	88	67	58	Predominantly traffic noise
Night	21/7/2015 1:50	70	57	53	Light traffic
	21/7/2015 2:35	76	58	53	Light traffic



Measurement Location

Noise Logger

Table F10: Attended Noise Measurements at Location 6, the Peter Doherty Institute

Period	Date / Time (hours)	Noise Level, dB(A)			Comments
		L_{Amax}	$L_{Aeq,10mins}$	L_{A90}	
Day	15/7/2015 15:55	97	75	65	Predominantly traffic noise. L_{Amax} due to motorcycle
	15/7/2015 16:40	88	71	66	Predominantly traffic noise
Evening	20/7/15 19:20	85	68	58	Predominantly traffic noise
	20/7/15 20:25	95	72	58	Predominantly traffic noise
Night	21/7/2015 1:45	70	57	54	Light traffic
	21/7/2015 2:40	76	58	53	Light traffic

Measurement Location

Noise Logger

Table F11: Attended Noise Measurements at Location 7, corner of Pelham and Elizabeth Streets

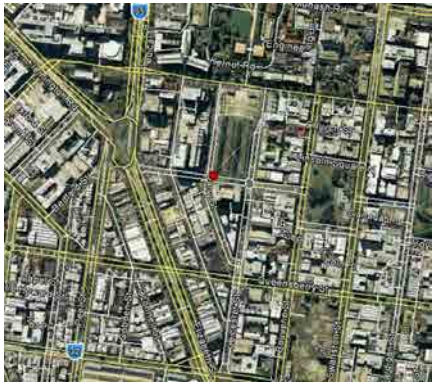
Period	Date / Time (hours)	Noise Level, dB(A)			Comments
		L_{Amax}	$L_{Aeq,10mins}$	L_{A90}	
Day	28/7/2015 9:35	91	71	60	Predominantly traffic noise Occasional trams
	28/7/2015 12:00	88	68	59	Predominantly traffic noise Occasional trams
Evening	29/7/2015 20:00	83	67	57	Predominantly traffic noise Occasional trams
	29/7/2015 21:00	81	66	55	Predominantly traffic noise Occasional trams
Night	29/7/2015 2:00	84	62	47	Predominantly traffic noise
	29/7/2015 3:05	73	58	49	Predominantly traffic noise

Measurement Location

Noise Logger

Table F12: Attended Noise Measurements at Location 8, University Square – corner of Barry and Pelham Streets

Period	Date / Time (hours)	Noise Level, dB(A)			Comments
		L_{Amax}	$L_{Aeq,10mins}$	L_{A90}	
Day	28/7/2015 10:05	78	59	54	Light traffic
	28/7/2015 12:15	73	58	53	Light traffic
Evening	29/7/2015 20:15	74	56	49	Light traffic
	29/7/2015 21:20	69	53	48	Light traffic
Night	29/7/2015 2:15	61	45	44	Light traffic
	29/7/2015 3:20	56	45	43	Light traffic

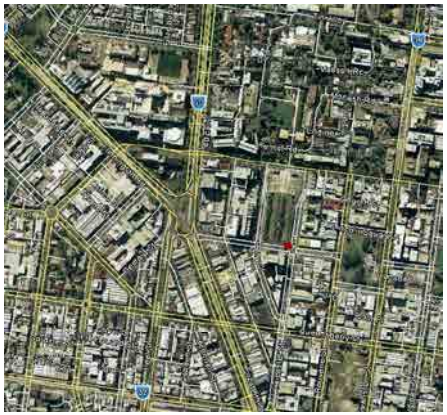


Measurement Location

Noise Logger

Table F13: Attended Noise Measurements at Location 9, University Square– corner of Pelham and Leicester Streets

Period	Date / Time (hours)	Noise Level, dB(A)			Comments
		L_{Amax}	$L_{Aeq,10mins}$	L_{A90}	
Day	28/7/2015 10:40	88	65	53	Predominantly traffic noise Window cleaner machinery at 20 m
	28/7/2015 12:30	87	65	54	Predominantly traffic noise Busy foot traffic with students talking
Evening	29/7/2015 20:15	83	60	49	Predominantly traffic noise
	29/7/2015 21:20	82	60	50	Predominantly traffic noise
Night	29/7/2015 2:15	61	43	42	Light traffic
	29/7/2015 3:20	61	45	42	Light traffic



Measurement Location

Noise Logger

Table F14: Attended Noise Measurements at Location 10, University Square – corner of Grattan and Leicester Streets

Period	Date / Time (hours)	Noise Level, dB(A)			Comments
		L_{Amax}	$L_{Aeq,10mins}$	L_{A90}	
Day	28/7/2015 11:10	84	70	58	Predominantly traffic noise
	28/7/2015 12:45	84	68	56	Predominantly traffic noise
Evening	29/7/2015 20:35	77	66	53	Predominantly traffic noise
	29/7/2015 21:35	77	66	53	Predominantly traffic noise
Night	29/7/2015 2:30	81	58	44	Light traffic
	29/7/2015 3:35	71	55	44	Light traffic

Measurement Location

Noise Logger

Table F15: Attended Noise Measurements at Location 11, University Square – corner of Barry and Grattan Streets

Period	Date / Time (hours)	Noise Level, dB (A)			Comments
		L_{Amax}	$L_{Aeq,10mins}$	L_{A90}	
Day	28/7/2015 11:35	88	70	58	Predominantly traffic noise
	28/7/2015 1:00	93	78	57	Predominantly traffic noise
Evening	29/7/2015 20:35	76	64	56	Predominantly traffic noise
	29/7/2015 21:35	73	63	55	Predominantly traffic noise
Night	29/7/2015 2:30	78	55	46	Predominantly traffic noise
	29/7/2015 3:35	70	54	47	Predominantly traffic noise

Measurement Location

Noise Logger

Table F16: Attended Noise Measurements at Location 12, Howard Florey Laboratories

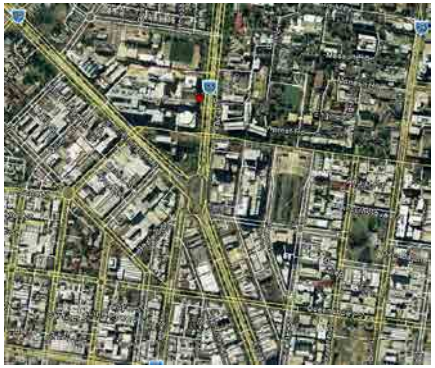
Period	Date / Time (hours)	Noise Level, dB(A)			Comments
		L_{Amax}	$L_{Aeq,10mins}$	L_{A90}	
Day	29/7/2015 15:35	79	66	61	Predominantly traffic noise Occasional trams
	29/7/2015 16:30	75	64	60	Predominantly traffic noise Occasional trams
Evening	29/7/2015 19:45	73	63	58	Predominantly traffic noise Occasional trams
	29/7/2015 20:50	76	63	58	Predominantly traffic noise Occasional trams
Night	29/7/2015 1:45	76	62	55	Predominantly traffic noise UoM mechanical service noise
	29/7/2015 2:50	77	61	55	Predominantly traffic noise UoM mechanical service noise

Measurement Location

Noise Logger

Table F17: Attended Noise Measurements at Location 13, Melbourne Private Hospital

Period	Date / Time (hours)	Noise Level, dB(A)			Comments
		L_{Amax}	$L_{Aeq,10mins}$	L_{A90}	
Day	29/7/2015 15:00	77	64	59	Predominantly traffic noise Occasional trams
	29/7/2015 16:15	86	67	59	Predominantly traffic noise Occasional trams
Evening	29/7/2015 20:00	72	61	57	Predominantly traffic noise Occasional trams
	29/7/2015 21:05	77	63	56	Predominantly traffic noise Occasional trams
Night	29/7/2015 2:00	70	58	53	Predominantly traffic noise Hospital mechanical service noise
	29/7/2015 3:05	69	58	53	Predominantly traffic noise Hospital mechanical service noise



Measurement Location

Noise Logger

Table F18: Attended Noise Measurements at Location 14, University High School

Period	Date / Time (hours)	Noise Level, dB (A)			Comments
		L_{Amax}	$L_{Aeq,10mins}$	L_{A90}	
Day	29/7/2015 14:15	78	64	55	Predominantly traffic noise Occasional trams
	29/7/2015 16:00	84	67	58	Predominantly traffic noise Occasional trams
Evening	29/7/2015 19:45	76	63	53	Predominantly traffic noise Occasional trams
	29/7/2015 20:50	77	64	54	Predominantly traffic noise Occasional trams
Night	29/7/2015 1:45	74	57	49	Predominantly traffic noise
	29/7/2015 2:45	73	57	49	Predominantly traffic noise

Measurement Location

Noise Logger

Table F19: Attended Noise Measurements at Location 15, Latrobe House, 200 Latrobe Street, Melbourne

Period	Date / Time (hours)	Noise Level dB(A)			Comments
		L_{Amax}	$L_{Aeq,10mins}$	L_{A90}	
Day	5/10/2015 10:15	81	68	63	Predominantly traffic and pedestrian noise with occasional trams
	5/10/2015 11:05	84	69	63	Predominantly traffic and pedestrian noise with occasional trams
Evening	8/10/2015 20:05	79	68	63	Predominantly traffic and pedestrian noise with occasional trams
	8/10/2015 21:00	78	68	62	Predominantly traffic and pedestrian noise with occasional trams
Night	8/10/2015 00:40	73	63	58	Predominantly traffic and pedestrian noise with occasional trams
	8/10/2015 1:40	79	62	57	Predominantly traffic and pedestrian noise with occasional trams

Measurement Location

Noise Logger

Table F20: Attended Noise Measurements at Location 16, 31 A'Beckett Street Melbourne

Period	Date / Time (hours)	Noise Level dB(A)			Comments
		L_{Amax}	$L_{Aeq,10mins}$	L_{A90}	
Day	16/12/2015 15:55	81	66	63	Predominantly traffic and pedestrian noise
	16/12/2015 16:25	84	66	63	Predominantly traffic and pedestrian noise
Evening	16/12/2015 19:20	79	63	59	Predominantly traffic and pedestrian noise
	16/12/2015 19:50	78	64	60	Predominantly traffic and pedestrian noise
Night	17/12/2015 2:25	73	51	50	Predominantly traffic and pedestrian noise
	17/12/2015 2:40	79	52	50	Predominantly traffic and pedestrian noise

Measurement Location

Noise Logger

Table F21: Attended Noise Measurements at Location 17, 81 Franklin Street Melbourne

Period	Date / Time (hours)	Noise Level dB(A)			Comments
		L_{Amax}	$L_{Aeq,10mins}$	L_{A90}	
Day	16/12/2015 16:10	82	69	64	Predominantly traffic and pedestrian noise
	16/12/2015 16:40	94	68	65	Predominantly traffic and pedestrian noise
Evening	16/12/2015 19:35	79	68	63	Predominantly traffic and pedestrian noise
	16/12/2015 20:05	78	68	62	Predominantly traffic and pedestrian noise
Night	17/12/2015 2:40	73	63	58	Predominantly traffic and pedestrian noise
	17/12/2015 3:25	79	62	57	Predominantly traffic and pedestrian noise

Measurement Location

Noise Logger

Table F22: Attended Noise Measurements at Location 1, UniLodge, 228 Flinders Street, Melbourne

Period	Date / Time (hours)	Noise Level dB(A)			Comments
		L_{Amax}	$L_{Aeq,10mins}$	L_{A90}	
Day	16/12/2015 15:55	80	70	64	Predominantly traffic and pedestrian noise with occasional trams
	16/12/2015 16:25	92	71	64	Predominantly traffic and pedestrian noise with occasional trams
Evening	16/12/2015 19:20	79	67	61	Predominantly traffic and pedestrian noise with occasional trams
	16/12/2015 19:50	82	68	59	Predominantly traffic and pedestrian noise with occasional trams
Night	17/12/2015 2:25	83	66	55	Predominantly traffic and pedestrian noise with occasional trams
	17/12/2015 2:40	84	64	55	Predominantly traffic and pedestrian noise with occasional trams

Measurement Location

Noise Logger

Comment: Adjusted for reflection

Table F23: Attended Noise Measurements at Location 19, Fawkner Park

Period	Date / Time (hours)	Noise Level dB(A)			Comments
		L_{Amax}	$L_{Aeq,10mins}$	L_{A90}	
Day	31/1/2016 14:45	76	61	52	Predominantly traffic and pedestrian noise
	31/1/2016 15:15	77	61	52	Predominantly traffic and pedestrian noise
					
Measurement Location				Noise Logger	

Table F24: Attended Noise Measurements at Location 20, 142 Cross Street, Footscray

Period	Date / Time (hours)	Noise Level dB(A)			Comments
		L_{Amax}	$L_{Aeq,10mins}$	L_{A90}	
Day	11/3/2016 14:06	81	58	49	Predominantly traffic, train and pedestrian noise
	11/3/2016 14:39	71	56	49	Predominantly traffic, train and pedestrian noise
Evening	-	-	-	-	-
	-	-	-	-	-
Night	11/3/2016 01:47	74	48	46	Predominantly cricket and mechanical service noise
	11/3/2016 02:42	61	50	47	Predominantly cricket and mechanical service noise
					
Measurement Location				Noise Logger	

Table F25: Attended Noise Measurements at Location 20, 70 Cross Street, Footscray

Period	Date / Time (hours)	Noise Level dB(A)			Comments
		L_{Amax}	$L_{Aeq,10mins}$	L_{A90}	
Day	11/3/2016 14:06	82	61	52	Predominantly traffic, train and pedestrian noise
	11/3/2016 14:39	83	62	51	Predominantly traffic, train and pedestrian noise
Evening	15/3/2016 20:01	75	60	50	Predominantly traffic and pedestrian noise
	15/3/2016 20:40	69	57	50	Predominantly traffic and pedestrian noise
Night	11/3/2016 02:14	58	46	44	Predominantly mechanical service noise
	11/3/2016 03:00	56	46	44	Predominantly mechanical service noise

Measurement Location

Noise Logger

F.3 Internal Noise Measurements

F.3.1 Summary

Noise measurements have been undertaken at both:

(i) Residential locations in the near vicinity of tram tracks and/or over the MURL. The purpose of these measurements is to determine typical ground-borne noise levels in residential receivers due to tram or train passbys.

(ii) Bio-resources facilities

F.3.2 Methodology

The locations where internal noise measurements have been conducted are provided in Table F26.

Table F26: Description of measurement locations

Location	Address	Description
Precinct 1: Tunnels Precinct		
1	72 Provost Street, North Melbourne	Ground floor - room contained couches and tables
2	479 Swanston Street, Melbourne	9th floor - room was empty
3	QV2 Swanston Street, Melbourne	5th floor - room contained a bed
4	260 Little Collins Street, Melbourne	1st floor - room contained a bed
5	180 Toorak Road W, South Yarra	1st floor - room contained a bed
6	WEHI – Level 4 bio-resources room	A small congested room
7	RMH – Level 6 bio-resources room	A large open room
8	RMH - Basement bio-resources room	Located in the basement of the hospital
9	PDI Auditorium	Located on the Royal Parade facade
10	PDI – Level 9 Bio-resources facility	Smaller rooms that are isolated from external noise
11	UoM – Level 9 Bio-resources facility	Small rooms located on Grattan Street facade
12	UoM – Level 9 Bio-resources facility	Small rooms located on Grattan Street facade

F.3.2.1 Noise Monitoring Approach

Noise Monitoring has been conducted in compliance with AS 1055.1-1997.

Measurements have been conducted inside buildings with windows closed.

The preferred measurement positions have been at least 1 m from the walls or other major reflecting surfaces and 1.2 m to 1.5 m above the floor.

F.3.2.2 Acoustic Equipment

Details of the acoustic equipment used to conduct these measurements are provided in Table F27. All acoustic equipment has current calibration certificates and these are provided in Section F.7

Table F27 : Noise Measurement Equipment

Manufacturer	Type of Instrument	Serial No.	Last Calibration Date
Bruel & Kjaer	Sound Level Analyser 2250	2506886	28/09/2015
Bruel & Kjaer	Acoustic Calibrator	2542100	3/09/2015

The Sound Level Meters was checked for calibration before and after each set of measurements. A windshield was fitted to the microphone for all measurements.

F.3.3 Results

The results of the residential noise measurements are presented In Table F28.

Table F28: Results of residential noise measurements

Location	Date	$L_{Amax, slow}$ dB(A)	Comments
1	22/10/2015	26 - 31	tracks were continuously welded
2	14/10/2015	28 - 31	trams were travelling over track crossovers
3	1/10/2015	32 - 36	trams were travelling on tracks with joints
4	14/10/2015	30 - 38	trams were travelling on tracks with joints
5	24/9/2015	28 - 35	trams were travelling over track crossovers

The results of the noise measurements in Bio-resources facilities (and Lecture Theatre) are presented in Table F29. Some of the levels have been frequency truncated.

Table F29: Results of noise measurements in Bio-resources facilities (and Lecture Theatre)

Location	Date	Noise Level dB			Comments
		L_{max}	L_{eq}	L_{90}	
6	15/10/2015	77	61	58	The bio-resources are located in a small congested room closed off to the corridor with a sealed door. They are typically exposed to: music, mechanical services, chatter, doors slamming shut, objects falling to the floor, vacuum cleaners (69 dBL_{Aeq}). According to those who work with these bio-resources, loud noises for extended periods of time are a concern.
7	15/10/2015	79	60	57	These bio-resources are in a large area open to work spaces. The room is located at the façade on Royal Parade. These bio-resources are typically exposed to: music, mechanical services, chatter, cleaning and traffic and sirens from outside. During the site visit a worker emptied a basket of equipment into a sink causing a loud crashing noise (not measured). The worker explained that these bio-resources are occasionally exposed to high noise levels from similar tasks and not affected by them.
8	15/10/2015	88	78	76	Access was not permitted and so a noise measurement was taken in the corridor adjacent to the bio-resources room. The door was shut but had gaps (no seals). Noise sources outside the Bio-resources room include: cleaning and chatter. The main noise source inside the room is constant pump noise for filtration.
9	28/10/2015	45 (dBA)	37 (dBA)	36 (dBA)	The auditorium is located on the Royal Parade façade of PDI. Traffic noise from Royal Parade was audible at the rear of the auditorium. Mechanical service noise was audible.
10	28/10/2015	78	70	68	Access could not be obtained to the Bio-resources facility. Two acoustic doors (fully sealed) and a 2 m lobby separates the ferret rooms from work spaces (common rooms). Pressurized air can be heard in both the ferret rooms and the common rooms. A 1-minute measurement of this pressurized air was undertaken in the common room. According to those who work with the bio-resources, they are sensitive to noise and vibration. They are frequently exposed to human speech (they are comfortable with this), however, are sensitive to short sharp noises (including from humans). The doors for the rooms close slowly and do not slam shut to minimise the noise impact on the bio-resources.
11	16/12/2015	58	49	48	Access could not be obtained to the Bio-resources rooms. Measurements were undertaken at the corridor. According to those who work with the bio-resources, careful consideration is taken to keep noise and vibration levels compliant with Australian Standards.
12	16/12/2015	46	45	44	Access could not be obtained to the Bio-resources rooms. Measurements were undertaken at the corridor. According to those who work with the bio-resources, they are sensitive to noise and vibration. Careful consideration is taken to keep noise and vibration levels compliant with Australian Standards.

F.4 : External Vibration Measurements

F.4.1 Summary

External vibration measurements have been conducted at 39 locations across the proposed Melbourne Metro alignment. The locations have been strategically selected in order to present the existing vibration levels.

F.4.2 Methodology

F.4.2.1 Approach

Attended vibration measurements have been carried out at 39 locations to determine the baseline vibration levels in the vicinity of the Melbourne Metro. By undertaking attended measurements the cause of vibration levels have been able to be identified and data integrity has been maintained.

Vibration measurements have been undertaken using a vibration logger which consists of an accelerometer placed firmly on the ground. Vibration levels have been measured as Peak Particle Velocity (mm/s).

The vibration measurements have been undertaken for a length of time that includes the expected vibration sources e.g. heavy truck, rail vehicle etc. The measurements have been undertaken for a minimum period of 30 minutes.

F.4.2.2 Acoustic Equipment

Details of the acoustic equipment used to conduct these measurements are provided in Table F30. All acoustic equipment has current calibration certificates and these are provided at the end of this Appendix.

Table F30: Noise Measurement Equipment

Manufacturer	Type of Instrument	Serial No.	Last Calibration Date
SVANTEK	SVAN958 Vibration Analyser	28435	3/04/2014

F.4.2.3 Meteorological Conditions

Meteorological conditions were fine with some windy conditions. The measurements were unaffected by the weather.

F.4.2.4 Vibration Measurement Locations

Attended vibration measurements have been carried out at 39 locations in the vicinity of the Melbourne Metro alignment. The specific locations are shown in Figure F25.

F.4.3 Results

Vibration levels have been measured at 40 locations in the vicinity of Melbourne Metro alignment. Details of the vibration locations and a summary of the results is provided in Table F31 and graphs of the results provided in Figure F26 to Figure F65.

These results are presented as peak particle velocity, PPV, which is defined as: the highest instantaneous sum of velocity vectors of the ground movement caused by the passage of vibration.

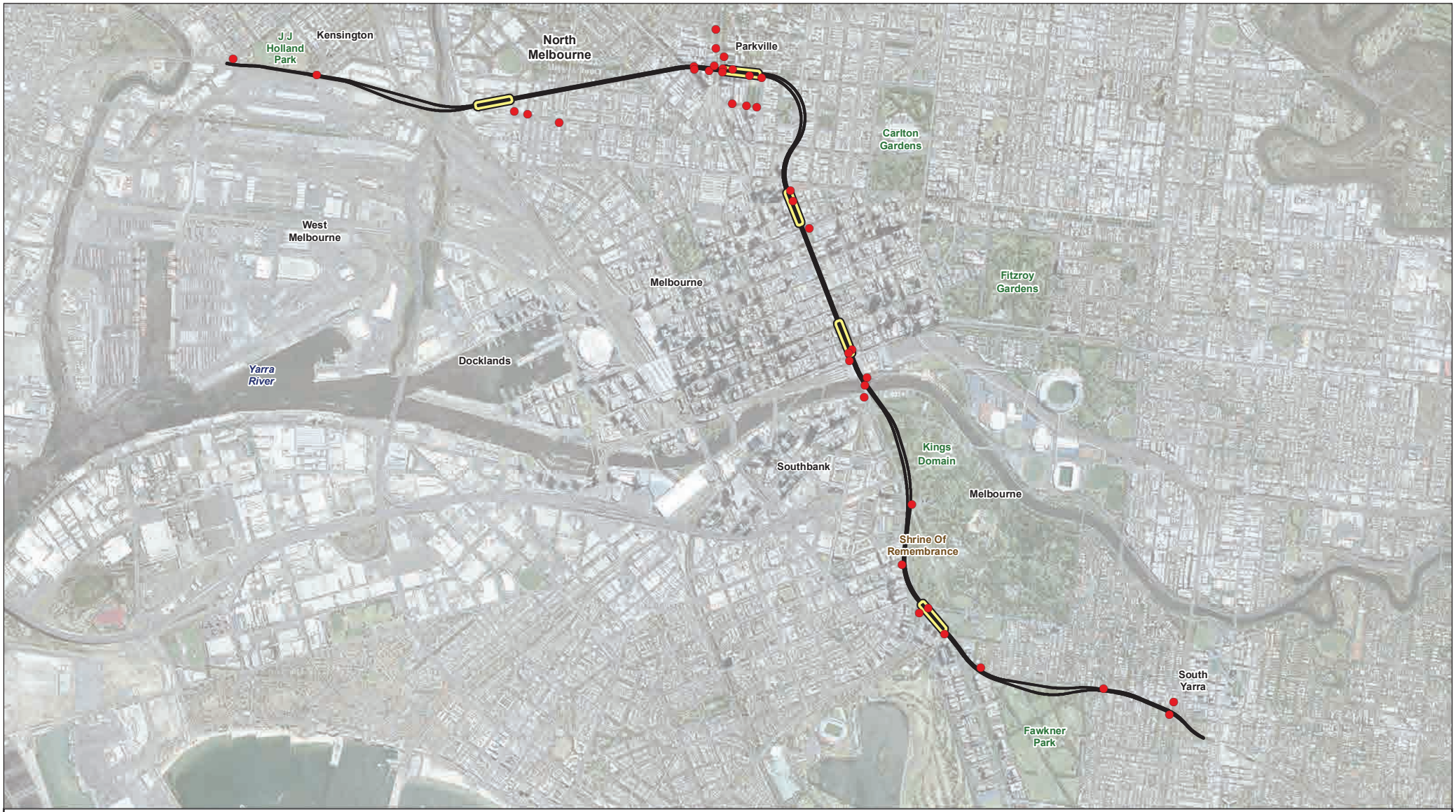


Figure F25: Vibration Measurement Locations

Table F31: Vibration Measurement Locations

Location No.	Location	Maximum PPV Levels (mm/s)	Comments
Western Portal Precinct			
1	148 Kensington Road, Kensington	1.5	Truck at 15m travelling over a road imperfection
2	9-15 Childers Street, Kensington	1	Comeng and Siemens trains at 20 m
Arden Station Precinct			
3	760 Queensberry Street, North Melbourne	4.2	Truck at 3 m travelling over a road imperfection
4	736-738 Queensberry Street, North Melbourne	1	Truck at 3 m
5	201 Abbotsford Street, North Melbourne	1.3	Tram at 15 m and Trolley at 10 m
Parkville Station Precinct			
6	Grattan Street, Parkville (between Flemington Rd and Royal Parade)	1.1	Taxi at 2 m
7	Grattan Street, Parkville (between Flemington Rd and Royal Parade)	2.9	Bus and dump truck at 1 m
8	Grattan Street, Parkville (between Flemington Rd and Royal Parade)	1.7	Pedestrian at 0.1 m
9	Royal Melbourne Hospital Royal Parade, Parkville	0.5	Tram at 20 m
10	Grattan Street/Royal Parade, Parkville	0.8	Tram at 20 m
11	Grattan Street/Elizabeth Street, Parkville	0.9	Tram at 20 m
12	Grattan Street/Berkeley Street, Parkville	1	Bus at 5 m
13	Corner of Pelham and Elizabeth Streets	0.8	Tram at 15 m
14	University Square – corner of Barry and Pelham Streets	0.8	Pedestrians at 0.3 m
15	University Square – corner of Pelham and Leicester Streets	0.2	
16	University Square – corner of Grattan and Leicester Streets	0.3	
17	University Square – corner of Barry and Grattan Streets	0.2	
18	Howard Florey Laboratories – Royal Parade	0.7	Tram at 15 m
19	Melbourne Private Hospital – Royal Parade	1	Tram at 20 m
20	University High School – Royal Parade	0.6	Tram at 20 m
CBD North Station Precinct			
21	420 Swanston Street, Melbourne	1.6	Tram at 10m and Tram at 15 m
22	402 Swanston Street, Melbourne	5.2	Dual carriage Tram at 10 m travelling over rail joints
23	179 Latrobe Street, Melbourne	3.2	City Circle Tram at 15 m travelling over rail joints
CBD South Station Precinct			
24	2 – 22 Swanston Street, Melbourne	2.1	Tram at 10 m
25	1 Swanston Street, Melbourne	7	Tram at 5 m + Tram at 10 m travelling over rail joints
26	226 Flinders Street, Melbourne	1.3	Tram at 5 m and double decker bus at 2 m
27	2 Princes Walk, Melbourne	0.2	
28	Princes Bridge St. Kilda Road, Melbourne	4	Tram at 7 m travelling over rail joints
29	80 St. Kilda Road, Melbourne	3.1	Tram at 10 m
Domain Station Precinct			
30	Marquis of Linlithgow Memorial – St. Kilda Road	0.3	Tram at 50 m
31	262 – 310 St. Kilda Road, Melbourne	0.6	Tram at 15 m
32	340 St. Kilda Road, Melbourne	0.7	Tram at 20 m
33	Tram shelter St. Kilda Road, Melbourne	3.2	Tram at 5 m
34	South African Soldiers Memorial – St. Kilda Road	0.3	Tram at 20 m
35	321 St. Kilda Road, South Melbourne	0.9	Tram at 20 m
36	402 St. Kilda Road, Melbourne	0.5	Skateboard at 3 m
Other			
37	14 Arnold Street, South Yarra	1	Truck at 3 m
38	68 Toorak Road, South Yarra	1.7	Tram at 5 m
39	723 Punt Road, South Yarra	3.2	Tram at 5 m
40	162 Toorak Road, South Yarra	2	Tram at 5 m

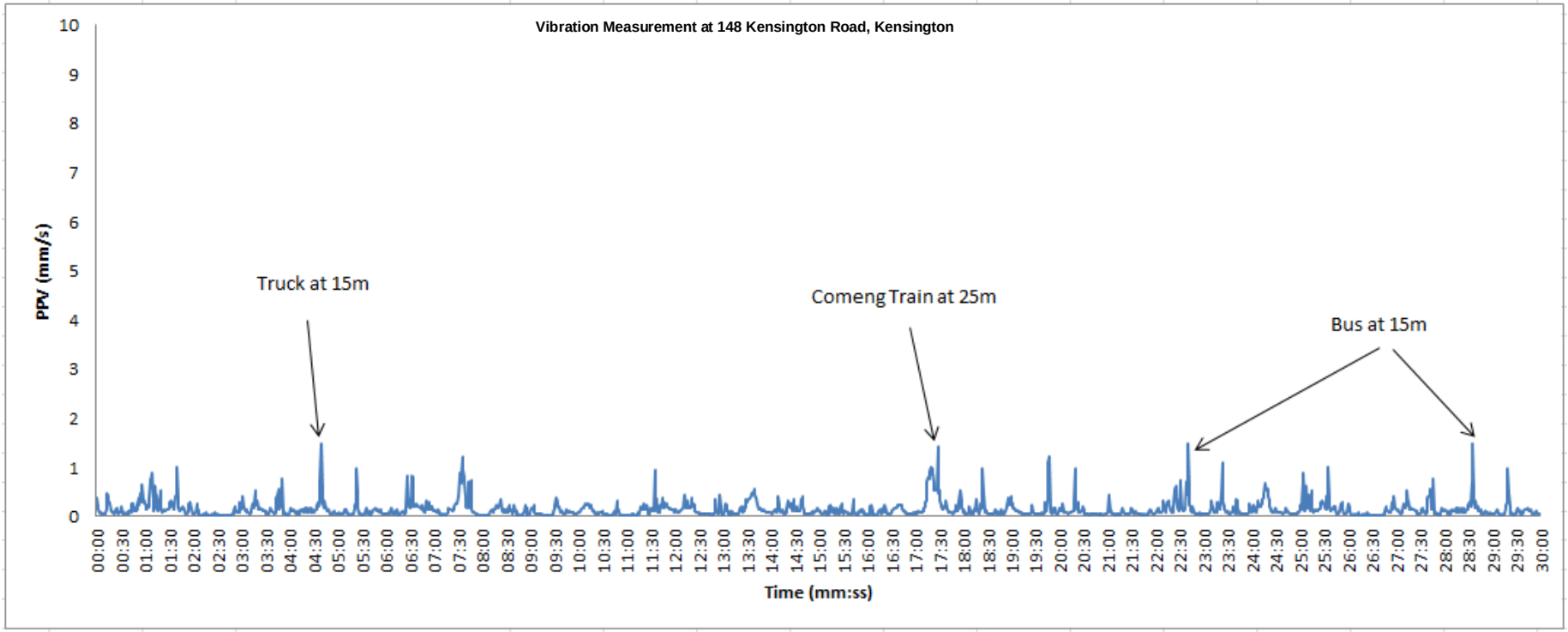


Image 1: Measurement equipment

Image 2: Imperfection on Kensington Road

Image 3: Measurement Location

Measurements commenced at 9:02 hours on 30/6/2015. Vibration sources included: cars, buses, trucks, trains, street sweepers, pedestrians. There was an imperfection (image 2) on the road that influenced the data.

Figure F26: Vibration levels measured at Location 1: 148 Kensington Road, Kensington

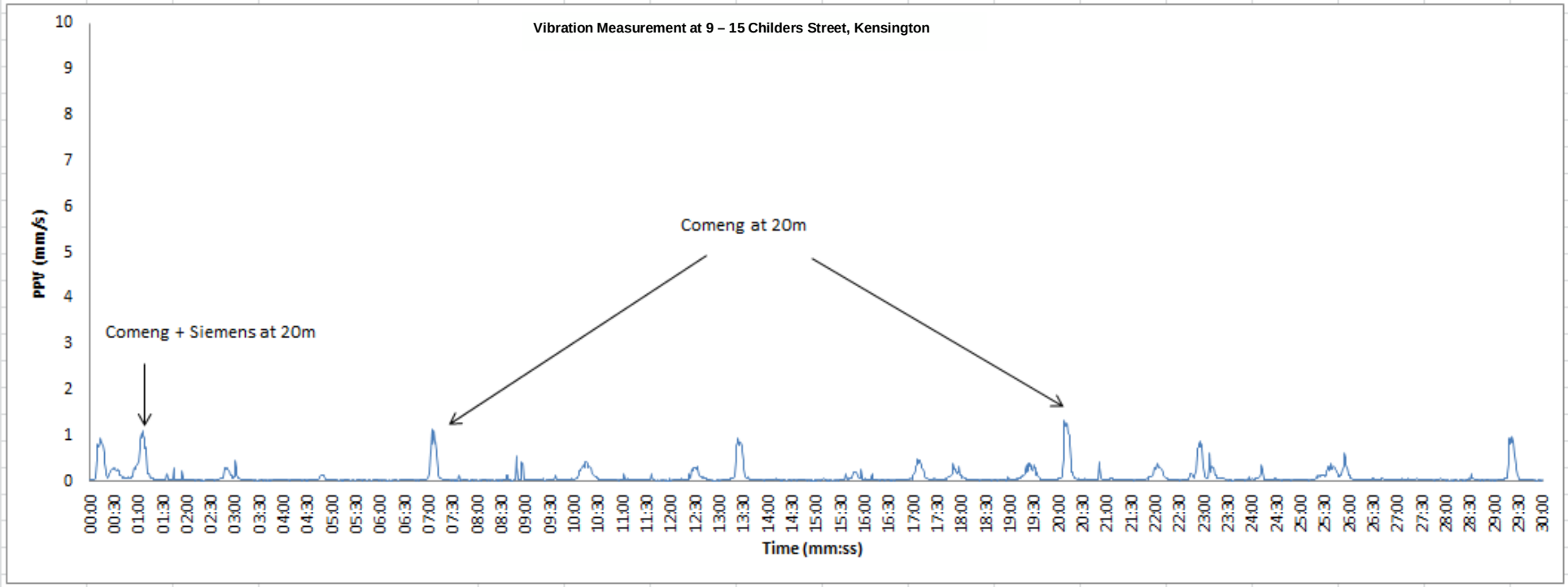


Image 1: Measurement equipment

Image 2: Proximity to track

Image 3: Measurement Location

Measurements commenced at 9:19 hours on 30/6/2015. Vibration sources included cars, trains, trucks and pedestrians.

Figure F27: Vibration levels measured at Location 2: 9 - 15 Childers Street, Kensington

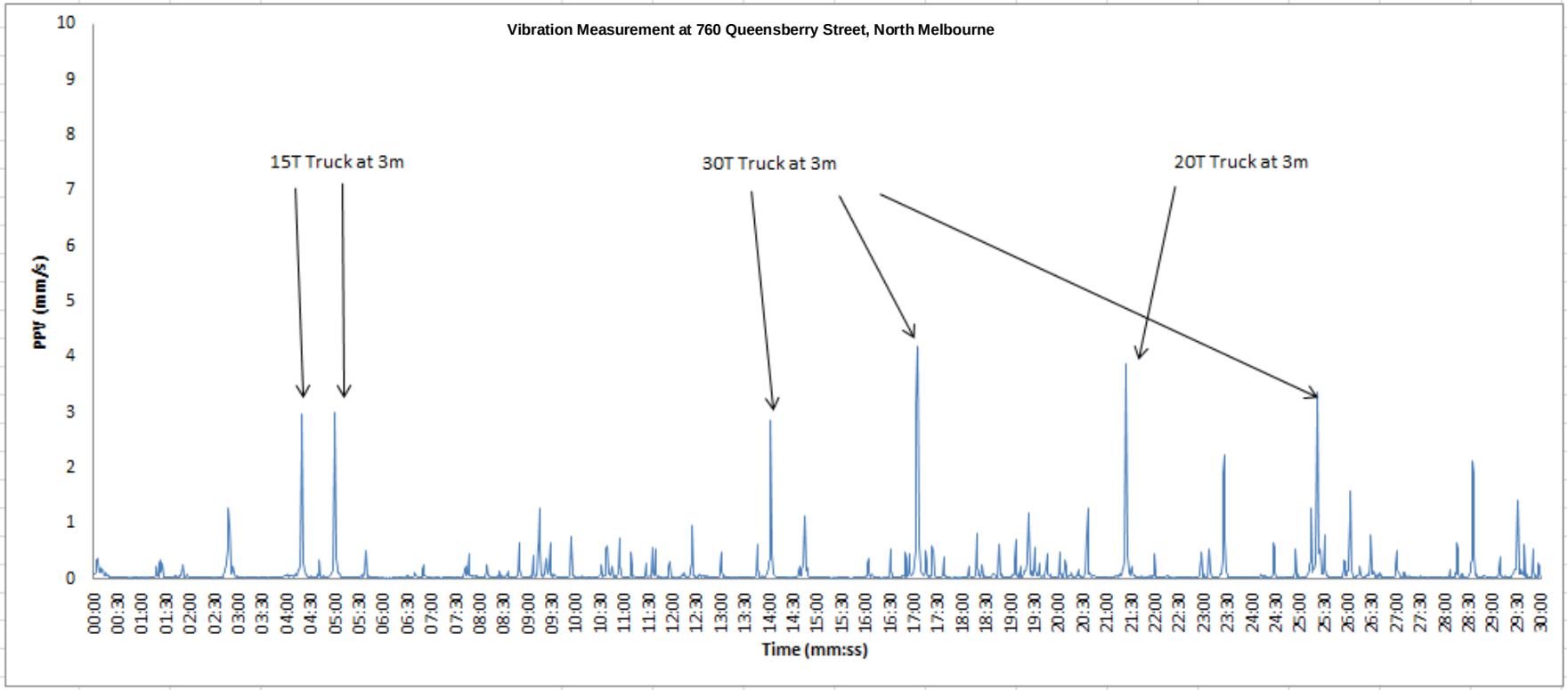


Image 1: Measurement equipment

Image 2: Imperfection on Lauren Street

Image 3: Measurement Location

Measurements commenced at 10:09 hours on 30/6/2015. Vibration sources included cars and trucks. There was an imperfection on the road (image 2) that had a significant influence on data.

Figure F28: Vibration levels measured at Location 3: 760 Queensberry Street, North Melbourne

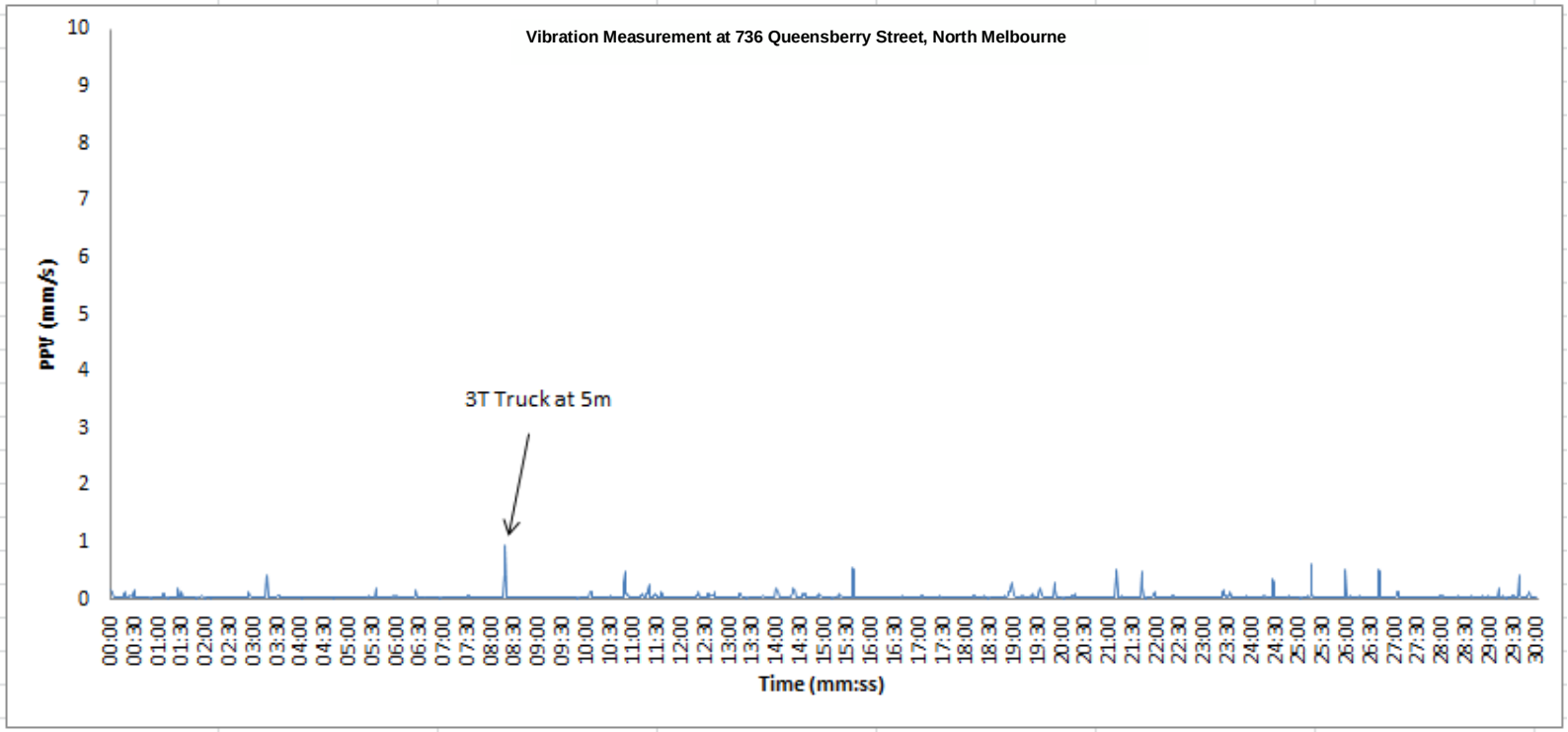


Image 1: Measurement equipment

Image 2: Queensbury Street

Image 3: Measurement Location

Measurements commenced at 10:45 hours on 30/6/2015. Vibration sources included cars, trucks and pedestrians.

