BHM Two LLP

Hanover House, Cheltenham

Noise Impact Assessment

298355-RSK-RP-01-(00)

APRIL 2021

QUALITY ASSURANCE

Client:	BHM Two LLP
Project Name:	Hanover House, Cheltenham
RSK Acoustics Project No.:	298355
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Document history

Rev.	Purpose Description	Author	Reviewer	Date
--	Report for internal review	FG	JM	16.04.2021
00	Report issued to client	FG	JM	16.04.2021

FG – Federico Gottardo, MIOA (Senior Acoustic Consultant)
JM – Jonathan Mart, MIOA (Associate Director, Acoustics)

 Where field investigations have been carried out, these have been restricted to a level of detail required to achieve the stated objectives of the work. This work has been undertaken in accordance with the quality management system of RSK Environment.

CONTENTS

1 INTRODUCTION

1.1 Instruction

RSK Environment Ltd has been instructed by Foundation Architecture (on behalf of BHM Two LLP) to undertake a noise impact assessment, for the conversion of the upper storeys of Hanover House, Cheltenham (GL50 1SD), to residential.

This report describes the assessment methodology, the baseline conditions currently prevailing across the application site and the effect of the noise levels on the proposed residential development.

Mitigation measures have been identified where necessary and practicable to achieve appropriate acoustic standards.

1.2 Objectives

The noise assessment is required to:

- Identify sources of noise that may impact upon the residents of the proposed development;
- Quantify and report the noise climate (existing and future) across the site to determine the suitability of the site for the proposed residential use;
- Specify the level of noise mitigation that would be required to reduce the potential for disturbance at future sensitive receptors; and
- Inform the architect design and suggest any appropriate mitigation measures.

1.3 Exclusions

Traffic movements from the development are expected to be minimal in relation to the current traffic composition and significantly below the required level to affect nearby receptors. The potential for noise impacts as a result of traffic movements associated with the development would therefore be negligible (in accordance with The Design Manual for Roads and Bridges (DMRB) and has been discounted for the purposes of this assessment.

Levels of vibration from typical free-flowing traffic would be imperceptible at nearest proposed residential locations and therefore an assessment of traffic induced vibration has been discounted.

1.4 Local Authority Consultation

Consultation was sought on 19 February 2021 with Cheltenham Borough Council with regards to RSK's proposed monitoring methodology and scope of assessment. A detailed scope was issued to the local authority detailing the likely noise sources and our proposed methodology in which to account for those licenced premises currently closed as a result of the Covid-19 pandemic. The response from Ms Esme Rouse, dated 23 February 2021 stated, *"Environmental Protection are concerned that any noise assessment carried out when licensed premises are closed due to COVID-19 restrictions* *would not be an accurate representation of the noise sources at the proposed site, in light of this we would request that the assessment is not undertaken until the neighbouring licensed premises are reopened".*

RSK sought clarity on this position via an email response dated 25 February 2021, particularly with regards to operation of the licensed premises. Given RSK's experience of similar licensed premises and use of existing RSK data on patron noise, the client advised that it would be preferential to commence the survey and assessment in line with RSK's proposal. The rationale for this approach was that the client was not in a position to halt the project indefinitely until such time that the United Kingdom returned to 'normal', post pandemic conditions.

2 REGULATORY FRAMEWORK

2.1 National Planning Policy Framework (NPPF): 2019

The National Planning Policy Framework (NPPF) (published March 2012 & updated February 2019) is the means by which noise is considered within the planning regime. The NPPF does not contain assessment design target, instead providing a series of policies, giving local authorities the flexibility in meeting the needs of local communities. The NPPF states:

"Planning policies and decisions should contribute to and enhance the natural and local environment by […] 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."

"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:

> *a) 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;*
>
> *b) identify and protect tranquil areas which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason."*

"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). 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."

The suitability of internal noise levels within a development for its intended uses can be determined with reference to BS8233.

2.2 Noise Policy Statement for England (NPSE): 2010

The Noise Policy Statement for England is published by the Department for Environment, Food and Rural Affairs (Defra) and sets out the approach to noise within the Government's sustainable development strategy.

The significance of impacts from noise within the NPSE are defined as follows:

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

<u>NOEL – No Observed Effect Level</u>

- *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.*

<u>LOAEL – Lowest Observed Adverse Effect Level</u>

- *This is the level above which adverse effects on health and quality of life can be detected.*

Extending these concepts for the purpose of this NPSE leads to the concept of a significant observed adverse effect level.

<u>SOAEL – Significant Observed Adverse Effect Level</u>

- *This is the level above which significant adverse effects on health and quality of life occur.*

The three aims of the NPSE are stated as:

- *Avoid significant adverse impacts on health and quality of life from environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development.*
- *Mitigate and minimise adverse impacts on health and quality of life from environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development.*
- *Where possible, contribute to the improvement of health and quality of life through the effective management and control of environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development.*

2.3 National Planning Practice Guidance (NPPG): 2014

The National Planning Practice Guidance (NPPG) is written in support of the NPPF and provides an increased level of specific planning guidance. NPPG states that noise needs to be considered when new developments may create additional noise and when new developments would be sensitive to the prevailing acoustic environment. NPPG also states that, where practicable, there may be opportunities to consider improvements to the acoustic environment and that noise can over-ride other planning concerns but should not be considered in isolation, separately from the economic, social and other environmental dimensions of proposed development. NPPG reflects the overall aim of NPSE and expands on many of its concepts, in particular NOEL, LOAEL and SOAEL.

2.4 BS 7445-1:2003 'Description and measurement of environmental noise. Guide to quantities and procedures'

The three-part standard BS 7445 provides the framework within which environmental noise should be quantified. Part 1 provides a guide to quantities and procedures and Part 2 provides a guide to the acquisition of data pertinent to land use. Part 3 provides a guide to the application of noise limits.

BS 7445 also refers to a further standard, BS EN 61672, which prescribes the equipment necessary for such measurements. Whilst BS 7445 does not prescribe the meteorological conditions under which noise measurements should or should not be taken, it does (part 2, paragraph 5.4.3.3) recommend that in order

> *"…to facilitate the comparison of results (measurements of noise from different sources), it may be necessary to carry out measurements under selected meteorological conditions which are reproducible and correspond to quite stable propagation conditions."*

These conditions include:

- wind speed not exceeding 5 m/s (measured at a height of 3 to 11 m above the ground);
- no strong temperature inversions near the ground; and
- no heavy precipitation.

2.5 BS 8233: 2014 'Guidance on sound insulation and noise reduction for buildings'

British Standard (BS) 8233 establishes internal ambient noise levels for dwellings based upon occupancy patterns and derived from World Health Organisation (WHO) guidelines for community noise. These are summarised below:

Table 2.1 Summary of Internal Ambient Noise Levels

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

BS8233 also provides design targets for external noise and Section 7.7.3.2 states:

"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."

BS 8233 also provides design targets for various types of space such as hotels and rooms for residential purposes. Section 7.7.5 of the aforementioned standard references the design target within Table 2.1 of this report as being applicable for residential care homes and has therefore been used as a basis to inform the design of the proposed care home within the development.

2.6 World Health Organisation Guidelines: 2000

The World Health Organisation (WHO) Guidelines for Community Noise was published in 2000 as a response to a need for action together with a generic need for improvements in legislation at a national level. Although not legislation, this document provides general guidance and guidelines which have been set for different health effects, using the lowest noise level that produces an adverse health effect in specific human environments. The guideline levels which are relevant to this assessment are set out in Table 2.2.

Table 2.2 WHO Guidelines for Community Noise Levels

Specific Environment	Critical health effect(s)	$L_{Aeq,T}$ (dB)	Time base, T (hours)	$L_{AF,max}$ (dB)
Outdoor Living Area	Serious annoyance, daytime and evening	55	16	-
	Moderate annoyance, daytime and evening	50		
Dwelling, indoors	Speech intelligibility and moderate annoyance, daytime and evening	35	16	-
Inside bedrooms	Sleep disturbance, night-time	30	8	45[a]
Outside bedrooms	Sleep disturbance, window open (outdoor values)	45	8	60

[a] *Should not exceed 45 dB L_{AFmax} more than 10-15 times a night*

2.7 The Building Regulations 2010, Approved Document E

Approved Document E (ADE) provides guidance on the resistance to the passage of sound in domestic buildings, in schools and flats. This guidance applies to new buildings, to alterations to pre-existing premises and to buildings being converted to flats.

The document provides guidance on sound proofing, including the transmission of sounds between walls, ceilings, windows and floors. It covers unwanted sound travel within different areas of a building, including common areas within schools and buildings containing flats, and in-between connecting buildings.

While 43 dB $D_{nT,w+Ctr}$ is the minimum requirement for flats formed by a material change of use, ADE notes that this is intended for between spaces used for normal domestic purposes. Between areas used for communal or non-domestic purposes, a higher standard of sound insulation may be required depending on the level of noise generated. ADE +10 dB or an ambient noise level target of NR10 in the residential space are examples of criteria often adopted.

2.8 Professional Practice guidance on Planning and Noise (ProPG): 2017

The Professional Practice Guidance on Planning and Noise is written to provide practitioners with guidance on a recommended approach to the management of noise within the planning system in England. The CIEH, IOA and the ANC have worked together to produce the guidance which encourages better acoustic design for new residential development and aims to protect people from the harmful effects of noise. This Professional Practice Guidance is based on the best knowledge available at the time of publication. It does not constitute an official government code of practice and neither replaces nor provides an authoritative interpretation of the law or government policy on which users should take their own advice as appropriate.

In relation with achieving internal noise values with open windows ProPG states that:

"*Where it is not possible to meet internal target levels with windows open, internal noise levels can be assessed with windows closed, however any façade openings used to provide whole dwelling ventilation (e.g. trickle ventilators) should be assessed in the "open" position and, in this scenario, the internal* L_{Aeq} *target levels should not normally be exceeded".*

Acoustic Design

ProPG encourages the use of acoustic design as a means to inform the site masterplans and is key to avoiding or reducing to a minimum any adverse effects on any sensitive internal or external spaces. In considering acoustic design, consideration should be given by the developer to the management of noise through a hierarchy of potential mitigation measures which may include:

- Maximising the separation distance between source and receiver;
- Incorporate noise barriers (where applicable) to screen the development site (or individual plots) from significant sources of noise;
- Use existing features to reduce noise propagation across the site;
- Orientate the buildings in a manner which reduces the noise levels within habitable rooms (particularly bedrooms);
- Building envelope design to mitigate the noise to acceptable levels, whilst providing adequate ventilation.

2.9 BS 4142: 2014 + A1: 2019 'Methods for rating and assessing industrial and commercial sound'

BS 4142: 2019 describes the methods for rating and assessing noise from industrial or commercial sources, including manufacturing processes, fixed installations and plant equipment, loading of goods and sound from mobile plant. The standard is applicable for the purpose of assessing sound at proposed new dwellings, through the determination of a rating level of an industrial or commercial noise source.

Where certain acoustic features are present at the assessment location, a character correction should be applied to the specific sound level to give the rating level to be used in the assessment.

- A difference of around +10 dB or more is likely to be an indication of a significant adverse impact, depending on the context.
- A difference of around +5dB is likely to be an indication of adverse impact depending on the context.

- Where the rating level does not exceed the background sound level, this is an indication of the specific sound source having a low impact depending on the context.

BS8233 provides good internal design threshold for new developments, including residential. This standard is derived from the WHO Guidelines for Community Noise (see above). For the use of BS 4142 in assessing new residential development applications ProPG (Paragraph 2.43) states that:

"Professional judgement will have to be exercised in addressing these sorts of issues. One possible approach may be to apply BS 4142:2014 character corrections to the noise level guideline values in order to derive suitable effect thresholds and/ or mitigation design targets and to use the same reference time periods recommended in the standard".

Where the initial estimate of the impact needs to be modified due to the context, all pertinent factors should be taken into account, including:

- The absolute level;
- The character and level of the residual sound;
- The sensitivity of the receptor and whether dwellings will already (or likely) to incorporate design measures that secure good internal and/or outdoor acoustic conditions, such as: i) façade insulation treatments, ii) ventilation and/or cooling, and iii) acoustic screening.

BS 4142 states that, *"A correction of up to +9 dB can be applied for sound that is highly impulsive, considering both the rapidity of the change in sound level and the overall change in sound level. Subjectively, this can be converted to a penalty of 3 dB for impulsivity which is just perceptible at the noise receptor; 6 dB where it is clearly perceptible, and 9 dB where it is highly perceptible".*

On a site such as this, it is therefore not considered appropriate to use the BS 4142 impact assessment method as a means of solely determining suitability for the development site. Based on the guidance provided in BS 4142, the context and incorporated design measures should be the primary features of determining suitability and therefore, BS 8233 and WHO are considered to be the principle standards for derivation of design targets and subsequent assessment. However, the contextual nature of the noise sources (as discussed in BS 4142) and the penalty corrections (for tonality, impulsive, intermittent or other relevant features of noise sources) should be considered and applied to the noise source predictions/measurements or to the BS 8233/WHO design target (as per ProPG above). Appropriate corrections to the design targets within BS 8233/WHO have therefore been applied (in accordance with BS 4142) to account for the underlying nature of activities of the surrounding commercial premises.

2.10 Acoustics Ventilation and Overheating - Residential Design Guide: 2020

Whilst the noise criteria outlined within BS 8223: 2014 provides guidance for 'normal' conditions, it is widely considered that a relaxation in acoustic criteria is permissible during peak summer months where occupants may be willing to compromise on noise ingress for purpose of thermal comfort. Suitable internal noise levels during overheating periods (i.e. when open windows or other measures are required to be implemented for the control of overheating) are provided in *Acoustics Ventilation and Overheating: Residential Design Guide (AVO)*.

A summary of the recommended levels for the most noise-sensitive spaces (bedrooms) are provided below in Table 2.3 for average ambient noise levels throughout a given time period (L_{Aeq}) and maximum noise levels (L_{max}) during the night.

Table 2.3 Design Criteria

Period	Normal condition (As per BS 8223)	Overheating condition
Daytime (07:00 to 23:00)	35 dB $L_{Aeq,16hr}$	40 – 50 dB $L_{Aeq,16hr}$
Night-time (23:00 to 07:00)	30 dB $L_{Aeq,8hr}$ 45 dB L_{Amax}	35 – 42 dB $L_{Aeq,8hr}$ 65 dB L_{Amax}*

**Note L_{AFmax} refers to the level not normally exceeded, and not the 10th highest L_{AFmax} highest level used within WHO guidelines*

The lower ambient noise level thresholds in the overheating condition (40 dB(A) and 35 dB(A) for day and night respectively) correspond to the recommendation within BS 8233:2014 for internal noise levels that would be considered "reasonable" under normal conditions.

The appropriate target level within the range is determined by considering the duration for which windows or ventilation openings are required to be utilised to control overheating. While there are no defined values as to what is considered "rarely" or "most of the time", guidance is provided through assessment of overheating risk assessments or thermal modelling output.

It should be noted that the noise levels stated are considered to apply for transportation noise sources and industrial noise is not considered by the AVO guide. It is therefore necessary to include the previously identified corrections to measured noise levels for acoustic characteristics of industrial sound that residents may find more annoying or disturbing (e.g. where noise sources have prominent tonal qualities, are intermittent or are impulsive).

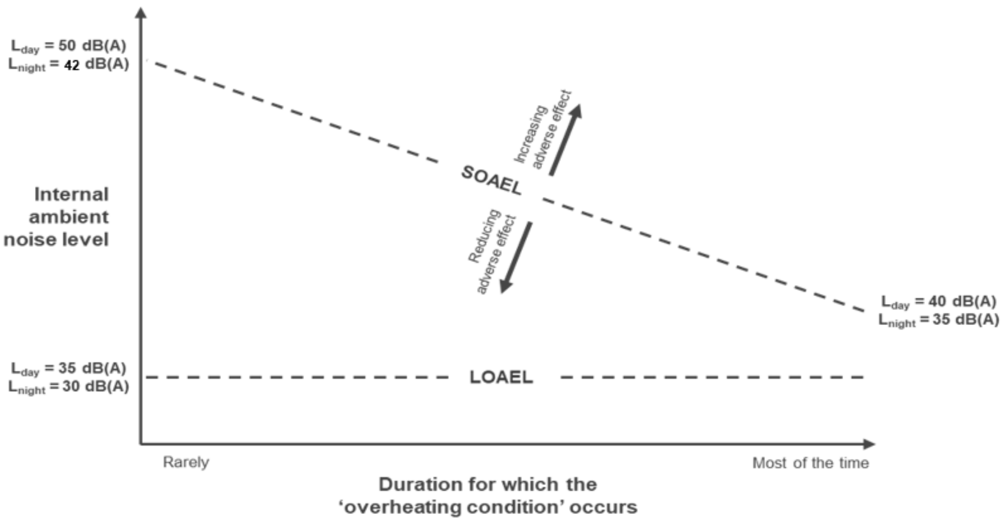


Figure 2.1 Relationship between internal ambient noise level and duration of overheating situation

2.11 International Standard ISO 9613:1996

ISO 9613-2 *'Acoustics – Attenuation of sound during propagation outdoors – Part 2 General method of calculation'* specifies an engineering method for calculating the attenuation of sound during outdoor propagation conditions. The methodology accounts for a number of physical effects including:

- Geometrical divergence (also known as distance loss or geometric damping);
- Atmospheric absorption;
- Ground effect;
- Reflection from surfaces; and
- Screening by obstacles.

The method predicts noise levels under metrological conditions favourable to propagation from the sound source to the receiver, such as downwind conditions, or equivalently, propagation under a moderate ground-based temperature inversion as commonly occurs at night.

2.12 IoA Good Practice Guide on the Control of Noise from Pubs and Clubs

Released by the Institute of Acoustics in 2003, the 'Good Practice Guide on the Control of Noise from Pubs and Clubs' provides guidance for the assessment and control of noise affecting noise sensitive receptors from pubs and clubs. No specific numerical criteria is provided, however the guide advises on the main sources of noise that can cause disturbance from entertainment venues including: music, singing and speech (both amplified and non-amplified); activities within gardens and other outdoor spaces; rowdy behaviour; plant and machinery and use of car parks. For venues where entertainment takes place on regular basis, it is suggested that music and associated sources should not be audible inside nearby noise sensitive receptors. The guide is designed to assist local authority officers and venue owners in the prevention and resolution of noise disturbance and complaints.

3 DEVELOPMENT LOCATION

3.1 Site Location and Description

Hanover House is located on Montpellier, Cheltenham. The building comprises of basement, ground and two upper floors. The building is currently leased to 'ASK' restaurants who occupy the basement/ground floor for restaurant operations, with first/second floors currently unused.

The site is located within an existing commercial setting, which includes fashion retail, a bespoke kitchen designer and a wine bar, within the immediate vicinity of Hanover House along Montpellier Arcade. To the west of Hanover House, is another row of commercial shops, predominantly fashion, and an area of permit holders car parking. The site is accessed via the A4015 to the east of the site, which provides the main thoroughfare into Cheltenham town centre.

