
Tan Property Company Ltd

***Conversion of a building to residential flats,
Station Approach, Emsworth, Hampshire***

Noise Impact Assessment Report

Report No: 197/Rep 1/Rev 0/Jun 2017



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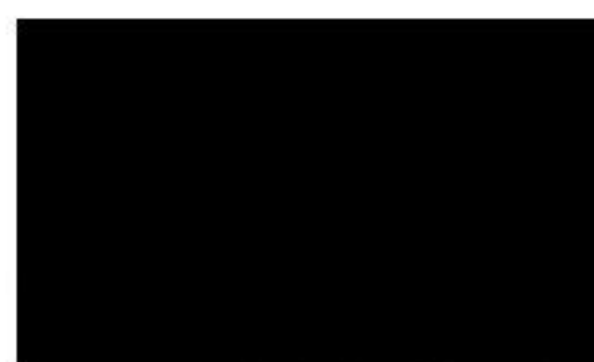
FINAL REPORT

REPORT NO: 197/Rep 1/Rev 0/JUN 2017

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SUMMARY

Tan Property Company Ltd is involved with conversion of an existing building to residential flats. This building borders a railway line to the north and an access road to the south and is not too far from a main road North Street to the east and the A27 that is not too far to the north. The Local Authority Planning Office highlighted some concern about the possible adverse impact of noise arising from these sources within the proposed new flats; it has therefore requested a noise assessment.

The client approached Dr H S Sagoo – an experienced independent Noise and Vibration Consultant – to undertake the noise survey and prepare the requisite noise assessment.

The site visit indicated that the major source of noise in the area was due to road traffic on A27 and North Street and trains on the adjacent railway tracks.

An ambient noise survey was undertaken commencing Wednesday, 21st June 2017 for three days but vandals disturbed and damaged the equipment on Thursday afternoon. The survey was to understand the noise climate in close vicinity of the building proposed for conversion immediately south of Emsworth station.

The results of groundborne vibration measurements indicate that vibration levels are a magnitude below the level considered to cause even cosmetic damage to a building. The measured vibration dose value is at a level associated with 'low probability of adverse comments' from future residents.

The noise survey shows that the ambient noise level towards the railway tracks is higher. As a result, the assessment of internal noise levels in accordance with the requirements of BS8233 shows that glazing configuration should be carefully selected; it is recommended that 6/20/12, 13/12/13 laminate or 6/100/6, or similar, is used.

No further mitigation measures are deemed necessary and therefore, the planning department should approve the planning application.

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1. INTRODUCTION

Tan Property Company Ltd is involved with conversion of an existing building to residential flats. This building borders a railway line to the north and an access road to the south and is not too far from a main road to the east and the A27 to the north. The Local Authority Planning Office highlighted some concern about the possible adverse impact of noise arising from these sources within the proposed new flats; it has therefore requested a noise assessment.

The client approached Dr H S Sagoo – an experienced independent Noise and Vibration Consultant – to undertake the noise survey and prepare the requisite noise assessment.

The purpose of this report is to describe the site, the nearest residential areas, brief details of the proposal and outline the assessment methodology including the findings of the noise survey, assessment of the noise impact in accordance with the appropriate national guidance, and finally, recommend noise mitigation measures as necessary.

2. DESCRIPTION OF THE SITE

The proposed site is adjacent to the southern platform of Emsworth station on the Southampton to Brighton railway line. North Street connects the station to the town centre and is about 50 m to the east; the A27 Trunk Road is about 60-70 m to the north. There are commercial premises beyond this building and their vehicular access is via Sultan Road which is right in front of the proposed building. See Figure 1.

The proposed building is close to the station and as a result there are many sources of noise including car parking, car movements, and people walking and talking close by.

The fabric of this two storey building is typically commercial in nature; i.e. the walls are brick up to about 2m and the upper floor is lined on the outside with corrugated metal sheets which also form the pitched roof. See Photos. Internally, the building is lined with plaster to create internal partitions with a suspended ceiling. However, the building had been vandalised and all of the glass windows, doors and internal plaster, ceiling tiles, electric cables etc, were strewn across the open spaces. This is clear on the photos.

3. DEVELOPMENT PROPOSAL

The current proposal is to convert the building into four flats; two on the ground floor and two on the first. The existing and proposed ground floor layouts are shown in Figure 2 and the proposed first floor layout is similar to the ground floor.

4. ASSESSMENT CRITERIA

Noise criteria

The local authority takes account of guidance in the National Planning Policy Framework¹ and as regards noise in bedrooms the NPPF refers to BS 8233 which is discussed below.

The World Health Organisation's 'Guidelines for Community Noise'² recommends environmental daytime and evening noise limits to avoid unnecessary annoyance. The recommended maximum external environmental daytime noise is 55 dB L_{Aeq} over the 16 hour period (07.00 – 23.00 hrs). For the evening a 48 dB L_{Aeq} 8-hour noise level (23.00 – 07.00 hrs) is a recommended maximum.

For guidance on internal noise levels BS 8233³ is also relevant. Table 4 of this document recommends the following internal noise levels for residential development. This has been reproduced in the table below.

Criterion	Typical Situations	$L_{Aeq,T}$ dB	
		Daytime 07:00 to 23:00	Night-time 23:00 to 07:00
Resting	Living rooms	35 dB $L_{Aeq, 16\text{ hr}}$	-
Dining	Dining room/area	40 dB $L_{Aeq, 16\text{ hr}}$	-
Sleeping (daytime resting)	Bedroom	35 dB $L_{Aeq, 16\text{ hr}}$	30 dB $L_{Aeq, 8\text{ hr}}$

Table 1 BS 8233 Indoor ambient noise levels for dwellings

Vibration criteria for building damage

BS 7385⁴ sets guide values for building vibrations based on the lowest vibration above which damage has been credibly demonstrated. The response of a building to groundborne vibration is affected by various features of a building such as, the type of foundation, underlying ground conditions, type of building construction, the state of repair, etc. The response also depends upon whether the vibration is continuous or transient.

It is generally accepted that the level of vibration varies at various points on the building. Consequently, this standard recommends that measurement should be taken close to the base of the building on the side facing the source of vibration. The measurement should record the peak particle velocity (ppv), which has been found to be the best descriptor for correlating with vibration induced damage. In accordance with this standard, limits for transient vibration above which cosmetic damage could occur to a light framed structure or a residential building is 15 mm/s ppv at 4 Hz increasing to 20 mm/s at 15 Hz, given in Table 1 of this standard and reproduced below. These guideline values are reduced by 50% for continuous vibration.

¹ National Planning Policy Framework 2012, Department for Communities and Local Government, London 2012.

² World Health Organisation, 'Guidelines for Community Noise', 2000.

³ British Standard 8233:2014 'Guidance on Sound Insulation and Noise Reduction for Buildings', BSI.

⁴ British Standard 7385, 'Evaluation and measurement for vibration in buildings', BSI, 1990.

The standard also considers that there is little probability of fatigue damage occurring in residential buildings due to construction activities or vibration generated by road traffic. This standard also mentions that vibration inside a building caused by internal activities, such as door slams and footfalls, can exceed that due to road traffic.

Table 1. Transient vibration guide values for cosmetic damage			
Line (see figure 1)	Type of building	Peak component particle velocity in frequency range of predominant pulse	
		4 Hz to 15 Hz	15 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above
NOTE 1. Values referred to are at the base of the building (see 6.3).			
NOTE 2. For line 2, at frequencies below 4 Hz, a maximum displacement of 0.6 mm (zero to peak) should not be exceeded.			

Table 2 Transient vibration guide for cosmetic damage

Vibration Criteria for human discomfort

Comments regarding building vibrations in residential situations are likely to arise from occupants when vibration levels are only slightly in excess of thresholds of perception. The vibration threshold of human perception is very much lower than the level that may cause cosmetic damage to buildings; i.e. 0.1 mm/s ppv compared with 15 mm/s ppv.

British Standard 6472⁵ sets out the threshold of vibration for humans together with the levels that are considered acceptable for the time of day and night and for the type of activity or building use.

In general, vibration dose values (vdv) may be used to assess the severity of impulsive or intermittent vibration, such as vibration from construction activity and trains as in this case. The vdv takes account of the vibration magnitude, its duration and the number of events and assesses this against the likelihood of adverse comments for given vdv scores, as shown in the following table.

Place	Low probability of adverse comment	Adverse comment possible	Adverse comment probable
Residential buildings 16-hr day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8-hr night	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

Vdv units: m/s^{1.75}

Table 3 Vibration dose values for level of adverse comment

⁵ British Standard 6472 'Guide to evaluation of human exposure to vibration in buildings', BSI, 2008

5. EXISTING AMBIENT NOISE AND VIBRATION MEASUREMENTS

The ambient noise levels were measured over a period commencing around noon on Wednesday, 21st June till Saturday, 24th June 2017. One sound level meter was installed on the railing on the fire exit towards the railway platform and set about 1 m from the building façade; see Photo 1; another meter was installed and set about 1 m from the façade facing the access road; see Photo 2. These instruments measured ambient noise levels with façade correction.