Figure F29: Vibration levels measured at Location 4: 736 Queensberry Street, North Melbourne

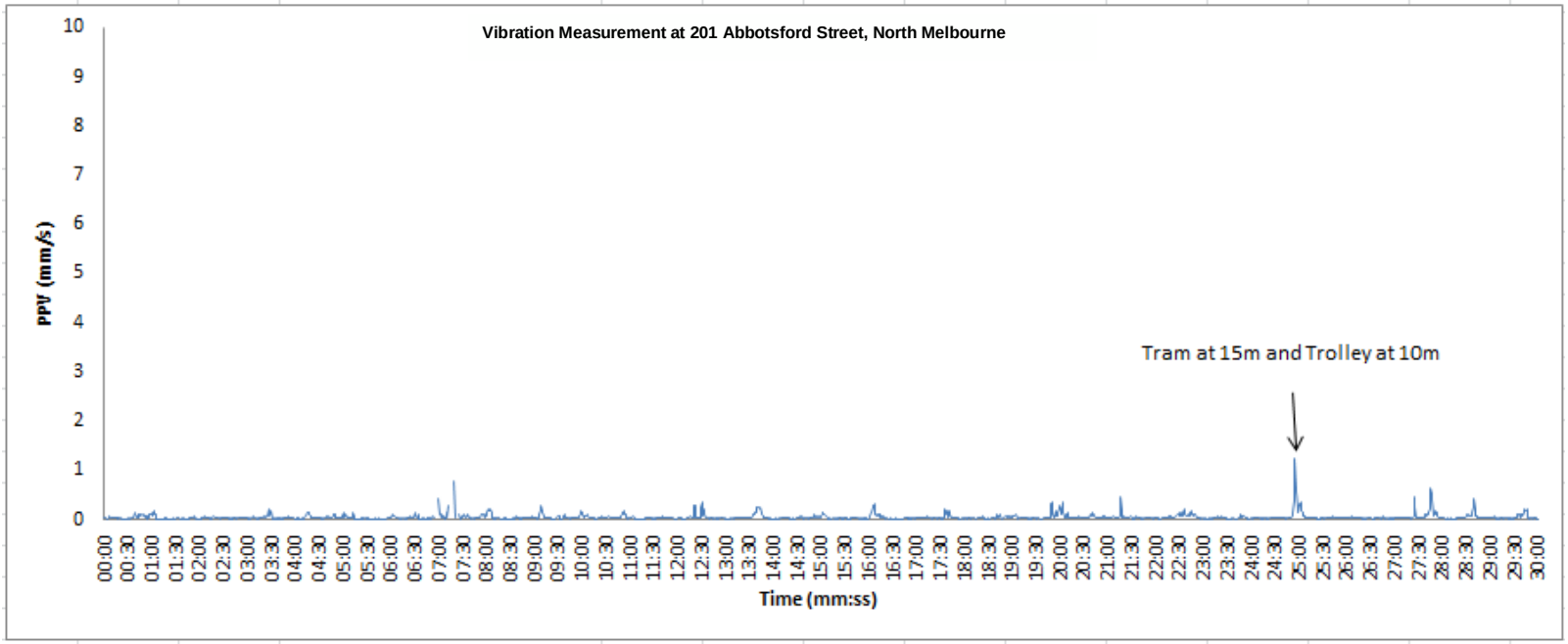


Image 1: Measurement equipment

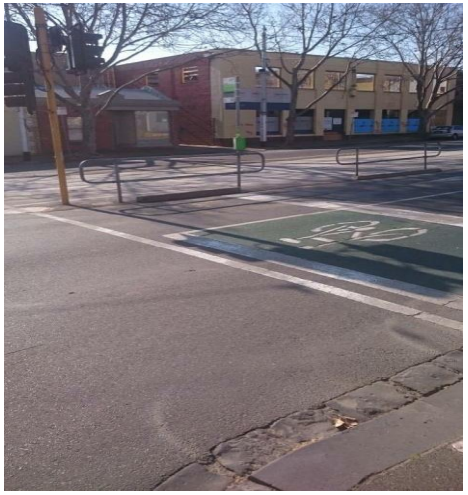


Image 2: Queensbury Street

Image 3: Measurement Location

Measurements commenced at 11:42 hours on 30/6/2015. Vibration sources included cars, trucks, trams and pedestrians.

Figure F30: Vibration levels measured at Location 5: 201 Abbotsford Street, North Melbourne

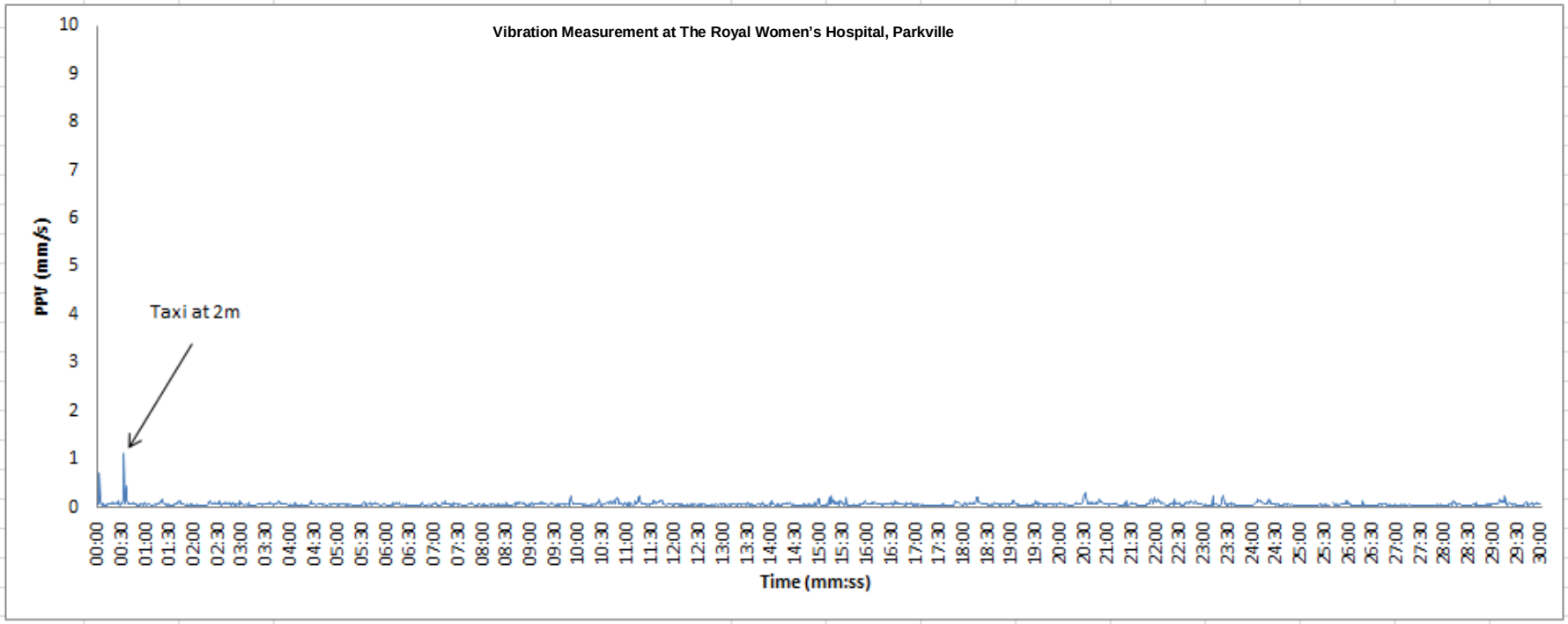


Image 1: Measurement equipment

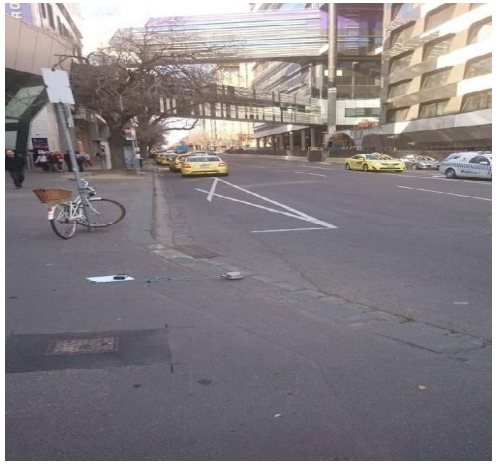


Image 2: Grattan Street

Image 3: Measurement Location

Measurements commenced at 13:51 hours on 30/6/2015. Vibration sources included cars, trucks, buses, ambulances and pedestrians.

Figure F31: Vibration levels measured at Location 6: The Royal Women's Hospital, Parkville

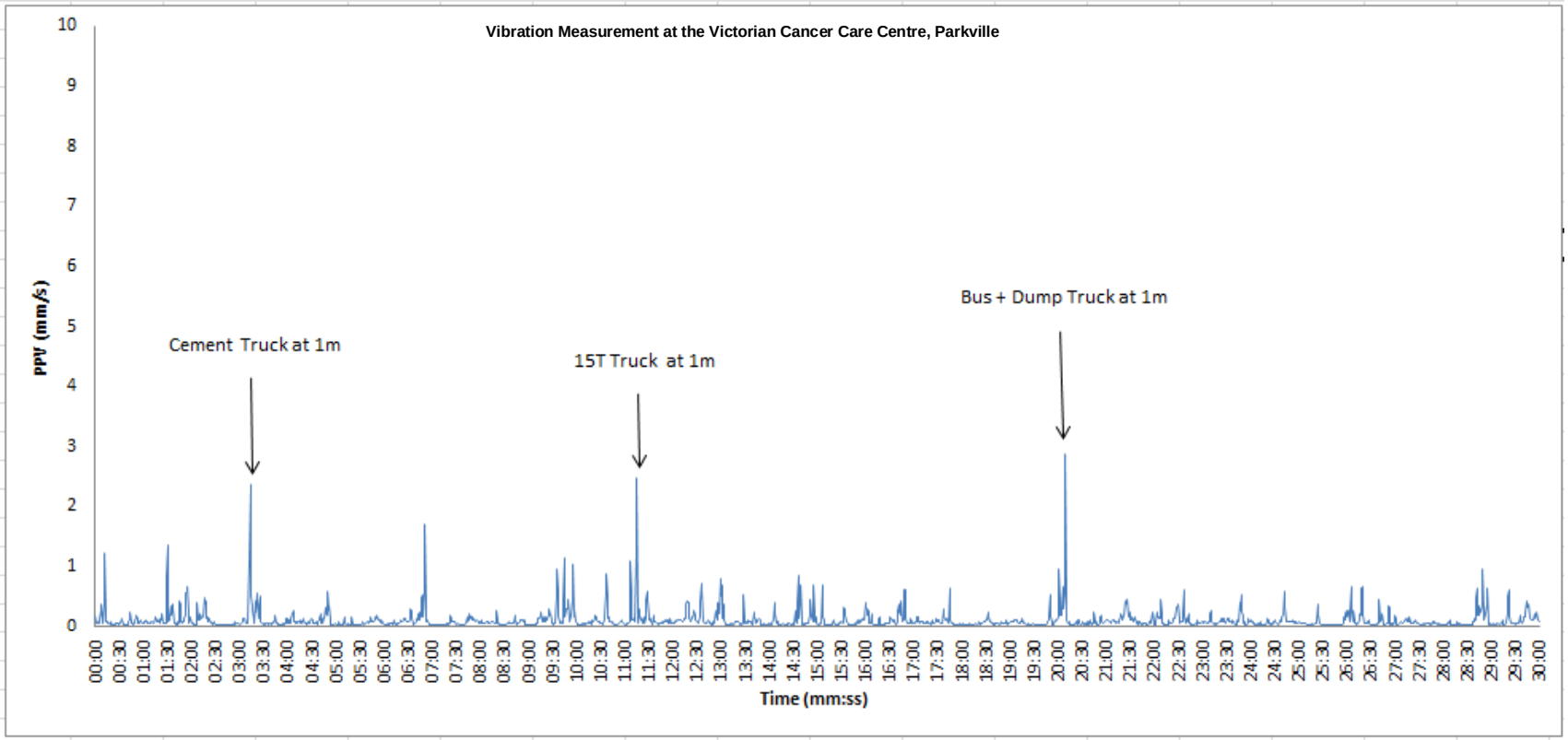


Image 1: Grattan Street

Image 2: Measurement equipment

Image 3: Measurement Location

Measurements commenced at 13:51 hours on 30/6/2015. Vibration sources included cars, trucks, buses, ambulances and pedestrians.

Figure F32: Vibration levels measured at Location 7: Victorian Comprehensive Cancer Centre, Parkville

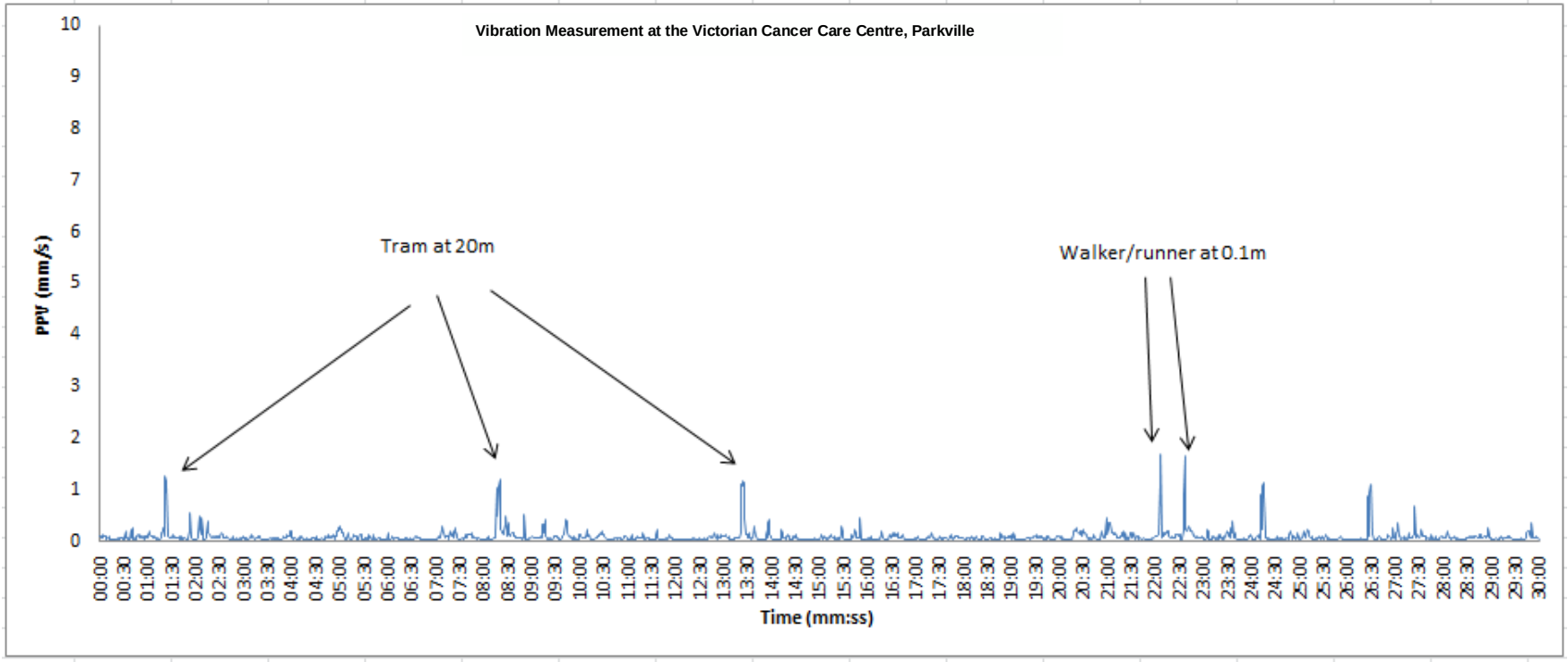


Image 1: Measurement equipment (Royal Parade)

Image 2: Grattan Street

Image 3: Measurement Location

Measurements commenced at 14:29 hours on 30/6/2015. Vibration sources included trams, cars, trucks, buses, ambulances and pedestrians.

Figure F33: Vibration levels measured at Location 8: Victorian Comprehensive Cancer Centre, Parkville

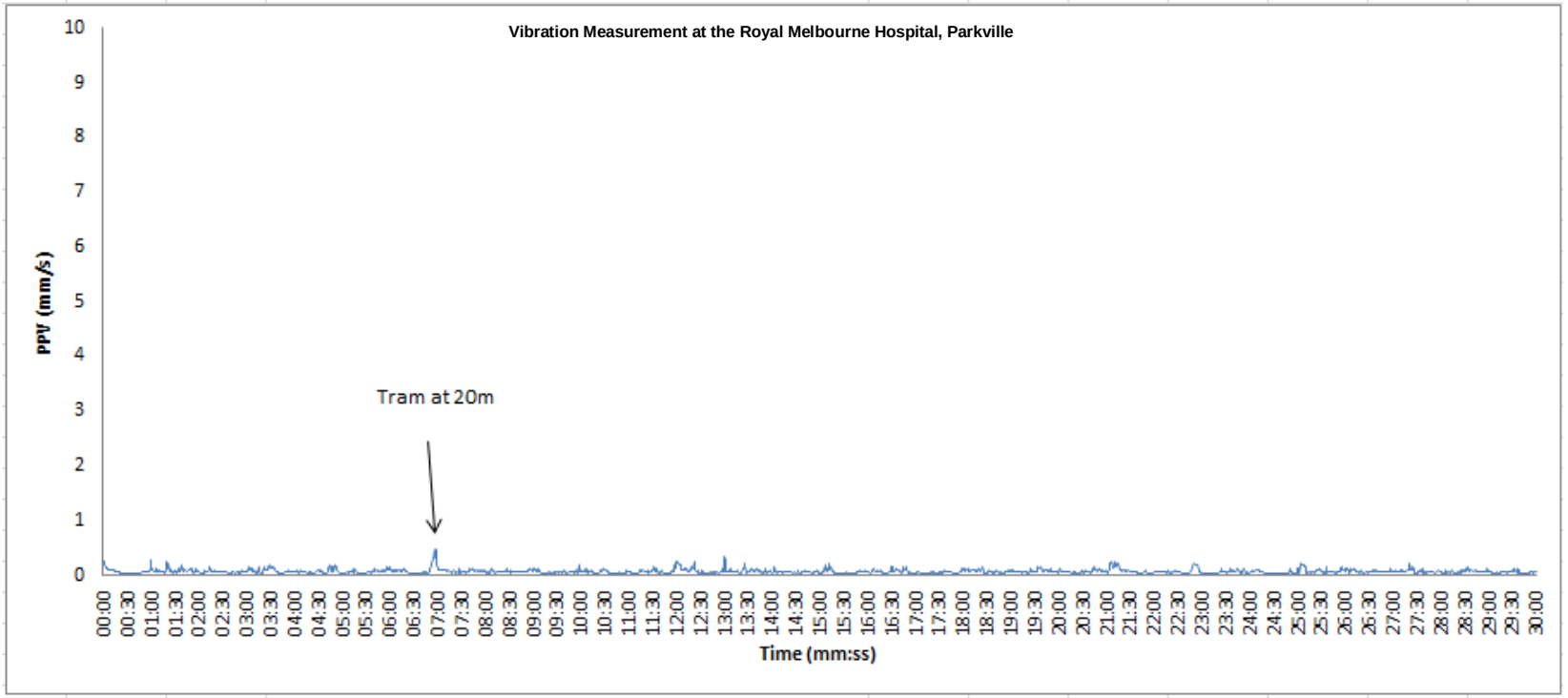


Image 1: Measurement equipment

Image 2: Royal Parade

Image 3: Measurement Location

Measurements commenced at 14:30 hours on 30/6/2015. Vibration sources included trams, cars, trucks, buses, ambulances and pedestrians.

Figure F34: Vibration levels measured at Location 9: the Royal Melbourne Hospital, Parkville

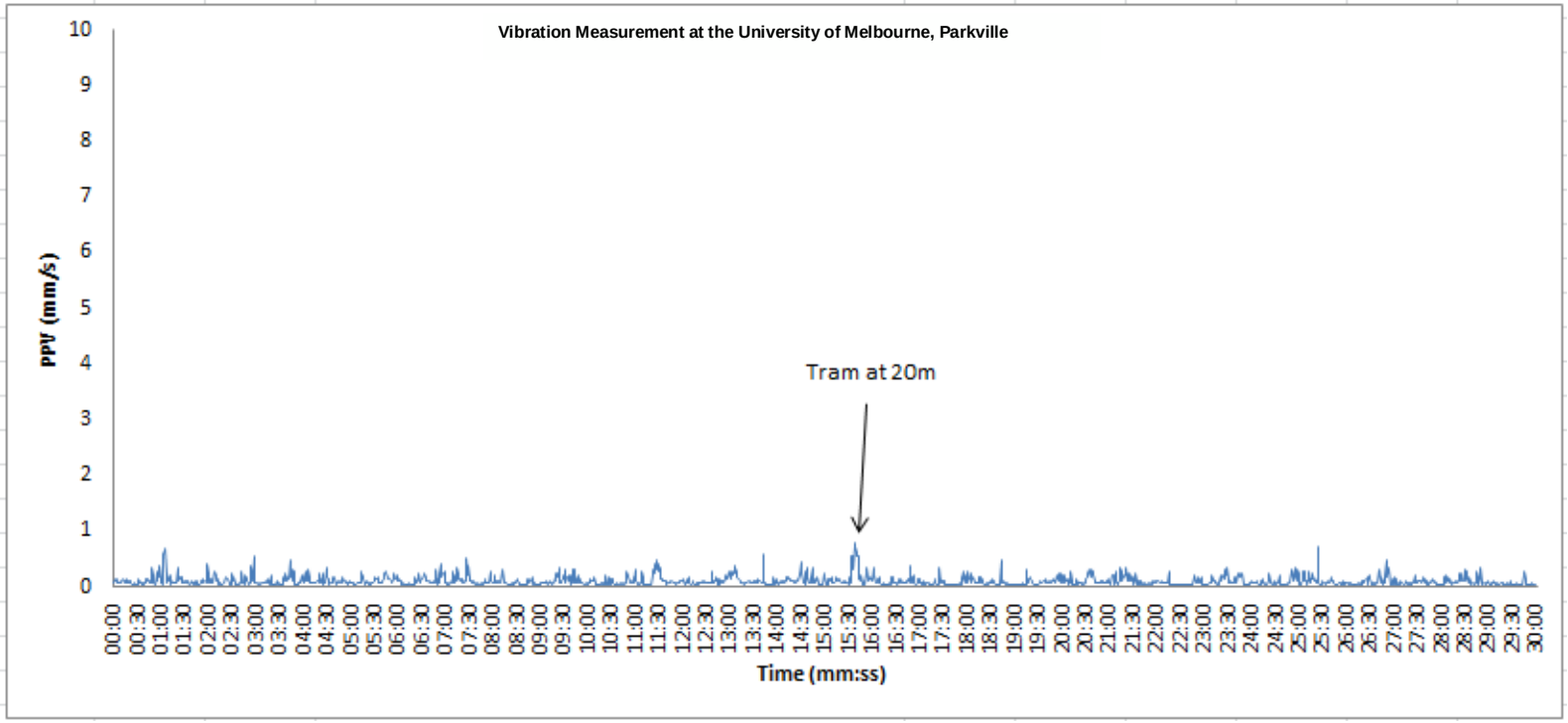


Image 1: Measurement equipment, Royal Parade

Image 2: Grattan Street

Image 3: Measurement Location

Measurements commenced at 15:03 hours on 30/6/2015. Vibration sources included trams, cars, trucks, buses, ambulances and pedestrians.

Figure F35: Vibration levels measured at Location 10: the University of Melbourne, Parkville

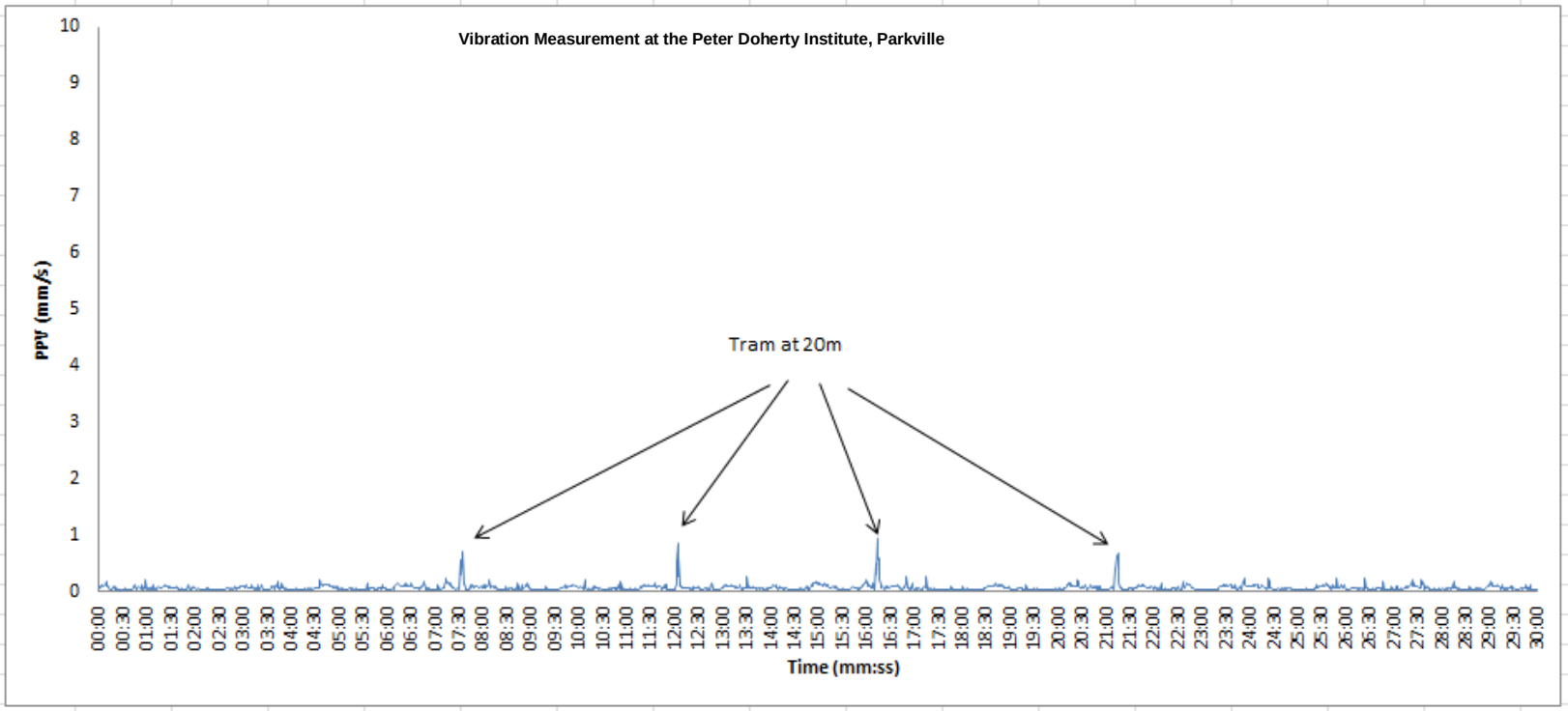


Image 1: Measurement equipment, Royal Parade

Image 2: Proximity to track on Royal Parade

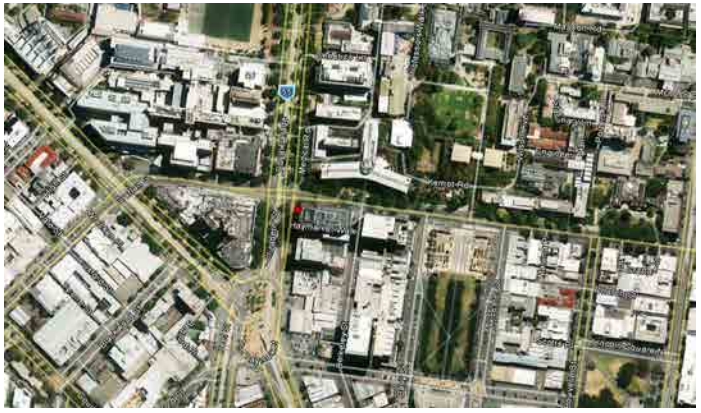


Image 3: Measurement Location

Measurements commenced at 3:02 hours on 30/6/2015. Vibration sources included trams, cars, trucks, buses, ambulances and pedestrians.

Figure F36: Vibration levels measured at Location 11: the Peter Doherty Institute, Parkville

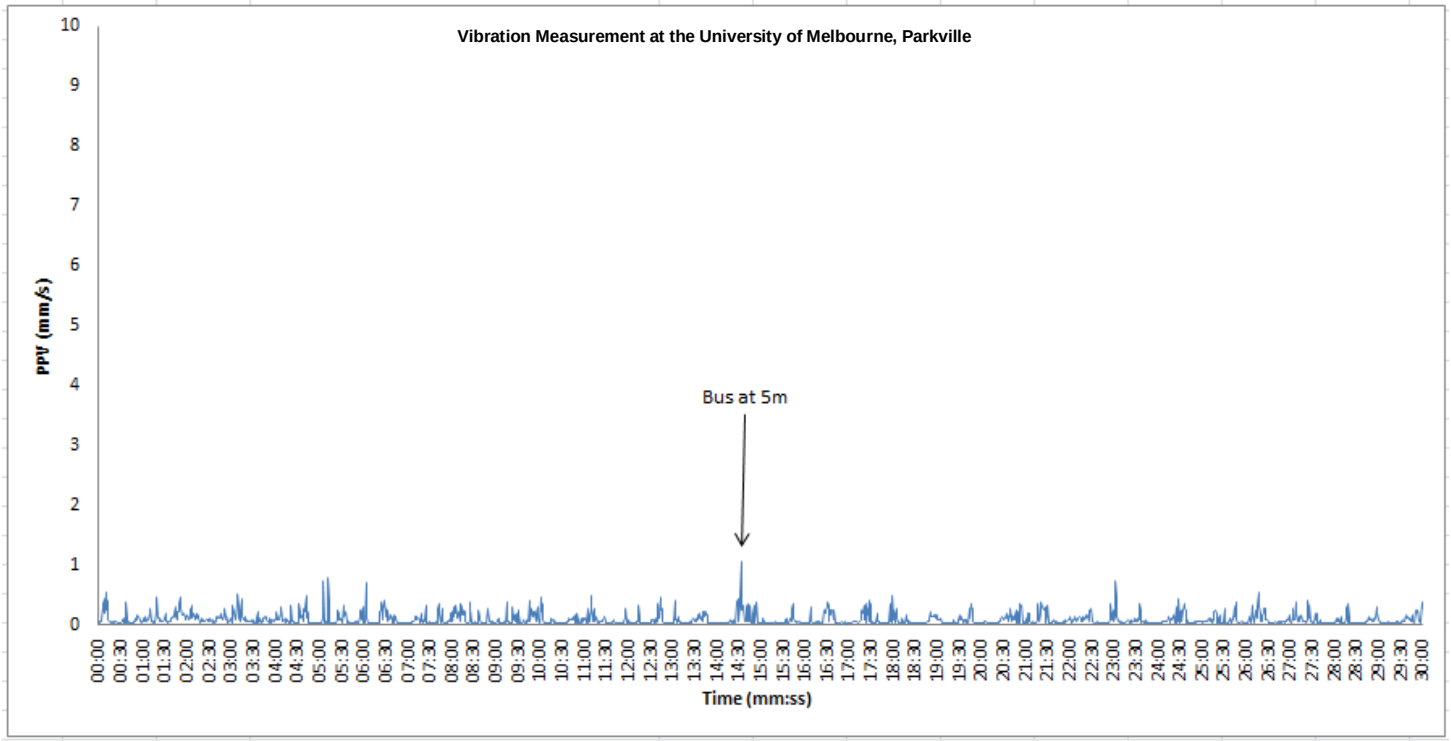


Image 1: Measurement equipment

Image 2: Grattan Street

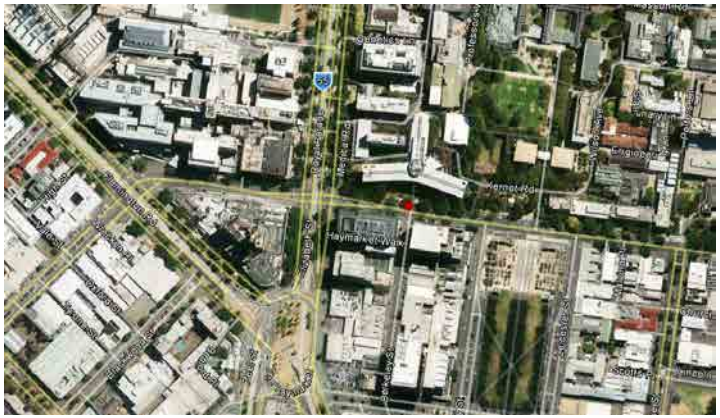


Image 3: Measurement Location

Measurements commenced at 15:38 hours on 30/6/2015. Vibration sources included trams, cars, trucks, buses, ambulances and pedestrians.

Figure F37: Vibration levels measured at Location 12: The University of Melbourne, Parkville

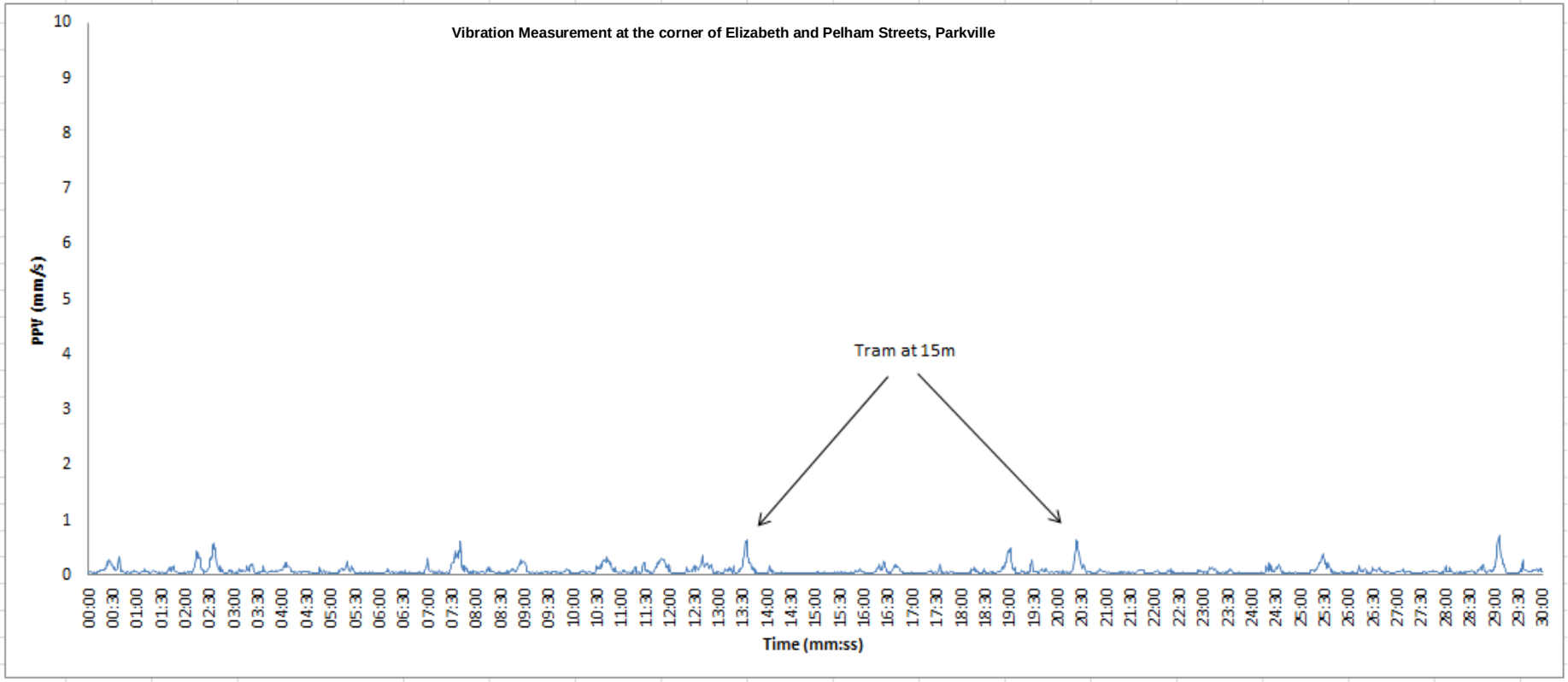


Image 1: Measurement equipment

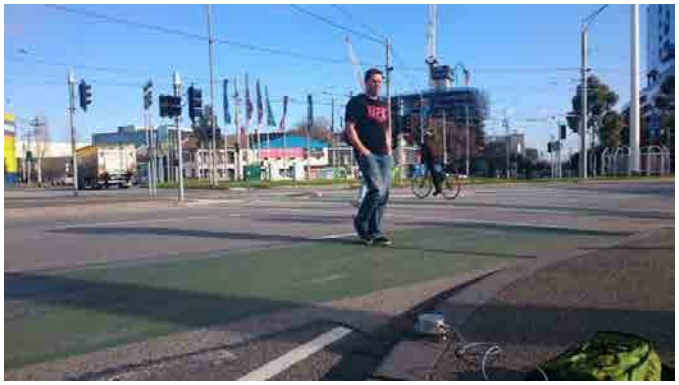


Image 2: Elizabeth Street

Image 3: Measurement Location

Measurements commenced at 9:13 hours on 28/7/2015. Vibration sources included cars, trucks, trams and pedestrians.

Figure F38: Vibration levels measured at Location 13: Corner of Pelham and Elizabeth Streets, Parkville

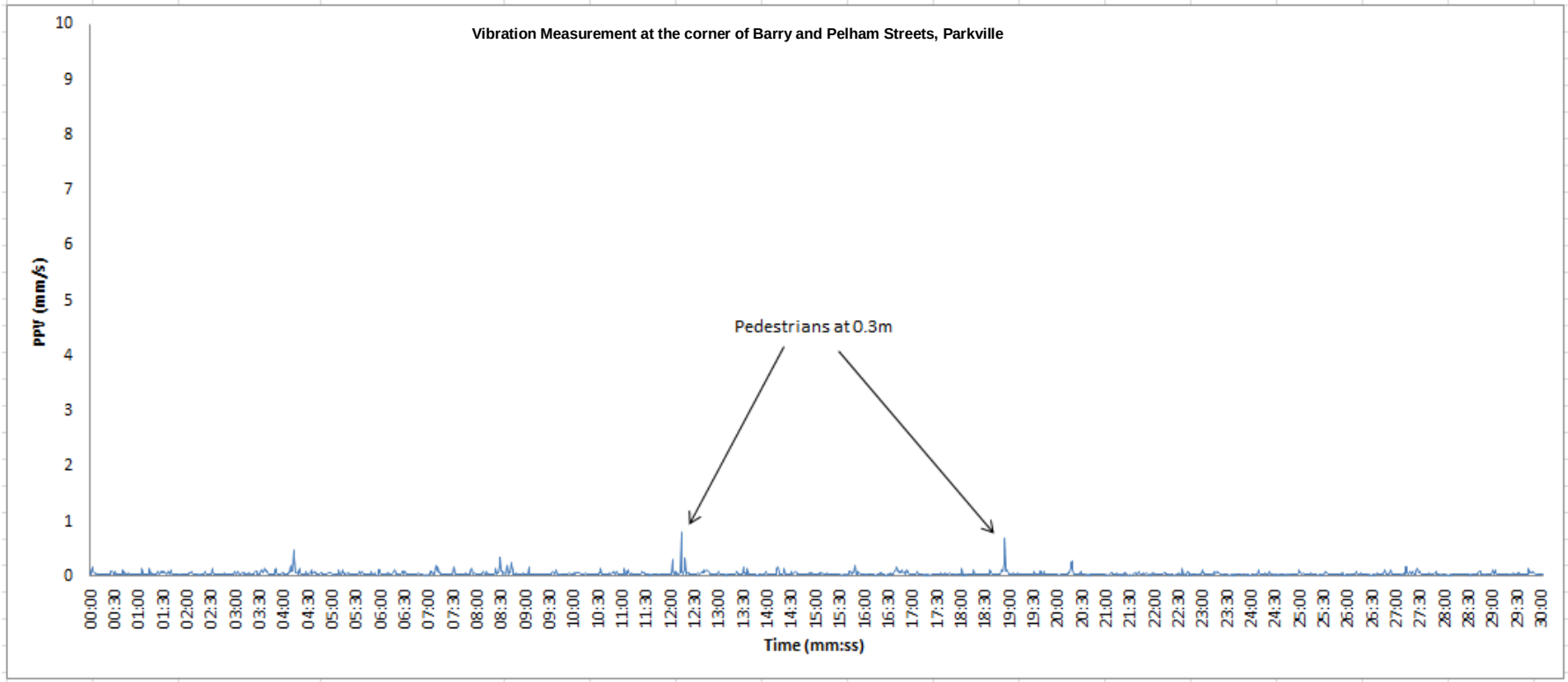


Image 1: Measurement equipment

Image 2: Pelham Street

Image 3: Measurement Location

Measurements commenced at 9:56 hours on 28/7/2015. Vibration sources included cars, trucks and pedestrians.

