Sustainable Acoustics

Space Solutions (UK) Ltd

KINGSWAY MEWS, LONDON

Noise and Vibration Assessment

Report No. 14-0218-0 R01.2

♦ PROTECT ♦ ENHANCE ♦ CONNECT

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Report No.:	14-0128-0 R01.2 CM CH
Date:	04 April 2016

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1 INTRODUCTION

Planning permission is being sought for a development at Kingsway Mews, Kingsway, London. It is proposed to develop the existing site into a mixed use residential and commercial development. The site is located adjacent to a railway and a road, and is under a Heathrow Airport flight path. The proposed development is therefore subject to potential noise and vibration impact, and Sustainable Acoustics Ltd has carried out an assessment of the effect of these on the proposed development.

2 SITE CONTEXT

The site is located on an existing area of garages and parking. There is currently a workshop operating on the site. The site is adjacent to a railway line, which connects Reading to London Waterloo. The site is also directly adjacent to Clifford Avenue/South Circular Road, which passes the site at a relative height of 5 m, and a portion of the site (currently the workshop) is located underneath the road.

The site is also underneath a Heathrow Airport flight path, which for a majority of the time operates on a 'westerly' flight pattern (during westerly winds, which are more common than easterly winds), so aeroplanes will be approaching the airport from the east, and therefore passing directly over the site.

The surrounding area of the site is residential, with only a few commercial premises located within the area.

3 POLICY AND GUIDANCE ON NOISE AND VIBRATION

3.1 National Policy

National Planning Policy Framework (NPPF)

Government policy on noise is set out in the National Planning Policy Framework (NPPF), published in 2012. This replaced all earlier guidance on noise and places an emphasis on sustainability. In section 11, Conserving and enhancing the natural environment, paragraph 109, it states:

The planning system should contribute to and enhance the natural and local environment by: preventing both new and existing development from contributing to or being put at unacceptable risk from, or being adversely affected by unacceptable levels of soil, air, water or noise pollution or land instability;

Paragraph 123 states:

Planning policies and decisions should aim to:

Avoid noise from giving rise to significant adverse impacts on health and quality of life as a result of new development;

Mitigate and reduce to a minimum other adverse impacts on health and quality of life arising from noise from new development, including through the use of conditions;

Recognise that development will often create some noise and existing businesses wanting to develop in continuance of their business should not have unreasonable restrictions put on them because of changes in nearby land uses since they were established.

In the context of the proposed scheme, the NPPF can be interpreted as favouring development of the site provided that any adverse noise impacts are mitigated to a level at which they have no significant impacts on health and quality of life.

Noise Policy Statement for England

Paragraph 123 of the NPPF also refers to advice on adverse effects of noise given in the Noise Policy Statement for England[i] (NPSE). This document sets out a policy vision to:

Promote good health and a good quality of life through the effective management of noise within the context of Government policy on sustainable development.

To achieve this vision the Statement identifies the following three aims:

Through the effective management and control of environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development:

- *Avoid significant adverse impacts on health and quality of life;*
- *Mitigate and minimise adverse impacts on health and quality of life;*
- *Where possible, contribute to the improvement of health and quality of life.*

In achieving these aims the document introduces significance criteria as follows:

SOAEL – Significant Observed Adverse Effect Level

This is the level above which significant adverse effects on health and quality of life occur. It is stated that "significant adverse effects on health and quality of life should be avoided while also taking into account the guiding principles of sustainable development".

LOAEL – Lowest Observed Adverse Effect Level

This is the level above which adverse effects on health and quality of life can be detected. It is stated that the second aim above lies somewhere between LOAEL and SOAEL and requires that: "all reasonable steps should be taken to mitigate and minimise adverse effects on health and quality of

[i] Department for Environment, Food and Rural Affairs, *Noise Policy Statement for England,* London, 2010

life while also taking into account the guiding principles of sustainable development. This does not mean that such adverse effects cannot occur."

NOEL – No Observed Effect Level

This is the level below which no effect can be detected. In simple terms, below this level, there is no detectable effect on health and quality of life due to the noise. This can be related to the third aim above, which seeks: "where possible, positively to improve health and quality of life through the pro-active management of noise while also taking into account the guiding principles of sustainable development, recognising that there will be opportunities for such measures to be taken and that they will deliver potential benefits to society. The protection of quiet places and quiet times as well as the enhancement of the acoustic environment will assist with delivering this aim."

The NPSE recognises that it is not possible to have a single objective noise-based measure that is mandatory and applicable to all sources of noise in all situations and provides no guidance as to how these criteria should be interpreted. It is clear, however, that there is no requirement to achieve noise levels where there are no observable adverse impacts but that reasonable and practicable steps to reduce adverse noise impacts should be taken in the context of sustainable development and ensure a balance between noise sensitive and the need for noise generating developments.

3.2 Local Policy

The London Borough of Richmond upon Thames does not have any planning policies specifically regarding noise or vibration impact on new residential developments, but does list Planning and Policy Guidance 24 (PPG24): Planning and Noise (1994) within its Development Management Plan, adopted in November 2011. PPG24 has since been archived, so it is considered appropriate to use other current guidance, outlined below.

3.3 Guidance on Noise and Vibration

National and local policies are designed to avoid the creation of new sensitive development which may be subject to unacceptable levels of noise and vibration, but specific guidance is not given on assessment methods to be used to achieve this objective. It is therefore considered appropriate to have regard for advice given in recognised national standards and guidance, which are discussed below.

British Standard 8233: 2014

The British Standard BS 8233: 2014, *Guidance on Sound insulation and noise reduction for buildings* provides additional guidance on noise levels from sources without specific character in the built environment, based on the recommendations of the World Health Organisation. It is, however, stated in the introduction that the suggested levels may need to be adjusted to suit local circumstances. The criteria for desirable levels of steady state, "anonymous" noise in unoccupied spaces within dwellings from sources such as road traffic, mechanical services and other continuously running plant, are tabulated below:

Activity	Location	07:00 to 23:00	23:00 to 07:00
Resting	Living room	35 dB $L_{Aeq, 16 hour}$	-
Dining	Dining room/area	40 dB $L_{Aeq, 16 hour}$	-
Sleeping (daytime resting)	Bedroom	35 dB $L_{Aeq, 16 hour}$	30 dB $L_{Aeq, 8 hour}$

Table 1: BS 8233 criteria for internal noise levels in dwellings

It is noted, however that where development is considered necessary or desirable, despite external noise level above WHO guidelines, the above target levels may be relaxed by up to 5 dB and reasonable conditions still achieved (note 7).

