

1 Technical Note – Sound Insulation Assessment

Introduction

- 1.1 Mayer Brown Limited has been instructed by Bloor Homes to prepare this Technical Note, which assesses the acoustic design of their development proposals for Phase 3B of the “Berewood” development in Waterlooville.
- 1.2 Outline planning consent for the development was granted by Winchester City Council (ref. 10/02862/OUT) in March 2012. Condition 16 of the Outline Planning Permission requires that:

“No relevant phase of the development hereby permitted shall commence until a scheme for protecting dwellings and their gardens from noise from the London Road has been submitted to and approved in writing by the local planning authority. Those dwellings shall not be occupied until the implementation of all works forming part of such approved noise protection scheme has been completed in full accordance with all detailed components of such scheme.”

- 1.3 The site is located approximately 140m west of the A3 (London Road) as shown in **Figure 1.1** below;



Figure 1.1: Site Location

1.4 The location of Phase 3B relative to the wider development site is shown in **Figure 1.2** below;



Figure 1.2: Berewood Site Phasing Plan

1.5 The proposed general arrangement of Phase 3B is presented in **Figure 1.3** below;

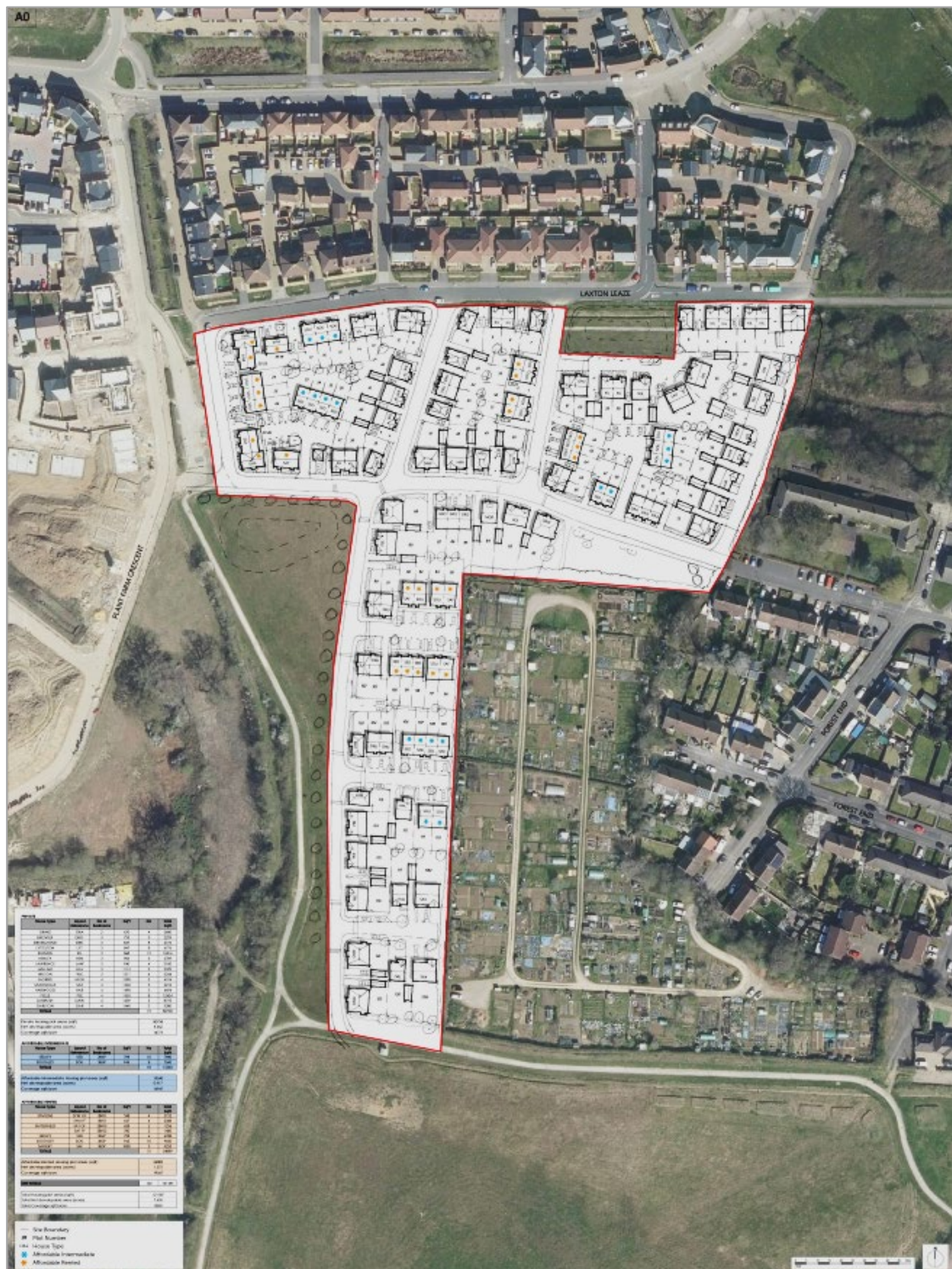


Figure 1.3: Phase 3B Berewood – Site Layout

2 Design Criteria and Assessment Methodology

2.1 Whilst the reason for Condition 16 is clear (i.e. “*protecting dwellings and their gardens from noise from the London Road*”) the condition does not make any specific reference to noise intrusion design targets or recommendations for external amenity areas.

2.2 The review presented in this Technical Note has therefore been informed by the guidance set out in:

- BS 8233: 2014: “*Guidance on Sound Insulation and Noise Reduction for Buildings*”; and
- “*ProPG: Planning & Noise – Professional Practice Guidance on Planning & Noise - New Residential Development*” published by the Association of Noise Consultants, Institute of Acoustics and Chartered Institute of Environmental Health, May 2017.

2.3 Both documents are referenced in paragraph 015, Reference ID: 30-015-20190722 of the Government’s Planning Practice Guidance¹.

[BS 8233: 2014 Sound Insulation and Noise Reduction for Buildings](#)

2.4 BS 8233: 2014 *Sound Insulation and Noise Reduction for Buildings* offers the following design guidance for indoor ambient noise levels within dwellings:

Activity	Location	07.00 to 23.00 hours	23.00 to 07.00 hours
Resting	Living Room	35dB L _{Aeq,16hour}	--
Dining	Dining Room/Area	40dB L _{Aeq,16hour}	--
Sleeping (daytime resting)	Bedroom	35dB L _{Aeq,16hour}	30dB L _{Aeq,8hour}

Table 2.1: BS 8233 Indoor Ambient Noise Level Design Guidance

2.5 A note accompanying the above table states:

“Regular individual noise events (for example, scheduled 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. Sporadic noise events could require separate values.”

