ELYSIAN

RESIDENCES

13-15a Alderton Hill, Loughton

Environmental Noise Survey

July 2018

HOARE LEA

Audit Sheet

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Contents

1. Introduction

Hoare Lea Acoustics has been appointed by Elysian Loughton Site Limited to conduct an environmental noise survey in order to support the planning application for the proposed C2 elderly housing development with integrated care facilities at 13, 15 and 15a Alderton Hill, Loughton within the Epping Forest District of Essex.

The proposal comprises the demolition of the houses at 13, 15 and 15a Alderton Hill and the erection of linked blocks of elderly persons apartments with integrated care facilities (use Class C2) with supporting amenity facilities, landscaping, 64 car spaces in under croft car parking at the rear and south side of the block, and associated ground works. The proposal will also include the installation of new mechanical services plant.

An environmental noise survey is required to quantify the existing ambient and background noise levels at the site in order to establish the design constraints on noise emissions from the operation of plant. The noise survey will also provide information required to establish the acoustic performance of the building façade and ventilation strategy to ensure that the internal living accommodation is in accordance with the Local Authority requirements.

This report provides a description of the results from the noise survey undertaken, an assessment to determine the external noise limits for building services plant required to meet the Local Authority's general noise emission limits and advice regarding the building envelope and ventilation strategy.

2. Site Description

2.1 Existing Site

13-15a Alderton Hill is formed of several detached residential dwellings, some of which are disused, and is located to the south of Alderton Hill and east of Roding Road.

The site is bound by the London Underground (Central Line) to the south, with Loughton Station located to the south west. It should be noted that at this point the Central Line runs Overground. In addition, Alderton Hill is predominantly formed of residential dwellings however to the north-west of the site is Roding Valley High School and further to the west is Sainsbury's with associated parking.

The proposed site (indicative only) is identified in Figure 1 overleaf.

2.2 Local Noise Environment

The surrounding noise climate is predominantly formed of road traffic noise from the immediate road network around the site, in particular Alderton Hill to the north.

The surrounding noise climate was observed to include contributions from trains using the London Underground to the south of the site. Train passes were observed to be infrequent (one train in each direction every 5 minutes i.e. two trains every five minutes) with services operating on the Central Line.

Additionally, it should be noted that the noise climate was observed to be influenced by construction noise from the McCarthy & Stone development to the west of the Site. Attempts were therefore made to undertake the surveys during a period of minimal activity to gain an accurate measure of the prevailing noise and vibration levels.

Figure 1: Plan of Existing Site (Indicative Only) © Google Earth

3. Basis of Assessment

3.1 National Planning Policy Framework (NPPF)

The National Planning Policy Framework (1) sets out the Government's current planning policies for England and how these are expected to be applied.

With regards to local noise planning policies, Section 11 paragraph 123 of the NPPF states:

'Planning policies and decisions should aim to:

- Avoid noise from giving rise to significant adverse impacts on health and quality of life as a result of new development;
- Mitigate and reduce to a minimum other adverse impacts on health and quality of life arising from noise from new development, including through the use of conditions;
- Recognise that development will often create some noise and existing businesses wanting to develop in continuance of their business should not have unreasonable restrictions put upon them because of changes in nearby land uses since they were established;
- Identify and protect areas of tranquillity which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason.'

Reference is made to the DEFRA Noise Policy Statement for England 2010 (NPSfE). This latter document is intended to apply to all forms of noise other than that which occurs in the workplace and includes environmental noise and neighbourhood noise in all forms.

The NPSfE advises that the impact of noise should be assessed on the basis of adverse and significant effect but does not provide any specific guidance on assessment methods or limit sound levels. Moreover, the document advises that it is not possible to have 'a single objective noise-based measure…that is applicable to all sources of noise in all situations'. It further advises that the sound level at which an adverse effect occurs is 'likely to be different for different noise sources, for different receptors and at different times'.

In the absence of specific guidance for assessment of environmental noise within the NPPF and the NPSfE, it is considered appropriate to base assessment on current British Standards and national guidance. These are considered to be Local Authority guidance, BS 4142 (2), BS 8233 (3) and the World Health Organisations (4) (WHO) guidelines.

3.2 BS 4142: 2014

Current Government advice to Local Planning Authorities in both England and Wales makes reference to BS 4142 as being the appropriate guidance for assessing commercial operations and fixed building services plant noise. This British Standard provides an objective method for rating the likelihood of complaint from industrial and commercial operations. It also describes means of determining noise levels from fixed plant installations and determining the background noise levels that prevail on a site.

The assessment of impacts is based on the subtraction of the measured background noise level from the rating level determined. The rating level is the source noise level (either measured or predicted) corrected for tone or character (if necessary). The difference is compared to the following criteria to evaluate the impact.

- A difference of around +10 dB or more is likely to be an indication of a significant adverse impact.
- A difference of around +5 dB indicates is likely to be an indication of an adverse impact.
- Where the rating level does not exceed the background noise level, this is an indication of the specific sound source having a low impact.

This method is only applicable for external noise levels.

3.3 BS 8233: Sound Insulation and Noise Reduction for Buildings

BS 8233: 2014 (2) provides guidance for control of noise in and around buildings, and suggests appropriate criteria and limits for different situations. The criteria and limits are primarily intended to guide the design of new or refurbished buildings undergoing a change of use.

Table 4 within BS 8233 provides desirable internal ambient noise levels for spaces in residential dwellings when they are unoccupied.

Activity	**Location**	**Daytime** (0700 to 2300)	**Night-Time** (2300 to 0700)
Resting	Living Room	35 dB $L_{Aeq,16hr}$	-
Dining	Dining Room / Area	40 dB $L_{Aeq,16hr}$	-
Sleeping (Daytime Resting)	Bedroom	35 dB $L_{Aeq,16hr}$	30 dB $L_{Aeq,8hr}$

Table 1: Indoor Ambient Noise Levels in Spaces for Dwellings

Supplementary Note 2 and 4 to Table 4 within BS 8233 are copied below for reference:

"NOTE 2 – the levels shown in Table 4 are based on the existing guidelines issued by the WHO…"

"NOTE 4 – regular individual noise events (for example, schedule aircraft or passing trains) can cause sleep disturbance. A guideline value may be set in terms of SEL or $L_{Amax,F}$ depending on the character and number of events per night."

Guidance provided within the superseded BS 8233: 1999 (5) stated that *"for a reasonable standard in bedrooms at night, individual noise events (measured with F-time weighting) should not normally exceed 45 dB L_{Amax}."* This follows current guidelines issued by the WHO.

3.4 Local Planning Policy

3.4.1 Epping Forest District Council, The Combined Local Plan 1998 & Alterations 2006 Policy Document, February 2008

Epping Forest District Council's Local Plan, adopted in January 1998, sets out a comprehensive framework of policies to enable the Council to control most forms of development within the District. In July 2006, alterations to the Local Plan were issued in order to keep the Local Plan up to date with revised Government guidance. The Combined Local Plan 1998 & Alteration 2006 Policy Document unifies all current policies into a single document.