The standard also recommends that for traditional external amenity areas, such as gardens, it is desirable that external noise levels do not exceed 50 dB $L_{Aeq, T}$, and that 55 dB $L_{Aeq, T}$ would be acceptable in noisier environments. However, it is recognised that these values may not be achievable in all areas where development is desirable and in such locations, development should be designed to achieve the lowest practicable levels.

It is also noted that noise limits should not be necessary for external areas, such as balconies, roof gardens and terraces, where normal external amenity space is limited. However, the general guidance for noise in amenity space used for relaxation is still appropriate in protecting these areas.

General recommendations for mitigation to enable these targets to be achieved are provided, including the use of bunds and barriers to reduce external noise and space planning and sound insulation for the control of internal noise levels.

British Standard 6472: 2008

British Standard 6472:2008, Part 1 is entitled *"Guide to evaluation of human exposure to vibration in buildings"* provides guidance and criteria for predicting how people inside buildings respond to building vibration (with the judgement criteria more stringent at higher frequencies than in the standard that was superseded in 2008) and the probability that vibration levels would be acceptable in the built environment. This is relevant when considering the suitability of location residential buildings close to vibration sources.

The criteria for unoccupied spaces within residential properties are tabulated below, where the values are Vibration Dose Values (VDV), based on frequencies weighted measurements:

Place and time	Low probability of adverse comment, $m/s^{1.75}$	Adverse comment possible, $m/s^{1.75}$	Adverse comment probable, $m/s^{1.75}$
Residential buildings – 16 hour daytime period	0.2 - 0.4	0.4 - 0.8	0.8 - 1.6
Residential buildings – 8 hour night time period	0.1 – 0.2	0.2 – 0.4	0.4 – 0.8

Table 2: BS 6472 assessment criteria for probability of adverse comment

4 NOISE AND VIBRATION SURVEY

4.1 Overview

A survey has been undertaken to quantify the levels of noise from the adjacent road, railway and aircraft flyovers, and additionally, vibration from the adjacent railway impacting upon the site and enable assessment against the above policy and guidance.

Noise and vibration measurements were taken between the dates of 15th – 19th January 2015. Continuous noise and vibration measurements were acquired in 15-minute intervals with the microphone located at 1.5 m from the roof of the existing garages, approximately 4 m from the road. The accelerometer was located on the ground directly below the microphone, positioned on a concrete slab. These positions are shown at Figure 1.

Additional attended measurements were taken across the car park whilst logging in this position to establish any difference in noise levels across the site. Two positions were chosen for these measurements, as shown on Figure 1, with the microphone at a height of 1.5 m from ground in both cases. A 1 second time history was taken during these measurements in order to accurately quantify the difference between these measurements and the continuous monitoring.

The weather during the measurement period was calm and dry with south westerly winds for a majority, with some periods of rain and higher winds. During Thursday 15th January the wind speeds were above 5 m/s during the day, but this has not resulted in elevated noise levels. The wind speeds dropped overnight between 15th-16th to below 3 m/s, remaining at approximately this speed for the rest of the measurement period, only increasing up to but not exceeding 5 m/s briefly on 17th. On the 18th wind speeds changed direction to a north-westerly wind, but stayed at below 3 m/s. There were brief periods of rain during the survey, but these were not enough to alter the noise measurements significantly.

4.2 Instrumentation

Continuous monitoring of sound and vibration levels was undertaken using a Svantek 958A Sound & Vibration Analyser (serial number 34551). For the sound measurements, a Svantek SV 12L pre-amplifier and 7052E ½-inch free field microphone (serial numbers 33541 & 55952) fitted. The microphone was fitted with a windshield during the measurements. For the vibration measurements, a Svantek SV84 tri-axial accelerometer (serial number C4559) on SV 207B ground vibration base plate was fitted. The sound & vibration level meter was last calibrated by the manufacturer on 17th October 2013.

Additional noise levels were measured using a Larson Davis type 824 Precision Sound Level Meter and Real Time Analyser (serial number 824A 1344), fitted with a Larson Davis type 2541 ½-inch free field microphone (serial number 4418) and Larson Davis type PRM 902 preamplifier (serial number 3544). The microphone was fitted with a windshield during the measurements. The sound level meter, microphone and preamplifier were last calibrated in a calibration laboratory on 18 June 2014. Calibration and conformance certificates are available.

Prior to and on completion of the survey, the sound level meter and microphone calibration was checked using a Larson Davis type CAL 200 Sound Level Meter Calibrator (serial number 2206). The

Calibrator was last calibrated on 18 June 2014, in accordance with the requirements of ISO 10012 and a calibration and conformance certificate is available. No significant change in the calibration level occurred during the survey.

4.3 Measured Noise Levels

The noise levels measured in 15 minute periods between 15th – 19th January 2015 are summarised in Table 3 below. The results are shown in full at Figure 2.

Period	Period Start	Period End	L_{Aeq} (dB) Range (15min)	L_{Aeq} (dB) Average (Day/Night 16/8hr)	L_{A90} (dB) Range (15min)	$L_{Amax,f}$ (dB) Range (15min)
Daytime	15/01/2015 11:45	15/01/2015 23:00	62 - 68	65	45 - 56	78 - 89
Night-time	15/01/2015 23:00	16/01/2015 07:00	49 - 67	61	31 - 56	64 - 87
Daytime	16/01/2015 07:00	16/01/2015 23:00	61 - 68	65	45 - 56	76 - 89
Night-time	16/01/2015 23:00	17/01/2015 07:00	53 - 66	61	36 - 49	66 - 88
Daytime	17/01/2015 07:00	17/01/2015 23:00	63 - 69	66	45 - 56	77 - 91
Night-time	17/01/2015 23:00	18/01/2015 07:00	53 - 66	61	35 - 51	65 - 90
Daytime	18/01/2015 07:00	18/01/2015 23:00	62 - 69	66	46 - 55	76 - 91
Night-time	18/01/2015 23:00	19/01/2015 07:00	50 - 68	61	35 - 54	66 - 88

Table 3: Summary of noise measurements at LT1

The results of the attended measurements measured alongside the long term measurements are shown at Figure 3.