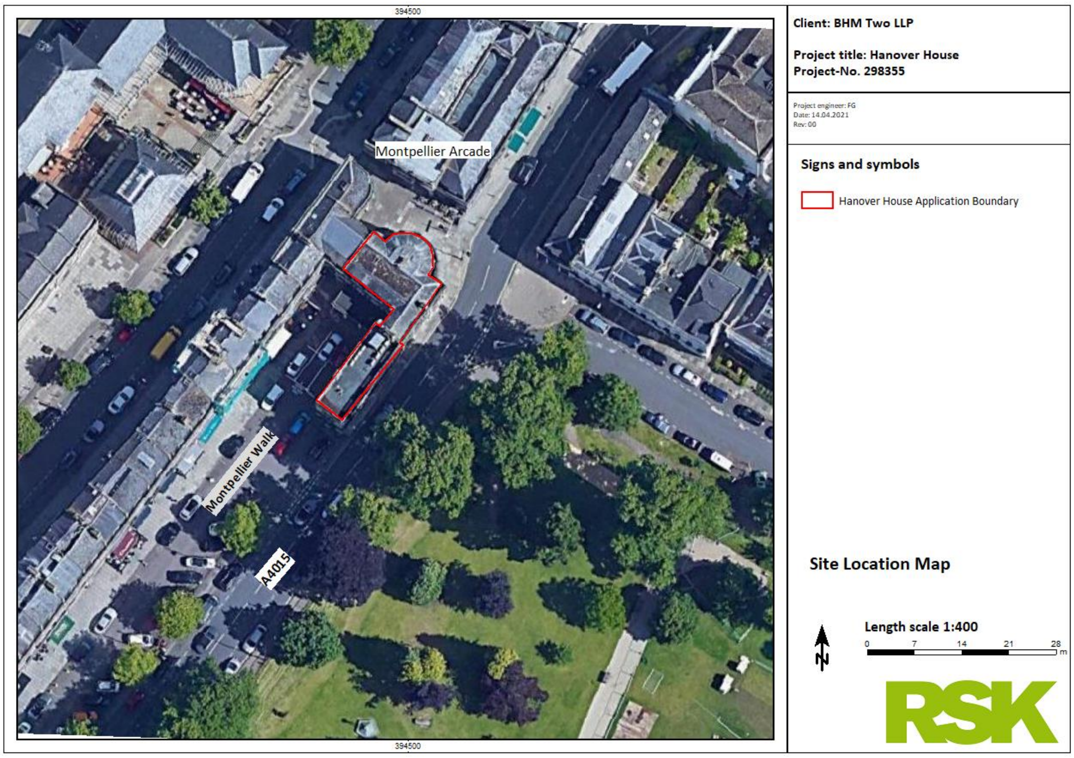


Figure 3.1 Site Location Map

3.2 Proposed Development

The application is to return the first and second floors of Hanover House to residential use, retaining the 'ASK' restaurant on the basement and ground floors. The proposed scheme comprises of four apartments, to create 1 no. 2-bed duplex, 1 no. studio, 1 no. 1-bed and 1 no. 2-bed. Given the building is Grade II listed, the proposals seek to retain and restore the existing building footprint and elevations.

Drawings no. 'P101 rev G' and 'P102 rev G' (provided by Foundation Architecture) detail the proposed first and second floor site layout. These are incorporated to Appendix 1.

4 SURVEY METHOD

4.1 Noise Survey Measurement Details

In order to quantify existing external and internal conditions, a baseline noise survey was undertaken between Wednesday 17 March and Wednesday 24 March 2021. Monitoring of external noise levels, consisted of the installation of one noise meter (UN-01) over a representative midweek and weekend period at a representative position of highest noise incident levels within the development site. This long-term measurement was supplemented by short-term attended measurements to quantify specific sources of noise, i.e from road traffic noise and the attenuation level achieved on those building facades not overlooking the A4015.

In addition, benchmark testing of the transmission of airborne sound through the floor (between ground and first) was undertaking on 17 March 2021 to quantify its existing performance. Given the ASK restaurant is to be retained, such testing is required to determine compliance with the sound insulation target within Approved Document E.

A description of the measurement positions and rationale is provided in Table 4.1:

Table 4.1 Measurement Location Details

No.	Location	Rationale
UN-01	East boundary façade	To quantify road traffic noise levels along A4015, deemed as the dominant noise source across the site.
AT-01	North boundary	To quantify road traffic noise levels along A4015 in relation to UN-01 and quantify noise screening factors.
AT-02	West boundary	
AT-03	North boundary	To quantify façade embedded ventilation outlet emissions.

Measurement locations are shown in Figure 4.1. A photographic account of each monitoring location can be found within Appendix 8.

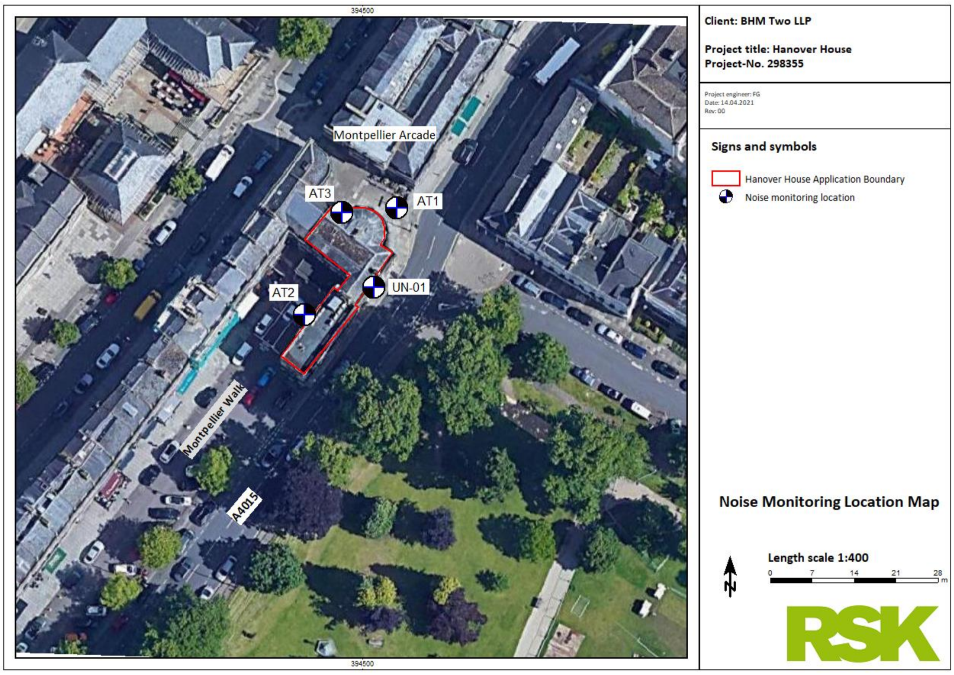


Figure 4.1 Measurement Locations

4.2 Survey Equipment

Noise monitoring was undertaken using the following equipment:

Table 4.2 Monitoring Equipment

Equipment	Type	Serial number	Calibration date
Class 1 Sound Level Meter	Rion NL-52	00386770	08/12/2020
		00976246	19/12/2019
		01043373	09/04/2019
		00464742	18/09/2020
Acoustic Calibrator	Rion NC-74	34291338	10/08/2020
Dodecahedron speaker	Look Line S103AC-DC	-	January 2019 (certificate of conformance)

All short-term attended noise measurements were undertaken in accordance with the requirements detailed in BS 7745, with the microphone positioned away from reflecting surfaces and (at least) 1.5 m above the ground height. The long-term noise meter was positioned outside the first floor window, with the microphone positioned at 1 metre from the vertical reflective surface of the building.

The calibration of each sound level meter was checked before and after the measurements, using the acoustic calibrator at 94 dB at 1 kHz; no significant calibration drift was noted.

The sound level meters used conform to the requirements of BS EN 61672-1:2013 and the calibrator used conforms to the requirements of BS EN 60942:2018. The equipment used has a calibration history that is traceable to a certified calibration institution. Measurements were logged in 15-minute samples (with supplementary 1 second L_p data) and obtained in third-octave bands and broadband mode, providing the following broadband indices; L_{Aeq}, L_{A10}, L_{A90} and L_{AFmax}.

The omnidirectional speaker is compliant with ISO 16283, ISO 140-3, ISO 10140, ISO 3382 and DIN 52210 standards to carry out airborne noise measurements.

4.3 Noise Environment

The noise environment across the site was dominated by road traffic movements along the A4015. To a lesser extent, plant noise associated with an extraction ventilation outlet embedded on Hanover's House northern façade (above the entrance door) was audible when in use, along with noise from pedestrian activity.

No other fixed plant was visually or audibly identified in relation to nearby commercial units, other than a flue outlet situated on the top of Hanover House's northern façade which was not audible during site attendance. It is understood that neither John Gordon's nor Door 4 premises nearby have an operational kitchen for preparing food.

Finally, the condenser units situated on Hanover House's roof were not perceived operational nor audible during attendance times.

4.4 Weather Conditions

Representative local weather conditions during the monitoring were obtained from www.wunderground.com (Station ID: IGLOUCES14 in the Landsdown area) and are summarised in Table 4.3 below:

Table 4.3 Summary of Weather Data

Date/Time	Average Temperature / ºC	Average Wind Speed / ms^{-1}	Dominant Wind Direction	Weather Conditions
17/03/2021	7.3	0.2	N	Calm and dry
18/03/2021	7.1	1.1	NNW	Calm and dry
19/03/2021	8.0	1.9	NNE	Intermittent rain between 06:30-11:00
20/03/2021	8.5	0.9	NW	Calm and Dry
21/03/2021	9.1	0.6	N	Calm and dry
22/03/2021	8.7	2.5	SSW	Windy and dry
23/03/2021	8.7	2.5	SSW	Windy and dry
24/03/2021	9.7	2.4	SW	Windy and dry

Weather conditions noted above are considered suitable for monitoring purposes in accordance with BS 7445.

5 NOISE SURVEY RESULTS

Measured noise levels at the unattended survey location UN-01 are summarised in Table 5.1. Vales are rounded to the nearest whole number.

5.1 Long Term Monitoring

Table 5.1 Noise Survey Results – Unattended Location UN-01 (East façade)

Date	Time period	Measured noise levels, dB [(1)]			
		$L_{Aeq,T}$	$L_{AFmax,15min}$	$L_{A90,T}$	$L_{A10,T}$
Wednesday 17/03/2021	15:00-23:00	68	111	48	69
	23:00-07:00	59	91	33	51
Thursday 18/03/2021	07:00-23:00	69	114	50	70
	23:00-07:00	59	87	34	51
Friday 19/03/2021	07:00-23:00	70	109	51	71
	23:00-07:00	57	85	29	51
Saturday 20/03/2021	07:00-23:00	68	108	49	69
	23:00-07:00	59	101	34	51
Sunday 21/03/2021	07:00-23:00	68	113	45	67
	23:00-07:00	57	88	30	47
Monday 22/03/2021	07:00-23:00	70	113	50	70
	23:00-07:00	59	97	32	49
Tuesday 23/03/2021	07:00-23:00	68	108	51	70
	23:00-07:00	58	85	36	51
Wednesday 24/03/2021	07:00-15:15	67	91	53	71
Average [(2)]	**Daytime**	**69**	**-**	**50**	**70**
	Night-time	**58**	**-**	**33**	**50**

(1) *$L_{Aeq,T}$ values are the logarithmic average of $L_{Aeq,15min}$ samples, and the $L_{A10,T}$ and $L_{A90,T}$ are the arithmetic average of $L_{A10,15min}$ and $L_{A90,15min}$ samples.*

Arithmetic average of derived daytime 16hr and night-time 8hr values

Daytime noise levels ranged between 67 – 70 dB $L_{Aeq,16hr}$ with a calculated weekly averaged noise level of 69 dB $L_{Aeq,16hr}$. Noise levels corresponding to measured night-time periods ranged between 57 – 59 dB $L_{Aeq,8hr}$, resulting in a calculated weekly averaged value of 58 dB LAeq,8hr. In general, averaged noise levels experienced small fluctuations during both daytime and night-time periods.

Analysis of audio recordings indicate that those highest maximum noise levels summarised in Table 5.1 correspond to siren noise from emergency vehicles and general noisy motorcycle and vehicular pass-by events.

5.2 Maximum Event Levels

A detailed appraisal of the night-time event levels has been undertaken to establish the 10th highest event level, in line with the most conservative interpretation of the WHO guidelines, which occurred during each night-time period (23:00 – 07:00) of the baseline survey. The appraisal has been achieved by plotting 1 sec L_{AFmax} data obtained from measurement position UN-01 over the night-time periods, from which individual events occurring with a difference of at least 30 seconds have been derived. Analysis of the data set has been included within the noise model for calibration purposes, to predict maximum noise levels at development façades.

Table 5.2 Summary of 10-th Highest L_{AFmax} (night-time)

Date	10-th Highest L_{AFmax} dB
17/03/2021	81
18/03/2021	82
19/03/2021	80
20/03/2021	78
21/03/2021	78
22/03/2021	81
23/03/2021	80

5.3 Short Term Monitoring

Measured noise levels obtained as part of the attended noise survey (external locations) are summarised in Table 5.3.

Table 5.3 Noise Survey Results – Attended Monitoring (12 April 2021)

Location	Time period	Measured noise levels, dB			
		$L_{Aeq,T}$	$L_{AFmax,15min}$	$L_{A90,T}$	$L_{A10,T}$
AT-01	12:30-15:00	66	91	53	68
AT-02	13:00-14:30	55	77	47	58
AT-03	16:18-16:19	73	75	72	73

To put in context the difference in noise levels achieved on the northern, eastern and western façades of Hanover House, results of measured noise levels undertaken simultaneously at these locations are presented in Table 5.4 and 5.5.

Table 5.4 Noise Survey Results Comparison – AT-01 (north façade) vs UN-01 (east façade)

Date	Time period	Measured noise levels, dB					
		$L_{Aeq,T}$		$L_{AFmax,15min}$		$L_{Aeq,T}$ Diff.	L_{AFmax} Diff.
		AT-01	UN-01	AT-01	UN-01		
12/03/21	12:30-15:00	66	67	91	91	-1	0

Table 5.5 Noise Survey Results Comparison – AT-02 (west façade) vs UN-01 (east façade)

Date	Time period	Measured noise levels, dB					
		$L_{Aeq,T}$		$L_{AFmax,15min}$		$L_{Aeq,T}$ Diff.	L_{AFmax} Diff.
		AT-02	UN-01	AT-02	UN-01		
12/03/21	13:00-14:30	55	67	77	91	-12	-14

A difference of 1 dB $L_{Aeq,T}$ was measured between the unattended monitor situated on the first floor facing the A4015 and the attended measurement representative of the north façade similarly overlooking the road (AT-01). However, a greater difference of 12 dB $L_{Aeq,T}$ was obtained with respect to the noise levels measured on the west façade (AT-02), which benefits from the screening provided by the building with a reduced line of sight to the A4015.

In terms of maximum noise levels, parity was measured between the unattended monitoring position (UN-01) and AT-01; and a reduction of 14 dB(A) when comparing AT-02 at the western façade of the building against UN-01.

6 ASSESSMENT METHODOLOGY

6.1 Noise Prediction Model

A computer noise model of the site has been constructed using SoundPLAN (v8.2) noise prediction software. The baseline noise model has been calibrated to the noise levels measured during the day and night time periods. The model has been set up with the following parameters.

Table 6.1 Modelling Parameters

Item	Setting
Algorithms	ISO 9613-2:1996
Ground Absorption	A hard, acoustically reflective ground surface has conservatively been assumed throughout (coefficient of 0.2).
Met Conditions	10 degrees Celsius 70% humidity Wind from source to receiver
Receptor Height (derived from supplied drawings)	Ground Floor – 1.5 m above ground First Floor – 4.5 to 5 m above ground Second Floor – 7.5 to 8 m above ground
Source Modeling	External noise sources, such as road traffic have been treated as line sources at 0.5 m height. Noise from road traffic sources was deemed as being the dominant consistent source affecting the proposed development site. Noise from the nearby fixed plant and patron noise modelled as point sources. Assumed outdoor space average source height taken to be 1.2 m for seated patrons and 1.7 for standing patrons. Extraction Vent and music breakout modelled as vertical area sources (see section 6.5). Existing buildings and structures identified have been modeled as structures to their relevant height.
Terrain	Terrain data assumed flat.

6.2 Validation of Noise Model – Existing Scenario

The predicted noise levels across the proposed development site have been validated against the measured levels at the baseline survey location(s). The model has considered road noise emissions for the following scenarios:

- Daytime - ambient $L_{Aeq,16hr}$;
- Night-time - ambient $L_{Aeq,8hr}$; and
- Night-time - ambient L_{AFmaxr}.

Differences between measured and predicted levels are presented in Table 6.2.

Table 6.2 Noise Model Validation (Existing Scenario)

Location	Measured Noise Level, dB			Predicted Noise Level, dB			Difference, dB		
	$L_{Aeq, T}$		10-th highest L_{AFmax}	Predicted Level, $L_{Aeq, T}$		10-th highest L_{AFmax}			
	Day	Night	Night	Day	Night	Night	Day	Night	Lmax
UN-01 (east façade)	66	55	78	66	55	78	0	0	0

The model has been calibrated at position UN-01 (east façade) which was dominated by road traffic noise along A4015.

A second validation exercise has been undertaken to verify that the noise reductions achieved during the attended monitoring exercise to the north and west of the site in relation to the eastern most exposed façade to road traffic (Table 5.4 and 5.5) correspond with those obtained in the noise model exercise.

The below noise predictions have been obtained using a calibrated noise level at UN-01 of 66 dB $L_{Aeq,T}$ and a maximum noise level of 78 dB.

Table 6.3 Noise Model Screening Validation (Short Term Measurements)

Predicted Level, $L_{Aeq,T}$ dB		Predicted Level, L_{AFmax} dB		$L_{Aeq,T}$ Diff. dB	L_{AFmax} Diff. dB
AT-01	AT-02	AT-01	AT-02	AT-01/AT-02	AT-01/AT-02
65	53	77	65	-1 / -13	-1 / -13

A difference of 1 dB(A) has been assessed between the predicted difference of $L_{Aeq,T}$ and L_{AFmax} values at AT-01 and AT-02 with respect to UN-01 in comparison with the measured differences obtained during the attended survey (Tables 5.4 and 5.5).

Based on the above, it is considered the model provides a good representation of the likely noise environment across the site. It should be noted that the existing model validation accounts for the influence of road traffic noise only; the inclusion of patron noise from 'John Gordon's Wine Bar' and 'Door 4' into the future development scenario is included in Section 6.5.

