Appendix K

Noise and vibration

Contents

K1 Full details of methodology

K1.1 Policy context

The following summarises the relevant legislation and planning policy used within the assessment of noise and vibration effects.

K1.1.1 National Planning Policy

Primary Legislation

Relevant legislation includes the Control of Pollution Act 1974. The construction noise and vibration assessment and envisaged mitigation are informed by this legislation. Specific references are made to sections of legislation as necessary. For example, 'Best Practicable Means' is defined in Section 72 of the Control of Pollution Act; and prior consent for the construction method and steps to minimise noise can be sought from local authorities under Section 61 of the Control of Pollution Act.

National Policy and Guidance

The National Planning Policy Framework 2019 (NPPF)[1] took effect to define the Government's planning policies for England. Key to this assessment are paragraphs 170, 180 and 182 of NPPF.

Paragraph 170 requires the planning system to "*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 noise pollution*".

Paragraph 180 of NPPF states that "*Planning policies and decisions should:*

- *mitigate and reduce to a minimum potential adverse impacts resulting from noise from new development – and avoid noise giving rise to significant adverse impacts on health and the quality of life; and*
- *identify and protect tranquil areas which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason;"*

Importantly, paragraph 182 states *"Planning policies and decisions should:*

- *ensure that new development can be integrated effectively with existing businesses and community facilities (such as places of worship, pubs, music venues and sports clubs); and*
- *Existing businesses and facilities should not have unreasonable restrictions placed on them as a result of development permitted after they were established. Where the operation of an existing business or community facility could have a significant adverse effect on new development (including changes of use) in its vicinity, the applicant (or 'agent of change') should be required to provide suitable mitigation before the development has been completed."*

[1] Department for Communities and Local Government (2019), revised National Planning Policy Framework http://www.communities.gov.uk/publications/planningandbuilding/nppf

The NPPF planning objectives reflect and are linked to the policies and objectives set out in the Noise Policy Statement for England (NPSE)[2].

The NPSE uses the key phrases 'significant adverse' and 'adverse'. In clarifying what these mean the NPSE notes that:

"There are two established concepts from toxicology that are currently being applied to noise effects, for example, by the World Health Organization. They are:

- *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.
- *LOAEL – Lowest Observed Adverse Effect Level*
  This is the level above which adverse effects on health and quality of life can be detected."

The Policy extends these concepts to include:

- *"SOAEL – Significant Observed Adverse Effect Level*
  This is the level above which significant adverse health effects on health and quality of life occur."

These terms are adopted in the Government's Planning Practice Guidance on noise (PPG-N)[3], which presents example outcomes to help characterise these effects (see Table 1).

[2] Department for Environment Food and Rural Affairs (2010), *Noise Policy Statement for England*
[3] Department for Communities And Local Government (2012) *National Planning Practice Guidance – Noise*, http://planningguidance.planningportal.gov.uk/blog/guidance/noise/noise-guidance/ (Revision date: 06 03 2014)

Table 1: Noise exposure hierarchy based on likely average response (based on PPG-N)

	Perception	Examples of outcomes	Increasing effect level	Action
← increasing noise level←	Not noticeable	No effect	No observed effect	No specific measures required
	No Observed Effect Level (NOEL)			
	Noticeable and not intrusive	Noise can be heard, but does not cause any change in behaviour or attitude. Can slightly affect the acoustic character of the area but not such that there is a perceived change in the quality of life.	No observed adverse effect	No specific measures required
	Lowest Observed Adverse Effect Level (LOAEL)			
	Noticeable and intrusive	Noise can be heard and causes small changes in behaviour and/or attitude, e.g. turning up volume of television; speaking more loudly; where there is no alternative ventilation, having to close windows for some of the time because of the noise. Potential for some reported sleep disturbance. Affects the acoustic character of the area such that there is a perceived change in the quality of life.	Observed adverse effect	Mitigate and reduce to a minimum
	Significant Observed Adverse Effect Level (SOAEL)			
	Noticeable and disruptive	The noise causes a material change in behaviour and/or attitude, e.g. avoiding certain activities during periods of intrusion; where there is no alternative ventilation, having to keep windows closed most of the time because of the noise. Potential for sleep disturbance resulting in difficulty in getting to sleep, premature awakening and difficulty in getting back to sleep. Quality of life diminished due to change in acoustic character of the area.	Significant observed adverse effect	Avoid
	Unacceptable Adverse Effect Level (UAEL)			
	Noticeable and very disruptive	Extensive and regular changes in behaviour and/or an inability to mitigate effect of noise leading to psychological stress or physiological effects, e.g. regular sleep deprivation/awakening; loss of appetite, significant, medically definable harm, e.g. auditory and non-auditory.	Unacceptable Adverse Effect	Prevent

The NPSE notes that it is not possible to have a single objective noise-based measure that defines SOAEL that is applicable to all sources of noise in all situations. Consequently, the SOAEL is likely to be different for different noise sources, for different receptors and at different times. It is for a project to identify relevant SOAELs taking account of the different sources of exposure and different receptors.

Any receptor forecast to experience an overall exposure from the Proposed Development that exceeds the relevant SOAELs is identified as being subject to significant adverse impact on health and quality of life (under Government noise policy) and hence identified as a likely significant adverse effect.

Where the noise level from the Proposed Development is between LOAEL and SOAEL, the NPSE states:

"*all reasonable steps should be taken to mitigate and minimise adverse effects on health and quality of life while also taking into account the guiding principles of sustainable development. This does not mean that such adverse effects cannot occur*."

Other factors, such as the number of dwellings affected and the magnitude of noise change, can result in impacts between LOAEL and SOAEL being reported as likely significant effects in EIA terms. The EIA process requires that likely significant effects are identified along with the envisaged mitigation to avoid or reduce these significant effects.

K1.1.2 Local Planning Policy

Westminster City Council (WCC) sets out guidance specifically on noise and vibration in relation to planning in the document Development Planning Delivery Unit: Standard Paragraphs Reference for: Conditions & Reasons (December 2013).

K1.1.3 Standards and Guidelines

Reference is also made to the following:

- British Standard BS4142: 2014+A1:2019. Methods for Rating and Assessing Industrial and Commercial Sound;
- British Standard BS5228:2009+A1:2014. Code of Practice for Noise and Vibration Control on Construction and Open Sites. Part 1 Noise and Part 2 Vibration;
- British Standard BS6472:2008 Part 1. Guide to Evaluation of Human Exposure to Vibration in Buildings – Vibration Sources other than Blasting;
- British Standard BS7385:1993 Part 2 Evaluation and Measurement for Vibration in Buildings – Guide to Damage Levels for Groundborne Vibration;
- British Standard BS8233: 2014. Guidance on Sound Insulation and Noise Reduction for Buildings;
- Design Manual for Roads and Bridges, LA111, Noise and Vibration. Highways England, Transport Scotland, Welsh Government and Department for Infrastructure, 2019;
- Guidelines for Community Noise, World Health Organization, 1999;
- Night Noise Guidelines for Europe, World Health Organization, 2009; and
- Calculation of Road Traffic Noise, Department of Transport, Welsh Office, 1988.

K1.2 Demolition and construction noise

Direct, temporary effects of noise are associated with construction. Impact thresholds for construction noise have been established by reference to the 'ABC method' described in Annex E of *BS5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – noise* (British Standards Institute, 2014). The ABC method defines the thresholds at building facades based on existing noise levels as set out in Table 2.

Where the forecast construction noise exceeds the relevant threshold, this is an indicator of a potential significant effect, as noted in BS5228-1 i.e. where the level of impact is sufficient that it may lead to a likely significant effect, once other aspects are considered.

For daytime, the widely used threshold of 75dBL_{Aeq} (category C in Table 2) has been taken to be the SOAEL for construction noise. Typically, a duration for the impact is also considered, such as being exceeded for one month or more. In the absence of a developed construction programme, in this case it has been cautiously taken that any exceedance of this threshold level is assessed as significant. The threshold was originally set to avoid interference with normal speech indoors, with windows closed (reference the Wilson Report, 1963). Windows and their sound insulation properties have improved substantially since the Wilson Report; the 75dBL_{Aeq} SOAEL is therefore likely to be precautionary for modern properties.

Table 2: Thresholds of potential significant effects of construction noise at residential buildings (from BS5228-1:2009+A1:2014)

Period	**Threshold value in decibels, dB$L_{Aeq,T}$**		
	Category A (LOAEL)[1]	**Category B (LOAEL)[2]**	**Category C (SOAEL)[3]**
Day: T=12hr, Weekdays, 07.00-19.00, T=6hr, Saturday, 07.00-13.00	65	70	75
Evenings and weekends: T=1hr, Weekdays 19.00–23.00, T=1hr, Saturdays 13.00–23.00, T=1hr, Sundays 07.00–23.00	55	60	65
Night: T=1hr, Every day 23.00–07.00	45	50	55
Notes: All noise levels are defined outdoors at the façade of the receptor [1] Used as impact criteria when baseline ambient sound levels (rounded to the nearest 5 dB) are less than these values [2] Used as impact criteria when baseline ambient sound levels (rounded to the nearest 5 dB) are the same as category A values [3] Used as impact criteria when baseline ambient sound levels (rounded to the nearest 5 dB) are higher than category A values.			

The day-time SOAEL assumed for construction reflects that construction noise is temporary and that higher levels of noise generally only occur for part of the construction programme.

For night-time, the *Night Noise Guidelines for Europe* (World Health Organisation (WHO), 2009) introduced an interim target of 55dB$L_{Aeq,8hr}$ measured outdoors as an annual average. Exceeding this noise threshold (category 'C' of the ABC impact criteria at night as shown in Table 2), for one month or longer has been adopted as the SOAEL for night-time construction noise. *The Night Noise Guidelines for Europe* is based on evidence gathered for long term exposure to primarily road and aircraft noise. There is no evidence of short-term construction noise leading to significant health effects. The WHO's interim target of 55dBL_{pAeq} is therefore applied to construction on a precautionary basis.