4.4 Measured Vibration Levels

The accelerometer was fixed to a base plate and placed on the concrete floor approximately 15 m from the closest railway line. Vibration levels were measured in three orthogonal axes, with the largest magnitude of vibration measured on the vertical axis. These were then directly converted to vibration dose values (VDV) by the meter.

The vibration dose values measured over each 16—hour daytime period and 8-hour night time period for the z-axis are given in Table 3 below.

Place and time	Thurs $m/s^{1.75}$	Fri $m/s^{1.75}$	Sat $m/s^{1.75}$	Sun $m/s^{1.75}$
Residential buildings – 16 hour daytime period	0.021	0.022	0.021	0.025
Residential buildings – 8 hour night time period	0.016	0.018	0.014	0.013

Table 4: Vibration dose values calculated from direct measurement

The measured vibration levels are shown at Figure 4 and Figure 5, as RMS and VDV values, which are discussed in the 5.2 of this report.

5 ASSESSMENT

5.1 Noise

5.1.1 Internal Noise Levels

It is proposed to develop the site including residential housing and commercial units. The residential properties are proposed to be located along the boundary of the site adjacent to the boundary. The proposed position of the houses is shown at Figure 6. The rear of the properties will therefore be subject to the most railway noise. Both sides of the houses will be subject to noise from the road and aircraft flyovers.

Figure 3 shows a time history of noise measured at the long term measurement position and the attended measurement positions simultaneously, with a resolution of one second. It was observed that the greatest noise impact on the site is due to aircraft flyovers, which can be seen on this graph where the two traces directly overlay each other. The train pass-bys are only clear at the long term measurement position on the roof of the existing garages, which had line of sight to the railway line. It is clear from these measurements however, that the aircraft fly-overs are the dominant source of noise across the site. This is also clear from the consistency of average noise levels over the day and night-time period. During the daytime the average noise levels were 65-66 dB $L_{Aeq,\,16hr}$, and during the night-time the average noise levels were 61 dB $L_{Aeq,\,8hr}$.

Assuming a level difference through a window partially open for ventilation of 15 dB (BS 8233 Annex G, example G.1), external levels of 50 dB $L_{Aeq,\,16hr}$ would allow the internal ambient noise levels in living rooms and bedrooms specified in BS 8233 to be achieved during the daytime, and external levels of 45 dB $L_{Aeq,\,8hr}$ would allow the internal ambient noise levels in bedrooms specified in BS8233 to be achieved during the night-time. The measured average daytime and night-time noise levels are therefore both significantly above the level at which the internal noise levels within BS 8233 can be achieved.

It is also important to take into account the maximum noise levels during the night-time. Maximum noise levels during the night-time ranged between 65 – 90 dB $L_{Amax,f}$, although for a majority of the night-time the maximum noise levels do not exceed 83 dB $L_{Amax,f}$. The highest noise levels are likely to be due to train passbys, however there are no windows to bedrooms at the rear of the property overlooking the railway so the mitigation measures should be designed to reduce the maximum noise levels due to aircraft fly-overs.

The likelihood of disturbance being caused by these maximum events is also dependant on the number of events during the night-time period. There is no recognised standard or government guidance with specific criteria for acceptable maximum levels, however World Health Organisation (WHO) Guidelines for Community Noise advises that for single sound events, the internal maximum sound level should generally not exceed 45 dB $L_{Amax,f}$ (based on 10-15 short term events in an 8 hour period), which corresponds to an external level of 60 dB $L_{Amax,f}$ (assuming 15 dB through a partially open window). It is therefore considered appropriate to attenuate the majority of the night-time to achieve below approximately 45 dB $L_{Amax,f}$, so that only very few higher noise levels remain during the night-time period. The lower number of maximum noise levels during the night-time period would not be considered to be likely to cause a disturbance.

In the daytime, there is no similar guidance with criteria for maximum noise levels. The number of maximum noise levels in the daytime will be significantly higher during the daytime, so with particularly high maximum noise levels, it is recommended to control the maximum noise levels in the living rooms of the properties, which are located on the ground floor and have windows facing the railway.

Mitigation will therefore be required to reduce the ambient and maximum noise levels within the residential properties for both the daytime and the night-time.

5.1.2 Roof Terraces

The roof terraces will be exposed to relatively high noise levels, approximately 10-15 dB above the levels recommended in BS 8233 for external amenity space. These levels will not be achieved in an external space due to the noise impact from aircraft directly above. However BS 8233 also states:

"it is also recognized that these guideline values are not achievable in all circumstances where development might be desirable… development should be designed to achieve the lowest practicable levels in these external amenity spaces, but should not be prohibited."

Noise levels could be marginally reduced by the use of soft ground coverings or by creating 'winter gardens' on the roof instead of open terraces (i.e. fully glazed rooms), however given the proximity to the Heathrow Airport flight path, it is considered that the noise levels on the roof terraces should not prohibit the development as a whole and should not result in the removal of provision of external amenity space.

5.2 Vibration

Groundborne Vibration

At no point, during either the day or night, do the values exceed those causing a '*low probability of adverse comment'* (as stated in Table 2). The vibration levels were measured approximately 15 m from the side of the railway line, and so are considered to be representative in terms of the potential impact on the proposed residential properties.

Structureborne Noise

The measured vibration levels have been used to estimate structureborne noise levels, using the methodology outlined in the Association of Noise Consultants' publication *Measurement & Assessment of Groundborne Noise & Vibration* (Fresco, 2001), which follow the simplified method to estimate building vibration response as described in Annex D.4 of BS 6472-1:2008 and using guidance contained within Federation of Transit Administration (USA), *Transport noise and vibration impact assessment* (May 2006). It should be noted that these methods are generally found to be conservative and may overestimate the resulting structureborne noise levels.

Maximum values have been calculated for all three axis of vibration, and it was found that noise generated by vibration in the vertical Z-axis was most significant. Resulting noise from vibration in the X- and Y- axes was found to be negligible.

Structureborne noise will be intermittent as the source in question is vibration from passing trains. Therefore, it is most appropriate to consider the maximum levels at night and these can be assessed in a similar way to airborne maximum noise levels in Section 5.1. It is relevant to assess the maximum noise levels due to structureborne noise using the same advice from the WHO guidelines, therefore against a criterion of 45 dB $L_{Amax,f}$.

