KP Acoustics Ltd.
info@kpacoustics.com
1 Galena Road, W6 0LT London, UK
+44 (0) 208 222 8778
www.kpacoustics.com

St Margarets Business Park Car Park London

Noise and Vibration Impact Assessment Report
Report 21056.NVA.01 Rev A

Godstone Developments
First Floor
83-84 George Street
Richmond
TW9 1HE

Registered in England Company No. 7947892
KP Acoustics is the Trading Name of KP Acoustics Limited

Report 21056.NVA.01 Revision History			
First Issue Date: 27/08/2020			
A	**14/03/2022** Updated for new scheme	D	
B		E	
C		F	

Written by:	**Checked by:**	**Approved by:**
John Cane MIOA Acoustic Consultant	**Daniel Green MIOA** Senior Acoustic Consultant	**Kyriakos Papanagiotou MIOA** Managing Director

Contents

List of Attachments

SUMMARY

KP Acoustics Ltd has been commissioned to assess the suitability of the site at St Margarets Business Park Car Park, London, TW1 1JN for a residential development in accordance with the provisions of the National Planning Policy Framework and the Noise Policy Statement for England (NPSE).

An environmental noise and vibration survey has been undertaken on site in order to establish the current ambient noise levels, as shown in Table 3.1. The survey was originally undertaken for the first issue of this report, dated 27/08/2022.

Sound reduction performance calculations have been undertaken in order to specify the minimum performance required from glazed elements in order to meet the requirements of BS8233:2014, taking into consideration the non-glazed external building fabric elements. The results of these calculations and the sound reduction performance requirements for the glazed elements are shown in Table 5.2.

The noise implications of the ventilation strategy have been considered, with options being provided to ensure that the ventilation requirements of Approved Document F are achieved.

No further mitigation measures should be required in order to protect the proposed habitable spaces from external noise intrusion.

Vibration calculations have been undertaken in order to assess the level of vibration occupants would be exposed to. The results of these calculations are shown in Table 7.1.

Re-radiated noise due to train pass-bys would be below the guidance criteria provided within ‘Crossrail 2: A Technical Guide For Developers’, ensuring that the effects of structure borne noise would not contribute to the overall airborne noise level experienced within the property.

1.0 INTRODUCTION

KP Acoustics Ltd has been commissioned by Godstone Developments, First Floor, 83-84 George Street, Richmond, TW9 1HE to assess the suitability of the site at St Margarets Business Park Car Park, London, TW1 1JN for a residential development in accordance with the provisions of the National Planning Policy Framework and the Noise Policy Statement for England (NPSE).

This report presents the results of the environmental survey undertaken in order to measure prevailing background noise and vibration levels and outlines any necessary mitigation measures.

2.0 SITE SURVEYS

2.1 Site Description

The site is bounded by Godstone Road to the North, dwellings to the West, Drummonds Place to the South, and Winchester Road to the East. Entrance to the site is located on Winchester Road. At the time of the survey, the background noise climate was dominated by rail traffic noise from the nearby railway to the south.

2.2 Environmental Noise Survey Procedure

A noise survey was undertaken on the proposed site as shown in Figure 2.1. The location was chosen in order to collect data representative of the worst-case levels expected on the site due to all nearby sources.

Continuous automated monitoring was undertaken for the duration of the survey between 14:42 on 13/07/20 and 14:42 on 14/07/20. The survey was originally undertaken for the first issue of this report, dated 27/08/2022.

Weather conditions were generally dry with light winds and therefore suitable for the measurement of environmental noise. The measurement procedure complied with ISO 1996-2:2017 Acoustics '*Description, measurement and assessment of environmental noise - Part 2: Determination of environmental noise levels*'.

2.3 Vibration Survey Procedure

Manual vibration measurements of vertical (z-axis) and horizontal (x - y axes) VDV levels were undertaken on site between 13:37 and 14:19 on 13/07/20, at the position shown in Figure 2.1.

This survey addressed national rail traffic vibration from the nearby railway. Measurements were undertaken for several train pass-bys in each direction in order to gain an understanding of vibration levels typical on site. The character of the vibration would be considered to be intermittent.

The vibration monitoring position was chosen in order to capture worst case expected levels of vibration as stated within BS6472-1:2008 *''Guide to evaluation of human exposure to vibration in buildings''.*

2.4 Measurement Locations

Measurement positions are as described within Table 2.1 and shown within Figure 2.1.

Icon	Descriptor	Location Description
(red circle)	Noise Measurement Position 1	The meter was installed on a tripod at 1.5m above ground level at the south side of the site, as shown in Figure 2.1.
(purple circle)	Vibration Measurement Position	The accelerometer was installed at the proposed location of the closest façade to the nearby railway tracks on a steel cube and placed on flat tarmac.