In respect of noise, the Combined Local Plan contains two relevant policies, *Policy RP5A and Policy DBE9.*

3.4.1.1 Policy RP5A – Adverse Environmental Impacts

Policy RP5A states the following:

"The Council will not grant planning permission for:

(i) development where it would cause excessive noise, vibration, or air, ground water or light pollution for neighbouring land uses, protected wildlife species and habitats; or

(ii) sensitive development such as housing (or other forms of residential occupation, including mobile homes and caravans), hospitals or schools which could be subject to either excessive noise from adjoining land uses or traffic (road, rail and air) or other forms of adverse environmental conditions such as air pollution;

except where it is possible to mitigate the adverse effects by the imposition of appropriate conditions."

3.4.1.2 Policy DBE9 – Loss of Amenity

Policy DBE9 states the following:

"The Council will require that a change or intensification of use, extension or new development does not result in an excessive loss of amenity for neighbouring properties. The factors which will be taken into account are:

(i) Visual impact;

(ii) Overlooking;

(iii) Loss of daylight / sunlight; and

(iv) Noise, smell or other disturbance."

3.4.2 Epping Forest District Council, Local Plan, Submission Version, December 2017.

Epping Forest District Council's Local Plan will replace the Combined Local Plan 1998 & Alterations 2006 Policy Document and sets out the proposed approach and detailed draft policies for the whole District for the period up to 2033.

In respect of noise, the Local Plan contains two relevant policies, *Policy DM 9* and *Policy DM 21.*

3.4.2.1 Policy DM 9 – High Quality Design

Policy DM 8 states the following under the heading *Privacy and amenity:*

"Development proposals must take account of the privacy and amenity of the development's users and neighbours. The council will expect proposals that:

iv. *Address issues of vibration, noise, fumes, odour, light pollution and microclimatic conditions likely to arise from the use and activities of the development."*

3.4.2.2 Policy DM 21 – Local Environmental Impacts, Pollution & Land Contamination

Policy DM 20 states the following:

"A. The council will require that local environmental impacts of all development proposals do not lead to detrimental impacts on the health, safety, well-being and the amenity of existing and new users or occupiers of the development site, or the surrounding land. These potential impacts can include, but are not limited to, air and water (surface and groundwater) pollution, dust, noise, vibration, light pollution, odours, and fumes as well as land contamination.

B. The Council will:

(i) Resist development that leads to unacceptable local environmental impacts, including, but not limited to, air pollution, noise and vibration, light pollution, odours, dust and land and water contamination."

3.5 Proposed Standards

In the absence of specific guidance within the existing and emerging Local Planning Policy, it is deemed appropriate to base the assessment on guidance provided within current British Standards. These are BS 4142: 2014 and BS 8233: 2014.

3.5.1 Building Services – Noise

On the basis of guidance provided within BS 4142: 2014, all building services plant shall be designed to achieve the following noise emission limits.

Description of Noise Source	Noise Emission Limit
Building Services Plant	$L_{Ar,Tr} = L_{A90,T} - 5$ dB

Table 2: Noise Emission Limits for Building Services

Additionally, for plant noise that is tonal, contains a specific character or is intermittent, the limits of Table 2 above need to include a character correction as defined within BS 4142.

3.5.2 Environmental Noise – Internal Noise Levels

On the basis of guidance provided within BS 8233: 2014, the development shall be designed to enable achieved of the internal noise levels stated within Table 3 below.

Location	Daytime (0700 to 2300)	Night-Time (2300 to 0700)
Living Room	35 dB $L_{Aeq,16hr}$	-
Bedroom	35 dB $L_{Aeq,16hr}$	30 dB $L_{Aeq,8hr}$ & 45 dB $L_{Amax,T}$
Dining Rooms	40 dB $L_{Aeq,16hr}$	

Table 3: Internal Noise Levels

4. Environmental Noise Survey

An acoustic survey has been carried out at the site to establish the prevailing environmental noise conditions local to the site, so as to determine building services plant noise emission limits and to advise upon the building envelope and ventilation strategy.

4.1 Methodology

The survey comprised four days of unattended automatic noise measurements at two locations by two noise monitors. The position of these monitors is shown as positions L1 and L2 in Figure 2 below. Measurements at position L1 were considered façade measurements, approximately 2m from the façade, whereas measurements at position L2 were considered “free-field”.

Measurements recorded at both positions consisted of fifteen minute samples of ambient noise levels ($L_{Aeq,15min}$ in dB), maximum noise levels ($L_{Amax,15min}$ in dB) and background noise levels ($L_{A90,15min}$ in dB) between Thursday 11th May 2017 and Monday 15th May 2017.

Sample octave band measurements have also been conducted at three positions. The position of these measurements is shown as positions S1, S2 and S3. These measurements were hand-held samples at a height of 1.2m above ground floor level and considered “free-field”.

Measurements conducted at position S1 were selected to quantify contributions from the Central Line, whereas measurements at positions S2 and S3 were selected to quantify contributions from road traffic on Alderton Hill.

Figure 2: Measurement Positions © Google Earth

The measurement instrumentation used is listed in Appendix A attached and a general acoustic terminology is provided in Appendix B.

During the measurement period, temperatures remained warm with some precipitation and winds varying in both direction and strength.

4.2 Results Summary

A time history of the L_{Aeq}, L_{A90} and L_{Amax} from the unattended measurements recorded at positions L1 and L2 is shown in Appendix C attached.

The results of the unattended measurements at positions L1 and L2 have been calculated into daytime ($L_{Aeq,16hr}$) and night-time ($L_{Aeq,8hr}$) equivalent levels, and are shown with the associated measured minimum background noise level ($L_{A90,T}$) and maximum instantaneous measured noise level ($L_{Amax,T}$) in Table 4 below.

It should be noted that the minimum daytime ($L_{A90,1hr}$) background noise level shown below is the lowest arithmetic average of the measured background noise levels ($L_{A90,15min}$) in an hourly period. Similarly, the maximum events shown in Table 4 are the maximum measured in each corresponding period.