Figure F39: Vibration levels measured at Location 14: University Square – corner of Barry and Pelham Streets, Carlton

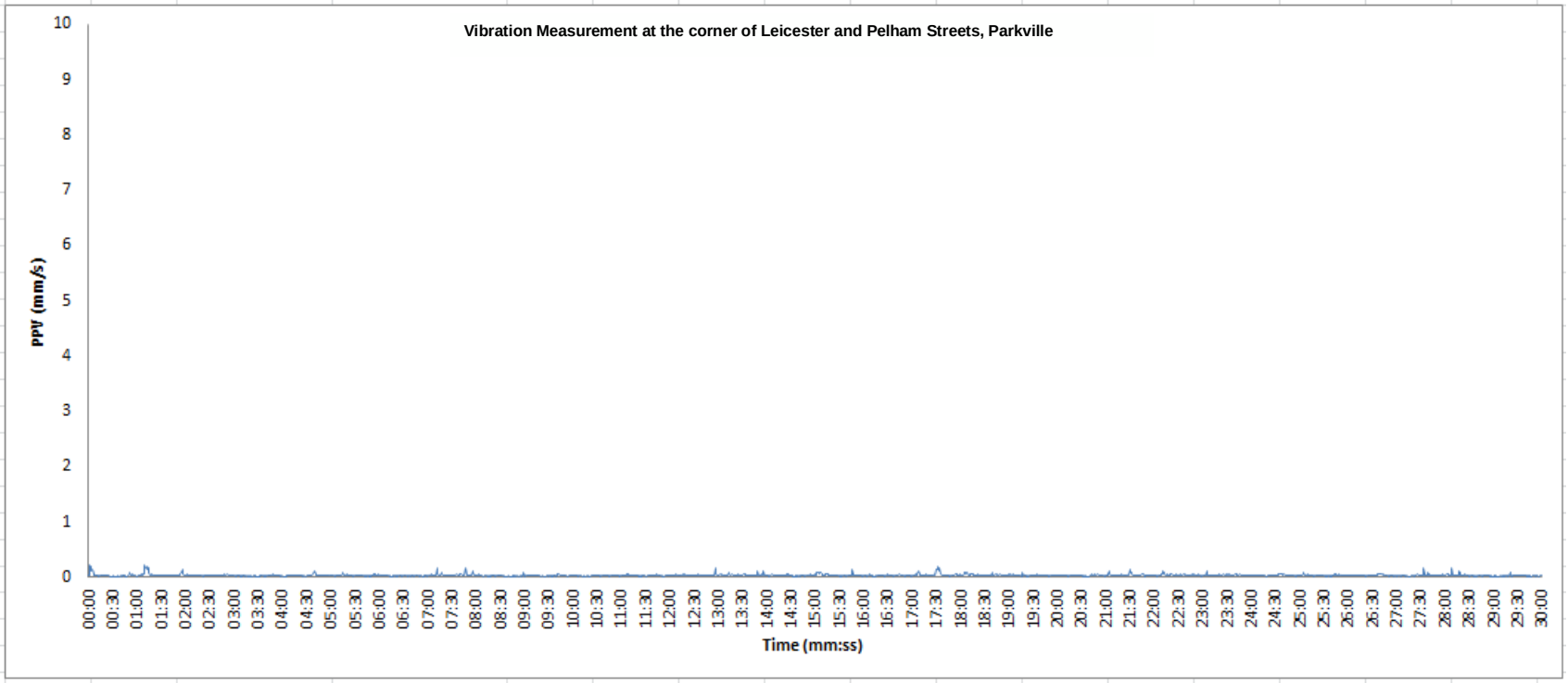


Image 1: Measurement equipment

Image 2: Pelham Street

Image 3: Measurement Location

Measurements commenced at 10:32 hours on 28/7/2015. Vibration sources included cars, trucks, buses and pedestrians.

Figure F40: Vibration levels measured at Location 15: University Square – corner of Leicester and Pelham Streets, Carlton

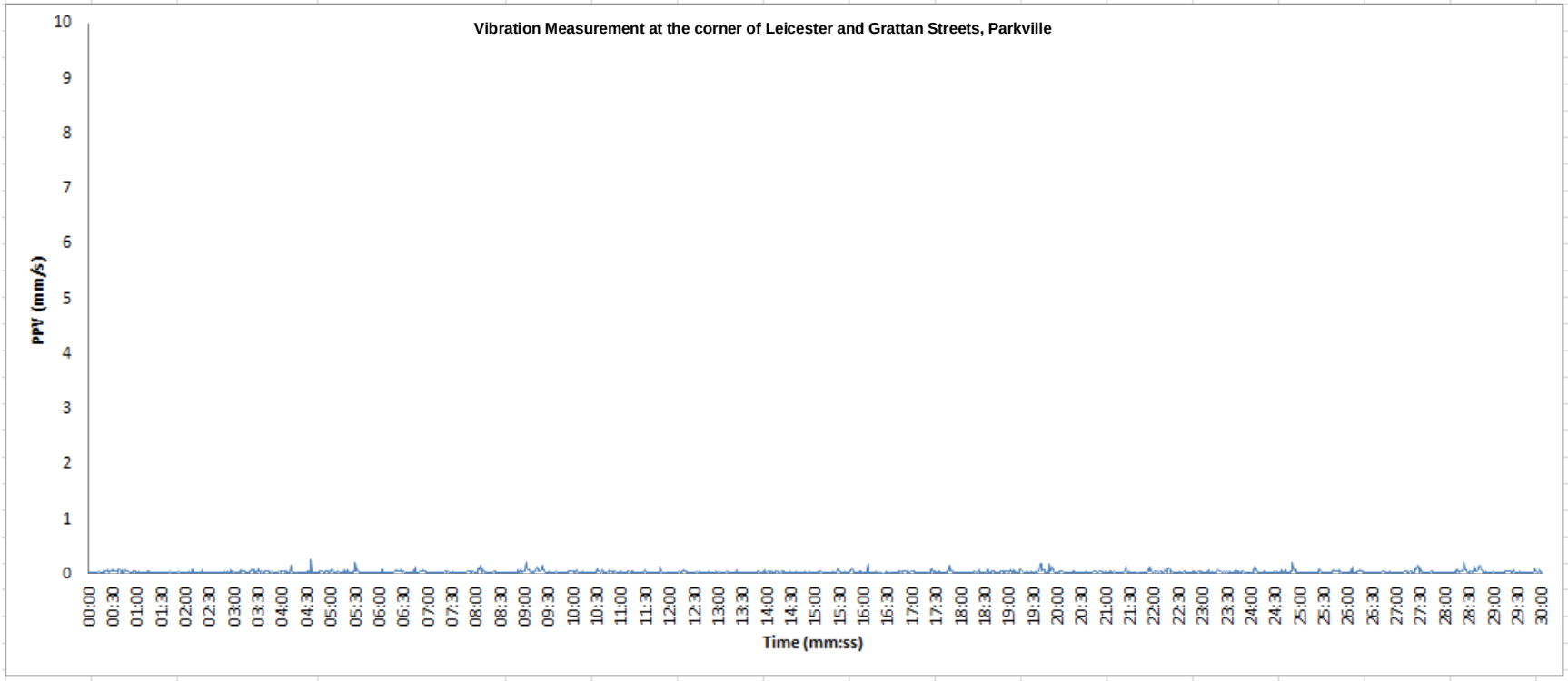


Image 1: Measurement equipment, Grattan Street

Image 2: Grattan Street

Image 3: Measurement Location

Measurements commenced at 11:06 hours on 28/7/2015. Vibration sources included cars, trucks, buses and pedestrians.

Figure F41: Vibration levels measured at Location 16: University Square – corner of Leicester and Grattan Streets, Carlton

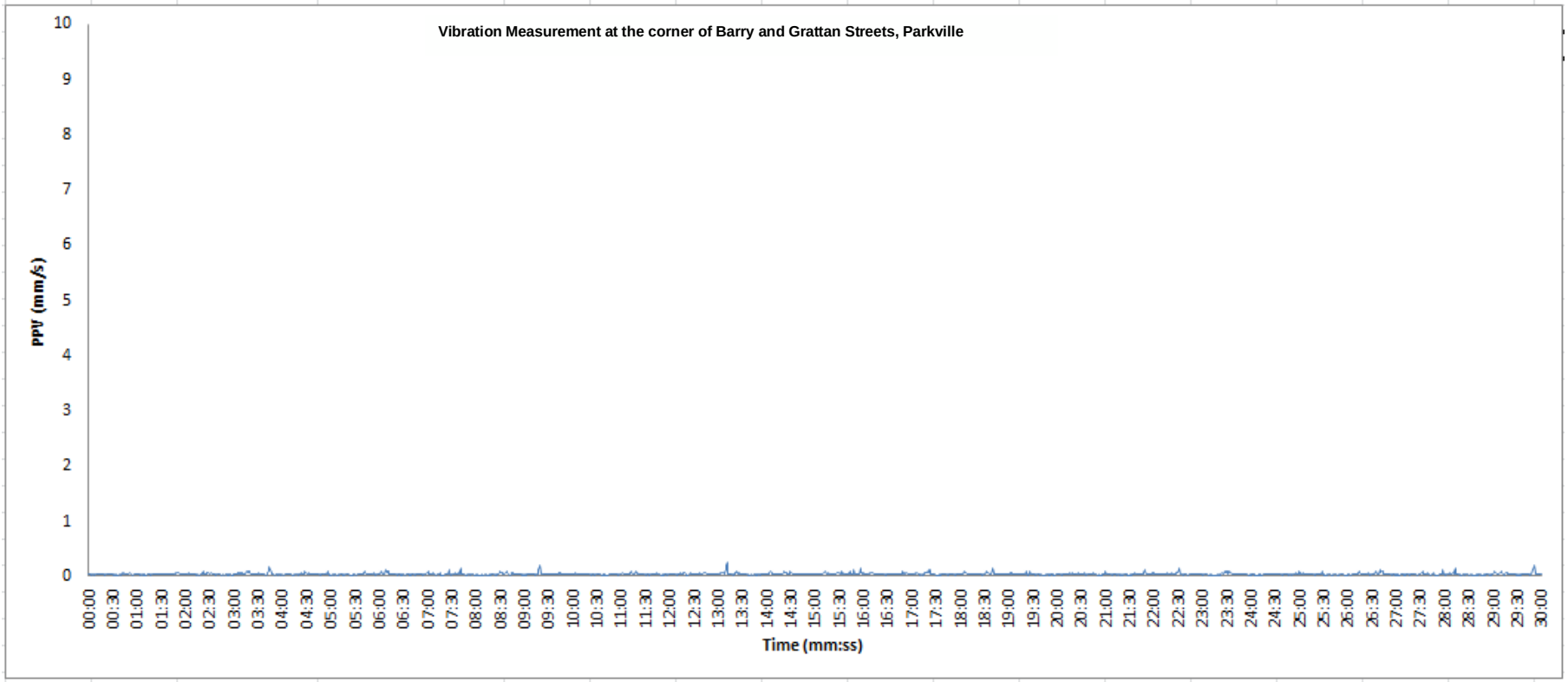


Image 1: Measurement equipment Grattan Street

Image 2: Grattan Street

Image 3: Measurement Location

Measurements commenced at 11:39 hours on 28/7/2015. Vibration sources included cars, trucks, buses and pedestrians.

Figure F42: Vibration levels measured at Location 17: University Square – corner of Barry and Grattan Streets, Carlton

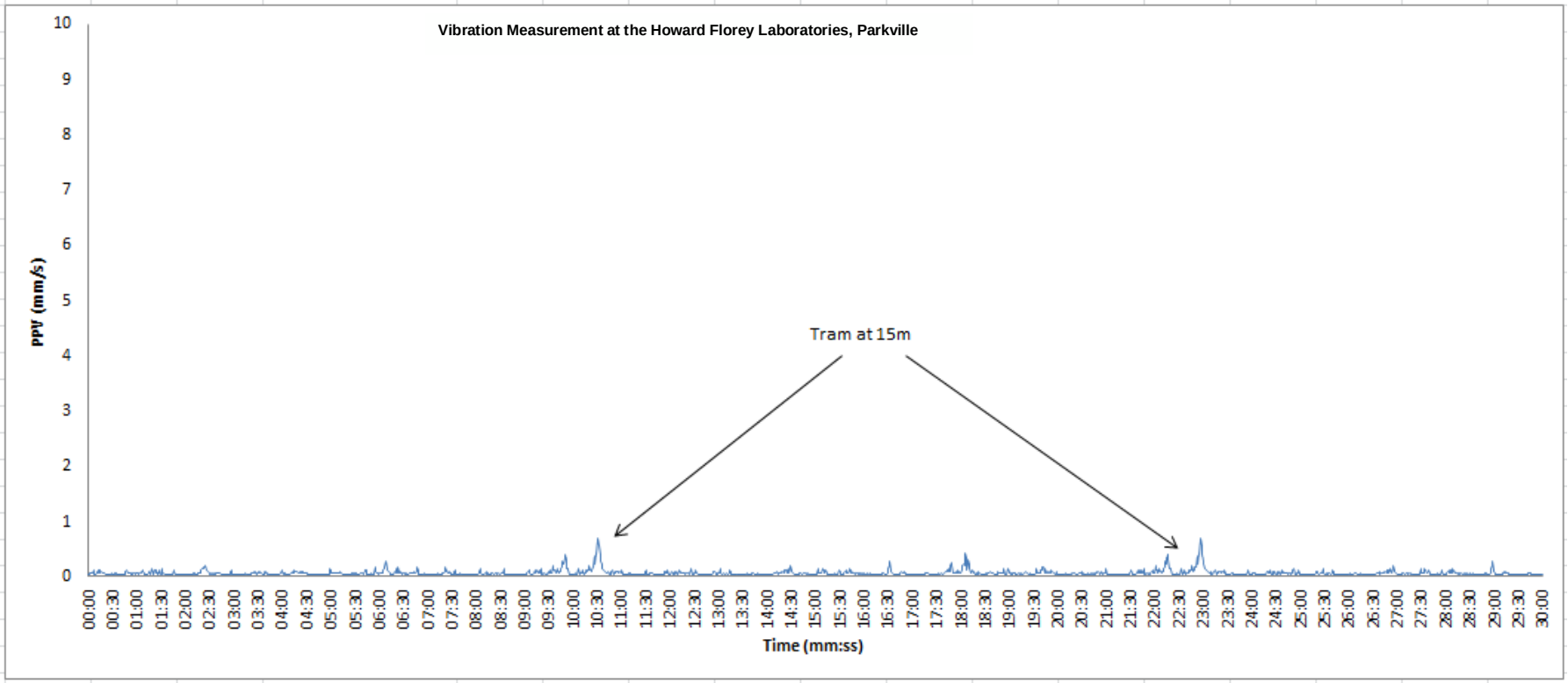


Image 1: Measurement equipment

Image 2: Royal Parade

Image 3: Measurement Location

Measurements commenced at 15:17 hours on 29/7/2015. Vibration sources included cars, trucks, trams and pedestrians.

Figure F43: Vibration levels measured at Location 18: Howard Florey Laboratories, Carlton

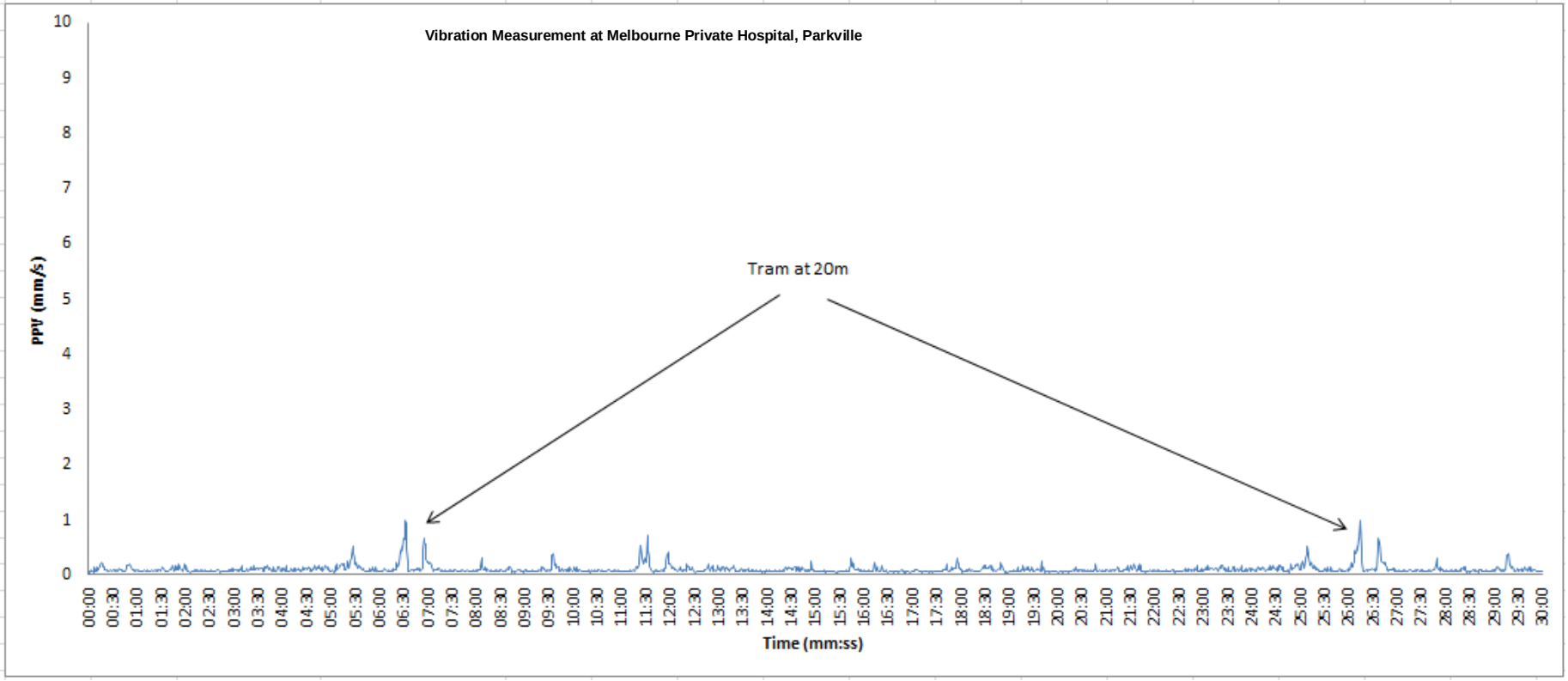


Image 1: Measurement equipment

Image 2: Grattan Street

Image 3: Measurement Location

Measurements commenced at 14:42 hours on 29/7/2015. Vibration sources included cars, trucks, trams and pedestrians.

Figure F44: Vibration levels measured at Location 19: the Melbourne Private Hospital, Parkville

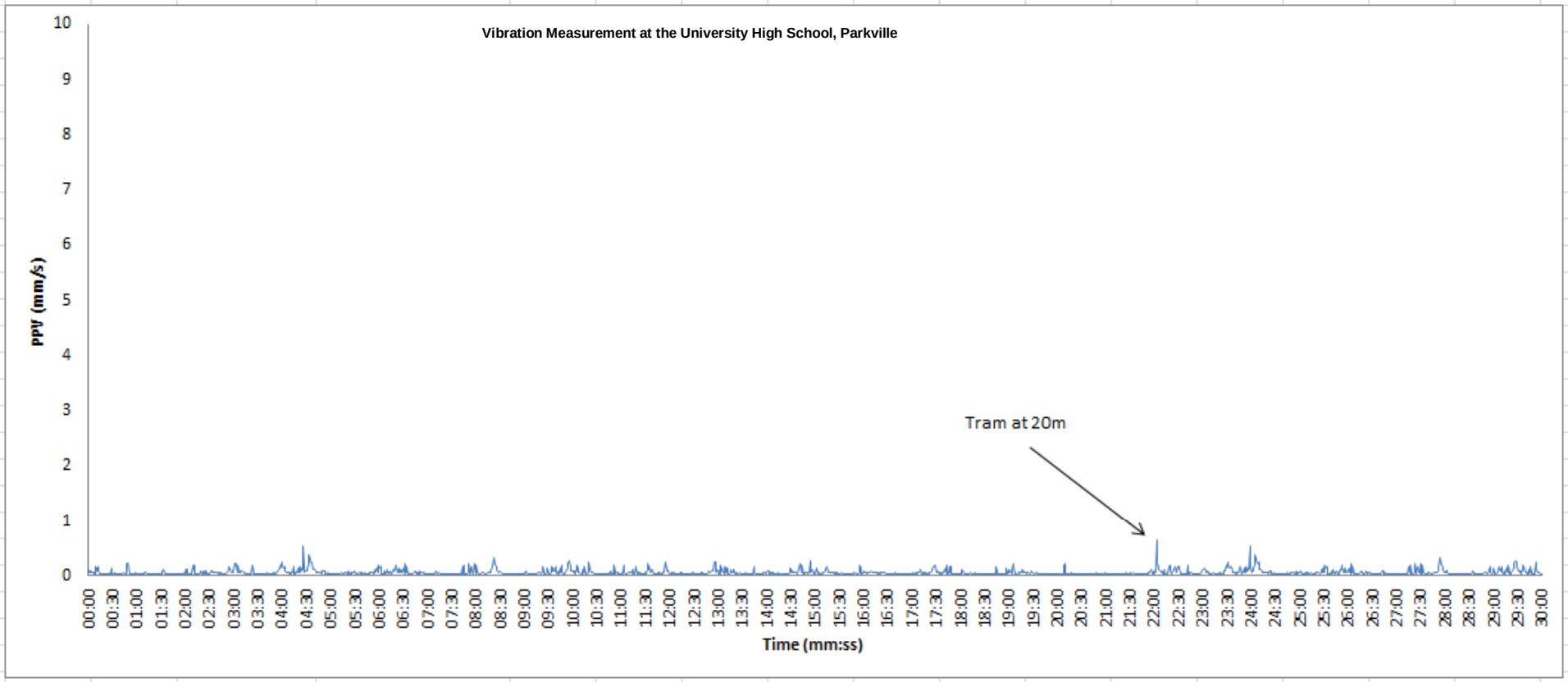


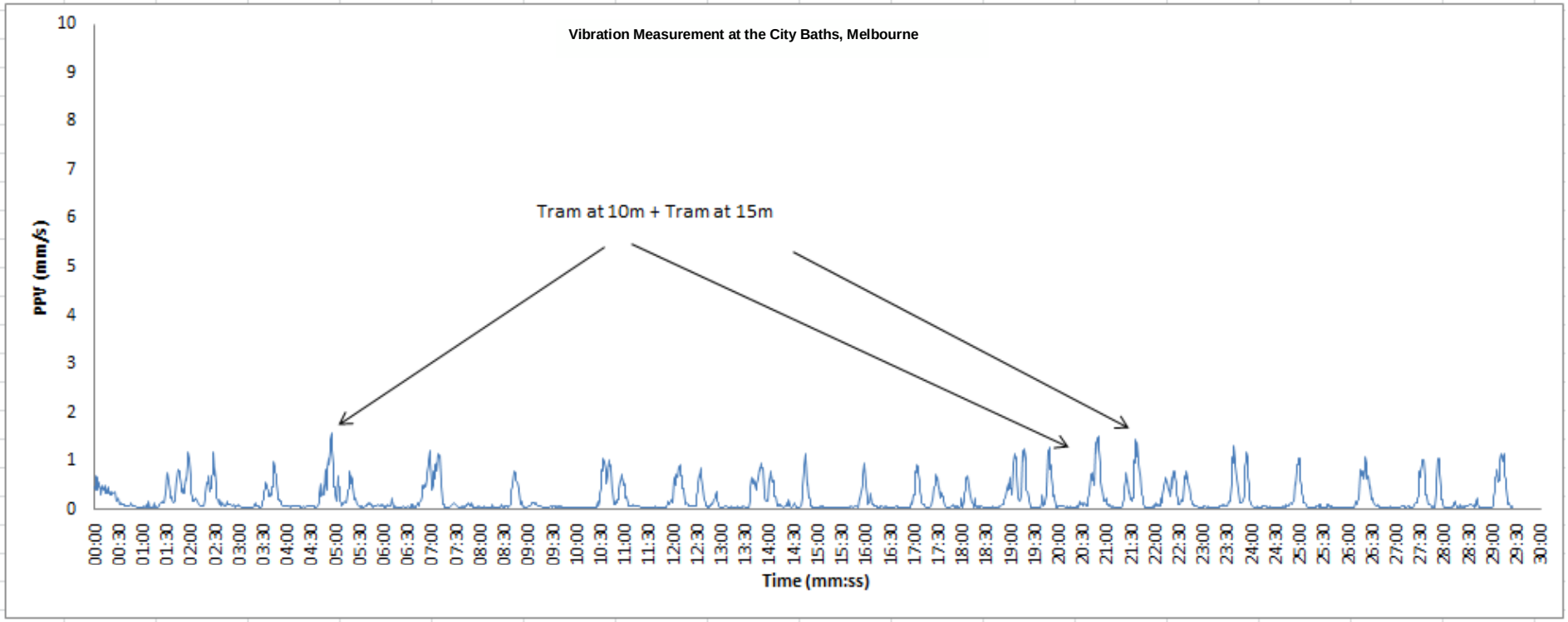
Image 1: Measurement equipment, Royal Parade

Image 2: Royal Parade

Image 3: Measurement Location

Measurements commenced at 14:06 hours on 29/7/2015. Vibration sources included cars, trucks, trams and pedestrians.

Figure F45: Vibration levels measured at Location 20: University High School, Parkville



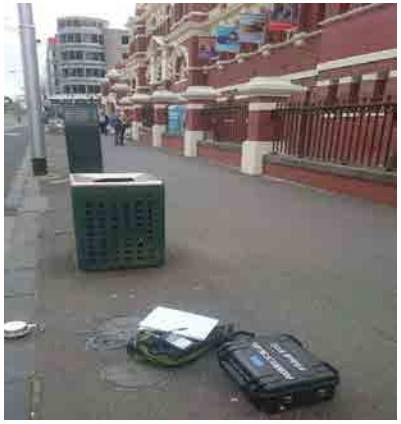


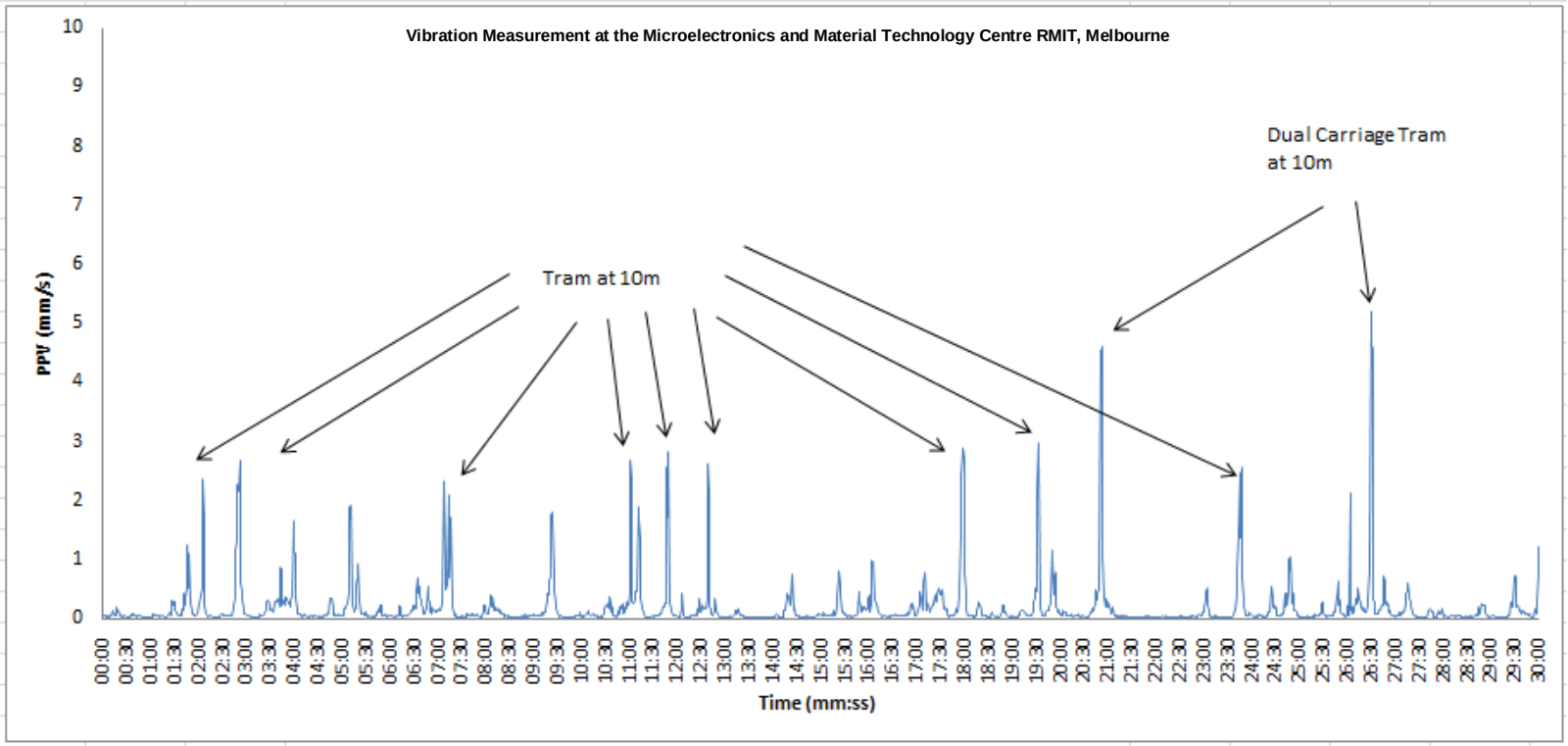
Image 1: Measurement equipment

Image 2: Proximity to track on Swanston Street

Image 3: Measurement Location

Measurements commenced at 9:16 hours on 1/7/2015. Vibration sources included trams, cars, trucks, buses and pedestrians.

Figure F46: Vibration levels measured at Location 21: The City Baths, Melbourne



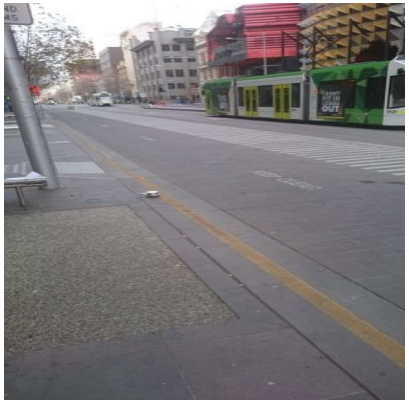


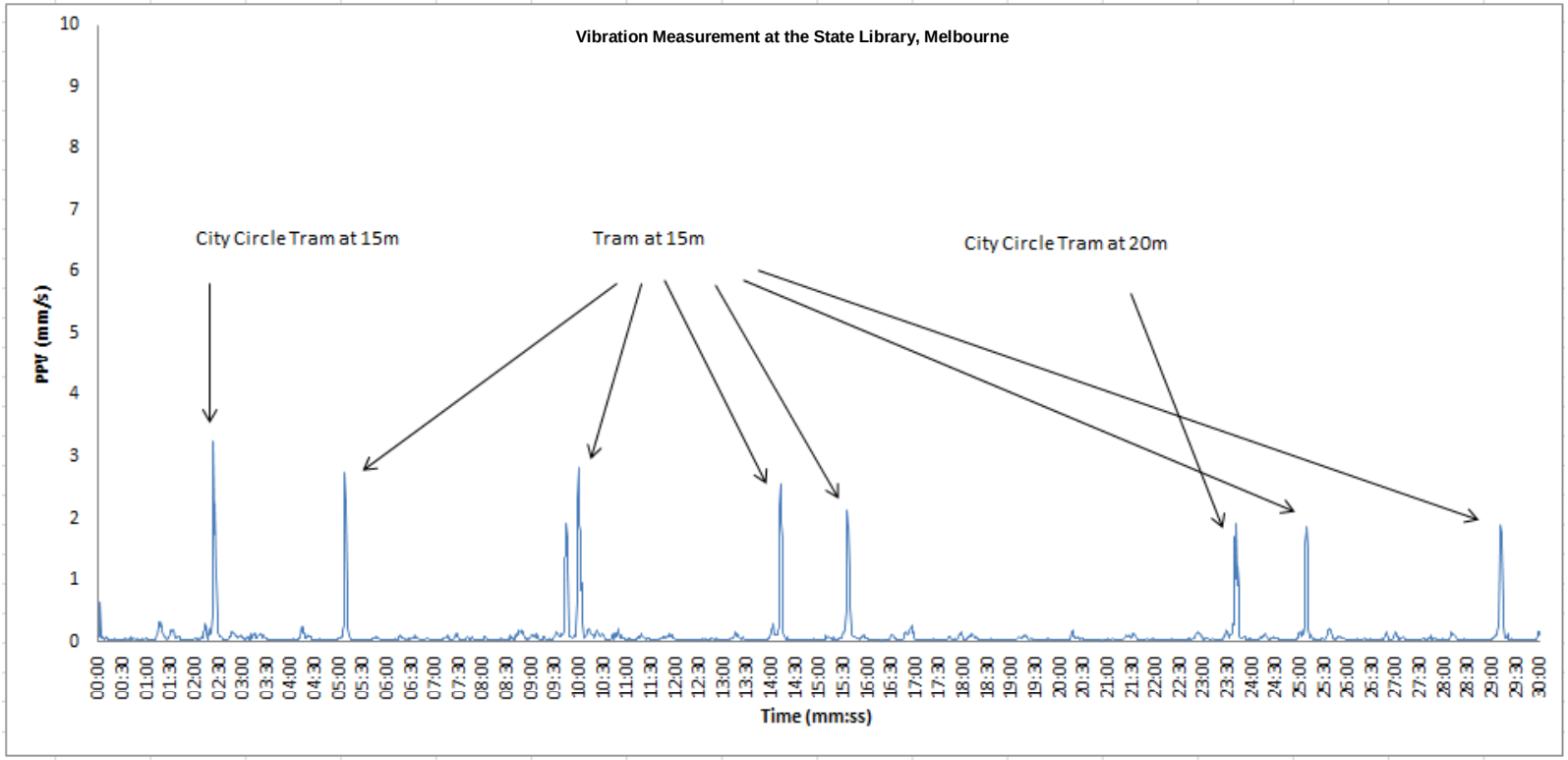
Image 1: Measurement equipment, Swanston Street

Image 2: Proximity to track on Swanston Street

Image 3: Measurement Location

Measurements commenced at 9:56 hours on 1/7/2015. Vibration sources included trams and pedestrians. High levels of vibration are due to jointed rail tracks.

Figure F47: Vibration levels measured at Location 22: The Microelectronics and Material Technology Centre, RMIT



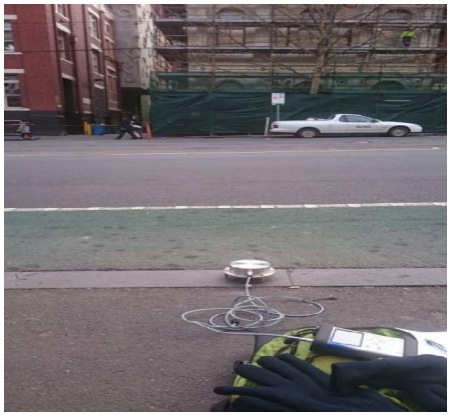


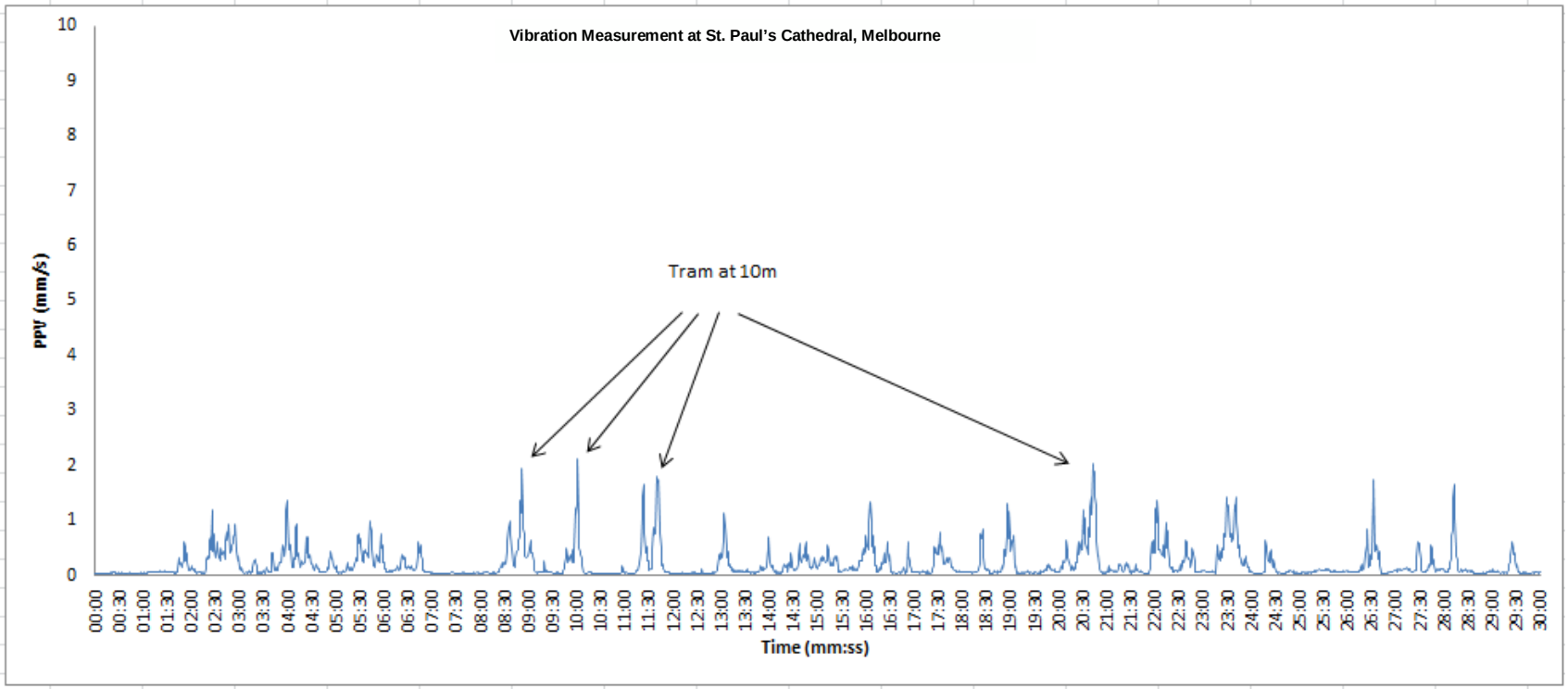
Image 1: Measurement equipment

Image 2: Proximity to track on Latrobe Street

Image 3: Measurement Location

Measurements commenced at 10:38 hours on 1/7/2015. Vibration sources included trams, cars, trucks, buses and pedestrians. High levels of vibration are due to jointed rail tracks

Figure F48: Vibration levels measured at Location 23: The State Library, Melbourne



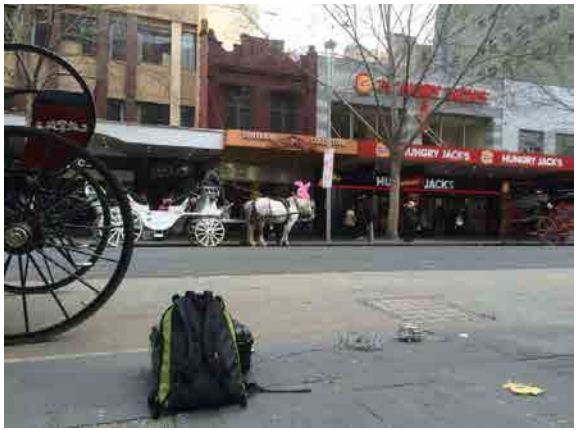


Image 1: Measurement equipment

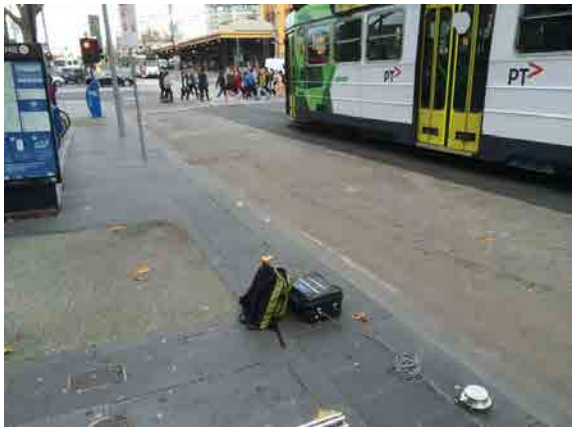


Image 2: Proximity to track on Swanston Street

Image 3: Measurement Location

Measurements commenced at 11:30 hours on 1/7/2015. Vibration sources included trams, cars, trucks, buses and pedestrians. High levels of vibration are due to jointed rail tracks.