For the evening, the SOAEL is set 10dB lower than the day-time SOAEL, consistent with the 'ABC criteria' (British Standards Institute, 2014) and the accepted criteria that date back to the *Advisory Leaflet 72 - Noise Control on Building Sites* (Department of the Environment, 1976).

Noise exposure between LOAEL and SOAEL is, in Government policy terms, an adverse observed effect but not a significant observed adverse effect. Such adverse effects relate to people's response to changes in local acoustic character particularly outdoors and to a lesser extent indoors. Adverse observed effects are identified where categories A or B from Table 2 apply and the forecast construction noise exceeds the relevant category but is below category C. This provides a simplified method for considering adverse effects from noise increases caused by construction. Such adverse effects under policy may be reported as likely significant effects in the ES following the consideration of the other significance criteria set out in this appendix (for example the number of receptors exposed to the adverse effect).

K1.3 Demolition and construction traffic noise

The significance criteria in Table 3 have been developed based upon DMRB, to assess noise effects arising from the traffic during the construction phase of the Proposed Development.

Table 3: Significance criteria for traffic noise assessments

<table>
<tr><th>Change in noise level, dBA</th><th>Impact category</th><th>Initial indicator of significance</th></tr>
<tr><td>> +10</td><td>Major adverse</td><td rowspan="3">Potentially significant increase</td></tr>
<tr><td>+5 to +10</td><td>Moderate adverse</td></tr>
<tr><td>+3 to +5</td><td>Minor adverse</td></tr>
<tr><td>0 to +3</td><td>Negligible</td><td rowspan="2">Unlikely to be significant</td></tr>
<tr><td>-3 to 0</td><td>Negligible</td></tr>
<tr><td>-3 to -5</td><td>Minor beneficial</td><td rowspan="3">Potentially significant decrease</td></tr>
<tr><td>-5 to -10</td><td>Moderate beneficial</td></tr>
<tr><td>< -10</td><td>Major beneficial</td></tr>
</table>

K2 Baseline survey details

Figure 1: Map of site showing noise survey locations

K2.1 Noise survey

The noise survey was carried out over the period 12th - 26th January 2018. The noise measurement locations are shown in Figure 1. The locations were chosen to provide an indication of the typical background noise levels at the nearest sensitive receptors (shown in blue), and to determine the existing noise climate at the proposed residential facades (shown in green).

A summary of the measured noise levels for daytime and night time are shown below. The $dBL_{A90,15mins}$ levels presented are the minimum measured noise levels. The $dBL_{Aeq,T}$ levels presented are logarithmic averages of the dBL_{Aeq} values measured over the survey period. The night time $dBL_{Amax,F}$ levels have been selected to represent a typical max event which would not be exceeded more than 10 times per night.

Table 4: Summary of measured daytime (07:00 – 23:00) noise levels, dB re. $2x10^{-5}$ Pa

Measurement location (see Figure 1)	Measurement type	Minimum $dBL_{A90,15mins}$	Average $dBL_{Aeq,16hr}$
A	Façade	48	70
B	Façade	47	68
C	Façade	43	68
1	Free-field	52	57
2	Façade	43	64

Table 5: Summary of measured night time (23:00 – 07:00) noise levels, dB re. $2x10^{-5}$ Pa

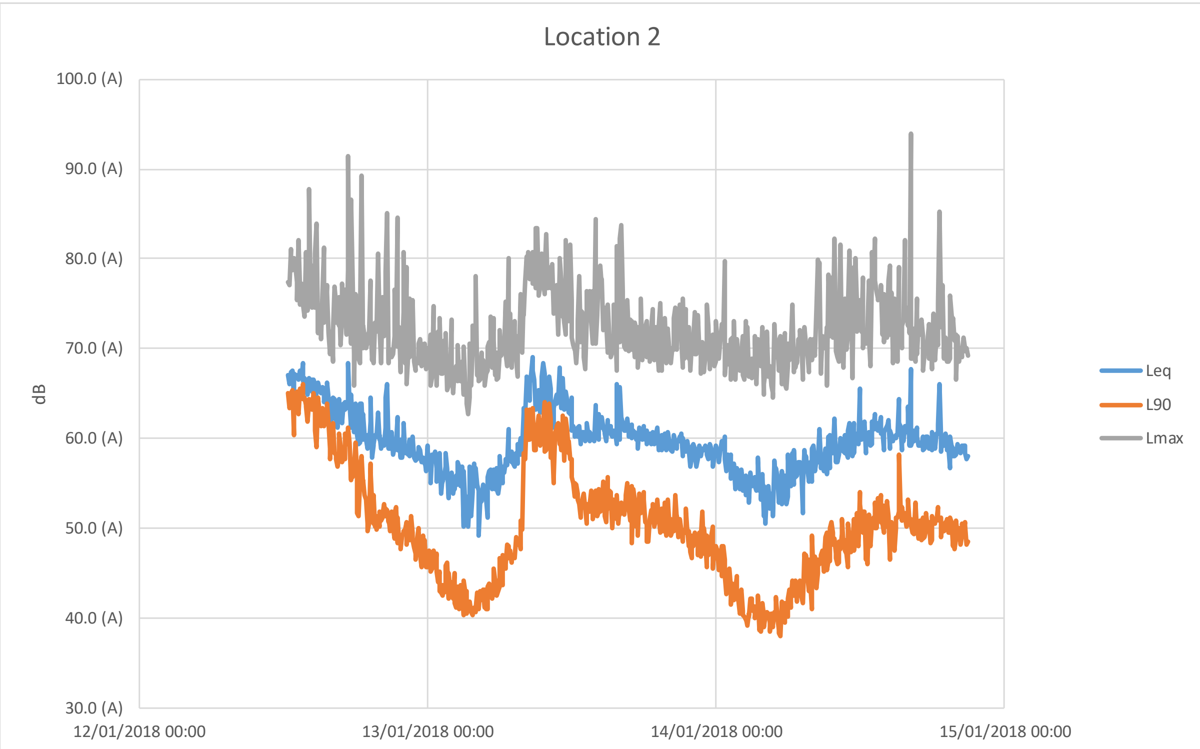
Measurement location (see Figure 1: Map of site showing noise survey locationsFigure 1**)**	**Measurement type**	**Minimum $dBL_{A90,15mins}$**	**Average $dBL_{Aeq,8hr}$**	**Typical $dBL_{AMax,F}$**
A	Façade	41	62	78
B	Façade	43	61	80
C	Façade	40	63	82
2	Façade	39	56	73

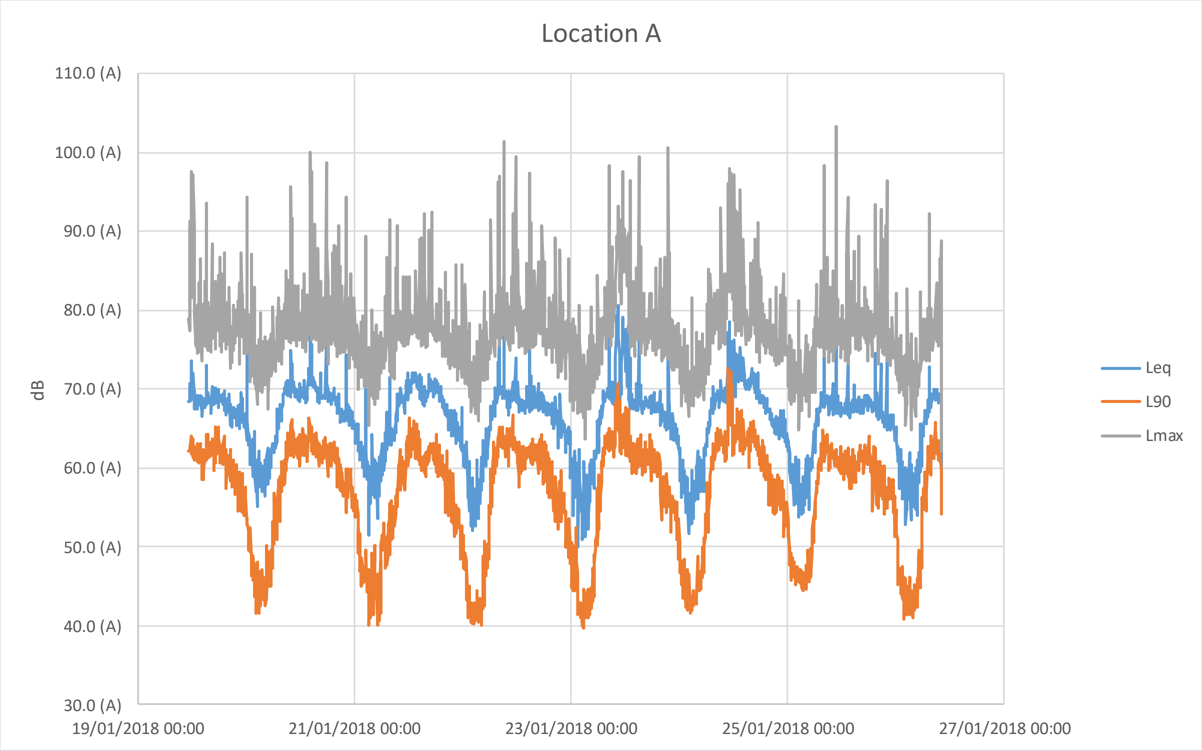
Measurements taken at location A were dominated by road traffic noise from Ebury Bridge, with further contributions from Ebury Bridge Road. Typical maximum noise level events were caused by emergency sirens, truck/bus pass-bys and train horns.

Measurements taken at location B were dominated by railway noise. The typical maximum noise levels were noted to be due to train horns and pantograph arcing noise.

