Hawkins environmental

Noise Assessment:

Lawnfield House, Maidenhead

Whitberry Ltd

12th October 2023

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1. INTRODUCTION

1.1. Overview

Hawkins Environmental Limited has been instructed by Whitberry Ltd to undertake a noise assessment for the redevelopment of Lawnfield House, Maidenhead.

During the planning process, it has been identified that the site may require a noise assessment to determine whether the site is suitable for residential use, due to its proximity to a number of busy roads. Consequently, a noise survey was conducted to characterise the noise climate of the site with the proposed layout. By measuring both the ambient and maximum noise levels it has been possible to determine whether mitigation is necessary to achieve reasonable internal and external noise levels. The results of the survey also give an indication of acceptable limits for plant noise emission.

The assessment adheres to the principles of Government planning policy in relation to noise, specifically enacted by the *National Planning Policy Framework (NPPF), the National Planning Practice Guidance (NPPG) on Noise* and *the Noise Policy Statement for England (NPSE).*

The recommended approach for assessing noise in relation to residential development has been adopted, which is currently the *Professional Practice Guidance on Planning and Noise: New Residential Development* (the "ProPG"), which adopts the criteria contained within *BS 8233: 2014 'Guidance on sound insulation and noise reduction for buildings'.* Consideration has also been given to the Association of Noise Consultants' *Acoustics, Ventilation and Overheating (AVO) Guide.*

All noise measurements were conducted in accordance with BS 7445-2: 1991 *'Description and measurement of environmental noise Part 2: Guide to the acquisition of data pertinent to land use'.*

1.2. The Nature, Measurement and Effect of Noise

Noise is often defined as sound that is undesired by the recipient. Whilst it is impossible to measure nuisance caused by noise directly, it is possible to measure the loudness of that noise. 'Loudness' is related to both sound pressure and frequency, both of which can be measured. The human ear is sensitive to a wide range of sound levels. The sound pressure level of the threshold of pain is over a million times that of the quietest audible sound. In order to reduce the relative magnitudes of the numbers involved, a logarithmic scale of decibels (dB) is normally used, based on a reference level of the lowest audible sound.

The response of the human ear is not constant over all frequencies. It is therefore usual to weight the measured frequencies to approximate the human response. The resulting 'A' weighted decibel, dB(A), has been shown to correlate closely to the subjective human response.

When related to changes in noise, a change of ten decibels from say 60 dB(A) to 70 dB(A) would represent a doubling in 'loudness'. Similarly, a decrease in noise from 70 dB(A) to 60 dB(A) would represent a halving in 'loudness'. A change of 3 dB(A) is generally considered to be just perceptible. **Table 1.1** details typical noise levels. A glossary of acoustic terms can be found in **Appendix 1**.

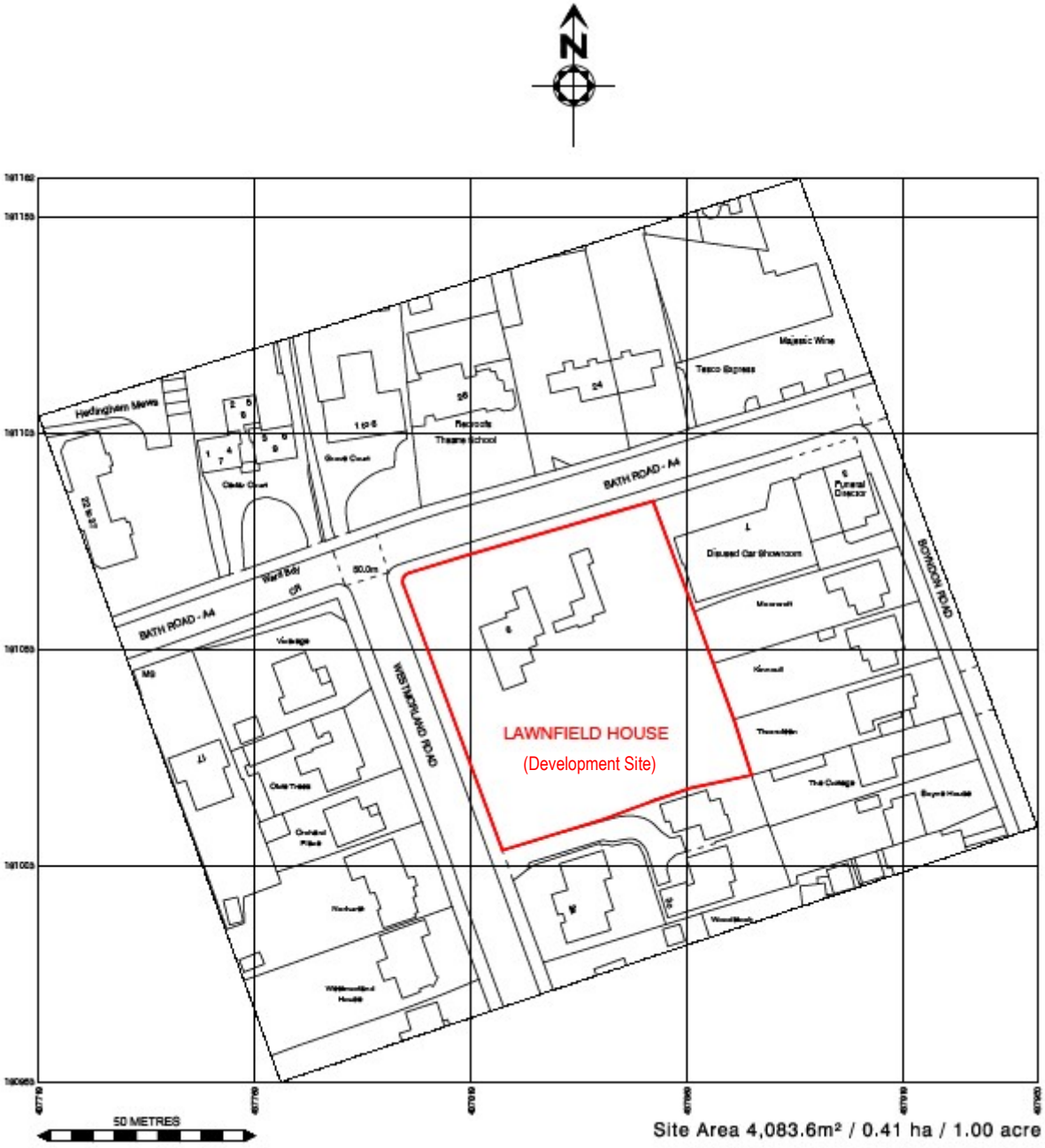
Table 1.1: Typical Noise Levels

Approximate Noise Level (dB(A))	Example
0	Limit of hearing
30	Rural area at night
40	Library
50	Quiet office
60	Normal conversation at 1 m
70	In car noise without radio
80	Household vacuum cleaner at 1 m
100	Pneumatic drill at 1 m
120	Threshold of pain

1.3. Site Description

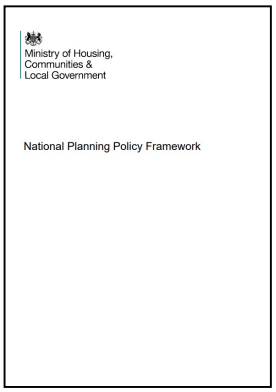
The development site is situated on the corner of Bath Road (A4) and Westmorland Road in Maidenhead within the Royal Borough of Windsor and Maidenhead. The site currently comprises of a six bedroom Edwardian house with stables and coach house with 1 acre of surrounding planted land. The proposed development sees the demolition of the house and the erection of a 71 bed care home featuring new landscaping and an area of car parking. A location plan of the proposed site can be seen in **Figure 1.1**.

Figure 1.1: Site Location Plan



2. PLANNING POLICY & GUIDANCE

2.1. National Planning Policy Framework (2021)



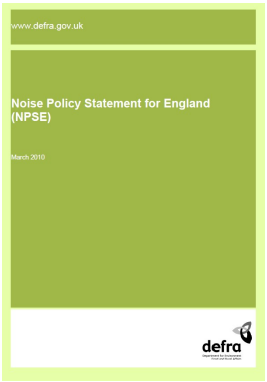
The National Planning Policy Framework (NPPF) was first published on the 27th March 2012 and revised July 2018, February 2019 and again in July 2021. The NPPF outlines the Government's environmental, economic and social policies for England. The NPPF sets out a presumption in favour of sustainable development which should be delivered with three main dimensions: economic; social and environmental (Paragraphs 7, 8, 10 and 11). The NPPF aims to enable local people and their councils to produce their own distinctive local and neighbourhood plans, which should be interpreted and applied in order to meet the needs and priorities of their communities.

The NPPF states that in the planning system *"Planning policies and decisions should contribute to and enhance the natural and local environment by… e) 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"* (Paragraph 174).

Paragraph 185 of the NPPF talks specifically about noise stating that *"Planning policies and decisions should also ensure that new development is appropriate for its location taking into account the likely effects (including cumulative effects) of pollution on health, living conditions and the natural environment, as well as the potential sensitivity of the site or the wider area to impacts that could arise from the development. In doing so they should: 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…"*

Specifically in relation to noise from existing commercial premises, Paragraph 187 of the NPPF notes: *"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".*

2.2. Noise Policy Statement for England (2010)



The Noise Policy Statement for England (NPSE) provides further guidance which is relevant to the policy set out in Paragraph 185 of the NPPF and states that: *"Within the context of sustainable development:*

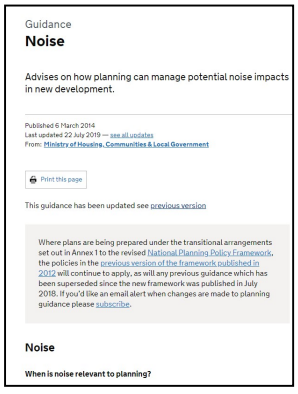
- *avoid significant adverse impacts on health and quality of life;*
- *mitigate and minimise adverse impacts on health and quality of life; and*
- *where possible contribute to the improvement of health and quality of life."*

NPSE introduces established concepts originally from the field of toxicology that are now being applied to noise impacts. They are:

- **NOEL – No Observed Effect Level** - This is the level of noise below which no effect can be detected. In simple terms, below this level, there is no detectable effect on health and quality of life due to the noise.
- **LOAEL – Lowest Observed Adverse Effect Level** - This is the level of noise above which adverse effects on health and quality of life can be detected.
- **SOAEL – Significant Observed Adverse Effect Level** - This is the level above which significant adverse effects on health and quality of life occur.

NPSE goes on to state that *"it is not possible to have a single objective noise-based measure that defines SOAEL that is applicable to all sources of noise in all situations. Consequently, the SOAEL is likely to be different for different noise sources, for different receptors and at different times. It is acknowledged that further research is required to increase our understanding of what may constitute a significant adverse impact on health and quality of life from noise. However, not having specific SOAEL values in the NPSE provides the necessary policy flexibility until further evidence and suitable guidance is available."*

2.3. Planning Practice Guidance



The Planning Practice Guidance (PPG) was launched on 6th March 2014 and has undergone regular revision, with the most recent changes to Noise Guidance coming in July 2019. PPG provides additional guidance and interpretation to the Government's strategic policies, outlined within the NPPF, in a web-based resource.

The NPPG provides more guidance on the assessment of noise for planning purposes and builds on the concepts of NOEL, LOAEL and SOAEL introduced in NPSE to establish whether noise is a factor that needs to be taken into account. It states*: "Local planning authorities' plan-making and decision taking should take account of the acoustic environment and in doing so consider:*

- *whether or not a significant adverse effect is occurring or likely to occur;*
- *whether or not an adverse effect is occurring or likely to occur; and*
- *whether or not a good standard of amenity can be achieved.*

In line with the Explanatory Note of the Noise Policy Statement for England, this would include identifying whether the overall effect of the noise exposure (including the impact during the construction phase wherever applicable) is, or would be, above or below the significant observed adverse effect level and the lowest observed adverse effect level for the given situation."