Measurements include the equivalent continuous noise level L_{Aeq} , the background noise level L_{A90} , the maximum level L_{Amax} and L_{A10} together with third octave frequency spectra. Explanation of acoustical terminology is given in Appendix 1.

The ambient groundborne vibration levels were monitored inside the building at the base of the façade closest to the railway track; see Photo 3. The thin carpet and the linoleum coverings were peeled back to a solid concrete surface on which the ppv and the vdv sensors were placed.

At the start of the survey it was dry and sunny (the hottest day since June 1976) with clear blue sky with a light south/southwest breeze of approximately 1.1 m/s with gusts up to 2.5 m/s. The weather continued dry until the end of the survey on Saturday.

6. INSTRUMENTATION

Noise measurements were taken using two 01dB Solo Type 1 integrating sound level meters (serial nos. 11649 and 10485) fitted with a ½ inch microphone. All were set-up to record frequency spectra of the ambient noise and were calibrated using a 01dB Calibrator (serial no. 130366) in accordance with the manufacturer's instructions before and after the measurements, and no drift in calibration level was observed.

The noise measurements include façade correction and measurements were conducted in accordance with the guidelines given in BS7445⁶.

Groundborne vibration was measured using a Vibrock two channel meter V901, serial 1006. This measured the peak particle velocity, ppv, of the vibration together the vibration dose value, vdv, in accordance with BS7385 and BS6472, respectively.

7. MEASUREMENT RESULTS

Ambient noise levels

Unfortunately, vandals had entered the building on Thursday afternoon and their actions meant that only one day's data was found to be useful. The complete results of the ambient noise survey at the two measurement locations are given in Appendix 3.

The survey findings show high ambient noise levels because this area has major roads A27 and North Street nearby and a busy railway line and that the façade facing the

⁶ BS7445:2003, 'Description and measurement of environmental noise; a guide to quantities and procedures', BSI.

railway has higher noise levels, as expected. The average and the highest values are given in the Table 4 for daytime 07:00 – 23:00 hrs and night-time 23:00 – 07:00 hrs for the survey period. With regard to residential flats, in accordance with BS8233 it is the average noise levels for daytime and night-time that are assessed. However, for a worst case scenario the assessment in this report is based on the highest hourly averages as these are considered to be higher; in general about 5-9 dB higher.

Ambient groundborne vibration

Full details of the vibration measurement results are given in Appendix 3 and a summary is given in Table 5. It is evident from the results that trains are attributable to intermittent groundborne vibration level of up to about 2 mm/s ppv measured at the base of this building. This vibration level is consistent with the fact that trains run smoothly on welded rails along this site; there was one uneven joint but this was close to the end of the platform to the eastern end and thus some distance from this building.

Day and date	Event no	Vibration dose value			Maximum Ppv
		X	Y	Z	
Wednesday, daytime – 16 hr	Ev 057	0.053	0.046	0.05	1.93
Thursday, daytime – 16 hr	Ev 059	0.074	0.062	0.067	1.80
Friday, daytime – 16 hr	No data				
Saturday, daytime – 16 hr	Ev 063	0.076	0.072	0.067	0.80
Wednesday, night-time – 8 hr	Ev 058	0.057	0.052	0.056	2.18
Thursday, night-time – 8 hr	No data				
Friday, night-time – 8 hr	Ev 062	0.065	0.062	0.06	1.90

Vdv units $\text{m/s}^{1.75}$, ppv units mm/s

Table 5 Groundborne vibration measurements

Observations

At the time of installing the monitoring equipment the following train movements were noted. It was noticed that some trains stop at Emsworth station and some do not. These events can be identified on the noise and vibration traces shown in Figure 4.

Time	Notes
21 st June 2017	
13:32	Train to west – noise level of approx 80 dB
13:42	Train to east
14:15	Train from west at platform
14:37	Train from west at platform
15:16	Train to east
15:17	Train from east at platform

Period start	LAeq	LAmix	LA90	LA10	Octave Band Centre Frequency Hz										
					16	32	64	125	250	500	1k	2k	4k	8k	16k
Daytime – hourly															
Roadside															
Wed from noon – Average	51.4	66.7	46.1	52.9	57.9	60.7	58.3	53.8	50.3	46.8	47.3	43.2	38.2	31.4	22.2
Wed - Max values	55.0	74.6	48.8	57.2	63.9	65.8	65.2	58.5	53.5	51.1	51.0	47.4	44.7	40.9	32.4
Thu till 17:00 – Average	54.7	73.3	48.7	55.7	65.9	65.1	61.6	55.3	51.9	49.8	50.0	47.0	43.8	39.9	30.5
Thu - Max values	58.6	80.1	49.4	58.2	69.2	66.6	65.4	57.7	54.0	53.4	53.3	52.5	49.0	54.4	38.5
Railway side															
Wed from noon – Average	63.9	82.7	57.3	64.9	65.4	64.6	64.8	60.4	62.2	60.1	60.4	55.1	49.2	49.4	39.5
Wed - Max values	66.7	84.6	59.1	66.6	67.9	67.2	69.5	62.3	64.6	63.9	62.9	60.6	51.5	51.5	41.0
Thu till 17:00 – Average	66.3	83.9	61.9	66.8	68.0	66.5	66.3	62.2	63.9	63.2	63.1	56.8	50.3	49.8	40.1
Thu - Max values	68.7	85.4	62.7	68.0	70.9	67.9	69.0	64.5	65.2	66.1	65.7	58.7	52.5	53.9	49.5
Night-time – hourly															
Roadside															
Wed – Average	45.0	57.0	40.0	47.1	55.9	54.0	51.6	46.6	43.8	39.8	39.5	36.4	32.9	26.7	16.8
Wed - Max values	54.0	65.6	48.4	56.7	61.0	64.2	60.3	55.2	52.1	49.8	49.8	46.3	43.0	36.7	26.1
Railway side															
Wed – Average	59.7	75.9	46.3	61.2	60.9	58.9	60.5	55.4	57.1	55.4	55.6	49.7	47.9	49.8	39.9
Wed - Max values	65.7	85.5	60.8	65.8	65.1	63.9	69.3	60.7	62.7	62.6	62.3	57.0	50.6	56.5	48.2

All noise levels are in dBA

Table 4 The hourly average and maximum measured ambient noise levels

8. ASSESSMENT OF GROUNDBORNE VIBRATION

Damage to building

The highest level of groundborne vibration measured is 2.18 mm/s ppv. This level is a magnitude below the level considered to cause even minor or cosmetic damage. Consequently, there is little likelihood of damage to the internal structure of the building.

Possible comments of residents

With regards to the likelihood of adverse comments from residents exposed to the vibration levels on site, the cumulative effect of all vibration events have been assessed and is at a level associated with 'low probability of adverse comments' in accordance with BS6472. This implies that even though the residents may actually detect individual vibration events they are generally unlikely to complain, particularly as this site is adjacent to a railway line.

9. ASSESSMENT OF INTERNAL NOISE

The transmission of external noise into the building is dependent on the acoustic properties of the building elements, i.e. the wall, windows and the roof. This building is of brick construction up to about 2m and then clad with corrugated metal sheets to the first floor and the roof. On the first floor the internal walls were lined with plaster (pre vandalism) with insulation in between and the roof was bare metal sheets with a suspended ceiling with tiles, see Photo 5.

The sound reduction R_w of a cavity brick wall is approximately 55 dB and the same can be achieved for a corrugated metal sheet outer with a suitable plasterboard lining system inside. These values are used in determining the glazing configuration.

Glazing specification

British Standard 8233 gives a methodology to calculate the glazing configuration required to achieve the target noise level inside a typical bedroom for a given noise level exposure outside. The calculated internal noise levels are based on the measured daytime and night-time averaged noise levels and on a glazing configuration that include an acoustic trickle ventilator and these are given in Table 6. The measured noise levels used in the BS8233 calculations are free-field values which are 3 dB lower than the measured levels.

The internal noise calculations are based on the glazing acoustic specification which are summarised in Table 7; these are taken from various sources. As mentioned above these calculations include an acoustic ventilator in the double glazing configuration.

	Glazing configuration					
	4/14/6	4/10/10	6/20/12	8.4/12/6 laminate	13/12/13 laminate	6/100/6 * 6/200/6 *
Windows in most exposed façade						
Daytime noise level						
Average	28.1	25.8	24.5	25.4	23.5	23.5
max event	30.2	28	26.7	27.5	25.6	25.6
Night-time noise level						
Average	21.1	18.8	17.5	18.4	16.5	16.5
max event	27.1	24.8	23.5	24.3	22.4	22.3

All noise levels are in dB

Table 6 Calculated internal noise levels for various glazing

	Octave band centre frequency Hz						Sound reduction Rw
	125	250	500	1000	2000	4000	
4/14/6	21.5	24.4	32.4	41.1	41	39.8	
4/10/10	25.8	29.7	36.1	39.0	41.3	44.7	
6/20/12	26	34	40	42	40	50	41
8.4/12/6 laminate	24.8	28.9	38.8	42.3	41.5	47	37
13/12/13 laminate	28	34	44	52	47	55	45
6/100/6 with acoustic reveals	28	35	45	47	48	54	45
6/200/6 with acoustic reveals	38	41	49	56	49	40	50

All noise values are in dB

Table 7 Acoustic specifications for glazing configurations

The survey results confirm daytime noise levels are higher than night-time: the average values differ by 5-9 dB whereas the maximum values differ by only a few dB. The recommended internal noise level given in BS8233 in bedrooms is 35 dB for daytime and 30 dB for night-time based on the average noise level. The calculations are based on both the average and the highest noise levels measured: use of the highest values in this assessment is easily considered to represent the worst case scenario.

