Curlew Development London Limited

BRITANNIA STREET CAR PARK

Noise and Vibration Assessment Report

RP AC 01
JANUARY 2025

PUBLIC

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NOISE AND VIBRATION REPORT (FIRST ISSUE) PUBLIC

PROJECT NO. 70075739

OUR REF. NO. RP AC 01

DATE: JANUARY 2025

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QUALITY CONTROL

Issue/revision	First issue	Revision 1	Revision 2	Revision 3
Remarks		Addressed comments		
Date	01/11/2024	13/01/2025		
Prepared by	S Schull	S Schull		
Signature		Stephanie.Schull@wsp.com Digitally signed by Stephanie.Schull@wsp.com DN: CN=Stephanie.Schull@wsp.com Date: 2025.01.13 13:31:24Z00'00'		
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Project number	70075739			
Report number	RP AC 01			

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1 INTRODUCTION

1.1 OVERVIEW

1.1.1. WSP UK Ltd is appointed by Curlew Development London Limited to provide noise and vibration engineering services to the Britannia Street Car Park development. The Site is located in Central London, and is above Thameslink and London Underground train lines. Accordingly, a noise and vibration survey has been carried out, to quantify the levels of noise and vibration affecting the Site. The results have been used to advise the design team and client on any measures that may be needed to control noise and vibration ingress.

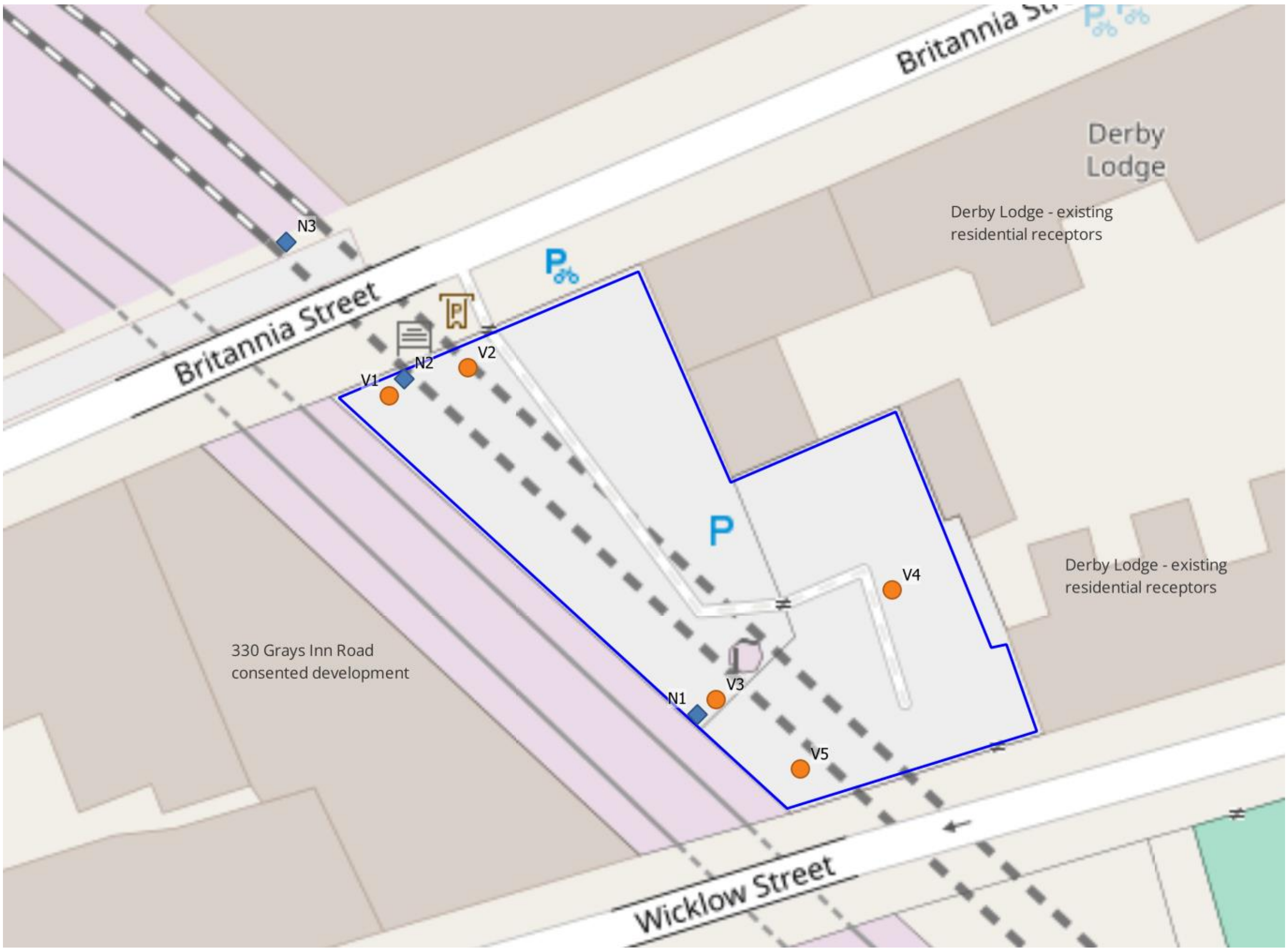
1.2 SITE DESCRIPTION

1.2.1. The Site is located in the Kings Cross Ward of London Borough of Camden (LBC), bounded by Britannia Street to the north; the three storey 'Help Musicians Building' and six storey Derby Lodge Buildings to the east; Wicklow Street to the south; and by London Underground railway lines (in a cutting) to the west. The Thames Link railway line also runs in a shallow tunnel beneath the western half of the Site.

1.2.2. The Site comprises undeveloped hardstanding in use as a public car park and includes a ventilation shaft linked to the Thames Link railway tunnel below the Site. The land to the west beyond the train lines, 330 Grays Inn Road, has received planning approval for a mixed-use development (reference: 2020/5593/P), that includes residential properties facing towards the Site.

1.2.3. A plan showing the location of the Site is presented in Figure 1-1 below.

Figure 1-1 – Site plan showing the location of the Site and survey positions



1.3 SUMMARY OF PROPOSALS

1.3.1. The proposed scheme comprises 121 student flats, with associated amenity space. The proposed building is intended to maximise the available space and would therefore directly adjoin the LU train cutting to the west.