Measurements taken in location C, 1 and 2 were dominated by road traffic noise from Ebury Bridge Road, with further contribution from Ebury Bridge. The typical maximum noise level events were caused by emergency sirens and HGV/bus pass-bys.

K2.1.1 Noise logger graphs

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100.0 (A)
90.0 (A)
80.0 (A)
70.0 (A)
60.0 (A)
50.0 (A)
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30.0 (A)
dB
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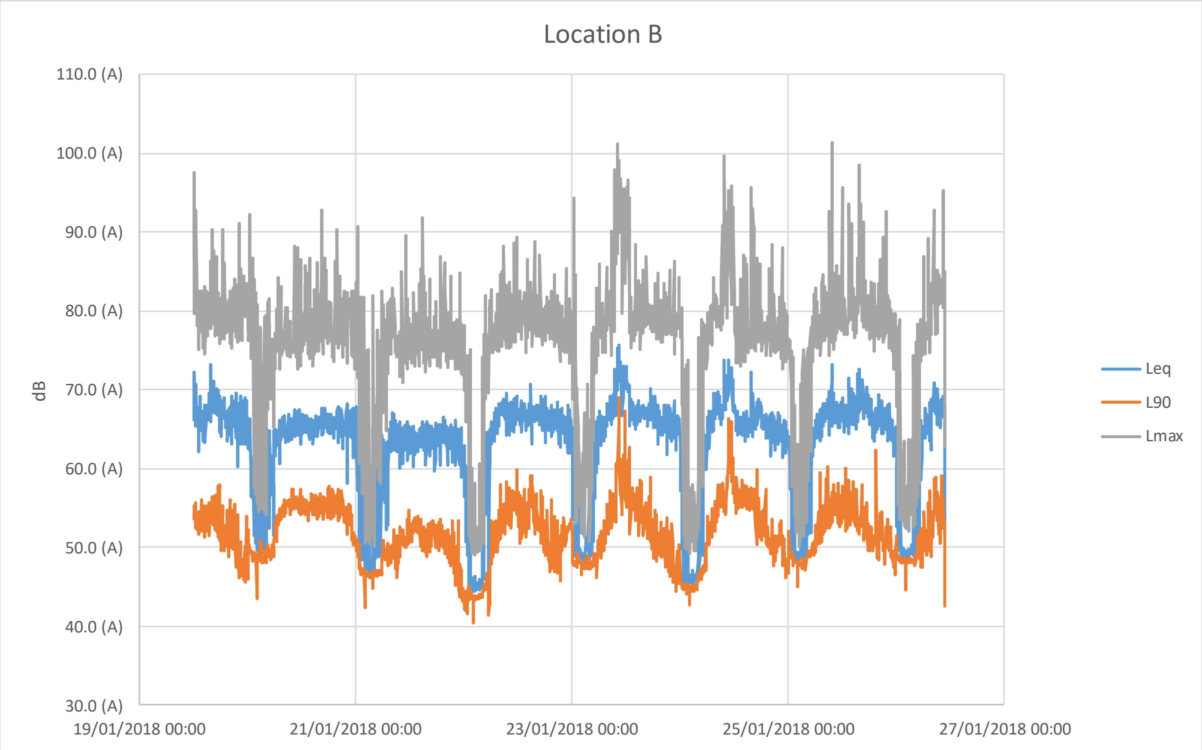
Leq
L90
Lmax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60.0 (A)
50.0 (A)
40.0 (A)
30.0 (A)
dB
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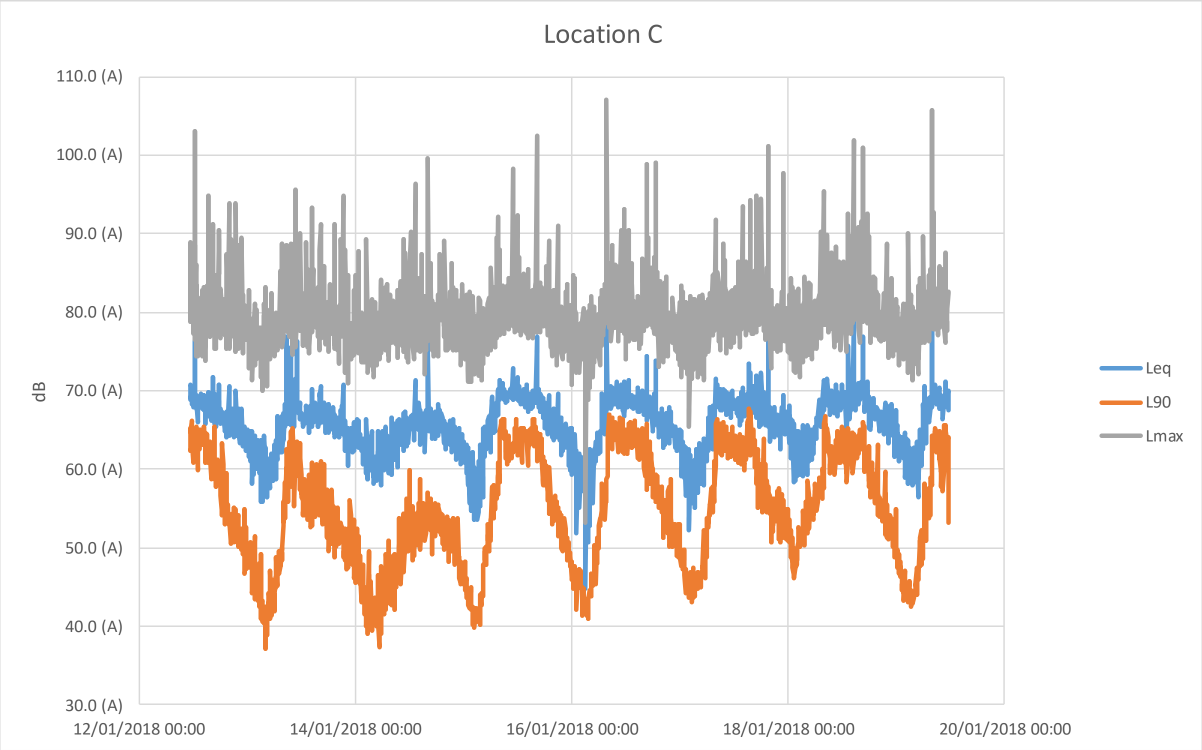
Leq
L90
Lmax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80.0 (A)
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60.0 (A)
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40.0 (A)
30.0 (A)
dB
12/01/2018 00:00
14/01/2018 00:00
16/01/2018 00:00
18/01/2018 00:00
20/01/2018 00:00
Leq
L90
Lmax

K3 Construction noise and vibration calculation assumptions and assessment tables

K3.1 Noise assumptions

This section provides the construction activity assumptions based on Arup's experience from similar projects (such as 6-8 Bishopsgate in the City of London), with input from the Arup construction team, which form the basis for the prediction of construction noise in accordance with BS 5228.

The following activities are anticipated to take place during the construction of the Proposed Development:

- Activity 1 – Site preparation and remediation;
- Activity 2 – Foundations and piling;
- Activity 3 – Erection of structure; and
- Activity 4 – Fitting out.

These activities would take place in different stages of the project and would require different plant items. This is reflected in the below tables which details the plant items used in the assessment construction noise calculations as required.

Table 6: Assumed plant items used in the assessment construction noise calculations

Plant	Construction Activity								Reference BS 5228	Description	Octave centre frequency sound pressure levels								A-weighted SPL at 10m
	1		2		3		4				63	125	250	500	1k	2k	4k	8k	
	No.	% on time	No.	% on time	No.	% on time	No.	% on time											
Breaker mounted on excavator	3	75							C5.1	Backhoe Mounted Hydraulic Breaker	86	80	78	77	81	83	82	81	88.0
Compressor for hand-held pneumatic breaker	2	50							C5.5	Compressor for Hand-held Pneumatic Breaker	84	73	64	59	57	55	58	47	65.0
Muck away lorry	60	2							C6.14	Dump Truck	89	94	89	85	83	81	76	71	89.0
Diesel generator (800 kVA)	1	75	1	75	1	75			C4.84	Diesel Generator	75	72	76	70	69	65	56	47	74.0
Power tools	5	25	5	25	20	25	20	25	C1.20	Lump Hammer	77	75	71	72	74	74	75	73	81.0
	5	25	5	25	20	25	20	25	C3.34	Gas Cutter (Cutting Top of Pile)	74	74	72	61	60	58	56	56	68.0
	5	25	10	25	20	25	20	25	C4.93	Angle Grinder (Grinding Steel)	57	51	52	60	70	77	73	73	80.0
	5	25	5	25	20	25	20	25	C4.95	Handheld Cordless Nail Gun	63	65	65	66	65	69	64	61	73.0
	5	25	5	25	20	25	20	25	C1.18	Gas Cutter	72	72	69	72	73	72	71	71	79.0
Crawler mounted piling rig			1	50					C3.21	Crawler Mounted Rig	81	81	78	76	74	72	68	63	79.0
Tracked excavator			3	50					C3.23	Tracked Excavator	84	76	67	64	62	59	53	43	68.0

Plant	Construction Activity								Reference BS 5228	Description	Octave centre frequency sound pressure levels								A-weighted SPL at 10m
	1		2		3		4				63	125	250	500	1k	2k	4k	8k	
	No.	% on time	No.	% on time	No.	% on time	No.	% on time											
Delivery vehicle			30	2	30	2	30	2	C11.9	Lorry	99	82	81	76	78	74	71	66	82.0
Cement mixer truck (idling)			2	50	1 per block	50			C4.19	Cement Mixer Truck (Idling)	77	71	65	65	66	66	60	51	71.0
Telescopic Handler			2	50	1 per block	50	1 per block	50	C2.35	Telescopic Handler	85	79	69	67	64	62	56	47	71.0
Concrete Pump			1	25	1 per block	25			C3.26	Concrete Pump	82	82	72	71	69	68	62	54	75.0
Caged material hoist (electric)					1 per block	50	1 per block	50	C4.61	Caged Material Hoist (Electric)	64	64	65	65	63	61	59	52	86.0
Tower crane					1 per block	25			C4.48	Tower Crane	82	77	80	76	66	66	56	50	64.0
Jet Wash					2	20			Measured data	Jet wash	59	53	54	62	72	79	75	75	79

