1 Dumpton Place, NW1 8JD

Noise and Vibration Impact Assessment Report

Izabelle Investments Ltd.

17th February 2012

Quality Management

Issue/revision	Revision 1	Revision 2	Revision 3
Remarks	Final Draft	Final Draft	
Date	27 October 2010	17 February 2012	
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Project number	12104209.001	12104209.002	
File reference	12104209.NAR1.2	12104209.NAR1.3	

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1 Introduction

1.1 WSP Acoustics has been commissioned by CgMs Consulting on behalf of Izabelle Investments Ltd to undertake a survey and assessment of the environmental noise and vibration levels affecting a mixed commercial and residential development, know as 1 Dumpton Place, London.

1.2 The purpose of this assessment is to establish the typical environmental noise and vibration levels affecting the external elevations of the proposed development during the daytime and night-time periods and to demonstrate the suitability of the site for residential and commercial use.

1.3 On the basis of the measured noise levels, generic advice has been provided on the required acoustic performance of the external building fabric elements to ensure that noise break-in is controlled to an acceptable level.

1.4 The noise survey and assessment has been undertaken in accordance Planning Policy Guidance Note (PPG) 24: 'Planning and Noise'. The noise requirements set out in the London Borough of Camden's Replacement UDP policy SD7: Appendix 1: 'Noise and Vibration Thresholds' are based upon PPG 24.

1.5 The vibration survey and assessment has been undertaken in accordance with British Standard 6472-1: 2008: 'Guide to evaluation of human exposure to vibration in buildings. Part 1: Vibration sources other than blasting'. The vibration requirements set out in the London Borough of Camden's Replacement UDP policy SD7: Appendix 1: 'Noise and Vibration Thresholds' are noted to be based upon BS 6472.

1.6 The criteria for external noise break-in, on which the generic acoustic requirements for the building fabric are based, are in accordance with the recommendations set out in British Standard BS 8233: 1999: 'Sound Insulation and Noise Reduction for Buildings – Code of Practice'.

1.7 This report sets out the results obtained from the environmental noise survey and the methodology used to assess the results. Details of relevant noise criteria are provided and the results of the generic assessment are presented, together with an assessment of the generic acoustic requirements for the building fabric elements.

1.8 This report is necessarily technical in nature and contains a certain amount of terminology relating to acoustics. To assist the reader, a glossary of terminology is presented in Appendix A.

2 Site Description

2.1 The site address is 1 Dumpton Place, an area of land located between the rear of the existing residential dwellings on Gloucester Avenue and multiple railway lines, situated in the Primrose Hill area of North London and was formally used as a Volvo automotive service and repair shop.

2.2 The Site is bounded to the north and west by the railway corridor containing several lines feeding in to Euston Station and to the south and east by the existing buildings facing Gloucester Avenue.

2.3 For the purpose of this assessment it is considered that the rail traffic will be the primary contributor of environmental noise and vibration. Existing buildings between the Site and Gloucester Avenue will provide significant screening to the road traffic noise.

2.4 A plan of the site can be seen in Appendix B.

3 Noise Assessment Criteria

PLANNING POLICY GUIDANCE NOTE 24

3.1 Planning Policy Guidance Note 24 (PPG 24) entitled *'Planning and Noise'*, published in September 1994, sets out the Government's policies on noise related planning issues. It gives guidance to local authorities in England on the use of their planning powers to minimise the adverse impact of noise. Specifically, it:

- outlines the considerations to be taken into account when determining planning applications for both noise-sensitive developments and for those activities which will generate noise;
- sets out Noise Exposure Categories for residential development, encourages their use and recommends appropriate levels for exposure to different sources of noise; and
- advises on the use of planning conditions to minimise the impact of noise.

3.2 The four Noise Exposure Category (NEC) bands set out in PPG 24 are designed to assist local planning authorities in evaluating applications for residential development in noisy areas. Table 1 summarises the planning guidance for each NEC band, whilst Table 2 sets out the corresponding noise levels relating to each NEC band for road traffic noise, rail traffic noise, air traffic noise and mixed sources noises (i.e. a combination of road, rail or air traffic noise).

Table 1 - Planning Advice for each Noise Exposure Category

NEC	Planning Advice
A	Noise need not be considered as a determining factor in granting planning permission, although noise at the high end of the category should not be regarded as a desirable level.
B	Noise should be taken into account when determining planning applications and, where appropriate, conditions imposed to ensure an adequate level of protection against noise.
C	Planning permission should not normally be granted. Where it is considered that permission should be given, for example because there are no quieter sites available, conditions should be imposed to ensure a commensurate level of protection against noise.
D	Planning permission should normally be refused.