2.6 The planning condition also makes reference to noise levels in external amenity spaces. Section 7.7.3.2 of BS 8233: 2014 states:

¹ <https://www.gov.uk/guidance/noise--2>

“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

ProPG: Professional Practice Guidance on Planning and Noise

- 2.7 “ProPG: Professional Practice Guidance on Planning Noise: New Residential Development” was published in May 2017. The guidance was authored by the Chartered Institute of Environmental Health (CIEH), Institute of Acoustics (IOA) and Association of Noise Consultants (ANC) and seeks to consolidate and standardise existing industry good practice in order to expedite the planning process with regard to the consideration of noise.
- 2.8 The guidance essentially promotes a two-stage assessment process to determine the suitability of a site for residential development and an appropriate noise mitigation strategy for addressing potential noise constraints.
- 2.9 A “Stage 1” assessment considers the initial noise “risk” of the site.
- 2.10 “Stage 2” of the ProPG guidance requires consideration of four key elements:
- **Element 1** – Good Acoustic Design Process
 - **Element 2** – Internal Noise Level Guidelines
 - **Element 3** – External Amenity Area Noise Assessment
 - **Element 4** – Assessment of Other Relevant Issues
- 2.11 Element 1 (Good Acoustic Design Process) encourages the development of sites with due regard to the following hierarchy of mitigation strategies:
- Reducing noise “at source”;
 - Providing “buffer” zones to limit noise exposure;
 - Reducing noise propagation across site (e.g. through the use of barriers);
 - Developing the layout of the site to optimise acoustic protection (e.g. through the use of “barrier” blocks to help further limit noise propagation and the use of courtyard style development to protect external amenity areas);

- The orientation/general internal arrangement of buildings (e.g. by locating non-habitable rooms on 'noisier' facades and more sensitive uses on acoustically screened facades); and
- Providing buildings with appropriate sound insulation through the specification of appropriate external fabric constructions (in particular windows) and providing appropriate alternative means of ventilation if acceptable internal noise levels cannot be achieved if windows are open.

2.12 In relation to Element 2 (Internal Noise Design Targets), Figure 2 of ProPG makes the following design recommendations:

ACTIVITY	LOCATION	07:00 – 23:00 HRS	23:00 – 07:00 HRS
Resting	Living room	35 dB $L_{Aeq,16\text{ hr}}$	-
Dining	Dining room/area	40 dB $L_{Aeq,16\text{ hr}}$	-
Sleeping (daytime resting)	Bedroom	35 dB $L_{Aeq,16\text{ hr}}$	30 dB $L_{Aeq,8\text{ hr}}$ 45 dB $L_{Amax,F}$ (Note 4)

Figure 2.2: ProPG Internal Noise Level Design Guidance

2.13 The above recommendations are accompanied by a number of notes. Of particular relevance are:

- **Note 4** – which clarifies that the recommended $L_{Amax,fast}$ value should not normally be exceeded 10 times per night; and
- **Note 5** – which states “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....”.

2.14 In relation to Element 3 (External Amenity Area Noise Assessment), the following guidance is given:

“The acoustic environment of external amenity areas that are an intrinsic part of the overall design should always be assessed and noise levels should ideally not be above the range 50 – 55 dB $L_{Aeq,16hr}$.

These guideline values may not be achievable in all circumstances where development might be desirable. In such a situation, development should be designed to achieve the lowest practicable noise levels in these external amenity spaces.”

- 2.15 Element 4 (Assessment of Other Relevant Issues) does not set out any quantitative technical guidance, but requires consideration of *“issues that should be considered about the noise aspects of a particular planning proposal for new residential development”*.

3 Existing Noise Environment

DEFRA Noise Mapping

- 3.1 Noise mapping of the strategic road and rail network is published by DEFRA to discharge the Government's obligations in relation to European Noise Directive (2002/49/EC), (which is transposed into English law by the Environmental Noise (England) Regulations 2006, as amended). The mapping provides noise contours for major roads and railways (major roads are those classified with more than 3,000,000 vehicle passages per year and for major railways, with more than 30,000 train movements per year).
- 3.2 The mapping of road traffic noise uses the calculation methodology set out in "*Calculation of Road Traffic Noise*" (CRTN), published by the Department of Transport (Welsh Office) (1988).
- 3.3 The latest mapping for roads was produced in 2017. All mapping is available at www.extrium.co.uk.
- 3.4 **Figures 3.1 and 3.2** below show the location of Phase 3B and published daytime ($L_{Aeq,16hour}$) and night-time ($L_{Aeq,8hour}$) noise contours for the A3 (London Road);