Table 2.1 Measurement positions and descriptions

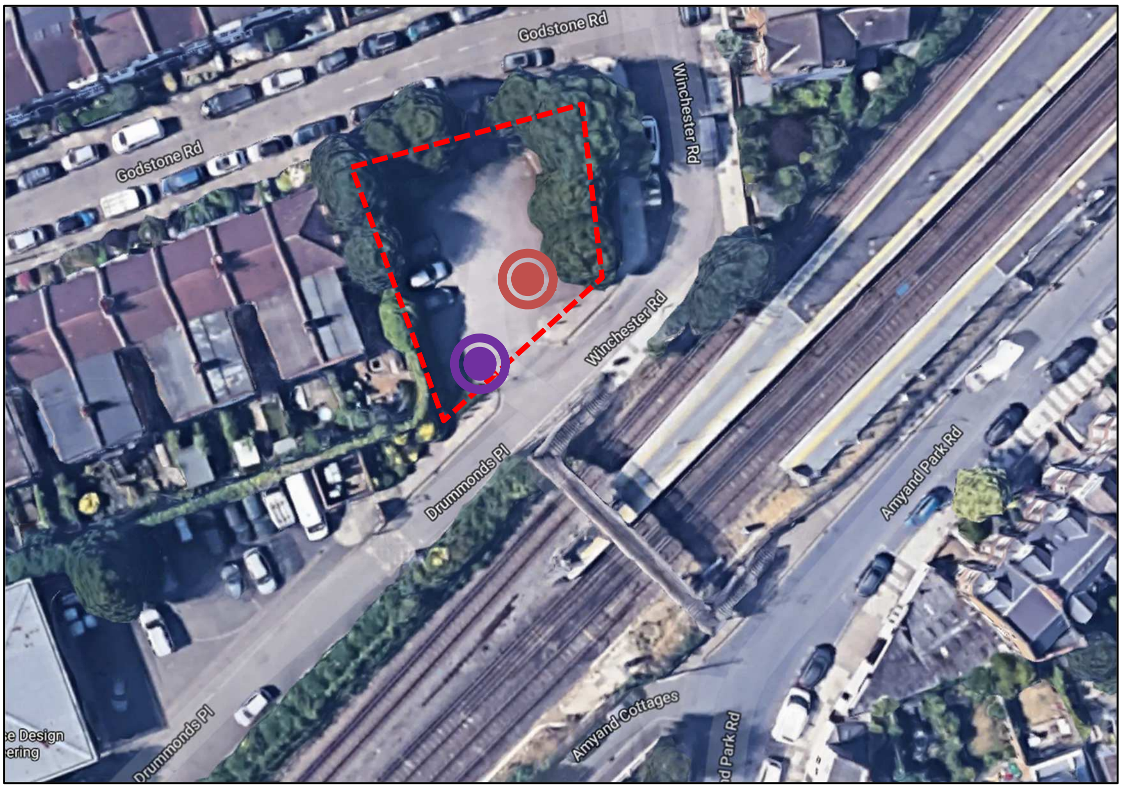

Figure 2.1 Site measurement positions (Image Source: Google Maps)

2.5 Equipment

The equipment calibration was verified before and after use and no abnormalities were observed. The equipment used is described within Table 2.2.

Measurement instrumentation		Serial no.	Date	Cert no.
Noise & Vibration Kit 1	Svantek Type 958A Class 1 Sound Level Meter	45579	20/08/2018	14010338
	Free-field microphone MTG MK255	11697		
	Preamp Svantek 2v12L	41535		
	Svantek External windshield	-	-	-
PCB Piezotronics 356B18 Triaxial Accelerometer		LW176243	29/01/2020	14014834-2
Larson Davis CAL200 Class 1 Calibrator		8932	11/02/2020	04624/2

Table 2.2 Measurement instrumentation

3.0 RESULTS

3.1 Noise Survey

The $L_{Aeq: 5min}$, $L_{Amax: 5min}$, $L_{A10: 5min}$ and $L_{A90: 5min}$ acoustic parameters were measured throughout the duration of the survey. Measured levels are shown as a time history in Figure 21056.TH1. Average daytime and night time noise levels are shown in Table 3.1.

Measured noise levels are representative of noise exposure levels expected to be experienced by all facades of the proposed development, and are shown in Table 3.1.

Time Period	Noise Measurement Position (Measured Noise level – dBA)
Daytime $L_{Aeq,16hour}$	61
Night-time $L_{Aeq,8hour}$	57

Table 3.1 Site average noise levels for daytime and night time

3.2 Vibration Survey

Table 3.2 provides a summary of typical train pass-by VDV levels for individual events. The data presented is the W_b weighted VDV level on the horizontal (x - y) axes, and W_d weighted VDV levels on the vertical (z-axis).