However, it goes into more detail about the subjective nature of noise and how the results of any assessment must be treated flexibly and pragmatically. The guidance states: *"The subjective nature of noise means that there is not a simple relationship between noise levels and the impact on those affected. This will depend on how various factors combine in any particular situation. These factors include:*

- *the source and absolute level of the noise together with the time of day it occurs. Some types and level of noise will cause a greater adverse effect at night than if they occurred during the day – this is because people tend to be more sensitive to noise at night as they are trying to sleep. The adverse effect can also be greater simply because there is less background noise at night;*
- *for a new noise making source, how the noise from it relates to the existing sound environment;*
- *for non-continuous sources of noise, the number of noise events, and the frequency and pattern of occurrence of the noise;*
- *the spectral content of the noise (i.e. whether or not the noise contains particular high or low frequency content) and the general character of the noise (i.e. whether or not the noise contains particular tonal characteristics or other particular features), and;*
- *the local arrangement of buildings, surfaces and green infrastructure, and the extent to which it reflects or absorbs noise.*

More specific factors to consider when relevant include:

- *the cumulative impacts of more than one source of noise;*
- *whether any adverse internal effects can be completely removed by closing windows and, in the case of new residential development, if the proposed mitigation relies on windows being kept closed most of the time (and the effect this may have on living conditions). In both cases a suitable alternative means of ventilation is likely to be necessary. Further information on ventilation can be found in the Building Regulations.*
- *In cases where existing noise sensitive locations already experience high noise levels, a development that is expected to cause even a small increase in the overall noise level may result in a significant adverse effect occurring even though little to no change in behaviour would be likely to occur.*
- *Noise Action Plans (where these exist), and, in particular the Important Areas identified through the process associated with the Environmental Noise Directive and corresponding regulations should be taken into account. Defra's website has information on Noise Action Plans and Important Areas. Local authority environmental health departments will also be able to provide information about Important Areas.*

- *the effect of noise on wildlife. Noise can adversely affect wildlife and ecosystems. Particular consideration needs to be given to the potential effects of noisy development on international, national and locally designated sites of importance for biodiversity;*
- *where 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.*
- *some commercial developments including restaurants, hot food takeaways, night clubs and public houses can have particular impacts, not least because activities are often at their peak in the evening and late at night. Local planning authorities will wish to bear in mind not only the noise that is generated within the premises but also the noise that may be made by customers in the vicinity".*

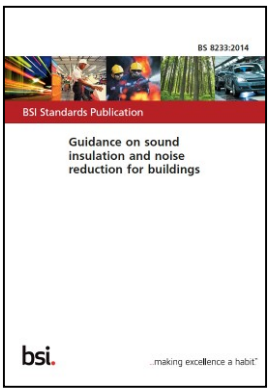
Table 2.1 shows examples of the noise hierarchy (adapted from the PPG) and shows that that the aim is to identify where the overall effect of the noise exposure falls in relation to SOAEL, LOAEL and NOEL. The implication of the advice is only noise that is 'noticeable and very disruptive' would be considered unacceptable and therefore, should be prevented. The inference, therefore, is that all other outcomes can be acceptable, depending upon the specific circumstances and level of mitigation..

Table 2.1: Noise Exposure Hierarchy

Perception	Examples of outcomes	Increasing effect level	Action	
Not noticeable	No Effect	No Observed Effect	No specific measures required	Low Noise Level
Noticeable and not intrusive	Noise can be heard but does not cause any change in behaviour or attitude. Can slightly affect the acoustic character of the area but not such that there is a perceived change in the quality of life.	No Observed Adverse Effect	No specific measures required	
Lowest Observed Adverse Effect Level				
Noticeable and intrusive	Noise can be heard and causes small changes in behaviour and/or attitude, eg turning up the volume of television; speaking more loudly; where there is no alternative ventilation, having to close windows for some of the time because of the noise. The potential for some reported sleep disturbance. Affects the acoustic character of the area such that there is a perceived change in the quality of life.	Observed Adverse Effect	Mitigate and reduce to a minimum	Increasing Noise Levels ↓
Significant Observed Adverse Effect Level				
Noticeable and disruptive	The noise causes a material change in behaviour and/or attitude, eg avoiding certain activities during periods of intrusion; where there is no alternative ventilation, having to keep windows closed most of the time because of the noise. The potential for sleep disturbance resulting in difficulty in getting to sleep, premature awakening and difficulty in getting back to sleep.	Significant Observed Adverse Effect	Avoid	
Noticeable and very disruptive	Extensive and regular changes in behaviour and/or an inability to mitigate the effect of noise leading to psychological stress or physiological effects, eg regular sleep deprivation/awakening; loss of appetite, significant, medically definable harm, eg auditory and non-auditory	Unacceptable Adverse Effect	Prevent	High Noise Level

3. ASSESSMENT METHODOLOGY & GUIDANCE

3.1. BS 8233: 2014 'Guidance on Sound Insulation and Noise Reduction for Buildings'



Originally published in 1999, the 2014 edition of BS 8233, significantly updates the guidance in light of the policy changes as a result of the advent of the NPPF and the withdrawal of PPG 24. The 2014 edition of BS 8233 sees a change in the title of the Standard, moving from a *'Code of Practice'* to *'Guidance'*, as the text '*largely comprises guidance that does not support claims of compliance'*.

BS 8233:2014 indicates that to control external noise ingress into a proposed development, a number of planning stages should occur as follows:

a) *"Assess the site, identify significant existing and potential noise sources, measure or estimate noise levels, and evaluate layout options.*

b) *Determine design noise levels for spaces in and around the building(s).*

c) *Determine sound insulation of the building envelope, including the ventilation strategy".*

BS 8233:2014 suggests design noise levels for various types of building. The recommended noise levels for dwelling houses, flats and rooms in residential use (when unoccupied) can be seen in **Table 3.1** below. This is replicated from Table 4 of Section 7.7.2 of BS 8233:2014. The guidance suggests that *"In general, for steady external noise sources, it is desirable that the internal ambient noise level does not exceed the guideline values"*. The noise levels in **Table 3.1** are marginally different to those published in BS 8233:1999 *'Sound insulation and noise reduction for buildings – Code of practice'*, but are based on the existing guidance from the current World Health Organisation (WHO) "Guidelines on Community Noise".

Table 3.1: Summary of Noise Criteria: BS 8233: 2014

Activity	Location	07:00 To 23:00	23:00 To 07:00
Resting	Living room	35 dB $L_{Aeq.16hour}$	-
Dining	Dining room/area	40 dB $L_{Aeq.16hour}$	-
Sleeping	Bedroom	35 dB $L_{Aeq.16hour}$	30 dB $L_{Aeq.8hour}$

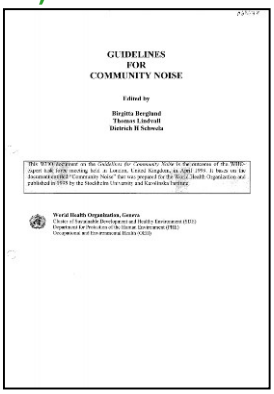
When considering the noise level criteria considered in **Table 3.1**, the following points should be noted:

- BS 8233: 2014 suggests that the above criteria should be adopted flexibly and that *"where development is considered necessary or desirable... the internal target level may be relaxed by up to 5 dB and reasonable internal conditions still achieved"*.
- The noise levels quoted above are annual averages and *"do not need to be achieved in all circumstances*" e.g. New Year's Eve or fireworks night.

- The noise levels in **Table 3.1** are *"for steady external noise sources"* such as traffic noise or plant noise. This is a departure from the 1999 version of BS 8233, where the recommended internal noise levels were irrespective of the external noise source and therefore included the suggestion that in order to achieve *"reasonable"* noise levels within bedrooms at night, L_{AFmax} noise levels should not exceed 45 dB. Whilst this has been omitted from the 2014 version of BS 8233, it does state that *"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."* Therefore, at sites which may be affected by individual noise events, it is more appropriate to use the guidance contained within the WHO *"Guidelines on Community Noise"* which suggest that good sleep will not generally be affected if internal levels of L_{AFmax} 45 dB are not exceeded more than 10-15 times per night.
- BS 8233:2014 notes that if the design of the building is *"relying on closed windows to meet the guide values, there needs to be appropriate alternative ventilation that does not compromise the facade insulation or resulting noise level".*
- BS 8233 provides guidance for noise in gardens and outdoor amenity space. It suggests that *"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."* The guidance does go on to say that these guideline values are not achievable in all circumstances and in some 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."*

3.2. World Health Organisation Guidelines for Community Noise (1999)

The 1999 World Health Organisation (WHO) guidance *"Guidelines for Community Noise"*, provides recommendations on maximum internal and external noise levels in a range of situations. The WHO guidelines are a consequence of a comprehensive review of the scientific evidence in relation to community noise exposure and the health and social aspects of such exposure. Whilst not adopted policy, the recommendations within the WHO Guidelines are often quoted and form the basis of the recommendations within BS 8233 and other similar guidance. A summary of the noise criteria can be seen in **Table 3.2**.

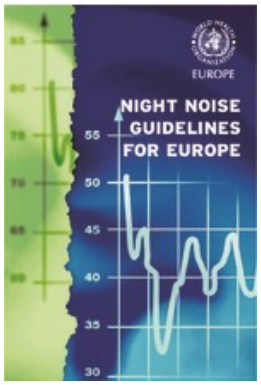

GUIDELINES
FOR
COMMUNITY NOISE

Edited by
Birgitta Berglund
Thomas Lindvall
Dietrich H Schwela

Table 3.2: Summary of Noise Criteria: WHO

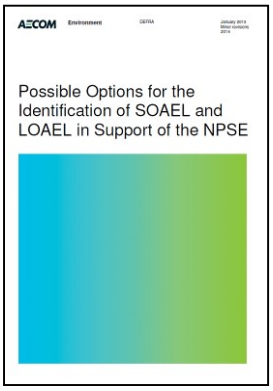
Residential Environment	Critical Heath Effect	L_{Aeq}	L_{AFmax}	Time Base
Outdoor living area	Serious annoyance, daytime and evening	55	-	07:00-23:00
	Moderate annoyance, daytime and evening	50	-	07:00-23:00
Dwelling, indoors	Speech intelligibility and moderate annoyance, daytime and evening	35	-	07:00-23:00
Inside bedrooms	Sleep disturbance, night-time	30	45	23:00-07:00
Outside bedrooms	Sleep disturbance, window open (outdoor values)	45	60	23:00-07:00

3.3. WHO Night Noise Guidelines for Europe (2009)



In 2009, the World Health Organisation published the *"Night Noise Guidelines for Europe"* as a partial update and extension to the *"Guidelines for Community Noise"*, specifically in relation to development on the scientific evidence of night noise exposure. The 2009 guidance suggests that a *"$L_{night,outside}$ of 40 dB should be the target of the night noise guideline (NNG) to protect the public, including the most vulnerable groups such as children, the chronically ill and the elderly"*. However, since that target would be impossible to achieve in many situations, a *"$L_{night,outside}$ value of 55 dB is recommended as an interim target for the countries where the NNG cannot be achieved in the short term for various reasons, and where policy-makers choose to adopt a stepwise approach"*.

3.4. Possible Options for the Identification of SOAELs and LOAELs in Support of the NPSE (2014)

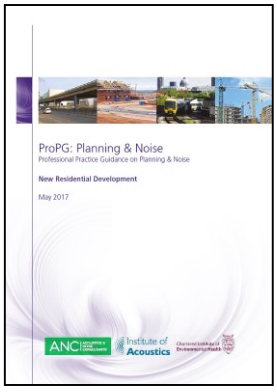


Published by Defra, based on a Research Project prepared by AECOM, *"Possible Options for the Identification of SOAELs and NOAELs in Support of the NPSE"* attempts to give values to the concepts of SOAELs and NOAELs, introduced by the Noise Policy Statement for England (NPSE). After the withdrawal of PPG24: Planning and Noise in 2012, which included Noise Exposure Categories, with specific numerical boundaries, the NPSE was heavily criticised for having no specific numerical guidance. Whilst the NPSE and NPPF encourage the development of location-specific criteria, in the context of the specific environment, the absence of guidance meant the implementation of the NPSE was difficult. Consequently, the project identifies both specific possible values and possible ranges of values for SOAELs and NOAELs for different noise sources. These values can be seen in **Table 3.3**.

Table 3.3: Possible Value & Ranges of Values for LOAEL & SOAEL

Source	Effect	LOAEL	SOAEL
Road	Annoyance (Daytime)	**56** *(53-59)*	**66** *(64-68)*
	Sleep (Night-time)	**46** *(43-52)*	**56** *(51-64)*
Rail	Annoyance (Daytime)	**63** *(61-66)*	**72** *(70-74)*
	Sleep (Night-time)	**55** *(52-63)*	**68** *(61-77)*
Air	Annoyance (Daytime)	**52** *(50-54)*	**60** *(58-62)*
	Sleep (Night-time)	**41** *(40-49)*	**53** *(47-60)*

3.5. ProPG: Planning & Noise Professional Practice Guidance (2017)



Planning & Noise: Professional Practice Guidance on Planning and Noise: New Residential Development (the "ProPG"), published May 2017, provides a recommended approach for dealing with noise within the planning process, specifically in relation to new residential developments.