2 POLICY AND GUIDANCE

2.1 LONDON BOROUGH OF CAMDEN COUNCIL REQUIREMENTS

2.1.1. Camden Council has adopted the Camden Local Plan in July 2017, which contains the policies for guiding planning applications.

2.1.2. Appendix 3: Noise Thresholds of the Camden Local Plan outlines the design criteria for vibration levels from uses such as railways, roads, leisure and entertainment premises and/or plant or machinery at which planning permission will not normally be granted.

Table 2-1 – Appendix 3 – Table A from Camden Local Plan

Vibration description and location of measurement	Period	Time	Vibration Levels (Vibration Dose Values)
Vibration inside dwellings	Day and evening	07:00 – 23:00	0.2 to 0.4 VDV $ms^{-1.75}$
Vibration inside dwellings	Night	23:00 – 07:00	0.13 VDV $ms^{-1.75}$

2.1.3. Camden's noise thresholds follow guidance in terms of various 'effect levels' as described in the National Planning Policy Framework and Planning Practice Guidance.

- NOEL – No Observed Effect Level
- LOAEL – Lowest Observed Adverse Effect Level
- SOAEL – Significant Observed Adverse Effect Level

2.1.4. The levels given in the table below are the noise levels applicable to noise sensitive residential development proposed in areas of existing noise given by Camden Council.

Table 2-2 – Appendix 3 – Table B from Camden Local Plan

Dominant noise source	Assessment Location	Design Period	LOAEL	LOAEL to SOAEL	SOAEL
Anonymous noise such as general environmental noise, road traffic and rail traffic	Noise at 1 metre from noise sensitive façade/free-field	Day	<50 dB $L_{Aeq,16hr}$*	50 dB to 72 dB $L_{Aeq,6hr}$*	>72 dB $L_{Aeq,16hr}$*
		Night	<45 dB $L_{Aeq,8hr}$ <40 dB $L_{Aeq,8hr}$**	45 dB to 62 dB $L_{Aeq,8hr}$* >40 dB L_{night}**	>62 dB $L_{Aeq,8hr}$*
	Inside a bedroom	Day	<35 dB $L_{Aeq,16hr}$	35 dB to 45 dB $L_{Aeq,16hr}$	>45 dB $L_{Aeq,16hr}$
		Night	<30 dB $L_{Aeq,8hr}$ 42 dB $L_{Amax,fast}$	30 dB to 40 dB $L_{Aeq,8hr}$ 40 dB to 73 dB $L_{Amax,fast}$	>40 dB $L_{Aeq,8hr}$ >73 dB $L_{Amax,fast}$
	Outdoor living space	Day	<50 dB $L_{Aeq,16hr}$	50 dB to 55 dB $L_{Aeq,16hr}$	>55 dB $L_{Aeq,16hr}$
Non-anonymous noise	See guidance note on non-anonymous noise				

*$L_{Aeq,T}$ values specified for outside a bedroom window are façade levels
**L_{night} values specified for outside a bedroom window are free field levels

2.2 BS 8233

2.2.1. This standard provides guidance for the control of noise in and around buildings. The guidance provided within the document is applicable to the design of new buildings, or refurbished buildings undergoing a change of use, but does not provide guidance on assessing the effects of changes in the external noise levels to occupants of an existing building.

2.2.2. The guidance provided includes appropriate internal and external noise level criteria which are applicable to dwellings exposed to steady external noise sources. It is stated that it is desirable that the internal ambient noise levels do not exceed the criteria set out in Table 2-3.

Table 2-3 - Summary of internal ambient noise levels to be achieved in habitable rooms when assessed in accordance with BS 8233

Activity	Location	Daytime (07:00 – 23:00)	Night-time (23:00 – 0700)
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 $L_{Aeq,8 hour}$
Note: Where development is considered necessary or desirable, despite external noise levels above WHO guidelines, the internal target levels may be relaxed by up to 5 dB and reasonable internal conditions still achieved.			

2.2.3. Whilst BS 8233 recognises that a guideline value may also be set in terms of SEL or L_{AFmax} for the assessment of regular individual noise events that can cause sleep disturbance during the night-time, a specific criterion is not stipulated. Notwithstanding the internal guideline values stated within BS 8233, reference has also been made in this assessment to the World Health Organisation (WHO) 1999: Guidelines for Community Noise.

2.2.4. With respect to external amenity space such as gardens and patios it is stated that it is desirable that the noise level does not exceed 50 dB $L_{Aeq,T}$, with an upper guideline value of 55dB $L_{Aeq,T}$ which would be acceptable in noisier environments. It is then confirmed that higher external noise criteria may be appropriate under certain circumstances such as within city centres urban areas, and locations adjoining the strategic network, where it may be necessary to compromise between elevated noise levels and other factors such as convenience of living, and efficient use of land resource.

2.3 WHO GUIDELINES

2.3.1. The internal ambient L_{Aeq} noise level criteria in BS 8233 are concordant with the guidance contained within the WHO Guidelines. The WHO Guidelines also provide guidance on suitable L_{Amax} noise levels during the night-time period. Specifically, it is stated that:

> *"Indoor guideline values for bedrooms are 30 dB L_{Aeq} for continuous noise and 45 dB L_{Amax} for single sound events."*

2.3.2. The L_{AFmax} criteria detailed within this document draws upon guidance from Vallet and Vernet, which states:

> *"For a good sleep, it is believed that indoor sound pressure levels should not exceed approximately 45 dB L_{AFmax} more than 10-15 times per night".*

2.4 BS 4142

2.4.1. BS 4142[1] describes methods for rating and assessing sound of an industrial and/or commercial nature. Such sound sources include industrial/manufacturing processes, sound from fixed installations comprising mechanical and electrical plant and equipment, sound from the loading and unloading of goods and materials, and sound from mobile plant and vehicles which are intrinsic to the overall sound emanating from premises or processes.

2.4.2. The standard describes methods using outdoor sound levels to assess the likely effects of sound on people who might be inside or outside a dwelling upon which sound is incident.

2.4.3. It is commonly applied in planning conditions, to reduce the likelihood of complaints from new industrial/commercial operations proposed near residential properties.

2.4.4. In summary, this methodology requires the following process:

- Predict the operational sound level from the source at each receptor (this is the 'specific level')
- Apply 'rating corrections' based on the likelihood that the sound sources will have distinguishable characteristics (that would make them more likely to stand out against the otherwise prevailing sound environment).
- Compare the 'rating level' against the typical background sound level

2.4.5. If the rating level does not exceed the background sound level, this is an indication of a low impact depending on the context.