Based on the guidelines in BS8233 which states 'the average noise levels in bedroom in the night-time period 23:00 to 07:00 hrs', then all of the window configurations given in Table 10 are acceptable. The ambient noise levels are not too onerous and hence Table 9 also shows that the internal noise levels based on the highest measured hourly values also meet the BS8233 recommended values.

In the case of glazing for the side façades, the measured noise levels would be approximately 3 dB lower due to restricted angle of view, and therefore any of the glazing configurations given above would be acceptable. Nevertheless, use of the same glazing configuration is recommended throughout to avoid confusion and the possibility of installing incorrect glazing.

Consideration of maximum noise levels

The highest maximum free-field noise level L_{Amax} measured during the night-time hours 23:00 – 07:00 hrs was 85.5 dB. The BS8233 acceptance criteria is 45 dB L_{Amax} inside the bedroom. Subsequently, a reduction of about 40 dB is required from the glazing. Therefore, glazing configuration 6/20/12, 13/12/13 laminate or 6/100/6 is necessary.

If mechanical ventilation is specified, then the acoustic ventilator in the glazing could be omitted from the calculations and this would lower the sound reduction required of the window by 2 to 3 dB; hence a glazing configuration of slightly lower specification could be selected.

Noise rating requirement

In general, the local authority expects a Noise Rating of NR30 for daytime and NR25 for night-time. As an example, the sound reduction in octaves due to the glazing construction given in Table 4 for 6/20/12 were subtracted from the measured average of hourly noise levels in octave band frequency for daytime and night-time and the resulting differences was drawn on NR curves, see Figure 5; this would represent the spectra of the internal noise. The resulting internal noise based on the measured façade noise levels is found to be NR18 for daytime and NR11 for night-time. Consequently, internal noise levels meet the local authority's requirements.

Whole house ventilation

As the external noise has higher peak levels it would be prudent to recommend mechanical ventilation to provide fresh air without opening the windows which would result in higher noise inside. Mechanical ventilation would also help meet the air quality requirements and possibly negate the requirement of an air quality assessment. Any noise ingress through the ducts or units from the high traffic noise should be minimised by positioning the air intake to the quieter side of the site and by acoustic treatment.

There are many manufacturers of mechanical ventilation systems. The internal noise from any system should be specified to be no more than NR15, so as to provide a safe margin and avoid the cumulative noise in the bedroom exceeding NR25 at night-time.

Air conditioning and air handling units

If any air con units are required, the cumulative noise of all the units should be about 10 dB below the lowest measured background noise level in the area of about 34 $L_{A90, 1 \text{ hr}}$. This is to meet the guidelines given in BS4142 to avoid adverse comments from the nearest residents. A detailed noise impact assessment may be required in accordance with BS4142 when more details are available. However, given that the noise of a typical a/c unit is generally low and given that the ambient noise levels close to the nearest residential properties are expected to be high due to trains and road traffic, it is unlikely that there will be an adverse noise impact.

10. RECOMMENDATIONS

The ambient noise levels and particularly the peak levels are high and it is therefore necessary to select a suitable glazing configuration from the choice given in this report

to ensure the recommended internal noise levels given in BS8233 are met. Glazing configuration 6/20/12, 13/12/13 laminate or 6/100/6 is recommended.

Although mechanical ventilation is not necessary as far as noise mitigation is concerned it would provide fresh air without opening the window, and mechanical ventilation may be necessary to meet the air quality requirements. If this is the case, the trickle vents that are allowed for in the calculations of internal noise levels are not required and as a result the glazing specification may be lowered by 2 to 3 dB.

If any mechanical ventilation or air conditioning/air handling plant is proposed, the cumulative noise emission target should be about 10 dB below the lowest measured background noise level of approximately 34 dB $L_{A90, 1-hr}$ to ensure that there are no adverse comments from nearby residents particularly at night-time, if these units are proposed to operate automatically at any time.

The results of groundborne vibration measurements indicate that vibration levels are a magnitude below the level considered to cause even cosmetic damage to a building. As regards the effect on residents the measured vibration dose value is at a level associated with 'low probability of adverse comments'.

11. MITIGATION MEASURES

Glazing configurations 6/20/12, 13/12/13 laminate or 6/100/6, or similar, is recommended.

The noise emission of any mechanical ventilation, a/c or air handling units should be specified to be below 24 dB L_{Aeq} to avoid adverse impact during night-time.