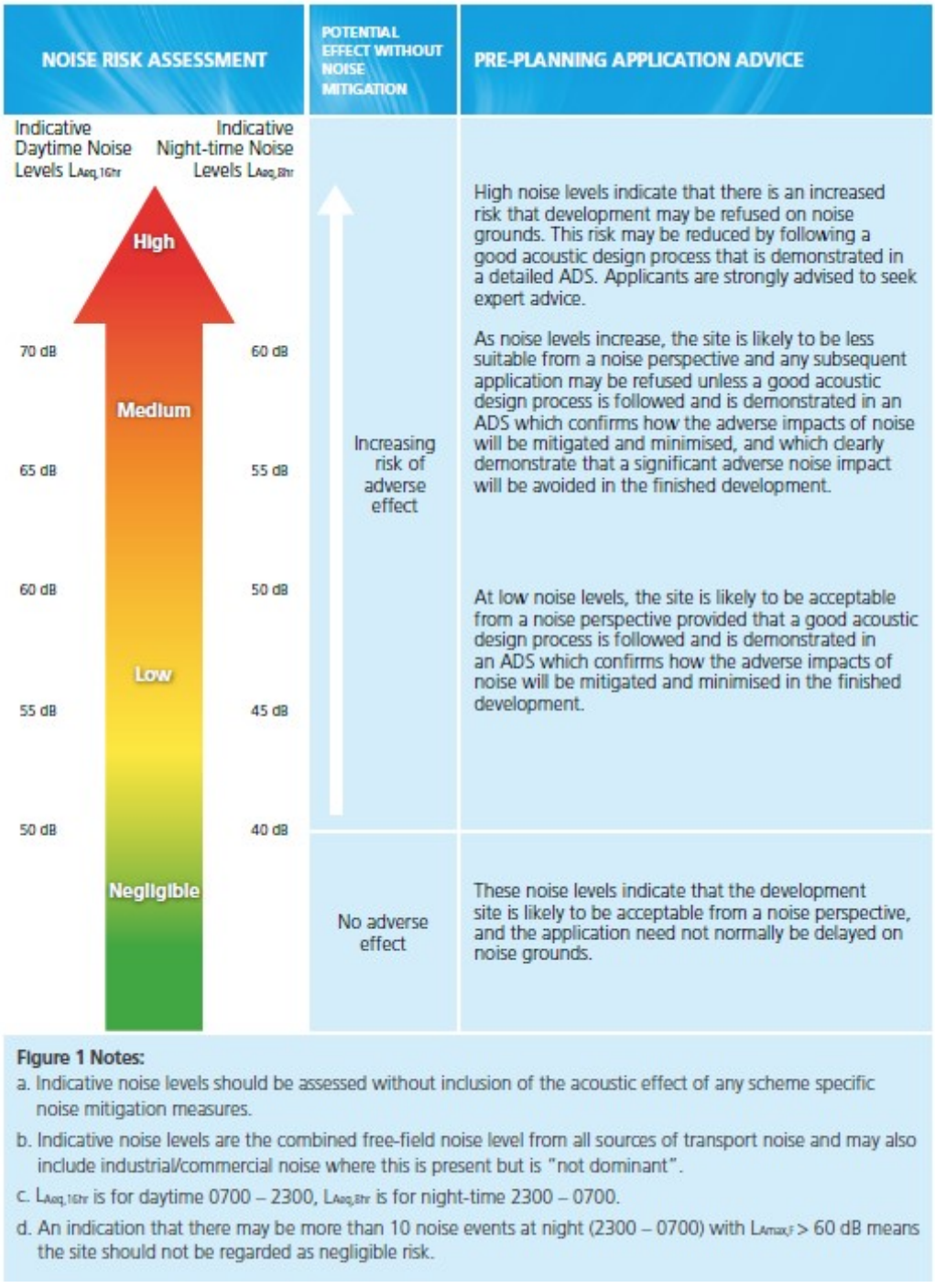
The ProPG follows a systematic, proportionate, risk-based, 2-stage approach. The two stages of the approach are:

- Stage 1 – an initial assessment where external noise is rated against the risk of adverse effect; and
- Stage 2 – a systematic consideration of four key elements to determine the suitability of the site for housing.

The results of the initial Site noise risk assessment will determine the appropriate risk of developing the Site from a noise perspective. This approach is intended to give the developer, the noise practitioner, and the decision maker an indication only of the likely suitability of the site for new residential development from a noise perspective. Thus, a site with a higher risk will be recognised as presenting more acoustic challenges than a site with a low or negligible risk.

Figure 3.1 outlines the initial site risk assessment. Stage 2 of the approach looks to determine whether a site is suitable for housing based on the noise risk of the site. Stage 2 essentially attempts to determine that good acoustic design principles have been incorporated into the design from the outset, that suitable internal noise levels can be achieved in habitable rooms and that suitable external noise levels can be achieved in gardens and outdoor amenity space.

Figure 3.1: Initial Site Risk Assessment (from the ProPG)

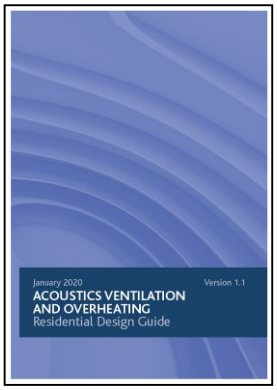


The ProPG encourages good acoustic design for all developments with the aim of protecting future residents from the effects of noise. Para 2.21 of the ProPG notes that in the first instance, it would be necessary to try to achieve suitable internal noise levels with windows open:

"Using fixed unopenable glazing for sound insulation purposes is generally unsatisfactory and should be avoided; occupants generally prefer the ability to have control over the internal environment using openable windows, even if the acoustic conditions would be considered unsatisfactory when open. Solely relying on sound insulation of the building envelope to achieve acceptable acoustic conditions in new residential development, when other methods could reduce the need for this approach, is not regarded as good acoustic design."

However, the ProPG notes that in some instances it is not possible to achieve suitable internal noise levels when windows are open. The notes to Figure 2 of the ProPG note *""designing the site layout and the dwellings so that the internal target levels can be achieved with open windows in as many properties as possible demonstrates good acoustic design. Where it is not possible to meet target internal levels with windows open, internal noise levels can be assessed with windows closed…".* In these instances, one must consider the impacts of ventilation and overheating, with the need to provide a good acoustic environment. The ProPG notes in Para 2.36 that where a *"scheme is reliant on open windows to mitigate overheating, itis also necessary to consider the potential noise impact during the overheating condition. In this case a more detailed assessment of the potential impact on occupants should be provided*".

3.6. Acoustics, Ventilation and Overheating Residential Design Guide (2020)



Published by the Association of Noise Consultants; the *Acoustics, Ventilation and Overheating (AVO) Guide* recommends an approach for acoustic assessments to take due regard of the interdependence of acoustics, ventilation and overheating. The approach ensures that the ventilation strategy of a building becomes an integral part of the acoustic design process.

The AVO Guide notes that *"The starting position when considering mitigation of noise impact on new residential development is to apply good acoustic design, site-wide, as described in the ProPG"*. Since the ProPG advocates the importance of at least attempting to achieve suitable internal noise levels with windows open, the starting point of the AVO Guide is to first see whether windows can be opened; therefore, it is clear that the AVO Guide should be applied after good acoustic design principles have been applied.

The AVO Guide makes it clear that as part of the acoustic design process, one needs to consider both whole house ventilation (which the AVO calls the *"ADF ventilation condition"*) and provisions for ventilation cooling to mitigate overheating (the *"overheating condition"*). The Guide notes that *"In terms of noise effect, the important distinction between these two situations is that the ADF ventilation condition applies for the entire time whereas the overheating condition applies only for part of the time"*.

Regarding the overheating condition, the AVO Guide notes *"it is considered reasonable to allow higher levels of internal ambient noise from transport sources when higher rates of ventilation are required in relation to the overheating condition. The basis for this is that the overheating condition occurs for only part of the time. During*

this period, occupants may accept a trade-off between acoustic and thermal conditions, given that they have some control over their environment. In other words, occupants may, at their own discretion, be more willing to accept higher short-term noise levels in order to achieve better thermal comfort. The importance of control is relevant to daytime exposure, but not to night time exposure where the consideration is sleep disturbance".

To estimate the potential impact in the overheating condition, a two-stage approach has been taken. The two levels of the approach are:

- Level 1 - an initial assessment where external noise is rated against the risk of adverse effect based on the assumption that opening windows are the primary means of mitigating overheating; and
- Level 2 – a systematic consideration of the potential for adverse effect on occupants based on internal ambient noise levels.

A Level 1 assessment looks at the external noise levels to determine whether a partially open window can be used to manage overheating, assuming a 13 dB attenuation for an open window. For *"negligible"* sites, no further action is required and open windows will be sufficient to manage overheating. For *"high"* risk sites, a Level 2 assessment is required. This is also recommended for *"medium"* risk sites. For a Level 2 assessment, the internal noise levels are calculated with windows open to determine the likely impact when windows are open to satisfy the overheating condition. **Table 3.4** summarises the approach and guidance from the AVO Guide. Essentially the guidance is used to determine whether or not windows can or cannot be opened. This guidance should be read in conjunction with Approved Document O of the Building Regulations.

Table 3.4: Initial Site Risk Assessment and Subsequent Guidance in Relation to the Overheating Condition

Daytime $L_{Aeq.16hour}$	Night-time $L_{Aeq.8hour}$	Night-time L_{AFmax}	Level 1 Risk	Level 2 Assessment	Outcome	Openable Windows?
≤ 48 dB(A)	≤ 43 dB(A)	-	***Negligible***	Not Required	*Noise can be heard, but does not cause any change in behaviour or attitude*	Yes
> 48 dB(A) to ≤ 53 dB(A)	> 43 dB(A) to ≤ 48 dB(A)	-	***Low***	Optional	*Limited behavioural change is expected unless conditions are prevalent for most of the time.*	Yes
> 53 dB(A) to ≤ 63 dB(A)	> 48 dB(A) to ≤ 55 dB(A)	Normally Exceeds > 74 dB(A) to ≤ 78 dB(A)	***Medium***	Recommended	*At higher noise levels, more significant behavioural change is expected and may only be considered suitable if occurring for limited periods.*	Yes, Depending on Duration
> 63 dB(A)	> 55 dB(A)	Normally Exceeds 78 dB(A) at night	***High***	Recommended	*Potential for sleep disturbance resulting in difficulty in getting to sleep, premature awakening and difficulty in getting back to sleep. Quality of life diminished due to change in acoustic character of the area.*	No

3.7. Approved Document O: Overheating (2021)

Approved Document O of the Building Regulations 'Overheating' (AD-O) was released in December 2021 and came into effect in England on 15th June 2022. It aims to protect the health and welfare of occupants of the building by reducing the occurrence of high indoor temperatures

AD-O requires the residential premises to:

- *limit unwanted solar gains in summer; and*
- *provide an adequate means to remove heat from the indoor environment.*

In meeting these requirements:

- *account must be taken of the safety of any occupant, and their reasonable enjoyment of the residence; and*
- *mechanical cooling may only be used where insufficient heat is capable of being removed.*

Whilst this is a standard in relation to the Building Regulations and not planning (i.e. compliance does not need to be demonstrated in order to obtain planning consent), consideration of the amenity of future residents (and therefore the overheating management strategy) is a material planning consideration and consequently it is recommended that AD-O is considered as part of the overall glazing, ventilation and overheating strategy of the development.

AD-O includes two methods for demonstrating compliance – the *"Simplified Method"*, which relies on limiting the glazed area of a room based on the location and orientation of the rooms, as well as whether the dwelling is cross ventilated, and the "*Dynamic Thermal Modelling Method"*. The "*Dynamic Thermal Modelling Method"* should be used for dwellings that do not satisfy the *"Simplified Method"* and relies on detailed modelling of the building and may require additional mechanisms to remove excess heat. These include:

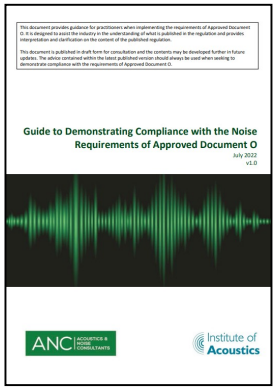
- Opening windows;
- Ventilation louvres in external walls;
- A mechanical ventilation system; and
- A mechanical cooling system.