K3.2 Noise assessment tables

Table 7: Estimation of noise levels at receptors for Phase 1

Receptor	Threshold value ($dBL_{Aeq,T}$)		Construction noise level ($dBL_{Aeq,T}$)			
	Weekday daytime (0700 - 1900)	**Saturday morning (0700 – 1300)**	**Activity 1**	**Activity 2**	**Activity 3**	**Activity 4**
No. 1 Ebury Bridge	70	65	64	58	62	62
Ebury Place	75	70	68	62	66	66
Cheylesmore House	70	70	**71**	65	69	69
20 – 42 Ebury Bridge Road	75	75	70	65	69	68
• Emboldened numbers indicate that the level exceeds the threshold level						

Table 8: Estimation of noise levels at receptors for Phase 2a

Receptor	Threshold value ($dBL_{Aeq,T}$)		Construction noise level ($dBL_{Aeq,T}$)			
	Weekday daytime (0700 - 1900)	**Saturday morning (0700 – 1300)**	**Activity 1**	**Activity 2**	**Activity 3**	**Activity 4**
No. 1 Ebury Bridge	70	65	**80**	**75**	**79**	**78**
Ebury Place	75	70	68	62	66	66
Cheylesmore House	70	70	**88**	**83**	**87**	**86**
20 – 42 Ebury Bridge Road	75	75	**81**	**75**	**80**	**79**
Phase 1	75	75	**89**	**84**	**88**	**87**
• Emboldened numbers indicate that the level exceeds the threshold level						

Table 9: Estimation of noise levels at receptors for Phase 2b

Receptor	Threshold value ($dBL_{Aeq,T}$)		Construction noise level ($dBL_{Aeq,T}$)			
	Weekday daytime (0700 - 1900)	**Saturday morning (0700 – 1300)**	**Activity 1**	**Activity 2**	**Activity 3**	**Activity 4**
No. 1 Ebury Bridge	70	65	**72**	**67**	**71**	**70**
Ebury Place	75	70	67	61	65	65
Cheylesmore House	70	70	**89**	**83**	**87**	**87**
20 – 42 Ebury Bridge Road	75	75	**81**	**76**	**80**	**79**
Phase 1	75	75	**89**	**84**	**88**	**88**
Phase 2a	75	75	**89**	**84**	**88**	**88**

- Emboldened numbers indicate that the level exceeds the threshold level

K3.3 Vibration assumptions

The following PPV values taken from BS5228-2 have been used to calculate the vibration levels caused by the rotary bored piling.

Table 10: Piling PPV levels

Piling phase	PPV at 20m (mm/s)
1 - Drilling in ground	0.49
2 - Pressing and turning of casing	0.47
3 - Drilling within casing	0.61
4 - Pressing and turning of casing	0.57

Calculations have assumed that piles are located in line with the façade of each superstructure and basement. Vibration levels have been calculated for the nearest possible pile locations for each receptor. This therefore assumes that only one pile would be driven at any one time.

For calculating the vibration produced by vibratory compacting, the following vehicle data has been used.

Table 11: Vibratory compaction vehicle data

Vehicle type	Max drum vibration amplitude (mm)	Drum width	Number of drums
Bomag BW 80 AD-2	0.5	0.9	2

K3.4 Vibration assessment tables

Table 12: Assessed vibration levels for piling

Receptor	Distance from pile (m)	Predicted PPV of piling phases (mm/s)			
		1	2	3	4
No. 1 Ebury Bridge	6.6	0.57	0.55	0.72	0.61
Ebury Place	80	0.08	0.08	0.10	0.09

Receptor	**Distance from pile (m)**	**Predicted PPV of piling phases (mm/s)**			
		1	2	3	4
Cheylesmore House	13	0.34	0.33	0.42	0.36
20 – 42 Ebury Bridge Road	20	0.24	0.23	0.30	0.26
Phase 1 of Proposed Development	11	0.38	0.37	0.48	0.41
Phase 2 of Proposed Development	15	0.30	0.29	0.38	0.32

Table 13: Assessed vibration levels for compaction

Receptor	**Distance from pile (m)**	**Predicted PPV at 1st floor (mm/s)**
No. 1 Ebury Bridge	6.6	2.56
Ebury Place	80	0.07
Cheylesmore House	13	1.01
20 – 42 Ebury Bridge Road	20	0.55
Phase 1 of Proposed Development	11	1.28
Phase 2 of Proposed Development	15	0.83

K4 Construction traffic data

For the assessment of construction traffic noise, a comparison is made between the baseline traffic flows and the predicted future traffic flows including traffic created by construction activities. The table below provides details of this assessment data.

Table 14: Baseline and future traffic flows used in the construction traffic noise assessment

Link name	Vehicle speed link km/h	18hr AAWT flows		18hr AAWT HGV flow	
		Baseline	Construction year	Baseline	Construction year
Ebury Bridge Road (1)	48	4769	5016	655	802
Ebury Bridge Road (2)	48	7700	8029	1133	1288
Ebury Bridge	48	5269	5335	1016	1086
Buckingham Palace Road	48	6250	6250	923	993

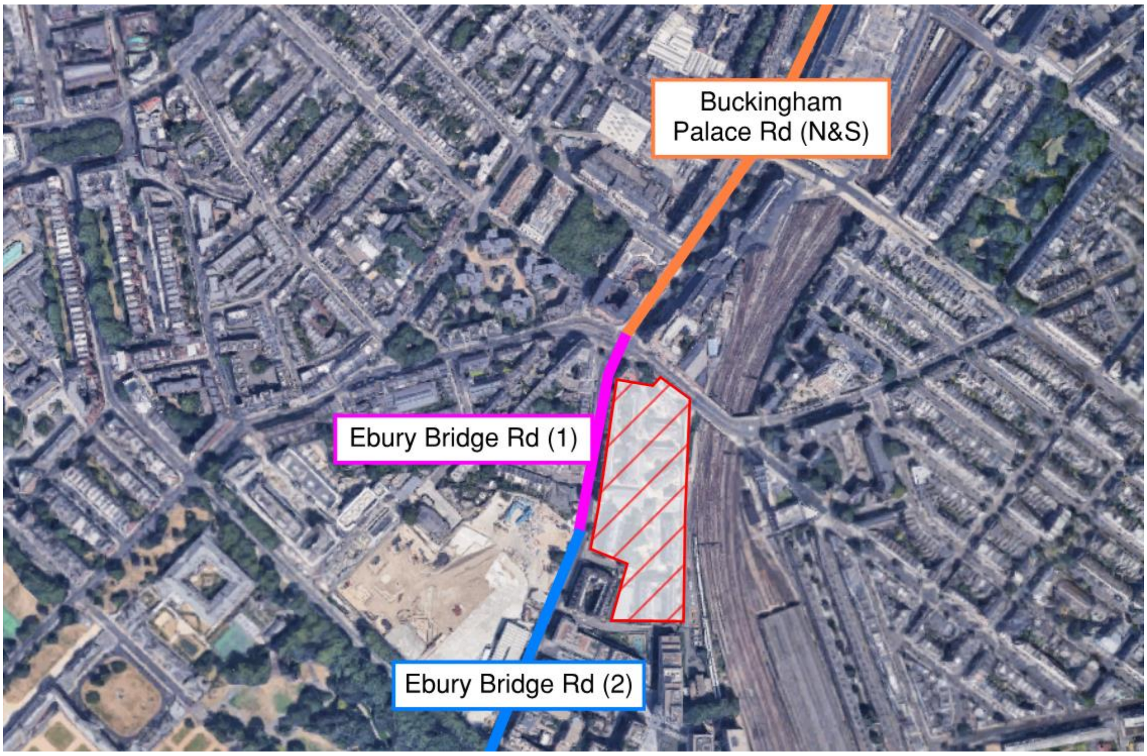


Figure 2: Local road links assessed for construction road traffic noise (Proposed Development shown in red hatch)

K5 Site suitability assessment

K5.1 Introduction

This appendix provides an assessment of noise and vibration in terms of the suitability of the site for residential development. The assessment has been undertaken with reference to the government's Planning Practice Guidance – Noise (PPG-N). Importantly PPG-N does not provide numerical values for the different effect levels, instead recognising that *"The subjective nature of noise means that there is not a simple relationship between noise levels and the impact on those affected. This will depend on how various factors combine in any particular situation"*.

It therefore remains for professional practitioners to carefully consider the PPG noise exposure hierarchy and seek to align it with significance criteria, having regard to British Standards, WHO guidance, and other relevant sources of information.

This section therefore considers the effects of baseline noise by reference to absolute noise criteria advised in:

- BS8233:2014: Sound Insulation and noise reduction for buildings – Code of practice;
- World Health Organization (WHO) Guidelines for Community Noise (1999);
- ProPG: Planning & Noise – New Residential Development (2017); and
- Planning criteria of Westminster County Council (WCC).

Vibration effects are assessed against the criteria advised in BS 6472:2008 – *Guide to evaluation of human exposure to vibration in buildings*. These are also in line with the WCC standard planning conditions.

K5.2 Assessment criteria

K5.2.1 Noise

Noise effects upon the proposed new residential dwellings have been considered by reference to criteria predominantly from BS 8233:2014, which are based on the WHO Guidelines for Community Noise, summarised belowTable 15.