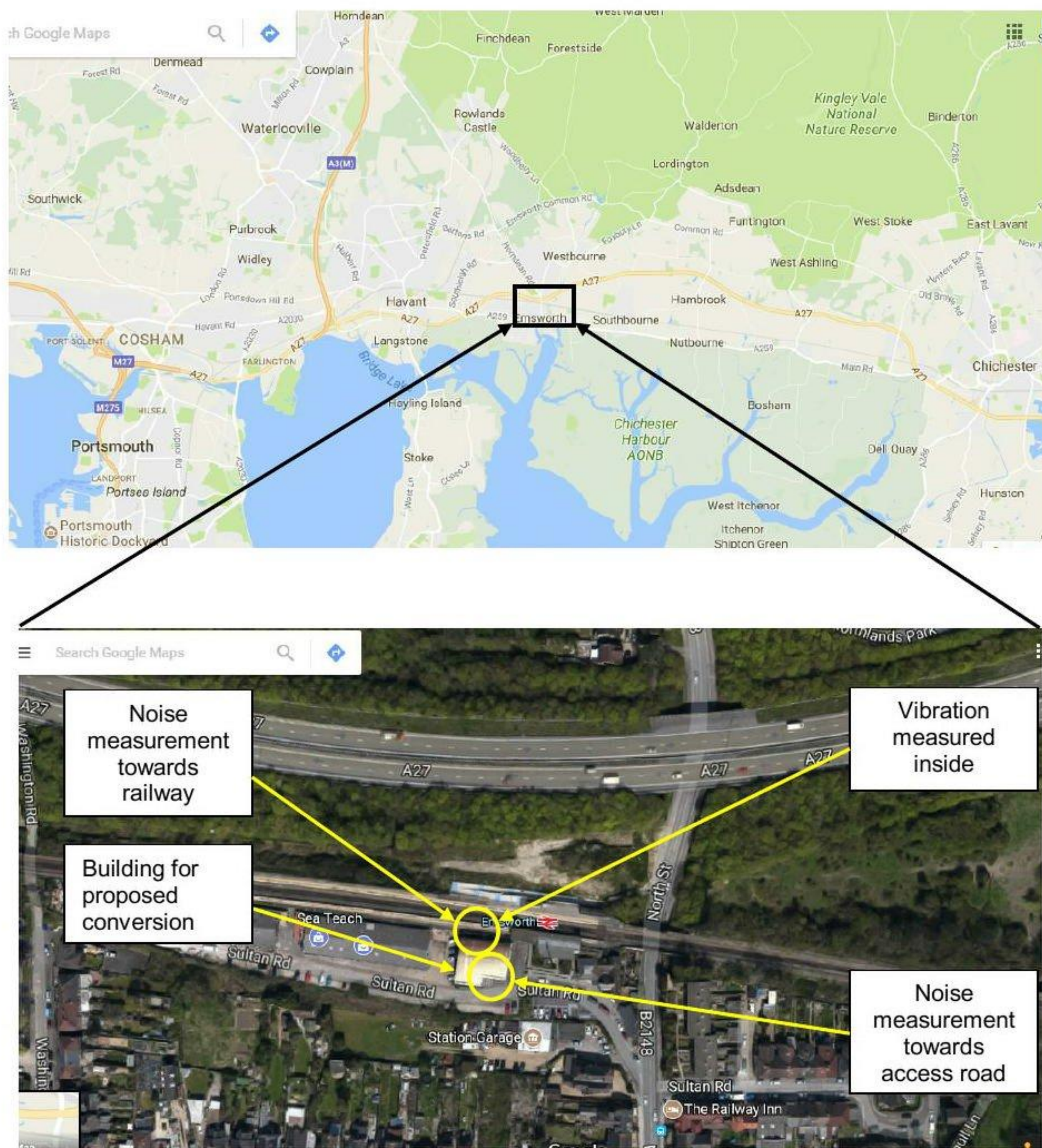


Figure 1 Map of site and measurement locations

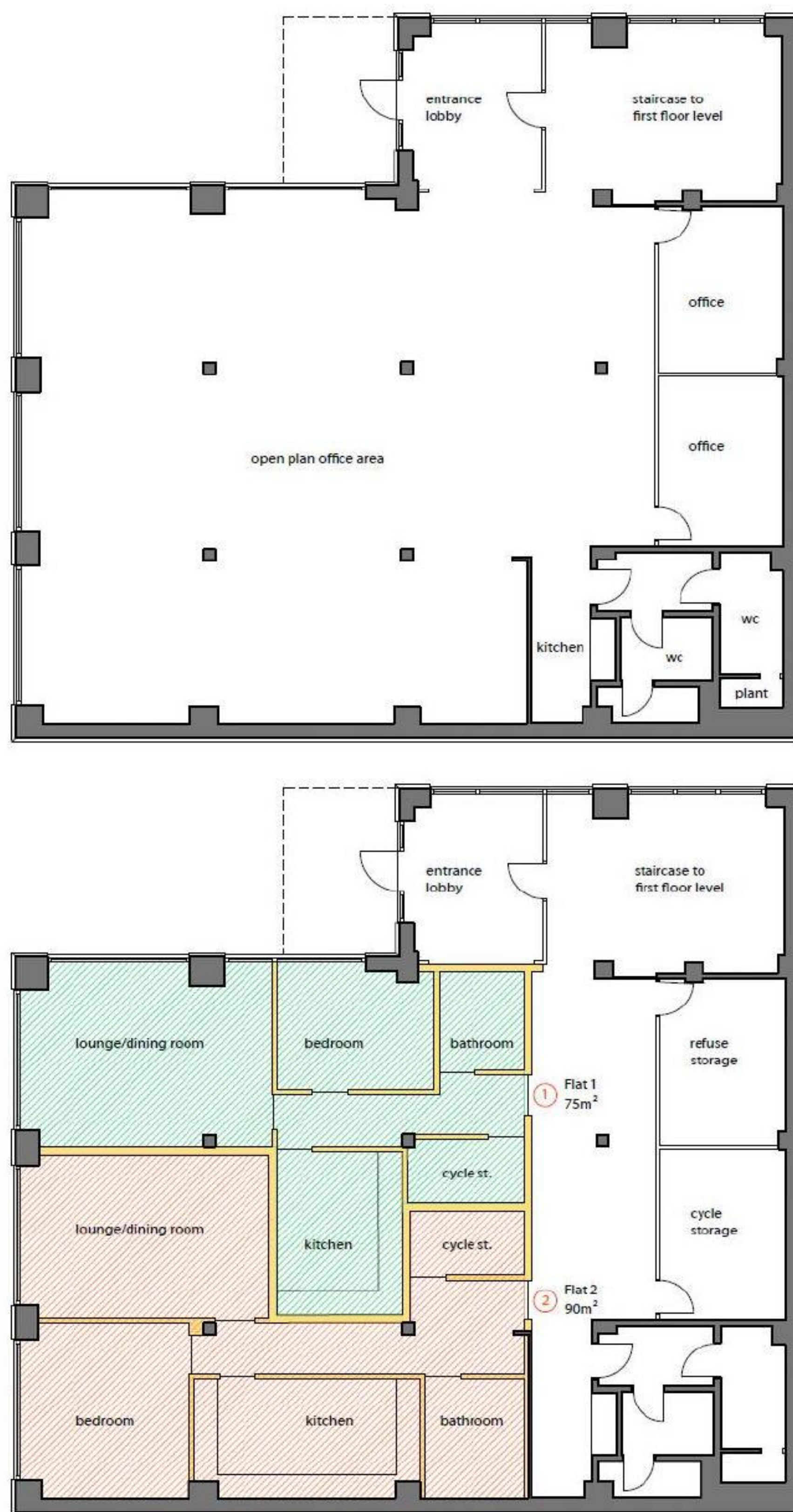
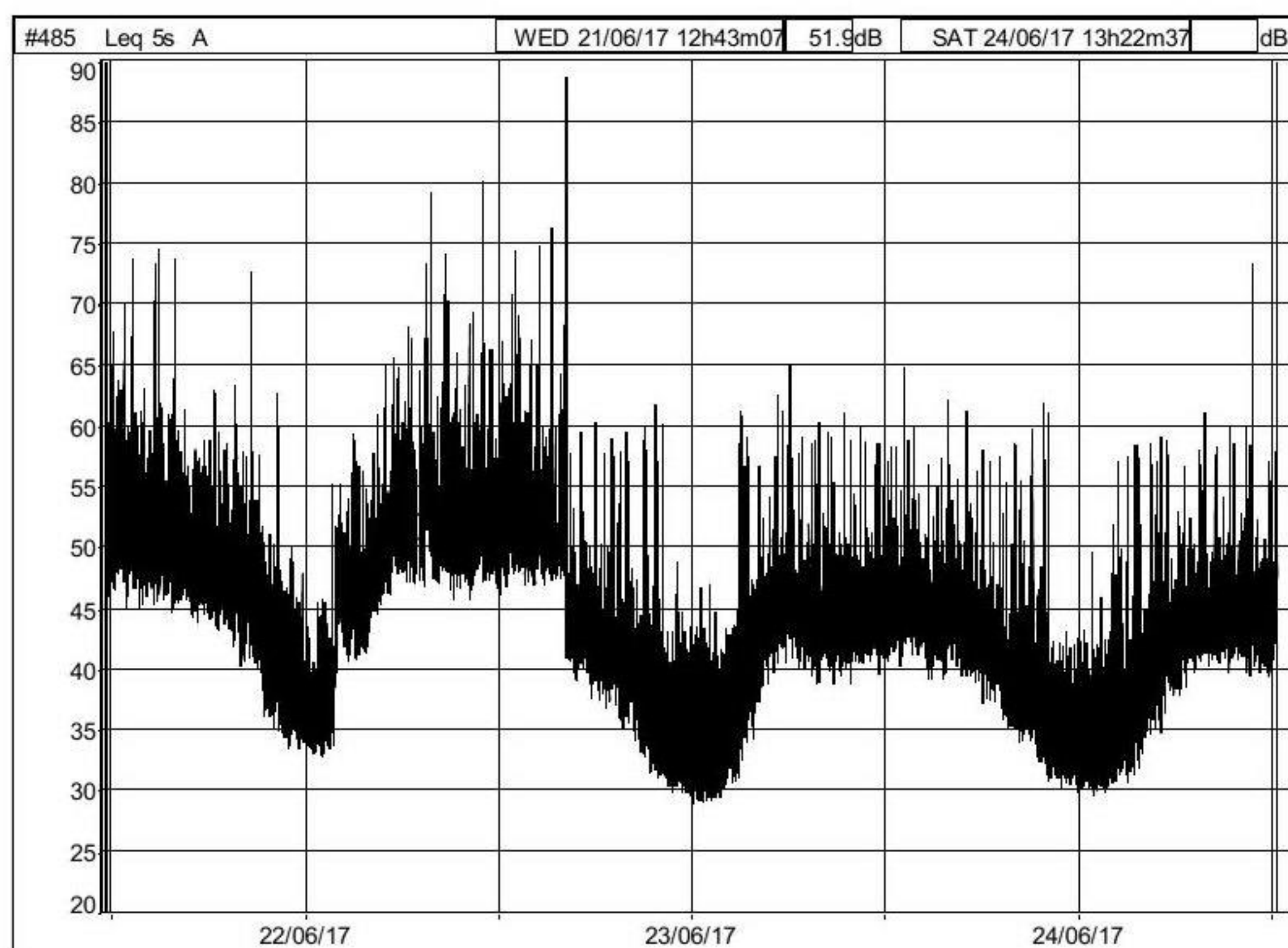
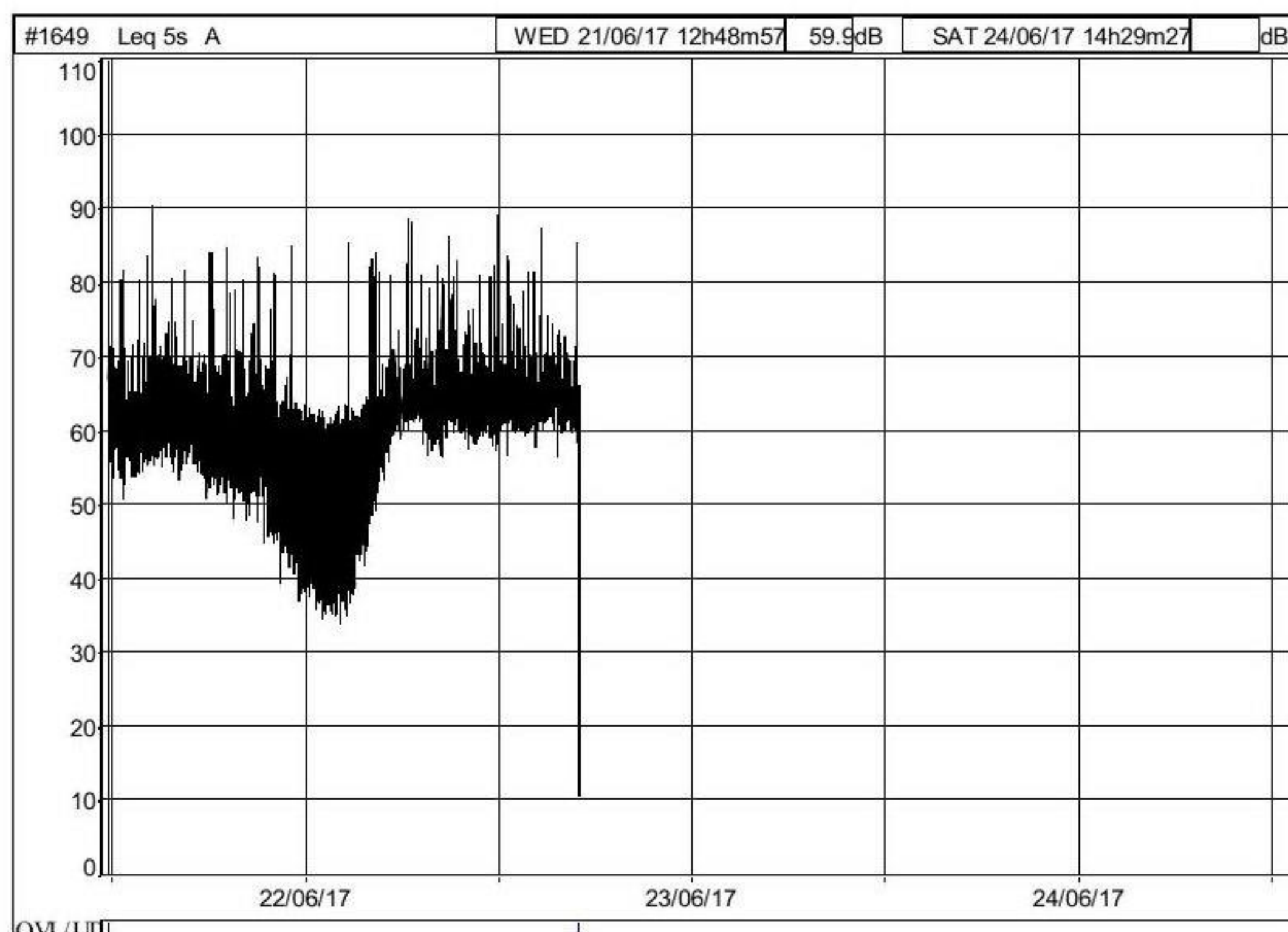