Measurement Type	W_d Weighted x-axis VDV $m/s^{-1.75}$	W_d Weighted y-axis VDV $m/s^{-1.75}$	W_b Weighted z-axis VDV $m/s^{-1.75}$
Train Pass-by from North-East to South-West	0.0008	0.0005	0.006
Train Pass-by from South-West to North-East	0.0009	0.001	0.007
Train Leaves Station from North-East to South-West	0.0006	0.0007	0.002
Train Arrives at Station from South-West to North-East	0.0008	0.0006	0.005

Table 3.2 VDV levels measured on site

Note that a number of individual train pass-bys were measured in order to ensure that worst case vibration levels incident on the site are accounted for.

4.0 NOISE AND VIBRATION ASSESSMENT GUIDANCE

4.1 Noise Policy Statement For England 2019

The National Planning Policy Framework (NPPF) has superseded and replaces Planning Policy Guidance Note 24 (PPG24), which previously covered issues relating to noise and planning in England. Paragraph 170 of the NPPF states that planning policies and decisions should aim to:

- preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability. Development should, wherever possible, help to improve local environmental conditions such as air and water quality, taking into account relevant information such as river basin management plans

In addition, Paragraph 180 of the NPPF states that '*Planning policies and decisions should also ensure that new development is appropriate for its location taking into account the likely effects (including cumulative effects) of pollution on health, living conditions and the natural environment, as well as the potential sensitivity of the site or the wider area to impacts that could arise from the development. In doing so they 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
- Identify and protect tranquil areas which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason

The Noise Policy Statement for England (NPSE) was developed by DEFRA and published in March 2010 with the aim to 'Promote good health and good quality of life through the effective management of noise within the context of Government policy on sustainable development.'

Noise Policy Statement England (NPSE) noise policy aims are as follows:

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

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

The Noise Policy Statement England (NPSE) outlines observed effect levels relating to the above, as follows:

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

As stated in The Noise Policy Statement England (NPSE), it is not currently possible to have a single objective based measure that defines SOAEL that is applicable to all sources of noise in all situations. Specific noise levels are not stated within the guidance for this reason, and allow flexibility in the policy until further guidance is available.

4.2 ProPG: Planning and Noise

As outlined above, the National Planning Policy Framework encourages improved standards of design, although it provides no specific noise levels which should be achieved on site for varying standards of acoustic acceptability, or a prescriptive method for the assessment of noise.

ProPG: Planning and Noise was published in May 2017 in order to encourage better acoustic design for new residential schemes in order to protect future residents from the harmful effects of noise. This guidance can be seen as the missing link between the current NPPF and its predecessor, PPG24 (Planning Policy Guidance 24: Planning and Noise), which provided a prescriptive method for assessing sites for residential development, but without the nuance of 'good acoustic design' as outlined in ProPG.

ProPG allows the assessor to take a holistic approach to consider the site's suitability, taking into consideration numerous design factors which previously may not have been considered alongside the noise level measured on site, for example the orientation of the building in relation to the main source of noise incident upon it.

It should be noted this document is not an official government code of practice, and neither replaces nor provides an authoritative interpretation of the law or government policy, and therefore should be seen as a good practice document only.

4.3 BS8233:2014

BS8233:2014 *'Sound insulation and noise reduction for buildings'* describes recommended internal noise levels for residential spaces. These levels are shown in Table 4.1.

Activity	Location	07:00 to 23:00	23:00 to 07:00
Resting	Living Rooms	35 dB(A)	-
Dining	Dining Room/area	40 dB(A)	-
Sleeping (daytime resting)	Bedrooms	35 dB(A)	30 dB(A)

Table 4.1 BS8233 recommended internal background noise levels

It should be noted that the recommended internal noise levels outlined above are not applicable under "purge ventilation" conditions as defined by Approved Document F of the Building Regulations, as this should only occur occasionally (E.G. to remove odour from painting or burnt food). However, the levels above should be achieved whilst providing sufficient background ventilation, either via passive or mechanical methods.

The external building fabric would need to be carefully designed to achieve these recommended internal levels.

In addition to guidance on internal levels, BS8233:2014 also states the following with regards to noise within external amenity spaces:

'For traditional external areas that are used for amenity space, such as gardens and patios, it is desirable that the external noise level does not exceed 50 dB $L_{Aeq,T}$, with an upper guideline value of 55 dB $L_{Aeq,T}$, which would be acceptable in noisier environments. However, it is also recognized that these guideline values are not achievable in all circumstances where development might be desirable. In higher noise areas, such as city centres or urban areas adjoining the strategic transport network, a compromise between elevated noise levels and other factors, such as the convenience of living in these locations or making efficient use of land resources to ensure development needs can be met, might be warranted. In such a situation, development should be designed to achieve the lowest practicable levels in these external amenity spaces, but should not be prohibited.'

As outlined above, the resulting noise levels in external amenity areas should not be a reason for refusal, providing that the noise levels are designed to be as low as practically possible within external amenity areas.

Expected levels within the proposed external amenity areas are outlined in Section x.x in more detail.