It is noted in paragraph 3.2 of AD-O that *"In locations where external noise may be an issue (for example, where the local planning authority considered external noise to be an issue at the planning stage), the overheating mitigation strategy should take account of the likelihood that windows will be closed during sleeping hours (11pm to 7am)"*.

It is noted in paragraph 3.3 of AD-O that windows are likely to be closed during sleeping hours if noise within bedrooms exceeds the following limits:

- 40 dB $L_{Aeq,T}$, averaged over 8 hours (between 11pm and 7am); and
- 55 dB L_{AFmax}, more than 10 times per night (between 11pm and 7am).

3.8. Guide to Demonstrating Compliance with the Noise Requirements of Approved Document O (2022)



Guide to Demonstrating Compliance with the Noise Requirements of Approved Document O was published jointly by the Institute of Acoustics and Acoustics and Noise Consultants in July 2022. The guide was compiled to aid acoustic professionals in demonstrating compliance with Approved Document O (AD-O) of the Building Regulations.

As noted above, AD-O provides guidance on when an open window cannot be used to deal with overheating. Whilst AD-O provides internal noise levels, the IOA/ANC Guidance translates this into external noise levels.

Table 3.5 shows the external noise levels above which it will not be possible to use the *"Simplified Method"* to demonstrate compliance with AD-O. The IOA/ANC Guidance notes that *"It may be possible to increase these values and still satisfy the requirements of the simplified method using acoustically specified balconies"*.

The Guidance goes on to note that *"Based on the external noise levels presented in (Table 3.5), it is likely that external noise will be an issue for many sites exposed to only modest levels of noise"*.

Table 3.5: External Noise Levels Above Which The Simplified Method Cannot Be Used

Parameter	High Risk Location[1]	Medium Risk Location[2]
$L_{Aeq,T}$, averaged over 8 hours (between 11pm and 7am)	44 dB	49 dB
L_{AFmax}, more than 10 times per night (between 11pm and 7am)	59 dB	64 dB

Note 1: High Risk Locations have been identified in Appendix C of AD-O as certain postcodes in London and select postcodes in Central Manchester .
Note 2: Medium Risk Locations are all other locations in England not previously identified as High Risk Locations.

If noise levels exceed the levels identified in **Table 3.5**, it will be necessary to use the "*Dynamic Thermal Modelling Method"* to demonstrate compliance with AD-O. It should be noted that exceedances of the above noise thresholds do not necessarily mean that windows cannot be opened or that mechanical ventilation is required. For example, it may be possible to remove adequate heat from the rooms using a combination of smaller openable windows areas (through either smaller openable glazed panels or by fitting window restrictors) and ventilation louvres in external walls. The AVO Guide provides more definitive guidance on when windows can and cannot be opened in relation to noise.

4. ENVIRONMENTAL NOISE SURVEY

4.1. Survey Overview

In order to determine the extent to which the site is affected by noise, a detailed noise measurement study has been carried out on the proposed development site. Noise measurements have been carried out in order to determine the overall $L_{Aeq.16hrs}$ and $L_{Aeq.8hrs}$ for the day and night time periods. In addition, the L_{Amax} L_{A10}, L_{A50}, and L_{A90} noise levels have also been measured.

All noise monitoring was conducted using a Norsonic 140 sound level meter, which conforms to BS EN IEC 61672-1: 2003 as a Class 1 precision measurement system. A Norsonic 1251 field calibrator was used before and after the measurement periods in order to ensure that the equipment had remained within reasonable calibration limits (+/- 0.5 dB).

All of the equipment used has been calibrated in accordance with the procedures set out in BS EN IEC 61672-2: 2003 and for the electrical testing of frequency filters as set out in BS EN IEC 61260. The equipment was calibrated at Campbell Associates Limited, in Great Dunmow, Essex. Campbell Associates Limited meets the laboratory accreditation requirements of the United Kingdom Accreditation Service (UKAS Lab No. 0789). Sound level meters are laboratory calibrated every two years, with field calibrators laboratory calibrated every twelve months. **Appendix 2** summarises the equipment used including serial numbers and calibration certificates.

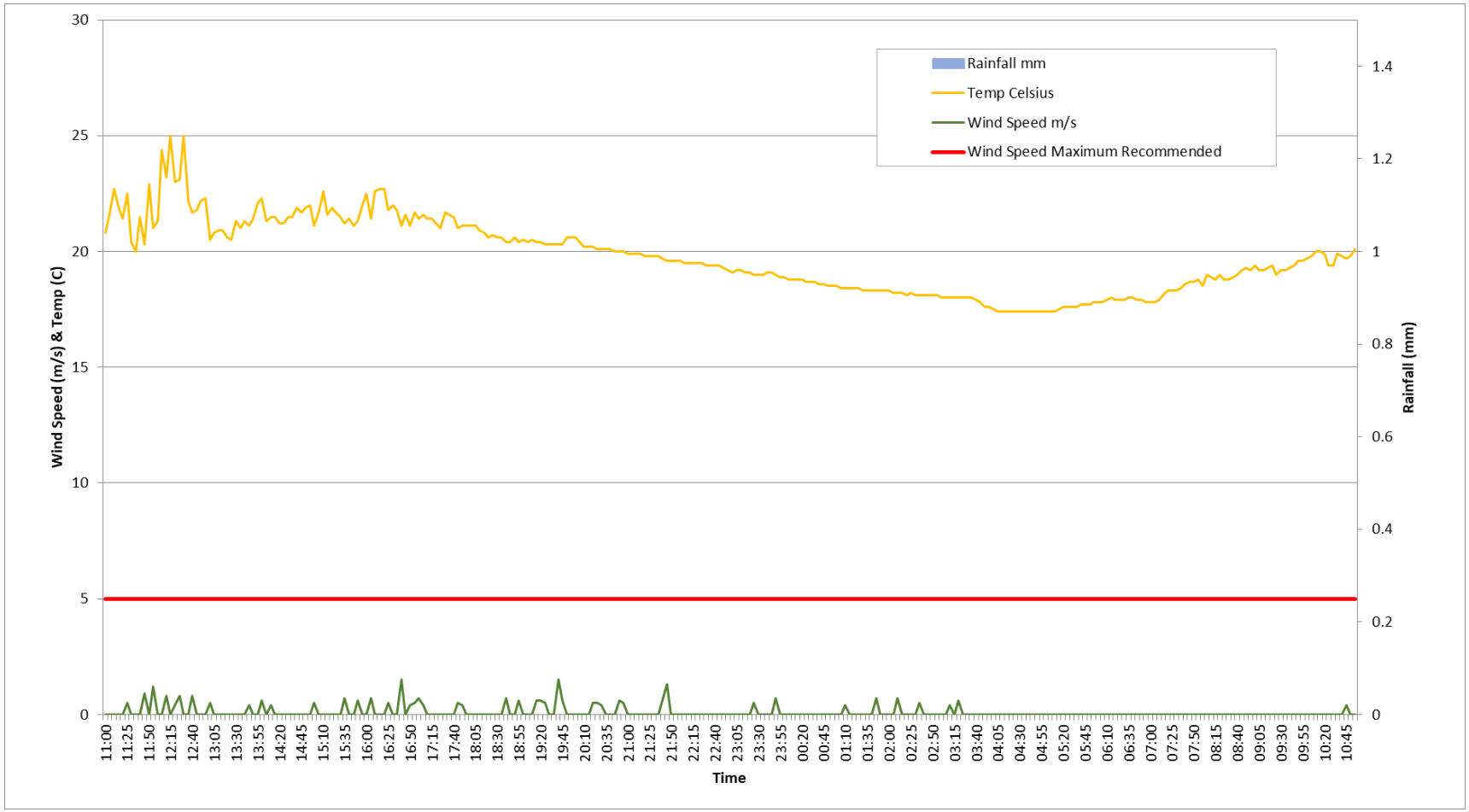
All noise monitoring has been conducted in accordance with the guidance set out in BS 7445-2: 1991 *'Description and measurement of environmental noise Part 2: Guide to the acquisition of data pertinent to land use*'. This standard details information that should be recorded in addition to the actual measured levels such as meteorological data, and a description of the noise source itself.

The survey was conducted on the 27th and 28th June 2023. The noise monitoring was conducted by Mathew Vaughan of Hawkins Environmental Limited. Mathew is an Associate Member of the Institute of Acoustics and holds a Masters of Science in Applied Acoustics from Solent University. Weather conditions were conducive to successful monitoring. During the measurement period, Hawkins Environmental measured the weather with a Kestrel 5000 windspeed and temperature logger, plus an 8in rain gauge with 1000 series Watchdog data logger. **Table 4.1** summarises the weather conditions during the measurement period, with the data presented in graphical form in **Figure 4.1**.

Table 4.1: Summary of Weather Conditions during the Noise Measurements

General Description	The measurement periods were warm for the time of year, with some sunshine during the day with light winds.
Windspeed	Average wind speeds were low, typically less than 0.5 m/s.
Temperature	The temperature went down to around 17°C at night, with daytime temperatures up to 25°C.
Precipitation	The measurement period remained dry.

Figure 4.1: Weather Data



Noise measurements were conducted at ground level at a measurement location representative of the worst affected façade of the proposed development. The measurement location is considered to be a freefield position. A map showing the measurement location in relation to the new site layout can be seen in **Figure 4.2**.

Figure 4.2: Noise Measurement Location & Proposed Ground Floor Plan

4.2. Noise Survey Results

The noise measurement study has identified that the primary noise source is road traffic noise attributed to Bath Road (A4) which runs adjacent to the northern boundary of the development site and Westmorland Road which runs adjacent to the western boundary of the site. Aircraft noise is also occasionally audible.

It is however noted that between approximately 04:15 and 04:50, there is a significant increase in $L_{Aeq,T}$ and L_{A10} values. Based on octave band analysis of the data which shows a significant elevation in noise levels at 4 kHz and 8 kHz, the period of the increase in level is likely analogous to dawn chorus.

The noise measurement data is detailed in **Appendix 3** and **Figure 4.3** and summarised in **Table 4.2** below.

Table 4.2: Summary of the Noise Level Measurements

Period (hours)	Measured Noise Level, dB			
	$L_{Aeq.T}$	Range $L_{Aeq.5mins}$	Range $L_{Amax.5mins}$	Range $L_{A90.5mins}$
7am to 11pm	58.2	50.5 – 74.7	60.9 – 95.9	33.9 – 53.6
11pm to 7am	52.3	26.5 – 63.3	36.7 – 77.5	23.5 – 45.2

4.3. Background Sound Levels

The background sound levels have been calculated in accordance with BS 4142:2014, which represents the most up-to-date guidance on the subject. Prior to the publication of the 2014 version of BS 4142, acousticians would use the lowest measured background sound levels; however, BS 4142: 2104 provides substantially more guidance on the determination of background sound levels. Section 8.1 of BS 4142: 2014 states that "*for this purpose, the objective is not simply to ascertain a lowest measured background sound level, but rather to quantify what is typical during particular time periods. Among other considerations, diurnal patterns can have a major influence on background sound levels and, for example, the middle of the night can be distinctly different (and potentially of lesser importance) compared to the start or end of the night-time period for sleep purposes*". The guidance goes on to say that *"a representative level ought to account for the range of background sound levels and ought not automatically to be assumed to be either the minimum or modal value"*.

In order to determine the background sound levels for the day and night-time periods, the background sound levels have been analysed over the appropriate time periods, i.e. 15 minutes for night-time (11 pm to 7 am) and 1 hour for the daytime periods. **Figure 4.4** and **Figure 4.5** detail the distribution of the background sound levels as described in BS 4142: 2014 for the day and night-time periods respectively.

It can be seen from **Figure 4.4** that during the day, the $L_{A90.1hour}$ ranged from 36 dB to 51 dB. It can be seen from **Figure 4.4** that most $L_{A90.1hour}$ noise levels were in the region of 47 to 51 dB and therefore, 47 dB is considered to be representative of the daytime background noise level.

It can be seen from **Figure 4.5** that during the night, the $L_{A90.15mins}$ ranged from 24 dB to 44 dB, with the largest number at 27 dB. To characterise a worst-case scenario in terms of night-time background noise levels, it is considered that 27 dB is the night-time background noise level.