Measurement Date	Time	Position L1						Position L2					
		Daytime			Night-Time			Daytime			Night-Time		
		$L_{Aeq,16hr}$ dB	Min $L_{A90,1hr}$ dB	Max $L_{Amax,T}$ dB	$L_{Aeq,8hr}$ dB	Min $L_{A90,15min}$ dB	Max $L_{Amax,T}$ dB	$L_{Aeq,16hr}$ dB	Min $L_{A90,1hr}$ dB	Max $L_{Amax,T}$ dB	$L_{Aeq,8hr}$ dB	Min $L_{A90,15min}$ dB	Max $L_{Amax,T}$ dB
Thursday 11th May 2017	1215 – 2300	60	40	88	-	-	-	55	39	79	-	-	-
11th / 12th May 2017	2300 – 0700	-	-	-	53	29	85	-	-	-	49	35	72
Friday 12th May 2017	0700 – 2300	61	43	97	-	-	-	55	43	74	-	-	-
12th / 13th May 2017	2300 – 0700	-	-	-	55	30	91	-	-	-	49	36	73
Saturday 13th May 2017	0700 – 2300	61	40	89	-	-	-	55	43	78	-	-	-
13th / 14th May 2017	2300 – 0700	-	-	-	54	32	80	-	-	-	49	38	72
Sunday 14th May 2017	0700 – 2300	60	40	89	-	-	-	54	40	81	-	-	-
14th / 15th May 2017	2300 – 0700	-	-	-	55	31	83	-	-	-	51	37	73
Monday 15th May 2017	0700 – 1545	61	52	81	-	-	-	56	48	87	-	-	-

Table 4: Measured Noise Levels at Positions L1 & L2

As shown in Table 7, noise levels measured by the unattended noise logger at position L1 indicate that the lowest background noise level was $L_{A90,1hr}$ 40 dB during the daytime and $L_{A90,15min}$ 29 dB during the night-time.

A summary of the attended measurements conducted at positions S1, S2 and S3 is provided in Table 5 below.

Measurement Position	**Typical $L_{Aeq,T}$** dB	**Ninetieth Percentile $L_{Amax,T}$** dB
S1	65	72
S2	72	79
S3	62	69

Table 5: Measured Noise Levels at Attended Positions

Full details of the hand-held octave band measurements at all positions during the daytime are shown in the tables within Appendix D attached.

5. Noise Sensitive Areas

A noise sensitive area is defined as landscapes or buildings where the occupiers are likely to be sensitive to noise created by plant installed in the proposed development, including residential areas. The nearest noise sensitive area is therefore identified as the proposed development itself, existing residential dwellings along Brook Road (approximately 20m to the north of the site) and Alderton Hill (immediately to the east of the site boundary) and residential dwellings within the McCarthy & Stone development (immediately to the west of the site boundary), as indicated in Figure 3 below.

Figure 3: Nearest Noise Sensitive Receptor © Google Earth

6. Noise Emissions of Fixed Plant

Noise levels due to building services serving the proposed development are advised to meet the following noise level criteria shown below in Table 6 one metre from the nearest noise sensitive area as identified in Section 6 above. These are based on the lowest background noise levels measured at position L1 which are deemed representative of the nearest noise sensitive receptor.

Period	**Lowest Prevailing Background Noise Level** $L_{A90,T}$ dB	**Noise Emission Limit Calculation** $L_{Ar,Tr}$ dB
Daytime (0700 to 2300)	40	35
Night-Time (2300 to 0700)	29	24

Table 6: Building Services Noise Emission Limits

It should be noted that each of the limits stated above are the combined operational noise levels of plant at the nearest noise sensitive façade. As such, the combined operational noise levels of all plant are required to achieve the noise limits defined above.

For plant noise that is tonal, contains a specific character or is intermittent, the limits of Table 6 above need to include a character correction as defined within BS 4142.

7. Noise Prediction Model

In order to predict the external noise levels present at each façade of the proposed development and to determine a suitable ventilation strategy, a noise map has been created using CADNA environmental noise prediction and mapping software.

A baseline noise map was generated of the existing site using the long term measurements at positions L1 and L2 along with all short term measurements. This model was calibrated for daytime equivalent noise levels ($L_{Aeq,16hr}$), night-time equivalent noise levels ($L_{Aeq,8hr}$) and the maximum ninetieth percentile night-time $L_{Amax,T}$.

The baseline noise map of the existing site during the daytime ($L_{Aeq,16hr}$) and night-time ($L_{Aeq,8hr}$ and $L_{Amax,T}$) at a height of 1.5m above ground floor level are shown in Appendix E attached. A height of 1.5m was chosen as this is the preferred measurement height for environmental noise measurement and thus appropriate for noise prediction.

Subsequently, a noise map was generated of the site with the proposed development in-situ. Appendix F attached displays the noise level map of the proposed development during the daytime ($L_{Aeq,16hr}$) and night-time ($L_{Aeq,8hr}$ and $L_{Amax,T}$) at a height of 1.5m above ground floor level. It should be noted that for the purposes of the modelling exercise, it has been assumed that the McCarthy & Stone development is complete.

Additionally, Appendix G attached displays a three dimensional representation of the noise map prediction for each of the proposed development façades. It should be noted that the noise mapping exercise takes into consideration all noise reflections that may occur off the proposed development and adjacent buildings.

8. Building Envelope & Ventilation Strategy

The sound insulation properties of the building envelope depend upon the external noise levels present at the façade and the proposed design criteria for the internal noise levels of specific rooms, dependant on their use. Table 7 overleaf assumes compliance with the internal noise levels stated in Table 3 and shows the level differences for varying spaces within the proposed development.

The examples shown represent the highest level differences required for each façade as identified in Figures 4 and 5 below and overleaf, based on the predicted data from the noise maps. It should be noted that the highest level difference (D) shown for bedrooms within Table 7 takes precedence.