Table 2 - Noise Levels corresponding to the NEC's for New Dwellings $L_{Aeq,T}$ dB

NEC	Road Traffic Noise Sources		Rail Traffic Noise Sources		Air Traffic Noise Sources		Mixed Noise Sources	
	Day 07:00 - 23:00	Night 23:00 - 07:00	Day 07:00 - 23:00	Night 23:00 - 07:00	Day 07:00 - 23:00	Night 23:00 - 07:00	Day 07:00 - 23:00	Night 23:00 - 07:00
A	<55	<45	<55	<45	<57	<47	<55	<45
B	55-63	45-57	55-66	45-59	57-66	47-59	55-63	45-57
C	63-72	57-66	66-74	59-66	66-72	59-68	63-72	57-66
D	>72	>66	>74	>66	>72	>68	>72	>66

3.3 In addition to the above, PPG 24 also states that during the night, (2300-0700 hours):

> *"Sites where individual noise events regularly exceed 82 dB L_{Amax} (slow) several times in any hour should be treated as being in NEC C, regardless of the L_{Aeq} (8 hour) (except where the L_{Aeq} (8 hour) already puts the site into NEC D)."*

3.4 PPG 24 allows a degree of Local Authority discretion in the application of the above criteria; up to 3 dB(A) either way. For the purposes of this report, however, the stated values have been taken as the assessment criteria.

3.5 Where the advice within PPG 24 is that conditions should be imposed to ensure a commensurate level of protection against noise, reference is made to other standards that establish suitable internal noise levels, such as British Standard (BS) 8233: 1999, the requirements of which are summarised below.

BRITISH STANDARD 8233

3.6 BS 8233: 1999 *"Sound Insulation and Noise Reduction for buildings – Code of Practice"* provides recommendations for the control of noise in and around buildings. It suggests appropriate criteria and limits for different situations, which are primarily intended to guide the design of new buildings or refurbished buildings undergoing a change of use rather than to assess the effect of changes in the external noise climate.

3.7 The Standard suggests suitable internal noise levels within different types of buildings, including residential dwellings. It suggests that an internal night-time noise level of 30 dB $L_{Aeq,T}$ within bedrooms is a 'good' standard and 35 dB $L_{Aeq,T}$ is a 'reasonable' standard. For living areas during the daytime, the standard recommends 30 dB $L_{Aeq,T}$ as a 'good' standard and 40 dB $L_{Aeq,T}$ as being a 'reasonable' standard. BS 8233 also states that individual noise events should not normally exceed 45 dB L_{Amax} in bedrooms at night.

BRITISH STANDARD 6472

3.8 British Standard 6472-1: 2008: *"Guide to evaluation of human exposure to vibration in buildings. Part 1: Vibration sources other than blasting"* nominates criteria for various categories of disturbance, the most stringent of which are the levels of building vibration associated with a "low probability of adverse comment" from occupants.

3.9 For intermittent vibration sources, such as train pass by events, it is generally accepted that higher vibration levels will be acceptable to occupants due to the short-term nature of the vibration emissions. Consequently, BS 6472 provides criteria for such events that are based on a vibration dose value (VDV), rather than a continuous vibration level.

3.10 The vibration dose value is dependant upon the level and duration of the short-term vibration event, as well as the number of events occurring during the daytime or night time periods, where applicable. Table 3 displays the vibration dose values given in BS 6472, above which various degrees of adverse comment may be expected in residential buildings.

Table 3 – Vibration Dose Values ($m/s^{1.75}$), above which various degrees of adverse comment may be expected in residential buildings.

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

3.11 For the purposes of this report, 'Low probability of adverse comment' values shown above in Table 3 have been taken as the assessment criteria.

4 Environmental Noise and Vibration Monitoring

4.1 WSP Acoustics have been involved with the development of this area for a number of years and have undertaken a noise and vibration survey on The Site for an earlier planning application in May 2008, and as such, have a robust set of data from that previous survey. Although noise and vibration data is generally considered to be valid for up to three years after the initial survey, a short-term comparison of train noise levels were measured again in August 2010 in order to highlight any significant discrepancies. Noise levels were discovered to have been consistent over this period and it was determined the 2008 data would be valid and shall be used as the baseline data for the following assessment.