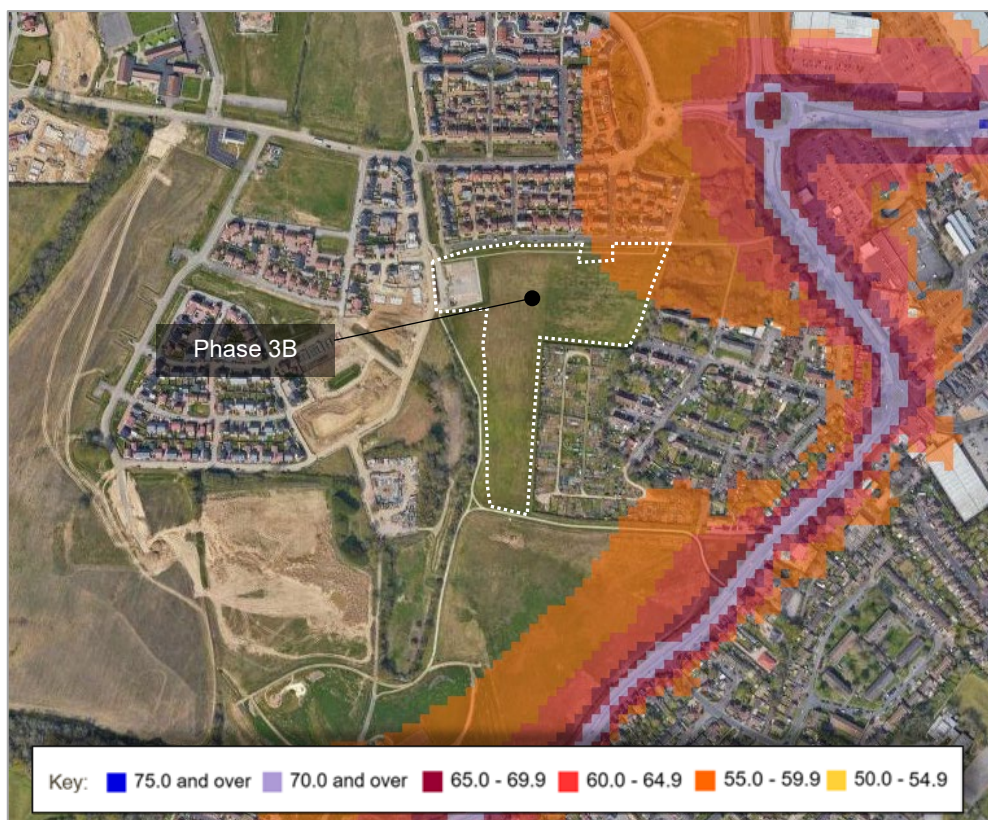


Figure 3.1: DEFRA Daytime $L_{Aeq, 16hour}$ – Road Traffic Noise

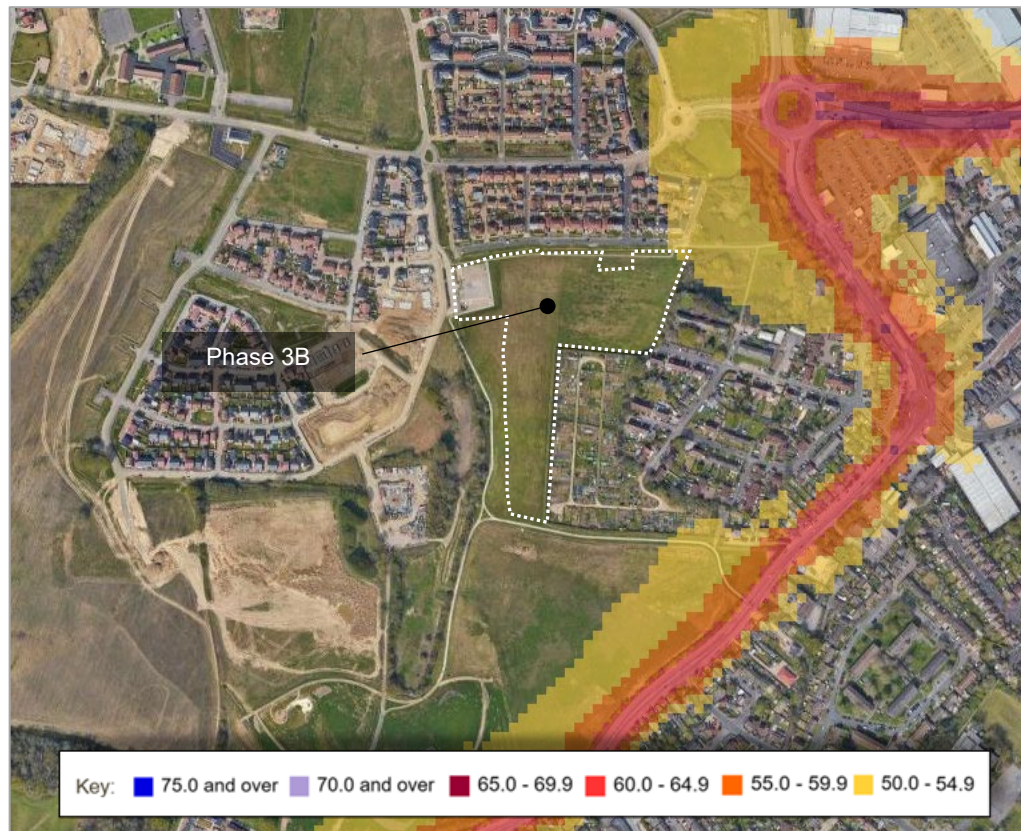


Figure 3.2: DEFRA Night-Time $L_{Aeq, 8hour}$ – Road Traffic Noise

- 3.5 **Figure 3.1** shows that daytime noise levels are modest with a small part of the north eastern area of the site within the 55dB – 59dB $L_{Aeq, 16hour}$ contour. The “worst case” sound level at the north-eastern corner of the site is estimated to be around 57dB $L_{Aeq, 16hour}$.
- 3.6 **Figure 3.2** shows that night-time noise levels are also modest and the “worst case” sound level at the north-eastern corner of the site is essentially contiguous with the 50dB $L_{Aeq, 8hour}$ noise contour.
- 3.7 Notwithstanding the above, there are a number of matters which require further consideration when interpreting the DEFRA mapping.
- 3.8 First, it should be noted that DEFRA contours are based on a assumed calculation grid height of 4m. When considering daytime noise levels (in the context of BS 8233: 2014 and ProPG guidance), it is usual to consider noise levels at a height of 1.5m. It can be reasonably assumed that noise levels at a height of 1.5m will be around 1dB(A) lower than the DEFRA values reported at 4m.
- 3.9 Second, it is clear from the shape of the contours presented by DEFRA that the modelling does not take into account the presence of other development phases on the site (presumably such development was not committed or built out at the time the modelling

was undertaken). This is an important consideration given that the presence of buildings will provide inherent mitigation, i.e. buildings will help act as “barrier blocks” which impede sound propagation across the site and/or reduce the ‘angle of view’ to the road (which will also result in lower noise levels). With regard to Phase 3B, it is estimated that development now built out within the Phase 1 area of the strategic site, will reduce noise propagation by around 2-3dB relative to the contours published by DEFRA.

- 3.10 Combining the matters discussed above, it is estimated that current noise levels characterising the eastern boundary of the Phase 3B development around will be around 3 - 4dB lower than indicated by the DEFRA noise mapping.
- 3.11 It is, therefore, estimated that daytime traffic noise from the London Road at the closest point on the boundary of Phase 3B will be in the order of 53-54dB $L_{Aeq,16\text{hour}}$ daytime and 46-47dB $L_{Aeq,8\text{hour}}$ night-time.

A further point to note is that the CRTN calculation methodology assumes a positive wind vector (i.e. an assumed wind direction blowing from the road towards the noise receptor). It is noted that Phase 3B lies to the east of the A3. Given that the prevailing wind direction for the site is from the south-west quadrant (as shown in the wind rose presented in **Figure 3.3** below), it follows that the DEFRA noise modelling is likely to ‘over-estimate’ noise levels characterising the site under normal prevailing meteorological conditions. Notwithstanding this, the assessment presented in this Technical Note assumes a precautionary approach based on the DEFRA modelling output.