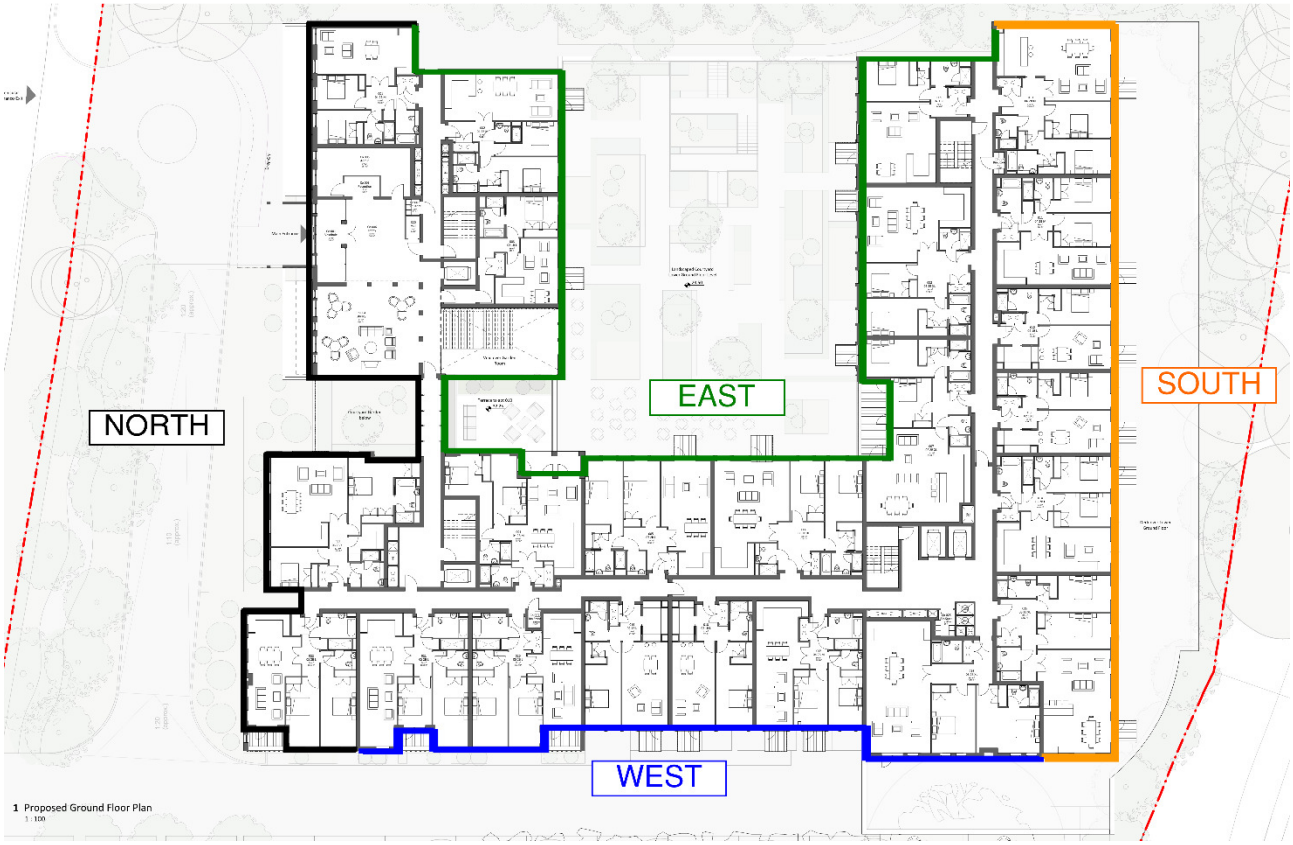


Figure 4: Façade Locations (Levels 0-3)

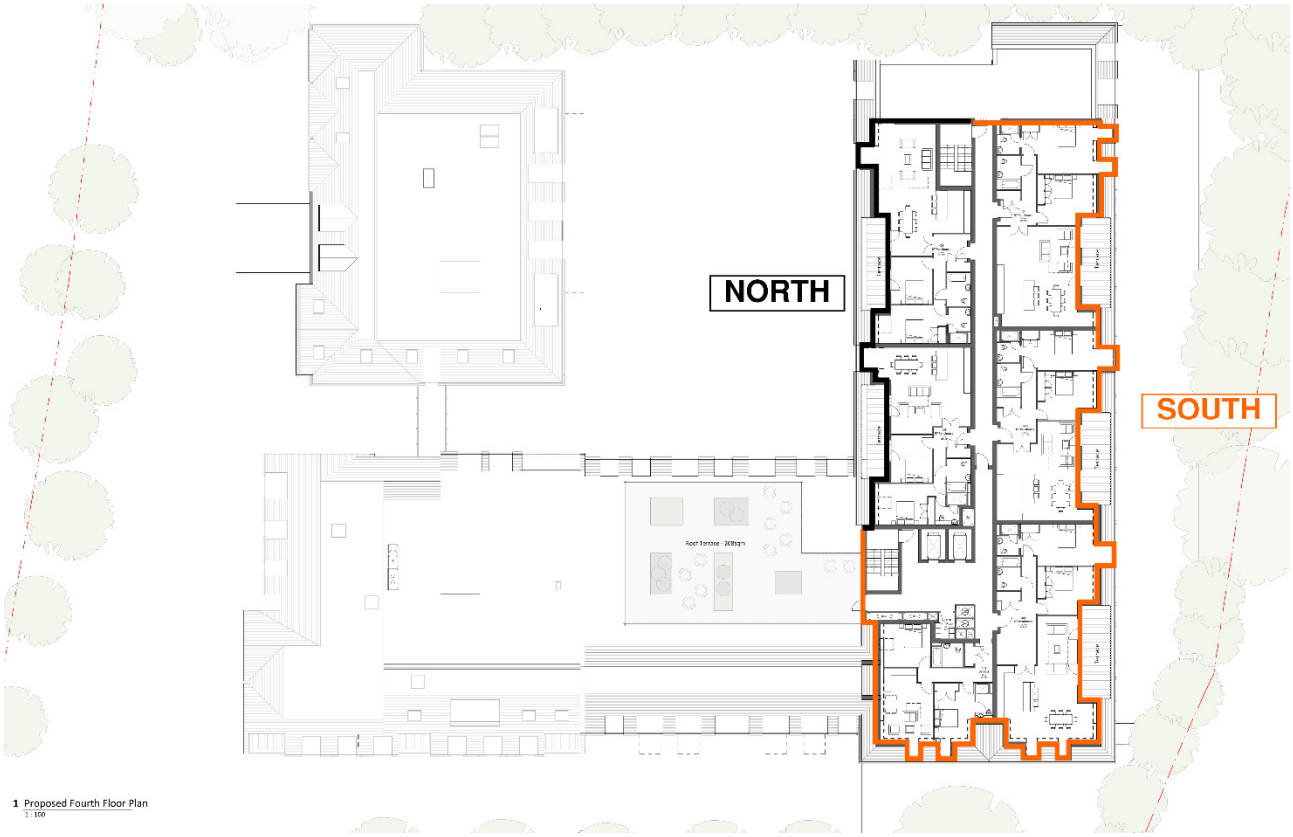


Figure 5: Façade Locations (Level 4)

Façade	Floors	Room Use	Noise Levels (dB)		
			Predicted External	Proposed Internal (Maximum)	Minimum Level Difference D
North	0 – 3	Living Room[1]	64	35	29
		Bedroom[1]	58	30	28
		Bedroom (L_{Amax})[2]	80	45	35
	4	Living Room[1]	50	35	15
		Bedroom[1]	45	30	15
		Bedroom (L_{Amax})[2]	67	45	22
West	All	Living Room[1]	60	35	25
		Bedroom[1]	54	30	24
		Bedroom (L_{Amax})[2]	75	45	30
East	All	Living Room[1]	53	35	18
		Bedroom[1]	47	30	17
		Bedroom (L_{Amax})[2]	70	45	25
South	All	Living Room[1]	62	35	27
		Bedroom[1]	57	30	27
		Bedroom (L_{Amax})[2]	76	45	31

Table 7: Notional Sound Insulation Values of Proposed Façade Construction

Note 1: Living rooms $L_{Aeq,16hr}$ (0700 to 2300) and bedroom $L_{Aeq,8hr}$ (2300 to 0700);

Note 2: Bedrooms $L_{Amax,T}$ (2300 to 0700);

Simple natural ventilation through the use of opening windows will provide a level difference (D) in the order of 10 to 15 dB. It can be seen from Table 7 above that all internal spaces, with the exception of rooms on the Courtyard façades require greater levels of sound insulation based on the measured external noise levels.

As stated previously, the values stated in Table 7 are based on the highest level predicted at each façade. More refined analysis indicates that natural ventilation via opening windows can be provided to the following apartments (as identified in Figure 6 below), whilst enabling achievement of the internal noise levels stated in Table 3 above:

Lower Ground Floor:
- B001;
- Guest Suite;
- B002; &
- B003.