Figure 2 Existing internal layout and proposed conversion

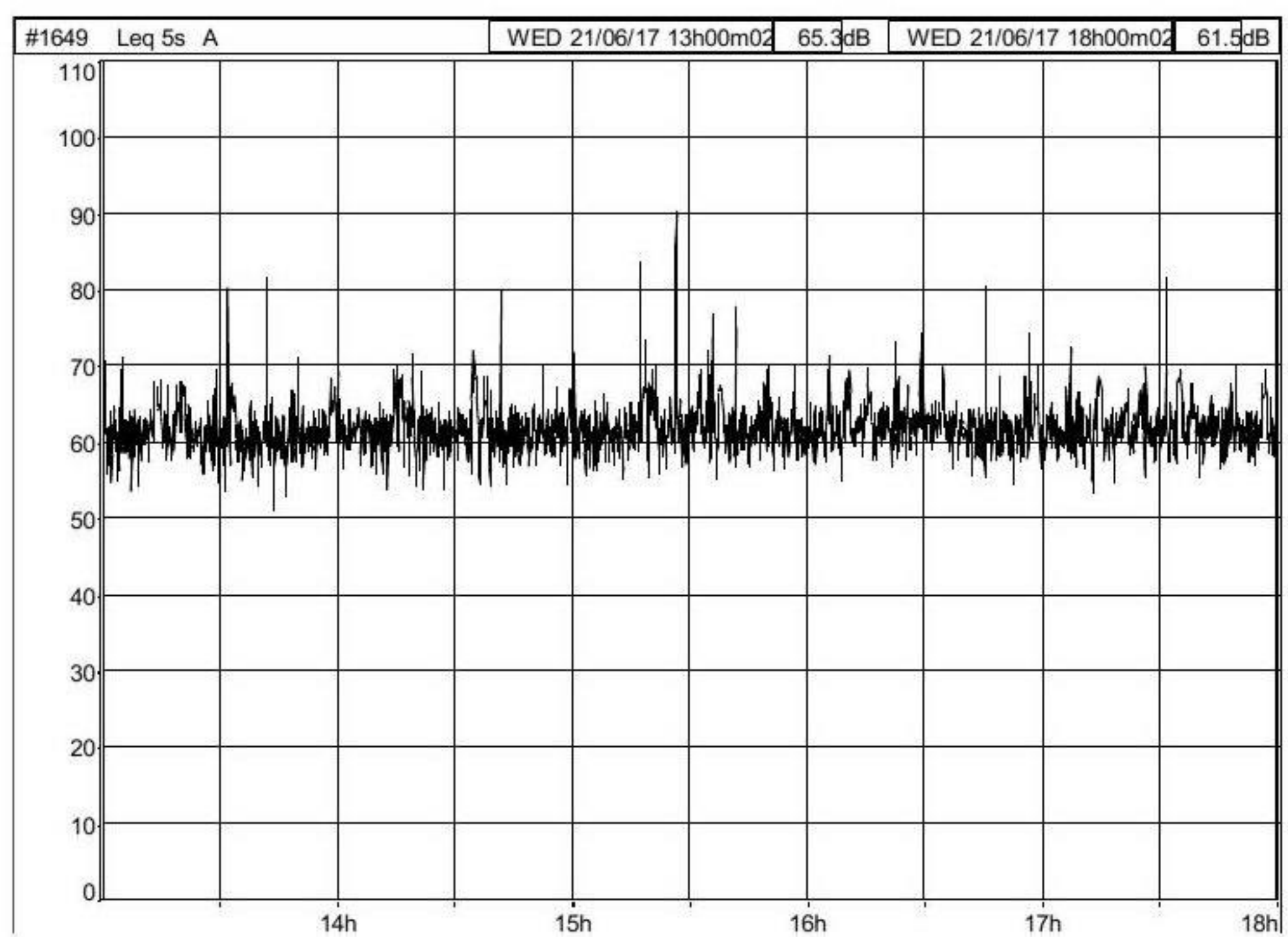


Measurement on access road side



Measurement on railway side

Figure 3 Measurement time histories – ambient noise



Event 057 21/06/17 13:23:1

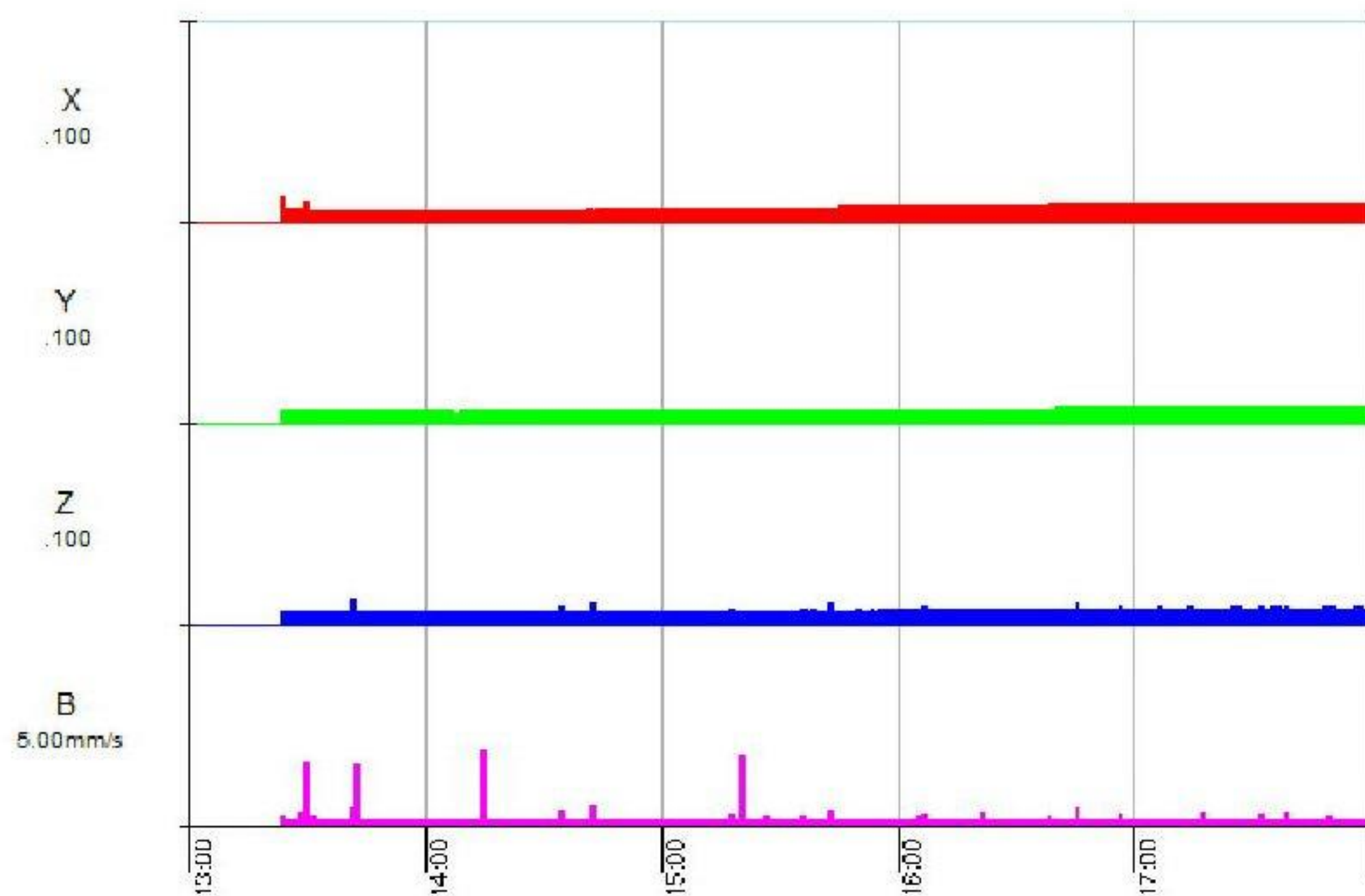
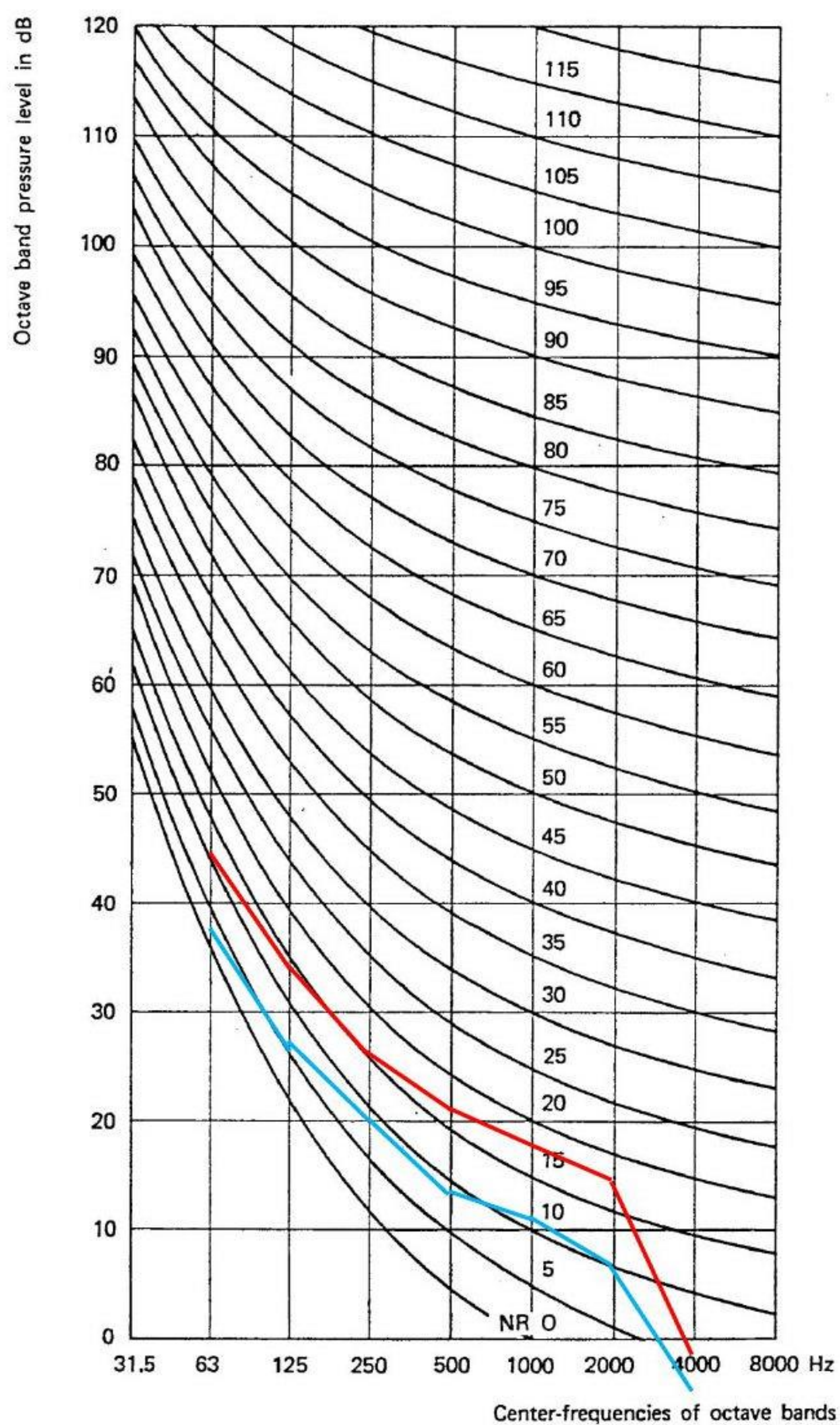


Figure 4 Noise and vibration traces showing trains events



Noise within bedroom with glazing 6/12/10;

Daytime average noise levels; — NR18
 Night-time average noise levels; — NR11

Figure 5 Noise rating curves for internal noise

Appendix 1 Acoustic Terminology

Appendix 1 Acoustic Terminology

Perception of sound. Sound is a rapid fluctuation in air pressure. The human ear can hear sensations of sound when the fluctuations occur between 20 times a second and 20,000 times a second. This is called the frequency of the sound and is measured in Hertz (Hz). The loudness of the sound depends on the amplitude of fluctuation in the air pressure. The ear has an approximately logarithmic response to the loudness of sound: for example, every doubling or halving in sound pressure gives an apparently equal step increase or decrease. In measuring environmental noise, sound pressure levels are therefore usually quoted in terms of a logarithmic unit known as a decibel (dB). Typically, the quietest sound that can be heard (the threshold of hearing) is 0 dB and the sound becomes painful at 120 dB. The sensitivity and frequency range of the ear varies somewhat from person to person and deteriorates with age and exposure to loud sounds

“A” Weighting. The human ear is not equally sensitive to sounds of different frequencies (i.e. pitch): it tends to be more sensitive in the frequency range of the human voice than at higher or lower frequencies. When measuring sound, compensation for these effects can be made by applying a frequency weighting, usually the so-called “A” weighting, although other weightings are sometimes used for special purposes. To signify that the “A” weighting has been applied, the symbol of dB(A) is often used. However, current practice tends to prefer the weighting letter to be included in the name of the measurement index, e.g. dB(A) L_{eq} and dB L_{Aeq} both refer to the “A” weighting equivalent continuous sound level in decibels.