6.3 Fixed Plant Noise

The following fixed plant sources have been introduced into the noise model in order to account for a conservative assessment scenario.

Table 6.4 Modelled Fixed Plant Items

Item	Location	Noise Emission Level dB	Operational Regime
Extraction Vent.	Above Hanover's House entrance on Montpellier Arcade	73 dB $L_{Aeq,T}$ at 20 cm	ASK Kitchen hours 12:00-22:00
Flue outlet	Top corner on north façade	Assumed 60 dB $L_{Aeq,T}$ at 1 metre	Assumed 24 hours (worst case)
8x condenser units	Hanover House's roof	67 dB Lw*	Assumed 24 hours (worst case)

*Assumed from representative DAIKIN 6.2 kW condenser unit datasheet model RXM-N series.

A tonal analysis of measured noise levels from the extraction ventilation outlet has been performed following the objective method in BS 4142. No tonal components have been identified. It is not considered that the remaining plant items incorporated in the assessment, in the context of the existing and future noise environment dominated by road traffic noise, has any tonal, impulsive or intermittent characteristics which can attract attention or be considered by default.

6.4 Music and Patron Noise

Music break-out from 'John Gordon's' and 'Door 4' has been included in the noise model assuming an internal noise level of 70 dB (to reasonably allow for conversations inside) and a minimum noise reduction provided by the shopfront glass of 32 dB (single 6.8 mm glazing). Observations during site attendance confirmed that the shopfronts did not have openable windows. A vertical area source covering both façades has therefore been introduced with a sound power level proportional to each glazed area.

Noise from the use of external areas/terraces has also been considered in the assessment. Based on aerial imagery and for assessment purposes a total of four tables and four standing conversations have been included at each site. Table 6.5 shows the source assumptions used for the assessment.

Table 6.5 Music and Patron Noise Assumptions

Source	Height relative to ground, m	Sound Pressure Level at 1 m, dB(A) per source	Assumptions	Referencing
Normal conversation - Seated	1.2	60	Source positioned at table locations.	ISO 9921:2003[1]
Normal conversation - Stood	1.7	60	Source spread throughout external areas.	ISO 9921:2003
Raised Voice - Seated	1.2	72	Source positioned at table locations.	ISO 9921:2003

[1] ISO 9921:2003 Ergonomics – Assessment of speech communication. International Organization for Standardization, Geneva, Switzerland (2003)

Source	Height relative to ground, m	Sound Pressure Level at 1 m, dB(A) per source	Assumptions	Referencing
Raised Voice - Stood	1.7	72	Source spread throughout external areas.	ISO 9921:2003
Music Façade break-out	-	38	Door 4 shopfront height 2.5 m John Gordon's shopfront height 3 m	L_W =38 (L_p) * 10 log S (surface)

The positioning of all sources considered in the assessment is presented in Figure 6.1.

Figure 6.1 Modelled Noise Sources

From an acoustic standpoint, it has been considered that Saturday / Bank Holiday opening times provide the most conservative assessment scenario in relation to the expected noise emissions from the aforementioned premises.

Information regarding the opening times of these premises found on their websites and on Cheltenham planning portal indicate that John Gordon's Saturday opening times were between 10:00 – 01:00 before the pandemic and Door 4 had permission to extend their activity on Bank Holidays until 01:00 (commencing at 15:00 on Saturday).

Patron noise from external areas has therefore been predicted considering the above noise emission levels detailed in Table 6.5, following the percentage distribution for standing/seated and raised voice/normal voice as per Table 6.6:

Table 6.6 Operational Music and Patron Noise Assumptions

Period	John Gordon's	Door 4
Daytime	10:00 – 19:00 4x seated conversations (75% of the time normal voice + 25% raised voice)	15:00 – 19:00 4x seated conversations (75% of the time normal voice + 25% raised voice)
Evening	19:00 – 23:00 +Music breakout (100%) +4x seated conversations (50% of the time normal voice + 50% raised voice) +4x standing conversations (50% of the time normal voice + 50% raised voice)	
Night	23:00 – 01:00 +Music breakout (100%) +4x seated conversations (25% of the time normal voice + 75% raised voice) +4x standing conversations (25% of the time normal voice + 75% raised voice)	

In order to account for the potential different character of patron noise, when considered in the context of the existing noise environment, a correction (penalty) of 3 dB has been applied. This is consistent with the 'other sound characteristics' correction as defined in Section 9.2 of British Standard BS 4142. Patron noise is not considered tonal or impulsive and therefore the +3 dB outlined in BS 4142 is considered a suitable correction.

The impact of patron noise from both 'John Gordon's' and 'Door 4' has been predicted and added to the existing baseline noise levels in order to ensure a suitably robust site suitability assessment.

6.5 Predicted Noise Levels

Noise predictions have been undertaken at each floor level along each building façade using the building footprints and floor locations provided by Foundation Architecture.

As discussed, the noise model accounts for the existing contributions from road traffic noise and the addition of both fixed plant, music and patron noise from those nearest venues.

A 3-D screenshot of the modelling, detailing the noise source locations in comparison with the development site is provided in Figure 6.2.

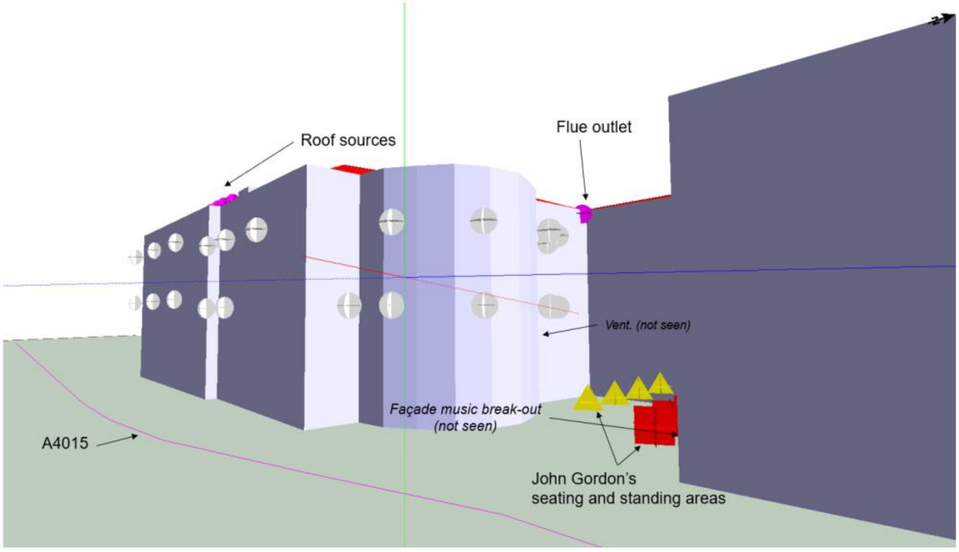


Figure 6.2 Screenshot of Noise Model (with development)

6.6 Maximum Noise Levels

An assessment of the maximum noise levels has been undertaken and discussed in Section 5.2 considering the maximum 10-th highest individual night maximum (L_{max}) measured events analysed during the night-time dataset in accordance with WHO guidelines.

Verification of the source of those measured maximum noise levels, has also been undertaken utilising the audio recordings obtained at UN-01. This assisted in clarifying the correct modelling of those attributable noise sources. The modelling therefore considers the pass-by road traffic events along the A4015.

6.7 Design Targets for Residential Development

For the purposes of this assessment, the acoustic design targets presented in Table 6.7 have been adopted. The design targets are based on the requirements of the appropriate guidelines for residential developments.

Table 6.7 Noise Design target for Residential Use

Condition	Criterion
Internal ambient daytime noise levels within dining rooms/areas (BS 8233)	40 dB $L_{Aeq,16hrs}$
Internal ambient noise levels within bedrooms at night (BS 8233)	30 dB $L_{Aeq,8hrs}$
Internal individual event levels within bedrooms during the night (>10 occurrences - ProPG)	45 dB L_{AFmax}
** 50 dB $L_{Aeq,T}$ is the desirable threshold level, 55 dB $L_{Aeq,T}$ is the upper guideline level. However, these guideline values may not achievable in all circumstances where development might be desirable. In such a situation, development should be designed to achieve the lowest practicable noise levels.*	

7 SITE SUITABILITY ASSESSMENT

7.1 Predicted Noise Levels

A noise assessment has been undertaken in order to determine the appropriate level of mitigation to ensure adequate internal noise targets. The assessment includes existing noise sources such as road traffic and fixed plant (captured during the baseline monitoring) and non-operational sources (music and patron noise) which are likely to recommence post pandemic. This method has been adopted to ensure a suitably robust assessment of the impact on residences at the proposed development site and inform suitable noise mitigation is designed at the building façade.

Table 7.1 summarises the predicted noise levels across the proposed development site at individual plot locations. The receptors included in the noise model and provided in the table below detail the predicted noise level at receptor heights indicative of first and second floor levels. The predicted façade levels are broken down according to the individual contribution of road traffic (averaged daytime and night-time levels), road traffic maximum night-time levels, fixed plant items, music break-out noise and patron noise from the nearby commercial premises.

In accordance with ProPG, a rating penalty in line with BS 4142 (see Section 2.99) has been applied to existing noise levels / predictions to account for the underlying nature of activities of the surrounding commercial premises. Based on the subjective method, a rating penalty of +3 dB for sounds which *are 'neither tonal, nor impulsive, nor intermittent, though otherwise readily distinctive against the residual acoustic environment'* has been considered to all daytime and night-time predicted levels ($L_{Aeq,T}$) at those façades.

Table 7.1 Noise Predictions Breakdown

Receptor	Floor	Dir	Road Noise Contribution, dB $L_{Aeq,T}$		Road Noise Contribution, dB L_{AFmax}	Fixed Plant Noise Contribution, dB $L_{Aeq,T}$		Music and Patron Noise Contribution, dB $L_{Aeq,T}$		All Sources Contribution, dB $L_{Aeq,T}$	
			Daytime	Night-time	Night-time	Daytime	Night-time	Daytime	Night-time	Daytime	Night-time
Hanover House F1_NE_1 (Flat 2 One Bed Bedroom)	F 1	NE	64.8	53.7	76.8	37.3	35.6	54.8	54.3	65.2	57.1
Hanover House F1_NE_2 (Flat 2 One Bed Living)	F 1	E	65.0	54.0	77.0	38.0	36.3	56.4	55.9	65.6	58.1
Hanover House F1_NE_3 (Flat 2 One Bed Living)	F 1	NE	63.3	52.2	75.3	42.2	38.3	58.5	58.1	64.5	59.1
Hanover House F1_NE_4 (Flat 2 Studio Dining)	F 1	N	60.3	49.3	72.3	46.7	44.3	58.6	58.2	62.7	58.9
Hanover House F1_NE_5 (Flat 2 Studio Dining)	F 1	N	59.0	48.0	71.0	51.3	45.1	57.6	57.1	61.8	57.9
Hanover House F2_NE_2 (Flat 4 Two Bed Bedroom)	F 2	E	64.0	53.0	76.0	38.3	36.8	55.3	54.7	64.6	57.0
Hanover House F2_NE_3 (Flat 4 Two Bed Bedroom)	F 2	NE	62.4	51.4	74.4	42.2	38.9	56.6	56.2	63.5	57.5
Hanover House F2_NE_4 (Flat 4 Two Bed Living)	F 2	N	59.8	48.8	71.8	46.5	44.7	56.7	56.2	61.7	57.2
Hanover House F2_NE_5 (Flat 4 Two Bed Living)	F 2	N	58.6	47.6	70.6	49.5	45.9	56.1	55.6	60.9	56.6
Hanover House NW_F2_1 (Flat 1 Bedroom)	F 2	NW	56.5	45.5	68.5	42.6	42.6	53.7	54.2	58.5	55.0
Hanover House NW_F2_2 (Flat 1 Living)	F 2	NW	53.7	42.7	65.7	46.1	46.1	54.4	54.9	57.4	55.7
Hanover House NW_F2_3 (Flat 1 Dining)	F 2	NW	52.4	41.4	64.4	45.4	45.4	54.0	54.6	56.6	55.3
Hanover House SE_F1_1 (Flat 1 Bedroom)	F 1	SE	66.0	55.0	78.0	31.3	31.3	32.1	32.2	66.0	55.0
Hanover House SE_F1_3 (Flat 1 Bedroom)	F 1	SE	66.0	55.0	78.0	35.1	35.1	34.5	34.2	66.0	55.0
Hanover House SE_F2_1 (Flat 1 Bedroom)	F 2	SE	64.6	53.6	76.6	37.1	37.1	33.3	33.5	64.6	53.7
Hanover House SE_F2_2 (Flat 1 Living)	F 2	SE	64.6	53.6	76.6	40.1	40.1	33.8	33.8	64.6	53.8
Hanover House SE_F2_3 (Flat 1 Dining)	F 2	SE	64.6	53.6	76.6	42.3	42.3	35.1	34.9	64.6	53.9
Hanover House SE_F2_6 (Flat 4 Bedroom)	F 2	SE	64.9	53.9	76.9	34.8	34.7	43.8	43.4	64.9	54.3
Hanover House SW_F1 (Flat 1 Bedroom)	F 1	SW	62.9	51.9	74.9	35.1	35.1	44.5	45.0	63.0	52.8
Hanover House SW_F1b (Flat 2 Studio Bedroom)	F 1	SW	49.9	38.9	61.9	40.1	40.0	51.2	52.0	53.8	52.4
Hanover House SW_F1c (Flat 2 Studio Bedroom)	F 1	SW	50.0	39.0	62.0	38.2	38.2	50.1	50.8	53.2	51.3
Hanover House SW_F2 (Flat 1 Bedroom)	F 2	SW	62.2	51.1	74.2	36.6	36.6	44.7	45.2	62.2	52.2
Hanover House SW_F2b (Flat 4 Dining)	F 2	SW	51.0	39.9	63.0	42.9	42.9	54.0	54.6	56.0	55.0
Hanover House SW_F2c (Flat 4 Dining)	F 2	SW	51.3	40.2	63.3	41.2	41.2	54.1	54.7	56.0	55.0

Table 7.2 Noise Predictions Breakdown

Receptor	Floor	Dir	All Sources Contribution + 3dB Character Correction, dB $L_{Aeq,T}$		Maximum Noise Level, dB L_{AFmax}	Highest envelope specification, dB(A)*		Envelope specification, dB(A)
			Daytime	Night-time	Night-time	Daytime	Night-time	
Hanover House F1_NE_1 (Flat 2 One Bed Bedroom)	F 1	NE	68	60	77	33	32	33
Hanover House F1_NE_2 (Flat 2 One Bed Living)	F 1	E	69	61	77	29	N/A	29
Hanover House F1_NE_3 (Flat 2 One Bed Living)	F 1	NE	68	62	75	28	N/A	28
Hanover House F1_NE_4 (Flat 2 Studio Dining)	F 1	N	66	62	72	26	N/A	26
Hanover House F1_NE_5 (Flat 2 Studio Dining)	F 1	N	65	61	71	25	N/A	25
Hanover House F2_NE_2 (Flat 4 Two Bed Bedroom)	F 2	E	68	60	76	33	31	33
Hanover House F2_NE_3 (Flat 4 Two Bed Bedroom)	F 2	NE	67	61	74	32	31	32
Hanover House F2_NE_4 (Flat 4 Two Bed Living)	F 2	N	65	60	72	25	N/A	25
Hanover House F2_NE_5 (Flat 4 Two Bed Living)	F 2	N	64	60	71	24	N/A	24
Hanover House NW_F2_1 (Flat 1 Bedroom)	F 2	NW	62	58	69	27	28	28
Hanover House NW_F2_2 (Flat 1 Living)	F 2	NW	60	59	66	20	N/A	20
Hanover House NW_F2_3 (Flat 1 Dining)	F 2	NW	60	58	64	20	N/A	20
Hanover House SE_F1_1 (Flat 1 Bedroom)	F 1	SE	69	58	78	34	33	34
Hanover House SE_F1_3 (Flat 1 Bedroom)	F 1	SE	69	58	78	34	33	34
Hanover House SE_F2_1 (Flat 1 Bedroom)	F 2	SE	68	57	77	33	32	33
Hanover House SE_F2_2 (Flat 1 Living)	F 2	SE	68	57	77	28	N/A	28
Hanover House SE_F2_3 (Flat 1 Dining)	F 2	SE	68	57	77	28	N/A	28
Hanover House SE_F2_6 (Flat 4 Bedroom)	F 2	SE	68	57	77	33	32	33
Hanover House SW_F1 (Flat 1 Bedroom)	F 1	SW	66	56	75	31	30	31
Hanover House SW_F1b (Flat 2 Studio Bedroom)	F 1	SW	57	55	62	22	25	25
Hanover House SW_F1c (Flat 2 Studio Bedroom)	F 1	SW	56	54	62	21	24	24
Hanover House SW_F2 (Flat 1 Bedroom)	F 2	SW	65	55	74	30	29	30
Hanover House SW_F2b (Flat 4 Dining)	F 2	SW	59	58	63	19	N/A	19
Hanover House SW_F2c (Flat 4 Dining)	F 2	SW	59	58	63	19	N/A	19

* Based on d*aytime criteria of 35 dB(A) for resting in bedrooms, daytime criteria of 40 dB(A) for living rooms and night time criteria in bedrooms of 30 dB(A) or 45 dB(A) Lmax*

Grid noise maps are provided in Appendices 2 – 4.

Table 7.3 Summary of Predicted Façade Noise Levels

Location	Floor	Daytime / $L_{Aeq,16hr}$ dB	Night-time / $L_{Aeq,8hr}$ dB	Night-time / L_{max} dB
North Façade	1	69	62	77
	2	68	61	76
East Façade	1	69	58	78
	2	68	57	77
South Façade	1	66	56	75
	2	65	55	74
West Façade	1	-	-	-
	2	62	59	69
** Predicted levels are inclusive of +3 dB character correction for fixed plant and/or patron noise.*				

Based on the predictions summarised in Table 7.3, sensitive rooms situated on the north and east façade would be exposed to the highest predicted noise levels. Highest daytime noise levels ranging between 62 – 69 dB(A) are expected to drive the mitigation specifications on the northern, eastern and southern façades, whereas night-time noise levels are predicted to drive the mitigation requirements on the western façade of the building.

7.2 Internal Noise Levels – Façade Treatments

Noise level reduction can be provided through various façade treatment methods such as glazing or ventilation products, however the level of mitigation would be dependent on factors such as room size and room volume. The level of mitigation would be subject to condition by local authority at a later stage within the planning process.

On the basis that a partially open window typically provides up to 13 dB of attenuation, it is apparent that the predicted noise levels will result in an exceedance of the recommended internal acoustic design target during a situation in which windows are partially open for ventilation purposes. Understandably, treatments at those façades facing west (and therefore away from the A4015) can afford a lower level of specification.