Figure 4.3: Noise Measurements

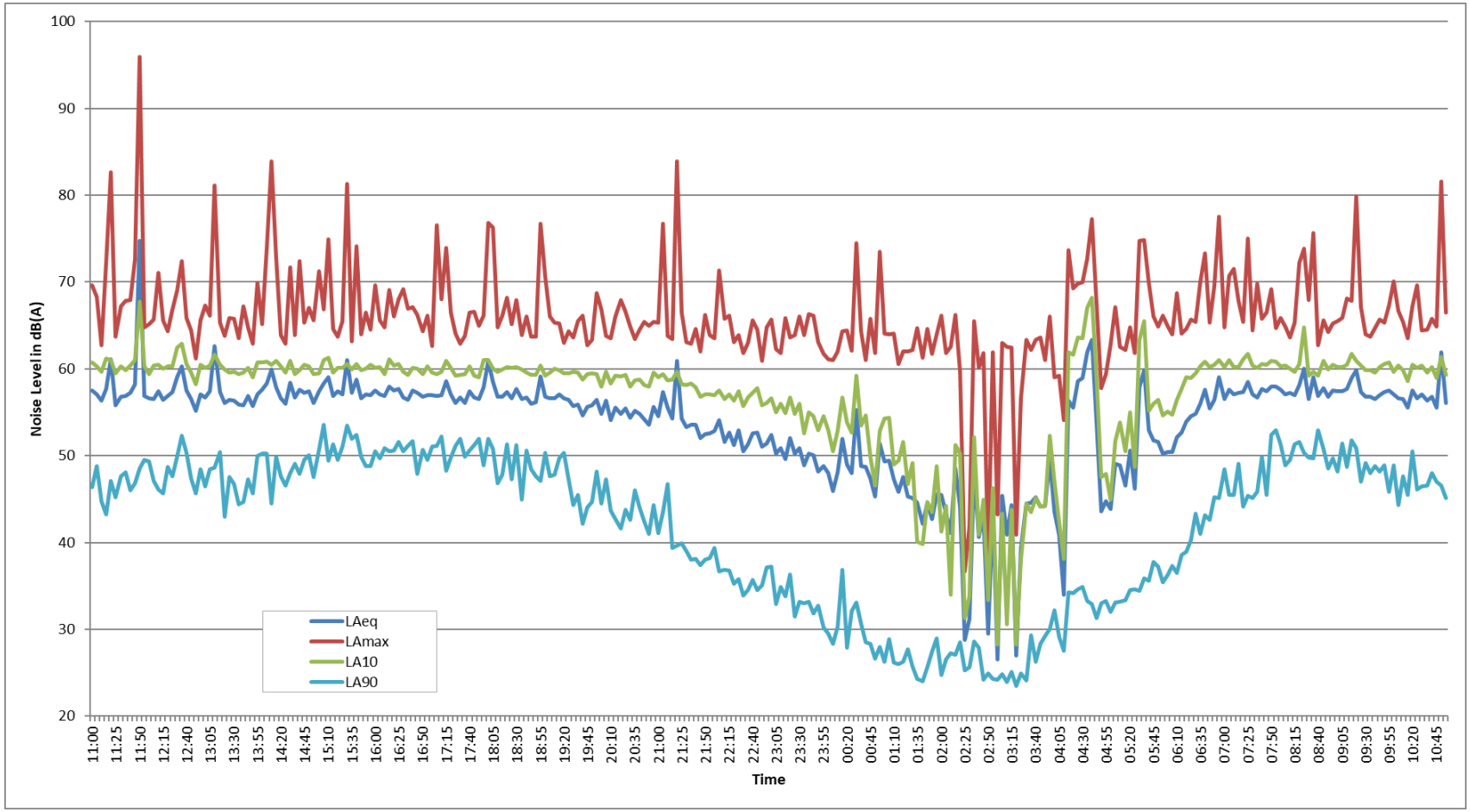


Figure 4.4: Distribution of Day Time $L_{A90.1hour}$ Sound Levels

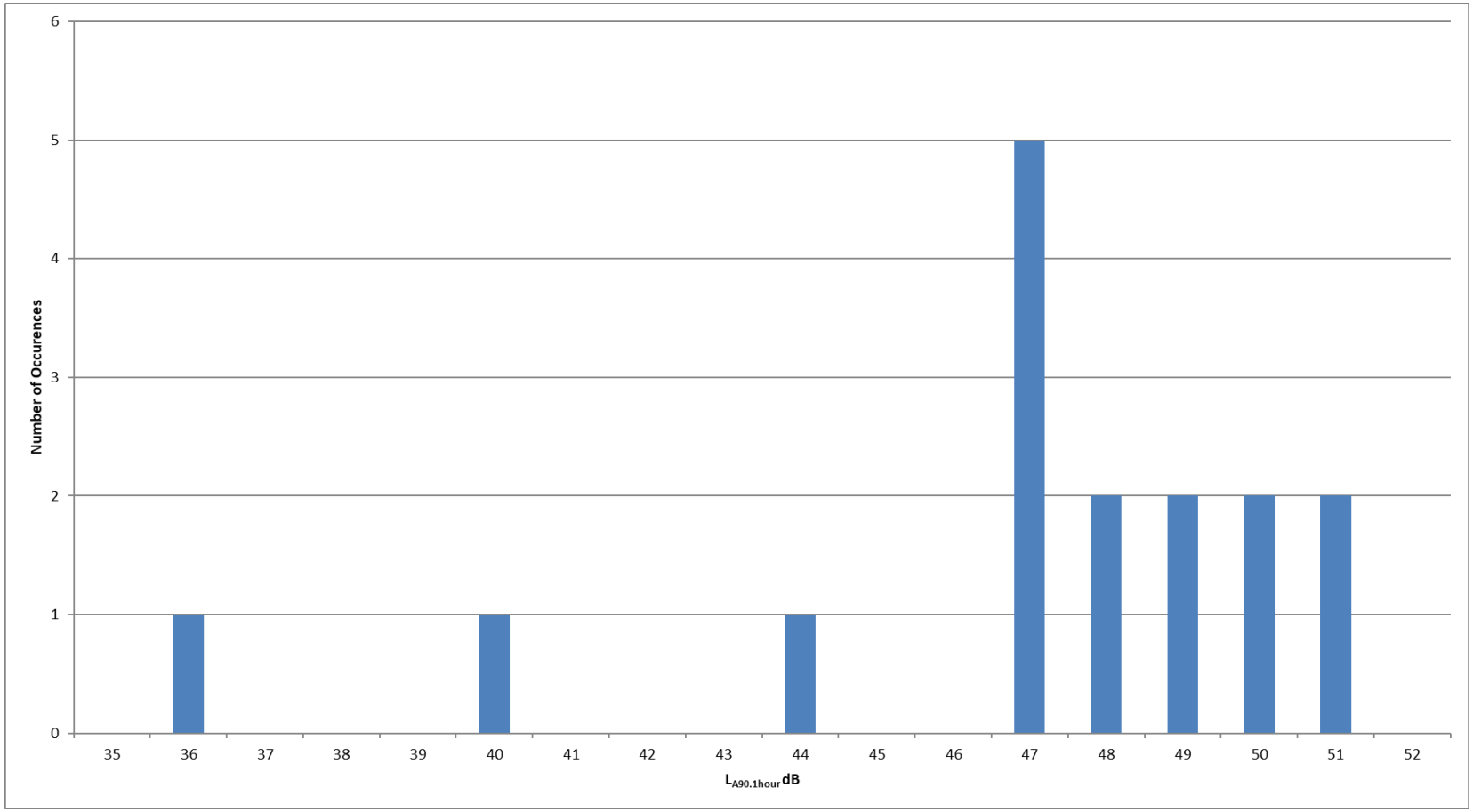
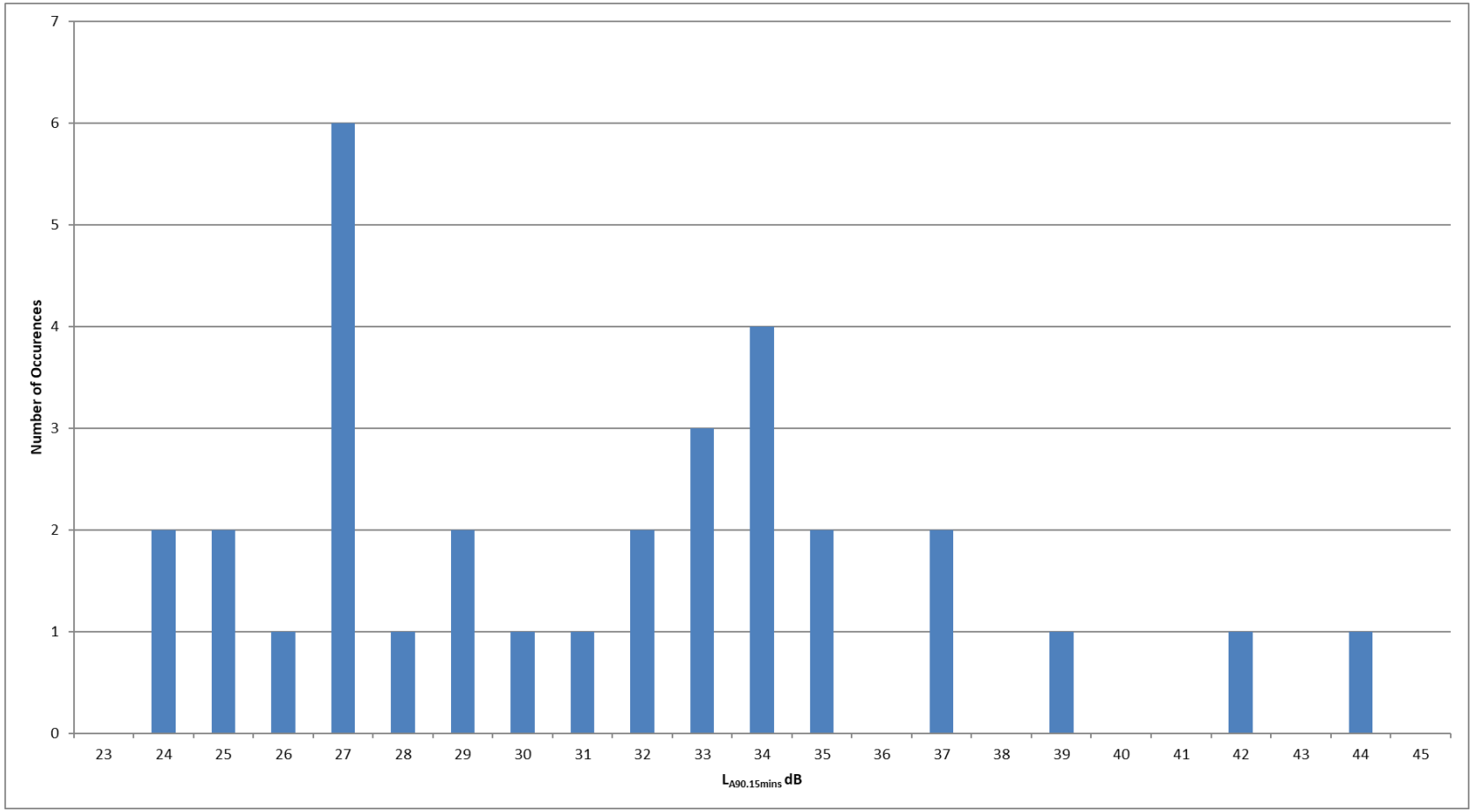


Figure 4.5: Distribution of Night Time $L_{A90.15mins}$ Sound Levels



5. PROPG STAGE 1: INITIAL SITE NOISE RISK ASSESSMENT

5.1. Site Classification - ProPG

The noise measurement survey determined the on-site noise levels. For the purposes of the assessment, the LOAEL and SOAEL levels have been determined from the Defra/AECOM research on LOAEL and SOAEL levels for road traffic sources. The Defra/AECOM research indicates that the typical average LOAEL would be around 56 dB(A) for the onset of daytime annoyance, with the SOAEL around 66 dB(A). For the onset of night time sleep disturbance, the LOAEL would be around 46 dB(A) and the SOAEL around 56 dB(A).