L_{AeqT} is a unit that also takes into account fluctuations in sound pressure levels. This unit takes into account both steady and impulsive noises and is defined as the steady, continuous sound pressure level which contains the same energy as the actual, fluctuating sound pressure level. It is necessary to state the time period over which the sound is measured, e.g. $L_{Aeq,(12\text{-hour})}$, typical in the case of daytime working and 5-minute for night-time.

L_{A90} is the level of A-weighted sound exceeded for 90% of the measurement period. It is generally used as a measure of the background noise in environment noise standards.

Appendix 2

Site Photographs



Photo 1 Long term measurement location – railing towards the station platform



Photo 2 Long term measurement location – on façade facing access road



Photo 3 Measurement of groundborne vibration at base of façade towards railway



Photo 4 Equipment vandalised – the building had been vandalised earlier



Photo 5 Roof cavity of the building above the suspended ceiling

Appendix 3 Noise measurement results

Table A3.1	Hourly averages for measurements at site boundary towards railway
Table A3.2	Hourly averages at façade facing the access road
Table A3.3	Results of groundborne vibration at base of façade facing the railway

Period start	LAeq	LAmax	LA90	LA10	Octave Band Centre Frequency Hz										
					16	32	64	125	250	500	1k	2k	4k	8k	16k
Wednesday															
21/06/2017 12:00	64.1	80.7	57.9	64.9	67.2	66.1	66.1	58.7	62.3	60.7	60.6	54.9	48.5	49.4	39.9
21/06/2017 13:00	66.3	81.3	57.9	65.5	67.9	67.2	69.5	62.2	64.6	63.9	62.7	56.2	51.5	50.0	40.0
21/06/2017 14:00	63.2	80.2	58.5	64.9	67.8	66.2	65.5	61.2	61.9	59.8	59.8	53.5	48.1	49.4	38.8
21/06/2017 15:00	66.7	83.4	58.8	66.1	67.4	66.3	65.9	60.8	62.5	61.8	62.9	60.6	50.0	49.6	41.0
21/06/2017 16:00	63.6	80.5	59.1	65.1	66.2	66.2	65.2	60.6	62.4	59.4	60.0	54.8	50.5	48.4	38.9
21/06/2017 17:00	63.4	81.8	58.9	65.5	66.1	65.9	65.5	61.1	61.9	59.6	60.2	53.5	48.2	48.8	39.3
21/06/2017 18:00	63.3	74.9	57.9	66.6	64.8	64.4	64.6	62.3	62.2	59.5	59.4	54.3	49.5	51.5	39.6
21/06/2017 19:00	64.4	84.1	57.2	64.5	65.2	64.2	63.4	59.6	61.7	60.1	61.4	55.8	49.2	49.4	39.8
21/06/2017 20:00	63.1	84.6	55.3	63.7	63.1	62.3	62.9	58.9	61.2	58.8	59.5	55.3	48.9	49.0	39.4
21/06/2017 21:00	62.1	80.2	54.8	63.8	62.3	61.7	61.7	60.1	61.4	58.2	58.4	53.1	47.8	48.6	38.3
21/06/2017 22:00	62.9	83.6	54.2	63.5	61.9	60.6	62.0	59.2	61.9	59.1	59.3	53.7	48.7	49.4	40.0
21/06/2017 23:00	61	81.2	49.5	61.3	60.3	58.7	59.0	54.7	58.9	56.7	57.8	51.7	47.6	48.6	38.9