There were only a small number of high maximum structureborne noise levels recorded in the night-time period above this threshold level; only a maximum of four 15-minute periods during the night-time recording maximum noise levels above this level. This is an indication that the impact of maximum structureborne noise levels will be low, however, since there have been some high noise levels predicted and if a light-weight construction is proposed, it would be recommended that further calculations are carried out once the development is in the design stage as the construction will be known and therefore the likely structureborne noise levels can be predicted with more accuracy.

6 MITIGATION

Noise

Some mitigation measures will be required in order to achieve the recommended internal ambient noise levels. The table below summarises the mitigation needs of the development.

	Measured noise level	Predicted internal noise level with open windows	Required internal noise level	Required reduction in noise level
Daytime	65-66 dB $L_{Aeq,\ 16hr}$	50-51 dB $L_{Aeq,\ 16hr}$	35 dB $L_{Aeq,\ 16hr}$	31 dB
Night-time	61 dB $L_{Aeq,\ 8hr}$	46 dB $L_{Aeq,\ 8hr}$	30 dB $L_{Aeq,\ 8hr}$	31 dB
	83 dB $L_{Amax,f}$	68 dB $L_{Amax,f}$	45 dB $L_{Amax,f}$	38 dB

Table 5: Summary of mitigation requirements

All of the above reductions are associated with the break-in noise from external noise sources. Due to the aircraft noise, options such as the use of noise barriers and alternative building layouts are not feasible in this case. It is therefore appropriate to mitigate the noise levels by improving the sound insulation of the building envelope.

To achieve the internal ambient noise levels above, natural ventilation is not an option, since the required attenuation is much larger than would be given by a partially open window. Assuming therefore that windows are closed, the glazing will need to be sufficient to reduce the internal ambient noise levels from road and railway noise. Standard thermal double glazing typically provides a weighted sound reduction value of approximately 33 dB $R_{w,}$ which will not be sufficient to reduce daytime or night-time internal noise levels to the required value.

The requirement for reduction of the maximum noise levels will be the most stringent, as a reduction of 38 dB is required.

Upgraded glazing will be required for all windows, so it is assumed that the same specification of glazing will be installed throughout. A suitable reduction to reduce the daytime and night-time ambient and maximum noise levels (based on the measured frequency spectrum) can be obtained by using glazing with a minimum weighted sound reduction of **40 dB R_w**. A potential glazing build-up to achieve this would be a **10 mm float outer pane with a 12 mm air gap and a 8.4 mm acoustic inner pane**. Other combinations can provide equivalent performance, and should be discussed with the glazing manufacturer. Specifications with similar thickness inner and outer panes should be avoided as these generally result in a reduced performance at higher frequencies due to coincidence effects.

Many conventional façade and roof constructions should provide sufficient sound attenuation; however, any lightweight façade and roof construction would need to be designed to ensure that sufficient sound insulation is provided to ensure the recommended internal noise levels are met. The specification would typically need to be around 10 dB higher than the weakest element (the windows).

Windows will need to be closed to provide the necessary sound reduction. To allow this to be possible, an alternative ventilation system will be required. The alternative ventilation system would need to be compatible with the requirements of parts F and L of the Building Regulations as well as being attenuated to ensure that the desired internal noise levels are met. Proprietary acoustic ventilation systems, comprising a combination of passive supply and mechanical extract (which can also be used to ventilate bathrooms and kitchens), that maintain the sound insulation requirements of the building envelope are available. Whole house ventilation systems with heat recovery are another option that can provide effective ventilation while maintaining the sound reduction required. The supply and extract elements of the system should be designed and located such that noise levels breaking in through the system are properly controlled.

Vibration & Structureborne Noise

There is a relatively small risk of the likelihood of structureborne noise affecting the residential properties, since the structure is likely to attenuate a large portion of the measured vibration levels on the ground, and the higher frequencies are unlikely to be re-radiated. However, it is recommended that further calculations are carried out once the construction method has been confirmed. This risk should be minimised through the use of solid masonry construction and light-weight constructions, such as timber frame, should be avoided. It is also recommended that large spread footing foundations should be used where new foundations are required, which should be over-engineered if possible, rather than piles. In general larger buildings and foundation result in a lower level of vibration transmitted through the structure.

7 CONCLUSION

A study has been undertaken to assess the likely impact of road, railway and aircraft noise, along with vibration from the railway line at the proposed development at Kingsway Mews, London.

Measured ambient noise levels during both the daytime and night-time periods indicate that mitigation measures will be required to achieve internal noise levels recommended in B S8233:2014 and WHO guidelines. To achieve this acoustic glazing has been specified to all windows, in conjunction with an alternative means of ventilation to open windows.

Measured vibration dose values (VDV) were found to be below the threshold where there exists a low probability of adverse comment, and so groundborne vibration due to the railway is not considered an issue. Predicted levels of maximum structureborne noise due to passing trains at night indicated that they may exceed the threshold of 45 dB L_{Amax}. It has therefore been recommended that further calculations are carried out during the design stage.

In conclusion, it is considered that the development can achieve recommended levels of internal noise and vibration, provided that a scheme of mitigation is adhered to, as outlined in Section 6.

Figure 1: Aerial view of site showing measurement positions (with approximate red boundary)