Ground Floor:
- 002;
- 003;
- 004;
- 005;
- 006;

First Floor:
- 102 – living room only;
- 103 – living room only;
- 106 – living room only;
- 107 – living room only;
- 108 – living room only;
- 109 – living room only; &

Second Floor:
- 203 – living room only;
- 206 – living room only;
- 207 – living room only;
- 208 – living room only;
- 209 – living room only; &

- 007;
- 008; &
- 009.
- 110 – living room only.
- 210 – living room only.

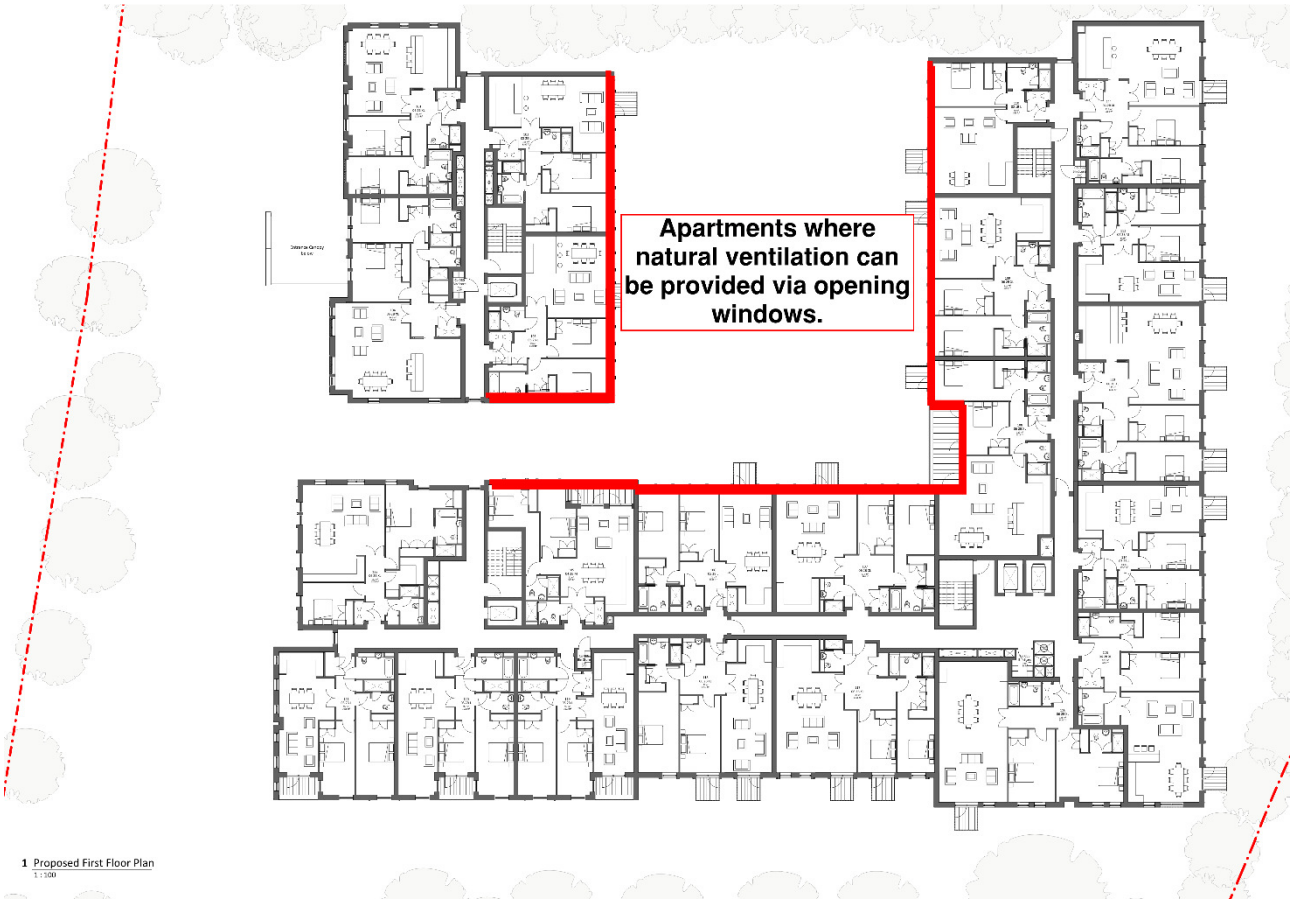


Figure 6: Apartments where Natural Ventilation can be provided via Opening Windows

As such, with the exception of those apartments identified, provision for alternative forms of ventilation will need to be made such that windows are not required to be opened for ventilation purposes. It should be noted that windows may be openable for purge ventilation within all apartments.

Table 8 overleaf details the minimum required $R_w + C_{tr}$ of all window elements (glazing, seals, frames etc.) to each room on each façade.

Façade	Floor	Minimum Required $R_w + C_{tr}$ (dB)	
		Living Room	Bedroom
North	0 – 3	29*	36
	4	15*	22*
West	All	25*	30*
East	All	18*	25*
South	All	27*	31*

Table 8: Minimum Required $R_w + C_{tr}$ of Glazed Elements

*Note *: Achievable with a standard thermal double-glazing unit.*

It should be noted that at this stage it is assumed that the non-glazed element on all façades will be capable of achieving a sound reduction of 46 dB $R_w + C_{tr}$. An example of an external wall capable of achieving this requirement is a 100mm cavity wall construction.

Examples of primary glazing configurations capable of achieving the minimum required $R_w + C_{tr}$ detailed within Table 8 are provided below:

- $R_w + C_{tr}$ 28 dB – 6mm glass, 16mm air gap, 4mm glass.
- $R_w + C_{tr}$ 32 dB – 10mm glass, 16mm air gap, 6mm glass.
- $R_w + C_{tr}$ 36 dB – 8mm glass, 16mm air gap, 10.4mm acoustic glass.

It should be noted that at this stage the required glazing sound insulation values have been based on a level difference comparison only. Detailed calculations will be required to be undertaken to determine refined glazing requirements once finalised plant and room values are available. As such, the sound insulation values stated within Table 8 are indicative and for guidance purposes only.

8.1 Compliance

In order to confirm the suitability of the proposed glazed and non-glazed elements, evidence of the laboratory sound insulation performance will be required for the entire unit as it will be installed (including glass, frame, seals, mullions and transoms). All acoustic testing shall be undertaken in controlled laboratory conditions in accordance with BS EN 140-3: 1995, BS 2750-3: 1995 Acoustics – *"Measurement of Sound Insulation in Buildings and of Building Elements. Part 3: Laboratory Measurement of Airborne Sound Insulation of Building Elements."* (6)

9. Summary and Conclusions

Hoare Lea Acoustics has conducted an environmental noise survey for the proposed C2 elderly housing development with integrated care facilities at 13, 15 and 15a Alderton Hill, Loughton within the Epping Forest District of Essex. Unattended noise monitoring throughout a typical four-day period and sample octave band measurements were conducted.