4.4 WHO Guidelines for Community Noise (1999)

WHO Guidelines for Community Noise (1999) recommends that internal noise levels for individual events should not exceed 45dB L_{Amax} more than 10-15 times per night.

It should be noted that this impact is increasingly being regarded as 'LOAEL' for this number of exceedances, as described in Section 4.1.

The external building fabric would need to be carefully designed to ensure that the above guidance is achieved.

4.5 BS6472-1-2008 - Vibration Assessment

BS 6472 provides guidance on predicting human response to vibration in buildings over the frequency range 0.5 Hz to 80 Hz. The vibration dose value 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 made of occupied space in buildings, whether residential, office or workshop.

Table 4.4 shows the different likelihoods of adverse comment from nearby vibration sources on residential occupants.

Place and time	Low probability of adverse comment $m.s^{-1.75}$	Adverse comment possible $m.s^{-1.75}$	Adverse comment probable $m.s^{-1.75}$
Residential buildings 16h day	0.2-0.4	0.4-0.8	0.8-1.6
Residential buildings 8h night	0.1-0.2	0.2-0.4	0.4-0.8

Table 4.4 Likelihood of comment on vibration perceived within residential dwellings

It should be noted that the vibration levels outlined in Table 3.1 are at the point of entry into the human body, and not the point of entry of vibration into the structure itself. In the cases where the proposed structure is not yet built and vibration measurements cannot be taken inside the building, losses should be accounted for due to the transfer function between the ground and building structure and its foundations. As ground conditions, foundation types, building construction, and floor construction and loading are all variables in terms of transfer function and losses, this report will assume piled foundations in rock and a negligible loss as a worst-case scenario.

In addition to potential losses as vibration passes from unloaded ground into the structure, amplification of vibration can occur as the vibration propagates across a suspended floor, such as in upper floors of the proposed building. As this is fully dependent on the input frequency of vibration and the natural frequency of the receiving structure, VDV levels would only be considered on the ground floor of the proposed development within this assessment.

4.6 Re-Radiated Noise Criteria

At present, there are no British Standards which provide guidance on assessing groundborne, structureborne or re-radiated noise associated with train pass-bys.

Re-radiated noise is of concern in scenarios where the VDV level is below the level of adverse comment, but the structure-borne noise associated with the vibration input could negatively impact the amenity of future residents in terms of noise.

The impact of re-radiated noise is particularly important to consider in scenarios where the dominant noise source cannot be seen, such as underground trains or surface trains in tunnels.

In this instance, the proposed building would directly overlook the existing railway line, and therefore there would be an airborne and structure borne noise contribution with regards to the overall noise level expected within the residence. Due to this fact, it is important to understand the level of re-radiated noise in order to ensure that it does not contribute to the overall airborne level to which the future residents of the building would experience.

In the absence of British Standard guidance, the criteria outlined in 'Crossrail 2: A Technical Guide For Developers' for the description of groundborne noise impacts inside dwellings due to train pass-bys are shown in Table 4.5.

Building	Groundborne Noise Level, $L_{Amax, f}$
Residential buildings	35dB

Table 4.5 CR2 Operational groundborne noise design criterion in residential buildings

5.0 EXTERNAL BUILDING FABRIC SPECIFICATION

Sound reduction performance calculations have been undertaken in order to specify the minimum performance required from glazed and non-glazed elements in order to achieve the recommended internal noise levels shown in Table 4.1, taking into account average and maximum noise levels monitored during the environmental noise survey.

As a more robust assessment, L_{Amax} spectrum values of night-time peaks have also been considered and incorporated into the glazing calculation in order to cater for the interior limit of 45 dB L_{Amax} for individual events, as recommended in WHO Guidelines.

Please note that the glazed and non-glazed element calculations would need to be finalised once all design proposals are finalised.

5.1 Non-Glazed Elements

It is currently understood that the non-glazed building façade is comprised of the elements as shown within Table 5.1 based on the construction detail provided. The anticipated sound reduction index has been calculated, and would be expected to provide the minimum figures shown in Table 5.1 when tested in accordance with BS EN ISO, 140-3:1995.

Element	Octave band centre frequency SRI, dB					
	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz
Cavity Wall (350mm thick brick/block cavity, incorporating 150mm Rockwool)	41	43	48	50	55	55

Table 5.1 Assumed sound reduction performance for non-glazed elements

5.2 Glazed Elements

Minimum octave band sound reduction index (SRI) values required for all glazed elements to be installed are shown in Table 5.2.The performance is specified for the whole window unit, including the frame and other design features such as the inclusion of trickle vents. Sole glass performance data would not demonstrate compliance with this specification.

The calculations below are undertaken for three façade areas, shown in Figure 5.1.