2.5 BS 6472-1: 2008

2.5.1. BS 6472-1[2] provides guidance on predicting human response to vibration in buildings over the frequency range 0.5 Hz to 80 Hz. Frequency weighting curves for human beings exposed to whole-body vibration are included, together with advice on measurement methods to be employed.

2.5.2. In assessing vibration, BS 6472 uses the 'vibration dose value' (VDV). The VDV is used to estimate the probability of adverse comment which might be expected from human beings experiencing vibration in buildings. Consideration is given to the time of day and use of the receptor. The VDV provides a means of specifying the time-varying, frequency-dependent vibration level of a given duration as a single number.

[1] BS 4142:2014+A1:2019 *Methods for rating and assessing industrial and commercial sound*, British Standards Institute
[2] BS 6472-1: 2008 *Guide to evaluation of human exposure to vibration in buildings – Part 1: Vibration sources other than blasting*, British Standards Institute

2.5.3. In terms of VDV over a 16-hour daytime period or 8-hour night-time period, the guidance in BS 6472 is summarised in Table 2-3.

Table 2-3 – Vibration dose values ($m \cdot s^{-1.75}$) above which various degrees of adverse comment may be expected in residential buildings

Place and Time	Low probability of adverse comment [1]	Adverse comment possible	Adverse comment probable [2]
Residential Buildings (16hr day)	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential Buildings (8hr night)	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

[1] Below these ranges adverse comment is not expected
[2] Above these ranges adverse comment is very likely

2.5.4. Where the vibration is intermittent and due to a number of similar vibration events, BS 6472 defines procedures for calculating the estimated Vibration Dose Value (eVDV), based on measurements or calculations undertaken for a sample of the events. The procedure for calculating the eVDV takes into account the number and duration of vibration events and the recorded or calculated value of the root mean square (r.m.s.) frequency weighted vibration acceleration. The frequency weighting takes into account the response of the human body to vibrations of different frequency. The eVDV can then be taken as the VDV for use in the assessment of human exposure to vibration in buildings.

2.5.5. The above guidance relates to vibration measured at the point of entry into the human body, which is usually taken to mean the ground surface or at a point mid-span of an upper-storey floor, rather than the point of entry into the building (a foundation element). As the Site is not developed, it was not possible in this instance to measure at an internal floor location so measurements have been undertaken at a location considered representative of the closest proposed build line to the vibration source.

2.6 GROUNDBORNE NOISE FROM TRAINS

2.6.1. Groundborne noise is a phenomenon whereby vibrations (for example from a railway) propagate into a building structure, causing various elements of the building structure such as walls and floors to vibrate. These vibrating elements then radiate sound in much the same way that a vibrating loudspeaker diaphragm radiates sound. Groundborne noise within buildings can often be perceptible even when the levels of physical vibration are below the threshold of human perception. The transmission path for groundborne noise is always via a solid medium, unlike airborne noise which usually enters a building via an open or poorly insulated window.

2.6.2. There are no international standards or other official European standards that provide guidance on acceptable levels of structure-borne noise from railways. In the absence of British, European or international standards, criteria adopted by the US Federal Transit Administration (USFTA), as presented in their document *Transit Noise and Vibration Impact Assessment*[3], are commonly used. Criteria based on the USFTA guidelines have been adopted by many rail operators and bodies in the UK, including the London Underground, Crossrail, the Channel Tunnel Rail Link and some local authorities.

2.6.3. According to the USFTA guidelines, the human response to different levels of groundborne noise is dependent on the spectral characteristics of the vibration. For spectrum peaks near 30 Hz, a level of 25 dB(A) is considered to represent the approximate threshold of perception, whilst 35 dB(A) represents the dividing line between being barely perceptible and distinctly perceptible. Corresponding levels of 40 dB(A) and 50 dB(A) are defined for mid-frequency groundborne noise with a vibration spectrum peak near 60 Hz. This is summarised in Table 2-4, which is taken from the guidelines.

2.6.4. Note that in Table 2-4 the metric that is used to quantify the level of groundborne noise is the maximum A-weighted sound level using the 'slow' time response, the $L_{Amax,slow}$, measured in decibels.

Table 2-4 – USFTA Guidelines for Groundborne Noise

Human Response	Noise Level ($L_{AS,max}$)	
	Low Frequency [1]	Mid Frequency [2]
Approximate threshold of perception for many humans. Low frequency sound usually inaudible, mid frequency sound excessive for quiet sleeping areas.	25 dB	40 dB
Approximate dividing line between being barely and distinctly perceptible. Many people find transit vibration at this level unacceptable. Low frequency noise acceptable for sleeping areas, mid frequency noise annoying in most quiet occupied areas.	35 dB	50 dB
Vibration acceptable only if there are an infrequent number of events per day. Low frequency noise unacceptable for sleeping areas, mid frequency noise unacceptable even for infrequent events with institutional land uses such as schools and churches.	45 dB	60 dB
Notes: 1. Approximate noise level when peak in vibration spectrum is near 30 Hz. 2. Approximate noise level when peak in vibration spectrum is near 60 Hz.		

[3] C.E.Hanson, D.A. Towers , L.D. Meister, *Transit noise and vibration impact assessment*, Federal Transport Administration, Report Number FTA-VA-90-1003-06, May 2006

2.7 SUMMARY OF CRITERIA ADOPTED FOR THE ASSESSMENT

2.7.1. In summary, the criteria adopted in this assessment are as follows:

- Indoors sound levels:
  - Daytime: 35 dB $L_{Aeq,16hr}$ in living spaces
  - Night-time: 30 dB $L_{Aeq,8hr}$ in bedrooms
  - Night-time: 45 dB L_{AFmax} in bedrooms not to be exceeded more than 10 times per night
- Indoors vibration levels:
  - Daytime: VDV 0.4 $m\cdot s^{-1.75}$ in living spaces
  - Night-time: VDV 0.2 $m\cdot s^{-1.75}$ in bedrooms
  - Re-radiated noise from vibration to not exceed 35dB $L_{AS,Max}$ internally during the night-time.

3 BASELINE NOISE AND VIBRATION DATA

3.1 OVERVIEW

3.1.1. A noise and vibration survey was carried out at the proposed Site, on Monday 6 and Tuesday 7 November 2023. The survey comprised a series of attended noise and vibration measurements of key sources that the proposed development is exposed to.