Period start	LAeq	LAmax	LA90	LA10	Octave Band Centre Frequency Hz										
					16	32	64	125	250	500	1k	2k	4k	8k	16k
Thursday															
22/06/2017 00:00	60.4	85	43.7	60.5	59.9	56.2	60.6	55.2	57.3	54.9	54.7	50.9	50.1	56.5	48.2
22/06/2017 01:00	54.9	63.6	41.3	59.4	59.3	54.8	55.2	50.8	52.1	49.6	50.7	43.8	45.9	48.2	38.2
22/06/2017 02:00	53.7	62.5	36.4	58.5	56.7	54.2	54.6	49.3	50.5	48.3	48.5	42.1	45.9	48.2	38.1
22/06/2017 03:00	61.3	85.5	38.4	59.7	60.7	62.3	69.3	60.7	58.3	58.0	57.5	52.2	48.7	48.6	38.4
22/06/2017 04:00	56.7	64.5	45.1	60.5	60.8	58.1	58.0	53.3	54.7	52.6	52.6	45.6	46.4	48.9	38.3
22/06/2017 05:00	65.7	84	55.1	63.8	64.7	62.9	63.5	59.6	62.7	62.6	62.3	57.0	50.6	50.4	40.0
22/06/2017 06:00	64.2	80.9	60.8	65.8	65.1	63.9	64.0	60.1	62.3	60.6	61.1	54.5	48.2	49.3	39.1
22/06/2017 07:00	68.7	84.7	62.7	66.5	66.6	66.3	66.4	62.1	64.8	66.1	65.7	58.7	52.5	53.9	49.5
22/06/2017 08:00	65.1	81	61.1	66.3	66.0	65.9	65.6	60.4	62.6	61.2	61.8	56.6	49.6	49.7	39.4
22/06/2017 09:00	66.2	84.3	61.1	66.2	67.0	66.2	66.3	61.0	64.3	63.5	62.8	56.7	49.8	49.6	40.7
22/06/2017 10:00	66.3	82.9	62.5	67.1	68.0	66.0	65.7	61.6	63.7	63.2	63.2	56.8	50.4	49.8	39.3
22/06/2017 11:00	65	81	61	65.7	68.7	66.2	65.3	60.6	63.0	62.0	61.8	55.1	49.2	48.3	38.2
22/06/2017 12:00	67.3	82.2	61.2	66.5	68.2	66.4	69.0	62.7	65.2	65.0	63.9	57.2	51.4	49.4	39.9
22/06/2017 13:00	66.9	83.8	62.6	68	70.9	67.9	66.8	64.5	65.2	64.2	63.5	57.3	50.6	49.2	38.4
22/06/2017 14:00	65.8	81.6	61.6	67.3	69.0	67.2	66.4	62.2	63.5	62.4	62.5	56.6	50.2	50.1	39.0
22/06/2017 15:00	66.5	84.6	62.2	66.6	68.7	66.3	66.2	62.6	63.9	63.5	63.4	56.8	49.9	49.4	39.4
22/06/2017 16:00	65.9	75.6	62.7	67.6	68.2	66.7	66.0	62.7	63.5	62.1	62.6	57.0	50.5	49.7	38.6
22/06/2017 17:00	65.7	85.4	62.3	66.8	67.0	66.1	65.9	63.2	63.7	62.0	62.7	56.3	48.9	48.5	38.5
22/06/2017 18:00	49.7	66.1	10.7	10.7	53.1	53.5	49.4	45.6	46.8	45.4	47.3	39.3	31.5	32.5	23.2
22/06/2017 19:00	10.8	10.9	10.7	10.7	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.9	7.0
22/06/2017 20:00	10.8	10.9	10.7	10.7	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	7.0
22/06/2017 21:00	10.8	10.8	10.6	10.7	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	7.0
22/06/2017 22:00	10.8	10.8	10.6	10.7	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	7.0

* all noise levels are in dB

Table C.1 Ambient noise results; hourly averages for measurements at site boundary towards railway

Period start	LAeq	LAmax	LA90	LA10	Octave Band Centre Frequency Hz										
					16	32	64	125	250	500	1k	2k	4k	8k	16k
Wednesday															
21/06/2017 12:00	53.1	65.1	48.5	54.5	63.2	65.2	61.1	54.6	52.3	48.8	49.1	45.0	40.6	34.2	24.1
21/06/2017 13:00	54.7	70	48.8	57.2	63.9	65.2	65.2	58.5	52.6	49.4	49.8	47.4	44.6	40.9	28.8
21/06/2017 14:00	54.4	73.7	48.4	56	60.9	63.5	60.8	58.3	52.7	48.8	51.0	46.7	41.0	35.2	24.4
21/06/2017 15:00	55	74.6	48.1	55.1	61.4	64.2	60.6	56.2	53.5	51.1	50.6	47.3	44.7	37.7	26.9
21/06/2017 16:00	53.4	73.7	48	53.7	60.4	65.8	60.8	55.5	50.9	47.5	49.8	46.4	40.3	31.6	28.9
21/06/2017 17:00	50.7	61.4	47.3	52.8	57.9	60.6	58.0	53.2	49.6	46.1	46.3	42.4	40.9	32.9	32.4
21/06/2017 18:00	50.2	58.9	45.9	52.3	56.7	59.4	56.7	52.1	49.1	46.2	45.8	41.1	40.4	31.6	18.5
21/06/2017 19:00	50.4	62.9	45.7	52.3	54.6	57.1	56.1	52.5	49.1	45.9	45.4	43.6	40.1	32.4	19.3
21/06/2017 20:00	49.3	63.4	44.3	51.2	53.7	57.2	54.7	52.5	49.0	45.2	44.9	42.1	34.1	28.1	15.7
21/06/2017 21:00	49.4	72.7	43.1	49.9	53.2	57.7	54.5	50.7	50.2	45.6	46.1	39.1	29.7	24.5	14.3
21/06/2017 22:00	44.5	57.7	38.8	47.2	51.5	51.9	52.1	47.9	44.5	40.5	41.5	34.4	23.3	16.6	10.7
21/06/2017 23:00	44.2	62.8	35.8	44.6	51.4	54.1	52.0	46.9	42.1	38.5	38.8	38.4	30.3	34.3	17.7

Period start	LAeq	LAmax	LA90	LA10	Octave Band Centre Frequency Hz										
					16	32	64	125	250	500	1k	2k	4k	8k	16k
Thursday															
22/06/2017 00:00	39.4	49.9	34.8	41.9	51.2	47.9	47.3	43.1	40.2	35.8	36.2	28.0	18.5	14.7	10.3
22/06/2017 01:00	36.7	45.5	33.8	38.7	50.2	47.1	46.4	42.6	39.8	33.1	32.1	24.2	18.4	15.9	10.6
22/06/2017 02:00	40.2	55.2	34.3	42.8	56.5	53.5	51.7	43.7	41.1	35.7	34.0	33.0	29.0	24.3	12.6
22/06/2017 03:00	48.1	56.2	43.8	50.7	58.2	52.2	47.8	42.9	41.7	36.9	36.6	44.7	41.6	28.1	14.8
22/06/2017 04:00	47.2	59.3	42.9	49.4	60.4	55.2	51.8	47.0	45.2	43.0	42.2	36.8	40.8	28.1	16.4
22/06/2017 05:00	49.8	61.6	45.9	51.7	58.2	58.0	55.7	51.0	48.0	45.4	45.8	39.9	41.3	31.5	26.1
22/06/2017 06:00	54	65.6	48.4	56.7	61.0	64.2	60.3	55.2	52.1	49.8	49.8	46.3	43.0	36.7	26.0
22/06/2017 07:00	53.5	68.1	48.7	55.7	60.0	64.6	61.4	54.1	51.4	49.2	49.5	45.5	42.2	37.4	27.1
22/06/2017 08:00	58.6	79.3	49.4	58.2	62.2	66.1	65.4	56.4	54.0	53.4	53.3	52.5	49.0	47.0	38.3
22/06/2017 09:00	55.3	74.1	48.8	55.9	64.4	64.2	61.6	54.6	51.8	50.2	51.1	48.8	44.6	38.2	27.3
22/06/2017 10:00	52.7	66.1	48.2	55.7	67.8	66.6	59.8	53.0	51.2	48.9	48.5	44.4	42.0	36.4	26.5
22/06/2017 11:00	53.4	69.4	48.3	56.3	69.2	65.3	61.3	53.5	50.9	49.2	48.8	45.7	43.7	38.0	27.8
22/06/2017 12:00	55.5	80.1	48.5	54.1	66.5	63.5	59.1	54.0	51.9	48.8	48.8	44.4	42.9	54.4	35.0
22/06/2017 13:00	53.3	70.8	48.6	54.5	68.6	64.7	63.9	57.7	51.6	48.1	48.6	45.9	42.5	35.2	27.2
22/06/2017 14:00	54.7	74.4	48.9	56.4	66.4	64.2	61.2	56.9	52.7	50.1	50.0	47.9	43.7	38.8	38.5
22/06/2017 15:00	54.8	74.8	48.9	55.2	66.4	65.2	61.5	57.1	52.1	50.4	50.5	47.3	43.9	36.4	29.0
22/06/2017 16:00	54.9	76.3	48.8	55.1	67.3	66.0	60.5	55.7	51.9	49.7	50.9	48.0	43.7	37.0	28.9
22/06/2017 17:00	62.5	88.7	41.6	54.2	62.2	63.3	57.7	55.0	54.0	56.7	59.7	52.3	53.8	48.3	45.7
22/06/2017 18:00	44.6	59.5	41.7	46.2	59.5	56.6	54.1	51.5	46.0	40.8	41.1	30.9	19.4	15.3	11.0
22/06/2017 19:00	43.6	60.4	39.6	45.1	59.3	55.0	52.9	50.2	45.6	40.2	39.7	30.0	19.4	15.4	11.0
22/06/2017 20:00	43.5	59	38.6	44.4	58.1	54.4	51.5	50.9	45.6	40.0	39.3	30.2	17.4	14.6	10.4
22/06/2017 21:00	41.7	59.5	36.8	43.4	56.4	52.8	50.9	47.7	43.4	38.7	37.9	27.9	16.8	14.2	10.4
22/06/2017 22:00	41.7	61.7	33.7	41.7	56.9	50.4	48.9	45.9	43.4	39.1	38.1	27.9	17.3	15.1	10.5