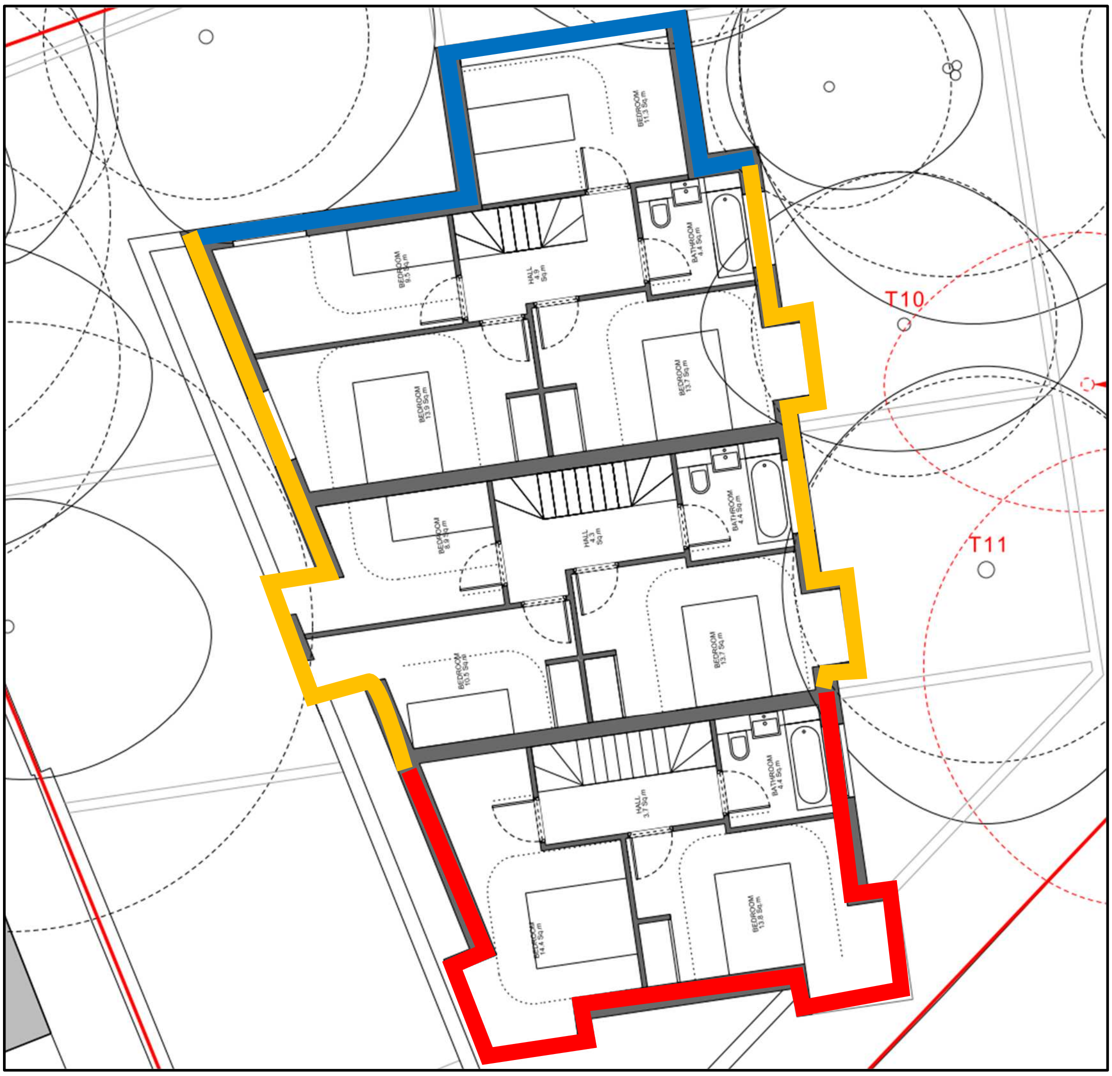

Figure 5.1 Façade areas for calculations (Image Source: Wimshurst Pelleriti)

Glazing performance calculations have been based both on average measured night-time noise levels as well as verified against the L_{Amax} spectrum of individual events in order to comply with a maximum internal noise level of 45dB(A) in bedrooms as recommended by World Health Organisation Guidelines. The combined most robust results of these calculations are shown in Table 5.2.

Elevation	Octave band centre frequency SRI, dB						R_w ($C;C_{tr}$), dB
	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	
North Elevations	27	26	33	39	39	47	36 (-1;-3)
Southernmost House Elevations	24	26	34	44	56	53	45 (-2;-7)
Front and Rear Elevations for Houses Furthest from Trainlines	24	26	27	34	40	38	37 (-1;-4)

Table 5.2 Required glazing performance

The nominated glazing supplier should verify that their proposed window system meets the attenuation figures shown at each centre frequency band as shown in Table 5.2.

Example glazing types that would be expected achieve the above spectral values are shown in Table 5.3.

Elevation	Example glazing type
North Elevations	6/12/10
Southernmost House Elevations	6/100/4 Double window
Front and Rear Elevations for Houses Furthest from Trainlines	10/12/6

Table 5.3 Example glazing types

All major building elements should be tested in accordance with BS EN ISO 140-3:1995.