3.1.2. The nearest receptors to the Site are existing flats at Derby Lodge to the east and proposed new flats at the consented mixed-use scheme at 330 Grays Inn Road to the west. Background sound levels have been measured at a position that is representative of Derby Lodge properties in the survey described below. Noise data were measured by others for the 330 Grays Inn Road scheme[4], which are considered to be representative for the purposes of setting plant noise limits for the proposed development.

3.2 EXISTING SOUND ENVIRONMENT

3.2.1. The sound environment at the Site is dominated by London Underground trains in the cutting to the west of the Site. Significant sound levels are also present from London Underground and Thameslink trains to the north of Britannia Street. Road traffic has a relatively low contribution, as the Site does not have a view of any main roads, and Britannia Street and Wicklow Street are trafficked slowly and infrequently. During the survey, several deliveries were made to businesses on Britannia Street. Cars occasionally arrived or departed the car park, but movements were infrequent and did not contribute significantly to the overall sound environment.

3.3 NOISE SURVEY

NOISE SURVEY EQUIPMENT

3.3.1. The monitoring was completed using the type 1 specification sound level monitoring equipment detailed in Table 3-1.

Table 3-1 – Equipment details

Location	Equipment	Make and Model	Serial Number	Last calibration date
N1	Sound Level Meter	01dB-Stell Duo	10616	18 May 2023
	Pre-amplifier	01dB-Stell PRE 22	10180	
	Microphone	G.R.A.S Type 40CD Condenser	154423	
	Calibrator	01dB Cal 21	34924053	15 May 2023

[4] *330 Gray's Inn Road London Environmental Noise Survey and Acoustic Design Statement Report* 26609/ADS2 28 February 2023, Hann Tucker Associates. Submitted with application ref: 2020/5593/P

N2 & N3	Sound Level Meter	01dB-METRAVIB Blue Solo 'Datalogging Integrating Sound Level Meter'	61331	11 October 2023
	Pre-amplifier	01dB-METRAVIB PRE 21 S	14575	
	Microphone	01dB Metravib MCE 212 Microphone	92344	
	Calibrator	Norsonic type 1251 Sound Calibrator	31460	29 September 2023

LONG-TERM MEASUREMENT (POSITION N1)

3.3.2. Sound level measurements were made between 12:00 on Monday 6 November and 10:00 on Tuesday 7 November 2023. The sound level meter was located along the west boundary of the Site, with the microphone secured to a pole approximately 4 m above ground level, so that it had a direct view of the LU train lines. Measurements were obtained in free-field conditions. The dominant sound sources at this position were the LU trains in the cutting on the south of the Site, but sound from the train lines on the north side of Britannia Street were also audible. Road traffic noise dominated between train passes. The monitoring position is shown in Figure 1-1.

3.3.3. The results of this measurement are shown in full in Appendix B, and summarised below in Table 3-2.

Table 3-2 – Summary of sound levels measured at N1

Period	Continuous equivalent	Maximum	Background sound
Day	67 dB $L_{Aeq,14hr}$	81 – 85 dB L_{AFmax} Mode: 82 dB L_{AFmax} (Based on the highest value in each one-hour period)	46 – 51 dB $L_{A90,1hr}$ Average: 49 dB $L_{A90,1hr}$
Night	61 dB $L_{Aeq,8hr}$	60 – 83 dB L_{AFmax} Mode: 79 dB L_{AFmax} 10th highest: 80 dB L_{AFmax} (Based on the highest value in each 5-minute period)	41 – 50 dB $L_{A90,15min}$ Average: 43 dB $L_{A90,15min}$

Table 3-3 – Typical spectral data from position N1

Description	Sound pressure level (dB) in octave bands (Hz)								L_{pA}
	63	125	250	500	1000	2000	4000	8000	
Day L_{eq}	64	65	64	65	64	58	54	45	67
Night L_{eq}	59	60	58	59	58	52	49	41	61
Night L_{Fmax} (10th highest)	70	74	72	76	77	69	66	58	80

SHORT-TERM NOISE MEASUREMENTS

3.3.4. Short-term sound level measurements were made at two positions (both free-field):

- N2: at the north Site boundary, at a height of ≈1.5 m, with a direct view of Britannia Street. Trains were clearly audible, although line of sight was blocked by the walls along Britannia Street. The measurement was made between 14:01 and 14:36 on Monday 6 November, and has been used to check calibration of the noise model. A sound level of 64 dB $L_{Aeq,35min}$ was measured.
- N3: on the north side of Britannia Street, at a height of ≈2.5 m, overlooking the train lines to the north. The measurement was made between 15:08 and 15:28, and has been used to allow noise modelling of the train lines to the north of Britannia Street (which include Thameslink as well as the LU trains).

3.3.5. The spectral results from N3 are presented below.

Table 3-4 – Octave band sound pressure levels measured at N3

Sound pressure level (dB L_{Zeq}) in octave bands (Hz)								L_{pA}
63	125	250	500	1000	2000	4000	8000	
67	73	78	76	68	63	60	56	76

3.4 VIBRATION SURVEY

METHODOLOGY

3.4.1. Attended vibration measurements were made at five positions on the existing ground of the Site, as shown in Figure 1-1. Each was chosen based on its proximity to the LU and Thameslink train lines, and likelihood of receiving significant vibration from either.

3.4.2. Vibration measurements were made on the test pile using a laptop-based monitoring system, as described in Table 3-5 below.

Table 3-5 – Vibration Monitoring Equipment Details

Equipment Description	Manufacturer & Type No.	Serial No.
4 Channel Analyser	01dB dB4	22553 DT9837 Rev B 00661256
Triaxial geophone	SINUS 902219.7	502501

3.4.3. The geophone was orientated with the X-axis parallel to the tunnels and was coupled to the ground under its own weight (2 kg).

3.4.4. The monitor was configured to record the RMS velocity in one-third octave bands for each axis, in one second intervals. This allows for detailed processing of the data after the survey, to select data from individual train passes.

3.4.5. Each time a train passed, it was logged as being either LU or Thameslink based on observations, to enable each to easily identified in the subsequent analysis.

3.4.6. The results of the vibration survey and the findings of the subsequent assessment are detailed in the following section.