Table 4 – Comparison of Noise Data from the two surveys

Period, T		Measured Façade Noise Levels, dB				
		$L_{Aeq, T}$	$L_{Amax, fast}$	$L_{Amax, slow}$	L_{A10}	L_{A90}
Sunday 22 August, 2010	Day (07:00 – 23:00)	63.9	89.5	86.8	61.7	41.4
	Night (23:00 – 07:00)	57.4	82	78.2	56.3	42.2
May 2008	Day (07:00 – 23:00)	62.3	97.9	93.5	57.4	46
	Night (23:00 – 07:00)	59.9	86.8	83.7	53	43

4.2 Noise measurements were undertaken on the roof of the exiting building overlooking train lines to the north. Vibration measurements were undertaken on the ground level of the site at the closest boundary to the railway corridor. These boundaries were considered to represent the worst case with regards to environmental noise and vibration impacts.

4.3 The environmental noise and vibration surveys commenced at 15:00 hours on Friday 16th May, and concluded at 15:00 hours on Tuesday 20th May 2008, although the assessment period has been taken as the 24 hours between 07:00 Monday 19th May and 07:00 Tuesday 20th May 2008 as the inclusion of the weekend measurements produced a lower average.

4.4 The details of the measurement equipment used during the noise survey are presented in Table 5.

Table 5 – Equipment Details

Equipment Description	Manufacturer & Type No.	Serial No.	Calibration Due Date
Sound Level Meter	01dB-Stell Solo Master	10706	16 December 2009*
Pre-amplifier	01dB-Stell PRE 21 S	11662	
Microphone	Microtech Gefell GmbH MCE212	57606	
Calibrator	01dB-Stell Cal 21	51031216	10 October 2008*
Seismograph	Instantel BlastMate III	BA8004 R 8.01	13 November 2009*
Triaxial Geophone	Insantel Standard Transducer	BG7029	13 November 2009*

* - calibration details correct at the time of the survey.

4.5 The sound level meter was fitted with a windshield during the survey and was calibrated prior to and upon completion of the survey. No calibration drifts were found to have occurred.

4.6 It should be noted that although the equipment calibrations dates are now expired, all equipment used during the initial survey were within calibration at the time of the survey, and all the equipment stated above is still in use and has been re-calibrated without incident.

4.7 The microphone was suspended from a pole on the roof approximately 1 metre from the façade overlooking the railway, and approximately 5 metres above ground level which is considered to be representative of the worst case apartment for the proposed development

4.8 Vibration measurements were undertaken on the ground level of the site at a position considered to be representative of the closest future build line to the railway. The triaxial geophone was placed on a hard concrete surface using a levelling plate, approximately 15 metres from the nearest regularly used railway line.

4.9 The approximate measurement positions are indicated on the site plan in Appendix B.

4.10 The weather conditions throughout the survey were considered to be suitable for noise monitoring, it being mainly dry with a light breeze.

4.11 The full noise survey results are presented as a Time History Graph in Appendix C, while a summary of the measured noise and vibration results are outlined in Table 6 and Table 7.

Table 6 – Measured Environmental Noise Levels

Period, T	Measured Façade Noise Levels (dB re 20 x 10^{-6})				
	$L_{Aeq, T}$	$L_{Amax, fast}$	$L_{Amax, slow}$	L_{A10}	L_{A90}
Day (07:00 – 23:00)	64	96	91	67	48
Night (23:00 – 07:00)	59	88	85	57	44

Table 7 – Maximum Measured Peak Particle Velocities

Period, T	Maximum Measured Peak Particle Velocity (mm/s)
Day (07:00 – 23:00)	0.32
Night (23:00 – 07:00)	0.22

4.12 From Table 6 above and the Time History Graph in Appendix C, it can be seen that L_{Amax} noise levels have been measured in accordance with both the 'fast' and 'slow' parameters. This has been necessary due to the fact that PPG 24 requires that night-time L_{Amax} measurements are undertaken on a 'slow' time weighting, whilst BS 8233 includes a L_{Amax} standard based upon a 'fast' time weighting.

4.13 Assessments of the above noise and vibration data, in terms of the criteria in outlined in Section 3, are presented in the following sections.

5 PPG 24 Assessment

5.1 Comparing the measured noise levels in Table 6 with the table of NEC's for rail traffic noise sources in Table 2 yields the following assessment.

Table 8 – PPG 24 Assessment Results

Period, T	$L_{Aeq, T}$ Noise Level[1]	Applicable NEC	Overall NEC
Day (07:00 – 23:00)	61	B	B
Night (23:00 – 07:00)	56	B	
Note 1: Measured $L_{Aeq, T}$ noise levels have been corrected by -3dB to reflect free field conditions.			