Background noise levels typical of the daytime and night-time have been measured and used to define building services plant noise emission limits at the nearest noise sensitive receptors. The nearest receptors have been identified as the proposed development itself, existing residential dwellings along Brook Road and Alderton Hill and residential dwellings within the McCarthy & Stone development.

During the daytime the combined building services plant noise emission contribution limit advised is 35 dB(A) and during the night-time the combined building services plant noise emission contribution limit advised is 24 dB(A), one metre from the nearest residential façade.

An assessment of the building envelope acoustic performance is provided with the minimum level difference (D) in accordance with the internal ambient noise levels stated within BS 8233: 2014. Several rooms have been identified as being capable of achieving the internal ambient noise levels with ventilation via opening windows. With the exception of these rooms, the ventilation strategy should allow for full mechanical ventilation of all spaces as the level differences required are above those achievable by simple means of natural ventilation.

Notional glazing requirements for varying internal spaces and indicative primary glazing configurations have been provided however, it should be noted that these performances are for guidance purposes only. Detailed calculations will be required to be undertaken to determine refined glazing requirements once finalised plans and room volumes are available.

The guidance provided within this report is sufficient to satisfy the requirements of the Epping Forest District Council, in our opinion.

10. References

1. ***National Planning Policy Framework, Department for Communities and Local Government, March 2012.***
2. ***BS 4142: 2014: 'Method for rating industrial and commercial sound'.***
3. ***BS 8233: 2014, "Guidance on Sound Insulation and Noise Reduction for Buildings", BSI.***
4. ***World Health Organisation (WHO) - Guidelines for Community Noise, 1999.***
5. ***BS 8233: 1999, 'Sound Insulation and Noise Reduction for Buildings - Code of Practice'.***
6. ***BS EN 140-3:1995, BS 2750-3:1995 Acoustics – "Measurement of Sound Insulation in Buildings and of Building Elements. Part 3: Laboratory Measurement of Airborne Sound Insulation of Building Elements".***

Appendix A: List of Measurement Equipment

Environmental Noise Survey

Sound Level Meter (Position L1 – Unattended)

- Rion NL-31 Sound Level Meter (Serial Number 00431026)
- Rion NH-21 Pre-Amplifier (Serial Number 21973)
- Rion NC-74 Sound Calibrator (Serial Number 34172704)
- Rion UC-53A Microphone (Serial Number 311039)

Sound Level Meter (Position L2 – Unattended)

- Rion NL-32 Sound Level Meter (Serial Number 01161938)
- Rion NH-21 Pre-Amplifier (Serial Number 21976)
- Rion NC-74 Sound Calibrator (Serial Number 34172704)
- Rion UC-53A Microphone (Serial Number 311043)

Noise Spectral Analyser (Octave Band Measurements at all Positions)

- Brüel and Kjær 2250 Sound Level Meter (Serial Number 3002554)
- Brüel and Kjær 2C0032 Pre-Amplifier (Serial Number 19475)
- Brüel and Kjær 4231 Sound Calibrator (Serial Number 1771159)
- Brüel and Kjær 4189 Microphone (Serial Number 2887250)

Sound level meters were field calibrated before and after noise survey and no discernible variations occurred.

Appendix B: Acoustic Terminology

Sound
Sound is produced by mechanical vibration of a surface, which sets up rapid pressure fluctuations in the surrounding air.

The Sound Pressure
The Sound Pressure is the force (N) of sound on a surface area (m2) perpendicular to the direction of the sound. The SI-units for the Sound Pressure are Nm-2 or Pa (Pascal).

Sound is measured with microphones responding proportionally to the sound pressure – p. The power is proportional to the square of the sound pressure.

The Sound Pressure Level
The human ear has an approximately logarithmic response to sound pressure over a very large dynamic range. The lowest audible sound pressure approximately 2 x 10-5 Pa (2 ten billionths of an atmosphere) and the highest is approximately 100 Pa.

It is therefore convenient to express the sound pressure as a logarithmic decibel scale related to this lowest human audible sound, where:

$$L_p = 10 \log\left(\frac{p^2}{p_{ref}^2}\right) = 10 \log\left(\frac{p}{p_{ref}}\right)^2 = 20 \log\left(\frac{p}{p_{ref}}\right)$$

Where:
L_p = sound pressure level (dB)
p = sound pressure (Pa)
p_{ref} = 2 x 10-5 – reference sound pressure (Pa)

In accordance with the logarithmic scale, doubling the sound pressure level gives an increase of 6 dB.

Decibel (dB)
The decibel is the unit used to quantify sound pressure levels as well as sound intensity and power levels.

In accordance with the logarithmic scale, an increase of 10 dB in sound pressure level is equivalent to an increase by a factor of 10 in the sound pressure level (measured in Pa). Subjectively, this increase would correspond to a doubling of the perceived loudness of the sound.

Sound Pressure Level of Some Common Sources
An indication of the range of sound levels commonly found in the environment is given in the following Table.

Source	Sound Pressure Level dB
Threshold of Hearing	0
Rustling Leaves	20
Quiet Whisper	30
Home	40
Quiet Street	50
Conversation	60
Inside a Car	70
Loud Singing	80
Motorcycle (10m)	90
Lawn Mower (1m)	100
Diesel Truck (1m)	110
Amplified Music (1m)	120
Jet Plane (1m)	130

Frequency
The rate at which the pressure fluctuations occur determines the pitch or frequency of the sound. The frequency is expressed in Hertz (Hz) or cycles per second.

Octave and Third Octave Bands
An octave is the interval between two points where the frequency at the second point is twice the frequency of the first.

There are many methods of describing the frequency content of a noise. The most common methods split the frequency range into defined bands, in which the mid-frequency is used as the band descriptor and in the case of octave bands is double that of the band lower. For example, two adjacent octave bands are 250 Hz and 500 Hz.

Third octave bands provided a fine resolution by dividing each octave band into three bands. For examples, third octave bands would be 160 Hz, 250 Hz and 315 Hz for the same 250 Hz octave band.

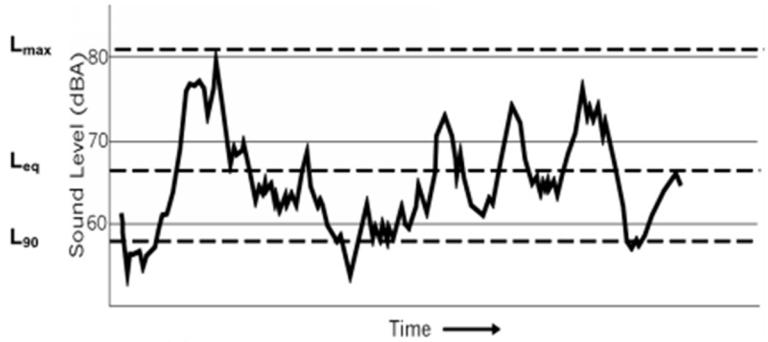
The human ear is sensitive to sound over a range of frequencies between approximately 20 Hz to 20 kHz and is generally more sensitive to medium and high frequency than to low frequencies within the range. This is the basis of the A-weighting.