4 NOISE ASSESSMENT

4.1 INTERNAL NOISE LEVELS IN HABITABLE ROOMS

4.1.1. An assessment of the measured noise levels has been undertaken in order to establish the impact of the prevailing noise climate on the future occupants of the proposed development. Any excesses of the adopted internal noise criteria have been determined and assessed assuming that windows are left partially opened. Table 3-3 provides a summary of the predicted external noise levels.

4.1.2. An initial assessment of noise break-in through the facades of the proposed residential properties has been undertaken to determine the minimum sound insulation performances of façade elements. The calculations have been carried out adopting the methodology set out in BS 12354-1:2007[5] and the following assumptions:

- Typical room dimensions of developments of a similar type, i.e. 2.5 m width, 6.9 m depth and 2.4 m in height;
- Maximum glazed area of 1.53 m^2 per window;
- Reverberation time of 0.5 seconds (from Approved Document E);
- The calculations include octave band data, based on the results from the baseline noise survey.

4.1.3. The assumed sound reduction indices (SRIs) for the solid façade elements are presented in Table 4-1.

Table 4-1 – Octave band sound reduction indices for typical façade components, dB

Construction Element	SRI (dB) at Octave Band Centre Frequency Façade Component (Hz)						Single Figure R_w, (Ctr)
	125	250	500	1k	2k	4k	
Brick wall	41	44	48	55	55	55	53 (-4)

4.1.4. Given the sound insulation performance of the solid faced elements presented above, the specification of appropriate glazing will be critical in ensuring the internal noise criteria are achieved.

4.1.5. Indicative proprietary glazing elements have been assumed in the calculations as a means of demonstrating a method of achieving acceptable internal noise levels. The required glazing SRis are outlined in Table 4-2.

[5] BS 12354-1:2017 *Building acoustics. Estimation of acoustic performance in buildings from the performance of elements. Airborne sound insulation against outdoor sound*

Table 4-2 – Octave band sound reduction indices for glazing, dB

Façade Element	SRI (dB) at Octave Band Centre Frequency Façade Component (Hz)						Single Figure R_{w}, (Ctr)
	125	250	500	1k	2k	4k	
Double glazed unit with 4/12/8.8 configuration	26	24	33	43	46	50	32

4.1.6. It should be noted that the above glazing type is provided as an indicative example to demonstrate that the internal noise level criteria can be achieved with commercially available technologies. Detailed noise break-in calculations should be undertaken at the detailed design stage to further inform any specification and tender documents, taking into account final room layouts, glazing dimensions, ventilation proposals and final proposed ground levels for the Site etc.

4.1.7. The glazing type proposed by Sheppard Robson will meet the criteria of 32 $R_{w,Ctr}$.

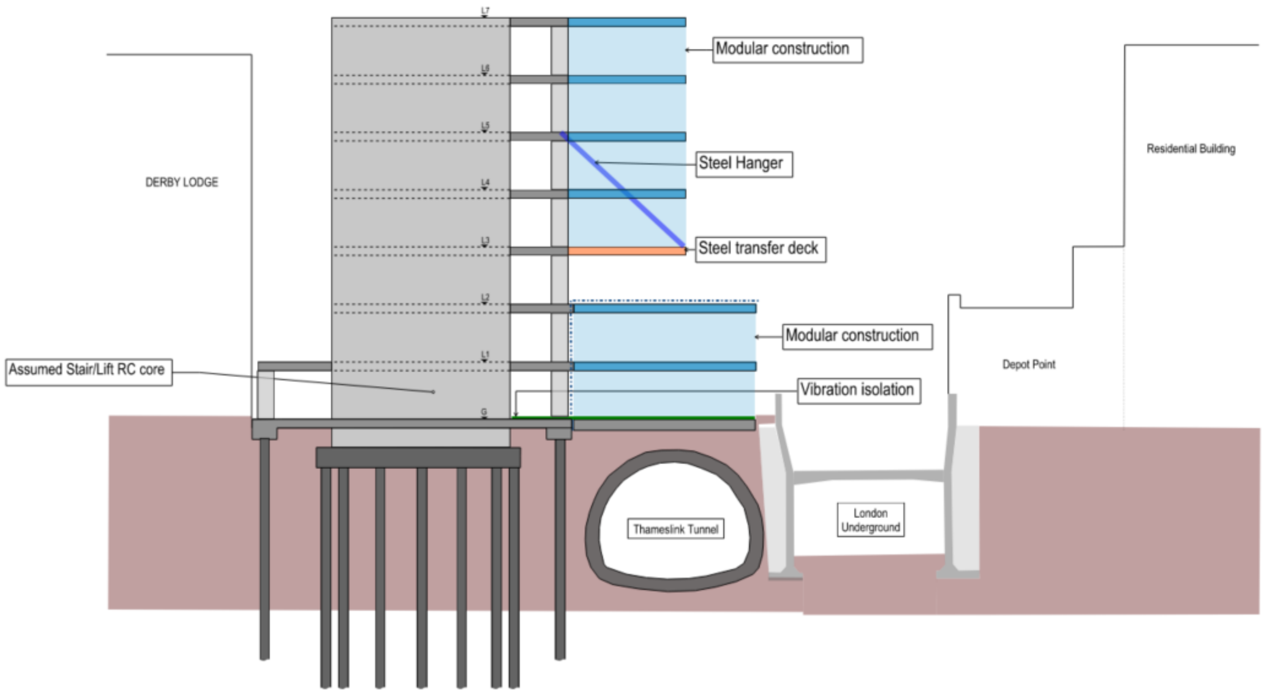
4.1.8. The proposed building's ventilation strategy is proposed to supply fresh air and comfort cooling utilising mechanical ventilation. Therefore, an overheating assessment is not necessary.

5 VIBRATION ASSESSMENT

5.1 VIBRATION PROPAGATION INTO THE PROPOSED BUILDING

5.1.1. The current proposals for the building indicate that the basement level would be lower than the existing ground level, and therefore closer to the tunnel than the existing ground level where the survey was carried out. However, no noise-sensitive uses are proposed at this level, so this is not expected to affect the vibration assessment.

Figure 5-1 – Structural engineer's section showing the anticipated depth of the tunnel relative to the proposed building



5.1.2. To take into account the effects of the foundation design for the new building, data relating to the dynamic vibration response of different types of building have been obtained from a number of sources, including Saurenman and Nelson (‘*A Prediction Procedure for Transportation Groundborne Noise and Vibration, Transport Research Record 1143, USFTA*’) and Villot *et al* (‘*Procedures to Predict Exposure in Buildings and Estimate Annoyance, a report from the RIVAS (Railway Induced Vibration Abatement Solutions) collaborative project’)*.