5.2 From the table above, it can be seen that noise levels at The Site are categorised into NEC B during both daytime and night time periods. $L_{Amax, slow}$ noise levels do not have any bearing on the L_{Aeq} derived PPG 24 NEC ratings as they do not regularly exceed 82 dB $L_{Amax, S}$ (see paragraph 3.3).

5.3 From Table 1, PPG 24 states that for sites falling into NEC B:

> *Noise should be taken into account when determining planning applications and, where appropriate, conditions imposed to ensure an adequate level of protection against noise.*

5.1 Based on the above, it is considered that, for residential development to be viable on the proposed development site, internal noise levels as stated within British Standard 8233 should be achieved within habitable rooms through careful acoustic design.

5.4 The following section, therefore, considers noise mitigation measures that can be designed into the external façade of the residential elements of the proposed building such that suitable internal noise levels may be obtained within the habitable rooms.

6 Noise Mitigation

6.1 Since this proposed development is in close proximity to the railway line, noise mitigation through the implementation of noise barriers, or measures to control noise at source, is considered to be impractical. Consequently, the most effective method of attenuating external noise is likely to be through the acoustic design of the external building fabric elements.

6.2 When assessing the sound insulation performance of external façades, it is generally the case that the glazed element is the weakest path for external noise intrusion into internal areas. It is understood that the external façade of the proposed residential development is to be of a substantial composite construction, or that any lightweight construction may have additional acoustic treatment to provide a minimum sound insulation performance of 55dB R_w. Noise intrusion through the window elements is, therefore, considered to be most critical in maintaining a suitable internal noise level.

6.3 In order to control external noise intrusion, it is considered that the minimum amelioration measure available to the future occupants of the properties would be to close the windows within the façades of the habitable rooms.

6.4 Consequently, a generic assessment has been undertaken to determine the acoustic requirements for the glazing system in order that BS 8233 internal noise levels may be achieved within habitable rooms.

6.5 For bedrooms and living rooms, the assessment has considered a nominal non glazed façade area of $3m^2$, with glazing elements of $6m^2$ in area. This is considered to represent a full height glazing scenario. The assessment has also considered a nominal room volume of $32m^3$.

6.6 It has been assumed that habitable rooms will be fitted with a reasonable amount of soft furnishings which will assist in controlling reverberant noise.

6.7 External L_{Aeq} noise levels have been based upon the noise data in Table 6, while night time $L_{Amax,\ fast}$ noise levels have been based on ‘typical’ L_{Amax} noise levels, and not the very highest level, which is likely to have been generated by an a-typical noise event.

6.8 The adoption of a ‘typical’ $L_{Amax,}$ noise level in this assessment is considered to be in line with the statement within BS 8233, where the $L_{Amax,\ fast}$ criterion should be ‘not normally exceeded’ (see paragraph 3.7).

6.9 Based on the results of our assessments, it is considered that the acoustic performance of the glazing units should achieve a performance of R_w 33dB as a minimum. In order that this glazing performance may be achieved, it is considered that a typical glazing configuration would be 6mm/12mm/6mm (glass/airspace/glass).

6.10 Given this glazing performance, the predicted internal noise levels are detailed Table 9.

Table 9 - Predicted Internal Noise Levels based on R_w 33dB glazing system

Period	Parameter	Measured Noise Level (dB)	BS 8233 Criteria (Good / Reasonable)	Predicted Internal Noise Level (dB)
Daytime	$L_{Aeq, 16 hour}$	62	30 / 40	35
Night-time	$L_{Aeq, 8 hour}$	57	30 / 35	29
	$L_{Amax, fast}$*	76	45	45
* External $L_{Amax, fast}$ level based upon 90th percentile measured noise level.				

6.11 From Table 9 it can be seen that the acoustic requirements of the glazing are dictated by the night time instantaneous $L_{Amax, fast}$ noise events, rather than the steady-state L_{Aeq} noise intrusion levels.

6.12 Based on the above, it is expected that glazing units achieving a sound insulation performance of 33dB R_w will ensure that recommended BS 8233 levels may be achieved within the habitable rooms of the proposed residential dwellings.

PROVISION OF ALTERNATIVE VENTILATION

6.13 In order that suitable internal noise levels may be maintained within habitable rooms, windows would need to remain closed. As such, an alternative source of ventilation will be necessary.

6.14 It is considered that the acoustic performance provided by the alternative ventilation supply, in terms of the $D_{n,e,w}$ parameter, should exceed the R_w acoustic performance provided by the glazing system by a minimum of 5dB. As such, it is recommended that the alternative ventilation source achieves a minimum sound insulation performance of 38dB $D_{n,e,w}$.