Independent testing at a UKAS accredited laboratory will be required in order to confirm the performance of the chosen system for an actual configuration.

6.0 VENTILATION

6.1 Ventilation Strategy

Based on the noise levels measured on site, appropriate ventilation systems are outlined in Tables 6.1, 6.2 and 6.3 below in order to ensure the internal noise environment is not compromised.

Ventilation System	Whole Dwelling Ventilation	Extract Ventilation
ADF System 1	Trickle or wall vents providing a minimum performance of 32dB $D_{,n,e,w}$	Intermittent extract fans
ADF System 3	Continuous mechanical extract (low rate) and trickle or wall vents for supply providing a minimum performance of 32dB $D_{,n,e,w}$	Continuous mechanical extract (high rate) with trickle or wall vents providing inlet air
ADF System 4	Continuous mechanical supply and extract (low rate)	Continuous mechanical supply and extract (high rate)

Table 6.1 Ventilation systems (North Elevations)

Ventilation System	Whole Dwelling Ventilation	Extract Ventilation
ADF System 1	Trickle or wall vents providing a minimum performance of 42dB $D_{,n,e,w}$	Intermittent extract fans
ADF System 3	Continuous mechanical extract (low rate) and trickle or wall vents for supply providing a minimum performance of 42dB $D_{,n,e,w}$	Continuous mechanical extract (high rate) with trickle or wall vents providing inlet air
ADF System 4	Continuous mechanical supply and extract (low rate)	Continuous mechanical supply and extract (high rate)

Table 6.2 Ventilation systems (Southernmost House Elevations)

Ventilation System	Whole Dwelling Ventilation	Extract Ventilation
ADF System 1	Trickle or wall vents providing a minimum performance of 42dB $D_{,n,e,w}$	Intermittent extract fans
ADF System 3	Continuous mechanical extract (low rate) and trickle or wall vents for supply providing a minimum performance of 42dB $D_{,n,e,w}$	Continuous mechanical extract (high rate) with trickle or wall vents providing inlet air
ADF System 4	Continuous mechanical supply and extract (low rate)	Continuous mechanical supply and extract (high rate)

Table 6.3 Ventilation systems (Front and Rear Elevations for Houses Furthest from Trainlines)

In the case of mechanical ventilation, systems should be designed to meet the internal noise levels as defined in CIBSE Guide A (2015), as shown in Table 6.4.

Room Type	LAeq, dB	NR
Bedrooms	30	25
Living Rooms	35	30
Kitchen	45-50	40-45

Table 6.4 CIBSE Guide A 2015 guidance levels for mechanical building services

In all cases, purge ventilation would be provided by openable windows. As outlined in Section 4.3, the internal noise level requirement would not be applicable during purge conditions as this would only occur occasionally.

7.0 VIBRATION ASSESSMENT

$VDV_{b/d,day}$ for the daytime period have been calculated based on formula 2 within Section 3.5 of BS6472-1:2008, as follows:

$$VDV_{b/d,day} = (t_{day}/\ t_{\tau})^{0.25} \times VDV_{b/d,\tau}$$

In order to ensure that the calculations of $VDV_{b/d,day}$ are as robust as possible, the highest individual VDV event level measured on site has been used. In this case, the highest individual VDV event level was from a train pass-by from south-west to north-east, over a total duration of 20 seconds.

The number of train pass-bys has been estimated for a worst case of 500 pass-bys for the full daytime period. This was estimated by multiplying the number of train passbys in the hour spent on site by 16 hours of operation and adding 100 pass-bys. This method was undertaken due to the lack of an available train timetable from the operating rail company.

The results from the calculations are shown in Table 7.1.

Axis	Vibration Measurement	Calculated VDV Level $m/s^{1.75}$	Likelihood of Comment
x	$VDV_{d,day}$	<0.00	Adverse comment is not expected
y	$VDV_{d,day}$	<0.00	Adverse comment is not expected
z	$VDV_{b,day}$	0.03	Adverse comment is not expected

Table 7.1 Daytime and night-time VDV levels and likelihood of comment in accordance with BS6472

As shown in Table 7.1, the most dominant axis of vibration is the z-axis with a $VDV_{d,day}$ of $0.003m/s^{1.75}$, which correlates with adverse comment not being expected from future occupiers within the development.

7.1 Re-Radiated Noise Assessment

Various methods for calculating re-radiated noise from vibration are currently in use, as outlined within the ANC Guidelines for Measurement & Assessment of Groundborne Noise and Vibration.