5.2 SELECTION OF DATA FOR USE IN ANALYSIS

5.2.1. In order to predict the levels of groundborne vibration and re-radiated noise arising from the passage of trains, as expected within the new building, a number of variables and assumptions have necessarily been made:

- Information relating to the design and setting-out of the new building has been taken from the drawings from Sheppard Robson.

- The estimated VDV (eVDV) has been predicted at the ground floor, which is considered to be a worst-case scenario as vibration will attenuate with increasing height. Additionally, there are no bedrooms on the ground floor so vibration levels in bedrooms will be lower than presented below.
- There are 30 Thameslink train events during a typical daytime period (07:00 – 23:00) and 3 train events during a typical night-time period (23:00 – 07:00), based on observations made on-Site and working timetables.
- There are 234 London Underground train events during a typical daytime period (07:00 – 23:00) and 42 train events during a typical night-time period (23:00 – 07:00), based on observations made on-Site and working timetables.
- The duration of a typical train pass-by is 10 seconds (based on the measured vibration data).

5.2.2. The vibration measurements made at the five positions has resulted in 82 measurements of train vibration.

5.2.3. A selection of the measured events exhibiting the highest levels of vibration at each location for each type of train have been used in the following analysis to determine the eVDV level. The results of these calculations are presented in Table 5-1.

5.3 eVDV RESULTS

5.3.1. Separate eVDV calculations have been undertaken for the Thameslink and LU for daytime and night-time periods based on the highest level measured, and assuming that all daytime and night-time events produce the same level of vibration (the peak vibration event measured during the survey).

Table 5-1 – Summary of predicted ground floor vibration dose values

Metric	Thameslink			London Underground		
	Vertical	Transverse	Longitudinal	Vertical	Transverse	Longitudinal
Maximum peak weighted acceleration, ms^{-2}	0.006	0.003	0.003	0.01	0.005	0.004
VDV, daytime (07.00 – 23.00 hours), $ms^{-1.75}$	0.05	0.03	0.02	0.12	0.06	0.05
VDV, night-time (23.00 – 07.00 hours), $ms^{-1.75}$	0.03	0.01	0.01	0.08	0.04	0.03

5.3.2. It can be seen by reference to the criteria in Table 2-3 and the daytime and night-time eVDVs calculated within ground floor dwellings, that the probability of adverse comment would be less than “low” when assessed in accordance with BS 6472-1.

5.4 RE-RADIATED NOISE RESULTS

5.4.1. The predictions presented in Table 5-2 relate to residential rooms on the lowest suspended floor. In order to avoid adding to the airborne sound contributions, the re-radiated sound level should be no higher than 35 dB $L_{Amax,slow.}$ A summary of the ground borne noise levels predicted for the lowest level bedrooms (i.e. the first floor) is presnted in Table 5-2 below.

Table 5-2 – Predicted re-radiated noise levels at the first floor

Position	Predicted re-radiated sound pressure level (dB $L_{Amax,slow}$)	
	Thameslink	London Underground
V1	44	43
V2	45	46
V3	42	40
V4	39	34
V5	44	45
Max	**45**	**46**

5.4.2. The results from Table 5-2 indicate that the ground borne noise values predicted for the first floor are likely to exceed a re-radiated noise level limit of 35 dB $L_{Amax,slow}$.

5.4.3. Re-radiated noise levels can be expected to reduce by 1-2 dB per floor above the one stated. VDVs can generally be expected to reduce by around 10% per floor.

5.4.4. Without mitigation, the eVDV criteria will be met according to the requirements set out by Camden Council. The re-radiated noise levels are however likely to exceed the adopted criterion.

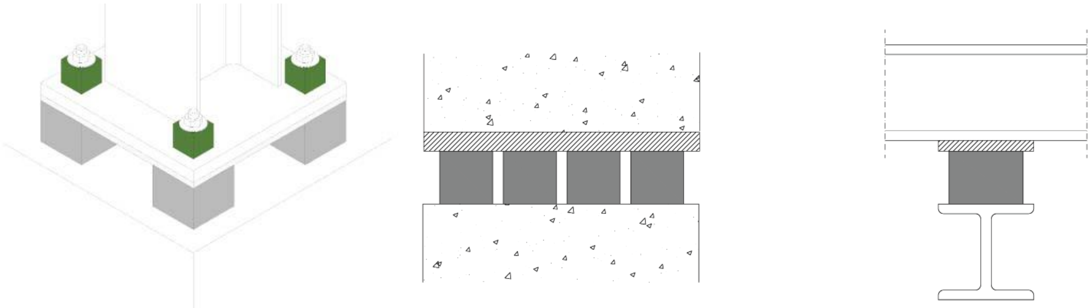
6 PROPOSED MITIGATION MEASURES

6.1 RECOMMENATIONS

6.1.1. Based on the results of the above assessment, it is considered that the building will require base isolation to meet the project's design criterion for re-radiated noise. 'Base isolation' involves the separation of the buildings through the use of isolation bearings between the above ground structure and the basement / foundation elements.

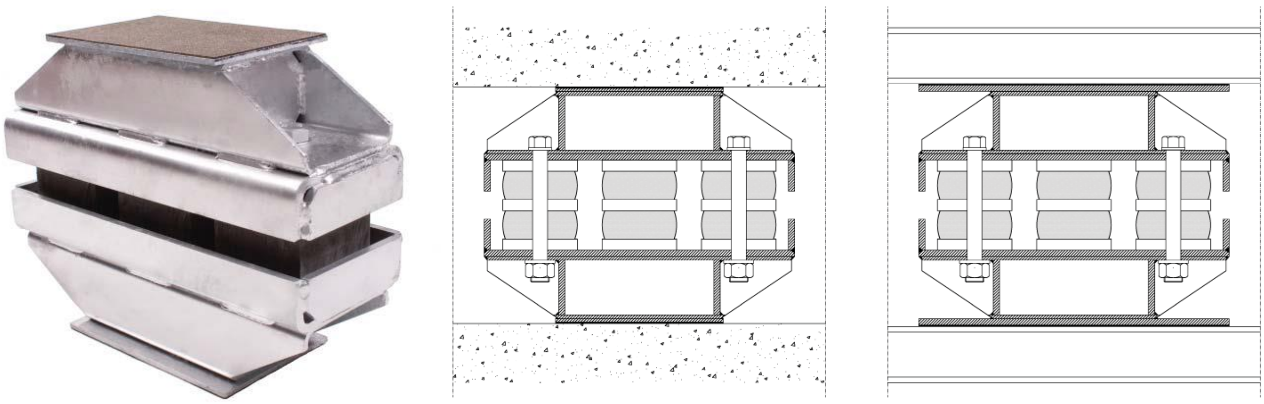
6.1.2. This would typically involve the inclusion of isolation bearings beneath the structural columns, as shown in Figure 6-1. Such bearings could be either based on a steel spring system or on an elastomeric material, depending on the required isolation frequency.