6.15 It is considered that this performance is achievable by commercially available acoustically treated window or façade mounted trickle ventilators. The alternative ventilation system should comply with the requirements within the current edition of Approved Document F of the Building Regulations.

7 BS 6472 Vibration Assessment

7.1 The Association of Noise Consultants Guidelines; *'Measurement & Assessment of Groundborne Noise & Vibration'* (2001) suggests the following method for estimating vibration dose values (eVDV) from measured particle velocity data for a given event;

$$eVDV = 1.4 \times 50.3 \times v_{rms} \times t^{0.25}$$

Where: v_{rms} = the rms particle velocity (m/s)

t = the duration of the vibration event (s)

7.2 From the calculated eVDV for each vibration event, the method for calculating the total VDV for the daytime and night time periods is given in BS 6472 as follows;

$$VDV = (\sum_{n=1}^{n=N} VDV_n^4)^{0.25}$$

Where: n = the number of eVDV events in the daytime or night time period.

7.3 Based upon the vibration data presented in Table 7, eVDV values have been calculated using the methods stated above. As the total number of train movements over the multiple tracks throughout the measurement duration can not be confirmed, an absolute worst case (and somewhat unrealistic) scenario of one movement every 5 seconds (i.e. every measurement interval) has been assumed for the calculations.

7.4 The BS 6472 assessment method strictly applies to vibration at the point of entry into the human body, usually taken to mean an upper storey floor (where ground vibration would be amplified). As such, it is necessary to apply a suitable transfer function/correction to the measured levels in order to estimate the vibration levels on the upper floors of the proposed building.

7.5 Based upon the guidance presented in *'Transmission of Ground-borne Vibration in Buildings'* by Jorgen Jakobsen, Journal of Low Frequency Noise and Vibration, Vol. 8 No. 3, 1989, it is considered that a worst case amplification factor of 2.5 would be suitable to predict vibration levels on the upper stories of the proposed residential building on the site.

7.6 The estimated VDVs both at the measurement position and on the upper stories of the proposed development are presented in Table 10 along with the criteria adopted from BS 6472.

Table 10 – eVDV Vibration Levels

Period, T	Maximum Measured Peak Particle Velocity (mm/s)	Total eVDV ($m/s^{1.75}$)[1]	Predicted eVDV on Upper Stories ($m/s^{1.75}$)	VDV Criteria ($m/s^{1.75}$)
Day (07:00 – 23:00)	0.32	0.016	0.04	0.2 to 0.4
Night (23:00 – 07:00)	0.22	0.010	0.025	0.1 to 0.2
Note 1: eVDV values are calculated in accordance with BS 6472 and assume a worst case number of total train movements (one movement every 5 seconds; i.e. every measurement interval).				

7.7 Calculated eVDV values presented in Table 10 are significantly below the nominated criteria even considering worst case number of train movements adopted for calculations. As such, environmental vibration need not be a consideration in the design of the proposed development.

8 Conclusions

8.1 WSP Acoustics has been commissioned by CgMs Consulting on behalf of Izabelle Investments Ltd to undertake a survey and assessment of the environmental noise and vibration levels affecting a new mixed commercial and residential development at 1 Dumpton Place, London.

8.2 Noise data was taken from a survey undertaken in May 2008 after confirming like for like noise levels were comparable.

8.3 Based upon the results of the previous environmental noise monitoring survey of the proposed development site, an assessment in accordance with PPG 24 has resulted in an NEC B rating along the northern façade overlooking railway line. This is considered to be the worst case boundary of the site affected by environmental noise.

8.4 The advice in PPG 24 for sites falling into NEC B is that noise should be taken into account when determining planning applications and, where appropriate, conditions imposed to ensure an adequate level of protection against noise.

8.5 From our assessments, glazing units should achieve a minimum sound insulation performance of 33dB R_w along the northern façade in order that BS 8233 internal daytime and night time noise levels may be achieved. This performance may be typically achieved by a 6mm/12mm/6mm (glass/airspace/glass) glazing systems.

8.6 It is considered that the minimum sound insulation performance of 33dB R_w is achievable by commercially available acoustically treated window or façade mounted trickle ventilators. The performance specifications for the alternative ventilation system should comply with the requirements within the current edition of Approved Document F of the Building Regulations.