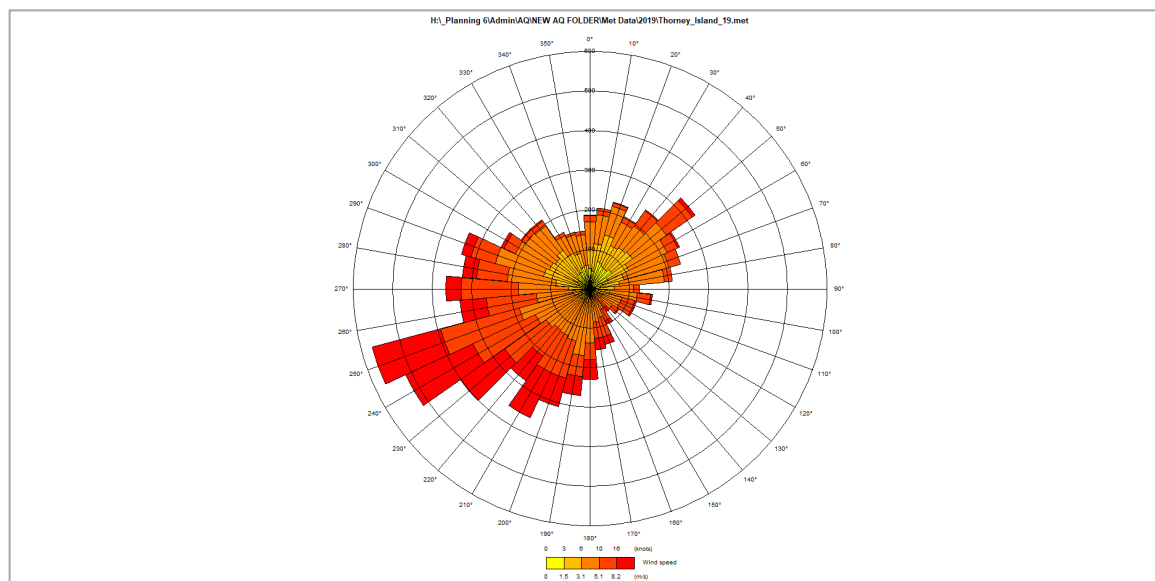


Figure 3.3: Wind Rose 2019 for Thorney Island Meteorological Station

4 ProPG – Stage 1 Noise Risk Assessment

- 4.1 As noted earlier, ProPG guidance is intended to assist with determining the suitability of sites for residential development to protect them against general transport related noise sources. Whilst the granting of outline planning permission by WCC demonstrates the wider suitability of the Berewood Development for residential use, the images below present a more detailed assessment of the noise “risk” of the Phase 3B, in line with ProPG Stage 1 guidance.
- 4.2 **Figures 4.1** and **4.2** below and overleaf present images from the an online tool² which combines the DEFRA noise mapping data for road and rail noise overlayed with the ProPG noise “risk” scale;

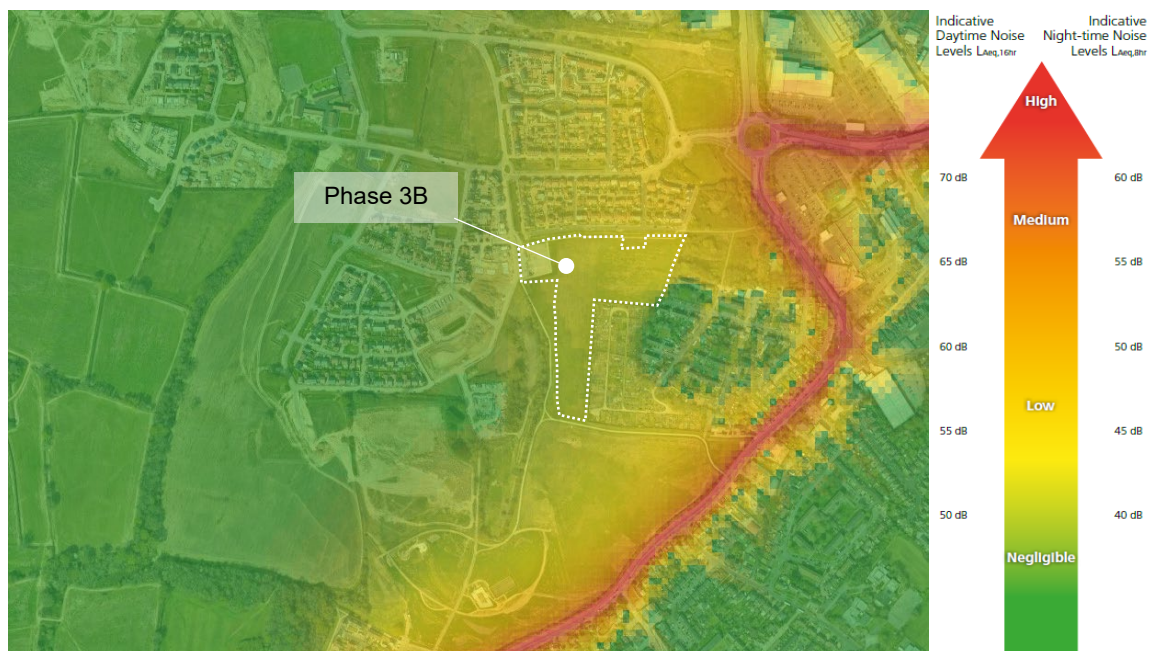


Figure 4.1: ProPG Stage 1 Assessment of Daytime Noise Levels ($L_{Aeq,16\text{hour}}$)

- 4.3 The above figures shows that Phase 3B is categorised as having a a “negligible to low” initial daytime noise risk.
- 4.4 **Figure 4.2** overleaf shows the night-time noise risk for the site.

² Noise Consultants Limited – Site Suitability Indicator <https://ssi.noiseconsultants.co.uk/#>



Figure 4.2: ProPG Stage 1 Assessment of Daytime Noise Levels ($L_{Aeq,16hour}$)

- 4.5 The above figures shows that Phase 3B is generally categorised as having a “low” initial night-time noise risk.
- 4.6 As noted earlier, an initial assessment of the traffic noise magnitude from the London Road suggests noise levels at the closest boundary of the site may be in the order of be in the order of 53 - 54 dB $L_{Aeq,16hour}$ daytime and 46 - 47dB $L_{Aeq,8hour}$ night-time.
- 4.7 **Figure 4.3** overleaf shows these estimated noise levels plotted against the Stage 1 ProPG guidance.