Table 5.1: Initial Site Noise Risk Assessment

Criteria	Daytime $L_{Aeq.16hr}$	Night time $L_{Aeq.8hr}$
Result	58 dB	52 dB
ProPG Noise Risk	Low	Low to Medium
Effect Level	Between LOAEL and SOAEL	Between LOAEL and SOAEL
Action	Mitigate and reduce to a minimum	Mitigate and reduce to a minimum

Based on the results shown in **Table 5.1,** the noise risk of the site is "*Medium"*, with the effect level between the LOAEL and the SOAEL. This suggests that there could be an observed effect of noise on the proposed development site and as a consequence, it will be necessary to mitigate and reduce noise for the future residents to a minimum. For a *"Medium"* risk site, a Stage 2 assessment with Acoustic Design Statement will be required, demonstrating a good acoustic design process has been followed, demonstrating how the adverse impacts of noise have been mitigated and minimised.

6. PROPG STAGE 2: ACOUSTIC DESIGN STATEMENT

The Stage 1 Initial Site Risk Assessment has identified that the noise risk is "*Medium*" and therefore, a Stage 2 assessment will be required, demonstrating a good acoustic design process has been followed, demonstrating how the adverse impacts of noise have been mitigated and minimised.

6.1. Element #1: Good Acoustic Design Process

Following a good acoustic design process is an implicit part of Government planning and noise policy and it is imperative that acoustic design is considered at an early stage of the development control process.

The ProPG requires the consideration of acoustic design and requires considerations such as checking the feasibility of relocating, or reducing noise levels from, relevant sources; considering options for planning the site or building layout; considering the options for screening buildings or sources; and considering the orientation of proposed buildings. These considerations will then inform how best to deal with excessive noise by either:

- Quietening or removing the source of noise;
- Attenuating the sound on its path to the receiver;
- Obstructing the sound path between the source and receiver; or
- Improving the sound insulation of the building envelope.

The orientation and layout of the proposed development has been designed with noise in mind, in combination with a number of other considerations as required by planning. The proposed building is conceptually a T-shaped rectangular building arranged with surrounding private garden spaces in addition to communal amenity areas. The gardens provide quiet communal and private outdoor amenity space, using the mass of the proposed building as an effective barrier to sound from road traffic noise. Alternative approaches to the layout were explored as part of a rigorous design process. The proposed scheme has been designed to deliver high quality accommodation that appropriately considers functionality, amenity, privacy, daylight and outlook as well as the ability to obstruct the sound path from external sources. Therefore, the optimum layout has been achieved in terms of acoustic design.

Existing trees will be retained with hedgerows planted to the boundaries of the private garden spaces. Previous research has demonstrated that vegetation would have a negligible impact when absorbing sound, however provides psychoacoustic benefits. For example, noise is noticed less when people cannot see the noise source. Therefore, planting can assist in masking the visual impact of noise sources and therefore they are less likely to notice the noise impacts from these sources.

6.2. Element #2: Internal Noise Levels

6.2.1. Criteria

The Initial Site Risk Assessment and good acoustic design process indicates that the sound insulation of the building envelope requires improvement and noise does need to be taken into account in the design of the building in order to meet the internal noise criteria contained within BS 8233 and the ProPG, and to comply with the guidance contained within the NPPF.

The appropriate design noise levels at this site are those identified in **Table 6.1** below.

Table 6.1: Summary of Noise Criteria: BS8233:2014 and ProPG

Activity	Location	07:00 to 23:00	23:00 to 0700
Resting	Living room	35 dB $L_{Aeq.16hour}$	-
Dining	Dining room/area	40 dB $L_{Aeq.16hour}$	-
Sleeping (daytime resting)	Bedroom	35 dB $L_{Aeq.16hour}$	30 dB $L_{Aeq.8hour}$ 45 dB L_{Amax} NOTE

Note: For a reasonable standard in noise-sensitive rooms at night (e.g. bedrooms) individual noise events should not normally exceed 45dB L_{Amax} more than 10 times a night.

Annex G of BS 8233 provides a rigorous calculation method for determining the internal noise levels within a proposed development.

6.2.2. Glazing Specification

The Sound Reduction Index (R_w sometimes noted as SRI) is the level of sound attenuation afforded by a particular material. It is possible to calculate the R_w of a particular facade to determine the internal noise level based on the noise survey results. It is widely known that a masonry wall will have a R_w of at least 50 dB. sometimes as high as 55 to 60 dB. The R_w of individual glazing solutions will vary considerably. However, BS 8233 notes that good quality insulating double glazed window units will typically have an R_w of 33 dB.

Using the equation in Annex G of BS 8233, it is possible to calculate the internal noise levels based on typical construction details. However, Annex G first suggests conducting simple calculations, to determine whether more detailed calculations are required.

The simple calculation procedure in Annex G notes that:

"The windows, and any trickle ventilators, are normally the weakest part of a brick and block facade. Insulating glass units have an insulation of approximately 33 dB R_w… assuming suitable sound attenuating trickle ventilators are used…". Consequently, it is possible to arithmetically subtract 33 dB from the external (freefield) noise levels to determine internal noise levels. The results of these calculations can be seen in **Table 6.2** below.

Table 6.2: The Simple Calculation Procedure from Annex G of BS 8233: 2014

Criteria	Daytime $L_{Aeq.16hr}$	Night time $L_{Aeq.8hr}$
External (freefield)	58 dB	52 dB
Criteria	35 dB	30 dB
Internal Noise Level (assuming R_w of 33)	25 dB	19 dB
Comparison to Criteria	-10 dB	-11 dB
Action	*More detailed calculation will not be required. Suitable internal noise levels can be achieved with a standard double glazed window system with a R_w of 33.*	

The above approximation includes a certain margin of error, since the R_w is based on insulation values relating to a pink noise spectrum - actual values achieved are lower for traffic noise. In addition, the above simple calculations do not take account of absorption, such as furnishings in the room. Consequently, the above is only a rough calculation which could underestimate noise levels by as much as 5 dB. Therefore, more detailed calculations may be required if the predicted internal noise levels higher are than 30 dB daytime and 25 dB night-time.

The results of the calculations in **Table 6.2** show that the internal noise levels will be more than 5 dB lower than the criteria; consequently, suitable internal noise levels can be achieved with standard double-glazed windows, which would typically have an R_w of 33 dB.

The R_w is the rating sound insulation of a building element. BS 8233: 2014 notes that *"these single-figure ratings are generally good predictors of subjective assessments of insulation of similar constructions. However, this is not always the case for different constructions, for example the low-frequency performance of a lightweight partition might be significantly different from that of a masonry partition with the same single-number rating, so it is prudent to examine the full measurement data in critical situations"*. One way that can be used to check for variations in frequency performance is to consider the C_{tr} correction quoted for glazing. The $R_w + C_{tr}$ is the dB insulation value against a standardised road traffic noise spectrum. For example, where a window is quoted as R_w (C_{tr}) = 33 (-3), this will perform better in the frequencies pertinent to traffic noise, when compared to a window quoted R_w (C_{tr}) = 33 (-7), despite the same R_w.

As a consequence of the above, it is always strongly recommended that any glazing solution is tested within the parameters of BS 8233: 2014, using full octave band data to determine suitability.

6.2.3. Ventilation, Overheating & the Opening of Windows

The ProPG notes that in the first instance, it would be necessary to try to achieve suitable internal noise levels with windows open. However, the ProPG notes that in some instances it is not possible to achieve suitable internal noise levels when windows are open.

The ProPG recommends a conservative estimate of 13 dB attenuation for a partially opened window. **Table 6.3** determines the internal noise levels with windows open. **Table 6.3** notes that suitable internal noise levels cannot be achieved within windows open. Therefore, one must consider the impacts of ventilation and overheating, with the need to provide a good acoustic environment.

Table 6.3: Internal Noise Levels Assuming a Partially Opened Window

Criteria	Daytime $L_{Aeq.16hr}$	Night time $L_{Aeq.8hr}$
External (freefield)	58 dB	52 dB
Criteria	35 dB	30 dB
Internal Noise Level Assuming a Partially Opened Window	45 dB	39 dB

The AVO Guide makes it clear that one needs to consider both whole house ventilation (which the AVO calls the *"ADF ventilation condition"*) and provisions for ventilation cooling to mitigate overheating (the *"overheating condition"*). The Guide notes that *"In terms of noise effect, the important distinction between these two situations is that the ADF ventilation condition applies for the entire time whereas the overheating condition applies only for part of the time"*.

The site cannot rely on the windows being opened for ventilation. Therefore, an alternative source of ventilation is required. The AVO Guide provides comprehensive guidance in relation to appropriate ventilation strategies.

It should be noted that if it is proposed to install trickle vents or any other acoustic ventilator that connects directly through the wall or window, it will be necessary to ensure that the acoustic performance of the ventilator is appropriate for the location. The performance of the acoustic ventilator will be presented as a $D_{n,e,w}$ rating, which is not directly comparable to a R_w rating used for windows. The $D_{n,e,w}$ is the weighted average composite loss of a typical wall with the vent installed; therefore, the R_w of the vent on its own will be less. Therefore, when selecting a vent, the $D_{n,e,w}$ value needs to be higher than the minimum R_w needed for the window, otherwise the this could lessen the sound reduction performance of the window. As a rough guide, the R_w is generally between 5 and 10 dB lower than the equivalent $D_{n,e,w}$ and it is therefore recommended that the $D_{n,e,w}$ of the vent is at least 7 dB higher than the R_w recommended for the window. For example, if a R_w of 30 dB is recommended for the window, the $D_{n,e,w}$ of the vent should be at least 37 dB.

With regards to overheating, the AVO Guide has determined that the site is a *"Medium"* risk site based on the criteria contained within **Table 3.4** of this report and the measured noise levels.

For a *"Medium"* risk site, windows can be opened to deal with overheating. However, the duration that the windows are expected to be opened is a factor when considering whether it is acceptable to rely on openable windows to deal with overheating. The guidance indicates that if the windows were *"rarely"* opened to deal with overheating, for example during the hottest nights of the year, this would be considered acceptable. However, if the windows were opened *"most of the time"* to deal with overheating, for example continuously from the end of May to the end of September, this may be considered unacceptable.

6.2.4. Consideration of Approved Document O of the Building Regulations

Under the guidance contained within Appendix C of AD-O, the site is located within a *"Medium Risk Location"*. It can be seen that the measured onsite noise levels are in excess of the maximum recommended levels displayed in **Table 3.5** pertinent to the Risk Location.

As the noise levels exceed the levels identified in **Table 3.5**, it will be necessary to use the "*Dynamic Thermal Modelling Method"* to demonstrate compliance with AD-O. It should be noted that exceedances of the above noise thresholds do not necessarily mean that windows cannot be opened or that mechanical ventilation is required. For example, it may be possible to remove adequate heat from the rooms using a combination of smaller openable windows areas (through either smaller openable glazed panels or by fitting window restrictors) and ventilation louvres in external walls. It should be noted that consideration of AD-O is only in relation to night time noise in bedrooms.

6.2.5. Variation Across the Development Site

Section 6.2.2 and **Section 6.2.3** of this report outline the glazing, ventilation and overheating requirements for the front of the site facing Bath Road (A4), where the measurements were undertaken. This is considered to be the worst affected façade. However, accommodation to the rear of the development, without a direct view of Bath Road (A4), is likely to benefit from lower noise levels.

Regarding glazing requirements, **Section 6.2.2** of this report notes that standard double glazed windows will be adequate on the front façade; as noise levels will be lower to the rear, it is possible to conclude that standard double glazed windows will be also be suitable for windows without a direct view of Bath Road (A4).

Regarding overheating and whether windows can be opened, **Section 6.2.3** notes that windows can be opened to deal with overheating, depending on duration. Since noise levels will be lower at accommodation to the rear of the development, without a direct view of Bath Road (A4), it is anticipated that noise levels would result in a *"medium"* risk under the AVO Guide and therefore the opening of windows where internal noise levels exceed the recommended levels within BS 8233 may be acceptable to address overheating, depending on the duration that windows need to be opened.

6.3. Element #3: External Amenity Areas

BS 8233 provides guidance for noise in gardens and outdoor amenity space. It suggests that *"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."* The guidance does go on to say that these guideline values are not achievable in all circumstances and in some 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."*

The location of the external amenity areas within the development is likely to be the optimal design in terms of reducing noise in outdoor amenity areas and is likely to be effective particularly in terms of reducing road noise from Bath Road (A4) and Westmorland Road. The $L_{Aeq.16hours}$ is expected to be in the region of 58 dB at amenity attached to the western façade of the development, which is in excess of the *"upper guideline value"* of 55 dB.

However, the arrangement of the communal amenity area to the rear of the property is likely to offer significant protection, potentially in the region of 10 dB. Therefore, whilst not all outdoor amenity space is likely to benefit from the acoustic screening that the communal external amenity area affords, the residents should have access to quiet outdoor amenity space onsite.