A-Weighting
The A-weighting is a correction term applied to the frequency range in order to mimic the sensitivity of the human ear to noise. It is generally used to obtain an overall noise level from octave or third octave band frequencies.

An A weighted value would be written as dB(A), or including A within the parameter term.

Noise Units
In order to assess environmental noise, measurements are carried out by sampling over specific periods of time, such as five minutes, the statistically determined results being used to quantify various aspects of the noise.

The figure below shows an example of sound level varying with time. Because of this time variation the same period of noise can be described by several different levels. The most common of these are described below.



$L_{eq,T}$
The $L_{eq,T}$ is a parameter defined as the equivalent continuous sound pressure level over a defined time period 'T'. It is the sound pressure level equivalent to the acoustic energy of the fluctuating sound signal.

The $L_{eq,T}$ can be thought of as an 'average' sound pressure level over a given time period (although it is not an arithmetic average). Typically the $L_{eq,T}$ will be an A-weighted noise level in dB(A) and is commonly used to describe all types of environmental noise sources.

$L_{01,T}$
The $L_{01,T}$ is a parameter defined as the sound pressure level exceeded for 1% of the measurement period 'T'.

It is a statistical parameter and cannot be directly combined to other acoustic parameter.

$L_{10,T}$
The $L_{10,T}$ is a parameter defined as the sound pressure level exceeded for 10% of the measurement period 'T'.

It is a statistical parameter and cannot be directly combined to other acoustic parameter and is generally used to describe road traffic noise.

$L_{90,T}$
The $L_{90,T}$ is a parameter defined as the sound pressure level exceeded for 90% of the measurement period 'T'.

It is a statistical parameter and cannot be directly combined to other acoustic parameter and is generally used to describe the prevailing background noise level.

$L_{max,T}$
The $L_{max,T}$ is a parameter defined as the maximum noise level measured during the specified period 'T'.

Specific Noise Level, $L_{Aeq,Tr}$
This is the equivalent continuous A-weighted sound pressure level at the assessment position due to a specific noise source operating over a given time interval.

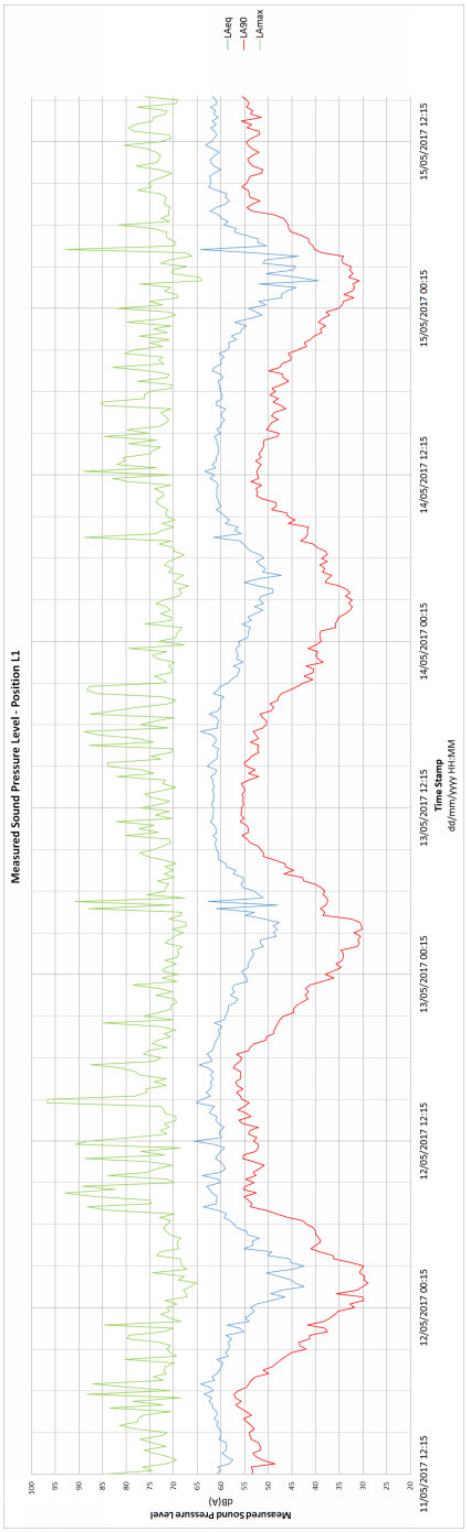
Free Field
A measurement taken in the free field is at least 3.5m from reflecting vertical surfaces and 1.2m from the ground.

Façade
A measurement is influenced by the reflection of sound from the façade of a building within 3.5m. A façade measurement is made 1m in front of the vertical building surface.

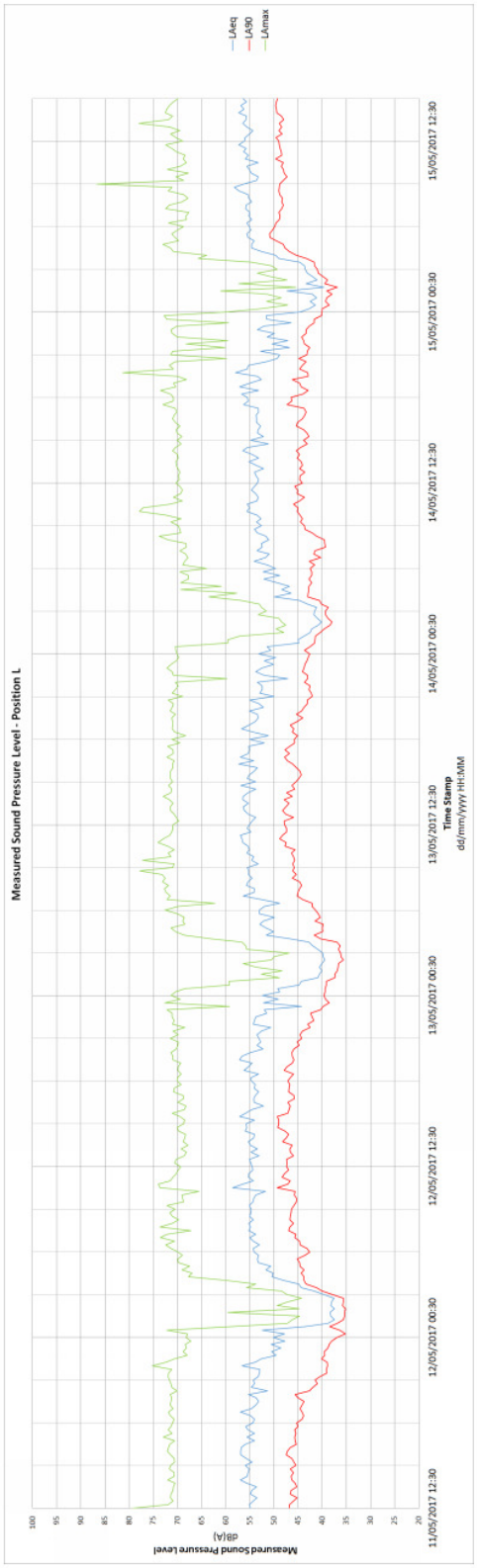
R_w
A single-number quantity which characterizes the airborne sound insulation of a material or building element in the laboratory. See BS EN ISO 717-1: 1997.