Table 15: Ambient noise level criteria for proposed new residential development

Activity	**Location**	**Daytime (07:00 - 23:00)**	**Night-time (23:00 to 07:00)**
Resting	Living room	35dB$L_{Aeq,16hour}$	-
Dining	Dining room / area	40dB$L_{Aeq,16hour}$	-
Sleeping	Bedroom	35dB$L_{Aeq,16hour}$	30dB$L_{Aeq,8hour}$
Outdoor living / amenity areas		55dB$L_{Aeq,16hour}$	-

BS 8233:2014 does not suggest maximum noise level limits for bedrooms at night. However, WHO: 1999 and ProPG advise that dB$L_{Amax,F}$ noise levels should not exceed 45dB more than 10-15 times per night.

The above noise criteria above are in line with the WCC standard planning conditions.

For this assessment, these criteria are considered to represent the Lowest Observed Adverse Effect Level. PPG-N advises that, at these levels, sound can be heard, but would not cause any change in behaviour or attitude, so no additional mitigation measures would be required.

K5.2.2 Vibration

Vibration effects upon the proposed new residential dwellings have been considered by reference to criteria predominantly from BS 6472:2008 – *Guide to evaluation of human exposure to vibration in buildings* and are provided below.

Table 16: Vibration Dose Value limits within residential and other noise-sensitive property

Period	**Vibration dose value limit ($m/s^{1.75}$)**
16-hour day-time (07:00 – 23:00)	0.40
8-hour night-time (23:00 – 07:00)	0.26

WCC does not provide standard planning conditions specifically for structure-borne noise (SBN), nor are there any current UK or International Standards which recommend acceptable noise levels. However, from Arup's experience on similar previous developments we suggest a suitable value would be 35dB$L_{Amax,S}$.

For this assessment, these criteria are considered to represent the Lowest Observed Adverse Effect Level.

K5.3 Baseline surveys

K5.3.1 Noise survey

Full baseline noise survey results are presented in Appendix K2. All measurements relevant to the assessment of site suitability are presented in this section with irrelevant data discounted. Measurement locations are shown in Figure 3.

Figure 3: Map of site boundary showing noise survey locations (1, 2, A, B and C)

Table 17: Summary of measured daytime (07:00 – 23:00) noise levels, dB re. $2x10^{-5}$ Pa

Measurement location (see Figure 3)	**Measurement type**	**Average $dBL_{Aeq,16hr}$**
A	Façade	70
B	Façade	68
C	Façade	68
1	Free-field	57
2	Façade	64

Table 18: Summary of measured night time (23:00 – 07:00) noise levels, dB re. $2x10^{-5}$ Pa

Measurement location (see Figure 3)	**Measurement type**	**Average $dBL_{Aeq,8hr}$**	**Typical $dBL_{AMax,F}$**
A	Façade	62	78
B	Façade	61	80
C	Façade	63	82
2	Façade	56	73

K5.3.2 Vibration survey

Arup's acoustics team has carried out a detailed vibration survey at the site and this section provides a summary of the procedure and key results. The vibration measurements were carried out at the locations indicated in Figure 4. These locations were chosen to provide an indication of the vibration levels along the eastern boundary of the site, which is expected to be the most affected by the passing of over ground trains.

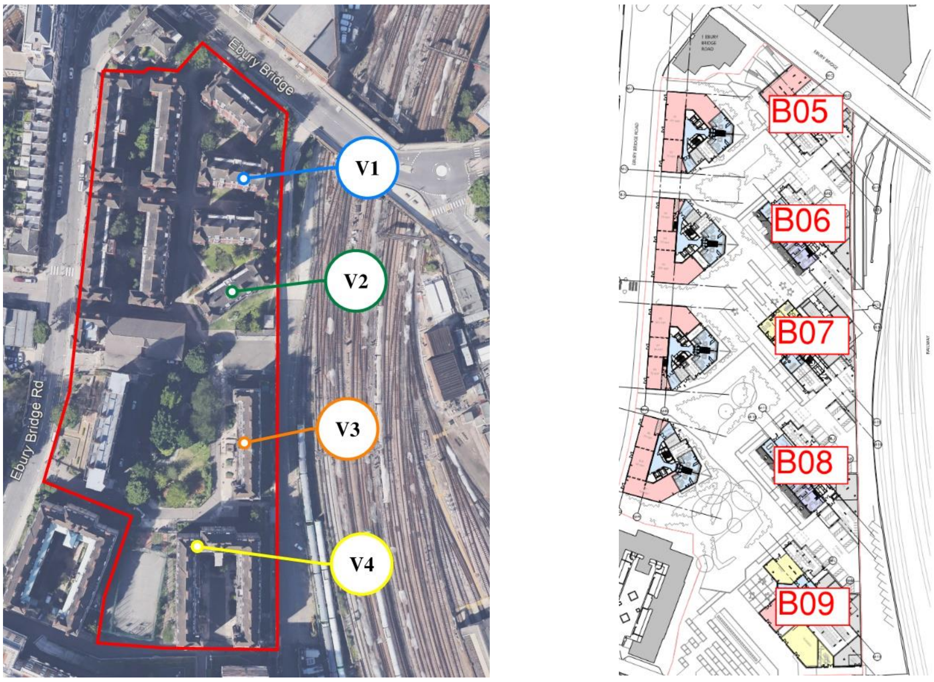


Figure 4: Site plan showing the locations of the supplementary vibration measurements and new Block locations

The vibration survey was carried out over the period between Friday 6th and Monday 9th December 2019. The measurements were all carried out on grade within existing properties of the Ebury Bridge Estate, located in Ground Floor Level flats of the following buildings:

- V1, at Pimlico House;
- V2, at Dalton House;
- V3, at Hillersdon House; and
- V4, at Doneraile House.

Monitoring devices were left unattended to record vibration continuously during the survey period, except for the device at V2, which due to technical issues only recorded for the first 7 hours; although the technical issues did not affect the quality of the recorded data.

Additionally, a CCTV camera was installed in a flat on the Third Floor Level of Hillersdon House, overlooking the railway to assist identification of train movements in the post-processing exercise.

During the three-day survey, approximately 2,000 train movements were detected by the measurement equipment.

K5.4 Assessment

K5.4.1 Noise

To fully understand the distribution of noise, the measured data have been used to validate a noise prediction model. The noise prediction model in turn has been used to create façade noise maps for the purposes of assessing façade sound insulation requirements.

Noise mapping has been conducted using SoundPLAN noise mapping software. SoundPLAN calculates noise levels in accordance with ISO 9613 – Acoustics – Attenuation of Sound

During Propagation Outdoors: Part 2: General Method of Calculation (1996). The prediction model accounts for topography, ground cover and screening and reflections caused by buildings and other features.

The validation and prediction of $L_{Aeq,T}$ noise levels is based upon nearby roads/railways being treated as line sources. The validation and prediction of $L_{Amax,F}$ noise levels is based upon the source being treated as a point source located at the nearest part of the road/railway to the building envelope.

K5.4.1.1 Modelled source types and levels

The following sound power levels (L_w) and source types have been used to represent the environmental noise sources surrounding the Proposed Development.

Table 19: Source types and levels, used to predict daytime $L_{Aeq,T}$ noise levels

Source	Source type	Octave-band centre frequency (Hz)								dBA
		63	125	250	500	1k	2k	4k	8k	
Ebury Bridge	Line (L_w/m)	87	81	77	76	77	74	72	70	82
Ebury Bridge Road	Line (L_w/m)	85	79	76	75	75	72	67	64	80
Railways (total)	Line (L_w/m)	83	82	85	82	79	76	77	76	86

Table 20: Source types and levels, used to predict night-time $L_{Aeq,T}$ noise levels

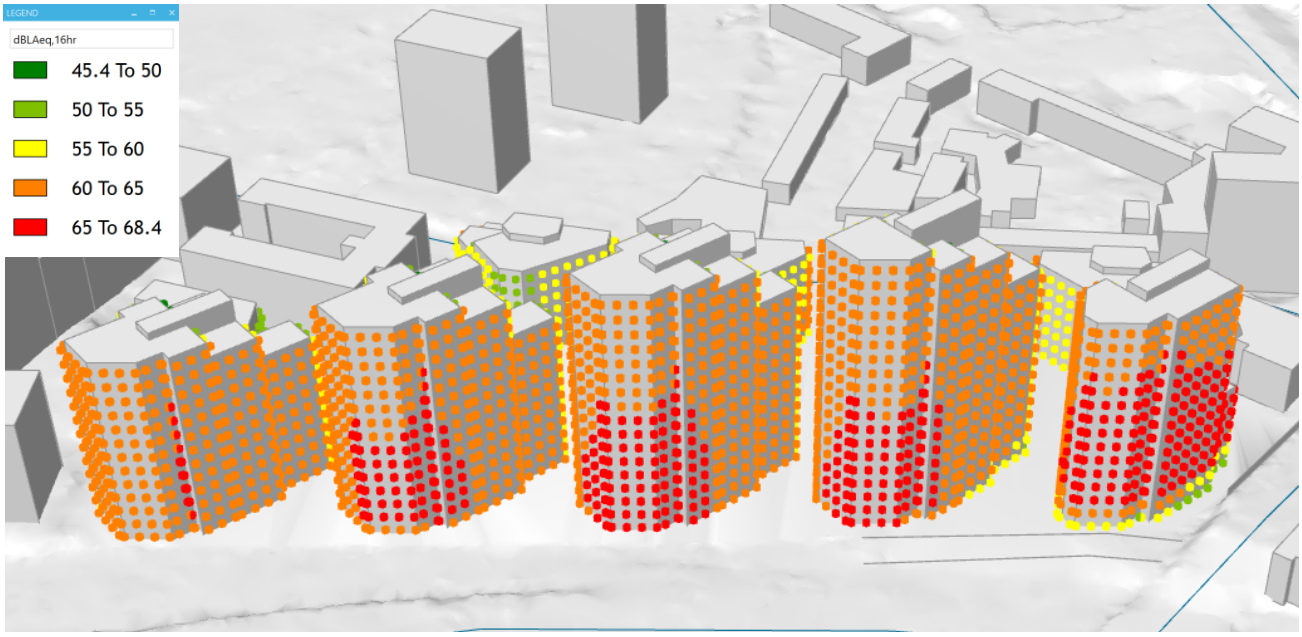
Source	Source type	63	125	250	500	1k	2k	4k	8k	dBA
Ebury Bridge	Line (L_w/m)	80	74	69	69	71	67	64	66	75
Ebury Bridge Road	Line (L_w/m)	80	73	70	69	71	67	62	58	74
Railways (total)	Line (L_w/m)	79	77	79	76	73	70	69	69	79