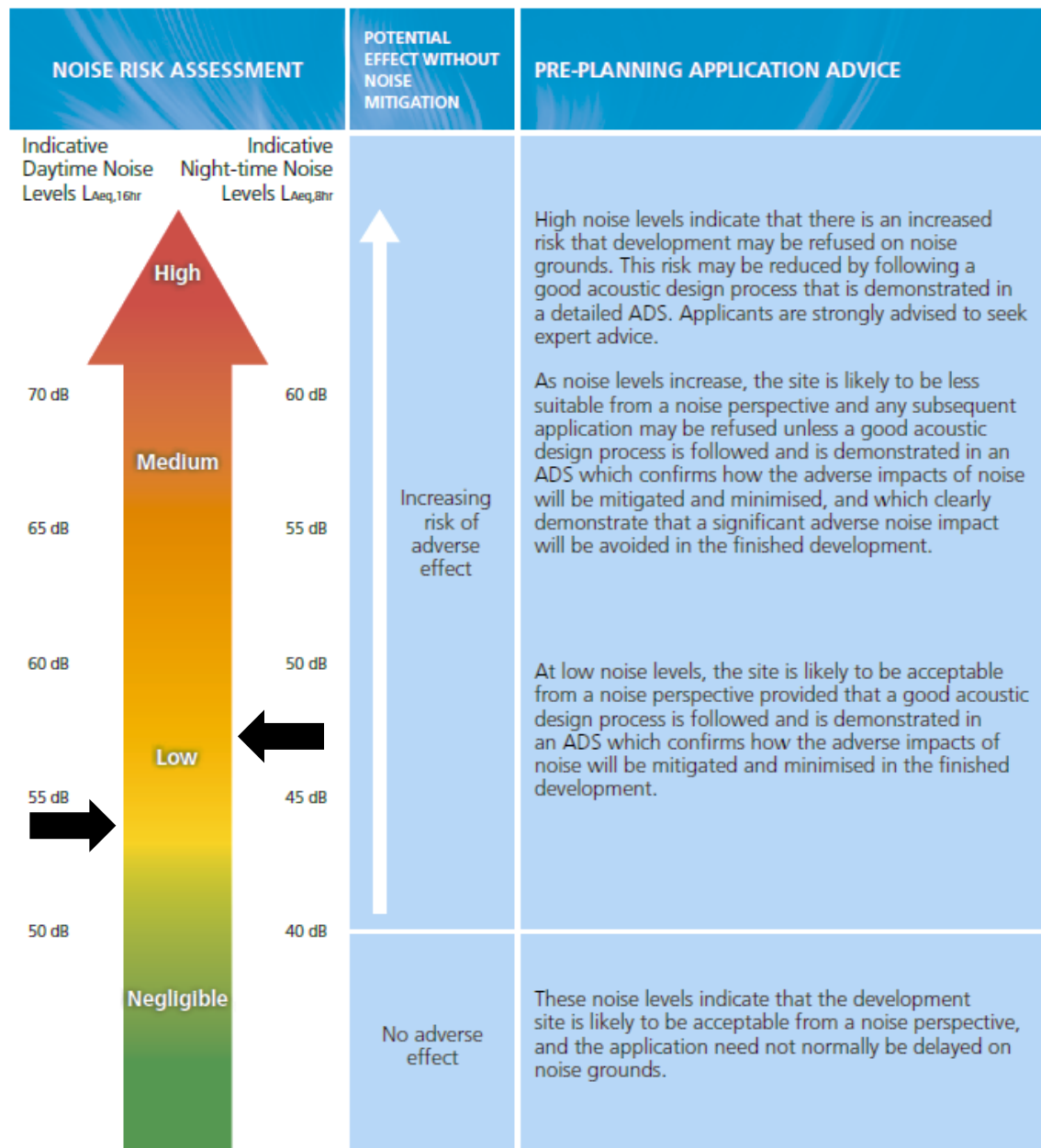


Figure 5.2: ProPG Initial Site Noise Risk Assessment

4.8 The above figure reconfirms the earlier conclusion of the daytime noise risk being just below a “low” categorisation whilst the night-time noise risk would be categorised as being just above a “low” risk.

4.9 For “negligible” risk sites, ProPG states:

“These noise levels indicate that the development site is likely to be acceptable from a noise perspective, and the application need not normally be delayed on noise grounds.”

4.10 For “low” risk sites, ProPG states:

“At low noise levels, the site is likely to be acceptable from a noise perspective provided that a good acoustic design process is followed and is demonstrated in an ADS which confirms how the adverse impacts of noise will be mitigated and minimised in the finished development”

Historic Noise Monitoring

- 4.11 In order to further consider the reasonableness of the above estimates, a review of the planning records for the detailed design of earlier phases of the Berewood development has been undertaken. Available planning records for the development of Phase 3A of the Berewood development (Winchester City Council planning ref: 16/02621/REM) is accompanied by a “Noise Impact Assessment Report”³. The assessment included baseline noise monitoring undertaken at the locations shown in **Figure 4.4** below, reproduced from the noise assessment report:



Figure 4.4: Phase 3A Historical Noise Monitoring Locations

- 4.12 Long-term noise monitoring at these locations resulted in a typical daytime noise level of 52dB L_{Aeq, 16hour} and a typical night-time level of 44dB L_{Aeq, 8hour} at Location 1 and 54dB L_{Aeq, 16hour} and 49dB L_{Aeq, 8hour} at Location 2. It should be noted that these noise levels

³ Winchester City Council Planning Portal https://planningapps.winchester.gov.uk/online-applications/files/82C9C74947669206940D6E0D926A1DEA/pdf/16_02621_REM-NOISE_IMPACT_ASSESSMENT-1301931.pdf

represent the total noise environment characterising the site (i.e. including not only noise from London Road, but also noise from other environmental sources (including other local road traffic, aircraft and birdsong, etc.)). This historic noise monitoring data therefore provides a strong corroboration that the estimate of noise from the London Road characterising Phase 3B (based on DEFRA noise modelling predictions) provides a robust characterisation of noise levels.