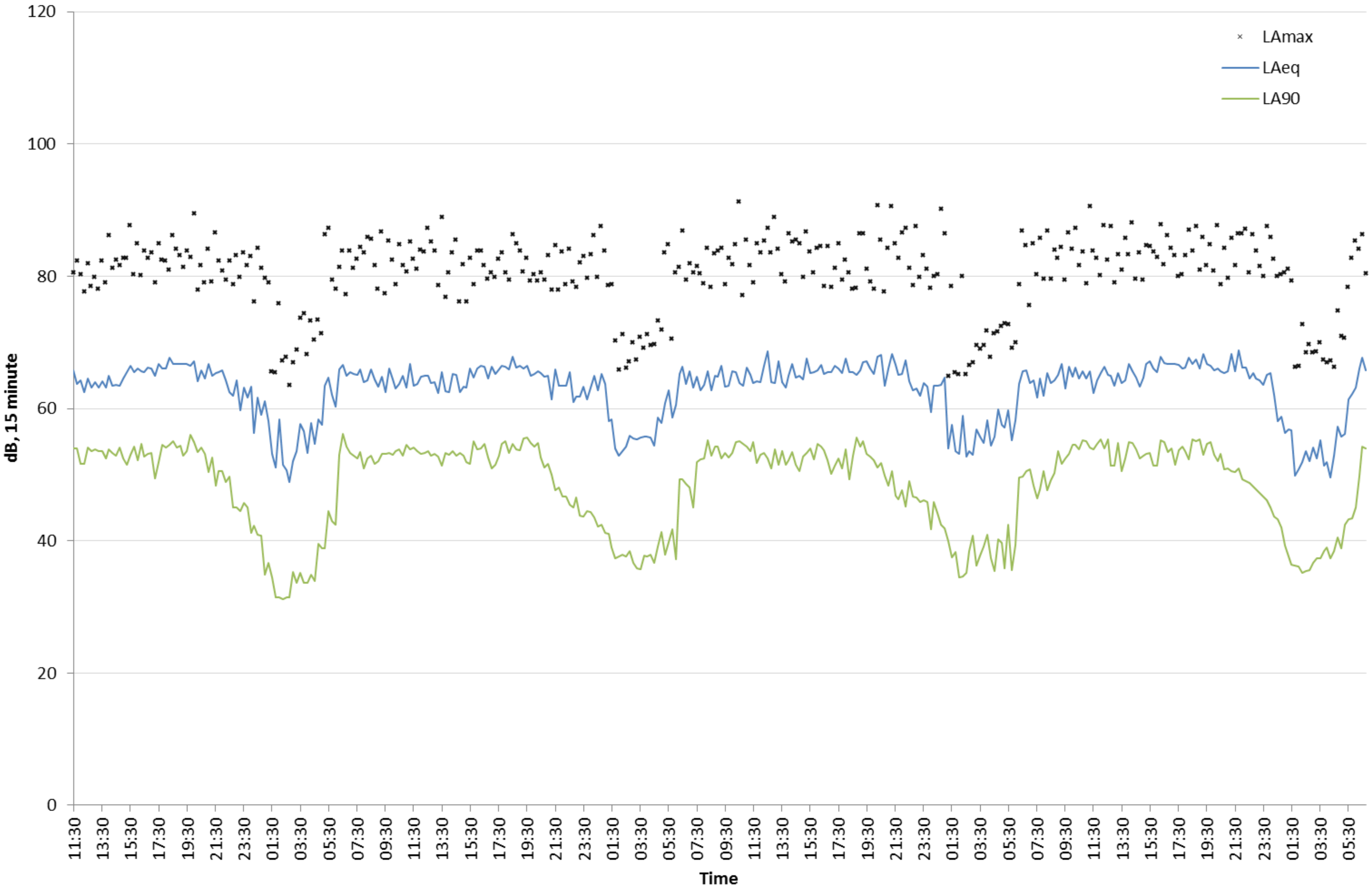

Figure 2: Long term noise measurement data at LT1

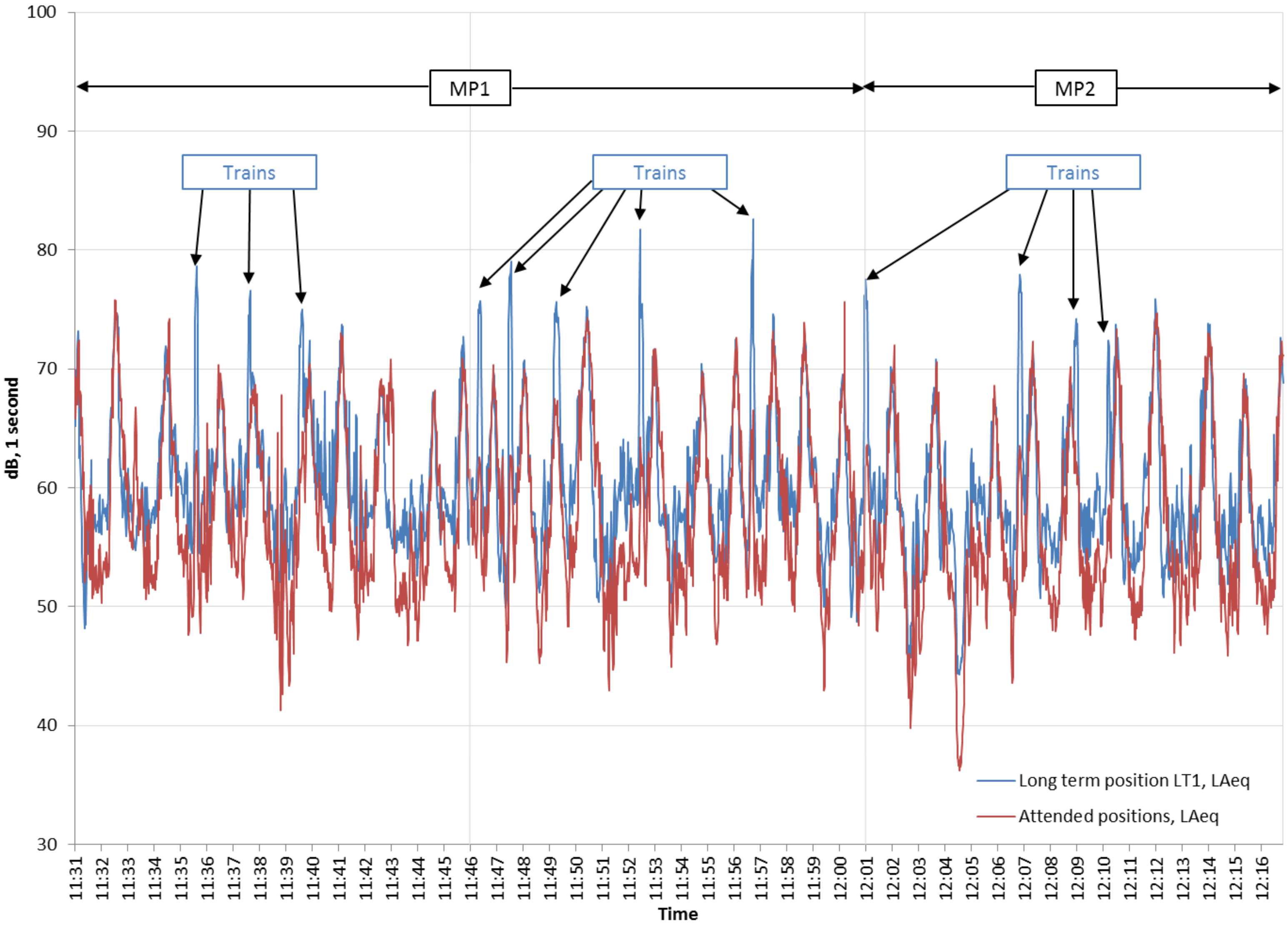

Figure 3: Simultaneous measurements