Appendix C: Time History of Unattended Measurement

Position L1



Position L2


LAeq
LA90
LAmax
Measured Sound Pressure Level - Position L
Measured Sound Pressure Level
dB(A)
Time Stamp
dd/mm/yyyy HH:MM
11/05/2017 12:30
12/05/2017 00:30
12/05/2017 12:30
13/05/2017 00:30
13/05/2017 12:30
14/05/2017 00:30
14/05/2017 12:30
15/05/2017 00:30
15/05/2017 12:30

Appendix D – Octave Band Levels at Measurement Positions

Position	Measurement Period	Duration	Sound Pressure Level per Octave Band Frequency in dB										$L_{Aeq,T}$
			16Hz	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	dB
S1	11/05/2017 12:28	00:00:21	58.5	59.9	66.0	58.3	55.8	56.7	51.6	46.7	45.5	39.8	57.1
	11/05/2017 12:29	00:00:15	66.1	66.9	72.6	68.1	63.6	65.4	58.4	52.5	52.4	57.2	65.4
	11/05/2017 12:33	00:00:20	58.2	61.3	64.7	58.1	57.2	56.9	50.9	46.8	45.6	39.7	57.2
	11/05/2017 12:39	00:00:17	62.2	60.7	64.5	59.1	57.3	57.3	51.2	47.6	47.0	40.2	57.7
	11/05/2017 12:39	00:00:14	66.6	68.8	72.4	68.8	64.7	67.3	58.3	53.2	52.3	55.5	66.2
	11/05/2017 12:41	00:00:14	68.4	67.6	72.2	68.2	64.5	67.9	58.0	55.4	58.1	65.9	68.9
S2	11/05/2017 12:44	00:00:10	68.3	71.5	73.0	67.6	66.7	66.2	67.6	62.9	54.6	48.5	70.8
	11/05/2017 12:45	00:00:07	75.6	82.1	84.2	68.1	68.4	67.9	69.7	65.6	57.5	48.3	72.8
	11/05/2017 12:45	00:00:13	65.5	73.8	72.7	65.1	66.5	66.5	69.7	64.6	53.7	45.6	72.1
	11/05/2017 12:45	00:00:06	65.6	69.8	76.7	65.4	65.7	66.8	69.8	65.1	52.8	43.1	72.3
	11/05/2017 12:46	00:00:14	61.8	69.1	73.3	68.4	66.2	66.3	68.2	62.9	55.2	48.6	70.9
	11/05/2017 12:46	00:00:10	66.4	69.3	72.2	70.6	67.5	68.2	69.6	64.2	54.4	46.9	72.3
S3	11/05/2017 12:48	00:00:07	63.5	66.9	73.6	66.0	59.6	57.7	60.1	53.6	43.2	31.6	62.8
	11/05/2017 12:48	00:00:07	59.6	68.2	72.7	65.3	63.5	62.1	60.9	55.5	48.5	41.6	64.7
	11/05/2017 12:49	00:00:22	60.6	65.7	71.7	59.4	55.4	54.0	54.5	49.6	41.2	33.5	57.9
	11/05/2017 12:49	00:00:13	57.6	62.4	71.1	62.7	55.9	53.6	55.1	49.5	40.9	33.2	58.3
	11/05/2017 12:50	00:00:12	59.4	64.9	71.0	60.4	56.0	55.2	58.7	53.6	43.6	33.7	61.2

Table 9: Ambient Levels Measured at all Positions

Position	Measurement Period	Duration	Sound Pressure Level per Octave Band Frequency in dB										$L_{Amax,T}$
			16Hz	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	dB
S1	11/05/2017 12:28	00:00:21	61.7	64.9	71.8	64.5	60.5	61.4	56.7	50.0	51.0	47.9	60.5
	11/05/2017 12:29	00:00:15	69.4	71.1	78.2	73.7	70.0	70.3	63.0	56.9	58.1	66.3	69.7
	11/05/2017 12:33	00:00:20	62.0	63.8	69.7	63.3	61.3	60.6	55.3	50.4	49.3	45.4	59.6
	11/05/2017 12:39	00:00:17	66.3	63.9	68.9	64.5	63.2	60.3	55.1	50.0	50.4	42.3	59.8
	11/05/2017 12:39	00:00:14	69.5	73.4	78.3	75.3	70.1	72.8	63.0	56.9	58.3	65.8	70.3
	11/05/2017 12:41	00:00:14	72.2	72.6	77.4	74.5	69.4	72.8	62.9	61.1	64.4	73.3	73.2
S2	11/05/2017 12:44	00:00:10	73.7	78.4	78.9	75.3	73.8	73.2	74.2	68.2	62.2	56.9	76.0
	11/05/2017 12:45	00:00:07	81.9	90.6	91.4	75.6	74.7	74.4	74.3	70.6	65.8	55.0	77.5
	11/05/2017 12:45	00:00:13	69.8	82.4	82.2	70.4	70.9	72.4	73.8	68.9	59.5	54.1	76.9
	11/05/2017 12:45	00:00:06	68.4	73.2	84.3	70.6	72.7	75.5	75.9	70.8	59.1	50.5	78.2
	11/05/2017 12:46	00:00:14	66.8	74.9	81.4	75.6	74.1	72.6	74.1	68.1	63.0	56.6	76.2
	11/05/2017 12:46	00:00:10	71.9	75.4	77.6	80.1	75.2	77.0	76.3	70.7	63.2	56.3	78.9
S3	11/05/2017 12:48	00:00:07	66.0	70.7	78.7	71.5	63.3	62.6	65.6	57.7	49.8	35.1	67.2
	11/05/2017 12:48	00:00:07	63.1	70.5	76.9	72.5	72.2	70.7	66.2	60.8	55.7	51.1	70.5
	11/05/2017 12:49	00:00:22	67.5	73.1	78.5	65.8	60.9	62.0	59.8	55.2	47.5	43.7	64.2
	11/05/2017 12:49	00:00:13	60.5	65.4	75.8	69.5	61.5	59.7	61.7	56.3	47.7	41.6	63.5
	11/05/2017 12:50	00:00:12	62.9	68.2	75.6	65.2	62.3	61.4	66.4	59.4	49.0	41.0	67.6

Table 10: Maximum Levels Measured at all Positions

Appendix E – Noise Map of Existing Baseline Site at 1.5m Above Ground Floor Level

Daytime $L_{Aeq,16hr}$