Table 21: Source types and levels, used to predict night-time $L_{Amax,F}$ noise levels

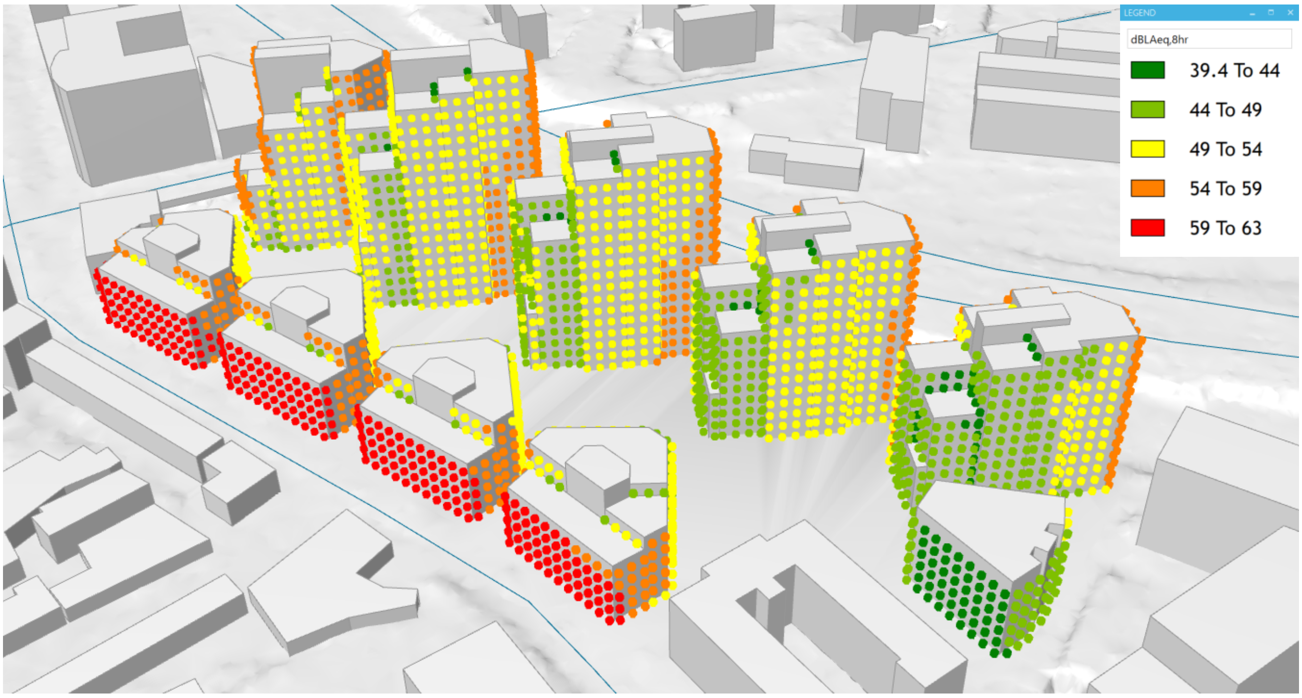
Source	Source type	63	125	250	500	1k	2k	4k	8k	dBA
Ebury Bridge	Point (L_w)	103	102	101	102	103	100	99	98	108
Ebury Bridge Road	Point (L_w)	103	102	101	102	103	100	99	98	108
Railways	Point (L_w)	104	102	115	111	110	110	110	110	118

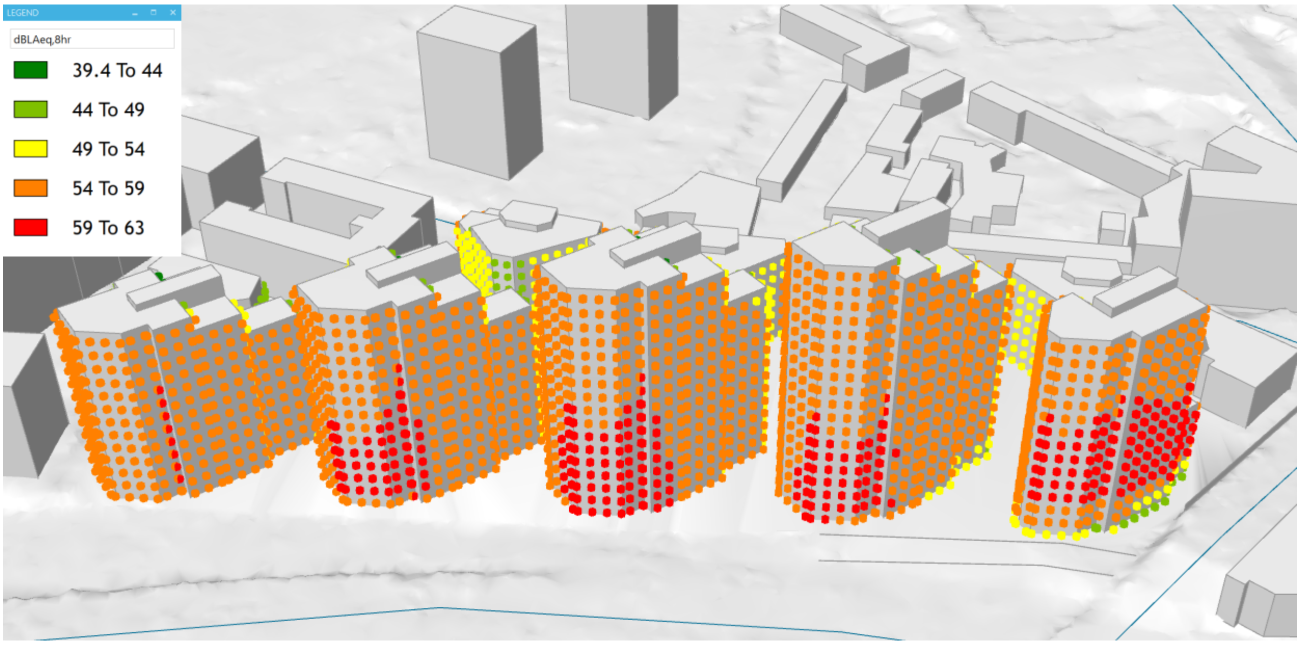
The following figures show the predicted results as noise maps at the facades of the Proposed Development. The levels shown are free-field levels.