* all noise levels are in dB

Table C.2 Ambient noise results; hourly averages for measurements at site boundary towards access road

		hourly vdv			cumulative vdv			Max hourly ppv	
Date		X	Y	Z	X	Y	Z	Max	Time
Ev 057					16 Hour				
21/06/2017					0.053	0.046	0.05	1.93mm/s	13:23:47
		1 Hour			Total				
21/06/2017	Hour 1	0.023	0.02	0.024	0.02	0.017	0.021	1.63mm/s	13:29:47
21/06/2017	Hour 2	0.022	0.02	0.024	0.025	0.022	0.027	1.93mm/s	14:14:07
21/06/2017	Hour 3	0.025	0.023	0.025	0.03	0.027	0.031	1.78mm/s	15:19:57
21/06/2017	Hour 4	0.029	0.026	0.027	0.035	0.031	0.035	.425mm/s	16:45:47
21/06/2017	Hour 5	0.032	0.027	0.029	0.04	0.035	0.039	.325mm/s	17:17:47
21/06/2017	Hour 6	0.033	0.028	0.03	0.044	0.038	0.042	1.85mm/s	18:14:17
21/06/2017	Hour 7	0.033	0.029	0.031	0.047	0.041	0.045	.525mm/s	19:09:37
21/06/2017	Hour 8	0.034	0.03	0.032	0.05	0.044	0.047	.525mm/s	20:38:37
21/06/2017	Hour 9	0.035	0.031	0.033	0.053	0.046	0.05	.700mm/s	21:09:37
Ev 058					8 Hour				
22/06/2017					0.057	0.052	0.056	2.18mm/s	03:40:30
		1 Hour			Total				
21/06/2017	Hour 1	0.033	0.03	0.033	0.033	0.03	0.033	.500mm/s	22:07:40
21/06/2017	Hour 2	0.034	0.031	0.033	0.04	0.036	0.039	.525mm/s	23:07:40
22/06/2017	Hour 3	0.034	0.031	0.033	0.044	0.04	0.043	.325mm/s	00:06:30
22/06/2017	Hour 4	0.034	0.031	0.033	0.048	0.043	0.046	.300mm/s	01:10:50
22/06/2017	Hour 5	0.034	0.031	0.033	0.051	0.046	0.049	.325mm/s	02:17:00
22/06/2017	Hour 6	0.034	0.031	0.033	0.053	0.048	0.052	2.18mm/s	03:40:30
22/06/2017	Hour 7	0.034	0.031	0.033	0.055	0.05	0.054	.300mm/s	04:03:50
22/06/2017	Hour 8	0.034	0.031	0.035	0.057	0.052	0.056	.600mm/s	05:03:10
Ev 059					16 Hour				
22/06/2017					0.074	0.062	0.067	1.80mm/s	18:33:10
		1 Hour			Total				
22/06/2017	Hour 1	0.036	0.031	0.033	0.036	0.031	0.033	.475mm/s	06:17:20
22/06/2017	Hour 2	0.036	0.031	0.033	0.043	0.036	0.039	.675mm/s	07:17:30
22/06/2017	Hour 3	0.036	0.031	0.033	0.048	0.04	0.043	.325mm/s	08:42:10
22/06/2017	Hour 4	0.036	0.031	0.033	0.052	0.043	0.047	.700mm/s	09:55:10
22/06/2017	Hour 5	0.037	0.031	0.033	0.055	0.046	0.05	.325mm/s	10:03:20
22/06/2017	Hour 6	0.037	0.031	0.033	0.057	0.048	0.052	.575mm/s	11:52:50
22/06/2017	Hour 7	0.037	0.031	0.034	0.06	0.05	0.054	.775mm/s	12:46:10
22/06/2017	Hour 8	0.037	0.031	0.033	0.062	0.052	0.056	.450mm/s	13:44:10
22/06/2017	Hour 9	0.037	0.031	0.033	0.064	0.053	0.058	.500mm/s	14:49:50
22/06/2017	Hour 10	0.037	0.031	0.033	0.066	0.055	0.059	.600mm/s	15:41:40
22/06/2017	Hour 11	0.037	0.031	0.033	0.067	0.056	0.061	.325mm/s	16:51:50
22/06/2017	Hour 12	0.037	0.031	0.034	0.069	0.057	0.062	.675mm/s	17:53:10
22/06/2017	Hour 13	0.037	0.031	0.033	0.07	0.058	0.064	1.80mm/s	18:33:10
22/06/2017	Hour 14	0.036	0.031	0.033	0.072	0.06	0.065	.550mm/s	19:08:00
22/06/2017	Hour 15	0.035	0.031	0.034	0.073	0.061	0.066	.575mm/s	20:06:00
22/06/2017	Hour 16	0.035	0.031	0.034	0.074	0.062	0.067	.650mm/s	21:07:30

Date		hourly vdv			cumulative vdv			Max hourly ppv	
		X	Y	Z	X	Y	Z	Max	Time
Ev 062					8 Hour				
24/06/2017					0.065	0.062	0.06	1.90mm/s	01:17:30
		1 Hour			Total				
23/06/2017	Hour 1	0.039	0.037	0.036	0.039	0.037	0.036	.575mm/s	22:06:50
23/06/2017	Hour 2	0.039	0.037	0.036	0.046	0.044	0.043	.600mm/s	23:10:00
24/06/2017	Hour 3	0.039	0.037	0.036	0.051	0.049	0.048	.375mm/s	00:14:10
24/06/2017	Hour 4	0.039	0.037	0.036	0.055	0.053	0.051	1.90mm/s	01:17:30
24/06/2017	Hour 5	0.039	0.037	0.036	0.058	0.056	0.054	.300mm/s	02:02:20
24/06/2017	Hour 6	0.038	0.037	0.035	0.061	0.058	0.056	.325mm/s	03:41:40
24/06/2017	Hour 7	0.038	0.036	0.034	0.063	0.06	0.058	.400mm/s	04:28:30
24/06/2017	Hour 8	0.038	0.036	0.035	0.065	0.062	0.06	.600mm/s	05:11:40
Ev 063					16 Hour				
24/06/2017					0.076	0.072	0.067	.800mm/s	09:55:30
		1 Hour			Total				
24/06/2017	Hour 1	0.037	0.036	0.033	0.037	0.036	0.033	.600mm/s	06:40:50
24/06/2017	Hour 2	0.037	0.036	0.033	0.045	0.042	0.039	.400mm/s	07:41:30
24/06/2017	Hour 3	0.037	0.036	0.033	0.049	0.047	0.043	.500mm/s	08:42:20
24/06/2017	Hour 4	0.038	0.036	0.033	0.053	0.051	0.047	.800mm/s	09:55:30
24/06/2017	Hour 5	0.038	0.036	0.034	0.056	0.054	0.05	.700mm/s	10:41:50
24/06/2017	Hour 6	0.038	0.036	0.035	0.059	0.056	0.052	.775mm/s	11:41:10
24/06/2017	Hour 7	0.038	0.036	0.034	0.061	0.058	0.055	.550mm/s	12:46:20
24/06/2017	Hour 8	0.038	0.036	0.033	0.064	0.06	0.056	.400mm/s	13:49:20
24/06/2017	Hour 9	0.038	0.036	0.033	0.065	0.062	0.058	.500mm/s	14:48:00
24/06/2017	Hour 10	0.038	0.036	0.033	0.066	0.063	0.058	.300mm/s	15:08:00

Table A3.3 Results of groundborne vibration at base of façade facing the railway