Figure 6-1 - Typical detail of simple bearings beneath structural column



6.1.3. This might be implemented as either a simple elastomeric bearing, as shown in Figure 6-1, or as a pre-compressed bearing/spring or series of bearings/springs within a box construction, as shown in Figure 6-2. One of the advantages of the boxed system is that it can provide a greater level of lateral stability.

Figure 6-2 – Typical detail of elastomeric bearings within a box construction



6.2 BEARING SPECIFICATIONS

6.2.1. The structural design concept for the building already includes a provision for this type of vibration isolation.

6.2.2. The isolation bearings will be required to meet a natural frequency of ≤7 Hz.

6.2.3. It should be noted that this natural frequency has been calculated based on the bearings having an assumed damping factor of 0.045, which will vary between manufacturers and products. These specifications will therefore need to be reviewed once a supplier has been selected, and taking into account the details structural design.

6.2.4. Springs or rubber bearings are available commercially that can meet this specification.

7 CONCLUSION

7.1.1. WSP UK Ltd has been appointed by Curlew Development London Limited to provide noise and vibration engineering services to the Britannia Street, London development.

7.1.2. Accordingly, a noise and vibration survey has been carried out on the Site, to quantify the levels of noise and vibration affecting the Site. The results have been used to advise the design team and client on any measures that may be needed to control noise and vibration ingress.

7.1.3. The results of noise levels in habitable rooms have demonstrated that appropriate internal ambient noise levels can be achieved providing that windows with the required sound insulation performance are provided.

7.1.4. The building will be ventilated and cooled by mechanical means, so there is no risk of excessive noise during overheating conditions.

7.1.5. A vibration assessment has been undertaken to predict the VDVs and re-radiated noise levels likely to occur in the proposed building. VDVs are predicted to result in less than a low probability of adverse comment from future residents.

7.1.6. The re-radiated noise levels are likely to exceed the adopted criteria. Base isolation specifications have been proposed to meet the design criteria.

7.1.7. The limitations of the report are detailed in Appendix C.

Appendix A

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.

Table A1 - Range of sound levels commonly found in the environment

Sound levels	Location
0 dB(A)	Threshold of hearing
20 to 30 dB(A)	Quiet bedroom at night
30 to 4 0dB(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

Sound levels	Location
110 to 130 dB(A)	Jet aircraft on take off
140 dB(A)	Threshold of pain

ACOUSTIC TERMINOLOGY

Table A2 - Acoustic terminology

Terminology	Meaning
dB (decibel)	The scale on which sound pressure level is expressed. It is defined as 20 times the logarithm of the ratio between the root-mean-square pressure of the sound field and a reference pressure ($2x10^{-5}$Pa).
dB(A)	A-weighted decibel. This is a measure of the overall level of sound across the audible spectrum with a frequency weighting (i.e. 'A' - weighting) to compensate for the varying sensitivity of the human ear to sound at different frequencies.
$L_{Aeq,T}$	L_{Aeq} is defined as the notional steady sound level which, over a stated period of time (T), would contain the same amount of acoustical energy as the A - weighted fluctuating sound measured over that period.
L_{Amax}	L_{Amax} is the maximum A - weighted sound pressure level recorded over the period stated. L_{Amax} is sometimes used in assessing environmental noise where occasional loud noises occur, which may have little effect on the overall L_{eq} noise level but will still affect the noise environment. Unless described otherwise, it is measured using the 'fast' sound level meter response.
L_{10} and L_{90}	If a non-steady noise is to be described it is necessary to know both its level and the degree of fluctuation. The L_n indices are used for this purpose, and the term refers to the level exceeded for n% of the time. Hence L_{10} is the level exceeded for 10% of the time, and the L_{90} is the level exceeded for 90% of the time.
$L_{Amax,s}$	A noise level index defined as the maximum A-weighted noise level measured using the 'slow' sound level meter response. This index is commonly used for the assessment of re-radiated noise from underground railways.
Free-field Level	A sound field determined at a point away from reflective surfaces other than the ground with no significant contributions due to sound from other reflective surfaces. Generally as measured outside and away from buildings.
Façade Level	A sound field determined at a distance of 1m in front of a large sound reflecting object such as a building façade.
Displacement, Acceleration and Velocity	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).

Terminology	Meaning
Root Mean Square (r.m.s.) and Peak Values	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.
Peak Particle Velocity (PPV)	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.
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 ms-1.75.
Estimated Vibration Dose Value (eVDV)	An estimated value of the VDV, calculated according to a procedure defined in BS6472. The eVDV is often used as an approximation to the VDV in situations where the vibration is intermittent in nature, as would be the case for railway vibration.
Re-Radiated Noise (Structure-borne Noise or Groundborne Noise)	When building elements or other structures are caused to vibrate, they can radiate noise. In the context of this report, re-radiated noise refers to the noise that may be heard from the vibrating building elements rather than any airborne noise from train movements.