5 Sound Insulation Assessment

Noise Intrusion/Background Ventilation

- 5.1 The proposed development will, as a matter of course, include the use of thermal double glazing (to comply with the statutory thermal requirements of Approved Document L1A of the Building Regulations 2010, as amended) and an appropriate scheme of ventilation (to comply with the statutory requirements of Approved Document F of the Building Regulations 2010, as amended).
- 5.2 Guidance in the Institute of Acoustics/Association of Noise Consultants publication *“Acoustics Ventilation and Overheating: Residential Design Guide”* (January 2020) indicates that the use of standard thermal double glazing and non-acoustic ventilators will typically provide adequate sound insulation to control noise intrusion into building at daytime sound levels up to around 56dB $L_{Aeq,16hour}$ and night-time sound levels of around 51dB $L_{Aeq,8hour}$. An extract from Table B-3 of this guidance is reproduced below:

ADF System	External noise ingress considerations	Mechanical system noise considerations	Approximate guideline free-field external noise limits. [Note 1]
1 or 2	Noise ingress is likely to be defined by the performance of the background ventilators (trickle vents), windows and other façade elements. Note that use of System 1, relying on the use of open trickle vents without opening windows may give rise to poor indoor air quality in airtight dwellings outside the winter period.	For System 1, intermittent kitchen and bathroom fans should have suitable noise levels to meet the guidelines in Table 3-4. System 2 has no mechanical components.	With standard double glazing and two trickle vents: • $L_{Aeq,16h}$ 56 dB day • $L_{Aeq,8h}$ 51 dB night • L_{Amax} not normally exceeding ~ 67 dB more than 10x per night With high performing acoustic glazing and two ‘acoustic’ trickle vents: • $L_{Aeq,16h}$ 66 dB day • $L_{Aeq,8h}$ 61 dB night • L_{Amax} not normally exceeding ~ 80 dB more than 10x per night

Figure 5.1: Extract from Table B-3 of AVOG Guidance

- 5.3 As discussed earlier, “worst case” noise levels characterising the eastern boundary of Phase 3B are estimated to be in the order of 53-54 dB $L_{Aeq,16hour}$ (daytime) and 46-47dB $L_{Aeq,8hour}$ (night-time). It follows that traffic noise from the London Road characterising the site should be readily controlled by the mitigation that will be inherently embedded within the scheme design control proposals (i.e. use of standard thermal double glazing and alternative means of ventilation).
- 5.4 It is, therefore, concluded that the proposed development will provide acceptable indoor noise levels for future residents, without the need for any “special” acoustic provisions.

Purge Ventilation

- 5.5 Approved Document F also requires that adequate provision is made for purge ventilation. Purge ventilation is the process of removing high concentrations of pollutants and water vapour released from occasional activities (such as painting and decorating) or accidental releases (such as smoke from burnt food or spillage of water). Since the need for purge ventilation is by its definition “occasional”, this is normally achieved by giving residents the ability to open their windows. Whilst noise intrusion will increase as a result of windows being open, the occasional and temporary occurrence of such a situation can be readily accepted, particularly since occupants are “*in control*” of both the timing and duration of purge ventilation being required.
- 5.6 Given the modest noise levels characterising the site, the use of openable windows to provide purge ventilation should not give rise to any adverse noise impact. Using openable windows is also considered to be entirely consistent with the guidance given in section 8.4.5.4 of BS 8233; 2014 which states:

8.4.5.4 Ventilation

*The Building Regulations’ supporting documents on ventilation [48, 49, 50] recommend that habitable rooms in dwellings have background ventilation. Where openable windows cannot be relied upon for this ventilation, trickle ventilators can be used and sound attenuating types are available. **However, windows may remain openable for rapid or purge ventilation, or at the occupant’s choice.***

- 5.7 The acceptability of using openable windows for providing purge ventilation is also in accordance with paragraph 2.35 of ProPG guidance which states:

It should also be noted that the internal noise level guidelines are generally not applicable under “purge ventilation” conditions as defined by Building Regulations Approved Document F, as this should only occur occasionally (e.g. to remove odour from painting and decorating or from burnt food).

Thermal Comfort

- 5.8 Whilst not a statutory requirement, ADF highlights that windows may also need to be used to provide “rapid” ventilation to facilitate cooling of the premises, to assist in avoiding “over-heating”.
- 5.9 Guidance on how to address the potential conflict between acoustics, noise and ventilation is set out in the Association of Noise Consultants/Institute of Acoustics publication “*Acoustics Ventilation and Overheating: Residential Design Guide*” (January

2020). Table 3.2 of the guidance provides a means of assessing the initial noise risk of the site based on a consideration of the daytime and night-time noise levels.

- 5.10 **Figure 6.1** shows how the estimated worst-case noise levels characterising Phase 3B would be assessed in accordance with this guidance.

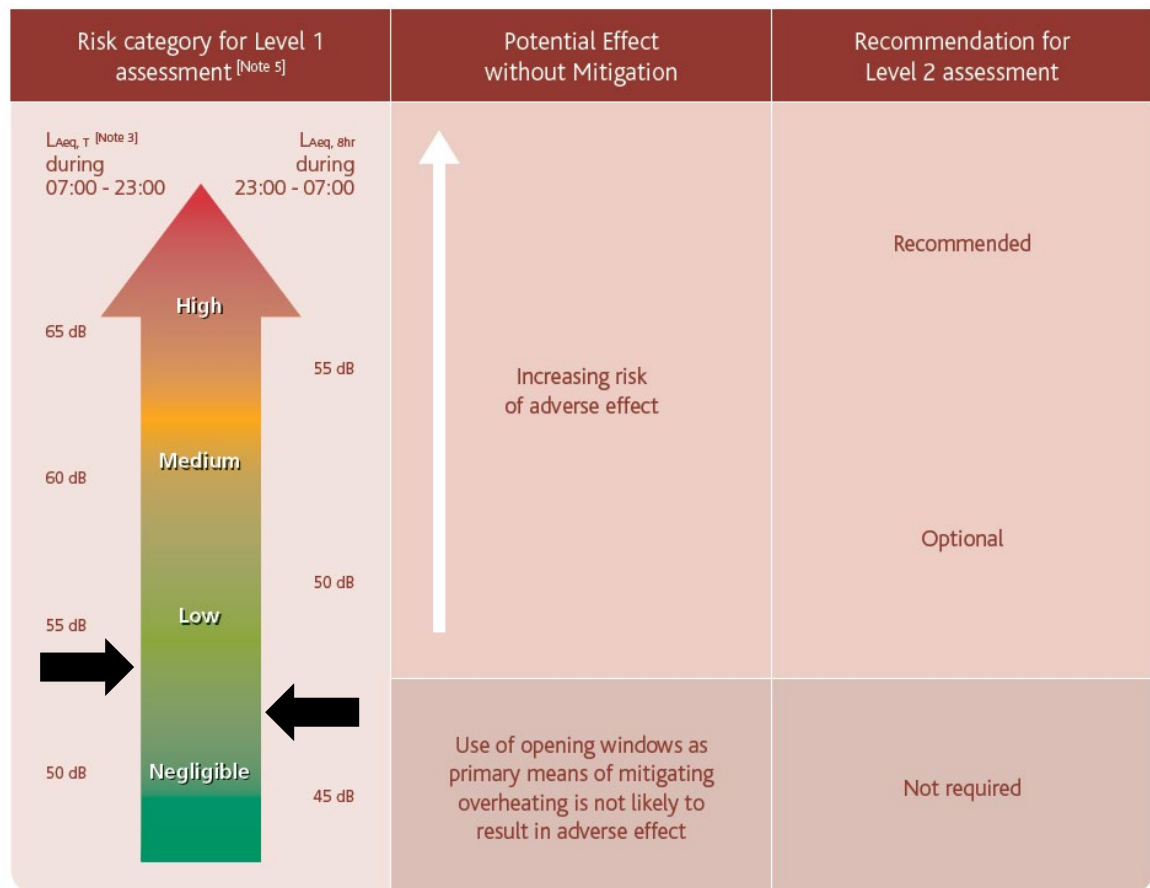


Figure 6.1: Level 1 AVOG Assessment

- 5.11 The above initial assessment shows that the use of opening windows as a primary means of mitigating overheating should not result in an adverse acoustic effect on future residents.