at LT1 and MP1/MP2

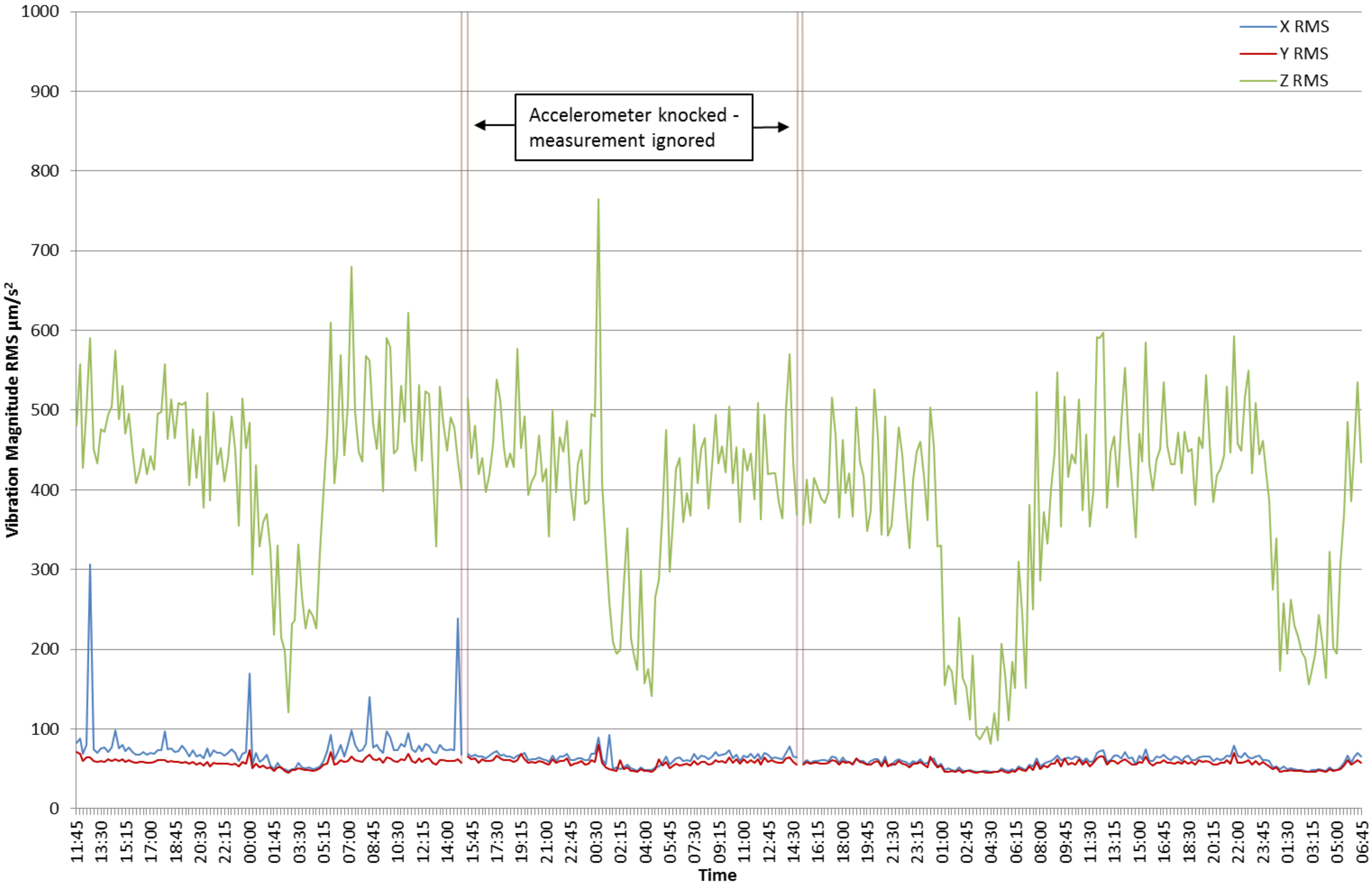

Figure 4: RMS vibration levels

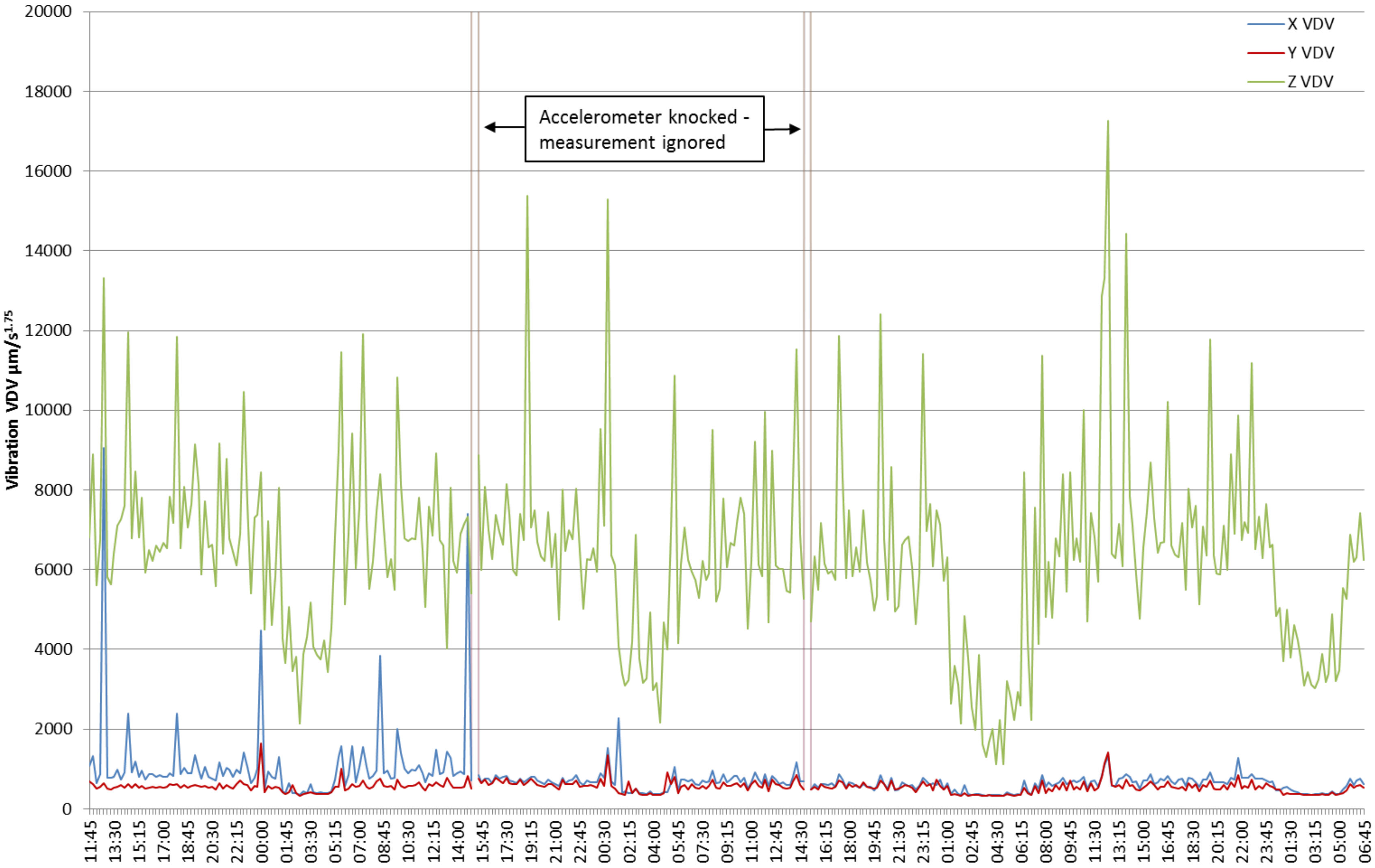

Figure 5: VDV Vibration levels