Appendix B

NOISE SURVEY RESULTS

Public

Daytime Data

Periods	Data type		
Period start	L_{Aeq}	L_{A90}	L_{Amax}
06/11/2023 12:00	67.4	49.9	81.6
06/11/2023 12:15	67.1	50.2	81.4
06/11/2023 12:30	67.9	50.5	82.1
06/11/2023 12:45	67.1	49.2	81.6
06/11/2023 13:00	68	49.7	81.6
06/11/2023 13:15	68.8	50	82.2
06/11/2023 13:30	66.6	49.9	81
06/11/2023 13:45	66.7	49.9	79.1
06/11/2023 14:00	67.1	49.3	81.7
06/11/2023 14:15	67	48.7	81
06/11/2023 14:30	67.2	48.9	81.3
06/11/2023 14:45	67	49.5	79.7
06/11/2023 15:00	66.9	49.2	82.2
06/11/2023 15:15	68.4	49.8	82.8
06/11/2023 15:30	68.1	48.9	83.2
06/11/2023 15:45	67.8	50.1	81
06/11/2023 16:00	66.7	51.3	80.4
06/11/2023 16:15	67.2	49.9	80.3
06/11/2023 16:30	67	49.6	81.5
06/11/2023 16:45	67.8	49.3	82

06/11/2023 17:00	68.6	49	81.7
06/11/2023 17:15	66.2	48.9	83.1
06/11/2023 17:30	68.5	49.2	81.6
06/11/2023 17:45	67.9	48.2	81.6
06/11/2023 18:00	68.1	48.6	81.4
06/11/2023 18:15	68	48.6	81.7
06/11/2023 18:30	67.8	49	81.6
06/11/2023 18:45	67.8	48.3	82.3
06/11/2023 19:00	67.8	49.1	81.9
06/11/2023 19:15	67.9	47.7	81.6
06/11/2023 19:30	68.7	48.2	84.6
06/11/2023 19:45	66.2	47.7	80.9
06/11/2023 20:00	68.3	47.8	82.5
06/11/2023 20:15	67.1	48.5	83.6
06/11/2023 20:30	66.2	47.9	81.6
06/11/2023 20:45	66.8	46.8	81.1
06/11/2023 21:00	65.6	46.6	81.5
06/11/2023 21:15	64.8	46	79.3
06/11/2023 21:30	66.6	45.7	81.5
06/11/2023 21:45	67.3	45.3	82
06/11/2023 22:00	67.1	47	81.1
06/11/2023 22:15	67.6	46.7	81.2
06/11/2023 22:30	66.4	45.4	81.3

06/11/2023 22:45	64.5	45.7	78.2
06/11/2023 23:00	65.6	45.4	79.2
06/11/2023 23:15	64.6	45.3	78.5
06/11/2023 23:30	65.3	44.5	80.5
06/11/2023 23:45	65.5	44.6	81.4
07/11/2023 00:00	66	44.5	81.1
07/11/2023 00:15	64.8	43	79.7
07/11/2023 00:30	63.3	42.3	79.6
07/11/2023 00:45	55.2	42.6	73.9
07/11/2023 01:00	50.2	42.1	73
07/11/2023 01:15	47.3	41.6	65.6
07/11/2023 01:30	51.3	42.1	63.9
07/11/2023 01:45	57.1	41.7	82.5
07/11/2023 02:00	56.7	41.3	83
07/11/2023 02:15	47.8	41	66.2
07/11/2023 02:30	50.5	40.6	70.3
07/11/2023 02:45	45.1	40.7	60.2
07/11/2023 03:00	46.3	40.6	60.1
07/11/2023 03:15	47.9	40.8	68.4
07/11/2023 03:30	49.9	41.3	64
07/11/2023 03:45	46.3	40.8	63
07/11/2023 04:00	45.9	41.5	60.5
07/11/2023 04:15	46.5	42.6	60.7

07/11/2023 04:30	51.3	43.6	69.4
07/11/2023 04:45	53.2	44	66.3
07/11/2023 05:00	56.9	43.7	73.9
07/11/2023 05:15	59.5	44.4	78.1
07/11/2023 05:30	61.3	44.6	78
07/11/2023 05:45	64	45	80.7
07/11/2023 06:00	63.6	46.4	78.1
07/11/2023 06:15	64.8	46.6	78.5
07/11/2023 06:30	64.3	47.5	78.5
07/11/2023 06:45	67.2	50.1	81.5
07/11/2023 07:00	68	48.9	81.4
07/11/2023 07:15	67.6	50.9	81.3
07/11/2023 07:30	67.4	50.7	81.1
07/11/2023 07:45	67.5	49	81.5
07/11/2023 08:00	68.3	48.9	83.3
07/11/2023 08:15	68	49	81.4
07/11/2023 08:30	68.1	51.4	82
07/11/2023 08:45	67.3	51.1	81.3
07/11/2023 09:00	67.4	50.9	81.6
07/11/2023 09:15	68.5	50.5	81.7
07/11/2023 09:30	67.4	50.5	81
07/11/2023 09:45	68.7	51.1	81.3
Overall	66.1	44	84.6

Night-time Data

Periods	Data type		
Period start	L_{Aeq}	L_{A90}	L_{Amax}
06/11/2023 23:00	65.6	45.4	79
06/11/2023 23:15	64.6	45.3	79
06/11/2023 23:30	65.3	44.5	81
06/11/2023 23:45	65.5	44.6	81
07/11/2023 00:00	66	44.5	81
07/11/2023 00:15	64.8	43	80
07/11/2023 00:30	63.3	42.3	80
07/11/2023 00:45	55.2	42.6	74
07/11/2023 01:00	50.2	42.1	73
07/11/2023 01:15	47.3	41.6	66
07/11/2023 01:30	51.3	42.1	64
07/11/2023 01:45	57.1	41.7	83
07/11/2023 02:00	56.7	41.3	83
07/11/2023 02:15	47.8	41	66
07/11/2023 02:30	50.5	40.6	70
07/11/2023 02:45	45.1	40.7	60
07/11/2023 03:00	46.3	40.6	60
07/11/2023 03:15	47.9	40.8	68
07/11/2023 03:30	49.9	41.3	64
07/11/2023 03:45	46.3	40.8	63

07/11/2023 04:00	45.9	41.5	61
07/11/2023 04:15	46.5	42.6	61
07/11/2023 04:30	51.3	43.6	69
07/11/2023 04:45	53.2	44	66
07/11/2023 05:00	56.9	43.7	74
07/11/2023 05:15	59.5	44.4	78
07/11/2023 05:30	61.3	44.6	78
07/11/2023 05:45	64	45	81
07/11/2023 06:00	63.6	46.4	78
07/11/2023 06:15	64.8	46.6	79
07/11/2023 06:30	64.3	47.5	79
07/11/2023 06:45	67.2	50.1	82
Overall	61.3	42	83

Appendix C

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 UK Limited. WSP UK 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 UK Limited and agree to indemnify WSP UK Limited for any and all loss or damage resulting therefrom. WSP UK 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 UK Limited reserve the right to review the information, reassess any new potential concerns and modify our opinions accordingly.

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