8.7 Based upon the results of an environmental vibration monitoring survey of the proposed development site, all vibration levels were found to be in compliance with the VDV criterion adopted from BS 6472. Measured vibration levels were well below the nominated criterion, and as such, environmental vibration need not be considered for design purposes for the development site.

8.8 As previously mentioned, the proposed development will also incorporate a commercial development. As details of what specific type of commercial premises will occupy the building is unclear at this point and that they generally have less stringent noise criterion than residential, adaption of the aforementioned measures will satisfy the generic internal noise criterion as given in BS8233 with regards to offices.

8.9 The limitations to this report are presented in Appendix D.

Appendix A Glossary of Acoustic Terminology

Noise

Noise is defined as unwanted sound. Human ears are able to respond to sound in the frequency range 20 Hz (deep bass) to 20,000 Hz (high treble) and over the audible range of 0 dB (the threshold of perception) to 140 dB (the threshold of pain). The ear does not respond equally to different frequencies of the same magnitude, but is more responsive to mid-frequencies than to lower or higher frequencies. To quantify noise in a manner that approximates the response of the human ear, a weighting mechanism is used. This reduces the importance of lower and higher frequencies, in a similar manner to the human ear.

Furthermore, the perception of noise may be determined by a number of other factors, which may not necessarily be acoustic. In general, the impact of noise depends upon its level, the margin by which it exceeds the background level, its character and its variation over a given period of time. In some cases, the time of day and other acoustic features such as tonality or impulsiveness may be important, as may the disposition of the affected individual. Any assessment of noise should give due consideration to all of these factors when assessing the significance of a noise source.

The most widely used weighting mechanism that best corresponds to the response of the human ear is the 'A'-weighting scale. This is widely used for environmental noise measurement, and the levels are denoted as dB(A) or L_{Aeq}, L_{A90} etc, according to the parameter being measured.

The decibel scale is logarithmic rather than linear, and hence a 3 dB increase in sound level represents a doubling of the sound energy present. Judgement of sound is subjective, but as a general guide a 10 dB(A) increase can be taken to represent a doubling of loudness, whilst an increase in the order of 3 dB(A) is generally regarded as the minimum difference needed to perceive a change under normal listening conditions.

An indication of the range of sound levels commonly found in the environment is given in the following table.

Typical sound levels found in the environment

Sound Level	Location
0 dB(A)	Threshold of hearing
20 to 30 dB(A)	Quiet bedroom at night
30 to 40 dB(A)	Living room during the day
40 to 50 dB(A)	Typical office
50 to 60 dB(A)	Inside a car
60 to 70 dB(A)	Typical high street
70 to 90 dB(A)	Inside factory
100 to 110 dB(A)	Burglar alarm at 1m away
110 to 130 dB(A)	Jet aircraft on take off
140 dB(A)	Threshold of Pain