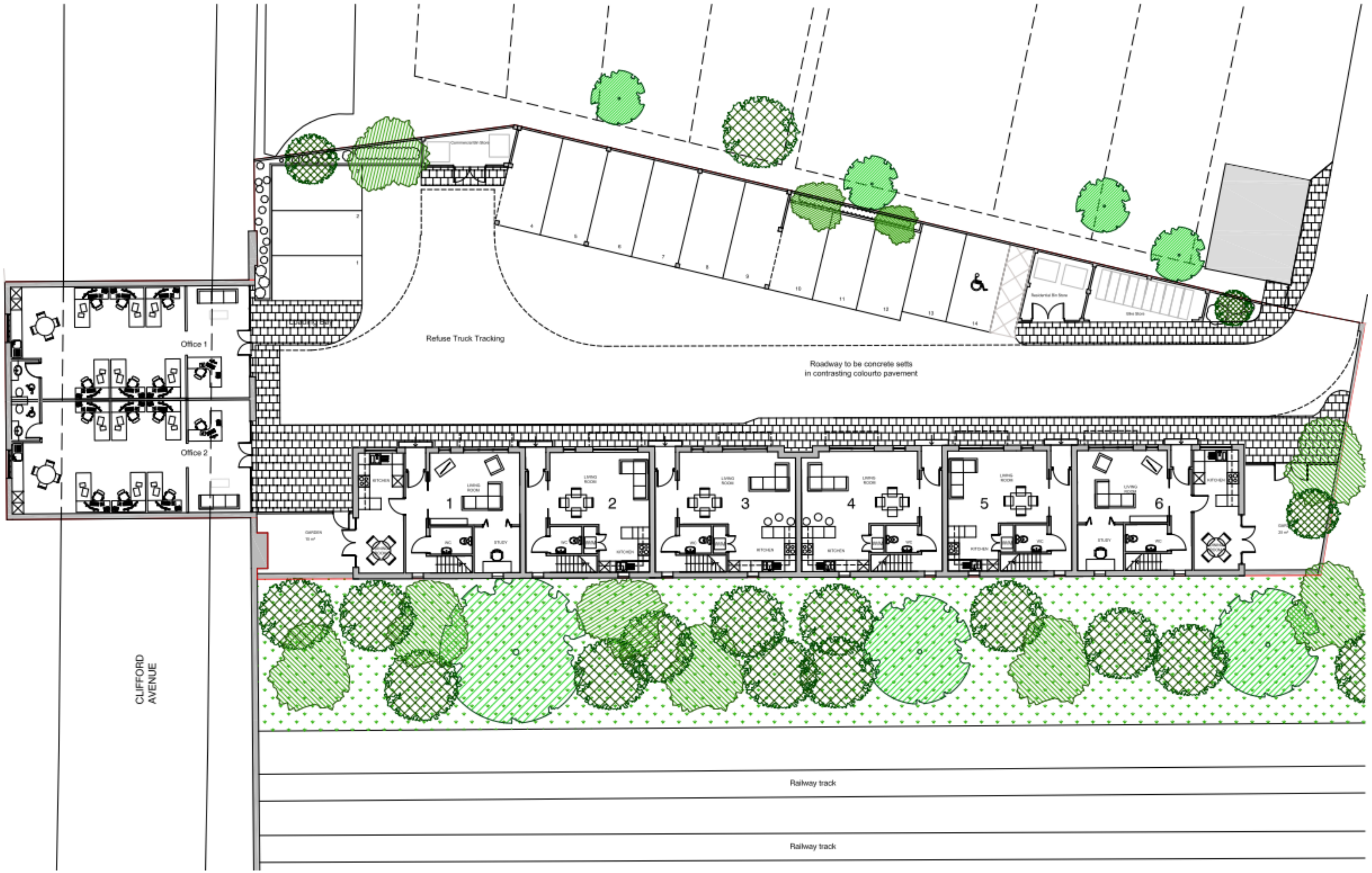

Figure 6: Proposed site layout (ground floor building layout)

Figure 7: Proposed building layout (first floor)