Figure F49: Vibration levels measured at Location 24: St. Paul's Cathedral, Melbourne

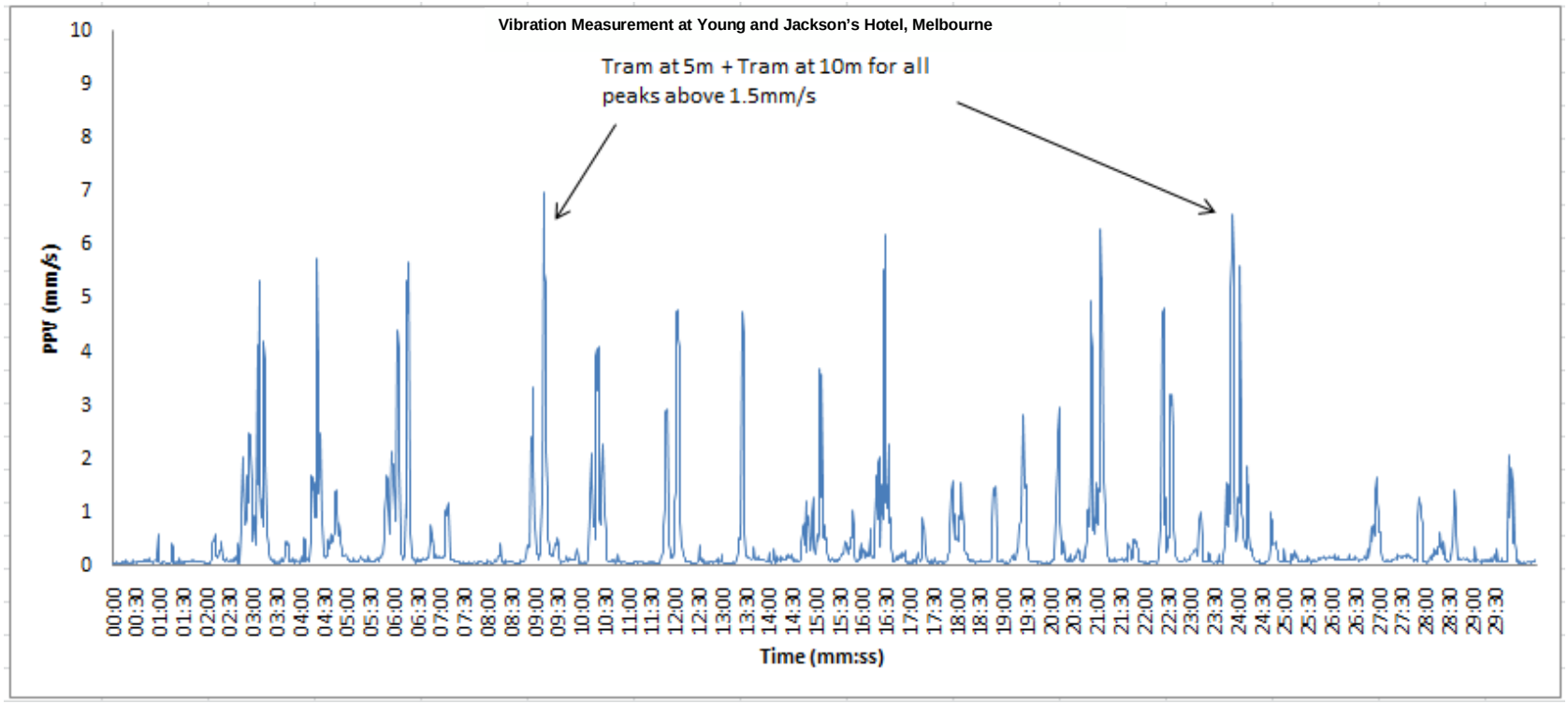


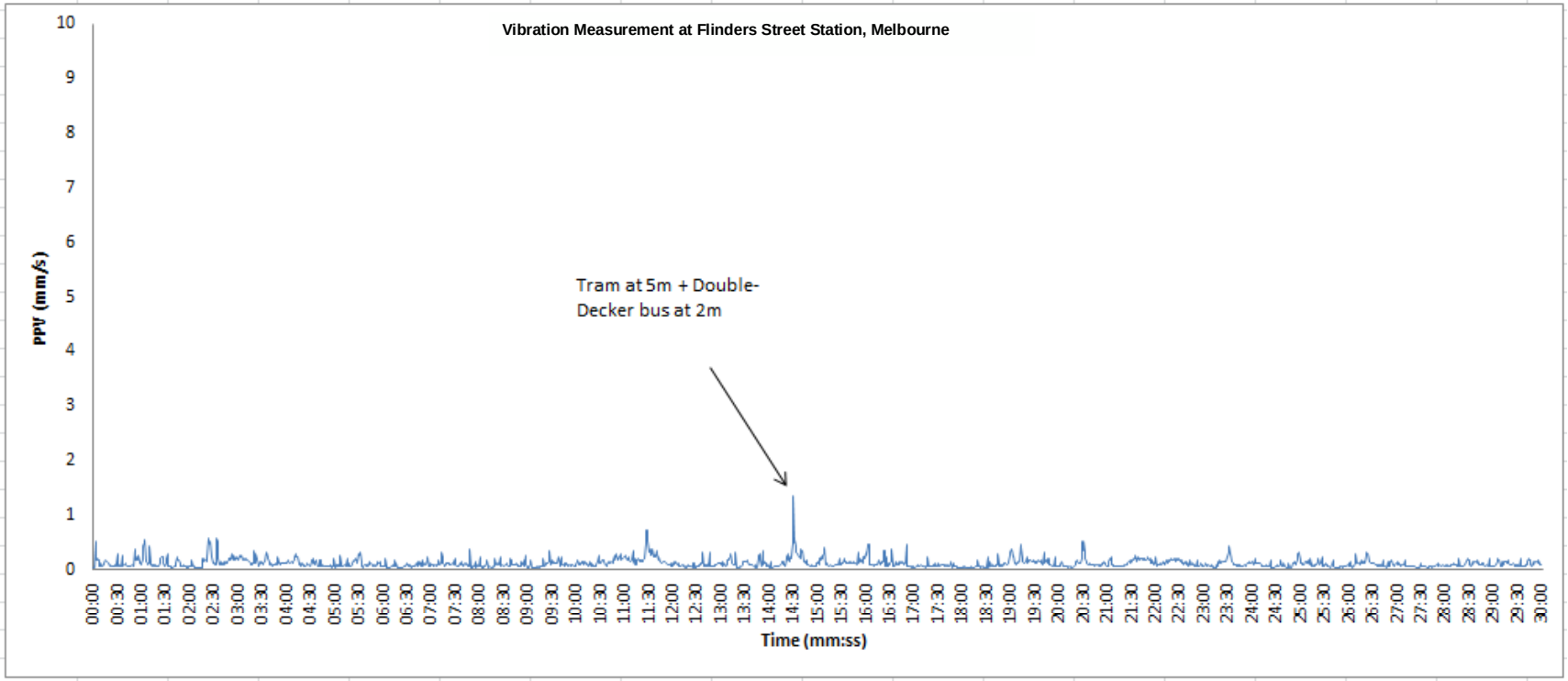
Image 1: Measurement equipment

Image 2: Proximity to track on Swanston Street

Image 3: Measurement Location

Measurements commenced at 11:29 hours on 1/7/2015. Vibration sources included trams, cars, trucks, buses and pedestrians. High levels of vibration are due to jointed rail tracks.

Figure F50: Vibration levels measured at Location 25: Young and Jackson's Hotel, Melbourne



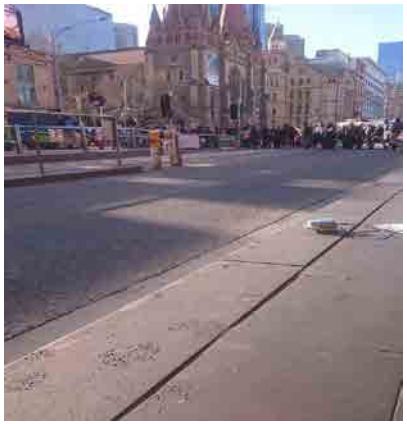


Image 1: Measurement equipment

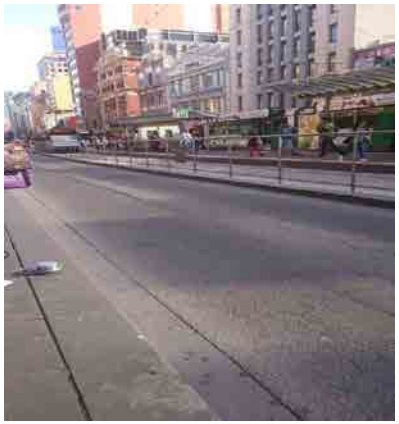


Image 2: Proximity to track on Flinders Street

Image 3: Measurement Location

Measurements commenced at 12:04 hours on 1/7/2015. Vibration sources included trams, cars, trucks, buses and pedestrians.

Figure F51: Vibration levels measured at Location 26: Flinders Street Station, Melbourne

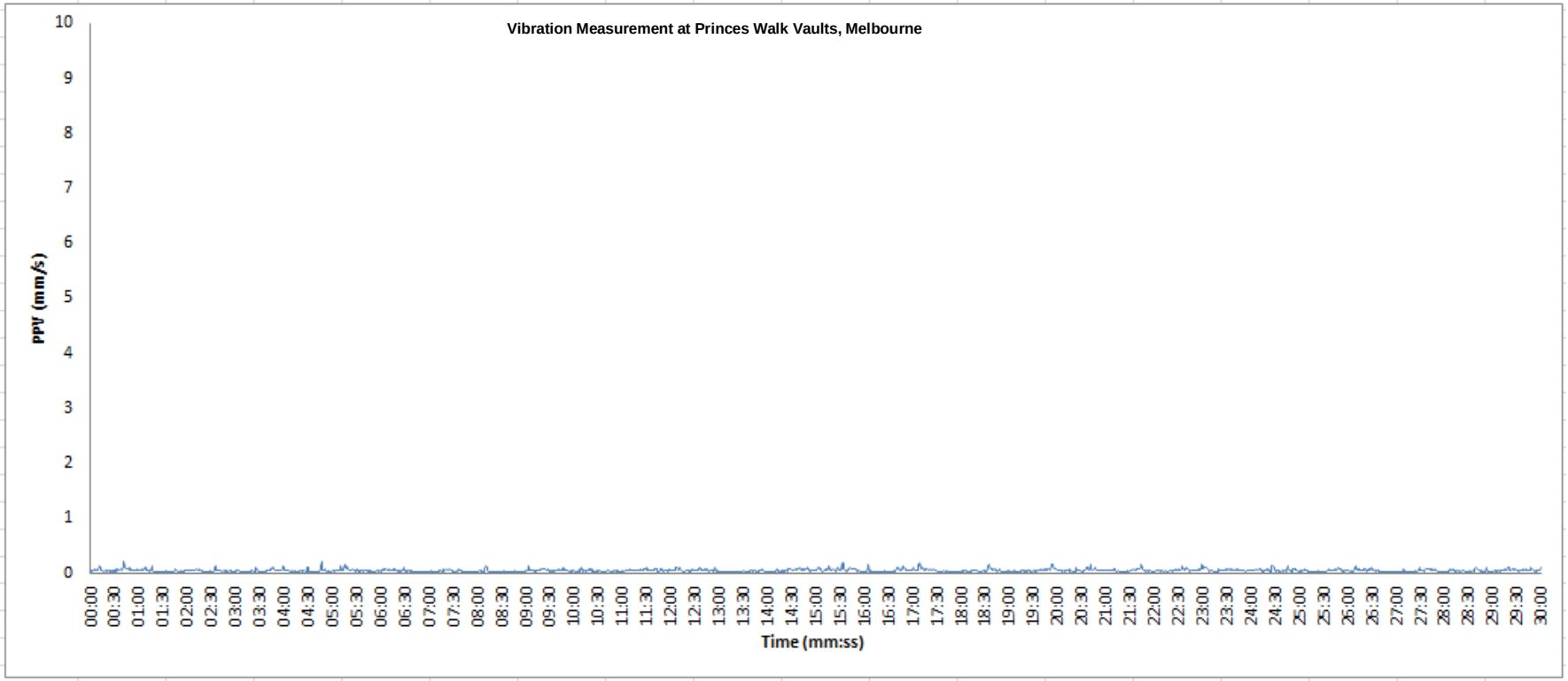


Image 1: Measurement equipment

Image 2: Yarra River

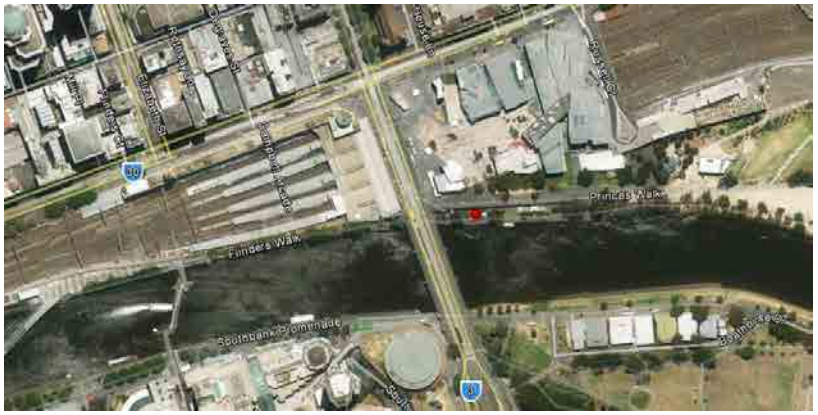
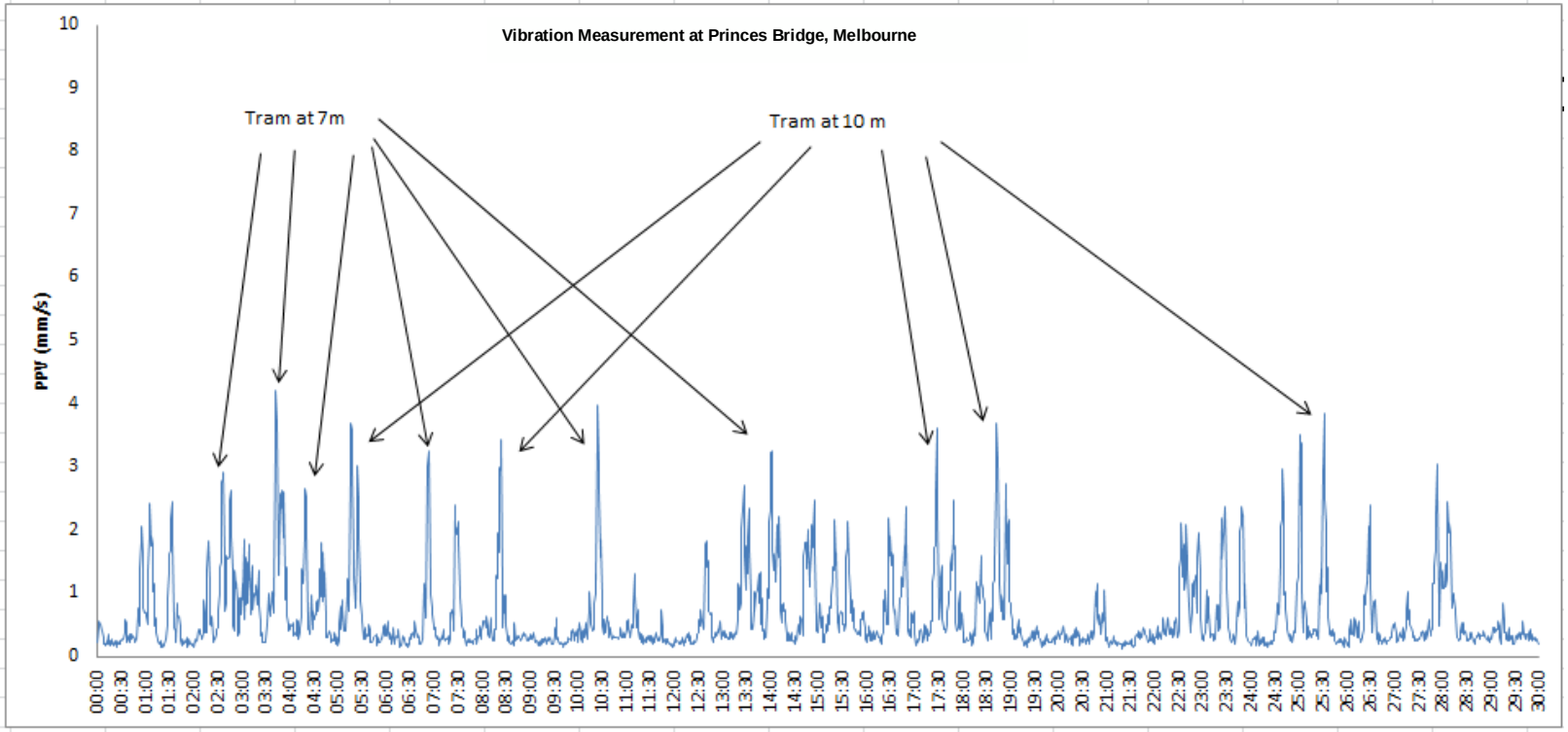


Image 3: Measurement Location

Measurements commenced at 12:25 hours on 1/7/2015. Vibration sources included boat traffic.

Figure F52: Vibration levels measured at Location 27: Princes Walk Vaults



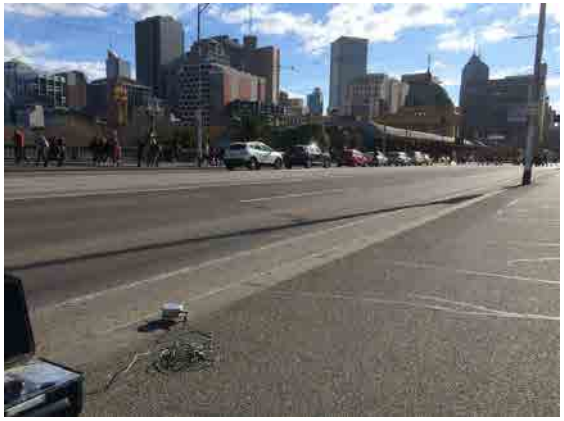


Image 1: Measurement equipment

Image 2: Proximity to track on Princes Bridge

Image 3: Measurement Location

Measurements commenced at 13:00 hours on 1/7/2015. Vibration sources included cars, trucks, trams, skateboarders and pedestrians. High levels of vibration are due to jointed rail tracks.

Figure F53: Vibration levels measured at Location 28: Princes Bridge, Melbourne

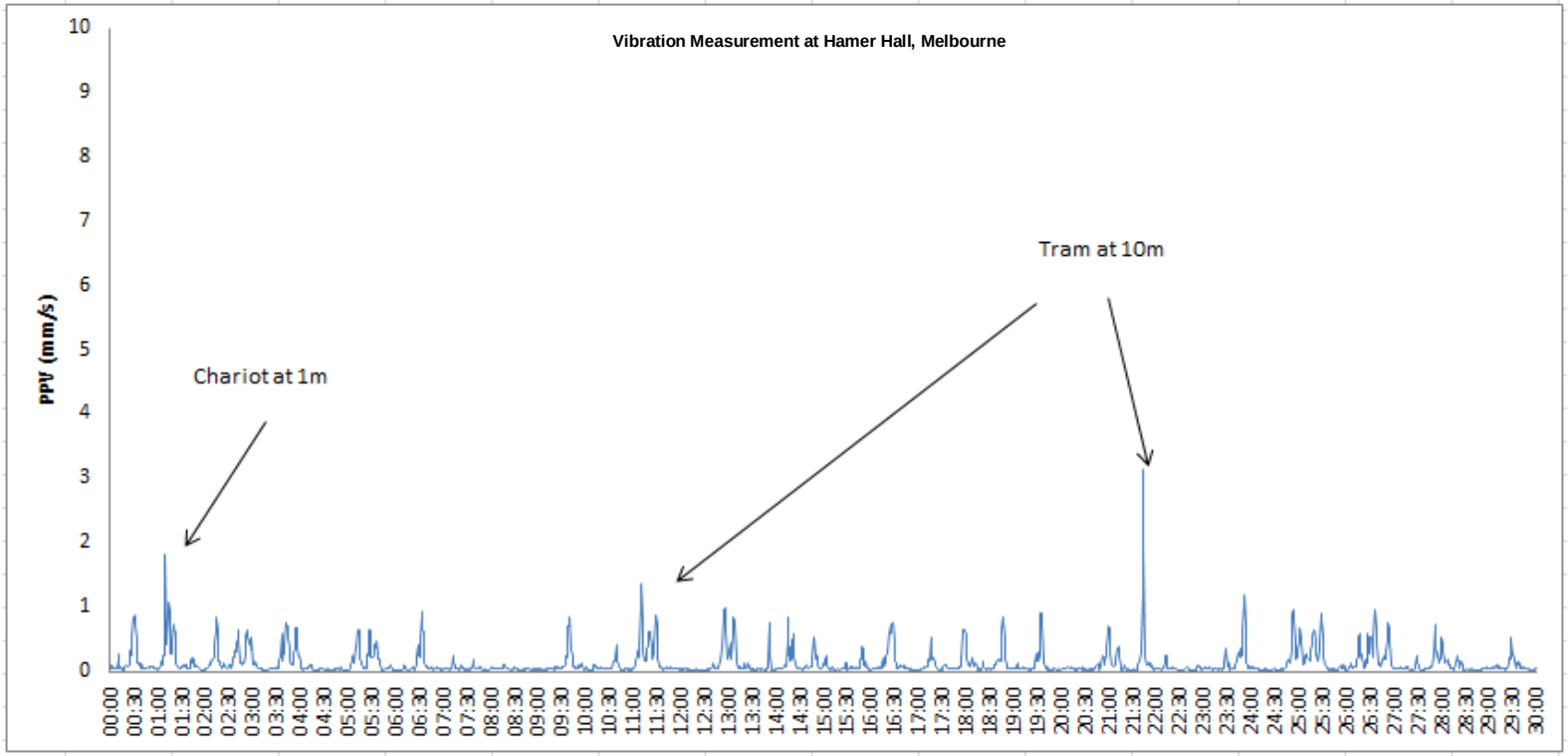


Image 1: Measurement equipment

Image 2: Proximity to track on Princes Bridge

Image 3: Measurement Location

Measurements commenced at 12:38 hours on 1/7/2015. Vibration sources included cars, trucks, trams, skateboarders and pedestrians.

Figure F54: Vibration levels measured at Location 29: Hamer Hall, Melbourne

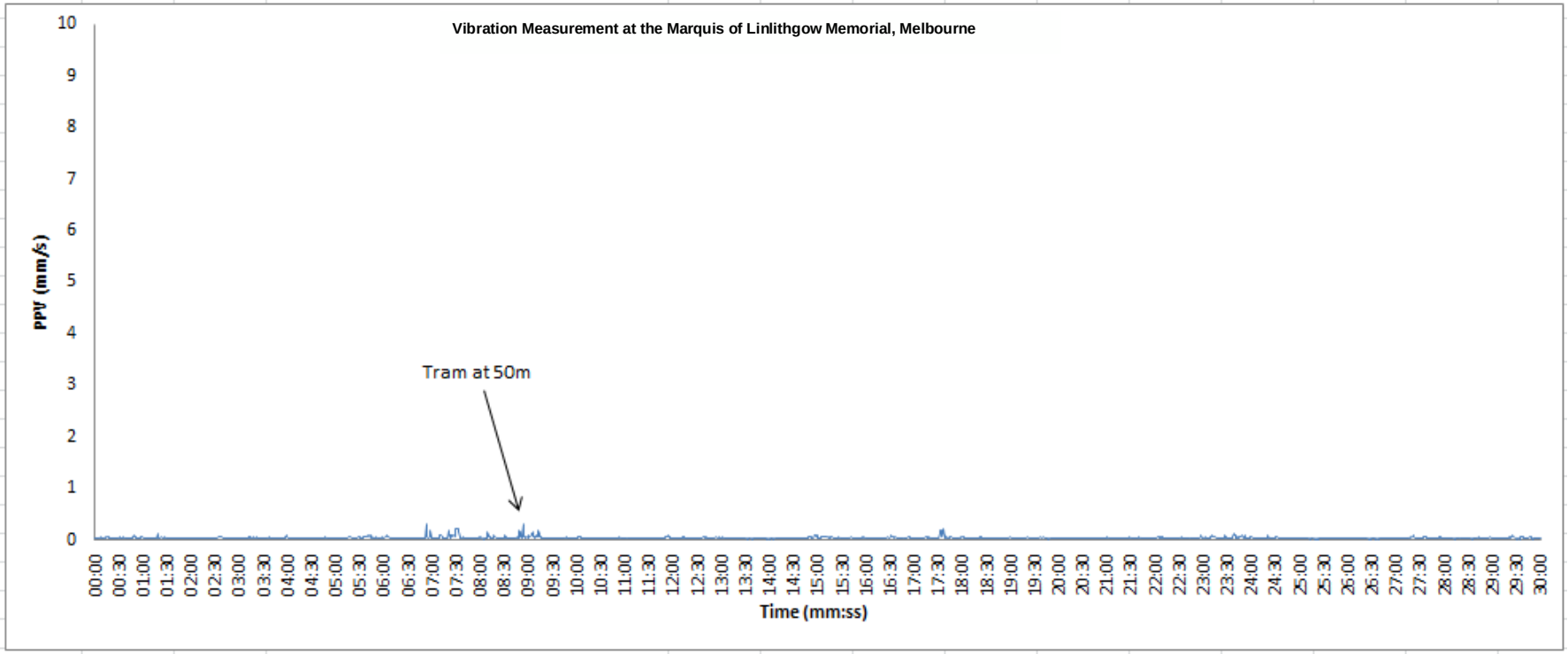


Image 1: Measurement equipment

Image 2: Proximity to track on St. Kilda Road

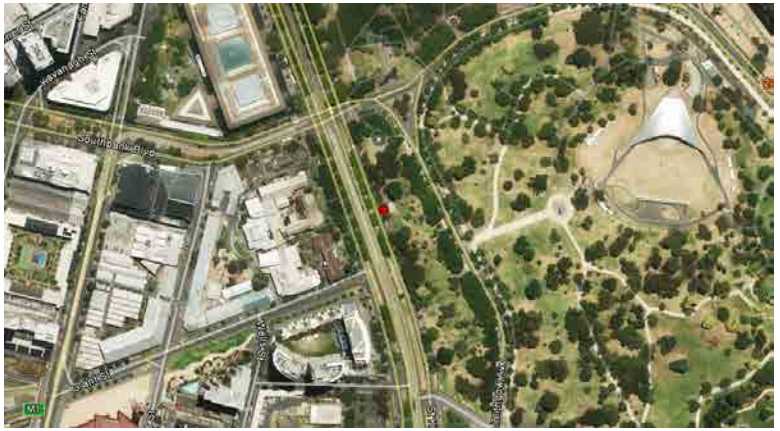


Image 3: Measurement Location

Measurements commenced at 14:04 hours on 1/7/2015. Vibration sources included cars, trucks, buses and trams.

Figure F55: Vibration levels measured at Location 30: Marquis of Linlithgow Memorial

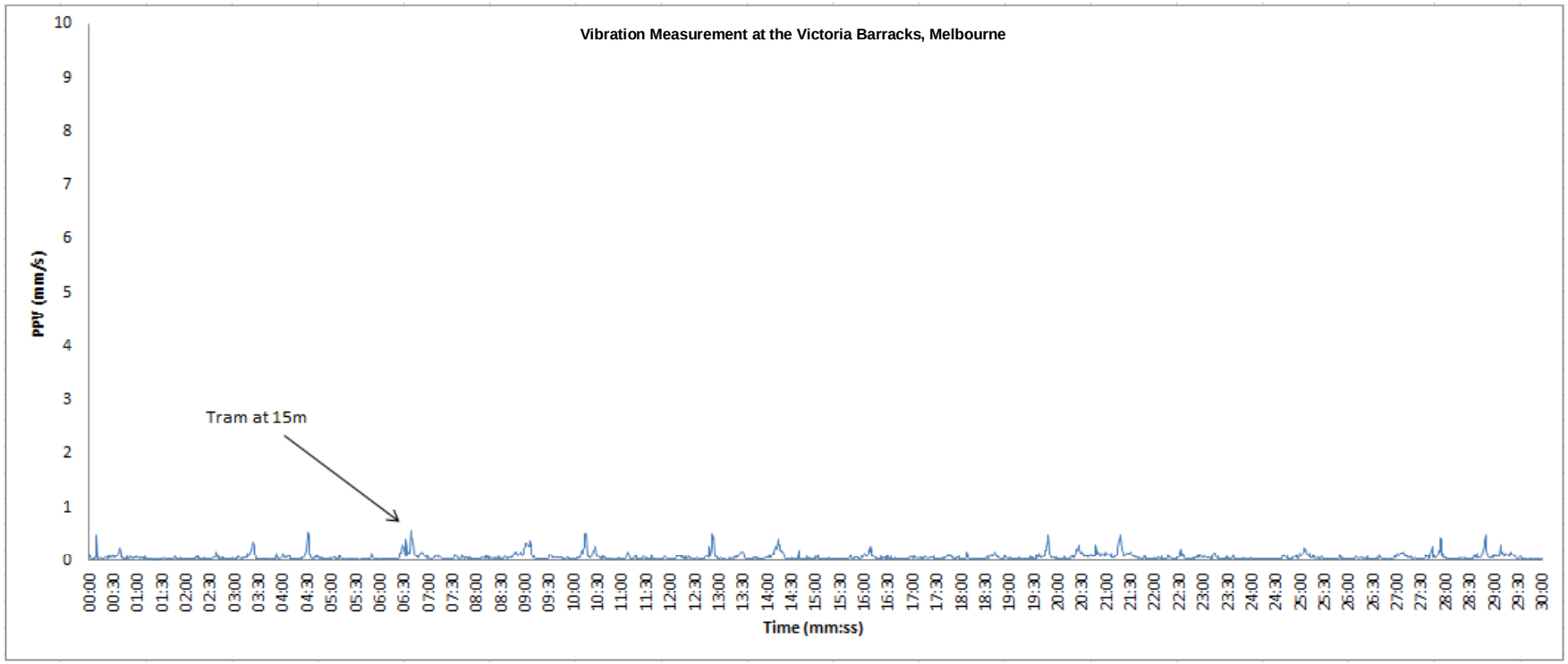


Image 1: Measurement equipment facing St. Kilda Road

Image 2: Victoria Barracks guard house

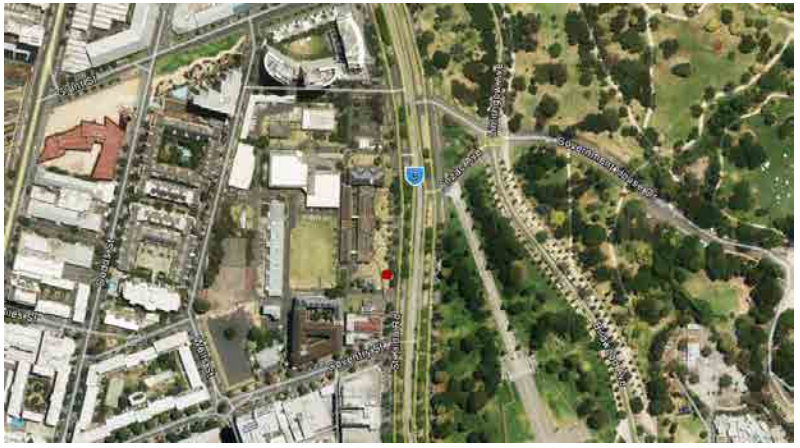


Image 3: Measurement Location

Measurements commenced at 15:21 hours on 10/9/2015. Vibration sources included cars, trucks, trams and pedestrians.

Figure F56: Vibration levels measured at Location 31: Victoria Barracks

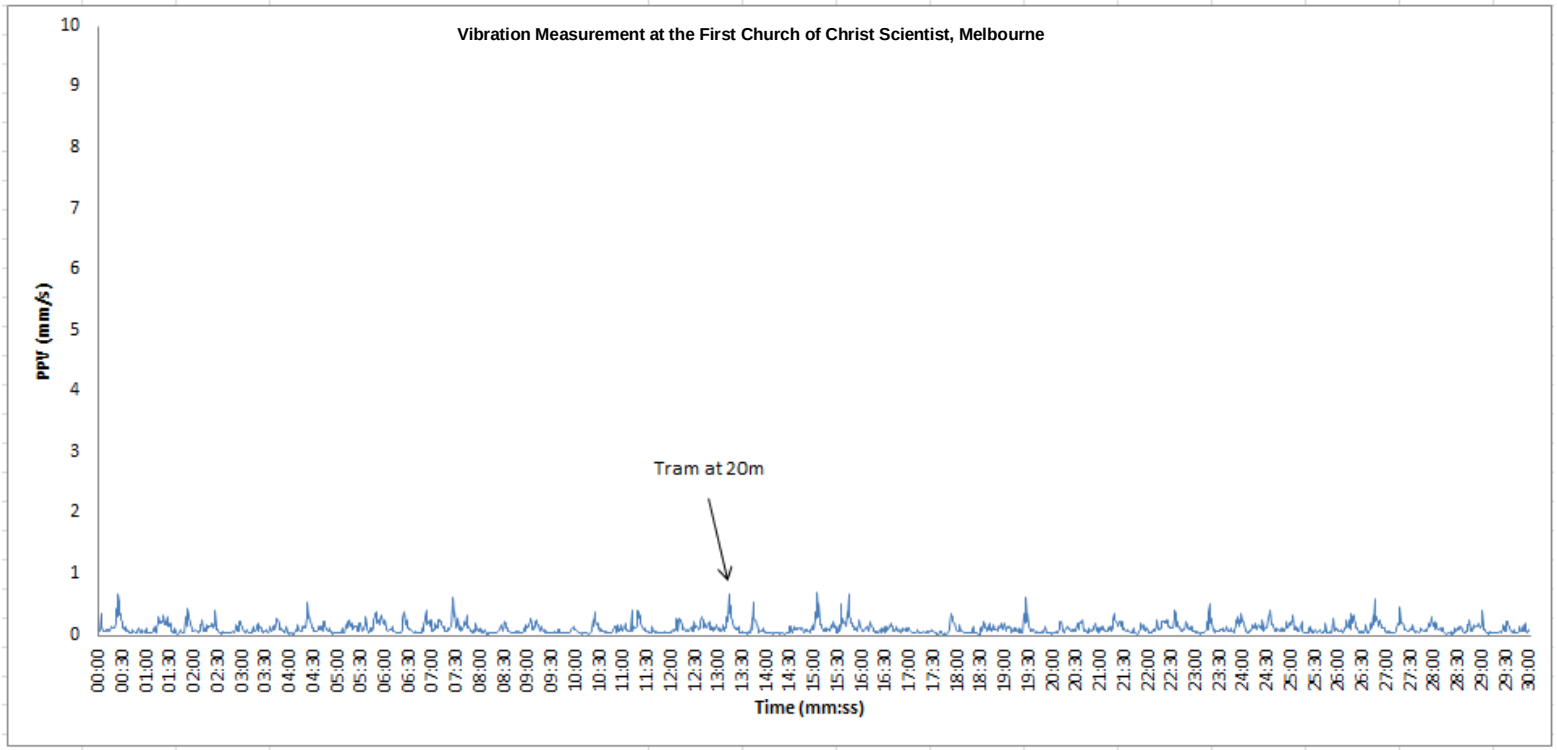


Image 1: Measurement equipment

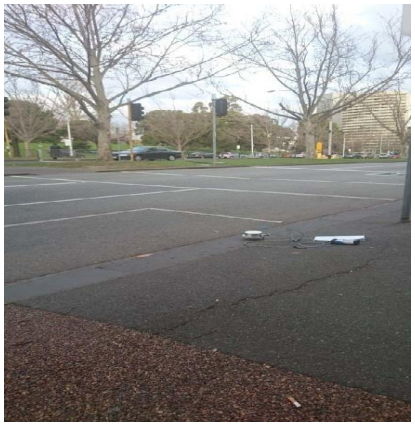


Image 2: St. Kilda Road

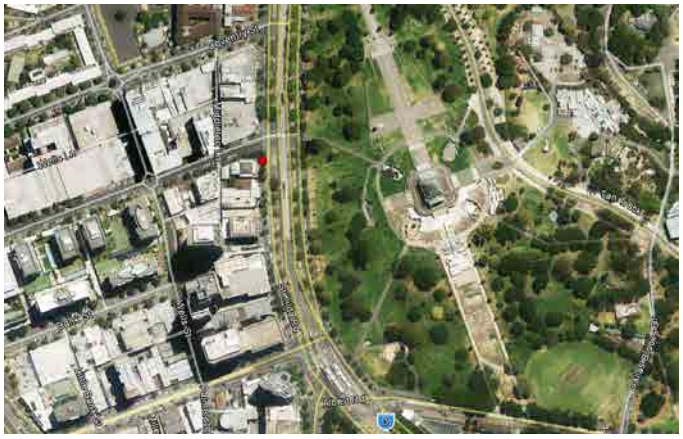


Image 3: Measurement Location

Measurements commenced at 15:39 hours on 1/7/2015. Vibration sources included cars, trucks, trams and pedestrians.

Figure F57: Vibration levels measured at Location 32: the First Church of Christ, Scientist

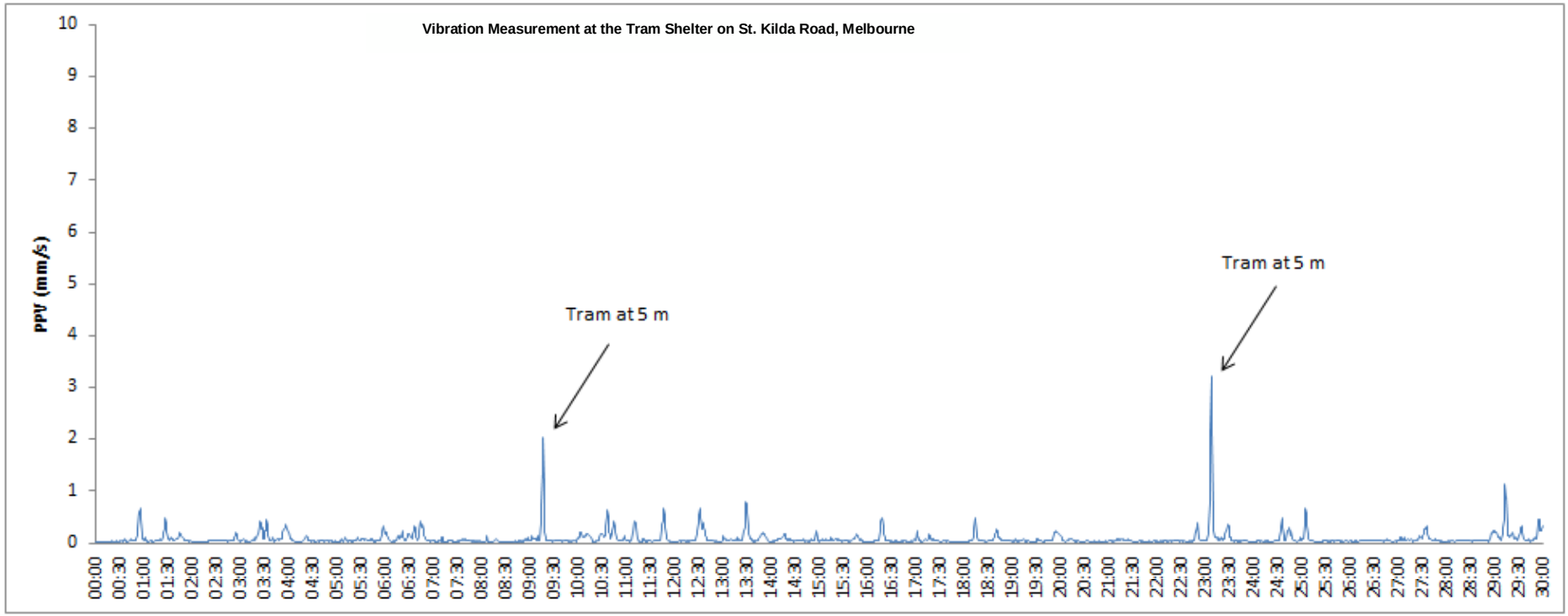


Image 1: Measurement equipment

Image 2: St. Kilda Road

Image 3: Measurement Location

Measurements commenced at 15:39 hours on 1/7/2015. Vibration sources included cars, trucks, trams and pedestrians.

Figure F58: Vibration levels measured at Location 33: Tram shelter, St. Kilda Road

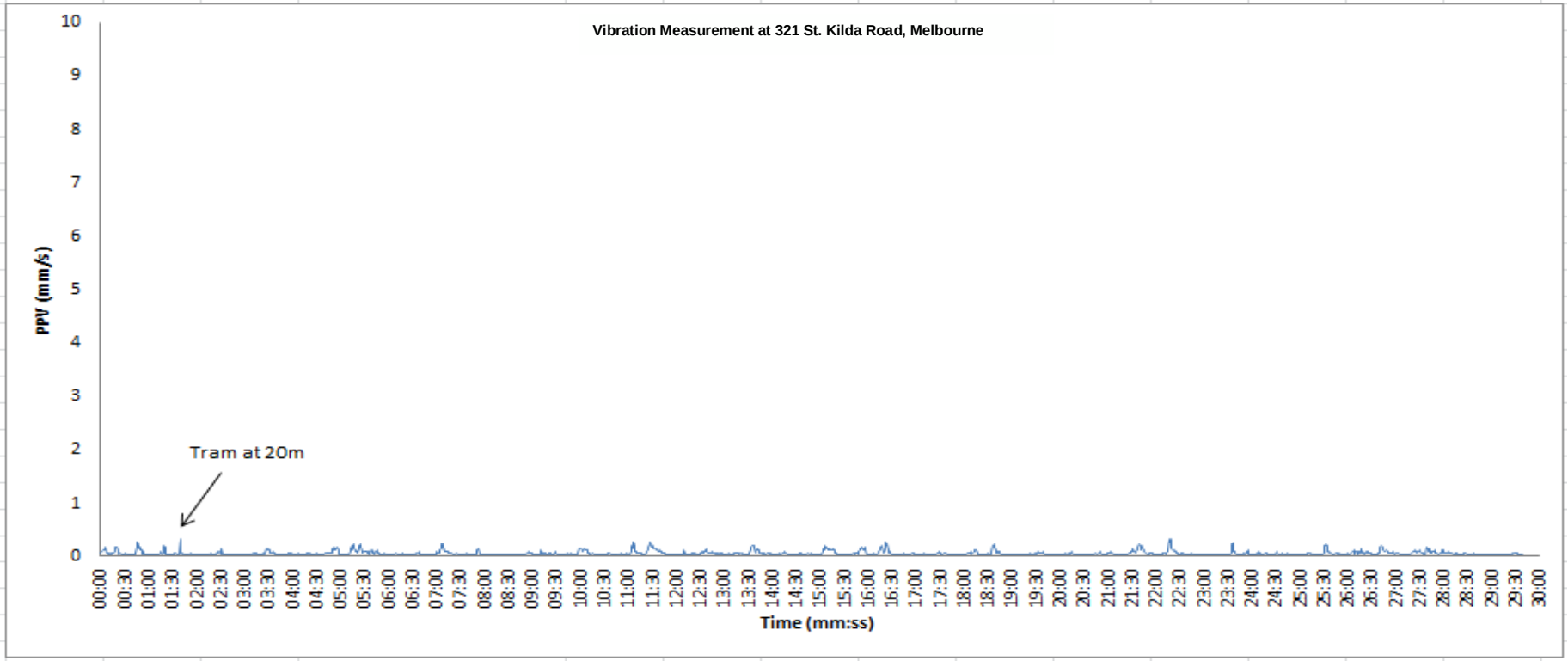


Image 1: Measurement equipment

Image 2: St. Kilda Road

Image 3: Measurement Location

Measurements commenced at 14:18 hours on 1/7/2015. Vibration sources included cars, trucks, trams and pedestrians.

