Noise Assessment:
Land at Cliff Hill, Denby Dale

June 2023






Experts in noise and vibration assessment and management

Document Control

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1 Introduction

1.1 This report describes the potential impact of noise upon the proposed residential development (the 'proposed development') at Cliff Hill, Denby Dale, Huddersfield (the 'site'). The assessment has been carried out by Noise Consultants Ltd on behalf of Urban Developments (York) Ltd.

1.2 The proposed development comprises the construction of 62 no. dwellings.

1.3 The assessment of the suitability of the site for noise-sensitive development has considered local ambient noise sources, including road traffic noise from the local road network.

1.4 **Figure 1** presents the site location within Denby Dale. The A636 Wakefield Road is located approximately 90 m to the south of the site. Immediately to the west of the site is Cumberworth Lane. The site is located within a predominantly residential area with farmland to the northwest.

Figure 1: Site Location Plan

1.5 This report has been prepared taking into account all relevant local and national policy, guidance and regulations, as fully detailed in **Appendix A1** and **Appendix A2**.

Local Authority Consultation

Pre-Application Response

1.6 A response from Kirklees Council (KC) Environmental Health (EH) department was provided as part of a pre-application advice request in October 2021. KC EH response (reference WK/202132360) included the following comments in respect of noise:

"*We have considered whether the proposed development may be adversely affected by existing noise sources and also whether noise from the proposed development may have an adverse impact on nearby noise sensitive receptors.*

The proposed development is located near to the busy Wakefield Road, as well as existing industrial and farm buildings, noise from which is likely to have an adverse impact on future occupiers of the site. We will therefore expect a noise impact assessment to be provided with any future application. The assessment should determine the existing noise climate taking all likely noise sources into consideration and then detail how this will affect the proposed development. It should also detail any noise mitigation measures that will be required so that satisfactory sound levels will be achieved both indoors and at any outdoor amenity areas at the development. If windows need to be kept closed to achieve satisfactory indoor sound levels then the mitigation measures will also need to include specific details of the alternative ventilation that will be provided as a substitute to opening windows. This needs to provide more than just background ventilation from trickle vent and in particular, needs to be capable of providing sufficient ventilation to give adequate cooling during hot weather to minimise the risks of overheating."

Consultation with Environmental Health

1.7 NCL contacted KC EH by email on 5th May 2022 in order to seek agreement on the noise assessment methodology.

1.8 A response was received on 6th May 2022 which confirmed the following:

"*In considering an application, we would look to the applicant to ensure all sources of noise are identified during the assessment process. If there are any identified mechanical plant, then a BS 4142 assessment will be required and collectively, the applicant would need to ensure both the internal and external levels meet with the requirements of BS 8233. Should any mitigation be proposed, then we would look to be provided with a specification of measures necessary and this would include alternative ventilation if windows have to be kept closed.*

Your proposed methodology considers these aspects and is therefore acceptable."

2 Assessment Approach

Baseline Noise Survey

2.1 To quantify current levels of ambient noise on the site, a noise survey comprising unattended measurements was conducted between Thursday 12th May and Friday 13th May 2022. The survey was designed to capture noise during the daytime (07:00 – 23:00hrs) and night-time (23:00 – 07:00hrs) periods.

2.2 **Figure 2** presents the noise survey locations, which are described in **Table 1** below. The noise monitoring locations were chosen to capture noise conditions across the site, primarily relating to road traffic noise from Cumberworth Ln and noise at the closest receptors.

2.3 The measurements were taken under free-field conditions at LT1, LT2, LT3 and LT4. Monitoring was supplemented by daytime observations of the noise climate at each monitoring location during the survey.