To ensure an appropriate internal acoustic standard within the proposed residential properties during normal conditions (non-overheating), the acoustic specifications set out in Table 7.3 are recommended for occupied bedrooms. The values in the table represent the highest level of attenuation afforded by the building envelope at each residential plot. Understandably, treatments at those façades facing away from the dominant noise sources can afford a lower level of specification.

Table 7.4 Initial Façade Treatment Recommendations

Mitigation Option	Element	Maximum Acoustic requirement for façade	
		Acoustic Performance	Type
A	Window	32 $R_W + C_{tr}$	Saint Gobain 8/14/6
	Ventilation	38 $D_{ne,w} + C_{tr}$	Greenwood 5000EA vent + 2 acoustic modules (5350mm2 EA)

Mitigation Option	Element	Maximum Acoustic requirement for façade	
		Acoustic Performance	Type
B	Window	36 $R_w + C_{tr}$	Saint Gobain 12(12)8.4A
	Ventilation	38 $D_{ne,w} + C_{tr}$	Greenwood 5000EA vent + 2 acoustic modules (5350mm^2 EA)
C	Window	40 $R_w + C_{tr}$	Saint Gobain Stadip Silence 10.8(20)8.8
	Ventilation	40 $D_{ne,w} + C_{tr}$	Greenwood 2500EAW.AC1 Vent + 1 acoustic external module (2670mm^2 EA)
D	Window	42 $R_w + C_{tr}$	Saint Gobain Stadip Silence 12(16)8
	Ventilation	40 $D_{ne,w} + C_{tr}$	Greenwood 2500EAW.AC1 Vent + 1 acoustic external module (2670mm^2 EA)

It should be noted that the acoustic performance requirements set out in Table 7.3 are readily available via a number of different specifications. Considering the proposed room dimensions, the acoustic performance requirements for the glazing and ventilation elements are summarised in Table 7.5.

Table 7.5 Suggested Façade Treatment Recommendations

Location	Floor	Assumed Room	Mitigation Option Required by Envelope
North Façade	1	Flat Two One Bedroom	C
	2	Flat Four Two Bed (large bedroom)	B
South Façade	1	Flat One Duplex Bedroom	B
	2	Flat One Duplex Bedroom/Study	B
East Façade	1	Flat One Duplex Bedroom	D
	2	Flat Four Two Bed (small bedroom)	D
West Façade	1	(common areas)	-
	2	Flat One Duplex Bedroom/Study	A

Detailed calculations are included in Appendix 6.

7.3 Overheating

In line with the guidance set out in the Acoustics, Ventilation and Overheating Residential Design Guide (AVO Guide), it is considered reasonable to allow higher levels of internal ambient noise when increased rates of ventilation are required in relation to an overheating condition. The basis for this is that the overheating condition occurs for a limited time and during this period, occupants may accept a trade-off between acoustic and thermal conditions, given that they have some control over their environment.

During an overheating condition, the preference is to adopt opening windows as a primary means of mitigating thermal issues, however, this is subject to the resultant internal ambient noise level.

On the basis that a partially open window provides 13 dB of attenuation, to meet an internal ambient level of 42 dB $L_{Aeq,8hr}$, the upper SOAEL limit for night-time hours, the external façade free-field level must not exceed 55 dB $L_{Aeq,8hr}$. The predicted external night-time noise levels range between 55 and 62 dB(A). The highest level of 62 dB(A) was predicted on the northern façade and together with the remaining building façades, noise levels are likely to exceed the upper night-time SOAEL limit. As such, the risk of overheating is deemed high and the use of open windows is unlikely to be an acceptable means of overheating control.

Assuming the same level of reduction for a partially open window during the daytime hours, the upper SOAEL limit for internal ambient levels would be 50 dB $L_{Aeq,16hr}$, meaning the external façade free-field level must not exceed 63 – 65 dB $L_{Aeq,16h}$. The predicted external day-time noise levels range between 62 and 69 dB(A), with the northern, eastern and southern façades likely to exceed the upper daytime SOAEL limit. As such, the risk of overheating is deemed high and the use of open windows is unlikely to be an acceptable means of overheating control.

Where the overheating assessment identifies apartments at high risk of overheating with windows closed and therefore likely to require windows to be open more regularly and for longer periods of time, an alternative ventilation strategy should be implemented to ensure suitable internal acoustic conditions. This strategy should incorporate one or more of the following:

- Additional control measures to reduce heat entering the building (e.g. solar shading) to minimise overheating risk and reduce duration for which windows are required to be open.
- Introduction of attenuated ventilation openings within the building façade. These should provide a suitable level of reduction in sound from outside to inside when in the open position. A sound reduction of this magnitude could be achievable using suitable high-performance trickle vents. The final specification will be determined by the space available, aesthetics and air volume / free area required for ventilation.
- Use of a comfort cooling or tempered fresh air system. This will require installation of some form of mechanical ventilation (e.g. fan coil unit and/or MVHR).

While mechanical comfort cooling can be used as a means of overheating control, it is recommended that this should only be considered where all other design measures have been investigated.

It is recommended input be sought from the wider design team to identify areas of high overheating risk and to ensure subsequent mitigation options compliment ventilation, architecture and structural design strategies and assessments.

8 INTERNAL BENCHMARK TESTING

The following summarises the results and observations taken from the acoustic testing and inspection carried out on Wednesday 17 March 2021. RSK Acoustics staff in attendance were Nathan Parker (AMIOA) and Matthew Thomson (MIOA).

Items presented in italics within Section 8 are additional observations/guidance. While outside the scope of the benchmark testing, these are important considerations which may require addressing at detailed design.

8.1 Site Observations

Restaurant

The restaurant aims to provide a relaxed family atmosphere, thus background music is typically acoustic/calm and played at a level such that people can hold a conversation. A number of Bose loudspeakers are mounted on the ceiling around the perimeter of the room (see Figure 8.1) but these are small in size and the type of music played does not have a strong bass beat.

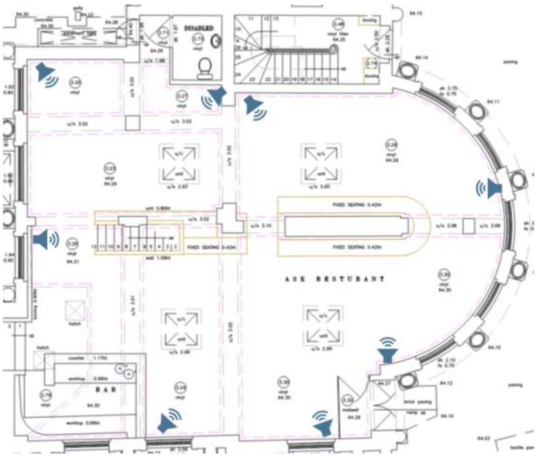


Figure 8.1 Loudspeaker locations

Sample measurements were taken in locations around the restaurant while music was playing at the level typically set during dinner service, as advised by the restaurant staff. Results are provided in Section 8.2. Staff noted that customers often ask for the music to be turned down if they are unable to clearly hold a conversation.

Kitchen

Noise generated from extract fans was just audible in the rooms above the kitchen during lulls in road traffic. Due to the confined nature of the kitchen and likely compromising transmission path via the stairwell, no sound insulation (SI) measurements were taken in this location. It is assumed that the floor construction would be continuous throughout the building and therefore results obtained in the other test locations are representative.

At various locations within the rooms above the kitchen vibration was perceptible underfoot. This has the potential to give rise to complaint, particularly in bedrooms at night. While no measurements of vibration were taken during attendance to quantify VDV levels, from previous experience it is recommended that mitigation measures be developed at detailed design to reduce the potential of adverse impact on future residents. This may be as straightforward as installing isolation mounts to the fan boxes

/ ductwork which is potentially rigidly mounted to the existing soffit / external wall (although this was not visually confirmed).

Upper floors

The upper floors are understood to have been previously used as office space when the building operated as a bank. Windows are sash-type single glazed and the frames in varying condition, with the majority sealed shut. Road traffic noise is prominent, particularly in room 3.07 which is perpendicular to the road outside. Based on measured external noise levels discussed in Section 7, replacement of the windows or inclusion of secondary glazing will be required as part of any refurbishment for residential use.

It is noted that the road traffic noise in the rooms overlooking the road was such that the mid to high frequency range of some SI measurements were background limited.

Much of the floor surface in the apartments above the restaurant is made up of plywood boards and appears to be temporary. This board layer has a significant number of gaps, ranging in size from small to large. The airborne sound insulation performance of the floor is therefore most likely to represent the main structure (construction to be confirmed by architect / building surveyor) with the temporary floor surface providing a negligible change in performance.

Figure 8.2 Floor condition

The partition between rooms 3.08 and 3.13 contains ventilation grilles, air conditioning units and a fireplace within the chimney. This creates a noise transmission path through which sound is audible when testing the floor however, is not easily measurable in comparison to the direct sound reduction through the main floor surface.

The presence of the former fireplace and new ventilation openings may cause additional acoustic issues when the wall is shared between future apartments, therefore it will be essential for Approved Document E compliance that these openings be properly sealed to match the performance of the surrounding wall (exiting performance not tested on site).

Figure 8.3 Air brick/air conditioner on first floor, second floor fireplace not shown

The partition between rooms 3.08 and 3.13 contains ventilation grilles, air conditioning units and a fireplace within the chimney. This creates a noise transmission path through which sound is audible when testing the floor however, is not easily measurable in comparison to the direct sound reduction through the main floor surface.

The wall/doors installed to create the new fire lobby should have sufficient acoustic performance such that this noise source is suitably mitigated. This should be developed at detailed design.

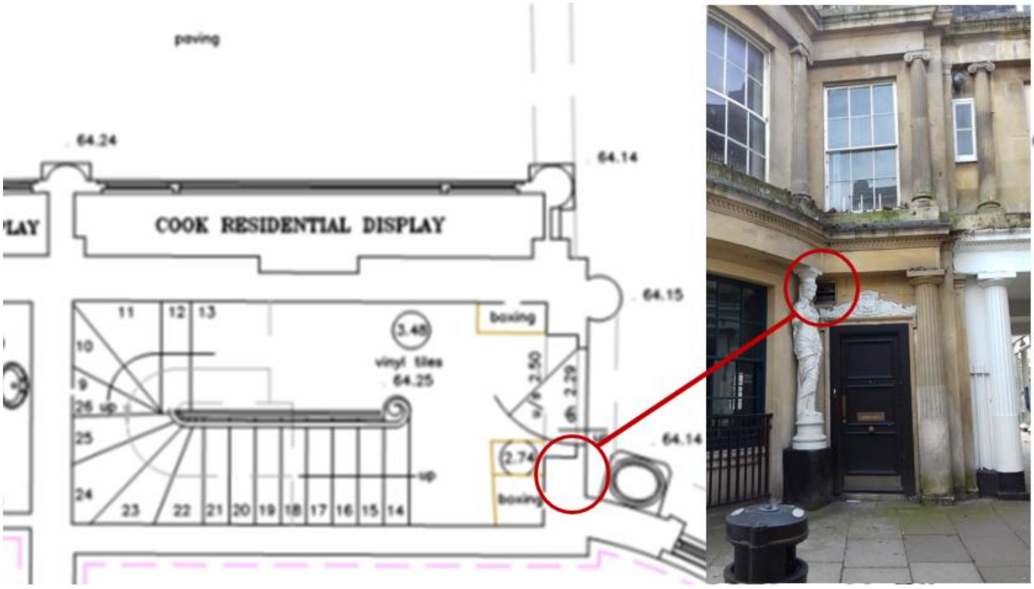


Figure 8.4 Stairwell plant termination

8.2 Internal Ambient Noise Measurements

A summary of the ambient noise level measurements obtained during the testing are summarised below:

Table 8.1 Measured Internal Ambient Measurements

No.	Description/Location	Measured Noise Level, dB $L_{Aeq,T}$
1	In restaurant while music playing and kitchen extracts running	59
2	In kitchen with extracts running and music playing	67
3	Ambient noise level in room 3.07	46
4	Ambient noise level in room 3.08	45
5	Ambient noise level in room 3.11	40

8.3 Testing Results

A summary of the sound insulation test results are provided below in Table 8.2 and in Appendix 7.

Table 8.2 Summary of Test Results

Test ID	Receiving Room	Proposed Use	Result, dB $D_{nT,w}+C_{tr}$
1	3.07 (Floor 1)	Bedroom	35
2	3.08 (Floor 1)	Lounge / diner	38
3	3.11 / 3.13 (Floor 1)	Studio	39

Without improvement the existing structure is unlikely to achieve the minimum airborne sound insulation required by Building Regulations (Approved Document E) for a separating floor.

While 43 dB $D_{nT,w}$+C_{tr} is the minimum requirement for flats formed by a material change of use, Approved Document E notes that this is intended for between spaces used for normal domestic purposes. Between areas used for communal or non-domestic purposes, a higher standard of sound insulation may be required depending on the level of noise generated. *Approved Document E* +10dB or an ambient noise level target of NR10 in the residential space are examples of criteria often adopted.

It is assumed that it would not be feasible to introduce a suspended ceiling to the ground floor space due to the height of the interior window casing. To enhance the performance to a standard acceptable in terms of Approved Document E, it will be necessary to increase the overall mass of the floor and address any gaps / service penetrations. This may require stripping the floor back to the joists and rebuilding to be most effective therefore early engagement with heritage to understand potential constraints is recommended.

9 CONCLUSIONS & RECOMMENDATIONS

RSK Environment Ltd has been instructed by Foundation Architecture on behalf of BHM Two LLP to undertake a noise impact assessment for the conversion of the upper storeys of Hanover House, Cheltenham (GL50 1SD), to residential.

A baseline noise survey has been undertaken to establish the pre-development noise levels across the site, with the resulting dataset used to inform the assessment. Noise monitoring comprised of unattended measurements over a representative midweek and weekend period supplemented by short-term manned measurements.

The dominant noise sources across the application site were noted to be attributable to vehicular traffic along the A4015. To a lesser extent, plant noise associated with an extraction ventilation outlet embedded on Hanover's House northern façade (above the entrance door) was audible when in use, along with noise from pedestrian activity.

The feasibility assessment for residential use accounts for the impacts from road traffic, fixed plant positioned on the building's roof and surroundings, and music/patron noise from the neighbouring bars through the application of a more stringent indoor target based on applicable penalty corrections in line with BS 4142.

A highest glazing specification of 42 dB R_w+C_{tr} has been suggested for most exposed bedrooms situated on the eastern façades, accompanied by high performance ventilators providing a sound reduction of 40 dB $D_{ne,w}$+C_{tr} in the open position. A reduction of this magnitude can be achieved with standard double glazing products.

Where apartments are at a low risk of overheating, a ventilation strategy during the overheating condition reliant on open windows is likely to be suitable due to the limited frequency and duration of opening. Where the overheating assessment identifies apartments at high risk of overheating with windows closed and therefore likely to require windows to be open more regularly and for longer periods of time, an alternative ventilation strategy should be implemented to ensure suitable internal acoustic conditions on those flats situated on the eastern, northern and western façades. This should be developed with input from the wider design team.

In summary, existing noise levels across the site are predicted to be of a magnitude suitable for the development assuming appropriate mitigation measures are included through design. The proposed development site is therefore considered to be suitable for the intended development.

10 REFERENCES

1. National Planning Policy Framework – Department for Communities and Local Government. March 2012 (as amended February 2019).

2. National Planning Policy Framework (NPPF): 2012.

3. Noise Policy Statement for England (NPSE). DEFRA, 2010.

4. Professional Practice guidance on Planning and Noise (ProPG): 2017.

5. World Health Organisation (WHO) Guidelines for Community Noise, 2000.

6. British Standard 4142: 2014+A1: 2019, 'Methods of rating industrial and commercial sound' British Standards Institution, 2019.

7. British Standard 7445-1: 2003, Description and measurement of environmental noise – Part 1: Guide to quantities and procedures. British Standards Institution, 2003.

8. British Standard 8233: 2014, Sound insulation and noise reduction in buildings – code of practice. British Standards Institution, 2014.

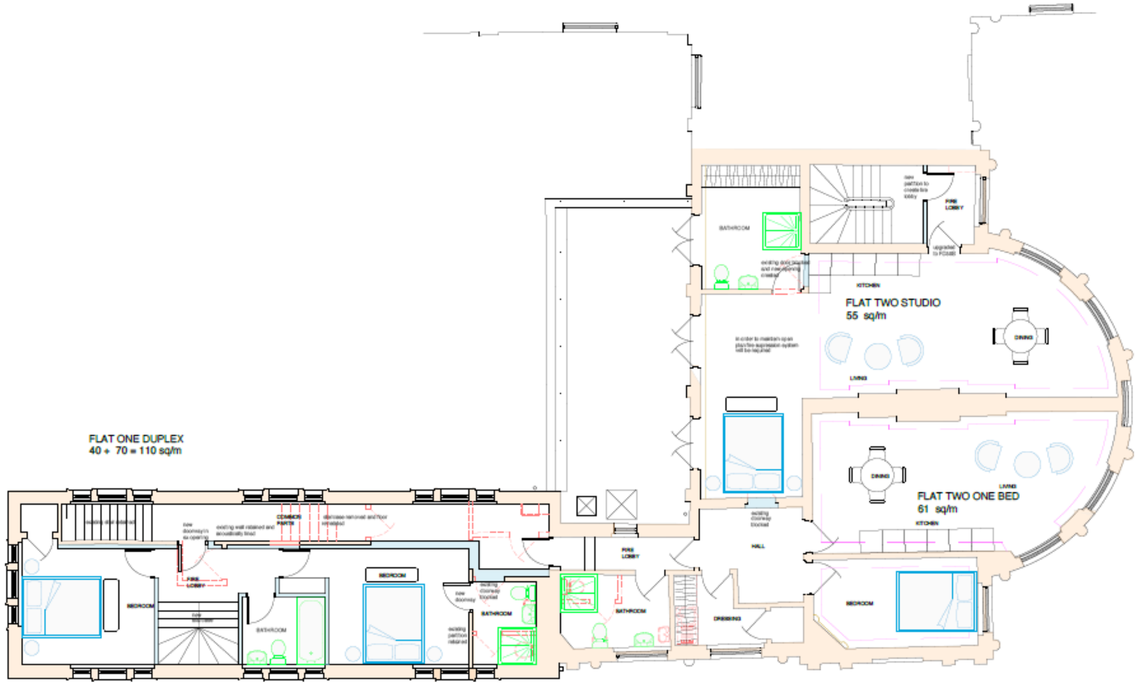
9. International Standard ISO 9613:1996 - Acoustics – 'Attenuation of sound during propagation outdoors'.