External Amenity

- 5.12 ProPG guidance recommends:

“If external amenity spaces are an intrinsic part of the overall design, the acoustic environment of those spaces should be considered so that they can be enjoyed as intended”.

The acoustic environment of external amenity areas that are an intrinsic part of the overall design should always be assessed and noise levels should ideally not be above the range 50 – 55 dB LAeq,16hr.”

- 5.13 As noted earlier, a “worst-case” daytime sound level of around 53-54 dB $L_{Aeq,16hour}$ from traffic on London Road is estimated. This is consistent with the suggested 50-55dB $L_{Aeq,16hour}$ range set out in ProPG guidance and therefore provides a clear indication that future residents will have access to appropriate external amenity areas.
- 5.14 It is, however, also worth noting that the above conclusion is drawn on the basis of an estimation of the existing “free-field” sound level. Noise propagation from London Road will also be further reduced by the presence of the proposed buildings on the site and fencing around gardens, etc. It can therefore be concluded that noise levels in external amenity areas provided by the development will be controlled comfortably in line with ProPG guidance

6 Conclusions

Existing Noise Environment

- 6.1 A review of publicly available noise mapping has been reviewed in order to ascertain indicative noise levels at Phase 3B of the development site. Existing noise levels at the eastern boundary of the site are modest, with estimated values of 53-54 dB $L_{Aeq,16hour}$ (daytime) and 46-47 dB $L_{Aeq,8hour}$ (night-time). The reasonableness of these estimates has also been verified by reference to historic noise monitoring data for earlier phases of the wider strategic development.

Noise Intrusion

- 6.2 Noise will be adequately controlled with the use of standard thermal double glazing and alternative means of ventilation (which will be installed as a matter of course to comply with the relevant statutory requirements of the Building Regulations 2010 (as amended). It can, therefore, be concluded that the proposed development should provide acceptable indoor noise levels for future residents.
- 6.3 The noise levels are also compatible with using opening windows to provide ventilative cooling as the primary means of mitigating overheating, whilst maintaining acceptable internal noise levels.

External Amenity

- 6.4 Noise levels in external amenity areas will be acceptably controlled in line with ProPG and BS 8233: 2014 guidance.

Conclusion

- 6.5 It is concluded that the location of the site (set some distance from the A3 London Road) and design measures embedded within the development proposals (to comply with statutory requirements of the Building Regulations) will adequately protect the future occupiers of the site from road traffic noise emanating from the A3 (London Road), as required by Condition 16 of the outline planning permission granted for the development.

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APPENDIX A – Glossary of Acoustics Terminology

General

A vibrating surface or turbulent fluid flow will cause pressure fluctuations in the surrounding air. These pressure fluctuations are perceived by the human ear as “sound”.

Measurement Units

The human ear can detect sound pressures as low as about 20 μPa , and can tolerate (for short periods) sound pressures as high as 200 Pa, an amplitude range of 10 million times. To take account of this huge amplitude range, sound pressure levels (often written in “acoustic shorthand” as SPL or Lp) are quantified using a logarithmic scale, the decibel (dB) scale. This is based on a reference pressure of 20 μPa , thus a sound pressure of 20 μPa would equate to 0dB and a pressure of 200Pa would equate to 140dB.

Frequency (Pitch) Characteristics

The sound received at any particular location is not solely influenced by the sound pressure level, the frequency characteristics (pitch) of the noise is also an important factor. Noise audible to a human (with “normal” hearing), typically covers the frequency range 20 Hertz to 20,000 Hertz. Hertz (Hz) are defined as the number of times the sound pressure fluctuates in one second. “Low” pitched sounds fluctuate less times per second than “high” pitched sounds. Whilst humans are capable of detecting a wide range of frequencies, the ear is not equally sensitive to all frequencies – the ear is most sensitive at frequencies towards the middle of the audible range and less sensitive to the lower and higher frequencies.

To take account of this frequency response, sound pressure fluctuations are normally quantified by applying a frequency-weighting network or filter which simulates the frequency response of the ear. In essence, this means that more significance is given to the frequencies at which the ear is most sensitive and less significance to those at which the ear is less sensitive. Noise measurements relating to human reaction are generally made using an “A-weighting” network. These measurements are reported as A-weighted decibels or dB(A). The A-weighted sound pressure level is written in “acoustic shorthand” as L_A .

Variation of Sound with Time

It will be appreciated that the sound pressure level of most noise sources will fluctuate with time. In order to take account of the way in which the human ear perceives noise, it is normal for the sound pressure level to be quantified using a time weighting network, to mimic the speed of response of the human ear. The standardised setting for most types of noise is a “Fast” time weighting.

The manner in which sound fluctuates with time can also influence the subjective manner in which noise is perceived. Noise can be continuous (showing no significant variation with time as in the case of a fan), intermittent (i.e. the noise is transient in its nature, such as a train pass-by) or impulsive (i.e. there is a sudden build up of noise - this can range from “clanking” types sounds as might be experienced next to railway goods yard or a high energy discharge such as an explosion)

Measurement of Sound

Sound pressure levels are measured using equipment comprising a pressure-sensitive microphone, associated amplifier, frequency weighting network, time weighted network and output indicator. In its simplest form this is a small hand-held instrument called a sound level meter. More sophisticated instrumentation (a sound level analyser) is also available which allows the real-time output of the frequency characteristics of the sound to be quantified.

Comparison of Sound Levels

To put the significance of noise measurement into context, the following Table presents the A-weighted sound pressure level of some typical sources:

Sound Pressure Level, dB(A)	Typical Noise Source . Activity
160	Saturn Rocket Taking Off
140	Military Jet Taking Off at 30m
100	Nightclub
90	Heavy goods vehicle driving past at 7m
80	Busy urban road
70	Domestic vacuum cleaner at 3m
60	Busy office environment
55	Normal speech at 1m
40	Whispered conversation at 2m
30	Bedroom at night (BS 8233: 1999)
20	Remote country location
0	Threshold of hearing – a very eery silence

Addition of Sound Levels

It is important to note that the use of a logarithmic scale to describe noise does not allow normal arithmetic addition. This means that two noise sources each generating a level of, say, 60dB(A) will not generate a combined sound level of 120dB(A). The values must be added logarithmically, which would actually yield a combined sound level of 63dB(A) in this example.