Predicted free-field daytime $dBL_{Aeq,16hr}$ noise levels

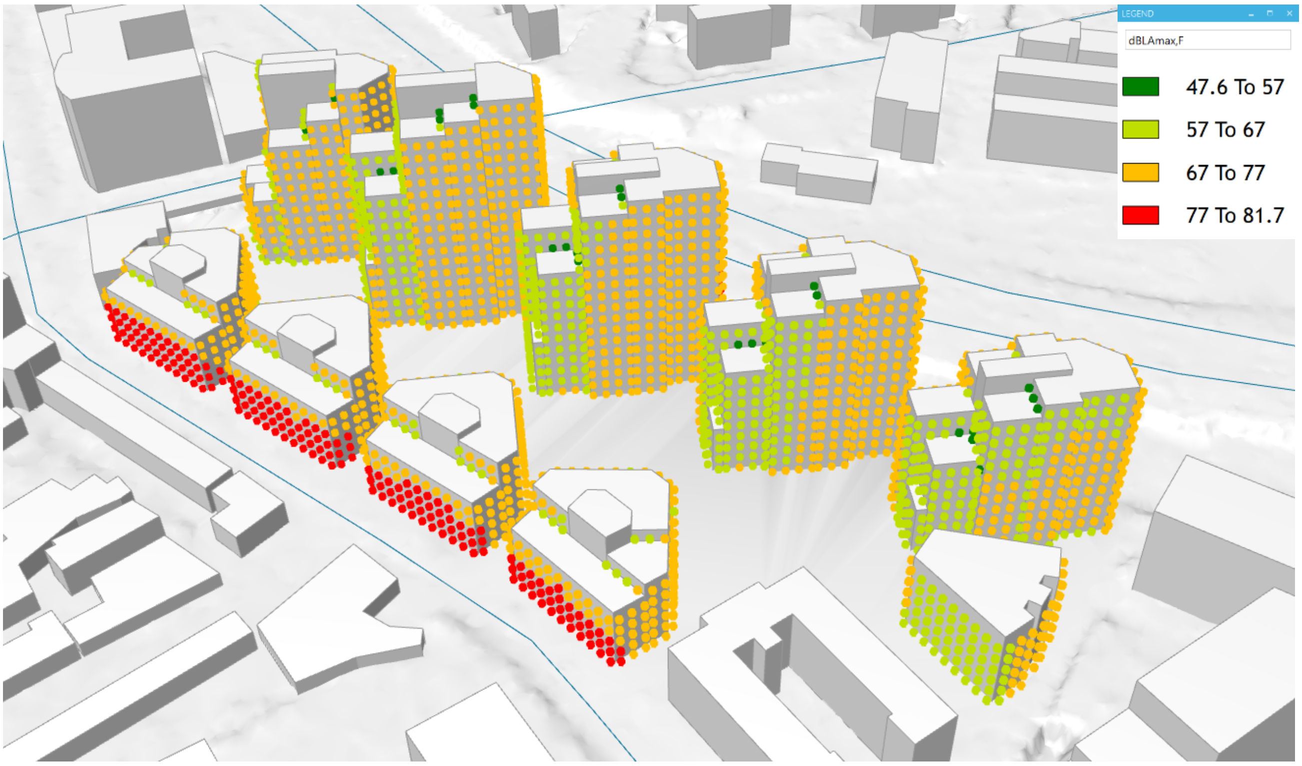


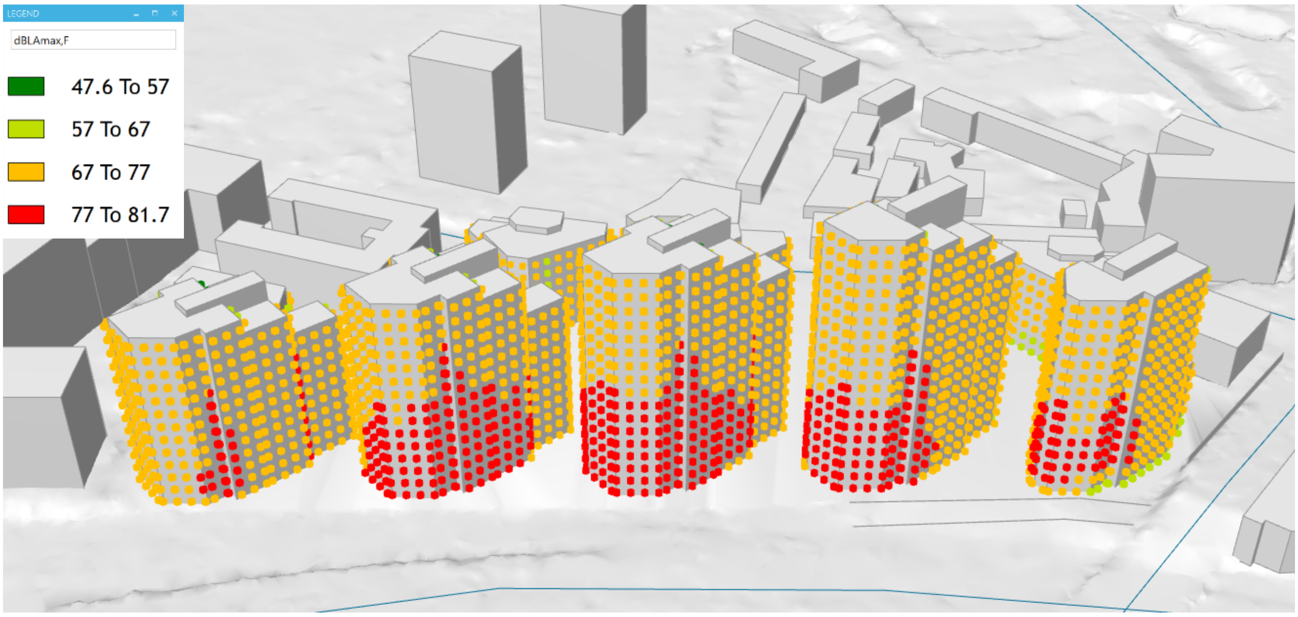
Predicted free-field night-time $dBL_{Aeq,8hr}$ noise levels





Predicted free-field night-time $dBL_{Amax,F}$ noise levels





K5.4.1.2 Outdoor amenity spaces

Environmental noise has been modelled in the outdoor amenity space as shown below. Noise levels are below the 55 $dBL_{Aeq,16hr}$ LOAEL within the majority of the outdoor amenity space.

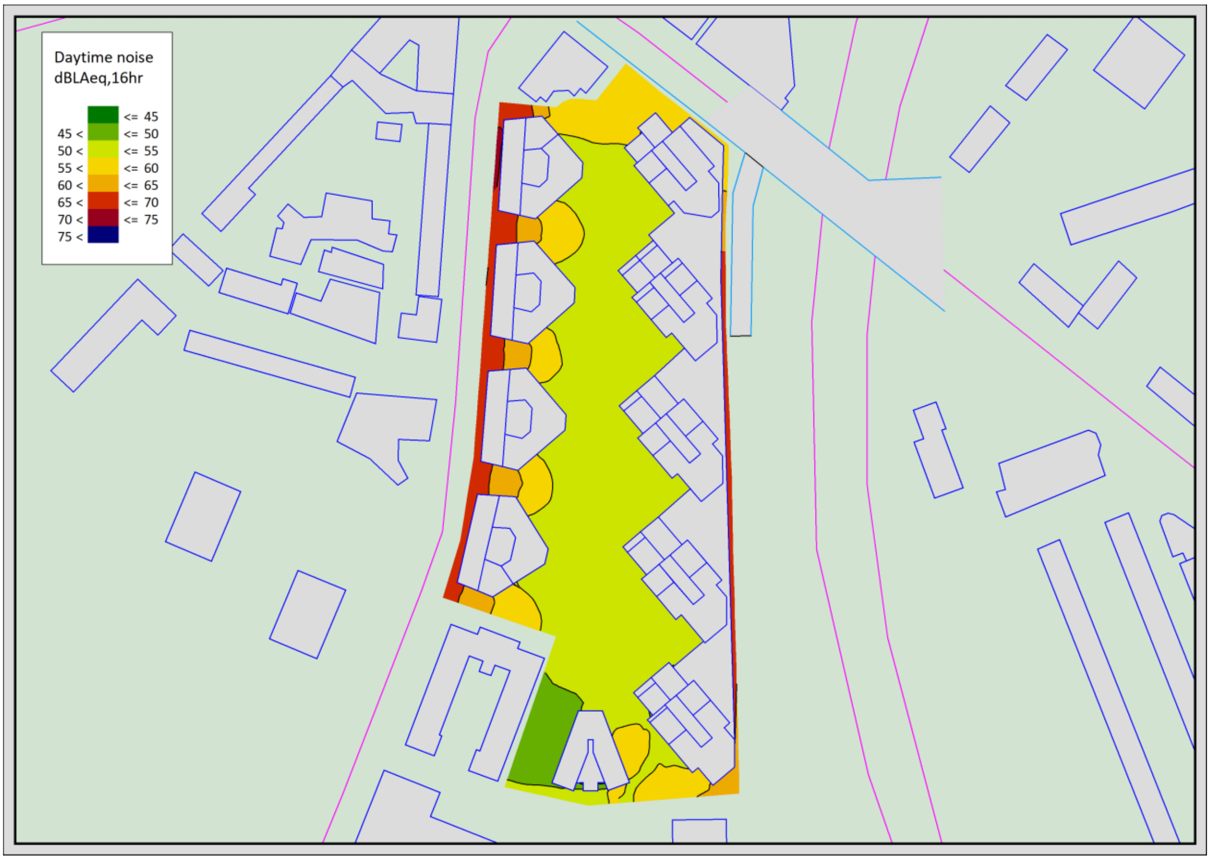


Figure 5: Daytime free-field noise levels in outdoor amenity spaces (modelled at 1.5m above ground level)

K5.4.1.3 Building envelope sound insulation

Building envelope sound insulation requirements are determined by the external noise levels and the targeted internal noise limits, which in this case are the LOAELs as given in Table 15. The most noise-exposed apartments of the Proposed Development have been used in the calculations, to illustrate that the site can be developed appropriately for residential use.

The prediction calculations have been performed for a ‘closed window’ situation, as the ventilation and cooling strategies do not rely on openable windows.

The latest architectural drawings have been used to measure façade areas, glazing areas and the internal room volumes. A mid-frequency reverberation time of 0.6s has been assumed for all rooms. It is assumed that non-glazed areas of façade would provide a sound insulation performance of at least $R_{w+}C_{tr}$ 46.

The required sound insulation performance would be highest on the lower parts of the facades over-looking the primary noise sources (Ebury Bridge, Ebury Bridge Road and the railway lines). Our analysis suggests that the glazing in these areas require a performance of $R_{w+}C_{tr}$ 41 to achieve the internal noise limits. An example of a glazing construction capable of achieving this performance is 16.8mm PVB interlayer glass / 16mm void / 16.8mm PVB interlayer glass.

Lower specification glazing may be sufficient in quieter locations and can be determined later in the design process using façade noise maps as illustrated above.

K5.4.2 Vibration

K5.4.2.1 Predicted structure-borne noise

The measured vibration spectra have been used to estimate the potential levels of structure-borne noise (SBN) ($L_{Amax,S}$) within the buildings of the Proposed Development. The possible response of the future buildings needs to be considered and spectral correction factors applied to the measured vibration spectra. These frequency-dependent corrections relate to:

- attenuation from floor to floor; and
- mid-span amplification on suspended floor slabs.

The SBN predictions have been based on the methodology and correction factors defined in the Association of Noise Consultants publication Measurement & Assessment of Ground borne Noise & Vibration.

No corrections have been applied for coupling losses between the ground and the building foundations. This is because the measurements were taken within the existing buildings and it is understood that the existing buildings have piled foundations as would remain the case for the future buildings.

The vibration energy at each building location has then been corrected to predict the SBN in the relevant space. It is assumed that Blocks B6 to B9 have at least one basement level and that the lowest level of residential is the ground floor of Blocks B6 and B8 and the first floor of Blocks B5, B7 and B9. The current proposals show that Blocks B6, B7 and B8 would have a common basement and so we have assumed a worst-case scenario in the following analysis, namely that each building would be exposed to the highest vibration levels (i.e. those measured at location V3).

The below table summarises the SBN predictions and the associated building corrections. The levels are the average level + 1 standard deviation predicted from each individual train event. These statistical results represent a reasonable upper-band approximation of the noise levels that may occur within a room or space.