6.4. Element #4: Other Relevant Issues

Good acoustic design principles which have been followed mean that the proposed development is in general compliance of the ProPG.

The proposed façade sound insulation performances mean that internal noise levels when windows are closed will be in line with ProPG internal noise criteria. When windows are open, for example to manage overheating, internal noise levels might be slightly higher than the desired levels.

Steps should be taken through effective architectural and ventilation design to minimise the regularity and duration that windows are required to be open. This, in conjunction with the good acoustic design principles adopted, would be considered to minimise any potential adverse effects of noise on occupants.

6.5. Recommendations to the Decision Maker

Since the internal and external noise criteria contained within BS 8233 and the ProPG guidance framework can be achieved and a reasonable level of acoustic design has been demonstrated, it is recommended to the decision maker that planning consent may be granted, subject to the inclusion of suitable noise conditions, to ensure suitable internal and external noise levels.

7. PLANT NOISE LIMITS

At this stage in the design process, the noise output of specific items of plant has yet to be determined; therefore it is not possible to provide a full and detailed assessment of the likely impact of plant noise. As a consequence, environmental noise limits for plant associated with the development should be set to protect the amenity of nearby noise sensitive premises, as well as future residents of the development itself in accordance with BS 4142: 2014 *'Methods for rating and assessing industrial and commercial sound'.*

Prior to the publication of the 2014 version of BS 4142, acousticians would use the lowest measured background noise levels; however, BS 4142: 2014 provides substantially more guidance on the determination of background noise levels. Section 8.1 of BS 4142: 2014 states that *"for this purpose, the objective is not simply to ascertain a lowest measured background sound level, but rather to quantify what is typical during particular time periods. Among other considerations, diurnal patterns can have a major influence on background sound levels and, for example, the middle of the night can be distinctly different (and potentially of lesser importance) compared to the start or end of the night-time period for sleep purposes"*. The guidance goes on to say that *"a representative level ought to account for the range of background sound levels and ought not automatically to be assumed to be either the minimum or modal value"*.

The background noise levels have been determined to be 47 dB(A) and 27 dB(A) during the day and night respectively. To ensure that an adverse impact as a consequence of plant noise is unlikely, it recommended that the Rating noise level from the plant is below background noise level, i.e. the Rating noise level should be no more than 47 dB(A) during the day and 27 dB(A) during the night at the closest residential property. The Rating noise level is the predicted cumulative noise level from all plant at the receptor location and should include penalties for tonality, impulsivity and/or intermittency if appropriate. The lower the Rating level is relative to the measured background sound level, the less likely it is that the specific sound source will have an adverse impact or a significant adverse impact.

8. CONSTRUCTION NOISE

Due to the size of the development and early outline stage of the proposals, a quantitative construction noise and vibration assessment has not been carried out. Instead, a qualitative assessment focussing on best practicable means has been completed. In general, the construction works with the greatest potential to generate noise are initial earthworks to level out the site, demolition and the piling of foundations. Building construction itself generally results in lower noise levels.

It is proposed that to minimise construction noise impacts, all construction work should take place in standard construction hours, which are:

Monday – Friday: 08:00 – 18:00

Saturdays: 08:00 - 13:00; and

Sundays and Public Holidays: No construction

It is recommended that the contractor would be required to follow Best Practicable Means to reduce the noise impact upon the local community including the following:

- Operating hours should be adhered to, with local residents being notified of any changes to the operating hours of the site;
- All construction plant and equipment should comply with EU noise emission limits;
- Where practicable, design and use of site hoardings and screens to provide acoustic screening of noise emitting equipment;
- Proper use of plant with respect to minimising noise emissions and regular maintenance. All vehicles and mechanical plant used for the purpose of the works should be fitted with effective exhaust silencers and should be maintained in good efficient working order;
- Selection of inherently quiet plant where appropriate. All major compressors should be 'sound reduced' models fitted with properly lined and sealed acoustic covers which should be kept closed whenever the machines are in use and all ancillary pneumatic percussive tools should be fitted with mufflers or silencers of the type recommended by the manufacturers;
- Machines in intermittent use should be shut down in the intervening periods between work or throttled down to a minimum;
- Plant and equipment such as flatbed lorries, skips and chutes should be lined with noise attenuating materials. Materials should be handled with care and be placed, not dropped. Materials should be delivered during normal working hours.
- All ancillary plant such as generators, compressors and pumps should be positioned so as to cause minimum noise disturbance, i.e. furthest from receptors or behind close boarded noise barriers. If necessary, acoustic enclosures should be provided and/or acoustic shielding;

- Making positive contact with local residents and providing information on the construction can be the most effective method of reducing the impact of construction noise on sensitive receptors. If appropriate, the above measures can be incorporated into a construction environmental management plan;
- Construction contractors should be obliged to adhere to the codes of practice for construction working given in BS 5228 and the guidance given therein regarding minimising noise emissions from the site; and
- Reference should be made to the Building Research Establishment, BRE 'Pollution Control' guidelines, Parts 1-57.Noise Monitoring.

9. OVERALL CONCLUSIONS AND RECOMMENDATIONS

A detailed noise measurement study has been carried out at the site in order to determine whether as a result of noise, there are any significant constraints on developing the site for use as a care home.

The study has shown that due to noise from surrounding roads and the wider environment, the site is considered a *"medium risk"* site under the Pro-PG, with noise levels between the Lowest Observed Adverse Effect Level (LOAEL) and the Significant Observed Adverse Effect Level (SOAEL); therefore, if the site is to come forward for residential development, noise must be considered and it must be mitigated and reduced to a minimum.

Using the guidance and calculation methods contained within BS 8233: 2014 '*Guidance on sound insulation and noise reduction for buildings',* it has been shown that the recommended maximum internal noise levels for each room use under BS 8233 can be achieved through the provision of suitable glazing and ventilation. A summary of the recommendations can be seen in **Table 9.1** below.

Table 9.1: Summary of Recommendations to Achieve Suitable Internal Noise Levels

	All façades	
	Bedrooms	Living Rooms
Minimum Sound Reduction of the Glazing in Relation to Noise	Standard doubling glazing, which would typically have a R_w of 33 dB or more.	
Ventilation Recommendations in Relation to Noise	Based on the onsite noise level, any ventilation system should be appropriate.	
Overheating Recommendations in Relation to Noise	Based on the onsite noise levels, windows can be opened to deal with overheating, depending on duration.	

Since the internal noise criteria contained within BS 8233 and the ProPG guidance framework can be achieved and a reasonable level of acoustic design has been demonstrated, it is recommended to the decision maker that planning consent may be granted, subject to the inclusion of suitable noise conditions, to ensure suitable internal and external noise levels.

Since it has been shown that the proposed development meets the guidance contained within BS 8233: 2014, it is considered that the proposed development complies with Paragraph 185 of the National Planning Policy Framework since the new development will not be *"put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution".* Since it has been shown that in terms of noise, the proposals adhere to local and national planning policy, it is considered that the noise environment of the site should not be a constraint on the proposed residential development.

Appendix 1
Glossary of Acoustic Terms

Appendix 1: Glossary of Acoustic Terms

Decibel (dB)	This is a tenth (deci) of a bel. Decibel can be a measure of the magnitude of sound, changes in sound level and a measure of sound insulation. Decibels are not an absolute unit of measurement but are an expression of the ratio between two quantities expressed in logarithmic form.
dB(A)	A-weighted decibels, i.e. decibel level incorporating a frequency weighting (A-weighting), which differentiates between sounds of different frequency (pitch) in a similar way to the human ear. Measurements in dB(A) broadly agree with people's assessment of loudness.
Freefield	A situation in which the radiation from a sound source is completely unaffected by the presence of any reflecting boundaries.
Hertz (Hz)	Unit of frequency, equal to one cycle per second. The frequency of sound waves refers to the number of pressure fluctuations per second. Frequency is related to the pitch of a sound.
$L_{Aeq,T}$	The equivalent steady sound level in dB(A) containing the same acoustic energy as the actual fluctuating sound level over the given period, T. For example, daytime noise is generally measured over a 16 hour period, so T is 16 hours. $L_{Aeq,T}$ can be measured directly with an integrating sound level meter.
L_{A10}	The 'A'-weighted sound pressure level of the residual noise in decibels exceeded for 10 percent of a given time and is the $L_{A10,T}$. The L_{A10} is used to describe the levels of road traffic noise at a particular location.
L_{A50}	The 'A'-weighted sound pressure level of the residual noise in decibels exceeded for 50 percent of a given time and is the $L_{A50,T}$.
L_{A90}	The 'A'-weighted sound pressure level of the residual noise in decibels exceeded for 90 percent of a given time and is the $L_{A90,T}$. The L_{A90} is used to describe the background noise levels at a particular location.
L_{Amax}	The 'A'-weighted maximum sound pressure level measured over a measurement period.
R_w (or SRI)	The weighted sound reduction index as a single number laboratory measured rating used to describe the sound insulation of building elements.

Appendix 2
Schedule of Equipment

Appendix 2: Schedule of Equipment

Equipment Set 3056:

Equipment Type	Manufacturer	Serial Number	Calibration Certification Number	Calibration Type	Date of Last Calibration Check	Date of Next Calibration Check
Nor-140 Type 1 Sound Level Meter	Norsonic	1403056	U42312	UKAS Calibration: 0789	2nd November 2022	November 2024
Nor-1209 Pre-amplifier	Norsonic	12528	U42312	UKAS Calibration: 0789	2nd November 2022	November 2024
Nor-1225 Microphone	Norsonic	98361	42311	UKAS Calibration: 0789	2nd November 2022	November 2024
Nor-1255 Sound Calibrator	Norsonic	25262	U42310	UKAS Calibration: 0789	2nd November 2022	November 2023
Nor-1284 Dehumidifier	Norsonic	222	Not Applicable			
Nor- 1212 Weather Protection Kit	Norsonic	Not Applicable				
Nor1408A/5 Extension Cable	Norsonic/Lemo	Not Applicable				

Laboratory Location
Campbell Associates Ltd
5b Chelmsford Road Industrial Estate
GREAT DUNMOW, Essex, GB-CM6 1HD
Phone 01371 871030

0789

Certificate of Calibration and Conformance

Certificate number: **U42312**

Test Object: **Sound Level Meter, BS EN IEC 61672-1:2003 Class 1**

Producer: Norsonic AS.
Type: 140
Serial number: 1403056
Customer: Hawkins Environmental
Address: The Square, Basing View, Basingstoke, Hampshire, RG21 4EB
Contact Person: Nick Hawkins
Order No: TBC

Introduction:
Calibration has been performed as set out in CA Technical Procedures which are based on the procedures for periodic verification of sound level meters as per the **Test Object** listed above. Results and conformance statement are overleaf and detailed results, where appropriate, are provided in the attached Measurement Report.

Tested:	*Producer*	*Type*	*Serial No*	*Certificate No*
Microphone	Norsonic	1225	98361	42311
Calibrator*	Norsonic	1255	125525262	U42310
Preamplifier	Norsonic	1209	12528	Included

* The calibrator was complete with any required coupler for the microphone specified.

Additional items that have also been submitted for verification:
Wind shield N/A
Attenuator N/A
Extension cable N/A
These items have been taken into account wherever appropriate.

Instruction Manual: Im140_1Ed8R0En Firmware Version: 2.1.670 The test object is a single channel instrument.

Conditions	*Pressure kPa*	*Temperature °C*	*Humidity %RH*
Reference conditions	101.325	23	50
Measurement conditions	100.82 ±0.08	23.40 ±0.2	47.98 ±0.2

Calibration Dates:

Received date:	24/10/2022	Reviewed date:	03/11/2022
Calibration date:	02/11/2022	Issued date:	03/11/2022

Technicians: (Electronic certificate)

Calibrated by: *Katie Brown*

Reviewed by: *Jenny Crawford*

Doc ref: Slm-Cert-Master-V3-05

Certificate of Calibration and Conformance

Continuation of Certificate number: **U42312**

The statements of conformance and observation notes detailed in this certificate are made with reference to the following standards in respect of the calibration of the test object.

Manufactured:	**BS EN IEC 61672-1:2003**
Periodic Tests:	**BS EN IEC 61672-3:2006**
Pattern Evaluation:	**BS EN IEC 61672-2:2003**

Conformance:
From markings on the sound level meter or by reference to the manufacturer's published literature it has been determined that the instrument submitted for verification was originally manufactured to the listed standard and similarly that the associated sound calibrator conforms to the BS EN IEC 60942 standard.