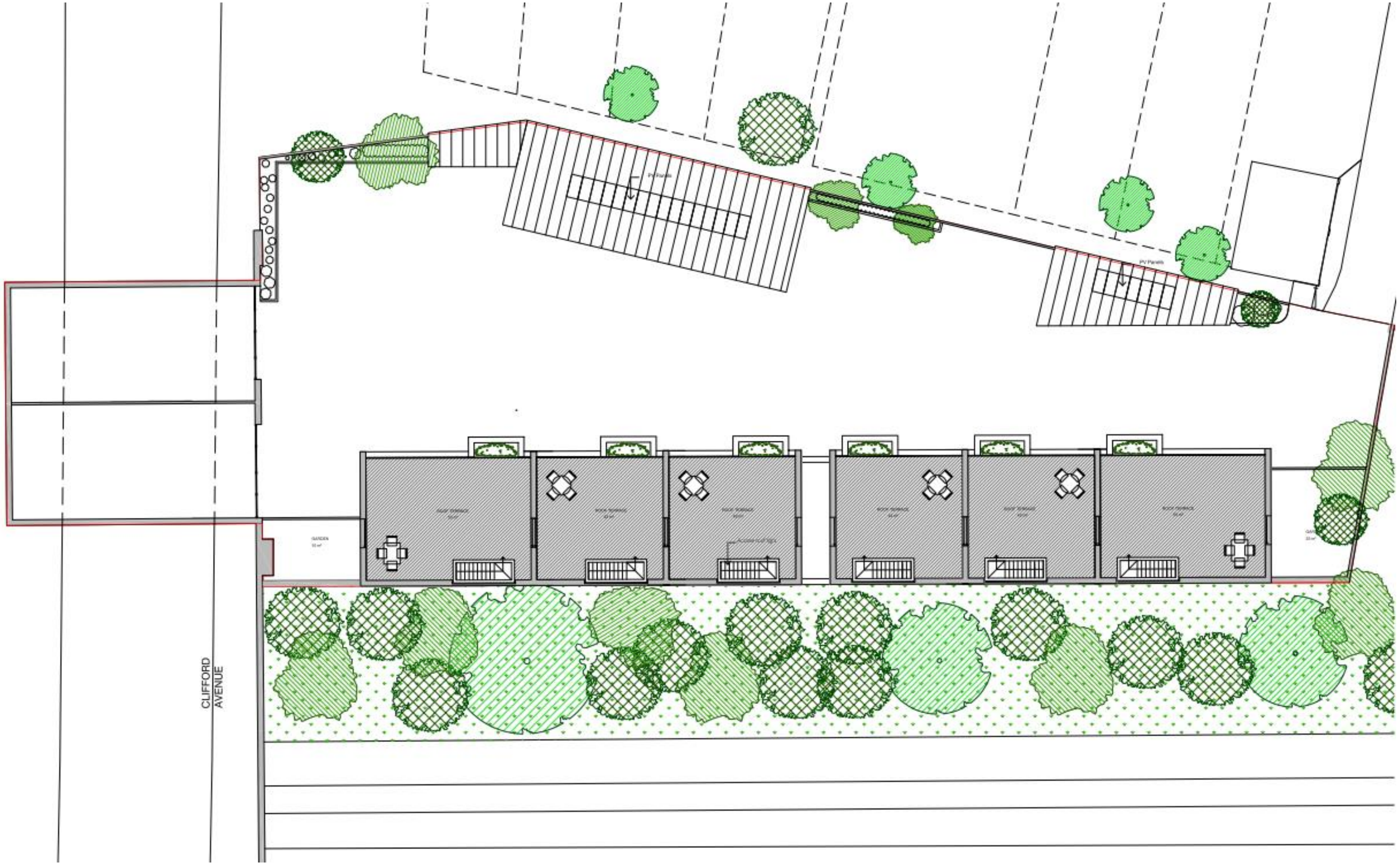

Figure 8: Proposed building layout (roof terrace)

APPENDIX 1 Acoustic Terminology

Environmental Noise

Environmental noise is normally described in terms of the single figure A-weighted sound pressure level, in decibels (dB). The A-weighting corresponds to the frequency sensitivity of the ear and, therefore, provides an approximation to the subjective response to sound at different frequencies. When a sound level is expressed in this way, the units can be denoted dB(A).

When sound is time varying, it is convenient to express the sound level using an indicator, or descriptor that takes account of this variation. Two types of indicator are in common use, the equivalent continuous sound level and the statistical indicators.

Equivalent continuous sound level

This indicator provides the overall noise exposure to time varying sound and is the energy average of the sound over a specified time period. It is the notional steady level that would, over a given period of time, deliver the same sound energy as the actual fluctuating sound over the same period. It is denoted $L_{eq,\,T}$, or, if A-weighted, $L_{Aeq,\,T}$, where T is the time period of interest.

Statistical indicators

The statistical indicators are also single figure descriptors, but provide additional information on the temporal variation of the noise level with time. The indicators are expressed as the sound level exceeded for a specified percentage of the time period of interest and the most commonly used are described below:

$L_{A90,\,T}$: the A-weighted noise level exceeded for 90% of the time period T. This indicator is representative of the noise level occurring in the absence of short-term events and is used in the UK to represent the background noise level.

$L_{Amax,\,T}$: the maximum A-weighted noise level that occurred during the time period T. It usually includes an additional subscript, slow (s) or fast (f), ie $L_{Amax,\,slow,\,T}$ or $L_{Amax,\,fast,\,T}$ which denotes the response time used in the analysis algorithm. The fast response tracks the maximum level of a rapidly changing sound more accurately than the slow response and the value is generally higher for impulsive or transient sounds.

Sound Power Level

The fundamental measure of sound power. Defined as

$$Lw = 10\log\frac{P}{P_0}\,dB$$

where P is the RMS value of sound power in watts and P_0 is 1pW.

The sound power level cannot be directly measured and is derived from measurements of the sound pressure level at a known distance from the source by correcting for the propagation distance and any directivity characteristics. For a source that is small relative to the propagation distance, it is assumed that the sound propagates spherically from the source. Where the source is close to a reflecting surface, such as the ground, hemispherical radiation is assumed. Other reflecting surfaces or directional characteristics can be taken into account as appropriate.

Ambient noise

Totally encompassing sound in a given situation at a given time usually composed of sound from many sources near and far.

Sound Reduction Index

The reduction in each frequency band when measured in a laboratory is the sound reduction index of a material element R. When measured as part of a 10m^2 area is then standardised for a set area of material between two know volumes, where that element is the acoustically weakest part. When weighted against a reference curve this is called the standardised weighted sound reduction index (R_w) in dB. This relates only to the element tested, and if tested in the field becomes (R'_w).

Vibration Dose Value

The quantity of vibration exposure can be assessed by measuring the vibration dose of a period, which is the rms acceleration as a root mean quad value. This is defined in BS6472:2008 as VDV.

Transfer Function

The function (between 0 and 1) which quantifies the efficiency with which vibrational energy is transferred between two points (typically ground into building); where 1 = 100% transfer of energy.