Table 22: Structure-borne noise predictions due to train movements and associated building correction assumptions

Prediction location	Representative measurement location	Foundation correction	Suspended slab correction	Floor attenuation	Predicted SBN ($dBL_{Amax,S}$), avg. + 1 S.D.
Block B5 – 1st floor residential	V1	No*	Yes	1 floor	13
Block B6 - Ground Floor residential	V3 (common basement)	No*	Yes	1 floor	24
Block B7 – 1st floor residential		No*	Yes	2 floors	21
Block B8 - Ground Floor residential		No*	Yes	1 floor	24

Prediction location	Representative measurement location	Foundation correction	Suspended slab correction	Floor attenuation	Predicted SBN ($dBL_{Amax,S}$), avg. + 1 S.D.
Block B9 – 1st floor residential	V4	No*	Yes	2 floors	19
* Measurements at all locations were made within the existing buildings					

Table 22 shows that the predicted average SBN levels are below the adopted LOAEL of 35$dBL_{Amax,S}$ recommended in Section K5.2.2.

During the survey, an exceedance of the LOAEL was predicted for one train (of the approximately 2000 recorded) passing the site at location V3 (Blocks B6, B7 and B8).

K5.4.2.2 Perceptible vibration (VDV)

Table 23 and Table 24 present the calculated VDVs for each survey location.

For locations V1, V3 and V4, the loggers continuously recorded vibration levels for approximately 3 days. Logger V2 recorded vibration levels for approximately 7 hours.

The 16-hour daytime and 8-hour night-time VDVs were calculated by extrapolating the data from the worst-affected 5-hour measurements during these periods i.e. data includes also extraneous events such as activities from the building. This method was chosen to give a reasonably worst-case assessment.

Table 23: Vibration dose values, per geocentric axes of motion, daytime period ($m/s^{1.75}$)

Location (see Figure 4)	Horizontal Axis (X)	Horizontal Axis (Y)	Vertical Axis (Z)
V1	0.006	0.006	0.035
V2	0.006	0.008	0.071
V3	0.008	0.004	0.047
V4	0.005	0.003	0.033

Table 24: Vibration dose values, per geocentric axes of motion, night-time period ($m/s^{1.75}$)

Location (see Figure 4)	Horizontal Axis (X)	Horizontal Axis (Y)	Vertical Axis (Z)
V1	0.003	0.003	0.020
V2	-	-	-
V3	0.004	0.002	0.030
V4	0.002	0.001	0.011

In some cases, the vibration levels within the new buildings could be higher than those measured because of structural amplification, therefore the above values include typical corrections to account for this. The predicted VDVs are significantly below the LOAEL discussed in Section K5.2.2 for perceptible vibration.

K5.5 Conclusion

A noise and vibration impact assessment has been conducted for the Proposed Development which considers the suitability of the location for residential use.

K5.5.1 Noise

Consideration has been given to the National Planning Policy Framework (NPPF), Planning Practice Guidance – Noise (PPG-N), Pro-PG and consultation with Westminster City Council. A noise survey has been conducted to identify noise sources within the local area and to evaluate the baseline noise environment. Validated noise modelling has been employed to predict the noise levels in external amenity spaces and at the facades of the Proposed Development, in order to define façade sound insulation requirements.

Noise levels in the majority of the outdoor amenity space have been assessed to be below the adopted 55 $dBL_{Aeq,16hr}$ LOAEL.

External noise levels affecting the outward-facing elevations are elevated, commensurate with the proximity to nearby roads and railways.

Outline noise mitigation has been developed for the building envelope to ensure that the LOAELs for internal noise levels are achieved. Calculations suggest that high specification glazing would be necessary in certain locations.

Subject to the provision of enhanced façade sound insulation and a ventilation and cooling strategy which does not rely on openable windows, the Proposed Development site is considered suitable for residential use. Importantly the area has significant existing precedence of residential uses.

K5.5.2 Vibration

A vibration survey has been conducted to measure the baseline vibration levels on site. The results of the survey have been used to calculate predictions of the vibration within residential spaces of the Proposed Development.

All but one of the approximately 2000 train events surveyed have been predicted to produce structure-borne noise below the adopted LOAEL, within the Proposed Development. This is considered acceptable.

The predicted train vibration levels were comfortably below the LOAEL for perceptible vibration.

As the predicted train vibration and associated noise levels are below the relevant LOAELs, the site is considered suitable for residential use.

K6 Acoustic terminology

Decibel (dB)

The ratio of sound pressures which we can hear is a ratio of 10^6:1 (one million:one). For convenience, therefore, a logarithmic measurement scale is used. The resulting parameter is called the 'sound pressure level' (L_p) and the associated measurement unit is the decibel (dB). As the decibel is a logarithmic ratio, the laws of logarithmic addition and subtraction apply.

dB(A)

The unit used to define a weighted sound pressure level, which correlates well with the subjective response to sound. The 'A' weighting follows the frequency response of the human ear, which is less sensitive to low and very high frequencies than it is to those in the range 500Hz to 4kHz.

In some statistical descriptors the 'A' weighting forms part of a subscript, such as L_{A10}, L_{A90}, and L_{Aeq} for the 'A' weighted equivalent continuous noise level.

Equivalent continuous sound level

An index for assessment for overall noise exposure is the equivalent continuous sound level, L_{eq}. This is a notional steady level which would, over a given period of time, deliver the same sound energy as the actual time-varying sound over the same period. Hence fluctuating levels can be described in terms of a single figure level.

Frequency

Frequency is the rate of repetition of a sound wave. The subjective equivalent in music is pitch. The unit of frequency is the hertz (Hz), which is identical to cycles per second. A 1000Hz is often denoted as 1kHz, e.g. 2kHz = 2000Hz. Human hearing ranges approximately from 20Hz to 20kHz. For design purposes the octave bands between 63Hz to 8kHz are generally used. The most commonly used frequency bands are octave bands, in which the mid frequency of each band is twice that of the band below it. For more detailed analysis, each octave band may be split into three one-third octave bands or in some cases, narrow frequency bands.

Maximum noise level

The maximum noise level identified during a measurement period. Experimental data has shown that the human ear does not generally register the full loudness of transient sound events of less than 125ms duration and fast time weighting (F) has an exponential time constant of 125ms which reflects the ear's response. Slow time weighting (S) has an exponential time constant of 1s and is used to allow more accurate estimation of the average sound level on a visual display.

The maximum level measured with fast time weighting is denoted as $L_{Amax, F}$. The maximum level measured with slow time weighting is denoted $L_{Amax, S}$.

Sound power level

The sound power level (L_w) of a source is a measure of the total acoustic power radiated by a source. The sound power level is an intrinsic characteristic of a source (analogous to its volume or mass), which is not affected by the environment within which the source is located.

Sound pressure level

The sound power emitted by a source results in pressure fluctuations in the air, which are heard as sound.

The sound pressure level (L_p) is ten times the logarithm of the ratio of the measured sound pressure (detected by a microphone) to the reference level of 2 x 10^{-5}Pa (the threshold of hearing).

Thus L_p (dB) = 10 log $(P1/P_{ref})^2$ where P_{ref}, the lowest pressure detectable by the ear, is 0.00002 pascals (ie 2x10^{-5} Pa).

The threshold of hearing is 0dB, while the threshold of pain is approximately 120dB. Normal speech is approximately 60dBL_A and a change of 3dB is only just detectable. A change of 10dB is subjectively twice, or half, as loud.

Statistical noise levels

For levels of noise that vary widely with time, for example road traffic noise, it is necessary to employ an index which allows for this variation. The L_{10}, the level exceeded for 10% of the time period under consideration, and can be used for the assessment of road traffic noise (note that L_{Aeq} is used in BS 8233 for assessing traffic noise). The L_{90}, the level exceeded for 90% of the time, has been adopted to represent the background noise level. The L_1, the level exceeded for 1% of the time, is representative of the maximum levels recorded during the sample period. A weighted statistical noise levels are denoted L_{A10}, dBL_{A90} etc. The reference time period (T) is normally included, e.g. dB$L_{A10, 5min}$ or dB$L_{A90, 8hr}$.

Typical levels

Some typical dB(A) noise levels are given below.

Table 25: Typical dB(A) noise levels

Noise Level, dB(A)	Example
130	Threshold of pain
120	Jet aircraft take-off at 100m
110	Chain saw at 1m
100	Inside disco
90	Heavy lorries at 5m
80	Kerbside of busy street
70	Loud radio (in typical domestic room)
60	Office or restaurant
50	Domestic fan heater at 1m
40	Living room
30	Theatre
20	Remote countryside on still night
10	Sound insulated test chamber

Vibration

Vibration may be expressed in terms of displacement, velocity and acceleration. Velocity and acceleration are most commonly used when assessing human comfort or structureborne noise issues.

Vibration magnitude may be quantified as a peak value, or as a root mean squared (rms) value. The rms value is of benefit because it takes into account both time history variation and energy content. The rms value is equal to 0.707 times the peak value.

The peak value, expressed as the peak particle velocity (PPV) is commonly used for construction vibration and is the parameter best correlated with building damage. PPV can also be related to the perceptible to people of vibration.

Generally, humans are more sensitive to changes in vibration amplitude than they are to changes in the duration of the exposure to vibration.

Vibration dose value (VDV)

This is a complex metric that has been identified as being the best objective measure of human disturbance from intermittent/transient vibration. The VDV is the fourth root of the time integral of the fourth power of the weighted acceleration. VDV are measured in units of $m/s^{1.75}$. The frequency weightings are defined in BS 6472-1: 2008 and in BS 6841: 1987.

The VDV doubles in magnitude with a doubling of vibration amplitude. However, a 16-fold increase in the duration of exposure to the vibration is required to double the VDV (without any change in amplitude).