10. The Building Regulations 2010. Approved Document E - Resistance to the passage of sound, HM Government.

11. Good Practice Guide on the Control of Noise from Pubs and Clubs, Institute of Acoustics, 2003.

12. Acoustics Ventilation and Overheating: Residential Design Guide (AVO), ANC, 2020.

APPENDIX 1: PROPOSED FLOOR LAYOUT



FIRST FLOOR PLAN

KEY

AERIAL VIEW

AERIAL VIEW

EXISTING

NEW

DEMOLITION

FOR PLANNING

Foundation architects

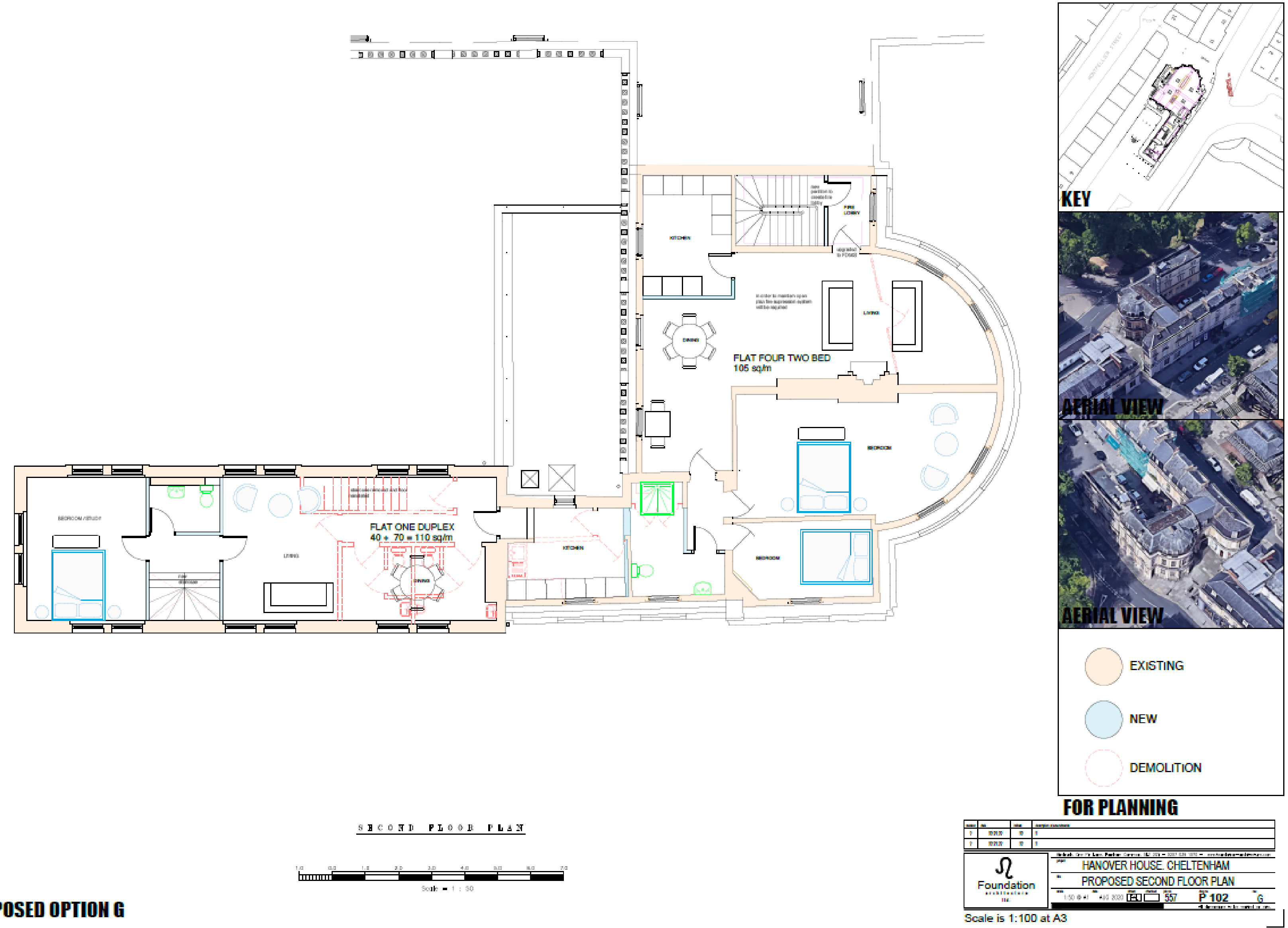
HANOVER HOUSE, CHELTENHAM

PROPOSED FIRST FLOOR PLAN

557 P 101 G

Scale is 1:100 at A3

PROPOSED OPTION G



PROPOSED OPTION G

APPENDIX 2: NOISE MONITORING LEVELS

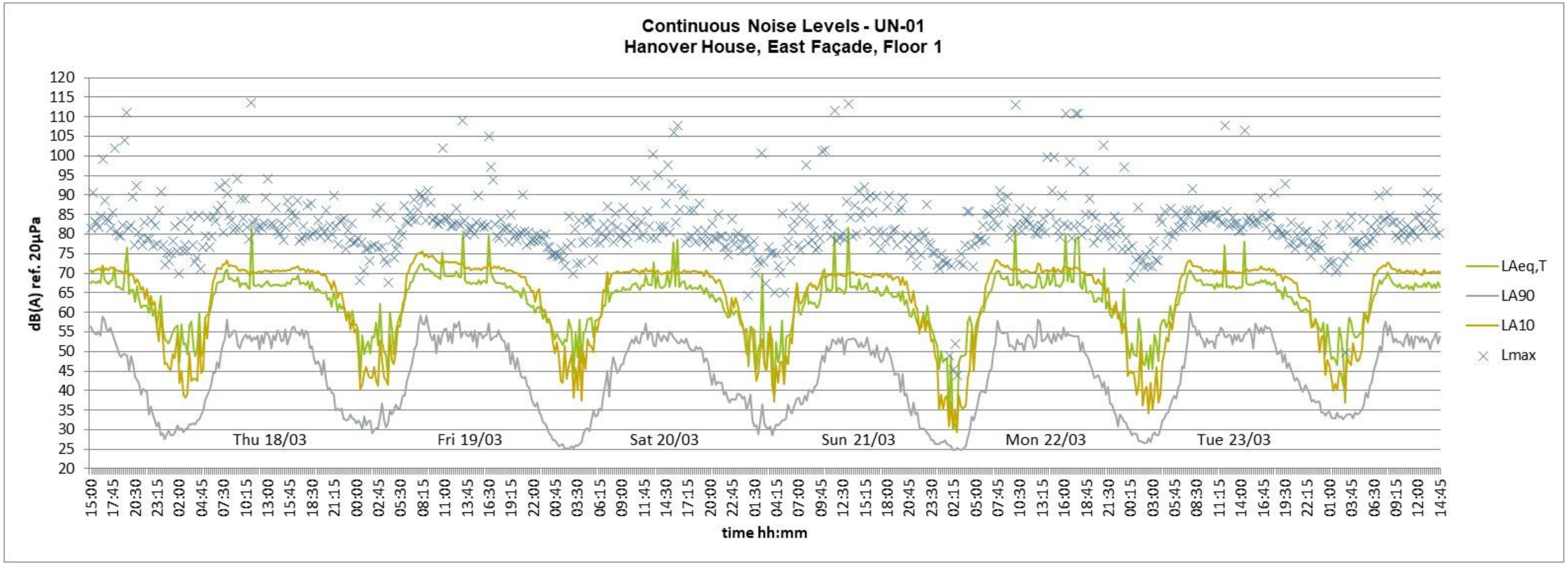


Table A1.1 UN-01 Averaged Daytime Spectrum (linear weighting)

Date and Time	Frequency $L_{Zeq,T}$ (dB)												
	12.5 Hz	16 Hz	20 Hz	25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	Total A
17-24 Mar 2021 07.00 – 23.00	65.4	64.7	62.9	61.8	65.0	69.8	70.3	67.3	63.5	62.2	60.8	59.0	**68.3**
	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1 kHz	1.25 kHz	1.6 kHz	2 kHz	2.5 kHz	
	57.4	58.9	58.5	56.1	55.2	56.6	58.4	59.9	60.4	61.7	55.5	52.7	

	3.15 kHz	4 kHz	5 kHz	6.3 kHz	8 kHz	10 kHz	12.5 kHz	16 kHz	20 kHz				
	50.7	48.2	46.5	44.6	41.7	39.2	36.7	32.9	28.9				

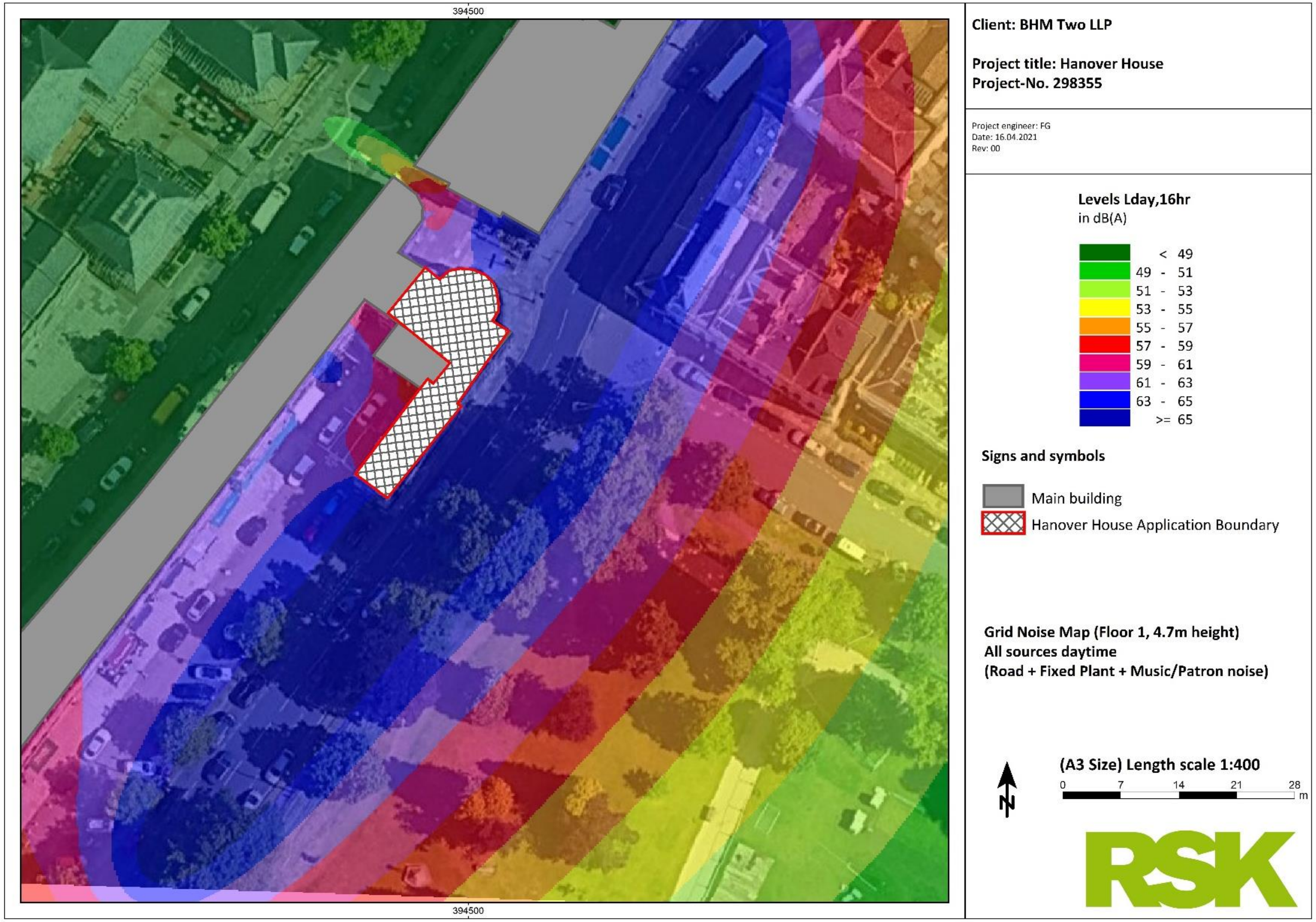
Table A1.2 UN-01 Averaged Night-time Spectrum (linear weighting)

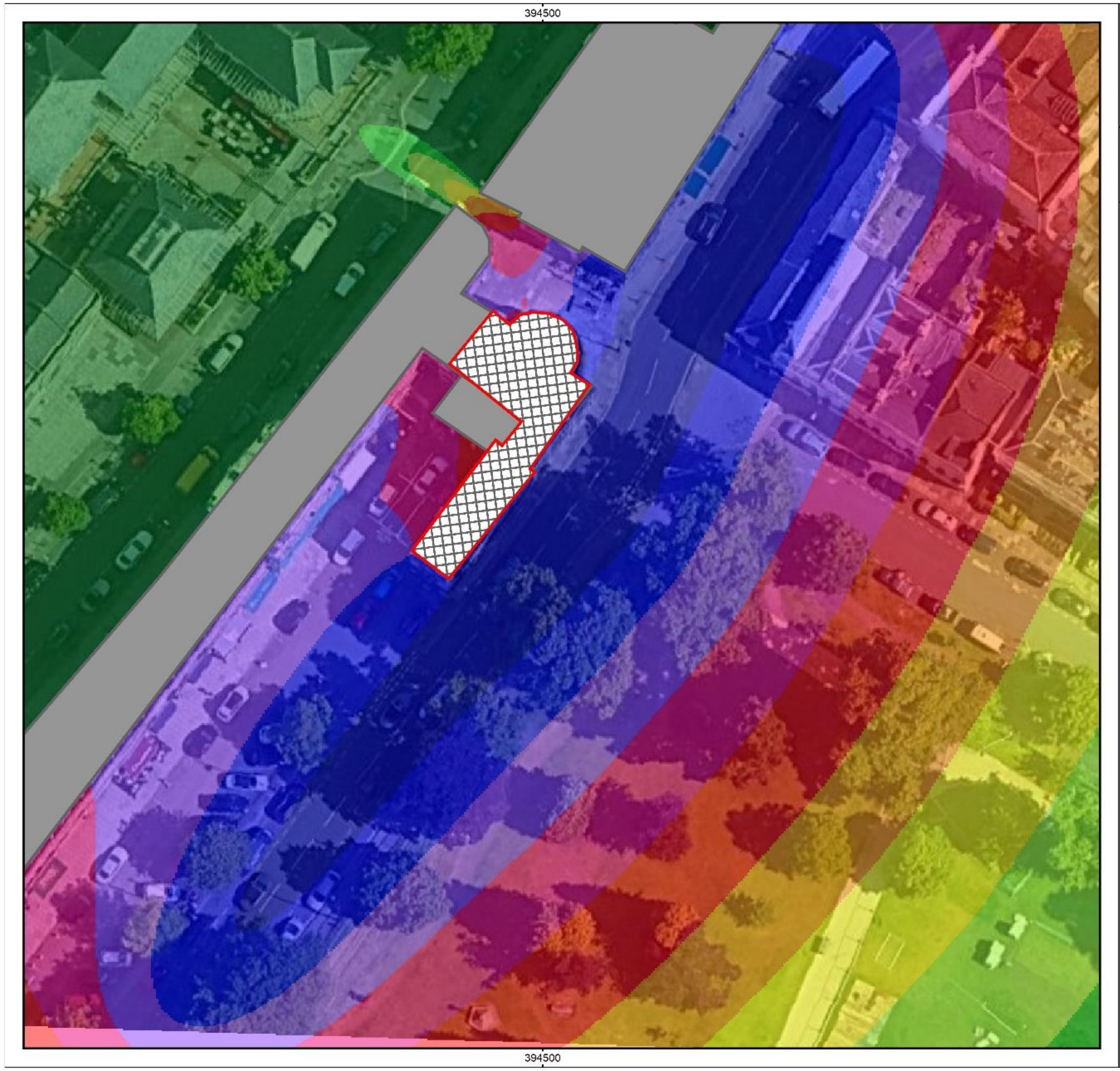
Date and Time	Frequency $L_{Zeq,T}$ (dB)												
	12.5 Hz	16 Hz	20 Hz	25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	Total A
17-24 Mar 2021 23.00 – 07.00	57.4	57.6	54.8	52.5	54.2	59.1	59.9	57	52.7	50.6	49.9	48.0	**58.1**
	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1 kHz	1.25 kHz	1.6 kHz	2 kHz	2.5 kHz	
	47.3	48.3	48.0	46.4	46.9	48.7	50.0	50.1	49.2	48.9	46.8	44.1	
	3.15 kHz	4 kHz	5 kHz	6.3 kHz	8 kHz	10 kHz	12.5 kHz	16 kHz	20 kHz				
	42.0	39.9	38.2	36.1	33.7	31.4	28.5	24.3	21.2				

Table A1.3 AT-03 Averaged Night-time Spectrum (linear weighting)

Date and Time	Frequency $L_{Zeq,T}$ (dB)												
	12.5 Hz	16 Hz	20 Hz	25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	Total A
24 Mar 2021 16.18-16:19	58.5	58.6	62.1	63.8	64.3	75.4	79.9	67.3	71.2	70.3	73.0	72.4	**72.9**
	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1 kHz	1.25 kHz	1.6 kHz	2 kHz	2.5 kHz	
	68.9	66.6	62.6	61.6	63.1	62.1	67.4	66.9	59.9	58.0	58.8	56.5	
	3.15 kHz	4 kHz	5 kHz	6.3 kHz	8 kHz	10 kHz	12.5 kHz	16 kHz	20 kHz				
	54.4	53.6	50.9	49.0	46.7	44	38.4	33.0	26.6				

APPENDIX 3: DAYTIME NOISE MAP





Client: BHM Two LLP

Project title: Hanover House
Project-No. 298355

Project engineer: FG
Date: 16.04.2021
Rev: 00

Levels Lday,16hr
in dB(A)

	< 49
	49 - 51
	51 - 53
	53 - 55
	55 - 57
	57 - 59
	59 - 61
	61 - 63
	63 - 65
	>= 65