Measurement Summary:

Indication at the calibration check frequency - IEC61672-3 Ed.1 #9	Passed
Self-generated noise - IEC 61672-3 Ed.1 #10.2	Passed
Acoustical signal tests of a frequency weighting - IEC 61672-3 Ed.1 #11	Passed
Electrical signal tests of frequency weightings - IEC 61672-3 Ed.1 #12	Passed
Frequency weightings: A Network - IEC 61672-3 Ed.1 #12.3	Passed
Frequency weightings: C Network - IEC 61672-3 Ed.1 #12.3	Passed
Frequency weightings: Z Network - IEC 61672-3 Ed.1 #12.3	Passed
Frequency and time weightings at 1 kHz IEC 61672-3 Ed.1 #13	Passed
Level linearity on the reference level range - IEC 61672-3 Ed.1 #14	Passed
Toneburst response - IEC 61672-3 Ed.1 #16	Passed
Peak C sound level - IEC 61672-3 Ed.1 #17	Passed
Overload indication - IEC 61672-3 Ed.1 #18	Passed

Comments
Correct level with associated calibrator is 113.9dB(A). Actual measured microphone response has been used for the determination of the combined acoustic and electrical frequency response.

Statement of Conformance
The sound level meter submitted has successfully completed the periodic tests of the standard listed for the environmental conditions under which the tests were performed. As public evidence(1) was available, from an independent testing organisation responsible for approving the results of pattern evaluation tests performed in accordance with the manufacturer's standard to demonstrate that the model of sound level meter fully conformed to the requirements of the said standard, the sound level meter submitted for testing conforms to the relevant class of the said standard.
(1 - evidence is held on file at the calibration laboratory)

Observations
The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k = 2, providing a coverage probability of approximately 95 %. The uncertainty evaluation has been carried out in accordance with UKAS requirements. Details of the uncertainty for each measurement are available from the Calibration Laboratory upon request. Details of the sources of corrections and their associated uncertainties that relate to this verification are contained within the test report accompanying this certificate.

Decision Rule
Basic Meter Function - The decision rules will be applied in accordance with the procedure as described in BS EN 61672-3:2006.

This certificate relates only to the items tested above.

** End of Certificate **

Laboratory Location
Campbell Associates Ltd
5b Chelmsford Road Industrial Estate
GREAT DUNMOW, Essex, GB-CM6 1HD
Phone 01371 871030

CALIBRATION

Certificate of Calibration

Certificate number: **42311**

Test Object: **Measurement Microphone**

Producer: **Norsonic AS.**
Type: **1225**
Serial number: **98361**
Customer: **Hawkins Environmental**
Address: **The Square, Basing View, Basingstoke, Hampshire, RG21 4EB**
Contact Person: **Nick Hawkins**
Order No: **TBC**

Measurement Results	Sensitivity (dB re 1V/Pa)	Sensitivity (mV/Pa)	Capacitance (pF)
Measurement 1	*-25.95*	*50.39*	*26.46*
Measurement 2	*-25.97*	*50.32*	*26.44*
Measurement 3	*-25.96*	*50.32*	*26.40*
Result (Average):	***-25.96***	***50.34***	***26.43***
Expanded Uncertainty:	0.10		2.00
Degree of Freedom:	>100		>100
Coverage Factor:	2		2

The stated sensitivity is the pressure sensitivity at 250Hz, S_{250}, and is valid at reference conditions. The following correction factors have been applied during the measurement:
Pressure:uncertainty dB/kPa Temperature:-0.005 dB/°C Humidity:0 dB/%RH

Conditions	*Pressure kPa*	*Temperature °C*	*Humidty %RH*
Reference conditions	101.325	23	50
Measurement conditions	100.988 ± 0.042	22.9 ± 0.1	48.7 ± 0.8

The calibration test report shown on the next page gives details of the response at other frequencies relative to this 250 Hz reference sensitivity. Results ≥100 Hz are obtained using an electrostatic actuator as described in BS EN 61094-6 and those below 100 Hz are obtained in a reference pressure chamber. Detailed results are available from the calibration laboratory upon request.

The reported expanded uncertainty of measurements is based on a standard uncertainty multiplied by the coverage factor of k=2, providing a coverage probability of approximately 95%. Where the degrees of freedom are insufficient to maintain this confidence level, the coverage factor is increased to maintain this confidence level.

Calibration Dates:

Received date:	24/10/2022	Reviewed date:	03/11/2022
Calibration date:	02/11/2022	Issued date:	03/11/2022

Technicians: (Electronic certificate)
Calibrated by: *Katie Brown*
Reviewed by: *Jenny Crawford*

Doc ref: Mic-Cert-Master-V3-04

Certificate of Calibration

Continuation of Certificate number: **42311**

Reference Calibrator: WSC11 - Nor-1253.26672
Measurement Record: K:\C A\Calibration\Nor-1504\Nor-1017 MicCal\NOR1225_98361_M1.nmf

Preconditioning
The equipment was preconditioned for more than 12 hours at the specified calibration temperature and humidity.

Instruments and Program
A complete list of instruments, hardware and software that have been used for this calibration is available from the calibration laboratory

Traceability
The measured values for sound pressure, frequency, voltage, capacitance, temperature, humidity and ambient pressure are traceable to an accredited national physical laboratory.

Observations
The differences between the two results at 100 Hz are within normal limits bearing in mind the different test methods and are taken into account in arriving at the uncertainties of measurement.

Method of Calibration
The open circuit sensitivity of the microphone has been determined at 250 Hz against a reference laboratory standard measurement microphone by insert voltage techniques using a laboratory standard sound calibrator as a transfer standard. The electrostatic actuator frequency response was then obtained for frequencies above 100 Hz as described in BS EN IEC 61094-6. In addition, where requested the optional free field frequency response over the range 2 – 100 Hz has been obtained using a pressure chamber; in this case the reference frequency is 100 Hz. All of these results and their associated uncertainties are detailed in the table on page 3 of this certificate. See the observations field below for details of any discrepancies between the 100 Hz results obtained via the electrostatic actuator and pressure chamber.

The overall uncertainty at any frequency σCombined,Fn may be obtained by combining the uncertainty of the open circuit sensitivity σS250 with the uncertainty of the actuator / or LF pressure response at any other frequency σAct,Fn where Fn is the uncertainty at the frequency of interest using the relationship:

$$\sigma Combined,Fn = 2\sqrt{(\sigma 2S250 + \sigma 2ActFn)}$$

Appendix to this certificate
Where data is available from the microphone manufacturer to correct the actuator / pressure frequency response to obtain the random incidence and / or free field response it is shown in the appendix to this certificate. The uncertainty information relating to these corrections is the responsibility of the microphone manufacturer and when it is available the total uncertainty for the corrected frequency response at each point may then be obtained by including the correction uncertainty in the root-sum-square formula given above. These responses are outside the UKAS accredited scope, but are provided for information.

Observations

Laboratory Location
Campbell Associates Ltd
5b Chelmsford Road Industrial Estate
GREAT DUNMOW, Essex, GB-CM6 1HD
Phone 01371 871030

0789

Certificate of Calibration and Conformance

Certificate number: **U42310**

Test Object: **Sound Calibrator**

Producer: **Norsonic AS.**
Type: **1255**
Serial number: **125525262**
Customer: **Hawkins Environmental**
Address: **The Square, Basing View, Basingstoke, Hampshire, RG21 4EB**
Contact Person: **Nick Hawkins**
Order No: TBC

Measurement Results	Level dB	Level Stability dB	Frequency Hz	Distortion %
Measurement 1	114.05	0.02	1000.00	0.34
Measurement 2	114.05	0.02	1000.00	0.36
Measurement 3	114.06	0.02	999.99	0.34
Result (Average):	**114.05**	**0.02**	**999.99**	**0.35**
Expanded Uncertainty:	0.1	0.02	1	0.1
Degree of Freedom:	>100	>100	>100	>100
Coverage Factor:	2	2	2	2

The stated level is relative to 20µPa. The level is traceable to National Standards. The stated level is valid at reference conditions. The following correction factors have been applied during the measurement
Pres:0 dB/kPa Temp:0 dB/°C Humi:0 dB/%RH Load volume: 0.00015 dB/mm3

Conditions	*Pressure kPa*	*Temperature °C*	*Humidity %RH*
Reference conditions	101.325	23	50
Measurement conditions	100.998 ±0.042	22.7 ±0.1	49.2 ±0.8

The reported expanded uncertainty of measurements is based on a standard uncertainty multiplied by the coverage factor of k=2, providing a level of confidence of approximately 95%. Where the degrees of freedom are insufficient to maintain this confidence level, the coverage factor is increased to maintain this confidence level. The uncertainty has been determined in accordance with UKAS requirements.

Records: K:\C A\Calibration\Nor-1504\Nor-1018 CalCal\2022\NOR1255_125525262_M1.nmf

Preconditioning
The equipment was preconditioned for more than 4 hours in the specified calibration environment.

Method
Calibration has been performed as set out in the current version of CA Technical procedure TP01

Calibration Dates:

Received date:	24/10/2022	Reviewed date:	03/11/2022
Calibration date:	02/11/2022	Issued date:	03/11/2022

Technicians: (Electronic certificate)
Calibrated by: *Katie Brown*
Reviewed by: *Jenny Crawford*

This certificate is issued in accordance with the laboratory accreditation requirements of the United Kingdom Accreditation Service. It provides traceability of measurement to the SI system of units and/or to units of measurement realised at the National Physical Laboratory or other recognised national metrology institutes. This certificate may not be reproduced other than in full, except with the prior written approval of the issuing laboratory.

Doc ref: Calb-Cert-Master-V3-05

Certificate of Calibration and Conformance

Continuation of Certificate number: **U42310**

Reference Microphone: WSM11 - GRAS40AG-291442

Measurements

The calibrator has been tested as described in the following annexes to BS EN IEC60942:2003 Sound Calibrators; B3.4 for sound pressure level, B3.5 for frequency, B3.6 for total distortion and A4.4 for short term stability of the pressure level.

Instruments and Program

A complete list of instruments, hardware and software that have been used for this calibration is available from the calibration laboratory

Comments

Statement of Conformance and Calibration

As public evidence was available*, from a testing organisation responsible for approving the results of pattern evaluation tests, to demonstrate that the model of sound calibrator fully conformed to the requirements for pattern evaluation described in annex A of BS EN IEC 60942:2003, the sound calibrator tested is considered to conform to all the class 1 requirements of that BS EN IEC 60942:2003.

*This evidence is held on file at the calibration laboratory.

Observations:

Continued on next page.

Certificate of Calibration and Conformance

Appendix 3
Summary of Noise Measurements

Appendix 3: Summary of Noise Measurements

Time	L_{Aeq}	L_{Amax}	L_{A10}	L_{A50}	L_{A90}
07:00	57.5	75.0	60.6	55.9	47.5
08:00	57.7	75.6	60.4	56.2	50.4
09:00	57.6	79.9	60.4	56.6	48.9
10:00	57.4	81.6	59.9	55.4	46.9
11:00	64.8	95.9	61.0	55.8	46.8
12:00	57.4	72.4	60.4	56.1	48.2
13:00	57.5	81.1	60.1	55.4	46.9
14:00	57.6	83.9	60.3	55.9	48.4
15:00	58.0	81.3	60.3	56.6	50.9
16:00	57.2	69.6	60.1	56.2	50.4
17:00	57.1	76.5	59.8	56.1	50.7
18:00	57.7	76.8	60.0	56.1	48.8
19:00	56.2	70.6	59.5	54.9	46.8
20:00	55.0	67.9	58.7	52.6	43.7
21:00	55.4	83.9	58.3	50.3	39.9
22:00	52.2	71.3	56.8	45.7	36.0
23:00	50.4	66.3	55.0	40.1	33.4
00:00	49.9	74.5	53.0	36.4	30.0
01:00	46.3	64.7	47.6	31.5	26.5
02:00	43.9	66.2	42.0	29.8	26.2
03:00	44.2	66.0	40.5	30.6	26.1
04:00	57.2	77.3	55.6	40.7	32.6
05:00	53.3	74.8	54.6	39.5	34.8
06:00	55.2	77.5	58.7	48.0	40.7
Day	**58.2**	**95.9**	**59.8**	**54.7**	**46.9**
Night	**52.3**	**77.5**	**50.9**	**37.1**	**31.3**