As acceleration data has been collected on site, the calculation and guidance provided within the following documents has been used for this assessment:

- Toronto Transit Commission, Yonge subway northern extension noise and vibration study. Books 1 and 2, Report RD 115/3, 1976
- Kurzweil L.G., (1979) Groundborne noise and vibration from underground rail systems, Journal of Sound and Vibration, 66(3), 363-370

The ANC Guidelines for Measurement & Assessment of Groundborne Noise and Vibration presents the following equation within Appendix C.7 (p199), based on the aforementioned guidance:

$$Lp = 20\log_{10}(A_{rms}/10^{-6}\ g) - 20\log_{10}(f) + 37$$

Where Lp = the calculated one-third octave band sound pressure level in the room (dB re $2x10^{-5}$ Pa)

g = gravitational acceleration constant ($9.81\ ms^{-2}$)

A_{rms} = rms acceleration in g in the one-third octave frequency band measured

f = the one-third octave band centre frequency (Hz)

Using the above calculation, the expected level of groundborne noise at ground floor level of the proposed building is shown in Table 7.2.

Building	Groundborne Noise Level, $L_{Amax, f}$
Ground Floor of Residential Building	10-29dB

Table 7.2 Groundborne noise level within proposed development site

Taking into account worst case vibration levels, the resultant groundborne noise level within a bedroom would be below the proposed noise criterion of 35dB LAmax. Therefore, no additional mitigation measures would be required in order to protect the proposed dwellings from groundborne noise.

It should be noted that the above calculation provides an estimate of groundborne noise levels only. More precise prediction can only be undertaken using numerical modelling methods based on finite-difference or finite-element techniques.

8.0 CONCLUSION

An environmental noise and vibration survey has been undertaken at St Margarets Business Park Car Park, London, TW1 1JN allowing the assessment of daytime and night-time levels likely to be experienced by the proposed development.

Measured noise levels allowed a robust glazing specification to be proposed which would provide internal noise levels for all residential environments of the development commensurate to the design range of BS8233.

No further mitigation measures should be required in order to protect the proposed habitable spaces from external noise intrusion.

Measurement of national rail from train activity indicates that vibration levels are below the threshold of human perception in the z-axis, in accordance with BS6472: 2008.

Re-radiated noise due to train pass-bys would be below the guidance criteria provided within 'Crossrail 2: A Technical Guide For Developers', ensuring that the effects of structureborne noise would not contribute to the overall airborne noise level experienced within the property.