Signs and symbols

Main building
Hanover House Application Boundary

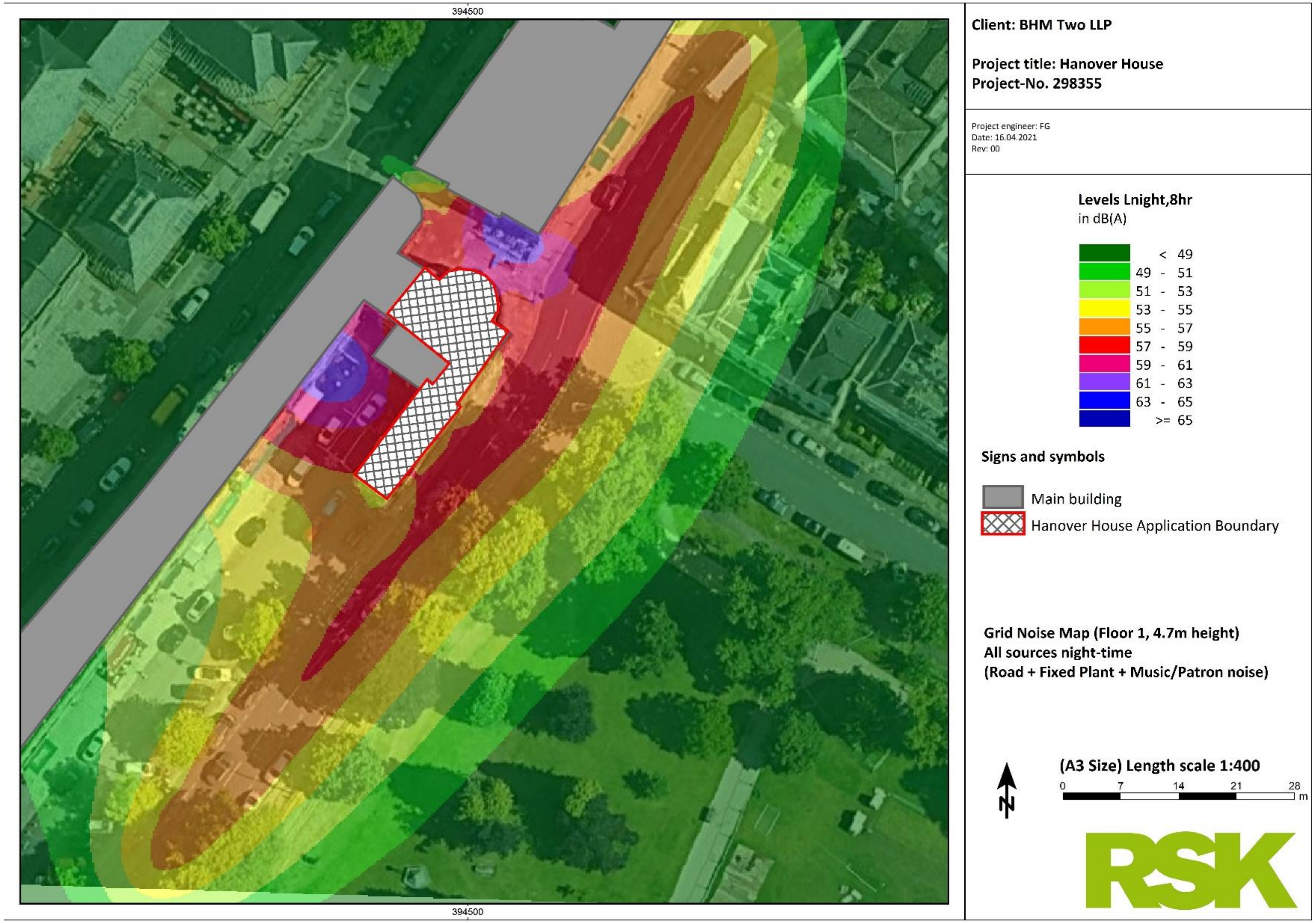
Grid Noise Map (Floor 2, 7.7m height)
All sources daytime
(Road + Fixed Plant + Music/Patron noise)

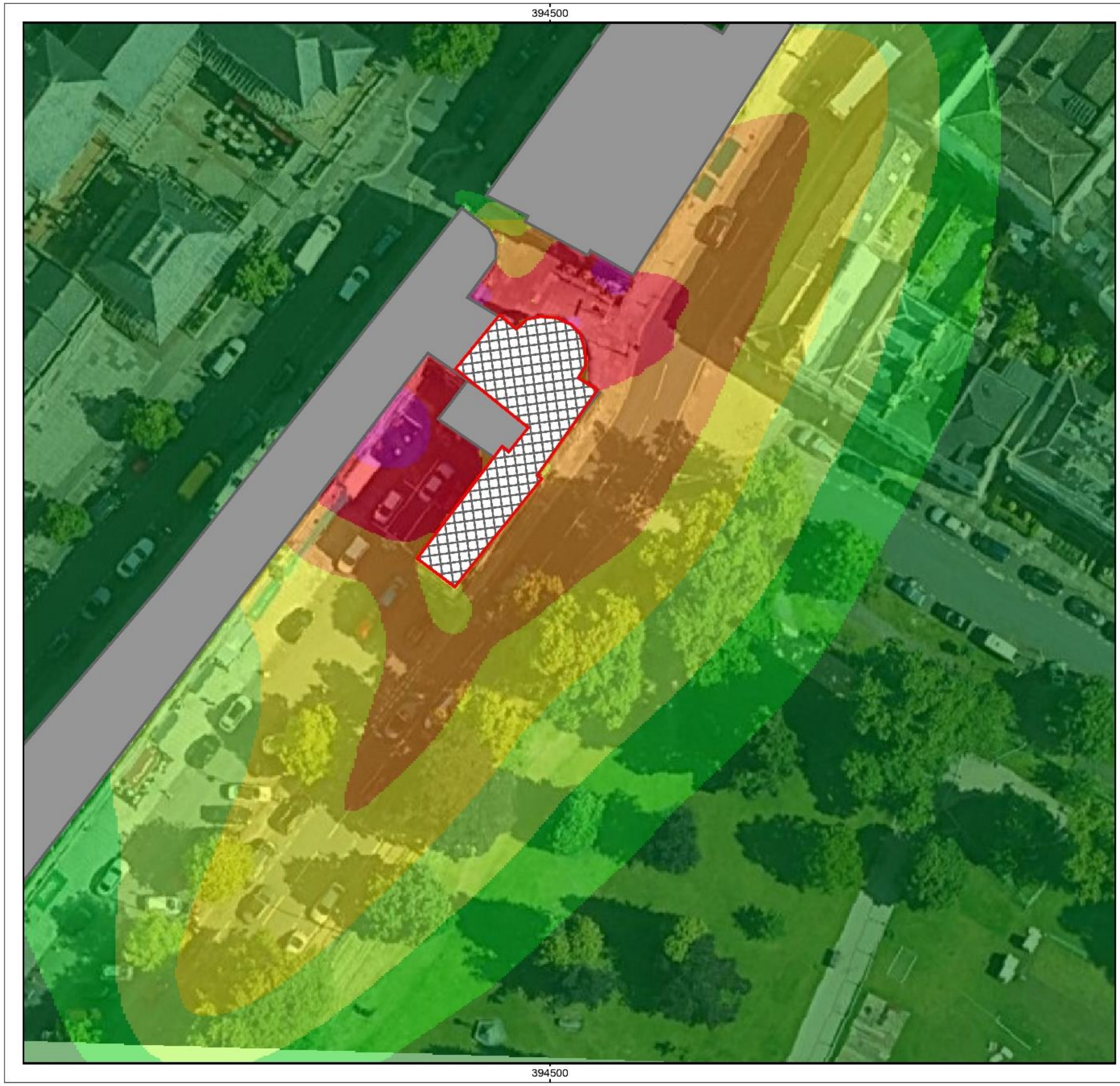
N

(A3 Size) Length scale 1:400

0 7 14 21 28 m

APPENDIX 4: NIGHT-TIME NOISE MAP





Client: BHM Two LLP

Project title: Hanover House
Project-No. 298355

Project engineer: FG
Date: 16.04.2021
Rev: 00

Levels Lnight,8hr
in dB(A)

	< 49
	49 - 51
	51 - 53
	53 - 55
	55 - 57
	57 - 59
	59 - 61
	61 - 63
	63 - 65
	>= 65

Signs and symbols

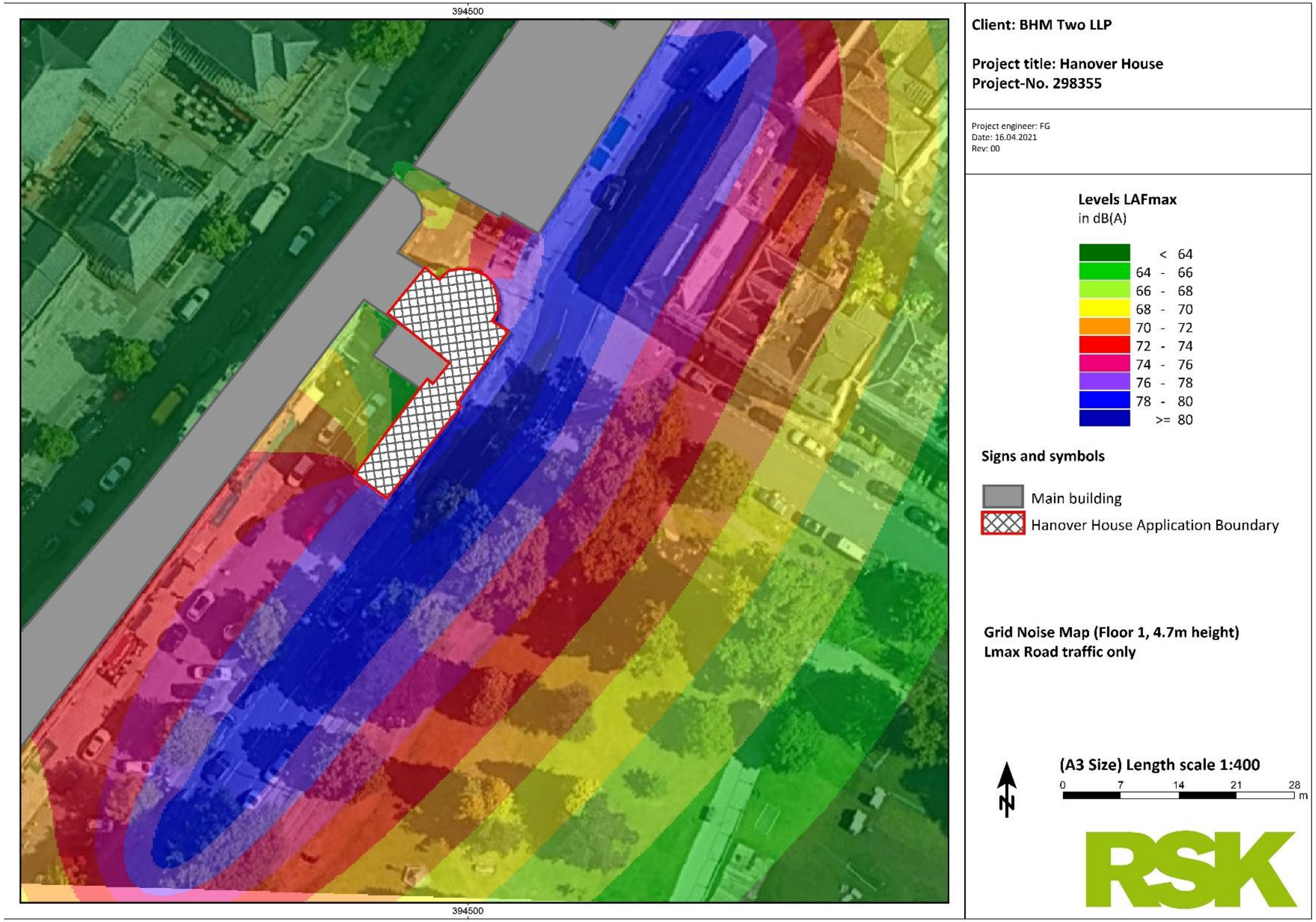
Main building
Hanover House Application Boundary

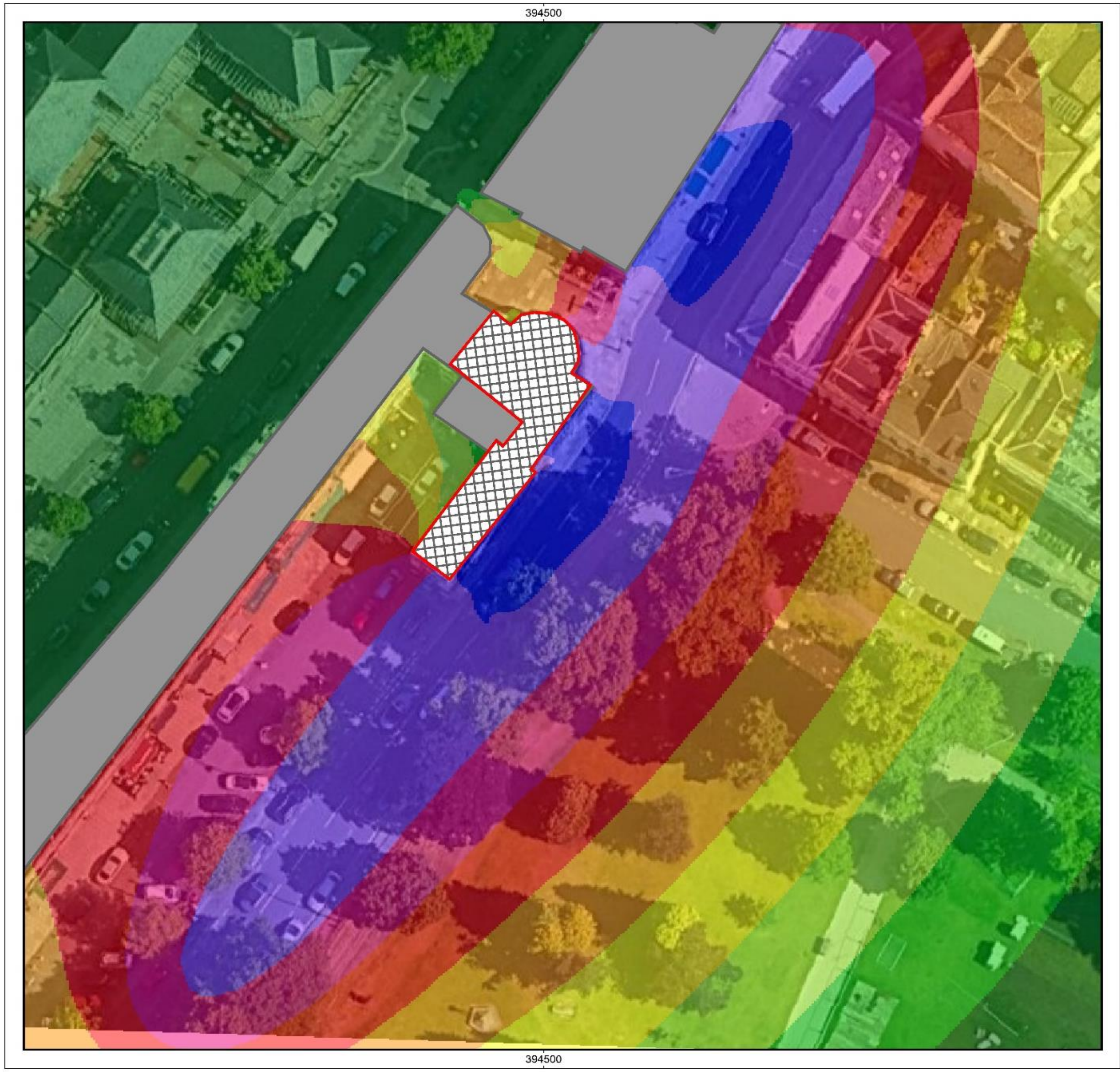
Grid Noise Map (Floor 2, 7.7m height)
All sources night-time
(Road + Fixed Plant + Music/Patron noise)

(A3 Size) Length scale 1:400

0 7 14 21 28 m

APPENDIX 5: NIGHT-TIME NOISE MAP – MAXIMUM NOISE LEVELS





Client: BHM Two LLP

Project title: Hanover House
Project-No. 298355

Project engineer: FG
Date: 16.04.2021
Rev: 00

Levels LAFmax
in dB(A)

	< 64
	64 - 66
	66 - 68
	68 - 70
	70 - 72
	72 - 74
	74 - 76
	76 - 78
	78 - 80
	>= 80

Signs and symbols

Main building
Hanover House Application Boundary

Grid Noise Map (Floor 2, 7.7m height)
Lmax Road traffic only

(A3 Size) Length scale 1:400

0 7 14 21 28 m

APPENDIX 6: NOISE BREAK-IN CALCULATIONS

BS 8233:2014 Façade Calculation

SETTINGS

Plot	Flat 2 One Bed	***Roof?***	☑	**dB $L_{eq,16hr}$**	69	**Migitation Option**
Unit		***Façade***	NE	**dB $L_{eq,16hr}$**	62	C - 40 dB Rw+Ctr / 1no. 40 Dn,e,w+Ctr
Room	Bedroom	***Floor***	F1	**dB L_{AFmax}**	77	Chobham Roof - 50 dB Rw

EXTERNAL NOISE LEVELS

	125	250	500	1 000	2 000	dB(A)
	Octave band centre frequency					
Assessment spectrum	*0*	*-7*	*-5*	*-2*	*-8*	
Derived level for calculation (free-field)	*69*	*62*	*64*	*67*	*61*	69

RESULT

	125	250	500	1 000	2 000	
Internal noise level	42	29	31	26	23	**33 dB(A) ±2**

ROOM PARAMETERS

Term	Description	Value m^2 / m^3
S_f	Façade area (including window)	8.0
S_{wi}	Window area	3.0
S_{ew}	S_f - S_{wi}	5.0
S_{rr}	Area of ceiling	10.0
S	S_f + S_{rr}	18.0
A_0	Reference absorption area (BS EN ISO 10140-2)	10.0
V	Volume	34.0

Term	Description	125	250	500	1 000	2 000	dB R_{w+Ctr}
		Octave band centre frequency					
$L_{eq,ff}$	Free field noise level	69	62	64	67	61	-
$D_{n,e}$	Trickle ventilator	41	40	36	46	42	40
R_{wi}	Glazing unit	28	35	41	47	52	39
R_{ew}	External wall (brick and block)	33	41	46	50	48	44
R_{rr}	Roof/ceiling	39	44	49	52	48	47
A	Equivalent absorption area	9.1	10.9	10.9	10.9	10.9	-

CALCULATION

Ref.	Term from equation (G.1)	125	250	500	1 000	2 000	dB(A)
		Octave band centre frequency					
B	$\frac{A_0}{S}10^{\frac{-D_{n,e}}{10}}$	0.00004	0.00006	0.00014	0.00001	0.00004	
C	$\frac{S_{wi}}{S}10^{\frac{-R_{wi}}{10}}$	0.00026	0.00005	0.00001	0.00000	0.00000	
D	$\frac{S_{ew}}{S}10^{\frac{-R_{ew}}{10}}$	0.00014	0.00002	0.00001	0.00000	0.00000	
E	$\frac{S_{rr}}{S}10^{\frac{-R_{rr}}{10}}$	0.00007	0.00002	0.00001	0.00000	0.00001	
F	$10\log(B+C+D+E)$	-32.9	-38.2	-37.8	-46.3	-43.1	
G	$10\log\frac{S}{A}$	3.0	2.2	2.2	2.2	2.2	
$L_{eq,2}$	A+F+G+3	42	29.3	31.2	25.7	23.2	32.5

BS 8233:2014 Façade Calculation

SETTINGS

Plot	Flat 4 Two Bed	***Roof?***	☑	**dB $L_{eq,16hr}$**	68	**Migitation Option**
Unit		***Façade***	NE	**dB $L_{eq,16hr}$**	61	B - 36 dB Rw+Ctr / 1no. 38 Dn,e,w+Ctr
Room	Larger Bedroom	***Floor***	F2	**dB L_{AFmax}**	76	Chobham Roof - 50 dB Rw