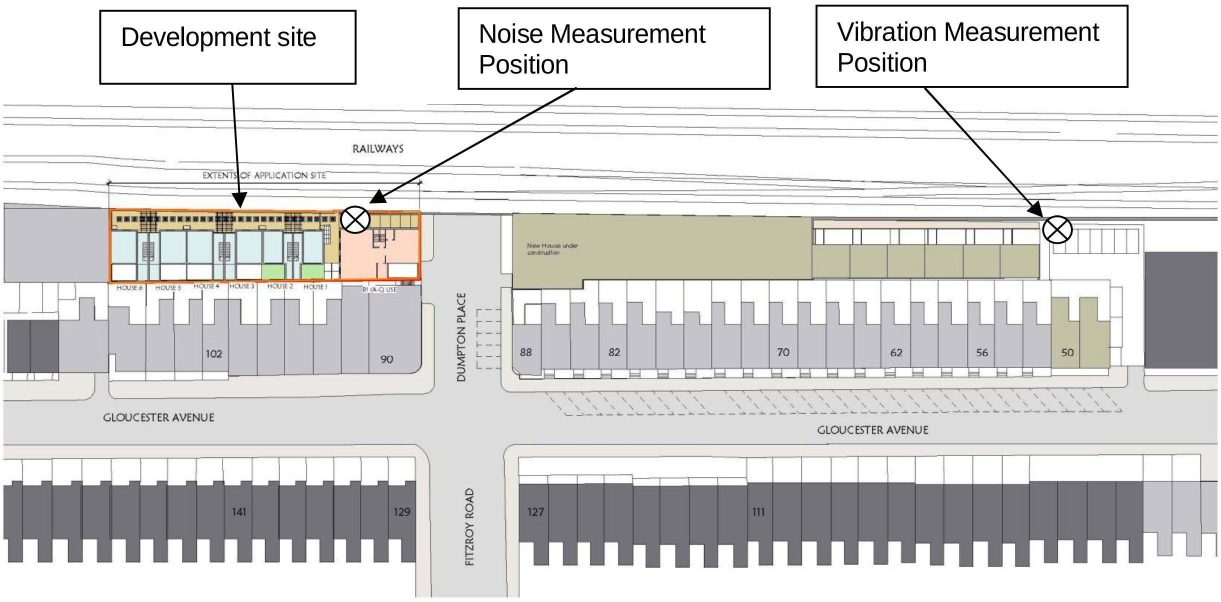
Terminology Relating to Noise

Sound Pressure	Sound, or sound pressure, is a fluctuation in air pressure over the static ambient pressure.
Sound Pressure Level (Sound Level)	The sound level is the sound pressure relative to a standard reference pressure of 20μPa (20x10-6 Pascals) on a decibel scale.
Decibel (dB)	A scale for comparing the ratios of two quantities, including sound pressure and sound power. The difference in level between two sounds s1 and s2 is given by 20 log10 (s1 / s2). The decibel can also be used to measure absolute quantities by specifying a reference value that fixes one point on the scale. For sound pressure, the reference value is 20μPa.
A-weighting, dB(A)	The unit of sound level, weighted according to the A-scale, which takes into account the increased sensitivity of the human ear at some frequencies.
Noise Level Indices	Noise levels usually fluctuate over time, so it is often necessary to consider an average or statistical noise level. This can be done in several ways, so a number of different noise indices have been defined, according to how the averaging or statistics are carried out.
Leq,T	A noise level index called the equivalent continuous noise level over the time period T. This is the level of a notional steady sound that would contain the same amount of sound energy as the actual, possibly fluctuating, sound that was recorded.
Lmax,T	A noise level index defined as the maximum noise level during the period T. Lmax is sometimes used for the assessment of occasional loud noises, which may have little effect on the overall Leq noise level but will still affect the noise environment. Unless described otherwise, it is measured using the 'fast' sound level meter response.
L90,T	A noise level index. The noise level exceeded for 90% of the time over the period T. L90 can be considered to be the "average minimum" noise level and is often used to describe the background noise.
L10,T	A noise level index. The noise level exceeded for 10% of the time over the period T. L10 can be considered to be the "average maximum" noise level. Generally used to describe road traffic noise.
Free-Field	Far from the presence of sound reflecting objects (except the ground), usually taken to mean at least 3.5m
Façade	At a distance of 1m in front of a large sound reflecting object such as a building façade.
Fast/Slow Time Weighting	Averaging times used in sound level meters.
Octave Band	A range of frequencies whose upper limit is twice the frequency of the lower limit.