Subjective Perception of Sound Levels Changes

With regard to the human perception of sound level changes, the human ear:

- Cannot generally perceive a sound level difference of less than 3dB(A)
- Will perceive a sound level difference of 4-5dB(A) as “noticeable”
- Will perceive a sound level difference of 10dB(A) as a doubling (or halving) of loudness.

Acoustic Terminology

As stated previously, most sources of noise will fluctuate with time. In order to characterize such noise, it is therefore normal to represent the noise climate using a variety of noise parameters and statistical indices. The most commonly adopted noise parameters are described below:

$L_{Aeq,T}$	This is the equivalent continuous A-weighted sound level measured over a specified time period "T". This is the notional continuous sound level which, over the time T, contains the same amount of energy as the actual fluctuating sound being measured. This parameter is widely accepted as being the most appropriate noise descriptor for most environmental noise and the effects of noise on humans.
$L_{Amax,fast}$	This is maximum A-weighted sound pressure measured with a fast frequency response recorded during the stated measurement period. It is typically used to characterise the highest sound level caused during a noise event.
$L_{A90,T}$	This is the A-weighted sound pressure level exceeded for 90% of the specified time period "T". It is normally used to describe the underlying background noise level of an environment since it inherently excludes the effects of transient noise sources.

Noise Rating (NR) Level

When describing noise from building services installations, it is common to express noise levels in terms of a Noise Rating (NR) Level. The NR level is determined by plotting the measured frequency spectrum of a noise against a series of reference curves, which roughly approximate to equal loudness values. This method permits higher sound levels at low frequencies corresponding to the sensitivity of the human ear. The NR level is defined as the value of the highest curve "touched" by the plotted frequency spectrum. For typical sources of building services noise, the overall A-weighted sound level is numerically around 5-6dB higher than the NR level of the noise.

Airborne Sound Insulation Measurement Parameters

The ability of a building element to reduce airborne noise can be described by a number of different parameters relevant to both laboratory and on-site performance evaluation. In general, the higher these values, the better the resistance of the construction to the transmission of airborne sound. The most commonly used parameters include:

R_w	The " Weighted Sound Reduction Index " (R_w) is a single value measure of the intrinsic sound reduction capabilities of a construction, as measured in an acoustic laboratory. Measurement values are determined in accordance with the BS EN ISO 10140 series of standards and weighted in accordance with BS EN ISO 717-1: 2013.
R'_w	The " Weighted Apparent Sound Reduction Index " (R'_w) is a single value measure of the apparent sound reduction capabilities of a construction, when installed on-site (which will normally be some way lower than the laboratory value due to less favourable installation conditions, the quality of workmanship, etc.). Measurement values are determined in accordance with the BS EN ISO 10140 series of standards and weighted in accordance with BS EN ISO 717-1: 2013. In practice, the R'_w of a construction can only be reliably determined if "direct" sound transfer through the partition can confidently be taken as the dominant noise transfer path (i.e. there is no "flanking" sound transmission).
D_w	The " Weighted Sound Level Difference " (D_w) is a single value measure of the on-site sound reduction between two rooms. This value inherently includes "direct" sound transmission through any separating construction and "flanking" transmission through other building elements.

Measurement values are determined in accordance with BS EN ISO 140-4: 1998 (for Building Regulations compliance purposes) or BS EN ISO 16283-1: 2014 and weighted in accordance with BS EN ISO 717-1: 2013.

$D_{n,fw}$	The " Weighted Normalised Flanking Level Difference " ($D_{n,fw}$) is a single figure measure of the sound reduction between two rooms solely due to sound transmission through a specified flanking path. This parameter is frequently used to provide an indication of the sound reduction capabilities of suspended ceiling and raised access floor constructions where there is common void between adjacent rooms or as a measure of sound that may be transmitted between rooms through external curtain walling. Measurements are undertaken in accordance with BS EN ISO 10848-2: 2017 and weighted in accordance with BS EN ISO 717-1: 2013.
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Impact Sound Insulation Measurement Parameters

Some building elements also have the potential to generate "impact" noise, for example due to human "footfall" on floor structures, or the impact of rainfall on lightweight roofing components. A variety of parameters are again available to define the amount of noise likely to be generated. In general, the lower these values, the less sound the construction will generate as a result of impacts. Typical measurements parameters include:

$L_{nT,w}$	The " Standardised Impact Sound Pressure Level " is a "single number" rating describing the intrinsic impact sound insulation capabilities of a construction (such as a floor system) as measured in an acoustics laboratory. Values are determined in a vertical sound transmission suite by locating a "tapping machine" in the upper room of the suite and measuring the amount of sound radiated by the floor in the room below. Measurement values are determined in accordance with the BS EN ISO 10140 series of standards and weighted in accordance with BS EN ISO 717-2: 2013.
$L_{n,fw}$	The " Normalised Flanking Impact Sound Pressure Level " is a "single number" rating describing the amount of flanking sound that would be transmitted to an adjoining space (separated by a partition) due to impacts on the test sample. It is, for example, used to indicate the amount of noise that may be generated due to footfall noise on a raised access floor system. Values are determined in a horizontal sound transmission suite by locating a "tapping machine" one side of a separating partition built off the test sample and measuring the amount of noise radiated by the floor in the adjoining space on the other side of the partition. Measurement values are determined in accordance with BS EN ISO 10848-2: 2017 and weighted in accordance with BS EN ISO 717-2: 2013.

Room Acoustic Measurements

T	The " Reverberation Time " (T) of a room is defined as the time taken for the sound energy produced by a source Time (RT) to decay by 60 dB after the source has been switched off. The reverberation time of a space can be calculated by considering the volume of the room and the areas and sound absorption qualities of room surface finishes. Small, "soft" rooms tend to give low reverberation times, whilst large, "hard" rooms tend to give long reverberation times.
α_p	The " Practical Acoustic Absorption Coefficient " (α_p) is a measure of how much sound energy is absorbed by a building element at a particular frequency, as measured in accordance with BS EN ISO 354: 2003.
α_w	The " Weighted Absorption Coefficient " (α_w) is a single figure measure of the overall sound absorption capabilities of a building element determined in accordance with BS EN ISO 11654: 1997.