EXTERNAL NOISE LEVELS

	125	250	500	1 000	2 000	dB(A)
	Octave band centre frequency					
Assessment spectrum	*0*	*-7*	*-5*	*-2*	*-8*	
Derived level for calculation (free-field)	*68*	*61*	*63*	*66*	*60*	68

RESULT

	125	250	500	1 000	2 000	
Internal noise level	40	29	31	23	18	**31 dB(A) ±2**

ROOM PARAMETERS

Term	Description	Value m^2 / m^3
S_f	Façade area (including window)	15.0
S_{wi}	Window area	2.0
S_{ew}	S_f - S_{wi}	13.0
S_{rr}	Area of ceiling	27.0
S	S_f + S_{rr}	42.0
A_0	Reference absorption area (BS EN ISO 10140-2)	10.0
V	Volume	68.0

Term	Description	125	250	500	1 000	2 000	dB R_{w+Ctr}
		Octave band centre frequency					
$L_{eq,ff}$	Free field noise level	68	61	63	66	60	-
$D_{n,e}$	Trickle ventilator	40	38	32	47	53	38
R_{wi}	Glazing unit	28	29	38	45	50	36
R_{ew}	External wall (brick and block)	33	41	46	50	48	44
R_{rr}	Roof/ceiling	39	44	49	52	48	47
A	Equivalent absorption area	18.2	21.9	21.9	21.9	21.9	-

CALCULATION

Ref.	Term from equation (G.1)	125	250	500	1 000	2 000	dB(A)
		Octave band centre frequency					
B	$\frac{A_0}{S}10^{\frac{-D_{n,e}}{10}}$	0.00002	0.00004	0.00016	0.00001	0.00000	
C	$\frac{S_{wi}}{S}10^{\frac{-R_{wi}}{10}}$	0.00008	0.00006	0.00001	0.00000	0.00000	
D	$\frac{S_{ew}}{S}10^{\frac{-R_{ew}}{10}}$	0.00016	0.00002	0.00001	0.00000	0.00000	
E	$\frac{S_{rr}}{S}10^{\frac{-R_{rr}}{10}}$	0.00008	0.00003	0.00001	0.00000	0.00001	
F	$10\log(B+C+D+E)$	-34.7	-38.3	-37.4	-48.6	-47.8	
G	$10\log\frac{S}{A}$	3.6	2.8	2.8	2.8	2.8	
$L_{eq,2}$	A+F+G+3	40	28.9	31.2	23.0	18.2	31.0

BS 8233:2014 Façade Calculation

SETTINGS

Plot	Flat 1 Duplex	*Roof?*	☑	*dB $L_{eq,16hr}$*	66	Migitation Option
Unit		*Façade*	S	*dB $L_{eq,16hr}$*	56	B - 36 dB Rw+Ctr / 1no. 38 Dn,e,w+Ctr
Room	Bedroom	*Floor*	F1	*dB L_{AFmax}*	75	Chobham Roof - 50 dB Rw

EXTERNAL NOISE LEVELS

	Octave band centre frequency					dB(A)
	125	250	500	1 000	2 000	
Assessment spectrum	*0*	*-7*	*-5*	*-2*	*-8*	
Derived level for calculation (free-field)	*66*	*59*	*61*	*64*	*58*	66

RESULT

	125	250	500	1 000	2 000	
Internal noise level	42	32	32	24	18	32 dB(A) ±2

ROOM PARAMETERS

Term	Description	Value m^2 / m^3
S_f	Façade area (including window)	24.0
S_{wi}	Window area	7.0
S_{ew}	S_f - S_{wi}	17.0
S_{rr}	Area of ceiling	12.0
S	S_f + S_{rr}	36.0
A_0	Reference absorption area (BS EN ISO 10140-2)	10.0
V	Volume	41.0

Term	Description	125	250	500	1 000	2 000	dB R_{w+Ctr}
$L_{eq,ff}$	Free field noise level	66	59	61	64	58	-
$D_{n,e}$	Trickle ventilator	40	38	32	47	53	38
R_{wi}	Glazing unit	28	29	38	45	50	36
R_{ew}	External wall (brick and block)	33	41	46	50	48	44
R_{rr}	Roof/ceiling	39	44	49	52	48	47
A	Equivalent absorption area	11.0	13.2	13.2	13.2	13.2	-

CALCULATION

Ref.	Term from equation (G.1)	125	250	500	1 000	2 000	dB(A)
B	$\frac{A_0}{S}10^{\frac{-D_{n,e}}{10}}$	0.00003	0.00005	0.00018	0.00001	0.00000	
C	$\frac{S_{wi}}{S}10^{\frac{-R_{wi}}{10}}$	0.00031	0.00024	0.00003	0.00001	0.00000	
D	$\frac{S_{ew}}{S}10^{\frac{-R_{ew}}{10}}$	0.00024	0.00004	0.00001	0.00000	0.00001	
E	$\frac{S_{rr}}{S}10^{\frac{-R_{rr}}{10}}$	0.00004	0.00001	0.00000	0.00000	0.00001	
F	$10\log(B+C+D+E)$	-32.1	-34.7	-36.4	-47.2	-48.0	
G	$10\log\frac{S}{A}$	5.1	4.4	4.4	4.4	4.4	
$L_{eq,2}$	A+F+G+3	42	32.0	31.8	23.9	17.6	32.2

BS 8233:2014 Façade Calculation

SETTINGS

Plot	Flat 1 Duplex	*Roof?*	☑	*dB $L_{eq,16hr}$*	65	Migitation Option
Unit		*Façade*	S	*dB $L_{eq,16hr}$*	55	B - 36 dB Rw+Ctr / 1no. 38 Dn,e,w+Ctr
Room	Bedroom/Study	*Floor*	F2	*dB L_{AFmax}*	74	Chobham Roof - 50 dB Rw

EXTERNAL NOISE LEVELS

	Octave band centre frequency					dB(A)
	125	250	500	1 000	2 000	
Assessment spectrum	*0*	*-7*	*-5*	*-2*	*-8*	
Derived level for calculation (free-field)	*65*	*58*	*60*	*63*	*57*	65

RESULT

	125	250	500	1 000	2 000	
Internal noise level	42	31	31	24	18	32 dB(A) ±2

ROOM PARAMETERS

Term	Description	Value m^2 / m^3
S_f	Façade area (including window)	29.0
S_{wi}	Window area	6.7
S_{ew}	S_f - S_{wi}	22.3
S_{rr}	Area of ceiling	16.0
S	S_f + S_{rr}	45.0
A_0	Reference absorption area (BS EN ISO 10140-2)	10.0
V	Volume	39.0

Term	Description	125	250	500	1 000	2 000	dB R_{w+Ctr}
$L_{eq,ff}$	Free field noise level	65	58	60	63	57	-
$D_{n,e}$	Trickle ventilator	40	38	32	47	53	38
R_{wi}	Glazing unit	28	29	38	45	50	36
R_{ew}	External wall (brick and block)	33	41	46	50	48	44
R_{rr}	Roof/ceiling	39	44	49	52	48	47
A	Equivalent absorption area	10.5	12.6	12.6	12.6	12.6	-

CALCULATION

Ref.	Term from equation (G.1)	125	250	500	1 000	2 000	dB(A)
B	$\frac{A_0}{S}10^{\frac{-D_{n,e}}{10}}$	0.00002	0.00004	0.00015	0.00000	0.00000	
C	$\frac{S_{wi}}{S}10^{\frac{-R_{wi}}{10}}$	0.00024	0.00019	0.00002	0.00000	0.00000	
D	$\frac{S_{ew}}{S}10^{\frac{-R_{ew}}{10}}$	0.00025	0.00004	0.00001	0.00000	0.00001	
E	$\frac{S_{rr}}{S}10^{\frac{-R_{rr}}{10}}$	0.00004	0.00001	0.00000	0.00000	0.00001	
F	$10\log(B+C+D+E)$	-32.6	-35.6	-37.3	-47.8	-48.0	
G	$10\log\frac{S}{A}$	6.3	5.5	5.5	5.5	5.5	
$L_{eq,2}$	A+F+G+3	42	31.3	31.1	23.5	17.7	31.7

RSK ACOUSTICS

BS 8233:2014 Façade Calculation

SETTINGS

Plot	Flat 1 Duplex	***Roof?***	☑	***dB $L_{eq,16hr}$***	69	**Migitation Option**
Unit		***Façade***	E	***dB $L_{eq,16hr}$***	58	D - 42 dB Rw+Ctr / 1no. 40 Dn,e,w+Ctr
Room	Bedroom	***Floor***	F1	***dB L_{AFmax}***	78	Chobham Roof - 50 dB Rw

EXTERNAL NOISE LEVELS

	Octave band centre frequency					dB(A)
	125	**250**	**500**	**1 000**	**2 000**	
Assessment spectrum	*0*	*-7*	*-5*	*-2*	*-8*	
Derived level for calculation (free-field)	*69*	*62*	*64*	*67*	*61*	69

RESULT

	125	250	500	1 000	2 000	
Internal noise level	44	31	31	26	23	**33 dB(A) ±2**

ROOM PARAMETERS

Term	Description	Value m^2 / m^3
S_f	Façade area (including window)	24.0
S_{wi}	Window area	7.0
S_{ew}	S_f - S_{wi}	17.0
S_{rr}	Area of ceiling	12.0
S	S_f + S_{rr}	36.0
A_0	Reference absorption area (BS EN ISO 10140-2)	10.0
V	Volume	41.0

Term	Description	Octave band centre frequency 125	250	500	1 000	2 000	dB R_{w+Ctr}
$L_{eq,ff}$	Free field noise level	69	62	64	67	61	-
$D_{n,e}$	Trickle ventilator	41	40	36	46	42	40
R_{wi}	Glazing unit	30	35	46	54	55	41
R_{ew}	External wall (brick and block)	33	41	46	50	48	44
R_{rr}	Roof/ceiling	39	44	49	52	48	47
A	Equivalent absorption area	11.0	13.2	13.2	13.2	13.2	-

CALCULATION

Ref.	Term from equation (G.1)	Octave band centre frequency 125	250	500	1 000	2 000	dB(A)
B	$\frac{A_0}{S}10^{\frac{-D_{n,e}}{10}}$	0.00002	0.00003	0.00007	0.00001	0.00002	
C	$\frac{S_{wi}}{S}10^{\frac{-R_{wi}}{10}}$	0.00019	0.00006	0.00000	0.00000	0.00000	
D	$\frac{S_{ew}}{S}10^{\frac{-R_{ew}}{10}}$	0.00024	0.00004	0.00001	0.00000	0.00001	
E	$\frac{S_{rr}}{S}10^{\frac{-R_{rr}}{10}}$	0.00004	0.00001	0.00000	0.00000	0.00001	
F	$10\log(B + C + D + E)$	-33.1	-38.5	-40.4	-48.4	-45.1	
G	$10\log\frac{S}{A}$	5.1	4.4	4.4	4.4	4.4	
$L_{eq,2}$	A+F+G+3	44	31.1	30.8	25.8	23.4	33.1

RSK ACOUSTICS

BS 8233:2014 Façade Calculation

SETTINGS

Plot	Flat 1 Duplex	***Roof?***	☑	***dB $L_{eq,16hr}$***	68	**Migitation Option**
Unit		***Façade***	E	***dB $L_{eq,16hr}$***	57	D - 42 dB Rw+Ctr / 1no. 40 Dn,e,w+Ctr
Room	Bedroom/Study	***Floor***	F2	***dB L_{AFmax}***	77	Chobham Roof - 50 dB Rw

EXTERNAL NOISE LEVELS

	Octave band centre frequency					dB(A)
	125	**250**	**500**	**1 000**	**2 000**	
Assessment spectrum	*0*	*-7*	*-5*	*-2*	*-8*	
Derived level for calculation (free-field)	*68*	*61*	*63*	*66*	*60*	68

RESULT

	125	250	500	1 000	2 000	
Internal noise level	44	31	30	26	23	**33 dB(A) ±2**

ROOM PARAMETERS

Term	Description	Value m^2 / m^3
S_f	Façade area (including window)	29.0
S_{wi}	Window area	7.0
S_{ew}	S_f - S_{wi}	22.0
S_{rr}	Area of ceiling	16.0
S	S_f + S_{rr}	45.0
A_0	Reference absorption area (BS EN ISO 10140-2)	10.0
V	Volume	39.0

Term	Description	Octave band centre frequency 125	250	500	1 000	2 000	dB R_{w+Ctr}
$L_{eq,ff}$	Free field noise level	68	61	63	66	60	-
$D_{n,e}$	Trickle ventilator	41	40	36	46	42	40
R_{wi}	Glazing unit	30	35	46	54	55	41
R_{ew}	External wall (brick and block)	33	41	46	50	48	44
R_{rr}	Roof/ceiling	39	44	49	52	48	47
A	Equivalent absorption area	10.5	12.6	12.6	12.6	12.6	-

CALCULATION

Ref.	Term from equation (G.1)	Octave band centre frequency 125	250	500	1 000	2 000	dB(A)
B	$\frac{A_0}{S}10^{\frac{-D_{n,e}}{10}}$	0.00002	0.00002	0.00006	0.00001	0.00001	
C	$\frac{S_{wi}}{S}10^{\frac{-R_{wi}}{10}}$	0.00016	0.00005	0.00000	0.00000	0.00000	
D	$\frac{S_{ew}}{S}10^{\frac{-R_{ew}}{10}}$	0.00025	0.00004	0.00001	0.00000	0.00001	
E	$\frac{S_{rr}}{S}10^{\frac{-R_{rr}}{10}}$	0.00004	0.00001	0.00000	0.00000	0.00001	
F	$10\log(B + C + D + E)$	-33.3	-39.1	-41.2	-48.8	-45.5	
G	$10\log\frac{S}{A}$	6.3	5.5	5.5	5.5	5.5	
$L_{eq,2}$	A+F+G+3	44	30.8	30.2	25.6	23.1	32.8

BS 8233:2014 Façade Calculation

SETTINGS						
Plot	Flat 1 Duplex	*Roof?*	☑	*dB $L_{eq,16hr}$*	62	**Migitation Option**
Unit		*Façade*	W	*dB $L_{eq,16hr}$*	59	A - 32 dB Rw+Ctr / 1no. 38 Dn,e,w+Ctr
Room	Bedroom/Study	*Floor*	F2	*dB L_{AFmax}*	69	Chobham Roof - 50 dB Rw

EXTERNAL NOISE LEVELS

	Octave band centre frequency					dB(A)
	125	**250**	**500**	**1 000**	**2 000**	
Assessment spectrum	*0*	*-7*	*-5*	*-2*	*-8*	
Derived level for calculation (free-field)	*59*	*52*	*54*	*57*	*51*	59

RESULT

	125	250	500	1 000	2 000	
Internal noise level	40	28	25	19	16	**28 dB(A) ±2**

ROOM PARAMETERS

Term	Description	Value m^2 / m^3
S_f	Façade area (including window)	29.0
S_{wi}	Window area	7.0
S_{ew}	S_f - S_{wi}	22.0
S_{rr}	Area of ceiling	16.0
S	S_f + S_{rr}	45.0
A_0	Reference absorption area (BS EN ISO 10140-2)	10.0
V	Volume	39.0

Term	Description	Octave band centre frequency 125	250	500	1 000	2 000	dB R_{w+Ctr}
$L_{eq,ff}$	Free field noise level	59	52	54	57	51	-
$D_{n,e}$	Trickle ventilator	40	38	32	47	53	38
R_{wi}	Glazing unit	21	26	36	42	38	32
R_{ew}	External wall (brick and block)	33	41	46	50	48	44
R_{rr}	Roof/ceiling	39	44	49	52	48	47
A	Equivalent absorption area	10.5	12.6	12.6	12.6	12.6	-

CALCULATION

Ref.	Term from equation (G.1)	Octave band centre frequency 125	250	500	1 000	2 000	dB(A)
B	$\frac{A_0}{S}10^{\frac{-D_{n,e}}{10}}$	0.00002	0.00004	0.00015	0.00000	0.00000	
C	$\frac{S_{wi}}{S}10^{\frac{-R_{wi}}{10}}$	0.00124	0.00039	0.00004	0.00001	0.00002	
D	$\frac{S_{ew}}{S}10^{\frac{-R_{ew}}{10}}$	0.00025	0.00004	0.00001	0.00000	0.00001	
E	$\frac{S_{rr}}{S}10^{\frac{-R_{rr}}{10}}$	0.00004	0.00001	0.00000	0.00000	0.00001	
F	$10\log(B + C + D + E)$	-28.1	-33.2	-36.9	-46.6	-44.1	
G	$10\log\frac{S}{A}$	6.3	5.5	5.5	5.5	5.5	
$L_{eq,2}$	A+F+G+3	40	27.7	25.4	18.7	15.6	28.0

APPENDIX 7: BENCHMARK TESTING RESULTS

Project no.	298399	**Source**	ASK Restaurant
Project	Hanover House, Cheltenham	**Volume**	470 m³ *(approx.)*
Client	Foundation Architecture	**Receiver**	3.07 (Bedroom)
Building	Hanover House	**Volume**	30 m³ *(approx.)*
Test date	17-Mar-21	**Area of Test**	10 m² *(approx.)*
Engineer	RSK	**Test Ref. No.**	Test 1

Rating of $D_{nT,w}$ in accordance with BS EN ISO 140-4 and BS EN ISO 717-1

f, Hz	Limit	D_{nT}	Rating Curve	Notable Deviations	Unfavourable Deviations	Limit	f, Hz	D_{nT}
50	*	26.4						
63		26.5				*	63	25.4
80		23.7						
100		18.9	28	9.1	9.1			
125		18.5	31	12.5	12.5		**125**	19.7
160		28.6	34		5.4			
200		34.7	37		2.3			
250	*	40.5	40			*	**250**	40.0
315	*	44.3	43					
400	*	49.1	46					
500	*	51.9	47			*	**500**	51.1
630	*	53.4	48					
800	*	52.9	49					
1000	*	54.6	50			*	**1000**	54.7
1250	*	57.1	51					
1600	*	57.7	51					
2000	*	56.9	51			*	**2000**	57.8
2500	*	57.8	51					
3150	*	62.0	51					
4000	*	65.5				*	4000	64.3
5000	*	66.3						

Weighted Standardised Level Difference, $D_{nT,w}$ =	47 dB
Spectrum adaption terms (C, C_{tr}) =	(-5 , -12)
Airborne Sound Insulation, $D_{nT,w} + C_{tr}$ =	**35 dB**

$C_{50\text{-}3150} \geq$	-5 dB;	$C_{50\text{-}5000} \geq$	-4 dB;	$C_{100\text{-}5000} \geq$	-4 dB
$C_{tr50\text{-}3150} \geq$	-13 dB;	$C_{tr50\text{-}5000} \geq$	-13 dB;	$C_{tr100\text{-}5000} =$	-12 dB