Figure F59: Vibration levels measured at Location 34: South African War Memorial, South Melbourne

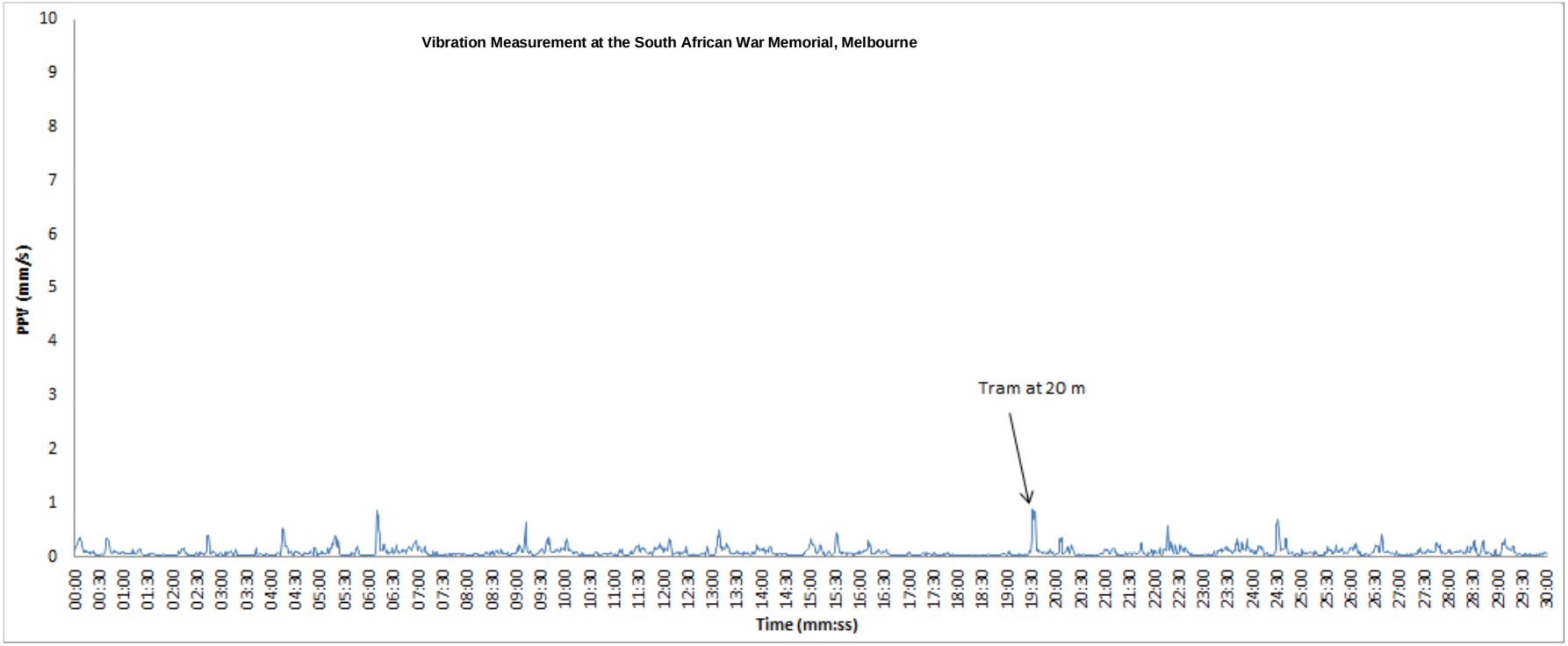


Image 1: Measurement equipment

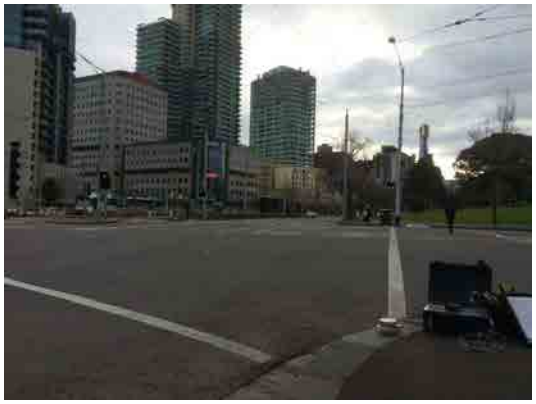


Image 2: Intersection between St. Kilda Road and Domain Road

Image 3: Measurement Location

Measurements commenced at 15:00 hours on 1/7/2015. Vibration sources included cars, trucks, trams and pedestrians.

Figure F60: Vibration levels measured at Location 35: 321 St. Kilda Road, Melbourne

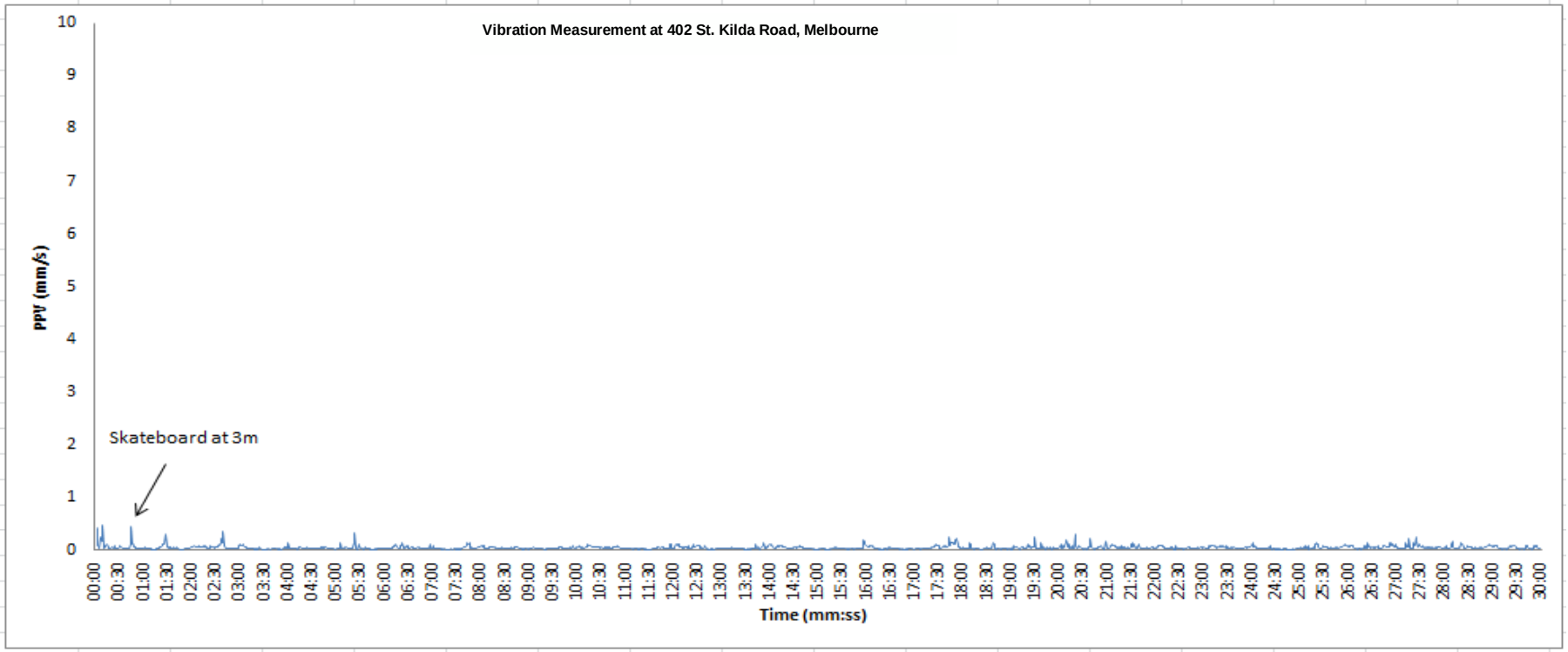


Image 1: Measurement equipment

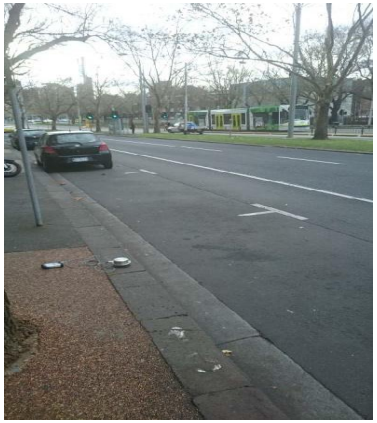


Image 2:St Kilda Road

Image 3: Measurement Location

Measurements commenced at 14:59 hours on 1/7/2015. Vibration sources included cars, trucks, trams and pedestrians.

Figure F61: Vibration levels measured at Location 36: 402 St. Kilda Road, Melbourne

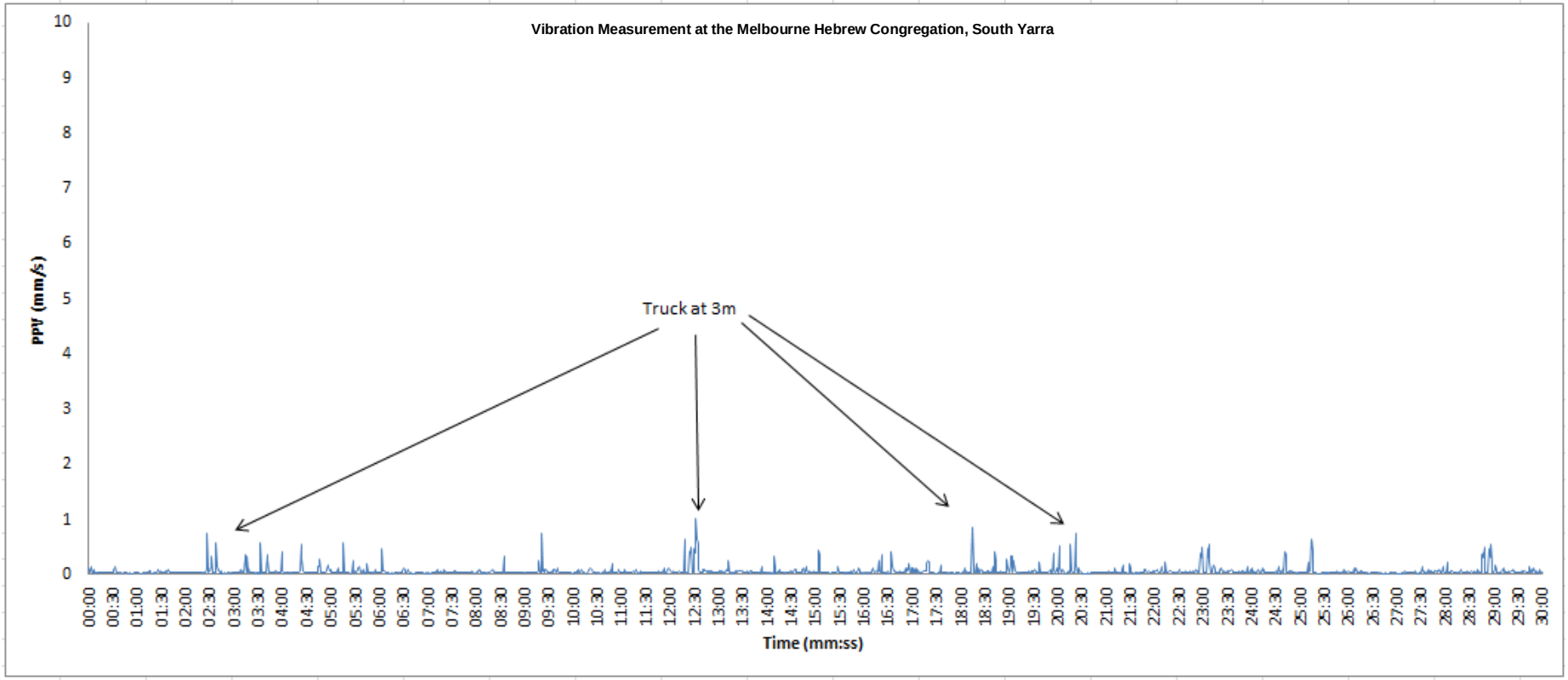


Image 1: Measurement equipment and Toorak Road

Image 2: Melbourne Hebrew Congregation Building

Image 3: Measurement Location

Measurements commenced at 12:05 hours on 18/9/2015. Vibration sources included cars, trucks and pedestrians.

Figure F62: Vibration levels measured at Location 37: Melbourne Hebrew Congregation, South Yarra

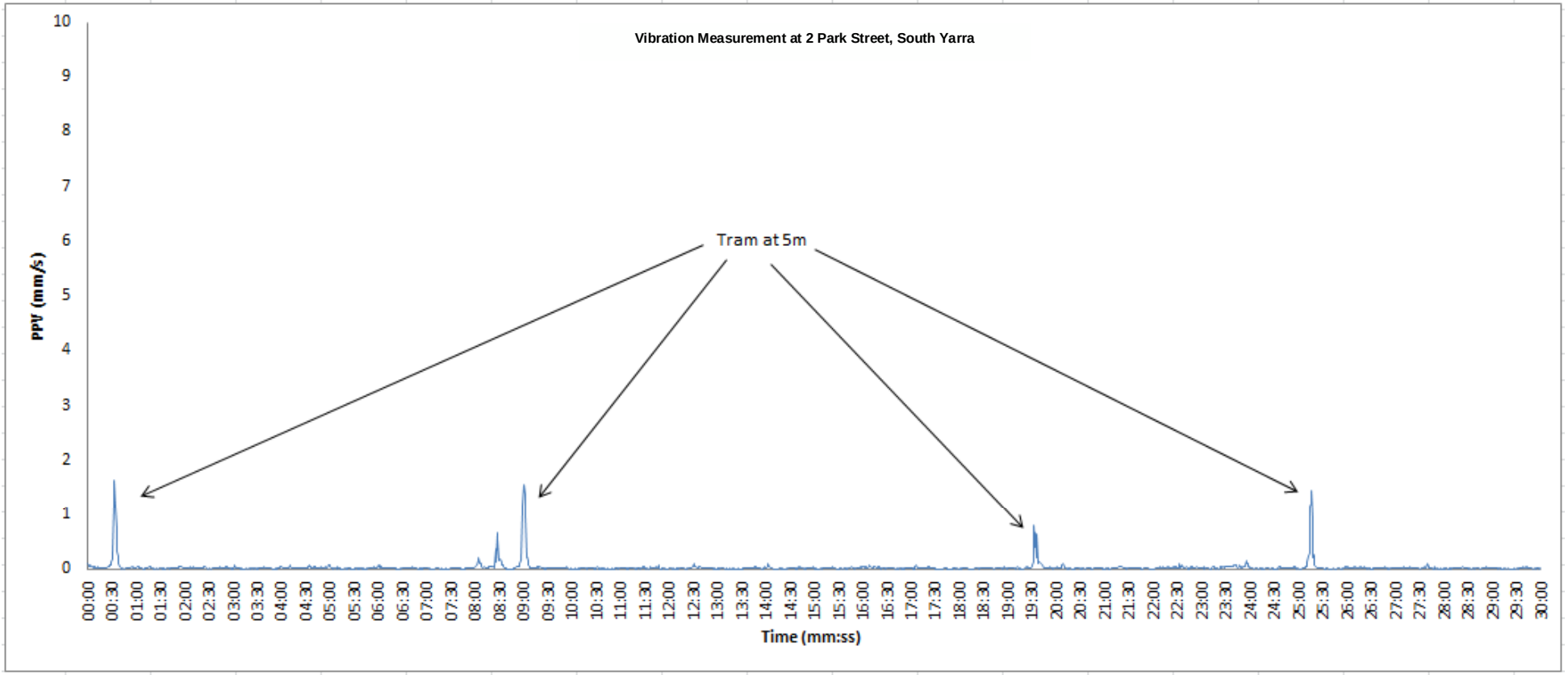


Image 1: Toorak Road

Image 2: Measurement equipment

Image 3: Measurement Location

Measurements commenced at 11:27 hours on 18/9/2015. Vibration sources included cars, trucks, trams and pedestrians.

Figure F63: Vibration levels measured at Location 38: 2 Park Street, South Yarra

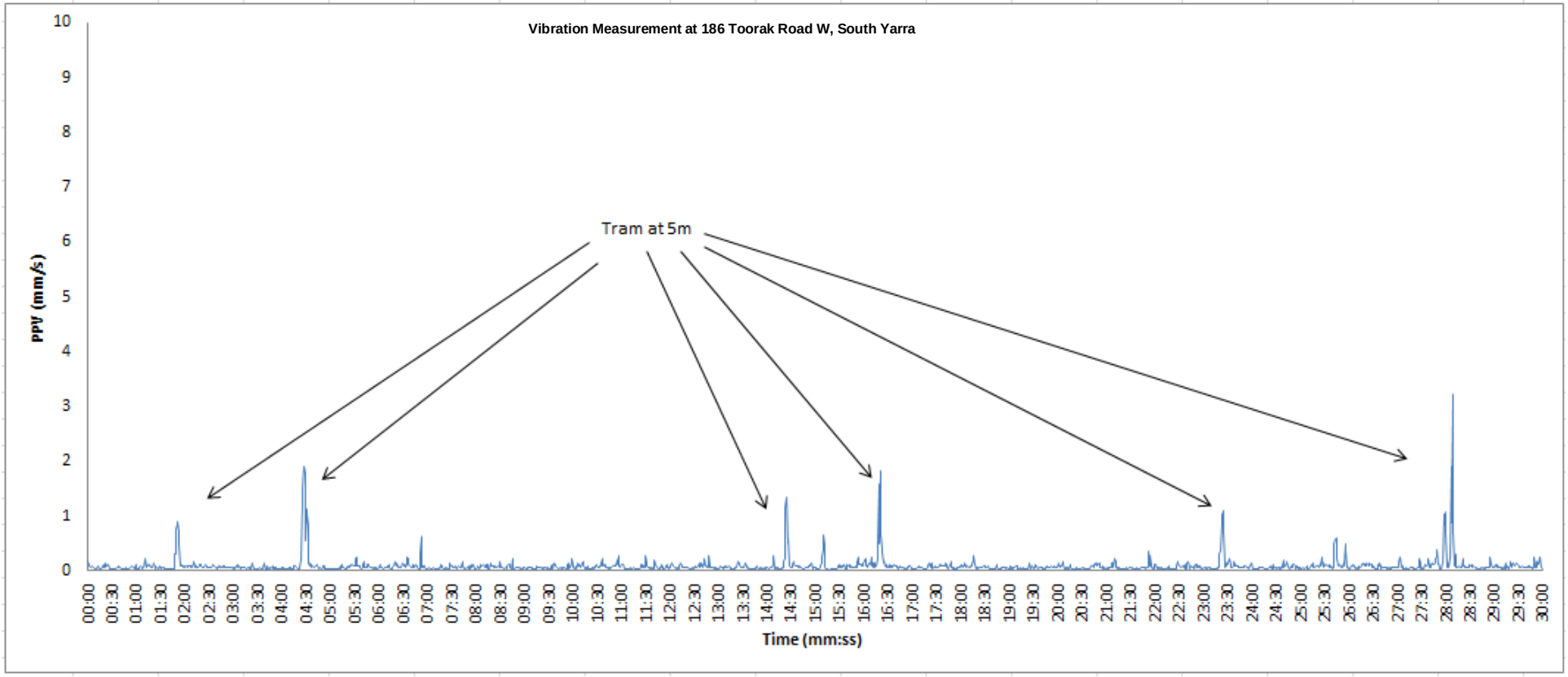


Image 1: Measurement equipment

Image 2: Intersection between Toorak Road and Punt Road

Image 3: Measurement Location

Measurements commenced at 10:50 hours on 18/9/2015. Vibration sources included cars, trucks, trams and pedestrians.

Figure F64: Vibration levels measured at Location 39: 186 Toorak Road W, South Yarra

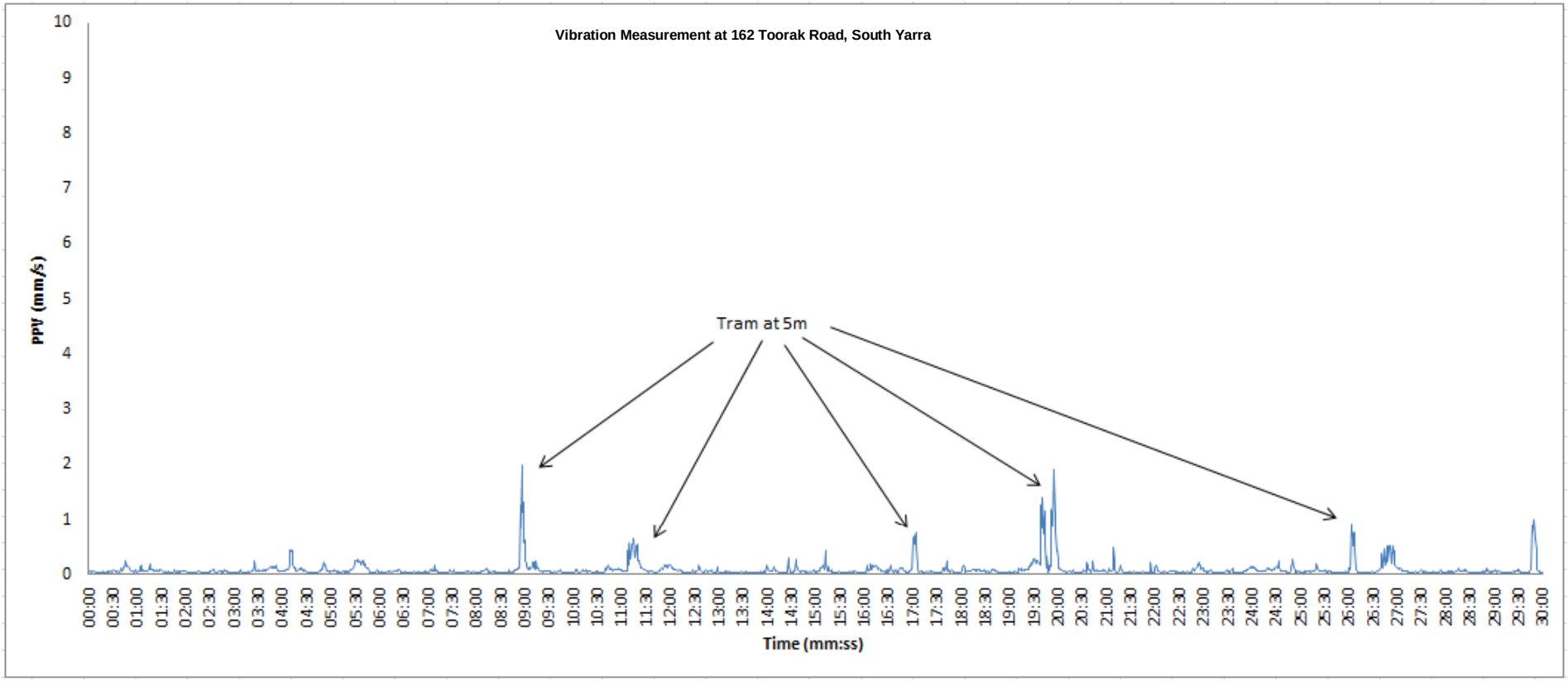


Image 1: Measurement equipment

Image 2: Toorak Road

Image 3: Measurement Location

Measurements commenced at 10:07 hours on 18/9/2015. Vibration sources included cars, trucks, trams and pedestrians.

Figure F65: Vibration levels measured at Location 40: 162 Toorak Road, South Yarra

F.5 Internal Vibration Measurements

F.5.1 Summary

There are a number of buildings in the vicinity of the Melbourne Metro in Parkville which house vibration sensitive equipment. Buildings in Parkville in the vicinity of the Melbourne Metro are shown in Figure F66 and indicative distances of buildings from construction sites are provided in Table F32.

Table F32: Indicative distances of buildings from construction site

Location	Approximate distance from construction site (m)
Royal Women's Hospital (RWH)	15 m to TBM, 250 m to station
Royal Melbourne Hospital (RMH), Building	15 m to TBM, 30 m to station
Melbourne Private Hospital (MPH)	80 m to station and TBM
Victorian Cancer Care Centre (VCCC)	15 m to TBM, 50 m to station
Peter Doherty Institute (PDI)	15 m to TBM, 15 m to station
University of Melbourne (UoM) Faculty of Medicine (FoM)	15 m to TBM, 15 m to station
University of Melbourne (U0M) Faculty of Engineering Building	15 m to TBM, 15 m to station
Howard Florey Laboratories (HFL)	30 m to TBM and station
Walter and Eliza Hall Institute (WEHI)	140 m to TBM, 200 m to station
Kenneth Myer Building (KMB)	140 m to TBM, and station
University High School (UHS)	200 m to TBM and 250 m to station
Bio 21 Institute	140 m to TBM and 300 m to the station

Vibration sensitive equipment has been identified at all locations presented in Table F32. Strategic locations have been identified for vibration measurements and these locations are provided in Section F.5.3.

Legend

- Proposed alignment
- Proposed Station Extent
- Hospital Measurement

Data Sources:
Proposed Infrastructure: AJM 2016
Contains Vicmap Information
© State of Victoria 2015
Aerial photo (DELWP, February 2015)

MELBOURNE METRO RAIL AUTHORITY

aurecon JACOBS Mott MacDonald AJM Joint Venture GRIMSHAW

Melbourne Metro Rail Project

Title:
Parkville Hospital Measurements

Drawing Number:			Revision:
MMR-AJM-PWAA-MP-NO-500196			P1
Drawn By:	Approved By:	Date:	Map Size:
A. French	N. Wehaj	8/04/2016	A4

0 50 100
Metres

G:\MMR-AJM\01_WIP\PW-1-AA-KG_GIS\640_Site_plans\MMR_0303_NoiseVibration_EES\MMR_0303_ParkvilleHospitals_EES_A4.mxd

Figure F66: Buildings in the vicinity of Melbourne Metro in Parkville

F.5.2 Methodology

F.5.2.1 Measuring Locations

Ambient vibration measurements were undertaken between October 2015 and February 2016 at the sites in Table F34 in order to determine the vibration levels to which sensitive equipment / bio-resources in these facilities is currently exposed. At each site vertical vibration was measured on the floor adjacent to the sensitive equipment or in a nearby room or corridor representative of the sensitive space if required due to equipment use or contamination protocols.

The selection of locations for ambient vibration (and noise) measurement within sensitive spaces was made on the basis of an assessment of their relative sensitivity and proximity to the Melbourne Metro alignment and construction works. As a general principle the highest sensitivity locations at closest proximity to the alignment were selected for measurement because the requirements of these sites govern the requirements for nearby sites. Some other sites were selected on the basis of being representative of a particular class of sensitive equipment or biological resource or on practical considerations such as access requirements or stakeholder request.

F.5.2.2 Approach

Vertical floor vibrations were monitored for approximately 30 minutes under 'normal' operating conditions at a mid-span position or position proximate to the sensitive equipment within each area to capture typical floor vibration levels due to staff footfall, doors closing as well as lifts and services operating. In addition, peaks in the frequency content of ambient floor vibration measurements or from a heal drop were used to estimate the lowest natural frequency of each floor. Staged walk-by tests were conducted using a metronome in order to match harmonics of the pacing frequency to the floor natural frequency or conduct a walk-by test at the maximum practical pacing frequency for high frequency slabs (slabs with natural frequencies greater than 10Hz). Accelerometers were mounted to the floor using bees wax to achieve a good connection to the floor that was free from rocking due to any uneven surfaces. Measurements were sampled at a frequency of 1000Hz. Figure **F67** shows a typical test setup with accelerometers mounted on the floor adjacent to microscopes.

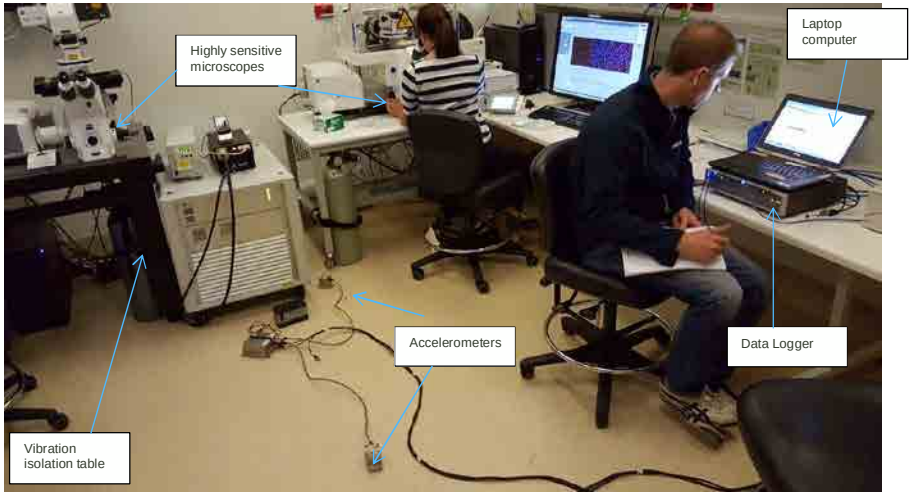


Figure F67: Typical floor vibration measurement setup

The acceleration time histories were recorded during the testing and post-processed to produce 1/3 octave band RMS velocities (1 – 80Hz) for comparison with ASHRAE curves that describe the tolerance of different classes of sensitive equipment to vibration. The maximum 1 second RMS 1/3 octave band vibration velocity between 1 and 80Hz was compared with the ASHRAE curves for vibration sensitive equipment to determine the vibration classification for each floor slab.

F.5.2.3 Equipment

The equipment used to measure floor slab vibration levels were Sunstrand QA700 servo accelerometers (nominal sensitivity of 2000 mV/g), an LMS SCADAS data acquisition system and laptop computer. Details are provided in Table F33 below.

Table F33: Vibration transducers for internal vibration measurements

Manufacturer	Type of Instrument	Serial No.	Last Calibration Date
Sunstrand	Servo accelerometer Type QA700	10852	October 2013
Sunstrand	Servo accelerometer Type QA700	10853	October 2013
Sunstrand	Servo accelerometer Type QA700	14340	October 2013
SVANTEK	SVAN958	28435	April 2014

F.5.3 Results

The results of ambient vibration monitoring in the vicinity of vibration sensitive equipment in Parkville is presented below. Table F34 provides a summary of measurement locations, the maximum 1/3rd octave levels and the corresponding ASHRAE vibration curve. Detailed results are provided in Figure F68 to Figure F104. In the figures, results are overlaid with the ASHRAE vibration curves to show the vibration performance category of each location.

Table F34: Summary of Baseline Floor Vibration Measurements

Location	Baseline 1/3rd octave level (mm/s RMS)	Baseline ASHRAE VC curve	Comments
Royal Melbourne Hospital			
Building 1B, Level 1, adjacent to Grattan Street	13 µm/s	VC-C / VC-B	
Clinical Sciences Building, Basement - Biological Resource	6 µm/s	VC-D	
Building 1B, Level 6 - Sensitive Biological Resource - (University of Melbourne)	20 µm/s	VC-B	
Royal Women's Hospital			
Level 1, adjacent to Grattan Street - 3.5T MRI	17 µm/s	VC-B	
Walter and Eliza Hall Institute			
Building 1, Level 4 - Microscopy	58 µm/s	Operating Room	
Building 1, Level 4 - Sensitive Biological Resource	43 µm/s	VC-A	
Peter Doherty Institute			
Level 7 - 1000 x Microscopy	48 µm/s	VC-A	
Level 9 - Sensitive Biological Resources Facility	35 µm/s	VC-A	
Basement (Electron Microscope)	6 µm/s	VC-D	
Howard Florey Laboratories			
Basement - MRI	11 µm/s	VC-C	
Melbourne Private Hospital			
Level 7 - X-Ray Labs	63 µm/s	Operating Room	
The University of Melbourne			
Bio-resources on Level 9 East-Wing	29 µm/s	VC-A	
Bio-resources on Level 9 West-Wing	20 µm/s	VC-B	
Laboratory (Level 9)	24 µm/s	VC-B	Contains several microscopes
Microscopy Room (Ground Floor)	28 µm/s	VC-B	
Confocal Room (E505 in Medical Building)	24 µm/s	VC-B	
Plant Room (C901 in Medical Building)	63 µm/s	Operating Room	
Bio-resources Lab (E702C in Medical Building)	21 µm/s	VC-B	
Laboratory (E708 in Medical Building)	48 µm/s	VC-A	Contains several microscopes
Laboratory (E638 in Medical Building)	30 µm/s	VC-A	Contains several microscopes
Laboratory (E609 in Medical Building)	88 µm/s	Operating Room	Contains several microscopes
Laboratory (E709 in Medical Building)	44 µm/s	VC-A	Contains several microscopes
Anatomy Museum Storage (E113 in Medical Building)	3 µm/s	VC-E	
Anatomy Museum (E301 in Medical Building)	9 µm/s	VC-C	
Foyer (N201 in Medical Building)	12 µm/s	VC-C	
Lecture Theatre (C216 in Medical Building)	31 µm/s	VC-A	
Conference Room (W206 in Medical Building)	14 µm/s	VC-B	
Anatomy Lab (E403 in Medical Building)	45 µm/s	VC-A	
X-Ray Labs (G04A – G04B in Building 167)	17 µm/s	VC-B	
Laboratories (115 – 118 in Building 165)	15 µm/s	VC-B	Contain several microscopes
PC2 Lab (112 in Building 165)	15 µm/s	VC-B	
Atomic Force Microscope (217 in Building 165)	15 µm/s	VC-B	
Leading Thermal Analyser (G04 – G10 in Building 165)	14 µm/s	VC-B	
Substance Analyser (G04 – G10 in Building 165)	18 µm/s	VC-B	
3D X-Ray (107 in Building 170)	20 µm/s	VC-B	
Kenneth Myer Building			
Ground floor - MRI	5 µm/s	VC-E	
Bio21 Institute			
Electron Scanning Microscope, Level 1	20 µm/s	VC-B	Isolated from the structure. Measurement on concrete slab. Approximately 50 m from Flemington Road
RMIT University			
Robotics Lab (Basement 2 in Building 100)	3 µm/s	VC-D	Contains lasers, 3D printers, robot arms
Electron Microscope (Level 7 in Building 14)	18 µm/s	VC-B	
Confocal Microscope (Level 5 in Building14)	14 µm/s	VC-B	
NMR Spectrometer (Ground in Building 3)	6 µm/s	VC-D	
The Fib (Level 4 in Building 7)	22 µm/s	VC-B	
Photonics Lab (Level 9 in Building 12)	19 µm/s	VC-B	Contains lasers

Note:
1 VCCC building foundations have been designed to account for some vibration

2 VCCC construction had no impact on Kenneth Myer building. Kenneth Myer building was built to a high standard to withstand vibration.

3 VCCC vibration criteria is from VCCC Project Volume 2, Part C, Technical Specification

4 No vibration sensitive equipment has been identified at the Alan Gilbert building

5 Bio 21 Institute has stated that the Scanning Electron Microscope is the most sensitive item of equipment and if compliance is achieved with its vibration requirements the all other equipment would also be able to operate.

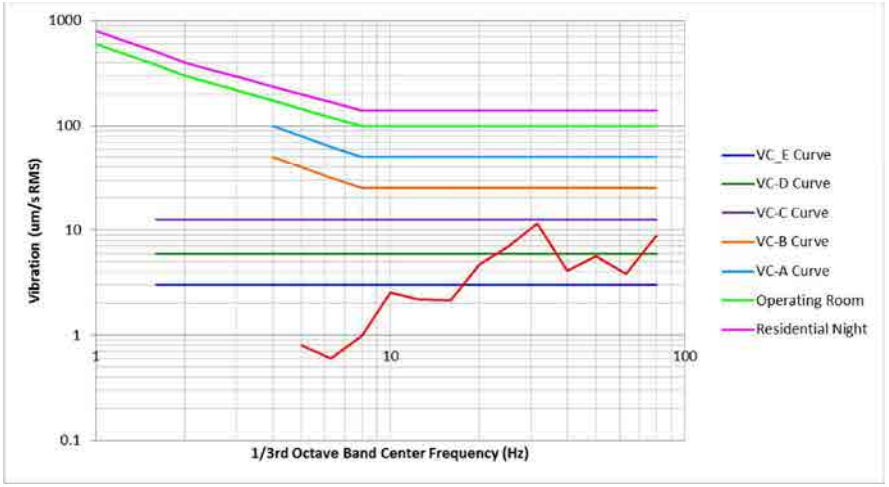


Figure F68: Royal Melbourne Hospital, Building 1B, Level 1, adjacent to Grattan Street

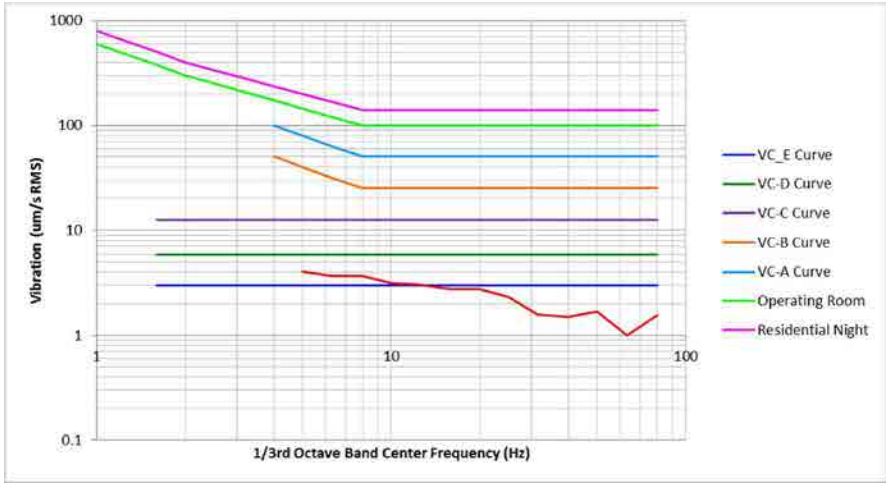


Figure F69: Royal Melbourne Hospital, Clinical Sciences Building, Basement - Sensitive Biological Resource

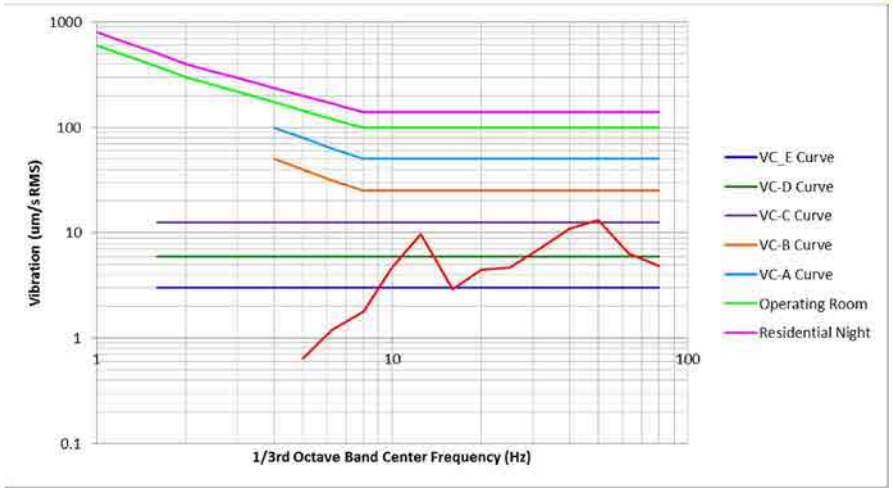


Figure F70: Royal Melbourne Hospital, Building 1B, Level 6, - Sensitive Biological Resource (University of Melbourne)

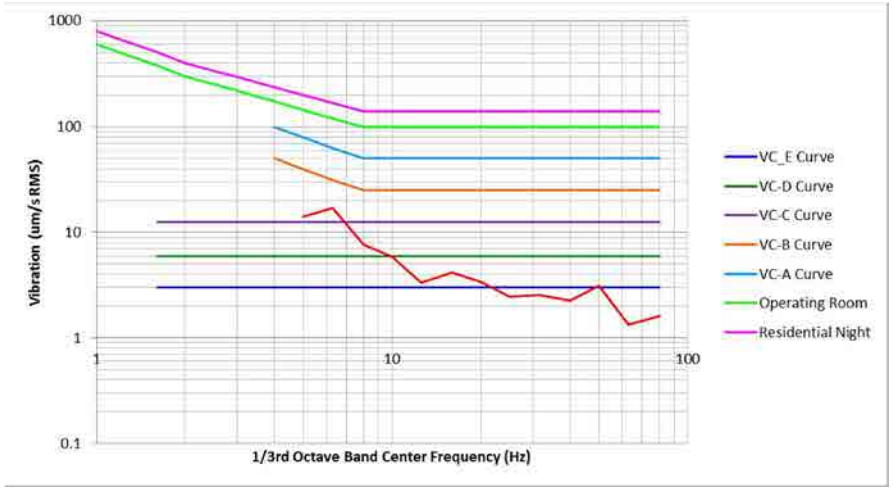


Figure F71: Royal Women's Hospital, Level 1, adjacent to Grattan Street - 3.5T MRI

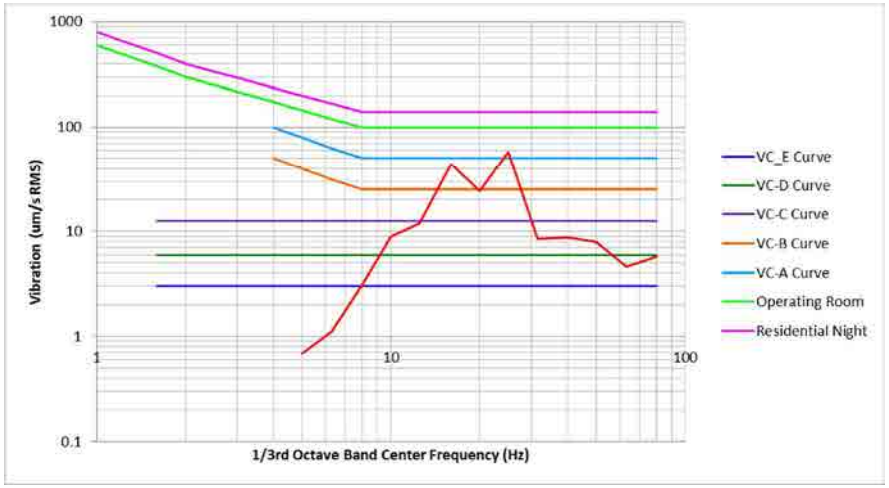


Figure F72: Walter and Eliza Hall Institute, Building 1, Level 4 – Microscopy

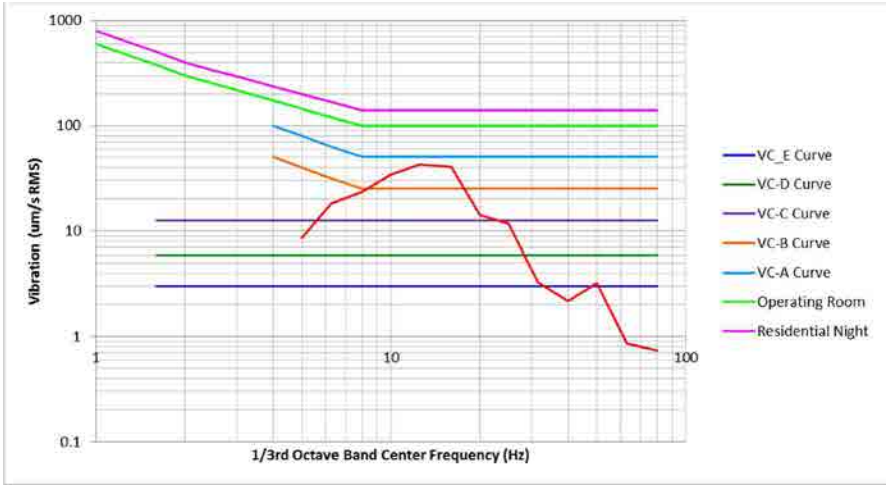


Figure F73: Walter and Eliza Hall Institute, Building 1, Level 4 - Sensitive Biological Resource