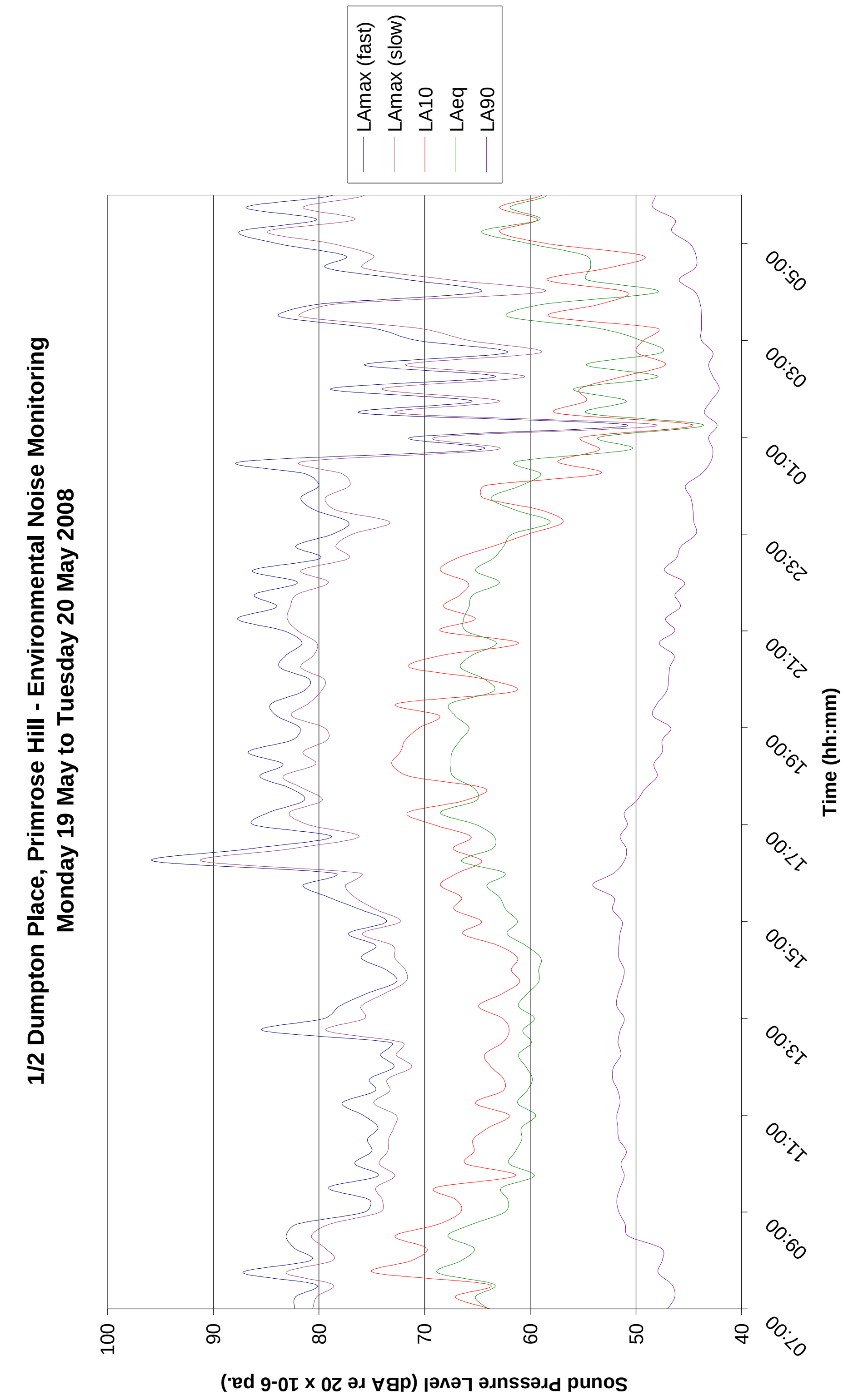
Terminology Relating to Vibration

Displacement, Acceleration and Velocity Root Mean Square (r.m.s.) and Peak Values Peak Particle Velocity (PPV)	Vibration is an oscillatory motion. The magnitude of vibration can be defined in terms of displacement (how far from the equilibrium position that something moves), velocity (how fast something moves), or acceleration (the rate of change of velocity). When describing vibration, one must specify whether peak values are used (i.e. the maximum displacement or maximum velocity) or r.m.s. / r.m.q. values (effectively an average value) are used. Standards for the assessment of building damage are usually given in terms of peak velocity (usually referred to as Peak Particle Velocity, or PPV), whilst human response to vibration is often described in terms of r.m.s. or r.m.q. acceleration.
Root Mean Square (r.m.s.)	The r.m.s. value of a set of numbers is the square root of the average of the squares of the numbers. For a sound or vibration waveform, the r.m.s. value over a given time period is the square root of the average value of the square of the waveform over that time period.
Vibration Dose Value (VDV)	This is a measure of the amount of vibration that is experienced over a specified period, and has been defined so as to quantify the human response to vibration in terms of comfort and annoyance. The Vibration Dose Value is used to assess the likely levels of adverse comment about vibration, and is defined mathematically as the fourth root of the time integral of the fourth power of the acceleration, after it has been frequency weighted to take into account the frequency response of the human body to a vibration stimulus. Measured in units of $m/s^{1.75}$.

Appendix B Site Plan



Appendix C Noise Measurement Results



Appendix D Limitations to This Report

This report has been prepared for the titled project or named part thereof and should not be used in whole or part and relied upon for any other project without the written authorisation of WSP Environmental Limited. WSP Environmental Limited accepts no responsibility or liability for the consequences of this document if it is used for a purpose other than that for which it was commissioned. Persons wishing to use or rely upon this report for other purposes must seek written authority to do so from the owner of this report and/ or WSP Environmental Limited and agree to indemnify WSP Environmental Limited for any and all loss or damage resulting therefrom. WSP Environmental Limited accepts no responsibility or liability for this document to any other party other than the person by whom it was commissioned.

The findings and opinions expressed are relevant to the dates of the site works and should not be relied upon to represent conditions at substantially later dates. Opinions included therein are based on information gathered during the study and from our experience. If additional information becomes available which may affect our comments, conclusions or recommendations WSP Environmental Limited reserve the right to review the information, reassess any new potential concerns and modify our opinions accordingly.