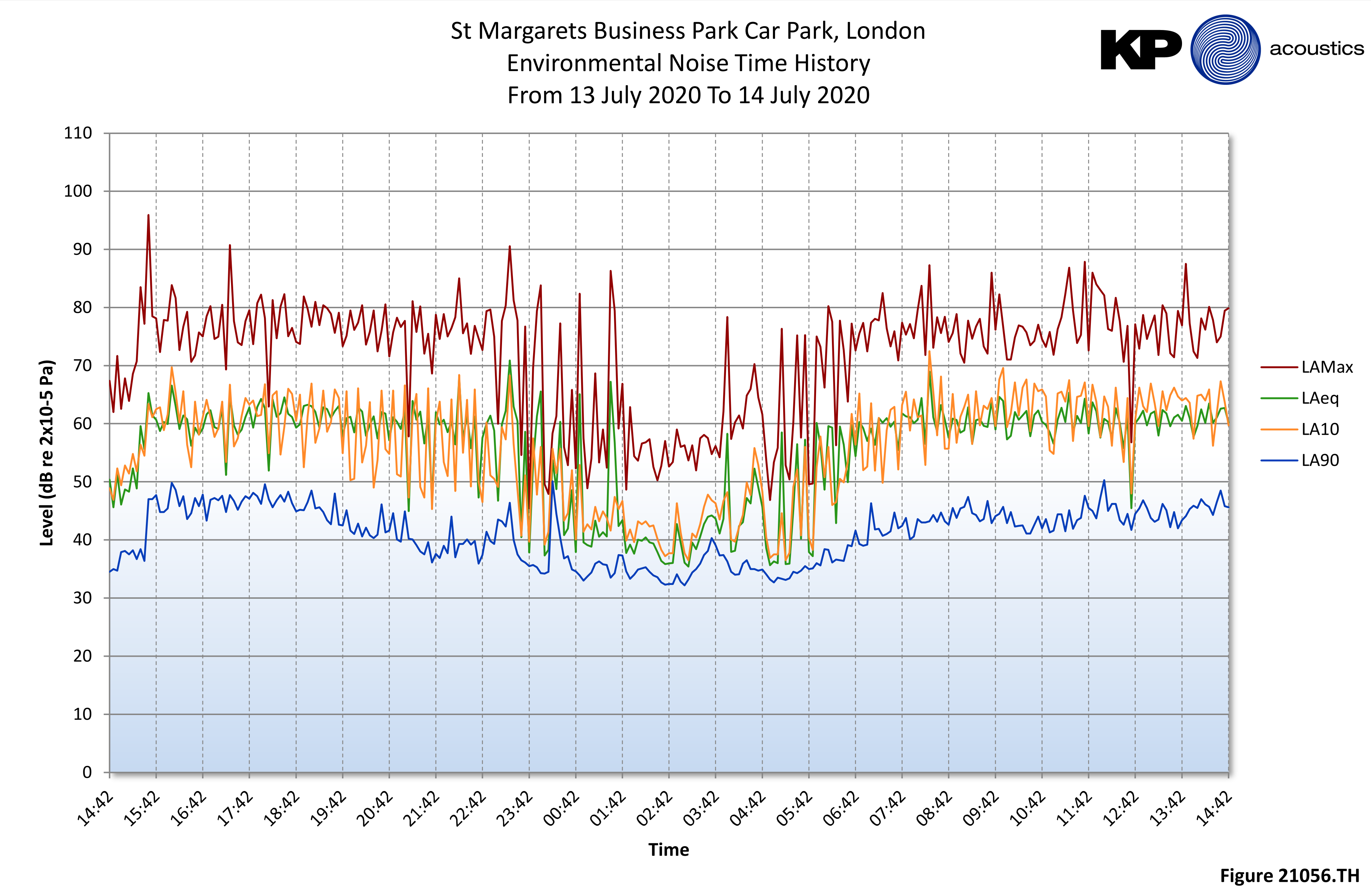

Figure 21056.TH

APPENDIX A

GENERAL ACOUSTIC TERMINOLOGY

Decibel scale - dB

In practice, when sound intensity or sound pressure is measured, a logarithmic scale is used in which the unit is the 'decibel', dB. This is derived from the human auditory system, where the dynamic range of human hearing is so large, in the order of 10^{13} units, that only a logarithmic scale is the sensible solution for displaying such a range.

Decibel scale, 'A' weighted - dB(A)

The human ear is less sensitive at frequency extremes, below 125Hz and above 16Khz. A sound level meter models the ears variable sensitivity to sound at different frequencies. This is achieved by building a filter into the Sound Level Meter with a similar frequency response to that of the ear, an A-weighted filter where the unit is dB(A).

L_{eq}

The sound from noise sources often fluctuates widely during a given period of time. An average value can be measured, the equivalent sound pressure level L_{eq}. The L_{eq} is the equivalent sound level which would deliver the same sound energy as the actual fluctuating sound measured in the same time period.

L_{10}

This is the level exceeded for no more than 10% of the time. This parameter is often used as a "not to exceed" criterion for noise.

L_{90}

This is the level exceeded for no more than 90% of the time. This parameter is often used as a descriptor of "background noise" for environmental impact studies.

L_{max}

This is the maximum sound pressure level that has been measured over a period.

Octave Bands

In order to completely determine the composition of a sound it is necessary to determine the sound level at each frequency individually. Usually, values are stated in octave bands. The audible frequency region is divided into 11 such octave bands whose centre frequencies are defined in accordance with international standards. These centre frequencies are: 16, 31.5, 63, 125, 250, 500, 1000, 2000, 4000, 8000 and 16000 Hertz.

Environmental noise terms are defined in BS7445, *Description and Measurement of Environmental Noise*.

APPENDIX A

APPLIED ACOUSTIC TERMINOLOGY

Addition of noise from several sources

Noise from different sound sources combines to produce a sound level higher than that from any individual source. Two equally intense sound sources operating together produce a sound level which is 3dB higher than a single source and 4 sources produce a 6dB higher sound level.

Attenuation by distance

Sound which propagates from a point source in free air attenuates by 6dB for each doubling of distance from the noise source. Sound energy from line sources (e.g. stream of cars) drops off by 3dB for each doubling of distance.

Subjective impression of noise

Hearing perception is highly individualised. Sensitivity to noise also depends on frequency content, time of occurrence, duration of sound and psychological factors such as emotion and expectations. The following table is a guide to explain increases or decreases in sound levels for many scenarios.

Change in sound level (dB)	Change in perceived loudness
1	Imperceptible
3	Just barely perceptible
6	Clearly noticeable
10	About twice as loud

Transmission path(s)

The transmission path is the path the sound takes from the source to the receiver. Where multiple paths exist in parallel, the reduction in each path should be calculated and summed at the receiving point. Outdoor barriers can block transmission paths, for example traffic noise. The effectiveness of barriers is dependent on factors such as its distance from the noise source and the receiver, its height and construction.

Ground-borne vibration

In addition to airborne noise levels caused by transportation, construction, and industrial sources there is also the generation of ground-borne vibration to consider. This can lead to structure-borne noise, perceptible vibration, or in rare cases, building damage.

Sound insulation - Absorption within porous materials

Upon encountering a porous material, sound energy is absorbed. Porous materials which are intended to absorb sound are known as absorbents, and usually absorb 50 to 90% of the energy and are frequency dependent. Some are designed to absorb low frequencies, some for high frequencies and more exotic designs being able to absorb very wide ranges of frequencies. The energy is converted into both mechanical movement and heat within the material; both the stiffness and mass of panels affect the sound insulation performance.