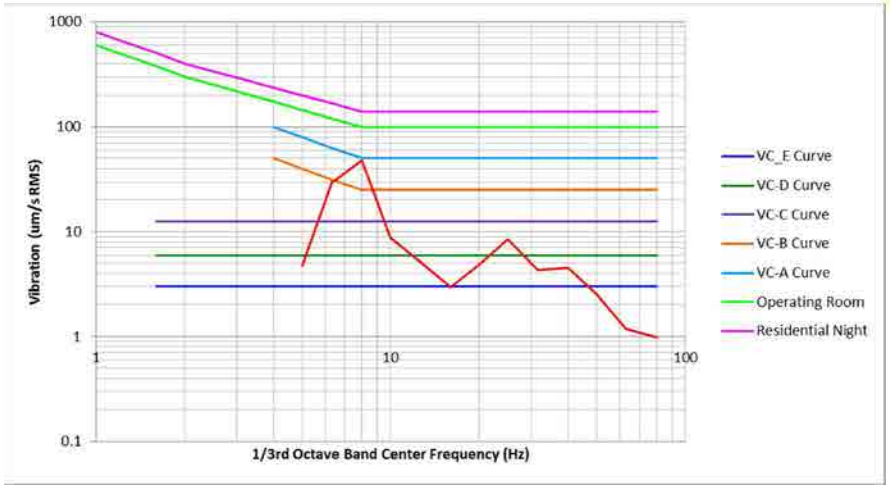


Figure F74: Peter Doherty Institute, Level 7 - 1000 x Microscopy

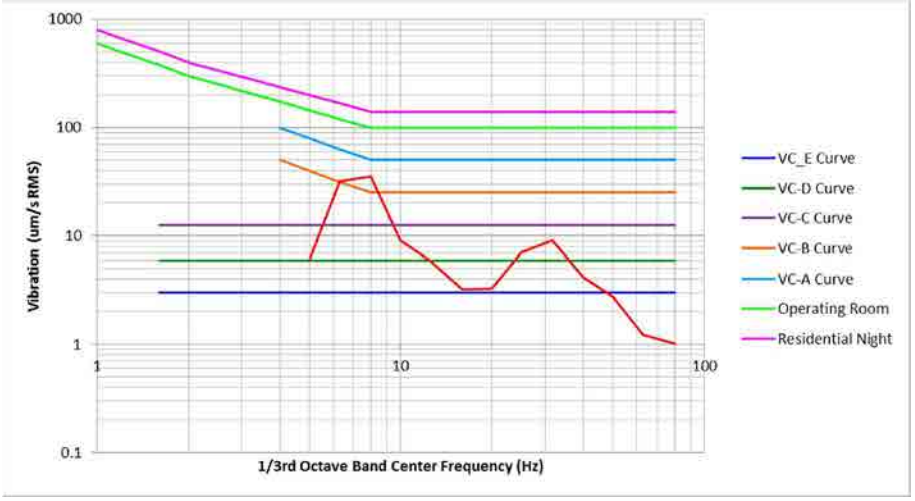


Figure F75: Peter Doherty Institute, Level 9 - Sensitive Biological Resources Facility

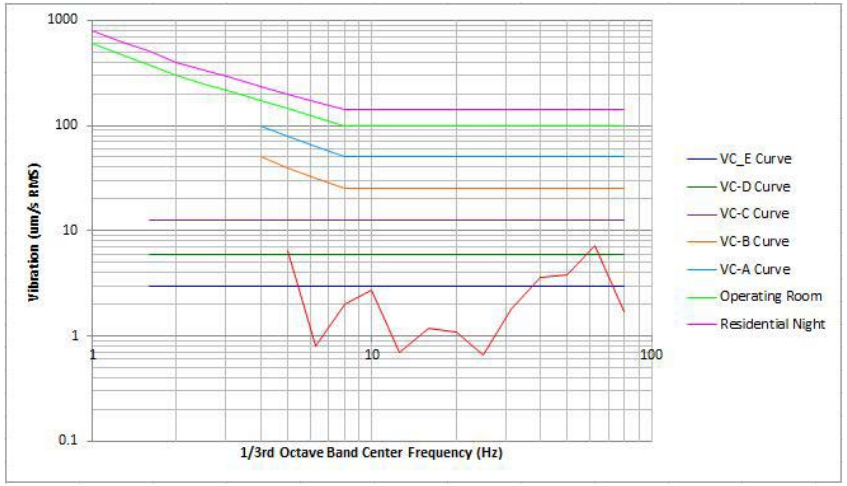


Figure F76: Peter Doherty Institute Basement - Electron Microscope

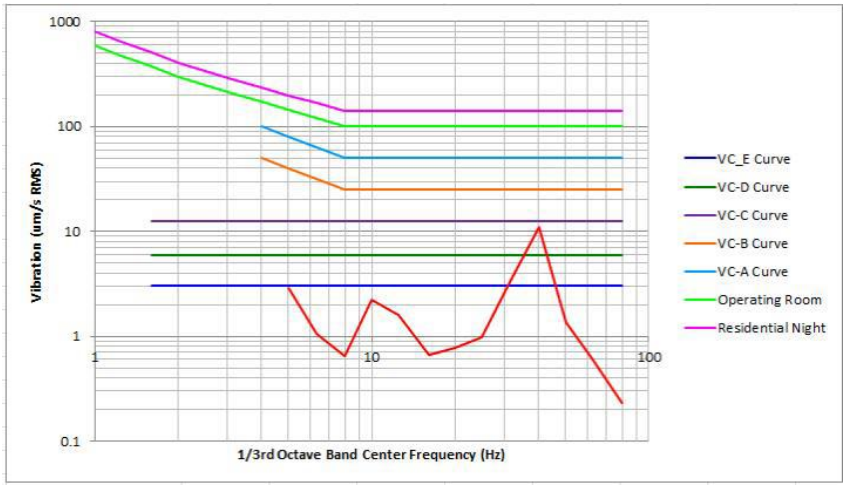


Figure F77: Howard Florey Laboratories, Basement - MRI

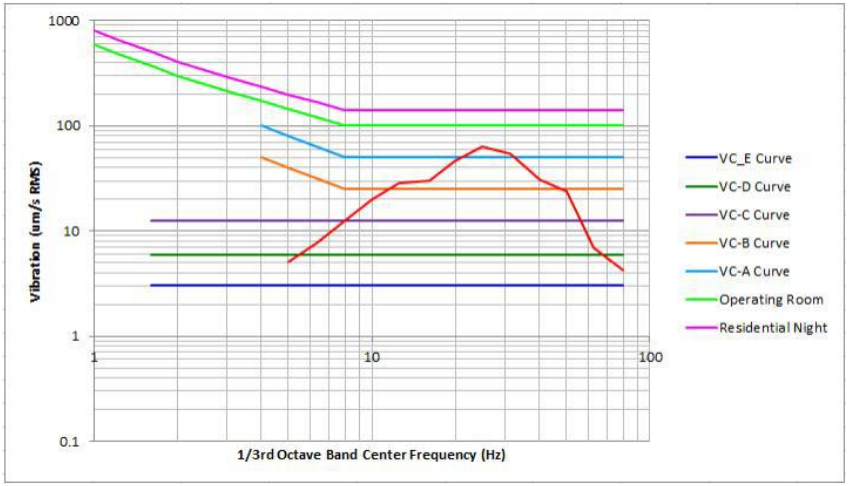


Figure F78: Melbourne Private Hospital, Level 7- X-Ray Lab

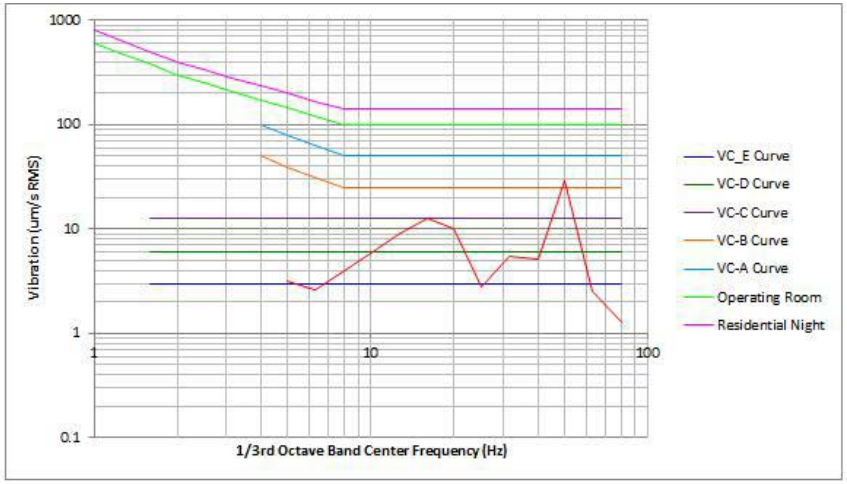


Figure F79: University of Melbourne Faculty of Medicine Building, Level 9 – East Wing

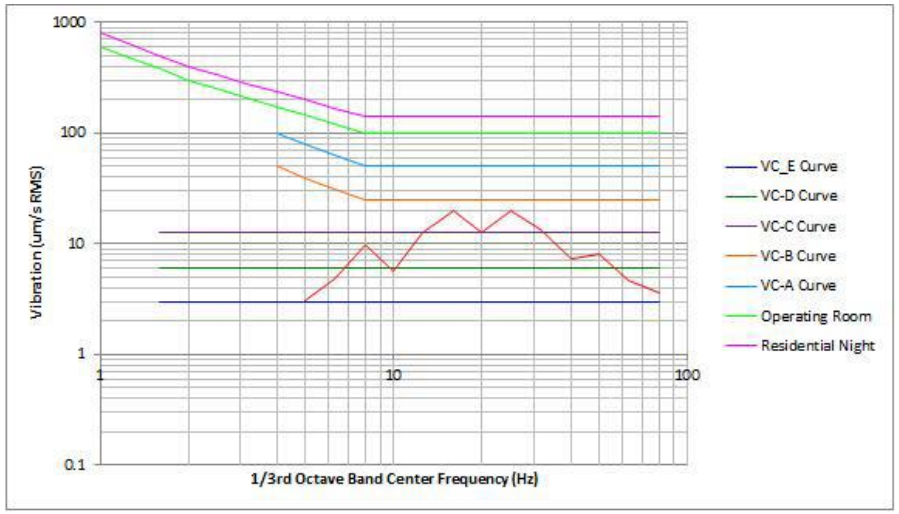


Figure F80: University of Melbourne Faculty of Medicine Building, Level 9 – West Wing

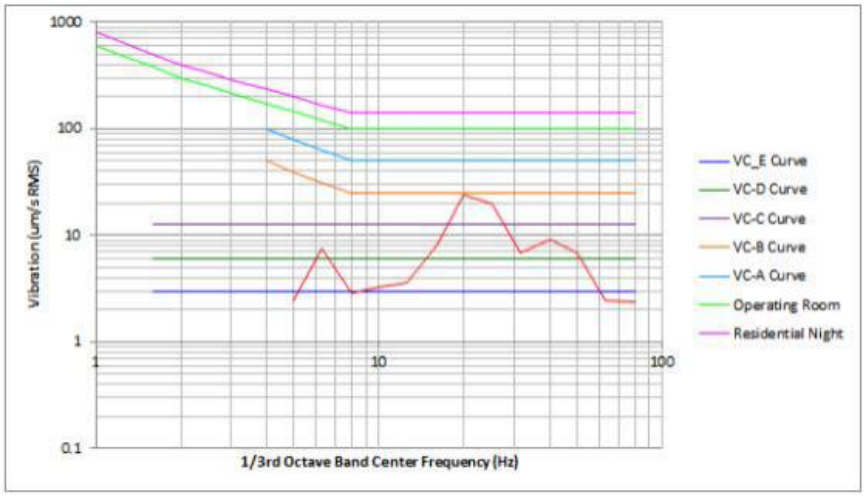


Figure F81: University of Melbourne Faculty of Medicine Building, Level 7 – Laboratory

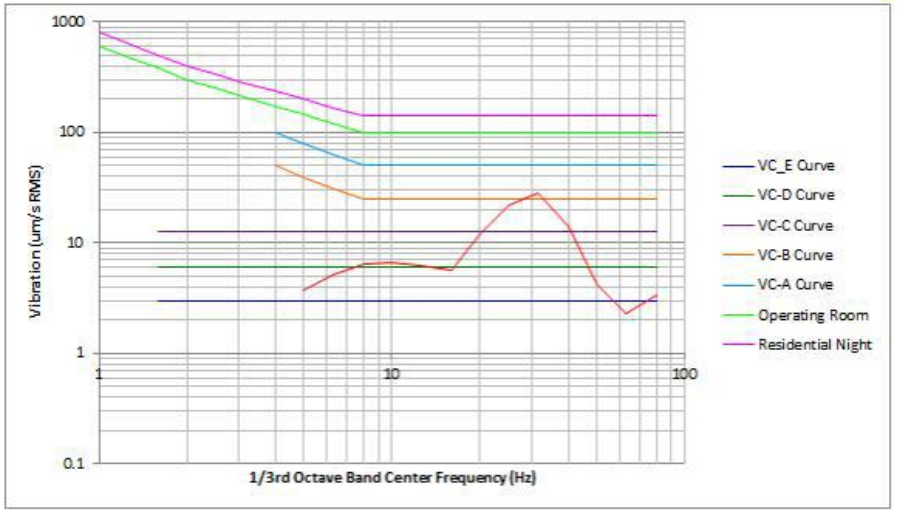


Figure F82: University of Melbourne Faculty of Medicine Building, Level 2 – Microscopy Room

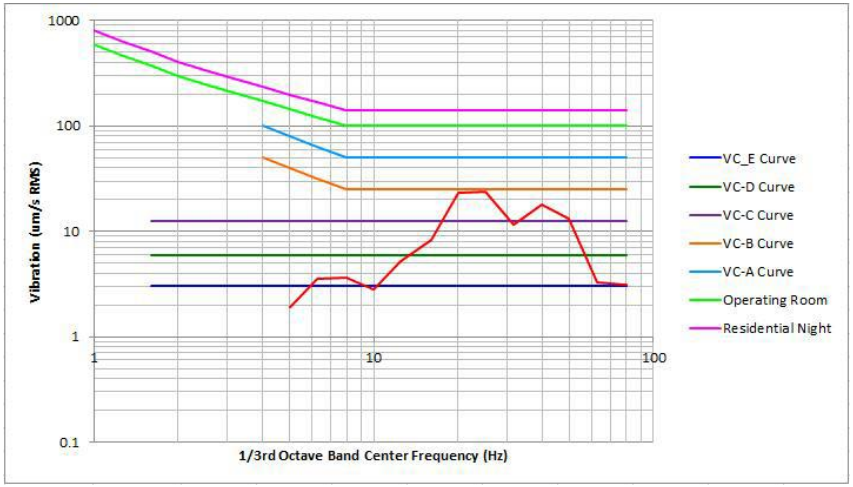


Figure F83: University of Melbourne Faculty of Medicine Building, Level 5 - Confocal Room

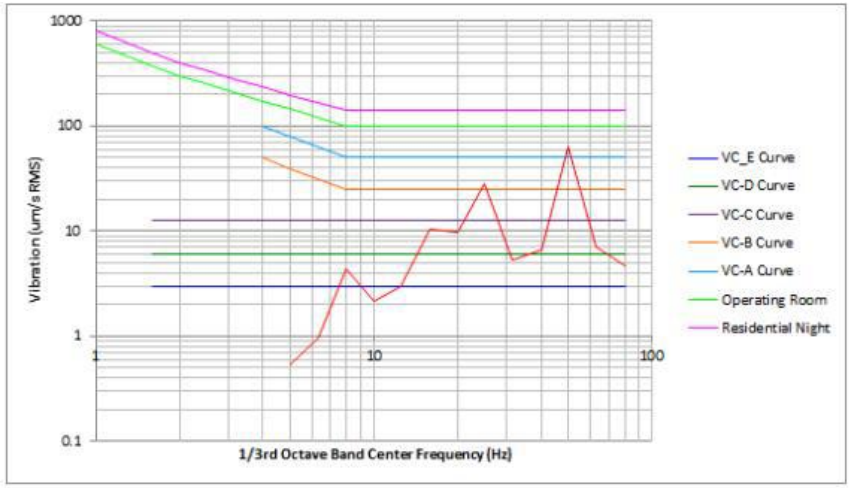


Figure F84: University of Melbourne Faculty of Medicine Building, Level 9 - Plant Room

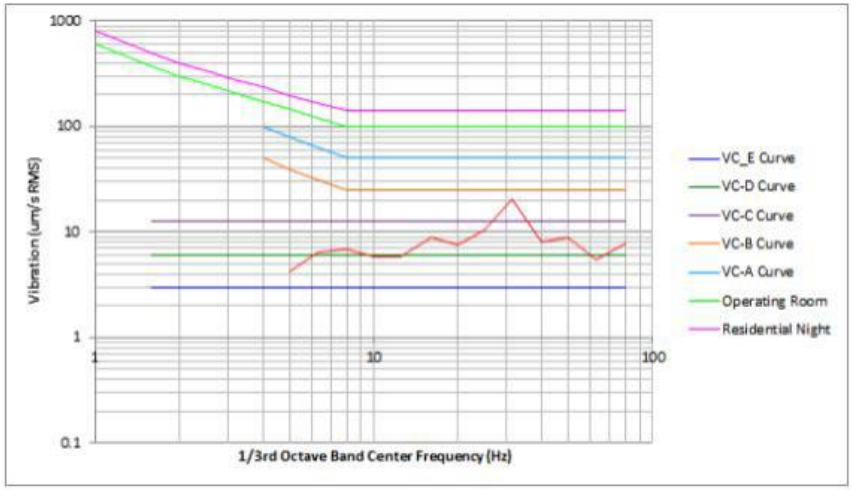


Figure F85: University of Melbourne Faculty of Medicine Building, Level 7 – Bio-resources Lab

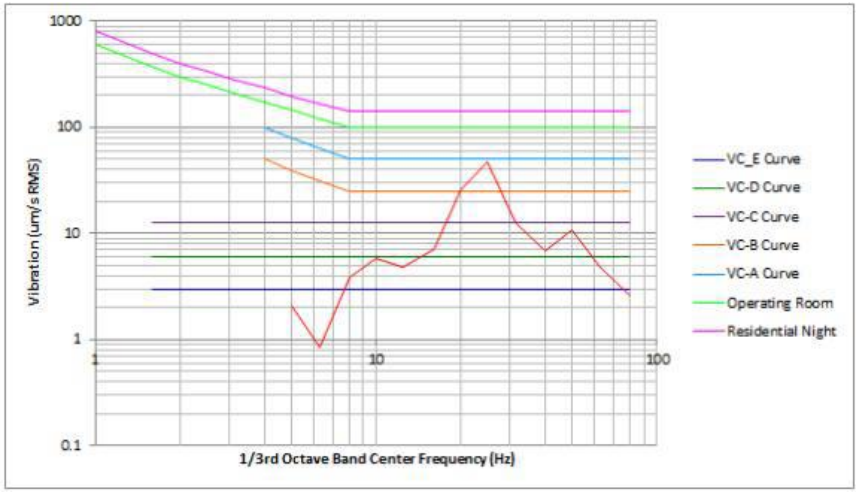


Figure F86: University of Melbourne Faculty of Medicine Building, Level 7 - Laboratory

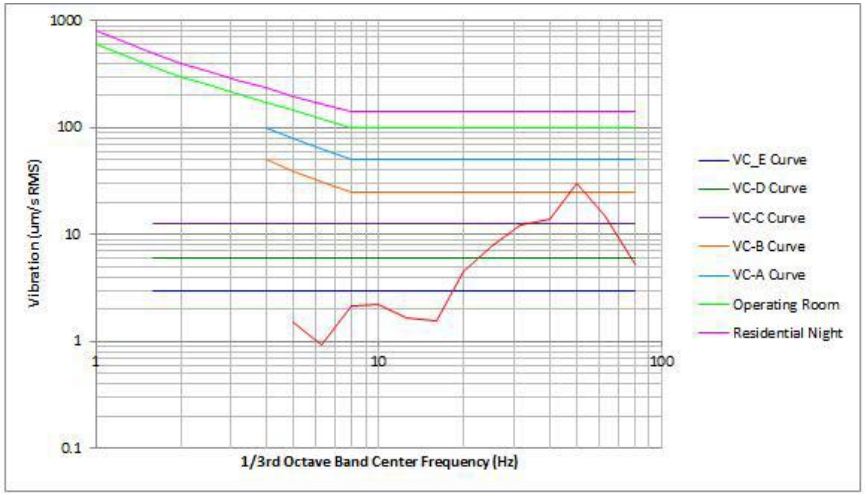


Figure F87: University of Melbourne Faculty of Medicine Building, Level 6 – Laboratory

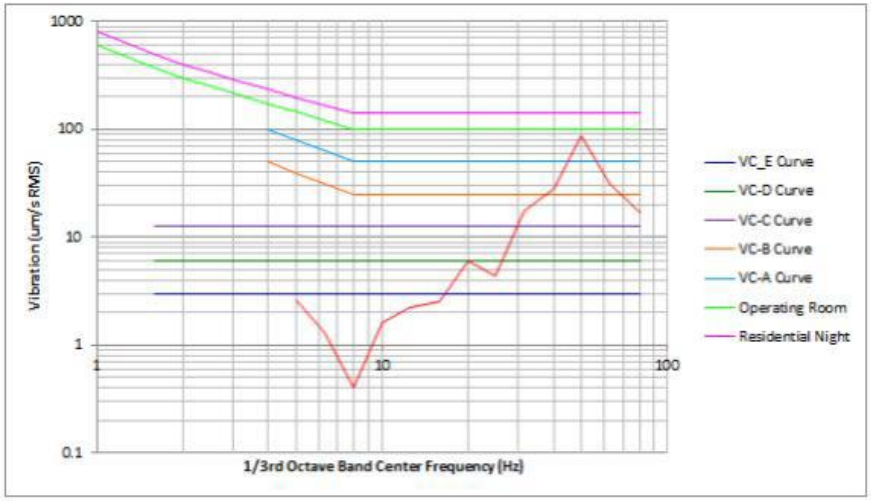


Figure F88: University of Melbourne Faculty of Medicine Building, Level 6 – Laboratory

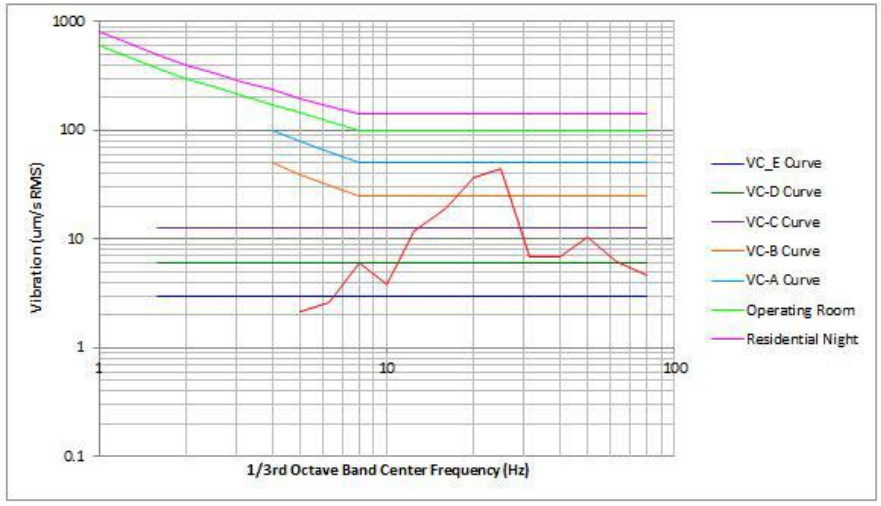


Figure F89: University of Melbourne Faculty of Medicine Building, Level 7 - Laboratory

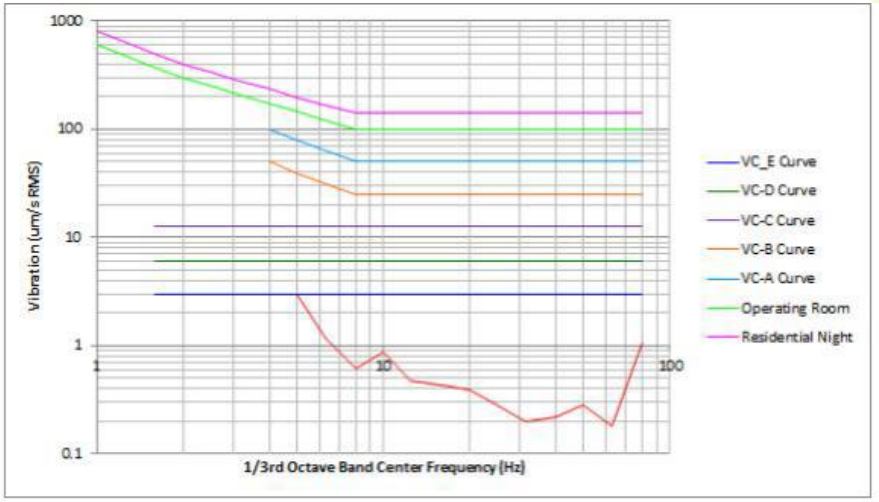


Figure F90: University of Melbourne Faculty of Medicine Building, Basement – Anatomy Museum Storage

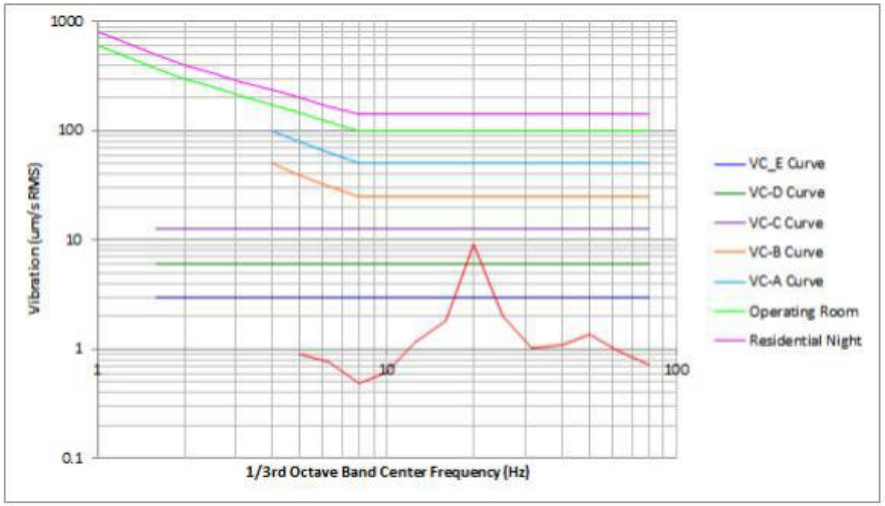


Figure F91: University of Melbourne Faculty of Medicine Building, Level 3 – Anatomy Museum

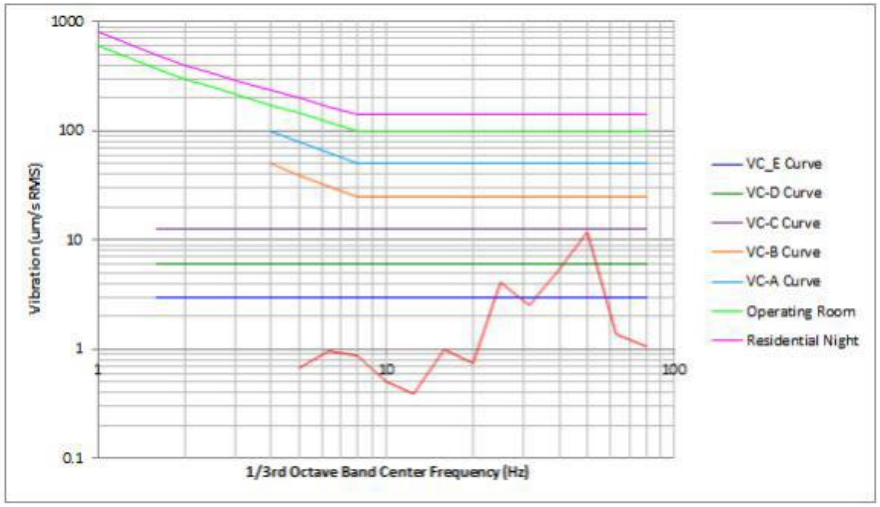


Figure F92: University of Melbourne Faculty of Medicine Building, Level 2 – Foyer

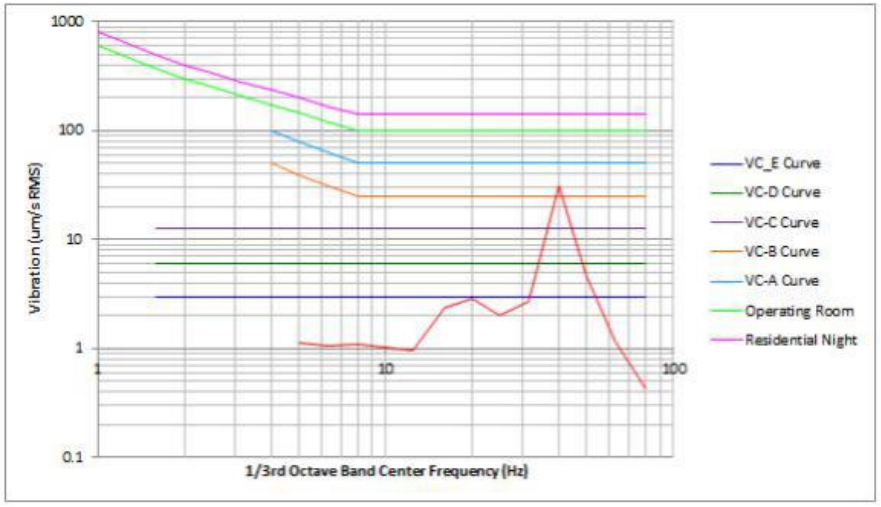


Figure F93: University of Melbourne Faculty of Medicine Building, Level 2 – Lecture Theatre

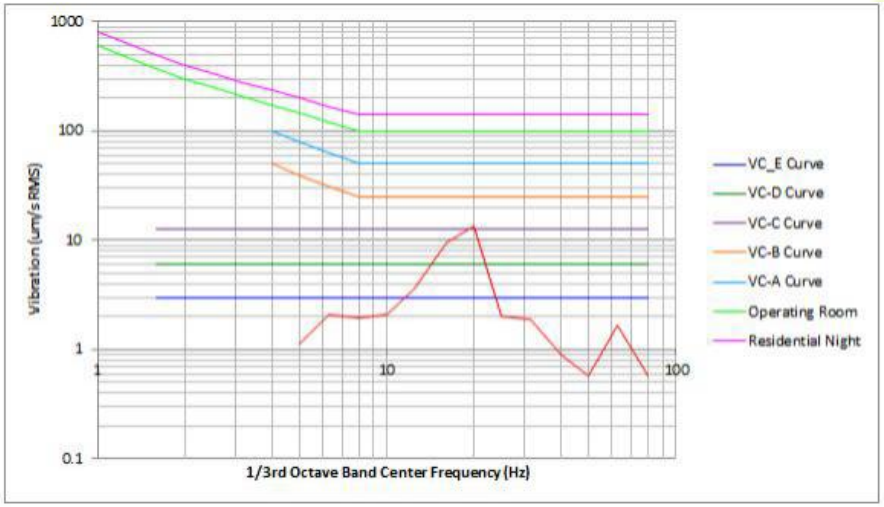


Figure F94: University of Melbourne Faculty of Medicine Building, Level 2 – Conference Room

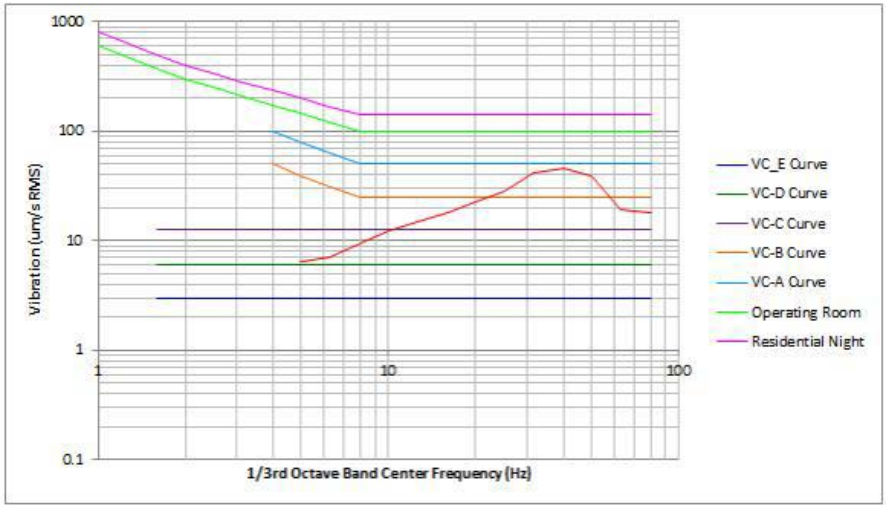


Figure F95: University of Melbourne Faculty of Medicine Building, Level 4 – Anatomy Lab

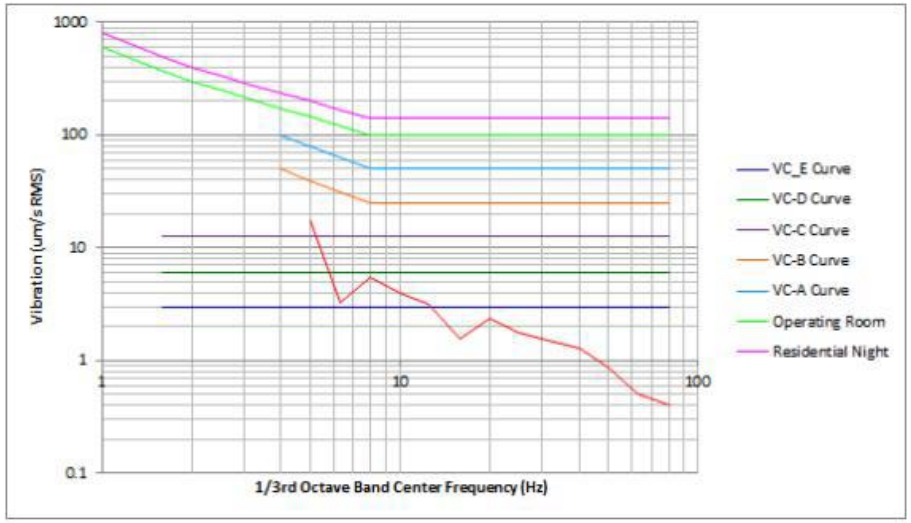


Figure F96: University of Melbourne Faculty of Engineering Building 167, Ground – XRAY Lab

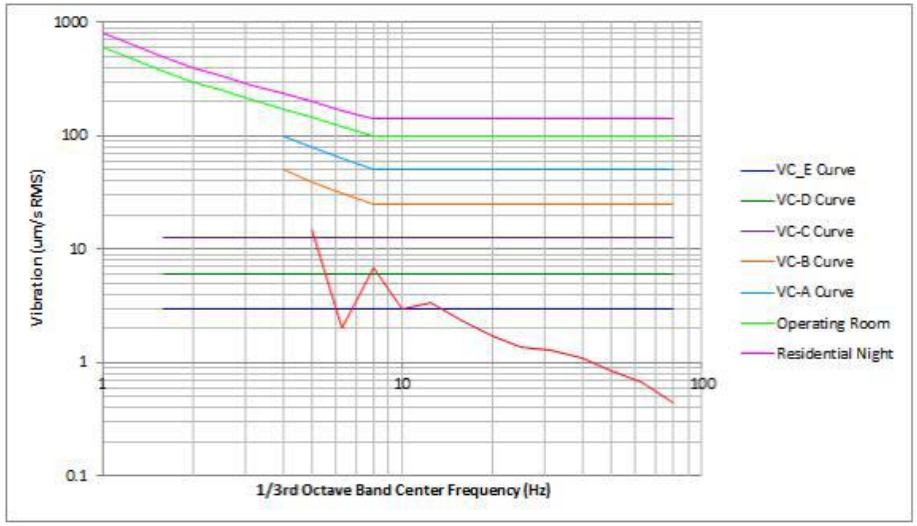


Figure F97: University of Melbourne Faculty of Engineering Building 165, Level 1 – Laboratories

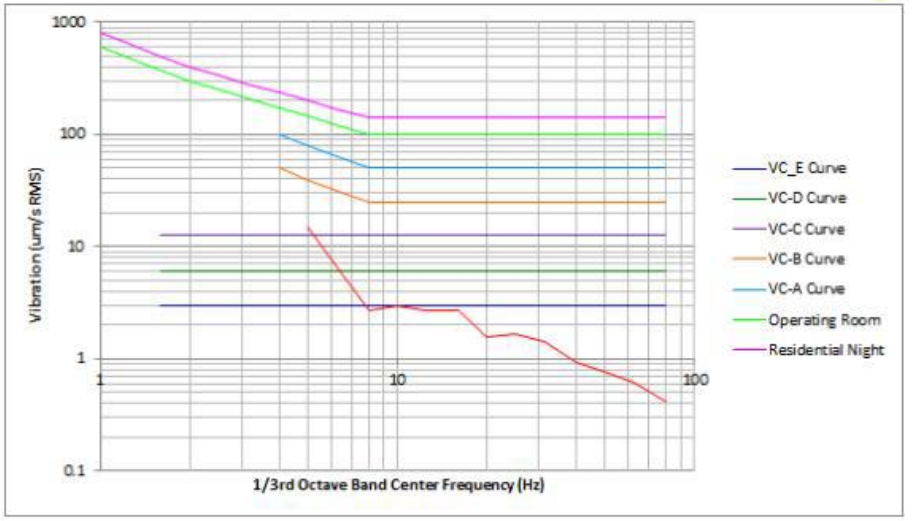


Figure F98: University of Melbourne Faculty of Engineering Building 165, Level 1 – PC2 Lab

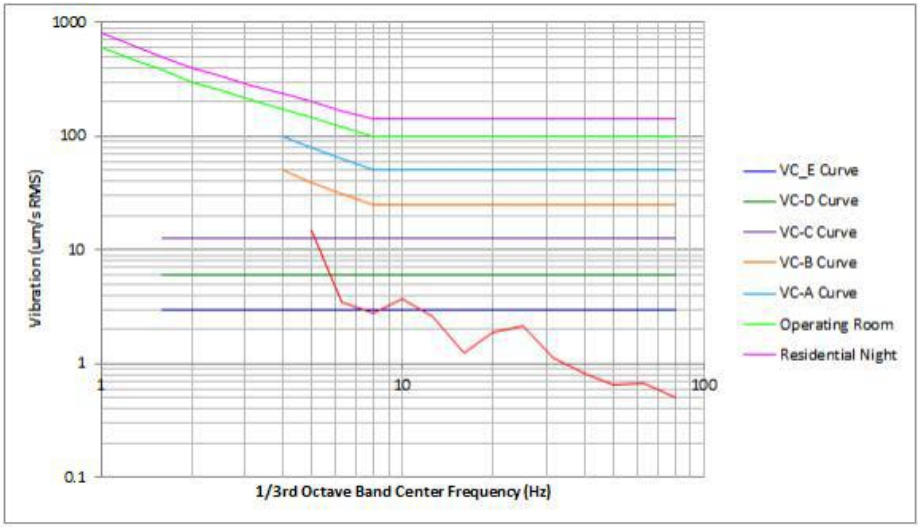


Figure F99: University of Melbourne Faculty of Engineering Building 165, Level 2 – Atomic Force Microscope

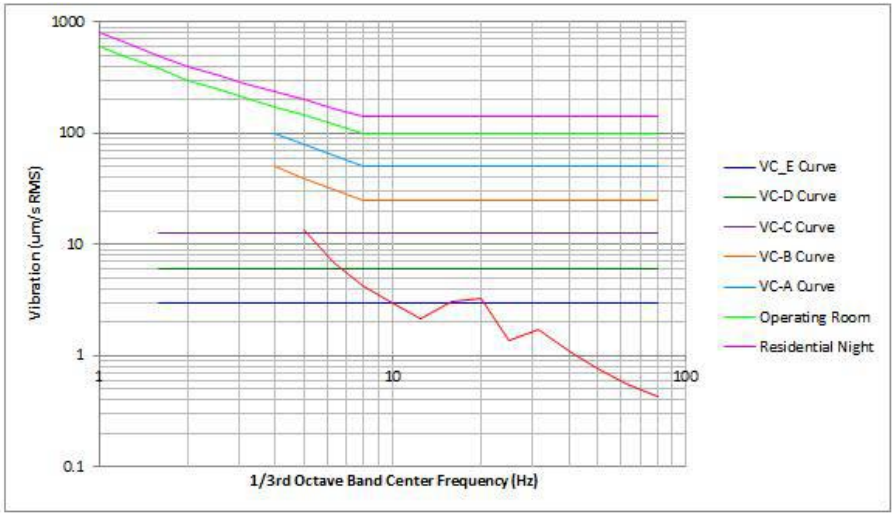


Figure F100: University of Melbourne Faculty of Engineering Building 165, Ground – Leading Thermal Analyser

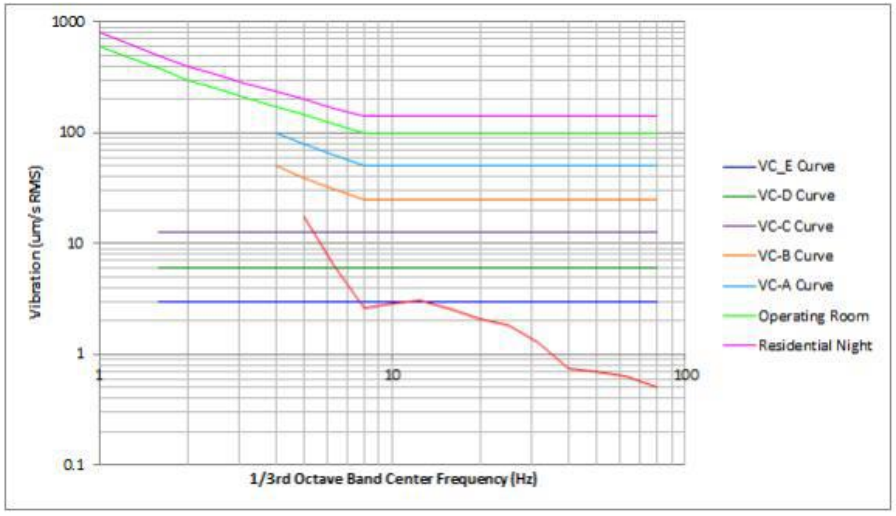


Figure F101: University of Melbourne Faculty of Engineering Building 165, Ground - Substance Analyser