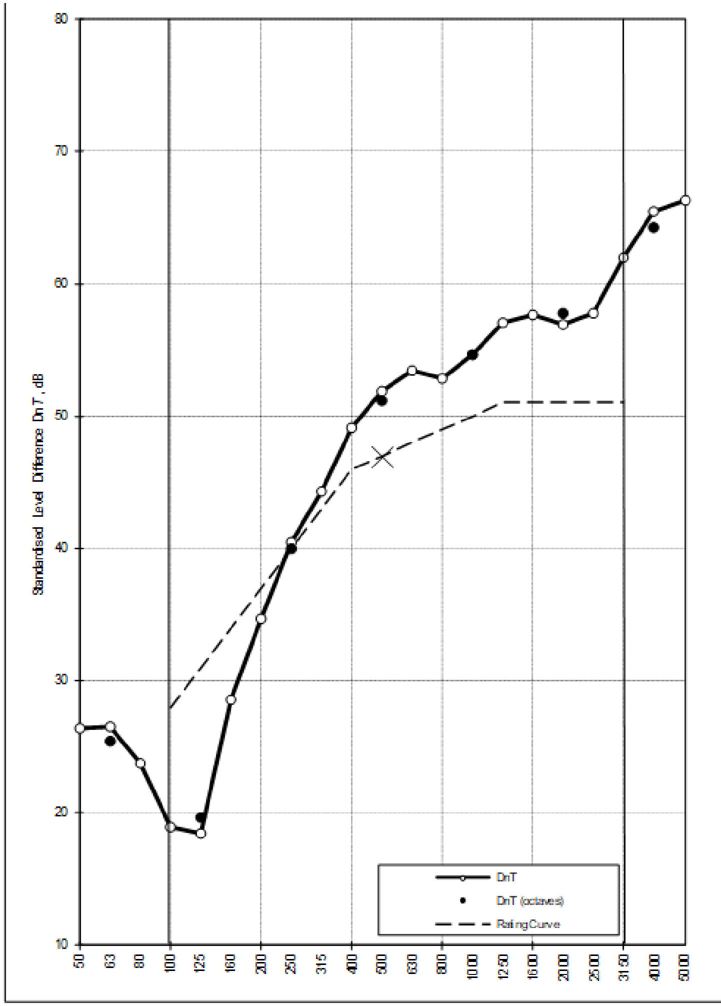


Figure A7.1 Test 1 – Receiving Room 3.07

Project no.	298399	**Source**	ASK Restaurant
Project	Hanover House, Cheltenham	**Volume**	470 m³ *(approx.)*
Client	Foundation Architecture	**Receiver**	3.08 (Lounge / Diner)
Building	Hanover House	**Volume**	85 m³ *(approx.)*
Test date	17-Mar-21	**Area of Test**	28 m² *(approx.)*
Engineer	RSK	**Test Ref. No.**	Test 2

Rating of $D_{nT,w}$ in accordance with BS EN ISO 140-4 and BS EN ISO 717-1

f, Hz	Limit	D_{nT}	Rating Curve	Notable Deviations	Unfavourable Deviations	Limit	f, Hz	D_{nT}
50		21.1						
63		20.1					63	20.8
80		21.5						
100		22.5	28		5.5			
125		21.6	31	9.4	9.4		**125**	23.1
160		27.9	34		6.1			
200		34.2	37		2.8			
250		39.2	40		0.8		**250**	38.1
315		41.9	43		1.1			
400		44.2	46		1.8			
500	*	49.9	47			*	**500**	47.6
630	*	51.1	48					
800	*	51.8	49					
1000	*	52.9	50			*	**1000**	53.5
1250	*	55.9	51					
1600	*	57.3	51					
2000	*	60.2	51			*	**2000**	61.0
2500	*	63.9	51					
3150	*	65.8	51					
4000	*	68.2				*	4000	67.6
5000	*	69.3						

Weighted Standardised Level Difference, $D_{nT,w}$ = 47 dB

Spectrum adaption terms (C, C_{tr}) = (-3, -9)

Airborne Sound Insulation, $D_{nT,w} + C_{tr}$ = 38 dB

$C_{50-3150}$ ≥	-4 dB;	$C_{50-5000}$ ≥	-3 dB;	$C_{100-5000}$ ≥	-2 dB
$C_{tr50-3150}$ ≥	-12 dB;	$C_{tr50-5000}$ ≥	-12 dB;	$C_{tr100-5000}$ =	-9 dB

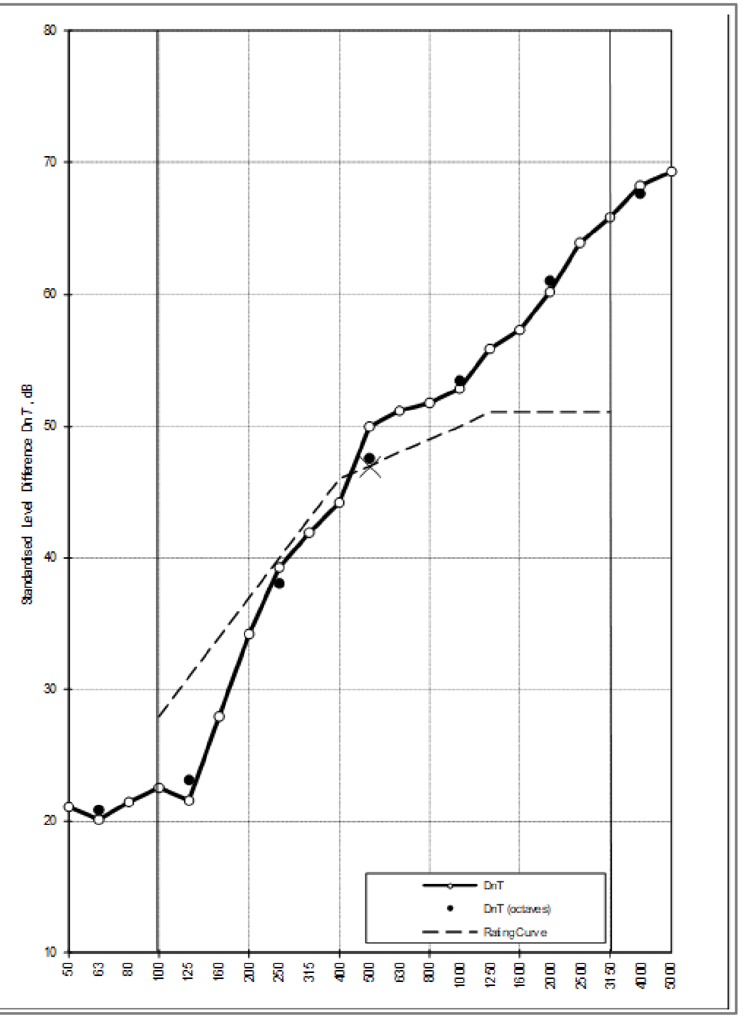


Figure A7.2 Test 2 – Receiving Room 3.08

Project no.	298399	**Source**	ASK Restaurant
Project	Hanover House, Cheltenham	**Volume**	470 m^3 *(approx.)*
Client	Foundation Architecture	**Receiver**	3.11 / 3.13 (Studio)
Building	Hanover House	**Volume**	135 m^3 *(approx.)*
Test date	17-Mar-21	**Area of Test**	45 m^2 *(approx.)*
Engineer	RSK	**Test Ref. No.**	Test 3

Rating of $D_{nT,w}$ in accordance with BS EN ISO 140-4 and BS EN ISO 717-1

f, Hz	Limit	D_{nT}	Rating Curve	Notable Deviations	Unfavourable Deviations	Limit	f, Hz	D_{nT}
50	*	19.8						
63		19.9					63	20.6
80		21.6						
100		23.9	29		5.1			
125		25.3	32		6.7		**125**	25.3
160		29.2	35		5.8			
200		32.8	38		5.2			
250		39.3	41		1.7		**250**	37.8
315		41.9	44		2.1			
400		44.4	47		2.6			
500		47.6	48		0.4		**500**	46.8
630		49.6	49					
800		50.9	50					
1000		53.2	51				**1000**	53.3
1250		56.1	52					
1600	*	57.4	52					
2000		58.3	52				**2000**	59.5
2500		61.7	52					
3150	*	64.9	52					
4000		68.7					4000	67.0
5000	*	67.5						

Weighted Standardised Level Difference, $D_{nT,w}$ = 48 dB

Spectrum adaption terms (C, C_{tr}) = (-3, -9)

Airborne Sound Insulation, $D_{nT,w} + C_{tr}$ = **39 dB**

$C_{50-3150} \geq$	-4 dB;	$C_{50-5000} \geq$	-3 dB;	$C_{100-5000} \geq$	-2 dB
$C_{tr50-3150} \geq$	-12 dB;	$C_{tr50-5000} \geq$	-12 dB;	$C_{tr100-5000} =$	-9 dB

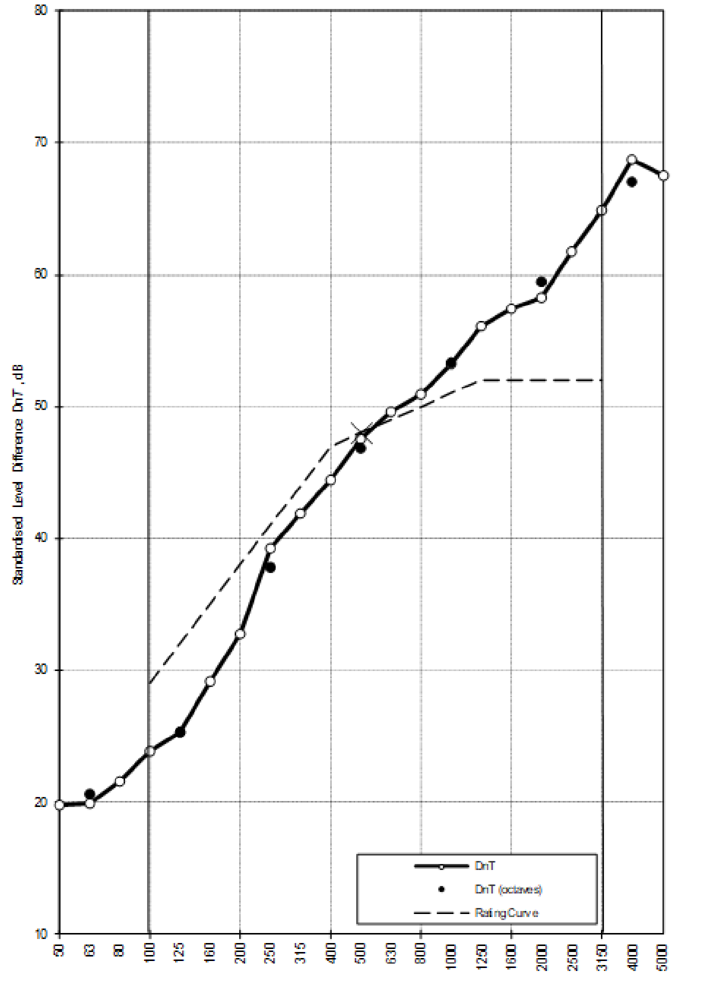


Figure A7.3 Test 3 – Receiving Room 3.11 / 3.13

APPENDIX 8: PHOTOGRAPHIC REPORT

Long term monitoring position UN-01 (east façade)

Long term monitoring position UN-01 (east façade)

Short term monitoring position AT-01 (north façade)

Short term monitoring position AT-02 (west façade)

Short term monitoring position AT-03 (west façade vent.)

APPENDIX 9: ACOUSTIC GLOSSARY

***L_p* - Sound Pressure Level**

The basic unit of sound measurement is the sound pressure level, which is measured on a logarithmic scale and expressed in decibels (dB). The logarithmic scale makes it easier to manage the large range of audible sound pressures, and also more closely represents the way the human ear responds to differences in sound pressure:

$L_p = 20 \log_{10} (p/p_o)$

where p = RMS (root mean square) sound pressure; and

p_0 = reference sound pressure 2×10^{-5} Pa.

Frequency Weighting Networks

Frequency weighting networks, which are generally built into sound level meters, attenuate the signal at some frequencies and amplify it at others. The A-weighting network approximately corresponds to human frequency response to sound. Sound levels measured with the A-weighting network are expressed in dB(A). Other weighting networks also exist, such as C-weighting which is nearly linear (i.e. unweighted) and other more specialised weighting networks. Variables such as L_p and L_{eq} that can be measured using such weightings are expressed as L_{pA} / L_{pC}, L_{Aeq} / L_{Ceq} etc.

Time Weighting

Sound level meters use various averaging times for the measurement of RMS sound pressure level. The most commonly used are fast (0.125 s averaging time), slow (1 s averaging time) and impulse (0.035 s averaging time). Variables that are measures with time weightings are expressed as L_{AFmax} etc.

***L_{Aeq}* – Equivalent Continuous Sound Pressure Level**

Sound levels tend to fluctuate, and as such an ‘instantaneous’ measurement like sound pressure level cannot fully describe many real-world situations. A summation can be made of the measured sound energy over a certain period, and a notional steady level can be calculated which would contain the same total energy as the fluctuating sound. This notional level is termed the equivalent continuous sound level L_{eq}. L_{eq} can be determined over any time period, which is indicated as $L_{eq,T}$ where T is the time period (e.g. $L_{eq,24h}$).

In mathematical terms, for n discrete sound level measurements, Leq is given by:

$L_{eq,T}$ = 10 log10 (t1 x 10L1/10 + t2 x 10L2/10 +… tn x 10Ln/10)/T

where t_1 = time at level L_1 dB;

t_2 = time at level L_2 dB;

and T = total time

***L_{max}* - Maximum Sound Pressure Level or Maximum Noise Level**

This is the maximum RMS sound pressure level occurring within a specified period. The time weighting is usually specified, such as in L_{Fmax}.

***L_N* - Percentile or Statistical Levels**

Sometimes it is useful to calculate the level which is exceeded for a certain percent of a total period. Background noise is often defined as the A-weighted sound pressure level exceeded for 90% of the specified period T, expressed $L_{90,T}$. Road traffic noise is often characterised in terms of $L_{A10,18}$

Sound Transmission via Building Façade: from inside to outside

The magnitude of the sound level transmitted from the inside of a room to the outside can be estimated by considering the direct airborne sound and the indirect transmissions via the flanking paths. The following formula is generally used to simplify the calculation assuming a direct sound contribution only.

$L_{out}=L_{in} – R – 6$ / $L_w=L_{out}+10 * \log S$ / $L_R=Lw-20 * \log r – 11 + D$

Being L_{out} the sound level just outside the façade arising from sound transmission;
R is the sound reduction index of the façade element;
S is the area of the façade element;
L_R is the sound level at a distance *r* from the façade behaving as a point source;

D is the directivity index (D=+3 source adjacent to one reflective plane)

Sabine Acoustics for Steady State Situations: Total Sound Pressure Level

The total sound pressure level at any point in the room is the result of the combination of the direct sound pressure level and the reverberant field dependant on the source and room surfaces.

$L_{TOTAL}=L_w + 10 * \log [(Q/4.\pi.r^2)+(4/RC)]$

Being L_{TOTAL} the total sound level at any point in the room;
Q is the directivity factor;
r is the distance from the source to the façade;

RC is the room constant, which depends on the total area of the room surfaces and the averaged absorption coefficient of those surfaces.

Ambient sound

totally encompassing sound in a given situation at a given time, usually composed of sound from many sources near and far. The ambient sound comprises the residual sound and the specific sound when present.

$L_a=L_{Aeq,T}$ – Ambient sound level

Equivalent continuous A-weighted sound pressure level of the totally encompassing sound in a given situation at a given time, usually from many sources near and far, at the assessment location over a given time interval, T. The ambient sound level is a measure of the residual sound and the specific sound when present.

$L_{A90,T}$ – Background sound level

A-weighted sound pressure level that is exceeded by the residual sound at the assessment location for 90% of a given time interval, T, measured using time weighting, F, and quoted to the nearest whole number of decibels.

Residual sound

Ambient sound remaining at the assessment location when the specific sound source is suppressed to such a degree that it does not contribute to the ambient sound.

Specific sound source

Sound source being assessed.

$L_{Ar,Tr}$ – Rating level

Specific sound level plus any adjustment for the characteristic features of the sound as per BS 4142:2014+A1:2019. Certain acoustic features can increase the significance of impact over that expected from a basic comparison between the specific sound level and the background sound level, for example: tonality, impulsivity, intermittency or other sound characteristics that are readily distinctive against the residual acoustic environment.

Single-number quantity for airborne sound insulation rating

Value, in decibels, of the reference curve at 500 Hz after shifting it in accordance with the method specified in this part of ISO 717.

Spectrum adaptation term

Value, in decibels, to be added to the single-number rating (e.g. R_w) to take account of the characteristics of particular sound spectra.

Normalized level difference, D_n

Level difference, in decibels, corresponding to the reference absorption area in the receiving room.

$D_n = D – 10 \log A/A_0$

Being:

- D the level difference in decibels, in the space and time average sound pressure levels produced in two rooms by one or more sound sources in one of them;

- A is the equivalent sound absorption area of the receiving room, in square metres;

- A_0 is the reference absorption area, in square metres (for rooms in dwellings or rooms of comparable size: A0 = 10 m^2).

Standardized level difference, D_{nT}

Level difference, in decibels, corresponding to a reference value of the reverberation time in the receiving room: $D_{nT} = D – 10 \log T/T_0$

Being:

- D the level difference in decibels, in the space and time average sound pressure levels produced in two rooms by one or more sound sources in one of them;

- T is the reverberation time in the receiving room;

- T_0 is the reference reverberation time; for dwellings, T_0 = 0,5 s.

Sound reduction index, R

Ten times the common logarithm of the ratio of the sound power, W_1, that is incident on the test element to the sound power, W_2, radiated by the test element to the other side: $R = 10 \log W_1/W_2$

For laboratory measurements using sound pressure, the sound reduction index is calculated using: $R = L_1 – L_2$ 10lg S/A

Where:

- L_1 is the energy average sound pressure level in the source room, in decibels;

- L_2 is the energy average sound pressure level in the receiving room, in decibels;

- S is the area of the free test opening in which the test element is installed, in square metres;

- A is the equivalent sound absorption area in the receiving room, in square metres.

Element-normalized level difference $D_{n,e}$

Level difference corresponding to a reference value of absorption area in the receiving room with sound transmission through the small technical element only: $D_{n,e} = L_1 – L_2 + 10 \log (A_0 / A)$

Where:

- L_1 is the energy average sound pressure level in the source room, in decibels;

- L_2 is the energy average sound pressure level in the receiving room, in decibels;

- A_0 is the reference absorption area, in square metres (for the laboratory, A_0 = 10 m^2);

- A is the equivalent absorption area in the receiving room, in square metres.