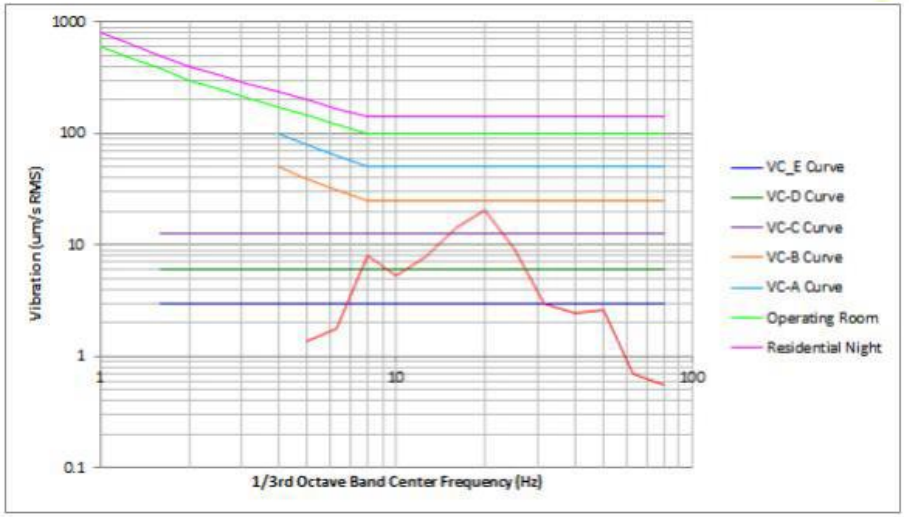


Figure F102: University of Melbourne Faculty of Engineering Building 170, Level 1 – 3D X-Ray

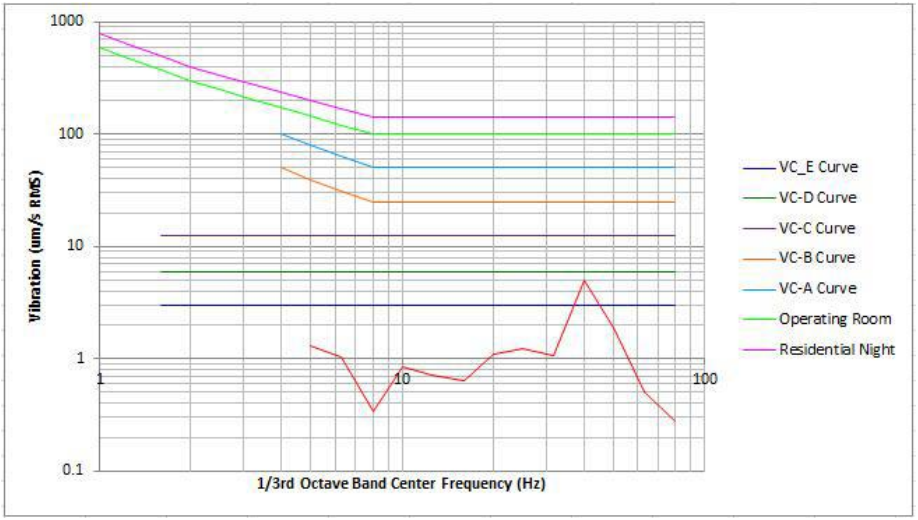


Figure F103: Kenneth Myer Building, Ground Floor – MRI

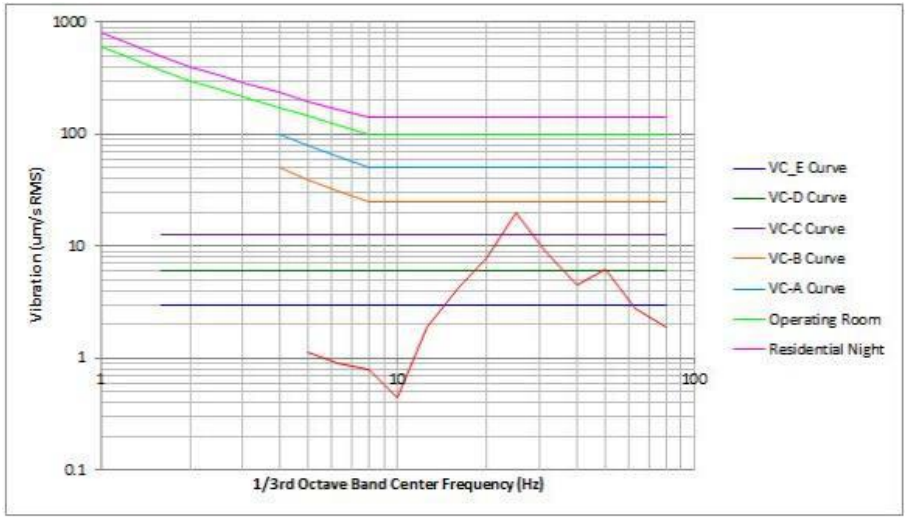


Figure F104: Bio21 Institute – Electron Scanning Microscope

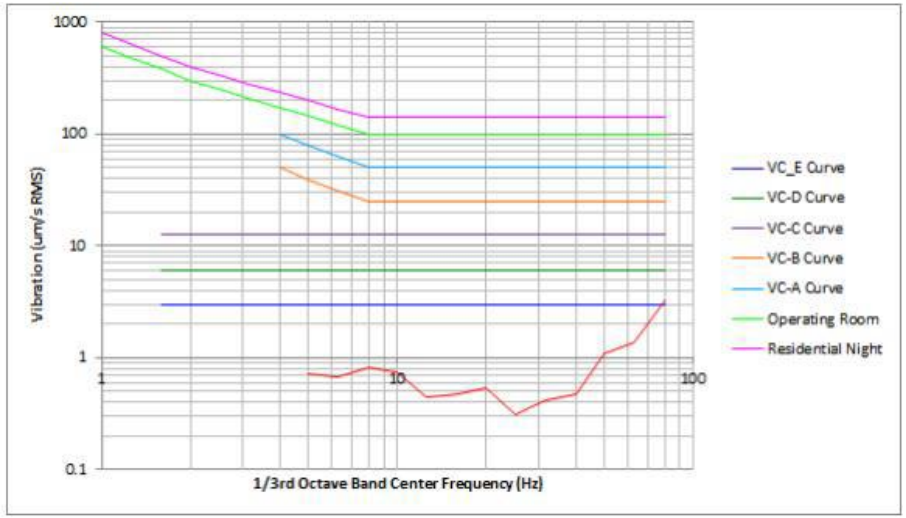


Figure F105: RMIT University Building 100, Basement 2 – Robotics Lab

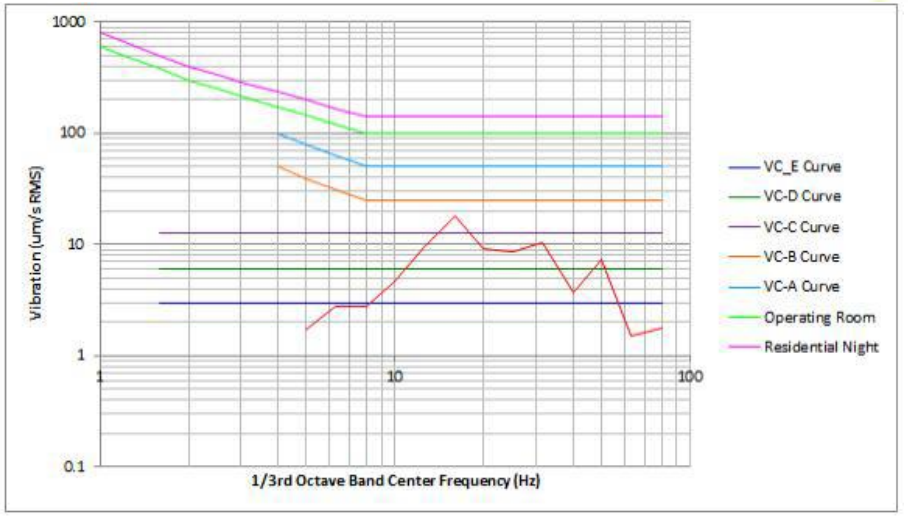


Figure F106: RMIT University Building 14, Level 7 – Electron Microscope

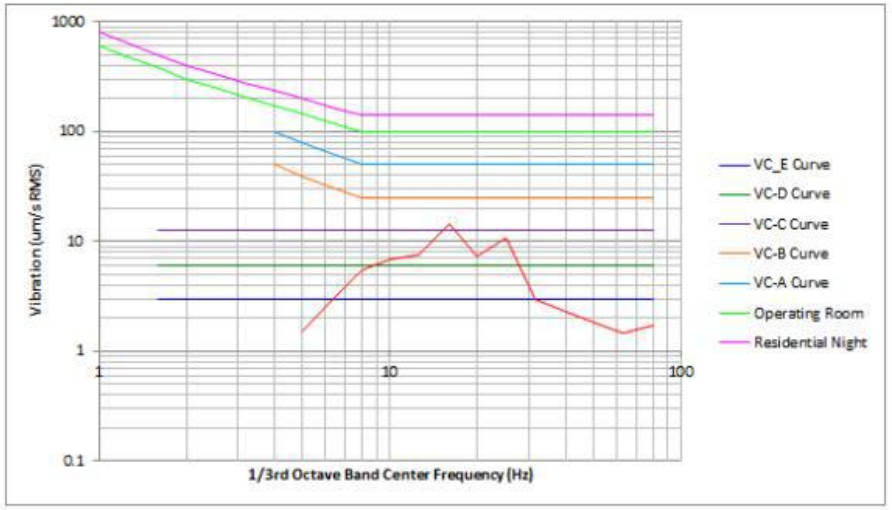


Figure F107: RMIT University Building 14, Level 5 – Confocal Microscope

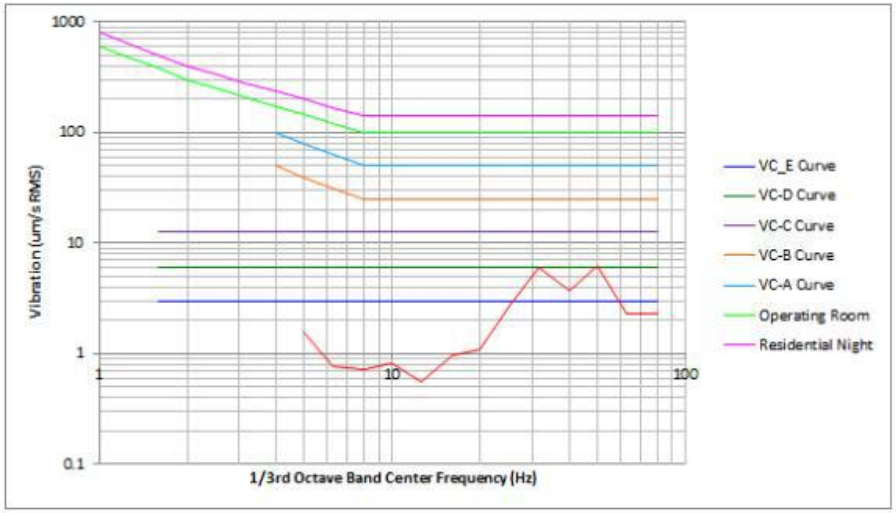


Figure F108: RMIT University Building 3, Ground – NMR Spectrometer

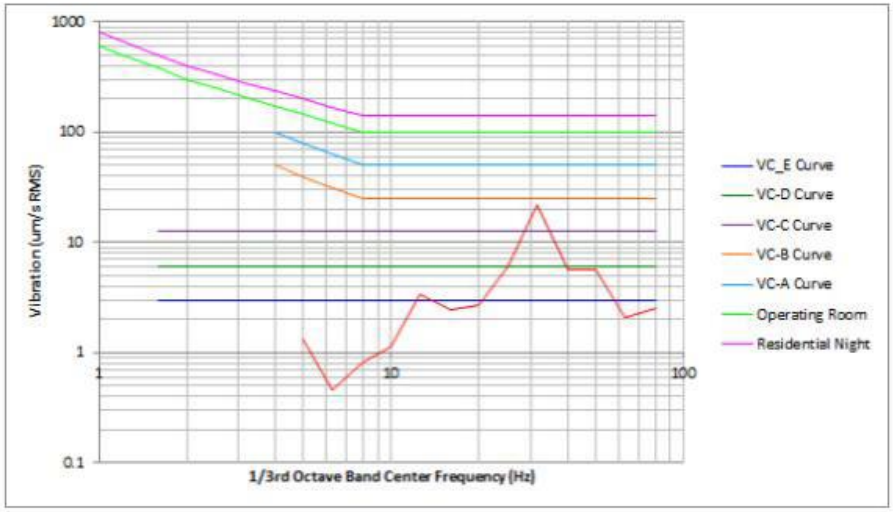


Figure F109: RMIT University Building 7, Level 4 – The Fib

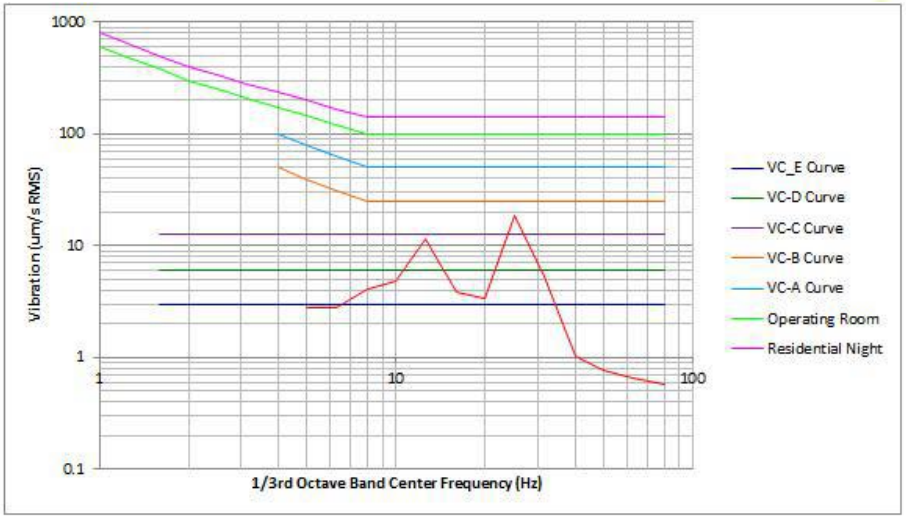


Figure F110: RMIT University Building 12, Level 9 – Photonics Lab

F.6 Underwater Ambient Noise Measurements

F.6.1 Summary

Underwater noise measurements have been conducted in the Yarra River to determine the typical existing ambient noise levels before any potential construction or operational noise associated with the Melbourne Metro is introduced.

The intention was to measure typical underwater noise levels experienced by marine life in the Yarra River to provide a baseline for any potential future impact associated with the Melbourne Metro.

F.6.2 Underwater Noise

Underwater noise, like airborne noise, is measured in decibels (dB) however; sound pressure level measurements for underwater noise are made with reference to 1 µPa as opposed to the reference for air which is 20 µPa. This results in a different range of typical noise levels (usually much higher) for underwater noise. Underwater noise levels are not directly comparable to noise levels in air.

Underwater noise is generally reported in terms of linear dB (or dB(Z)) as opposed to the A-weighting scale (dB(A)) which usually used in airborne acoustics. The dB(A) scale represents the subjective human response to noise. Since humans are not generally the subjects of interest in underwater noise impacts, it is more appropriate to use dB(Z).

A weighting correction for underwater noise has been developed to take into account the hearing response of various marine animals. These do not represent equal loudness curves (or Phons) and simply roll-off the lower and upper frequencies based on the estimated auditory bandwidth of the particular animal or group of animals under investigation. This weighting (M-Weighting) is the designated weighting for marine life (usually ocean) and is often grouped for a range of animals including low-frequency (e.g. baleen whales, M_{lf}), mid-frequency (majority of toothed whales, M_{df}), high frequency cetaceans (other toothed whales, M_{hf}) and Pinnipeds (e.g. seals and sea lions, M_{pw}), whose estimated auditory hearing range corresponds to 7 Hz - 22 kHz, 150 Hz - 160 kHz, 200 Hz - 180 kHz and 75 Hz - 30 kHz respectively[1].

F.6.3 Methodology

F.6.3.1 Underwater Noise Monitoring Locations

Underwater noise measurements were made at two locations:

Location 1 was off the western side (downstream of the bridge) of the Princes Bridge (St Kilda Road) approximately 4 m from the northern bridge pier, to minimise any acoustic reflections off the pier.

Location 2 was approximately 4 m to the south of the northern bridge pier of the Pony Island Southbank footbridge, off a viewing platform of the bridge.

These locations are shown in Figure F111.

F.6.3.2 Measurement Time and Meteorological Conditions

The underwater noise measurements were conducted between approximately 10:30 am and 1:00 pm on Thursday 23 July, 2015. The measurements were undertaken on a calm, partly cloudy day where there was no rain and the Yarra River was calm and not choppy.

During the underwater noise measurements the weather data from the nearest Bureau of Meteorology weather station (Melbourne Olympic Park, Station ID: 086338, approximately 1 km to the south-east) indicated a light breeze (11-18 km/hr from the north) with an air temperature of 11ºC increasing to 19ºC. The water temperature was not directly measured but is known to vary between 9ºC and 25ºC over the course of the year. Based on measured temperature data monitoring[2], the water temperature was expected to be approximately 12ºC during the underwater noise measurements.

The measurements were made between high tide (7:31 am) and low tide (1:31 pm), near the low tide, so that the river water flow was relatively low and it is not expected that river flow generated spurious noise levels. The measurements were made in the middle of the day as this is when the commercial and tourist ferries were most active and when the typically higher underwater noise levels would be experienced in the Yarra.

F.6.3.3 Acoustic Equipment

The equipment used to conduct the underwater noise measurements is shown in Table F36.

Table F35: Underwater Noise Measurement Equipment Details

Manufacturer	Type of Instrument	Serial No.	Last Calibration Date
Bruel & Kjaer	Sound Level Analyser 2250	2506886	11/09/2013
Bruel & Kjaer	Miniature Hydrophone Type 8103 D-500	2972963	28/11/2014
Bruel & Kjaer	Hydrophone preamplifier - Type 2647B	2979614	NA

The B&K 8103 miniature hydrophone has frequency response between the frequency ranges of:

0.1 kHz - 20 kHz of +1 dB, -1.5 dB

0.1 kHz - 100 kHz of +1.5 dB, -6 dB

[1] Underwater Piling Noise Guidelines, Government of South Australia (Nov 2012).

[2] Figure 11 and 18 - *Yarra River Focus Catchment Summary Report*, eWater Collaborative Research Centre (Sept 2011).

Figure F111: Underwater Noise Measurement Locations

F.6.3.4 Underwater Noise Monitoring

The measurement locations were selected to be representative of the general underwater acoustic environment.

A weighted line, marked at intervals, was used to first determine the approximate depth of the Yarra River at the two measurement locations. The water depth at Location 1 was found to be approximately 4.3 m deep and 3.5 m deep at Location 2.

The transducer was fixed to the line approximately 2 metres from the water surface and therefore approximately in the mid-water column at both measurement locations. The line was kept relatively taught to minimise any spurious signals due to vertical movement of the transducer in the water, where a change in pressure may be interpreted as an acoustic signal.

A metal piece was used to fix the transducer away from the line to protect the transducer and prevent it from hitting the line in the case of any turbulence in the water (e.g. ferry wake etc.).

The depth of the transducer was motivated by the desire to sample representative underwater noise, avoid as far as possible the acoustic reflections from water-air interface and any objects or acoustic reflections from the river bottom.

Measurements were made using the Advanced Sound Analyser mode of the B&K 2250 SLM, and measurement length was controlled manually to capture general underwater noise levels, as well as noise levels when ferries and other river traffic was active.

Two spotters were used to identify any ferries or other river craft movement during the measurements.

F.6.4 Results and Analysis

F.6.4.1 Location 1 - Princes Bridge

Ten measurements were made at Location 1. These included typical underwater noise levels where there was no obvious sign of watercraft on the river and during times when ferries and rowers were present. Table F36 presents the results of the measurements.

Table F36: Underwater Noise Measurement Results at Location 1

Ref	Start Time	Meas. Time (min:sec)	dB L_{Z90}	dB L_{Z50}	dB L_{Zeq}	dB L_{ZFMax}	dB L_{ZE}	Comment
1	10:51	1:56	134	137	139	146	160	No obvious ferry movements
2	10:53	3:08	136	139	142	154	165	No obvious ferry movements
3	10:57	2:56	136	139	142	151	164	Ferry from downstream passing under footbridge to the west and stopping at Southbank berth (Commercial Berth 16)
4	11:01	6:43	136	139	142	154	168	Ferry idling at Southbank berth (Commercial Berth 16) and ferry leaving Federation Square going upstream away from measurement location (from Commercial Berth 18)
5	11:08	0:56	137	139	142	151	159	Ferry passing under Princess Bridge - through far arch (approximately 40 m from transducer)
6	11:09	3:43	137	140	143	155	167	8-skull passing through near side arch
7	11:13	3:49	135	138	141	154	165	8-skull passing through far side arch
8	11:17	4:19	134	138	142	154	166	Some distant ferry noise
9	11:21	3:52	132	136	142	156	165	Some distant ferry noise
10	11:25	5:04	132	135	139	152	164	No obvious ferry movements

The measurements show that although there were times where there were no obvious sources of underwater noise, the ambient noise levels were quite high (Ref 1, 2, 10), with little difference compared to measurements when there were clearly sources of high underwater noise levels present relatively nearby (Ref 5).

The 1/3 octave noise levels were also measured and these are shown in Figure F112.

The high noise levels at low frequencies, with strong peaks at 16 Hz and a broader peak at 80 Hz, does not seem to correlate to the presence of nearby underwater noise sources such as ferries. The 1/3 octave band noise data shows that the presence of ferries or other significant noise sources can be identified, but the effect generally occurs at frequencies above 400 Hz.

The values in Table F32 are unweighted (linear) broadband noise levels. Relatively high levels at low frequencies dominate the overall noise levels regardless of the presence of nearby underwater nose sources.

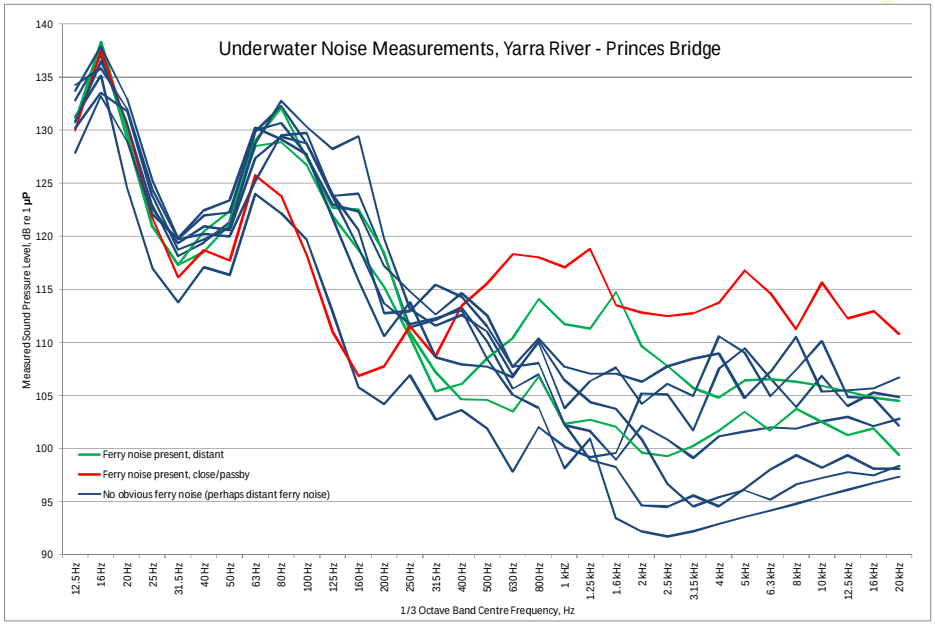


Figure F112: 1/3 Octave Band Noise Measurements at Location 1

The cause of the relatively high low frequency noise is not known, but may be associated with potentially significant sources of low frequency noise from international shipping and bulk container ships and carriers, located further downstream in the Yarra River approximately 3-4 km to the west. Given the distance from these potential noise sources and the width and depth of the Yarra River it would be expected that higher frequency underwater noise levels would dissipate faster than low frequency noise.

The red line in Figure F112 indicates the measured result when a commercial ferry passed beneath Princes Bridge (Ref 5), approximately 40 metres from the measurement location. The measured noise level may have been reduced due to the shielding of the bridge pier as the ferry passed under the bridge. Nevertheless, the measured noise levels at frequencies above 400 Hz were significantly higher than for the other measurement scenarios.

The two green lines in Figure F112 indicate measurements where ferries were present in the river, but located at commercial berths approximately 110 and 130 metres from the measurement location.

The blue lines in Figure F112 represent measurements where ferries were not present and there were no obvious sources of underwater noise in the immediate vicinity of the measurement location.

F.6.4.2 Location 2 - Pony Island, Southbank Pedestrian Bridge

A total of fifteen valid measurements were made at Location 2. During these measurements, the ferry traffic was more significant, with a number of ferries passing the measurement location and many arriving and leaving berths located near the measurement location. Table F37 presents the results of the measurements.

Table F37: Underwater Noise Measurement Results at Location 2

Ref	Start Time	Meas. Time (min:sec)	dB L_{Z90}	dB L_{Z50}	dB L_{Zeq}	dB L_{ZFMax}	dB L_{ZE}	Comment
11	11:49	6:21	134	137	140	147	166	Ferry at Commercial Berth 18 - Fed Square (approximately 350 m away)
12	11:56	6:37	132	135	138	152	164	Two ferries at Commercial Berth 18 - Fed Square (approximately 350 m away)
13	12:03	1:21	131	134	136	141	156	Ferry approaching from Princes Bridge (through left arch)
14	12:04	0:44	126	141	145	154	162	Ferry passing by measurement location under footbridge at a distance of approximately 10 m
15	12:09	4:14	137	141	143	153	167	No ferry movement
16	12:14	2:28	135	139	141	151	162	Ferry approaching from Princes Bridge (through left arch), then turning to berth at Southbank (Commercial Berth 16)
17	12:16	3:49	136	140	142	161	165	Ferry approaching from Princes Bridge (through left arch), then turning to berth at Southbank (Commercial Berth 16)
18	12:21	1:20	130	137	143	164	162	Ferry turning approaching footbridge from Southbank Commercial Berth 16
19	12:22	1:19	136	140	143	153	162	Ferry passing by measurement location under footbridge at a distance of approximately 10 m
20	12:30	0:47	134	138	149	171	166	Small ferry pass by measurement location from bay going upstream
21	12:32	3:34	135	139	142	153	165	Small ferry idling at Southbank Berth (Commercial Berth 16)
22	12:36	1:11	135	138	139	146	158	Small ferry heading from Southbank Berth (Commercial Berth 16) upstream away from measurement location
23	12:39	1:05	137	142	149	168	167	Ferry from bay going upstream close to measurement location
24	12:40	1:09	136	141	148	168	167	Ferry turning at Southbank Berth, approaching measurement location
25	12:45	1:45	136	141	146	160	166	Two ferry pass-bys both going downstream, close to measurement location (approximately 10 m)

The results at Location 2 are similar to those measured at Location 1, although there were a greater number of ferries operating near the measurement location. There was not a significant variation in the main acoustic descriptors.

Figure F113 shows the 1/3 octave band noise level for each of the measurements at Location 2. The low frequency peaks seen at Location 1 are still present and there appears to be another low frequency peak at 40 Hz. As with the measurements at Location 1, the presence of ferries is more easily determined by looking at the spectrum at frequencies above approximately 160 Hz. The measured noise levels are similar below this frequency, whether there are ferries nearby or not, but significantly higher when ferries are present at frequencies above 160 Hz.

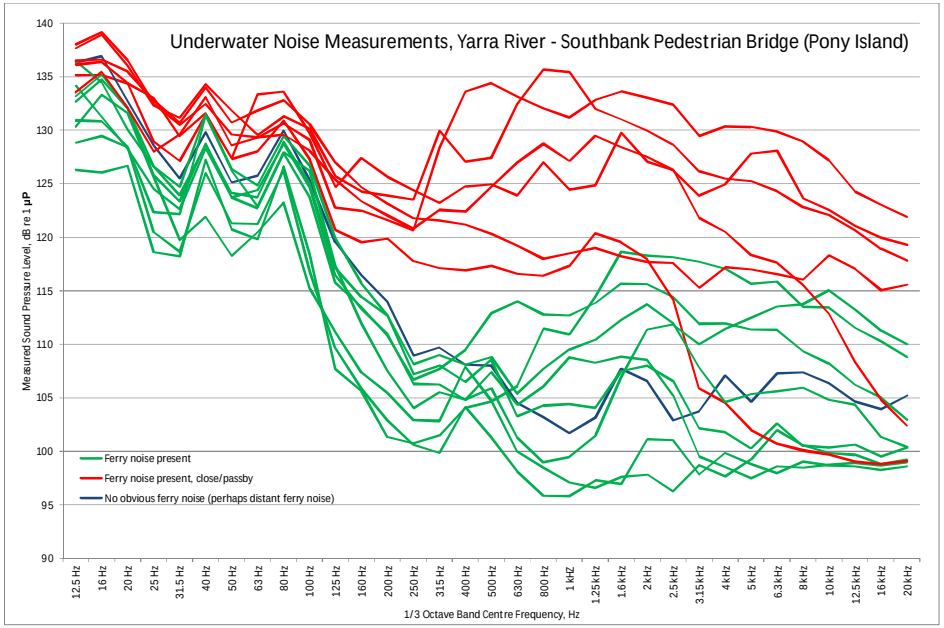


Figure F113: 1/3 Octave Band Noise Measurements at Location 2

The red lines in Figure F113 indicate measurements where ferries passed close to the measurement location, while the green lines show the measurement results when ferries were present. There was only one occasion when there were no obvious sources of underwater noise present in the river (blue line).

In general, the noise levels (above 160 Hz) were significantly higher when ferries passed by the measurement location (generally 10-20 metres from the transducer).

F.6.4.3 Summary of Noise Measurements

The combined 1/3 octave noise spectra from both underwater noise measurement locations is shown in Figure F114. This figure shows that there is a high level of noise at low frequency in a number of peaks (16 Hz, 40 Hz and 80 Hz) which was noted whether the ferries were present or not. For this reason the overall noise level descriptors of sound (dB L_{Z90}, dB L_{Z50}, dB L_{Zeq} etc.) was not found to be a good descriptor of the noise environment.

The noise associated with the ferry pass-bys was most easily identified at frequencies above approximately 250 Hz where the measured noise levels are generally above 115 dB, and up to 135 dB. The ambient noise level when there were no ferried or other significant noise sources identified nearby, the levels were generally less than 110 dB (above 250 Hz).

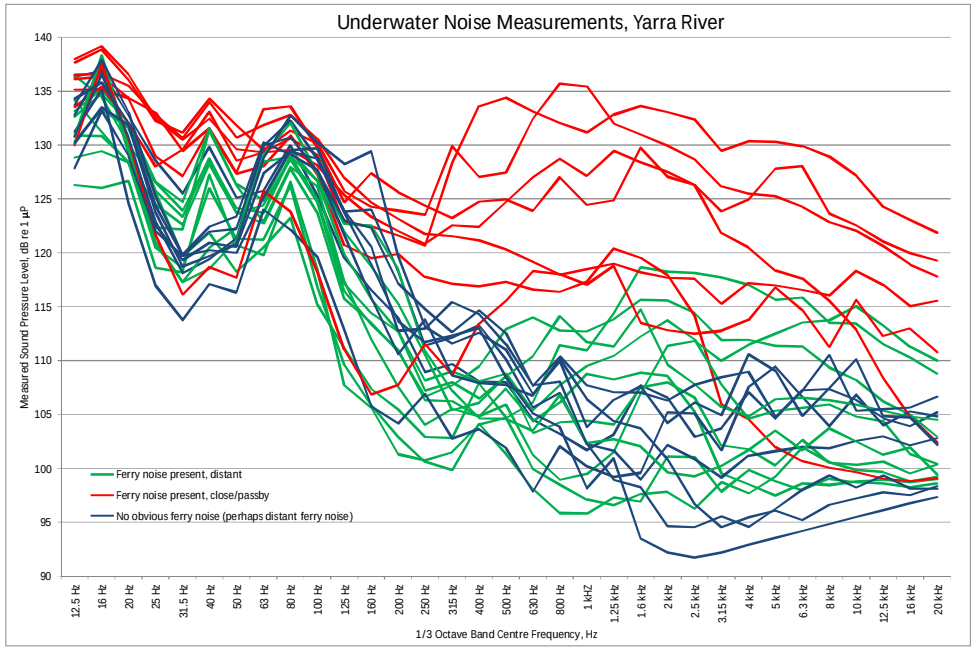


Figure F114: Combined 1/3 Octave Band Noise Measurements at both locations

F.6.5 Conclusion

Ambient underwater noise measurements have been conducted at two locations on the Yarra River, off Princes Bridge and off the Pony Island Southbank Footbridge.

The measurements indicated that the overall noise levels in the river did not vary significantly (136-149 dB L_{Zeq}) whether in the presence of ferries or when there were no obvious significant sources of underwater noise.

High levels of low frequency noise were measured in the river with peaks at 16 Hz, 40 Hz and 80 Hz (1/3 octave band centre frequencies) which were independent of the nearby presences of ferries or other clearly identifiable sources of underwater noise. These peaks dominated the overall noise levels so that there was little variation in the overall noise descriptors.

A significant increase in noise levels was measured at frequencies above 250 Hz when ferries passed close to the transducer (10 to 20 m from the transducer) and these ferry pass-bys were clearly identifiable in the measured 1/3 octave band noise data.

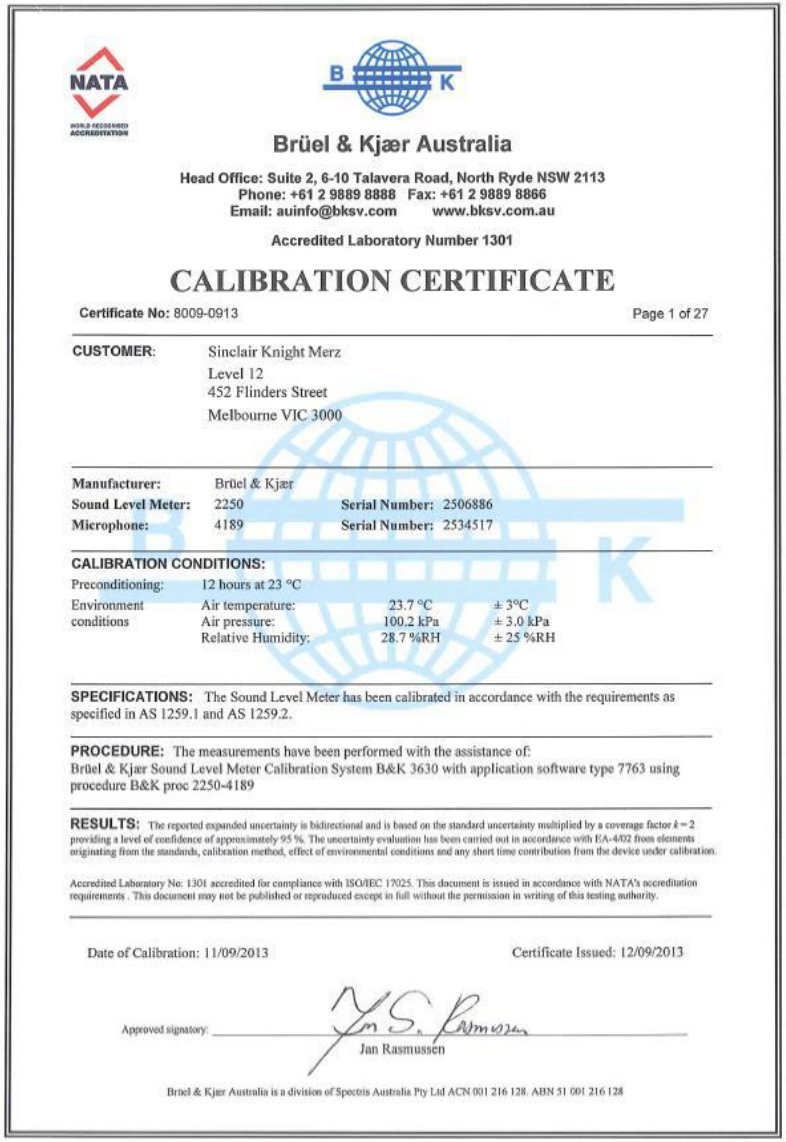
In general, the ambient noise level in the Yarra River, in the absence of ferry or other significant noise sources, was measured to be typically between 95-115 dB above 250 Hz. At distance of 10-20 metres of the moving ferries, the noise levels were measured to be typically between 115-135 dB, above 250 Hz.

These underwater noise measurements indicate that the overall noise level in the Yarra is dominated by low frequency noise and overall noise levels were found to be between 136-149 dB L_{Zeq}.

The ambient noise levels in the Yarra River above approximately 250 Hz varies significantly from as low as 95 dB (for an individual 1/3 octave band) in the absence of ferries to as high as 135 dB at approximately 10 metres from a passing ferry.

F.7 Calibration Certificates

F.7.1 Sound Level Meter and Calibrator Calibration Certificates



Brüel & Kjær Australia

Head Office: Suite 2, 6-10 Talavera Road, North Ryde NSW 2113
Phone: +61 2 9889 8888 Fax: +61 2 9889 8866
Email: auinfo@bksv.com www.bksv.com.au

Accredited Laboratory Number 1301

CALIBRATION CERTIFICATE

Certificate No: 8009-0913 Page 1 of 27

CUSTOMER: Sinclair Knight Merz
Level 12
452 Flinders Street
Melbourne VIC 3000

Manufacturer: Brüel & Kjær
Sound Level Meter: 2250 Serial Number: 2506886
Microphone: 4189 Serial Number: 2534517

CALIBRATION CONDITIONS:

Preconditioning:	12 hours at 23 °C		
Environment conditions	Air temperature:	23.7 °C	± 3°C
	Air pressure:	100.2 kPa	± 3.0 kPa
	Relative Humidity:	28.7 %RH	± 25 %RH

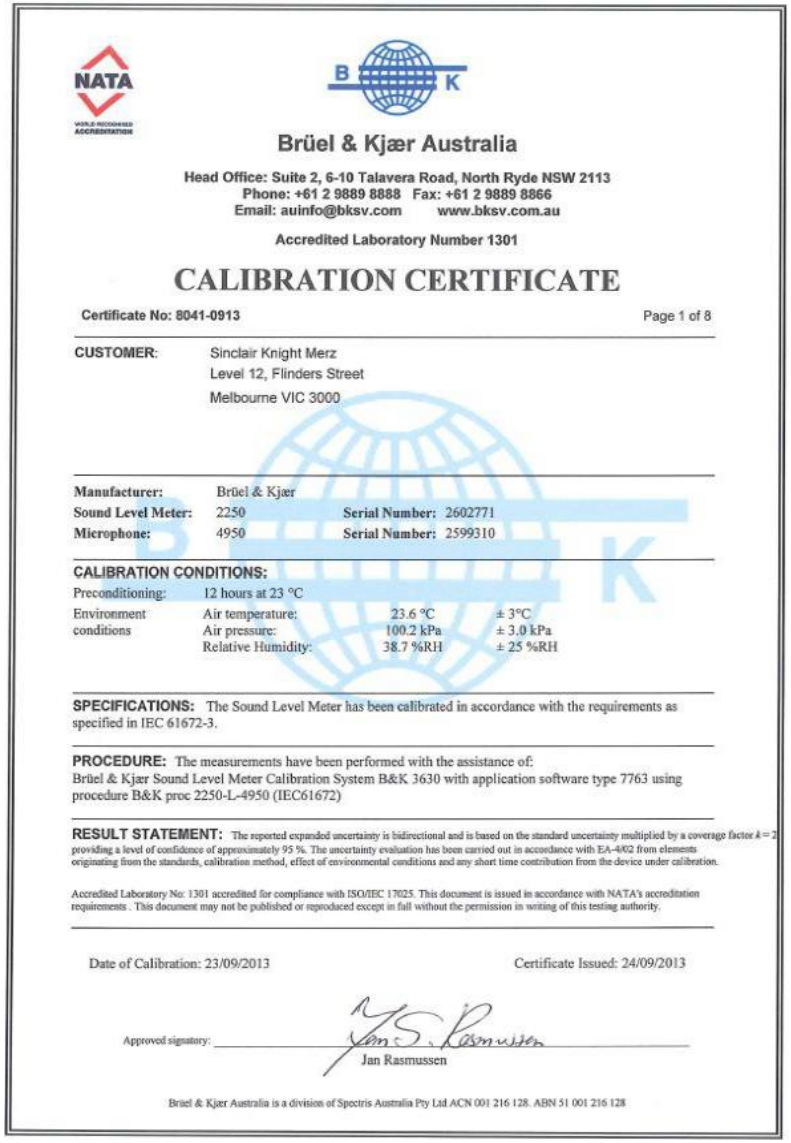
SPECIFICATIONS: The Sound Level Meter has been calibrated in accordance with the requirements as specified in AS 1259.1 and AS 1259.2.

PROCEDURE: The measurements have been performed with the assistance of:
Brüel & Kjær Sound Level Meter Calibration System B&K 3630 with application software type 7763 using procedure B&K proc 2250-4189

RESULTS: The reported expanded uncertainty is bidirectional and is based on the standard uncertainty multiplied by a coverage factor $k = 2$ providing a level of confidence of approximately 95 %. The uncertainty evaluation has been carried out in accordance with EA-4/02 from elements originating from the standards, calibration method, effect of environmental conditions and any short time contribution from the device under calibration.

Date of Calibration: 11/09/2013 Certificate Issued: 12/09/2013

Approved signatory: Jan Rasmussen



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Accredited Laboratory Number 1301

CALIBRATION CERTIFICATE

Certificate No: 8041-0913 Page 1 of 8

CUSTOMER: Sinclair Knight Merz
Level 12, Flinders Street
Melbourne VIC 3000

Manufacturer: Brüel & Kjær
Sound Level Meter: 2250 Serial Number: 2602771
Microphone: 4950 Serial Number: 2599310

CALIBRATION CONDITIONS:

Preconditioning:	12 hours at 23 °C		
Environment conditions	Air temperature:	23.6 °C	± 3°C
	Air pressure:	100.2 kPa	± 3.0 kPa
	Relative Humidity:	38.7 %RH	± 25 %RH

SPECIFICATIONS: The Sound Level Meter has been calibrated in accordance with the requirements as specified in IEC 61672-3.

PROCEDURE: The measurements have been performed with the assistance of:
Brüel & Kjær Sound Level Meter Calibration System B&K 3630 with application software type 7763 using procedure B&K proc 2250-L-4950 (IEC61672)

RESULT STATEMENT: The reported expanded uncertainty is bidirectional and is based on the standard uncertainty multiplied by a coverage factor $k = 2$ providing a level of confidence of approximately 95 %. The uncertainty evaluation has been carried out in accordance with EA-4/02 from elements originating from the standards, calibration method, effect of environmental conditions and any short time contribution from the device under calibration.

Date of Calibration: 23/09/2013 Certificate Issued: 24/09/2013

Approved signatory: Jan Rasmussen

Brüel & Kjær Australia

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Accredited Laboratory Number 1301

CALIBRATION CERTIFICATE

No.:8040-0913

Owner: Sinclair Knight Merz
Level 12, Flinders Street
Melbourne VIC 3000

CALIBRATION OF:

Manufacturer:	Brüel & Kjær		
Equipment Description:	Sound Calibrator	IEC Class:	1
Model Type:	4231	Serial Number.:	2542100

PROCEDURE:

The measurements have been performed with the assistance of Brüel & Kjær acoustic calibrator calibration application software Type 7794 using calibration procedure 4231 Complete

CALIBRATION CONDITIONS:

Environment conditions:

Air temperature:	23.3	°C
Air pressure:	100	kPa
Relative Humidity:	43.5	%RH

RESULTS:

- ☐ Initial Calibration
- ☐ Calibration before repair/adjustment
- ☒ Recalibration without repair/adjustment
- ☐ Calibration after repair/adjustment

SPECIFICATIONS:

The acoustic calibrator has been calibrated in accordance with the requirements as specified in IEC60942.
This Laboratory is accredited for compliance with ISO/IEC 17025
This document is issued in accordance with NATA's accreditation requirements
The reported expanded uncertainty is bidirectional and is based on the standard uncertainty multiplied by a coverage factor $k = 2$, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with EA-4/02 from elements originating from the standards, calibration method, effect of environmental conditions and any short time contribution from the calibrator under calibration.

Date of Calibration: 23/09/2013 Certificate issued: 23/09/2013

Approved Signatory: Jan Rasmussen

Brüel & Kjær Australia

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Accredited Laboratory Number 1301

CALIBRATION CERTIFICATE

No.:8010-0913

Owner: Sinclair Knight Merz
Level 12
452 Flinders Street
Melbourne VIC 3000

CALIBRATION OF:

Manufacturer:	Brüel & Kjær		
Equipment Description:	Sound Calibrator	IEC Class:	1
Model Type:	4231	Serial Number.:	2583258

PROCEDURE:

The measurements have been performed with the assistance of Brüel & Kjær acoustic calibrator calibration application software Type 7794 using calibration procedure 4231 Complete

CALIBRATION CONDITIONS:

Environment conditions:

Air temperature:	23.8	°C
Air pressure:	100.2	kPa
Relative Humidity:	28.4	%RH

RESULTS:

- ☐ Initial Calibration
- ☐ Calibration before repair/adjustment
- ☒ Recalibration without repair/adjustment
- ☐ Calibration after repair/adjustment

SPECIFICATIONS:

The acoustic calibrator has been calibrated in accordance with the requirements as specified in IEC60942.
This Laboratory is accredited for compliance with ISO/IEC 17025
This document is issued in accordance with NATA's accreditation requirements
The reported expanded uncertainty is bidirectional and is based on the standard uncertainty multiplied by a coverage factor $k = 2$, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with EA-4/02 from elements originating from the standards, calibration method, effect of environmental conditions and any short time contribution from the calibrator under calibration.

Date of Calibration: 11/09/2013 Certificate issued: 11/09/2013

Approved Signatory: Jan Rasmussen

Brüel & Kjær

Australian Calibration Laboratory
Suite 2, 6-10 Talavera Road, North Ryde NSW 2113, Australia

NATA
Laboratory No. 1301

CERTIFICATE OF CALIBRATION

Certificate No: CAU1500801 Page 1 of 10

CALIBRATION OF:

Sound Level Meter:	Brüel & Kjær	2250	No: 2602771
Microphone:	Brüel & Kjær	4950	No: 2599310
Preamplifier:	Brüel & Kjær	ZC-0032	No: 16596
Supplied Calibrator:	Brüel & Kjær	4231	No: 2542100
Software version:	BZ7130 Version 4.3.2	Pattern Approval:	Approved
Instruction manual:	BE-1774 Version 14	Identification:	

CUSTOMER:

Jacobs Group (Australia) Pty Ltd
Level 11
452 Flinders Street
Melbourne VIC 3000

CALIBRATION CONDITIONS:

Preconditioning: 4 hours at 23 °C
Environment conditions: *see actual values in **Environmental conditions** sections*

SPECIFICATIONS:

The Sound Level Meter has been calibrated in accordance with the requirements as specified in IEC61672-3:2006 class 1. Procedures from IEC 61672-3:2006 were used to perform the periodic tests.

PROCEDURE:

The measurements have been performed with the assistance of Brüel & Kjær Sound Level Meter Calibration System B&K 3630 with application software type 7763 (version 5.0 - DB: 5.00) and test procedure 2250-L-4950.

RESULTS:

	Initial calibration		Calibration prior to repair/adjustment
X	Calibration without repair/adjustment		Calibration after repair/adjustment

The reported expanded uncertainty is based on the standard uncertainty multiplied by a coverage factor $k = 2$ providing a level of confidence of approximately 95 %. The uncertainty evaluation has been carried out in accordance with EA-4/02 from elements originating from the standards, calibration method, effect of environmental conditions and any short time contribution from the device under calibration.

Date of Calibration: 03/09/2015 Certificate issued: 04/09/2015

Sajeeb Tharayil
Calibration Technician

Jan Rasmussen
Approved signatory

Brüel & Kjær

Australian Calibration Laboratory
Suite 2, 6-10 Talavera Road, North Ryde NSW 2113, Australia

NATA
Laboratory No. 1301

CERTIFICATE OF CALIBRATION

Certificate No: CAU1500884 Page 1 of 10

CALIBRATION OF:

Sound Level Meter:	Brüel & Kjær	2250	No: 2506886
Microphone:	Brüel & Kjær	4189	No: 2534517
Preamplifier:	Brüel & Kjær	ZC-0032	No: 10376
Supplied Calibrator:	Brüel & Kjær	4231	No: 2583258
Software version:	BZ7222 Version 4.3.2	Pattern Approval:	PTB
Instruction manual:	BE1712-18	Identification:	

CUSTOMER:

Jacobs Group (Australia) Pty Ltd
Level 11
452 Flinders Street
Melbourne VIC 3000

CALIBRATION CONDITIONS:

Preconditioning: 4 hours at 23 °C
Environment conditions: *see actual values in **Environmental conditions** sections*

SPECIFICATIONS:

The Sound Level Meter has been calibrated in accordance with the requirements as specified in IEC61672-3:2006 class 1. Procedures from IEC 61672-3:2006 were used to perform the periodic tests.

PROCEDURE:

The measurements have been performed with the assistance of Brüel & Kjær Sound Level Meter Calibration System B&K 3630 with application software type 7763 (version 5.1 - DB: 5.10) and test procedure 2250-4189.

RESULTS:

	Initial calibration		Calibration prior to repair/adjustment
X	Calibration without repair/adjustment		Calibration after repair/adjustment

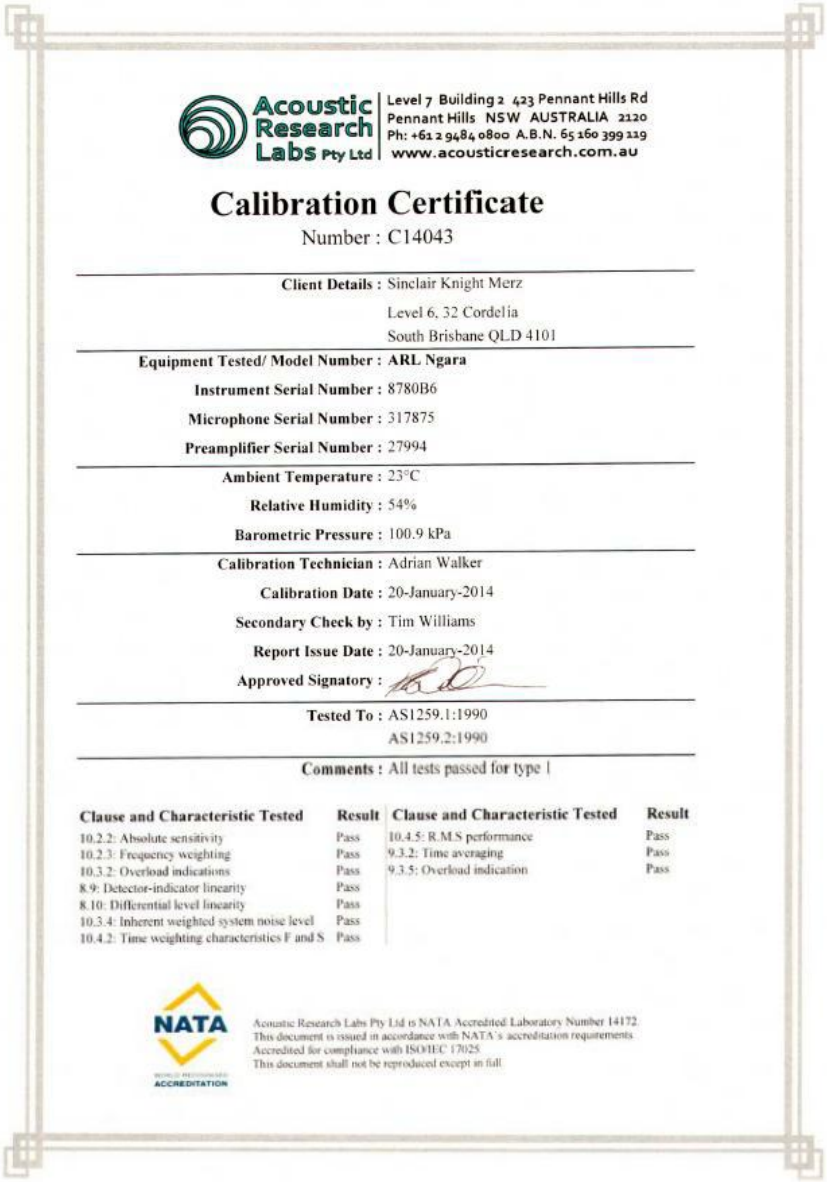
The reported expanded uncertainty is based on the standard uncertainty multiplied by a coverage factor $k = 2$ providing a level of confidence of approximately 95 %. The uncertainty evaluation has been carried out in accordance with EA-4/02 from elements originating from the standards, calibration method, effect of environmental conditions and any short time contribution from the device under calibration.

Date of Calibration: 2015-09-28 Certificate issued: 2015-09-29

Craig Robert Patrick
Calibration Technician

Jan Rasmussen
Approved signatory

F.7.2 NGARA Noise Loggers Calibration Certificates



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Ph: +61 2 9484 0800 A.B.N. 65 160 399 119
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Calibration Certificate

Number : C14043

Client Details : Sinclair Knight Merz
Level 6, 32 Cordelia
South Brisbane QLD 4101

Equipment Tested/ Model Number : **ARL Ngara**
Instrument Serial Number : 8780B6
Microphone Serial Number : 317875
Preamplifier Serial Number : 27994

Ambient Temperature : 23°C
Relative Humidity : 54%
Barometric Pressure : 100.9 kPa

Calibration Technician : Adrian Walker
Calibration Date : 20-January-2014
Secondary Check by : Tim Williams
Report Issue Date : 20-January-2014
Approved Signatory :

Tested To : AS1259.1:1990
AS1259.2:1990

Comments : All tests passed for type 1

Clause and Characteristic Tested	Result	Clause and Characteristic Tested	Result
10.2.2: Absolute sensitivity	Pass	10.4.5: R.M.S performance	Pass
10.2.3: Frequency weighting	Pass	9.3.2: Time averaging	Pass
10.3.2: Overload indications	Pass	9.3.5: Overload indication	Pass
8.9: Detector-indicator linearity	Pass		
8.10: Differential level linearity	Pass		
10.3.4: Inherent weighted system noise level	Pass		
10.4.2: Time weighting characteristics F and S	Pass		

NATA
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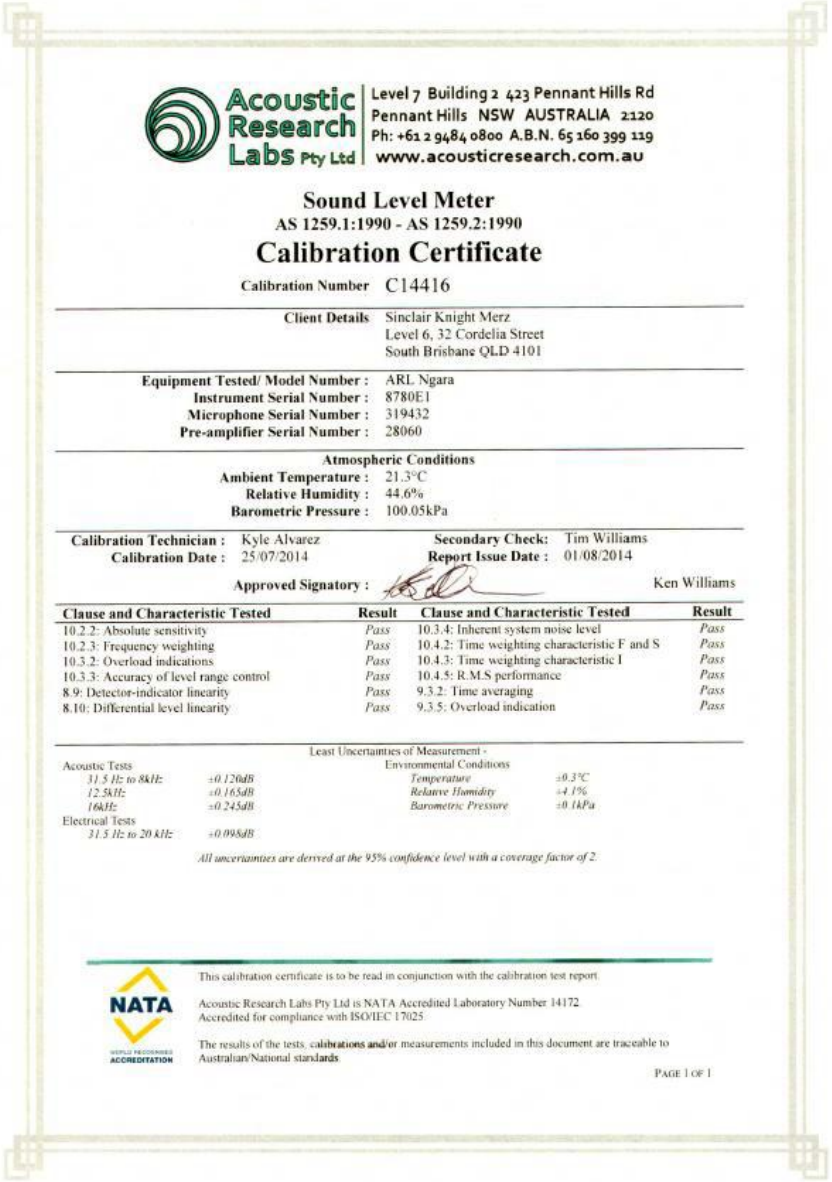

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Pennant Hills NSW AUSTRALIA 2120
Ph: +61 2 9484 0800 A.B.N. 65 160 399 119
www.acousticresearch.com.au

Sound Level Meter
AS 1259.1:1990 - AS 1259.2:1990

Calibration Certificate

Calibration Number C14416

Client Details Sinclair Knight Merz
Level 6, 32 Cordelia Street
South Brisbane QLD 4101

Equipment Tested/ Model Number : ARL Ngara
Instrument Serial Number : 8780E1
Microphone Serial Number : 319432
Pre-amplifier Serial Number : 28060

Atmospheric Conditions
Ambient Temperature : 21.3°C
Relative Humidity : 44.6%
Barometric Pressure : 100.05kPa

Calibration Technician : Kyle Alvarez
Calibration Date : 25/07/2014
Secondary Check: Tim Williams
Report Issue Date : 01/08/2014
Approved Signatory : Ken Williams

Clause and Characteristic Tested	Result	Clause and Characteristic Tested	Result
10.2.2: Absolute sensitivity	*Pass*	10.3.4: Inherent system noise level	*Pass*
10.2.3: Frequency weighting	*Pass*	10.4.2: Time weighting characteristic F and S	*Pass*
10.3.2: Overload indications	*Pass*	10.4.3: Time weighting characteristic I	*Pass*
10.3.3: Accuracy of level range control	*Pass*	10.4.5: R.M.S performance	*Pass*
8.9: Detector-indicator linearity	*Pass*	9.3.2: Time averaging	*Pass*
8.10: Differential level linearity	*Pass*	9.3.5: Overload indication	*Pass*

Least Uncertainties of Measurement -

Acoustic Tests		Environmental Conditions	
31.5 Hz to 8kHz	*±0.120dB*	*Temperature*	*±0.3°C*
12.5kHz	*±0.165dB*	*Relative Humidity*	*±4.1%*
16kHz	*±0.245dB*	*Barometric Pressure*	*±0.1kPa*
Electrical Tests			
31.5 Hz to 20 kHz	*±0.098dB*		

All uncertainties are derived at the 95% confidence level with a coverage factor of 2.

NATA
WORLD RECOGNISED ACCREDITATION

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Calibration Certificate

Number : C14368

Client Details :	Sinclair Knight Merz Level 11, 452 Flinders Street Melbourne VIC 3000
Equipment Tested/ Model Number :	**ARL Ngara**
Instrument Serial Number :	8780E3
Microphone Serial Number :	319434
Preamplifier Serial Number :	28062
Ambient Temperature :	24.6°C
Relative Humidity :	34.1%
Barometric Pressure :	100.56 kPa
Calibration Technician :	Luke Hudson
Calibration Date :	03-July-2014
Secondary Check by :	Tim Williams
Report Issue Date :	03-July-2014
Approved Signatory :	
Tested To :	AS1259.1:1990 AS1259.2:1990
Comments :	All tests passed for type 1

Clause and Characteristic Tested	Result	Clause and Characteristic Tested	Result
10.2.2: Absolute sensitivity	Pass	10.4.5: R.M.S performance	Pass
10.2.3: Frequency weighting	Pass	9.3.2: Time averaging	Pass
10.3.2: Overload indications	Pass	9.3.5: Overload indication	Pass
8.9: Detector-indicator linearity	Pass		
8.10: Differential level linearity	Pass		
10.3.4: Inherent weighted system noise level	Pass		
10.4.2: Time weighting characteristics F and S	Pass		

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Calibration Certificate

Number : C14295

Client Details :	Sinclair Knight Merz Level 11, 452 Flinders Street Melbourne VIC 3000
Equipment Tested/ Model Number :	**ARL Ngara S-Pack**
Instrument Serial Number :	87811E
Microphone Serial Number :	320655
Preamplifier Serial Number :	28214
Ambient Temperature :	23.6°C
Relative Humidity :	39.7%
Barometric Pressure :	99.62 kPa
Calibration Technician :	Kyle Alvarez
Calibration Date :	03-June-2014
Secondary Check by :	Sandra Minto
Report Issue Date :	03-June-2014
Approved Signatory :	
Tested To :	AS1259.1:1990 AS1259.2:1990
Comments :	All tests passed for type 1

Clause and Characteristic Tested	Result	Clause and Characteristic Tested	Result
10.2.2: Absolute sensitivity	Pass	10.4.5: R.M.S performance	Pass
10.2.3: Frequency weighting	Pass	9.3.2: Time averaging	Pass
10.3.2: Overload indications	Pass	9.3.5: Overload indication	Pass
8.9: Detector-indicator linearity	Pass		
8.10: Differential level linearity	Pass		
10.3.4: Inherent weighted system noise level	Pass		
10.4.2: Time weighting characteristics F and S	Pass		

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Calibration Certificate

Number : C14296

Client Details : Sinclair Knight Merz
Level 11, 452 Flinders Street
Melbourne VIC 3000

Equipment Tested/ Model Number : ARL Ngara S-Pack
Instrument Serial Number : 87811F
Microphone Serial Number : 320653
Preamplifier Serial Number : 28216

Ambient Temperature : 25.4°C
Relative Humidity : 64.5%
Barometric Pressure : 99.51 kPa

Calibration Technician : Kyle Alvarez
Calibration Date : 03-June-2014
Secondary Check by : Tim Williams
Report Issue Date : 07-July-2014
Approved Signatory :

Tested To : AS1259.1:1990
AS1259.2:1990

Comments : All tests passed for type 1

Clause and Characteristic Tested	Result	Clause and Characteristic Tested	Result
10.2.2: Absolute sensitivity	Pass	10.4.5: R.M.S performance	Pass
10.2.3: Frequency weighting	Pass	9.3.2: Time averaging	Pass
10.3.2: Overload indications	Pass	9.3.5: Overload indication	Pass
8.9: Detector-indicator linearity	Pass		
8.10: Differential level linearity	Pass		
10.3.4: Inherent weighted system noise level	Pass		
10.4.2: Time weighting characteristics F and S	Pass		

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Sound Level Meter

AS 1259.1:1990 - AS 1259.2:1990

Calibration Certificate

Calibration Number C14437

Client Details Jacobs
452 Flinders Street
Melbourne VIC 3000

Equipment Tested/ Model Number : ARL Ngara
Instrument Serial Number : 878110
Microphone Serial Number : 320560
Pre-amplifier Serial Number : 28236

Atmospheric Conditions
Ambient Temperature : 21.7°C
Relative Humidity : 31.9%
Barometric Pressure : 100.82kPa

Calibration Technician : Corey Stewart
Calibration Date : 12/08/2014
Secondary Check: Tim Williams
Report Issue Date : 14/08/2014
Approved Signatory : Ken Williams

Clause and Characteristic Tested	Result	Clause and Characteristic Tested	Result
10.2.2: Absolute sensitivity	*Pass*	10.3.4: Inherent system noise level	*Pass*
10.2.3: Frequency weighting	*Pass*	10.4.2: Time weighting characteristic F and S	*Pass*
10.3.2: Overload indications	*Pass*	10.4.3: Time weighting characteristic I	*Pass*
10.3.3: Accuracy of level range control	*Pass*	10.4.5: R.M.S performance	*Pass*
8.9: Detector-indicator linearity	*Pass*	9.3.2: Time averaging	*Pass*
8.10: Differential level linearity	*Pass*	9.3.5: Overload indication	*Pass*

Least Uncertainties of Measurement -

Acoustic Tests		Environmental Conditions	
31.5 Hz to 8kHz	*±0.120dB*	*Temperature*	*±0.3°C*
12.5kHz	*±0.165dB*	*Relative Humidity*	*±4.1%*
16kHz	*±0.245dB*	*Barometric Pressure*	*±0.1kPa*
Electrical Tests			
31.5 Hz to 20 kHz	*±0.098dB*		

All uncertainties are derived at the 95% confidence level with a coverage factor of 2.

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Calibration Certificate

Number : C14296

Client Details : Sinclair Knight Merz
Level 11, 452 Flinders Street
Melbourne VIC 3000

Equipment Tested/ Model Number : ARL Ngara S-Pack
Instrument Serial Number : 87811F
Microphone Serial Number : 320653
Preamplifier Serial Number : 28216

Ambient Temperature : 25.4°C
Relative Humidity : 64.5%
Barometric Pressure : 99.51 kPa

Calibration Technician : Kyle Alvarez
Calibration Date : 03-June-2014
Secondary Check by : Tim Williams
Report Issue Date : 07-July-2014
Approved Signatory :

Tested To : AS1259.1:1990
AS1259.2:1990

Comments : All tests passed for type 1

Clause and Characteristic Tested	Result	Clause and Characteristic Tested	Result
10.2.2: Absolute sensitivity	Pass	10.4.5: R.M.S performance	Pass
10.2.3: Frequency weighting	Pass	9.3.2: Time averaging	Pass
10.3.2: Overload indications	Pass	9.3.5: Overload indication	Pass
8.9: Detector-indicator linearity	Pass		
8.10: Differential level linearity	Pass		
10.3.4: Inherent weighted system noise level	Pass		
10.4.2: Time weighting characteristics F and S	Pass		

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Sound Level Meter

AS 1259.1:1990 - AS 1259.2:1990

Calibration Certificate

Calibration Number C14437

Client Details Jacobs
452 Flinders Street
Melbourne VIC 3000

Equipment Tested/ Model Number : ARL Ngara
Instrument Serial Number : 878110
Microphone Serial Number : 320560
Pre-amplifier Serial Number : 28236

Atmospheric Conditions
Ambient Temperature : 21.7°C
Relative Humidity : 31.9%
Barometric Pressure : 100.82kPa

Calibration Technician : Corey Stewart
Calibration Date : 12/08/2014
Secondary Check: Tim Williams
Report Issue Date : 14/08/2014
Approved Signatory : Ken Williams

Clause and Characteristic Tested	Result	Clause and Characteristic Tested	Result
10.2.2: Absolute sensitivity	*Pass*	10.3.4: Inherent system noise level	*Pass*
10.2.3: Frequency weighting	*Pass*	10.4.2: Time weighting characteristic F and S	*Pass*
10.3.2: Overload indications	*Pass*	10.4.3: Time weighting characteristic I	*Pass*
10.3.3: Accuracy of level range control	*Pass*	10.4.5: R.M.S performance	*Pass*
8.9: Detector-indicator linearity	*Pass*	9.3.2: Time averaging	*Pass*
8.10: Differential level linearity	*Pass*	9.3.5: Overload indication	*Pass*

Least Uncertainties of Measurement -

Acoustic Tests		Environmental Conditions	
31.5 Hz to 8kHz	*±0.120dB*	*Temperature*	*±0.3°C*
12.5kHz	*±0.165dB*	*Relative Humidity*	*±4.1%*
16kHz	*±0.245dB*	*Barometric Pressure*	*±0.1kPa*
Electrical Tests			
31.5 Hz to 20 kHz	*±0.098dB*		

All uncertainties are derived at the 95% confidence level with a coverage factor of 2.

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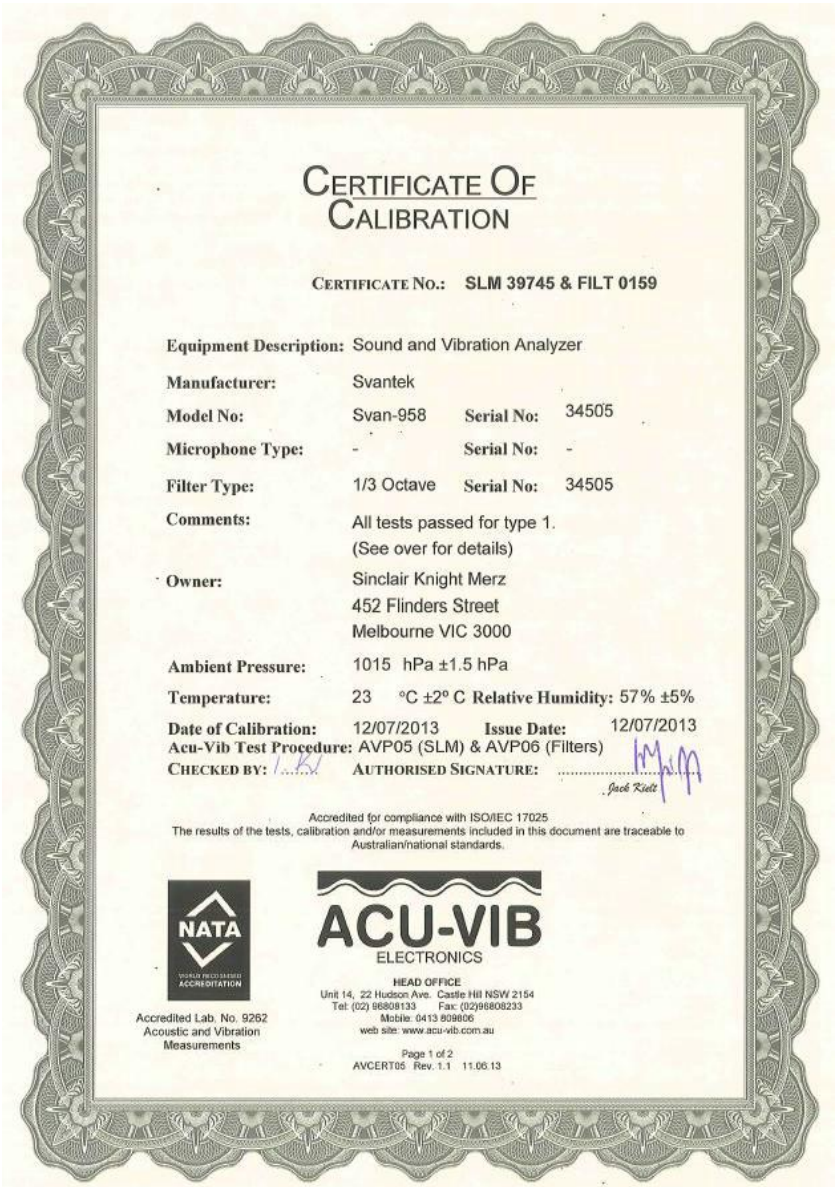
F.7.3 Vibration Analyser Calibration Certificates



CERTIFICATE OF CALIBRATION

CERTIFICATE NO.: SLM 39745 & FILT 0159

Equipment Description:	Sound and Vibration Analyzer		
Manufacturer:	Svantek		
Model No:	Svan-958	**Serial No:**	34505
Microphone Type:	-	**Serial No:**	-
Filter Type:	1/3 Octave	**Serial No:**	34505
Comments:	All tests passed for type 1. (See over for details)		
Owner:	Sinclair Knight Merz 452 Flinders Street Melbourne VIC 3000		
Ambient Pressure:	1015 hPa ±1.5 hPa		
Temperature:	23 °C ±2° C	**Relative Humidity:**	57% ±5%
Date of Calibration:	12/07/2013	**Issue Date:**	12/07/2013
Acu-Vib Test Procedure:	AVP05 (SLM) & AVP06 (Filters)		
CHECKED BY:		**AUTHORISED SIGNATURE:**	Jack Rielt

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NATA
ACCREDITATION
Accredited Lab. No. 9262
Acoustic and Vibration Measurements

ACU-VIB
ELECTRONICS
HEAD OFFICE
Unit 14, 22 Hudson Ave. Castle Hill NSW 2154
Tel: (02) 96808133 Fax: (02)96808233
Mobile: 0413 809806
web site: www.acu-vib.com.au

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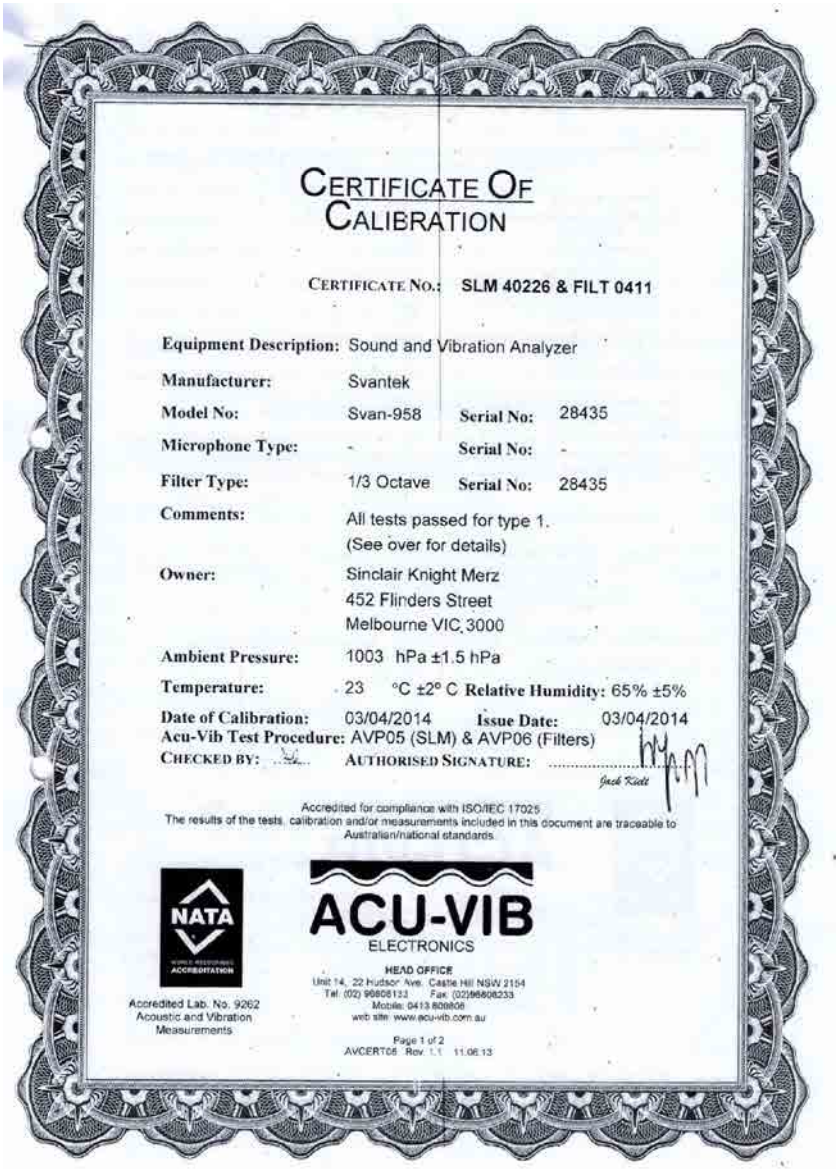
AVCERT05 Rev. 1.1 11.06.13



CERTIFICATE OF CALIBRATION

CERTIFICATE NO.: SLM 40226 & FILT 0411

Equipment Description:	Sound and Vibration Analyzer		
Manufacturer:	Svantek		
Model No:	Svan-958	**Serial No:**	28435
Microphone Type:	-	**Serial No:**	-
Filter Type:	1/3 Octave	**Serial No:**	28435
Comments:	All tests passed for type 1. (See over for details)		
Owner:	Sinclair Knight Merz 452 Flinders Street Melbourne VIC 3000		
Ambient Pressure:	1003 hPa ±1.5 hPa		
Temperature:	23 °C ±2° C	**Relative Humidity:**	65% ±5%
Date of Calibration:	03/04/2014	**Issue Date:**	03/04/2014
Acu-Vib Test Procedure:	AVP05 (SLM) & AVP06 (Filters)		
CHECKED BY:		**AUTHORISED SIGNATURE:**	Jack Rielt

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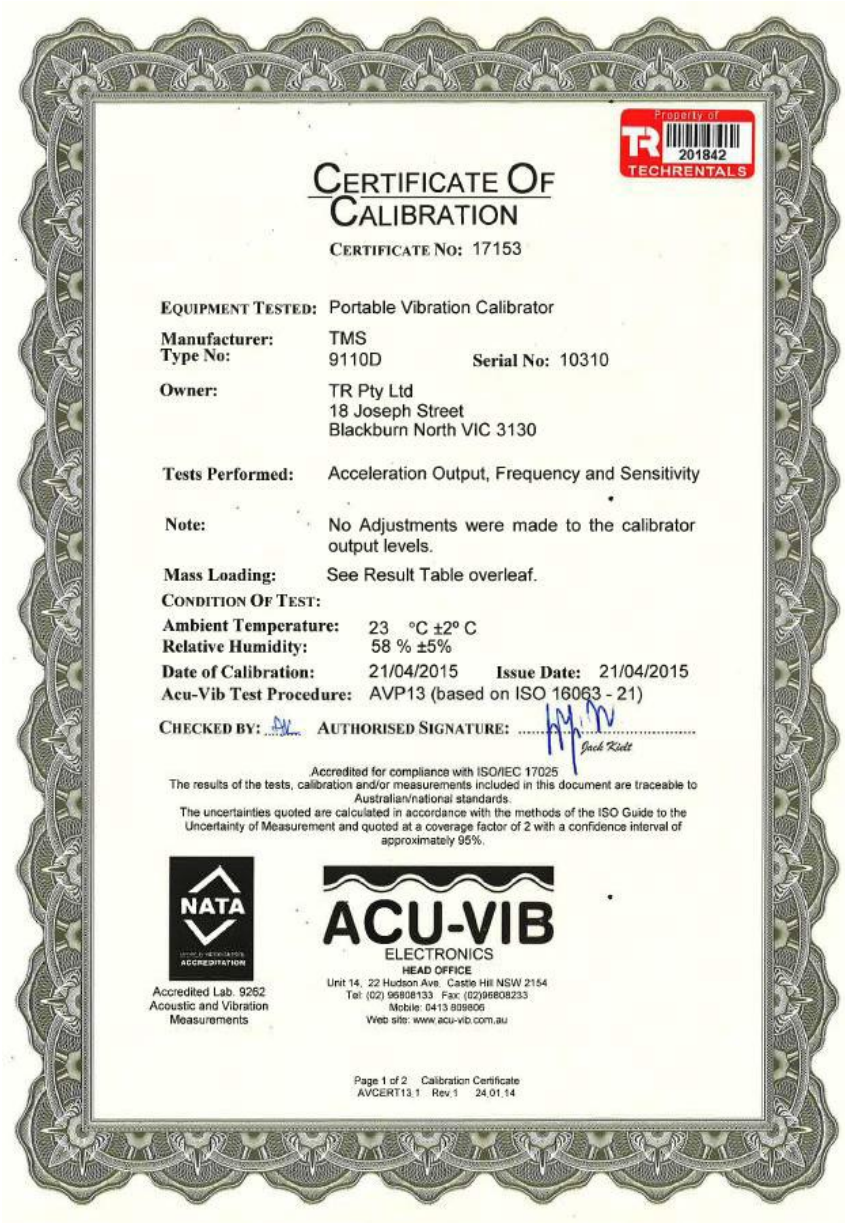
AVCERT05 Rev. 1.1 11.06.13



Property of TR 201842 TECHRENTALS

CERTIFICATE OF CALIBRATION

CERTIFICATE NO: 17153

EQUIPMENT TESTED: Portable Vibration Calibrator

Manufacturer: TMS
Type No: 9110D **Serial No:** 10310

Owner: TR Pty Ltd
18 Joseph Street
Blackburn North VIC 3130

Tests Performed: Acceleration Output, Frequency and Sensitivity

Note: No Adjustments were made to the calibrator output levels.

Mass Loading: See Result Table overleaf.

CONDITION OF TEST:

Ambient Temperature: 23 °C ±2° C
Relative Humidity: 58 % ±5%

Date of Calibration: 21/04/2015 **Issue Date:** 21/04/2015

Acu-Vib Test Procedure: AVP13 (based on ISO 16063 - 21)

CHECKED BY: ..... **AUTHORISED SIGNATURE:** .....
Jack Kidt

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The uncertainties quoted are calculated in accordance with the methods of the ISO Guide to the Uncertainty of Measurement and quoted at a coverage factor of 2 with a confidence interval of approximately 95%.

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Page 1 of 2 Calibration Certificate
AVCERT13.1 Rev.1 24.01.14

Calibration Chart for Hydrophone Type 8103-D-500

Brüel & Kjær

Serial No.: 2972963

Reference Sensitivity at 250 Hz* ± 2 % at 23.0 °C

Including integral cable 50.0 m

Voltage Sensitivity (Open Circuit Sensitivity):

-217.9 dB re 1 V/µPa** or 12.7 µV/Pa

Charge Sensitivity: 0.0988 pC/Pa

Capacitance (including integral cable): 7792 pF

Cable Capacitance: 95 pF/m

Leakage Resistance: 60 GΩ at 23.0 °C

Measuring Uncertainty

Sensitivity at 250 Hz: ± 0.25 dB
Frequency Response at 4 kHz to 200 kHz: ± 1 dB

Frequency Response (at ref. pos.):
Individual Free Field Frequency Response Curve attached

Measured in watertank at 20.1 °C

Summarized Specifications (re 250 Hz)

Frequency Response, PD values:
(For actual values, please see attached curve)

0.1 Hz to 20 kHz:	+1 dB, -1.5 dB
0.1 Hz to 100 kHz:	+1.5 dB, -6 dB
0.1 Hz to 180 kHz:	+3.5 dB, -14.0 dB

Horizontal Directivity 100 kHz:
(XY – plane) ± 2 dB

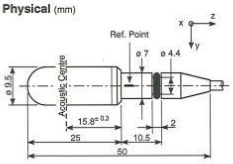
Vertical Directivity 100 kHz:
(XZ – plane) ± 4 dB

For further information, please see http://www.bk.dk and Product Data Sheet BP 0317

Date 28 Nov. 2014 07:55 Operator TF

9511456

Physical (mm)



Cable: Double shielded low noise

Weight (including 6 m cable): 170g

Environmental

Operating Temperature Range:
Short term – 40 °C to + 120 °C
Continuous – 40 °C to + 80 °C

Change of Sensitivity with Temperature:
Charge 0 to 0.03 dB/°C
Voltage 0 to – 0.03 dB/°C

Change of Sensitivity with Static Pressure:
0 to – 3 x 10^7 dB/Pa
(0 to – 0.03 dB/atm)

Temperature Transient Sensitivity: ≤ 50 Pa/°C
(ANSI S.2.11–1969); measured with Brüel & Kjær Charge Preamplifier Type 2626, LLF 3 Hz

Allowable Total Radiation Dose: 5 x 10^7 Rad

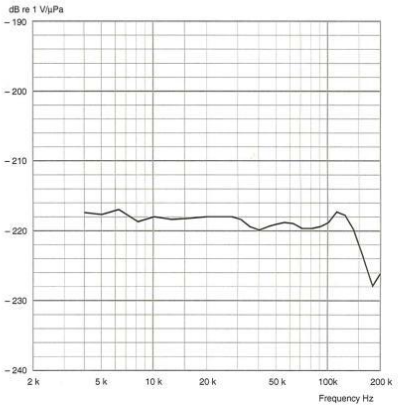
Acceleration Sensitivity: < 130 dB re 1 µPa/ms^{-2}

Maximum Operating Static Pressure:
4 x 10^6 Pa (40 atm)

Note: All Values are typical at 25 °C (77 °F), unless measurement uncertainty or tolerance limit is specified. All uncertainty values are specified at 2 σ (i.e. expanded uncertainty using a coverage factor of 2).

For further information see User manual

* Sensitivity Traceable to:
DPLA: Danish Primary Laboratory of Acoustics
NIST: National Institute of Standards and Technology, USA
** 1 Pascal = 1N/m^2 = 10 µbar



Frequency [kHz]	Sensitivity [dB re 1 V/uPa]	Frequency [kHz]	Sensitivity [dB re 1 V/uPa]
4.0	-217.4	50.0	-219.1
5.0	-217.7	56.1	-218.8
6.3	-217.0	63.0	-219.0
8.1	-218.7	71.0	-219.7
10.0	-218.0	80.0	-219.7
12.5	-218.4	90.0	-219.4
16.0	-218.2	100.0	-218.8
20.0	-218.0	112.0	-217.3
25.0	-218.0	125.1	-217.8
28.0	-218.0	140.0	-219.8
31.5	-218.4	160.0	-224.0
35.5	-219.4	180.0	-227.9
40.1	-219.9	200.1	-226.1
45.1	-219.4		

BC 0094-17

Calibration Chart for Hydrophone Type 8103-D-500 Serial No.: 2972963

121 Exhibition Street

Melbourne VIC 3000

PO Box 23061 Docklands VIC 8012 Australia