Figure 2: Noise Monitoring Locations

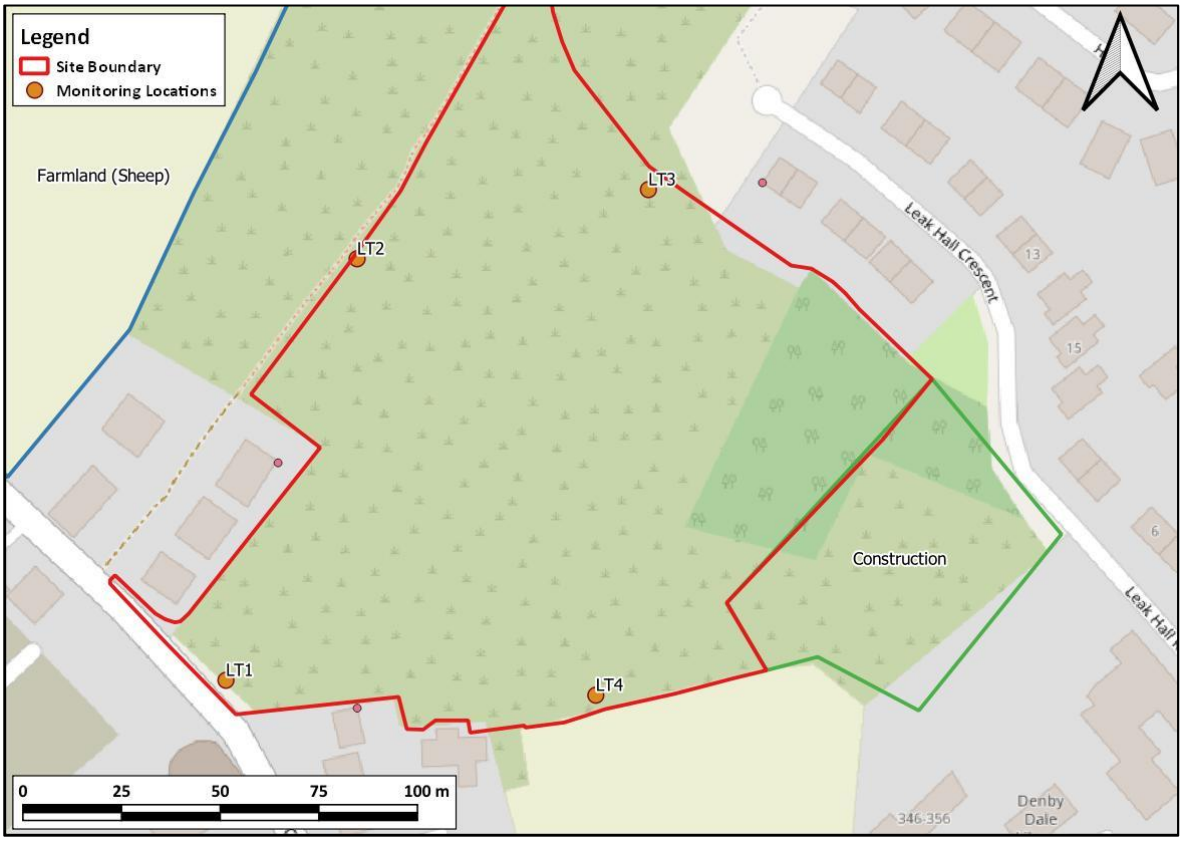

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Table 1: Summary of Survey Locations

Location	Description	Date and Time
LT1	Unattended, free-field measurement approximately 1 m to the north-east of Cumberworth Lane at a height of 1.2 m above ground level on the site and approximately 2.5 m above road level.	12:00 12th May 2022 – 14:00 13th May 2022
LT2	Unattended, free-field measurement approximately 1 m to the south-east of a Public Right of Way (PRoW) at a height of 1.2 m above ground level.	13:00 12th May 2022 – 14:15 13th May 2022
LT3	Unattended, free-field measurement approximately 4 m to the south-west of the houses on Leak Hall Crescent at a height of 1.2 m above ground level.	13:30 12th May 2022 – 14:30 13th May 2022
LT4	Unattended, free-field measurement along the southern boundary of the site away from any building at a height of 1.2 m above ground level. This location was approximately 95 m to the north of the A636 Wakefield Road.	14:00 12th May 2022 – 15:00 13th May 2022

2.4 The calibration level of the sound level meters (SLMs) was checked before and after each measurement with no significant drift in calibration recorded. Windshields were fitted to the microphones to minimise the effects of any wind-induced sound.

2.5 All measurements were conducted, where possible, in accordance with BS 7445-1:2003 '*Description and measurement of environmental noise. Guide to quantities and procedures*' (BS 7445, 2003).

Meteorological Conditions

2.6 The weather conditions between 12th and 13th May 2022 were mostly clear with wind speeds less than 4 ms^{-1}. The prevailing wind direction was from the west and there were no significant periods of rainfall during the measurement survey. The average temperature was 14°C during the daytime. No data was removed due to weather corrections.

Assessment Criteria

2.7 The assessment criteria set out in the following sections have been selected in accordance with the National legislation, policies, and guidance and by reference to the appropriate British and International standards outlined in **Appendix A1** and **Appendix A2**. Specific consideration has been given to:

- Planning Practice Guidance for Noise (PPG-Noise, 2019)
- Professional Practice Guidance: Planning & Noise – '*New Residential Development*' (ProPG, 2017)
- BS 8233:2014 '*Guidance on Sound Insulation and Noise Reduction for Buildings*' (BS 8233,2014)
- World Health Organization (WHO) '*Environmental Noise Guidelines for the European Region*' (WHO, 2018)

- Association of Noise Consultants (ANC), '*Acoustics, Ventilation and Overheating: Residential Design Guide*' (AVO Guide, 2020)

ProPG Stage 1: Site Suitability Assessment

2.8 The ProPG site noise risk classification presented in **Table A.2.1** of **Appendix A2** is a sliding scale that does not define precise noise exposure limits to site risk classification. For the purposes of this report, the noise thresholds that have been adopted to classify site risk are defined in **Table 2**, and are set for the daytime and night-time periods.

Selection of LOAEL and SOAEL

2.9 For the purposes of undertaking an initial site noise risk assessment in accordance with ProPG Stage 1, noise levels representing the 'Lowest Observed Adverse Effect Level' (LOAEL) and 'Significant Observed Adverse Effect Level' (SOAEL) have been selected based on recent precedents as described in **Appendix A1**.

2.10 The selected LOAELs align with the onset of adverse effects as outlined in **Table A.2.1**. The LOAEL is the level above which adverse effects on health and quality of life can be detected. Therefore, where noise exposure is below the LOAEL during both the daytime and the night-time periods, the noise risk is considered to be negligible.

2.11 The SOAEL is the level above which significant adverse effects on health and quality of life occur. Where one or more of the daytime or night-time noise levels exceeds the SOAEL, the noise risk is considered to be high.

Site Suitability Noise Exposure Thresholds

Table 2: Site Risk Noise Exposure Thresholds

ProPG Site Risk Category	Noise Exposure Threshold dB $L_{Aeq,16hr}$	Noise Exposure Threshold dB $L_{Aeq,8hr}$	ProPG Based Pre-Planning Application Advice
Negligible (Below LOAEL)	<50	<40	Indicates development site is likely to be acceptable from a noise perspective
Low (LOAEL- SOAEL)	50 – 63	40 – 55	Indicates development site is likely to be acceptable from a noise perspective provided that a good acoustic design process is followed and demonstrated
Medium (Above SOAEL)	63 – 70	55 – 66	Indicated site is less suitable from a noise perspective. A subsequent application may be refused unless a good acoustic design process is followed and demonstrated
High (UAEL)	>70	>66	Indicates an increased risk that the development would be refused on noise grounds.

2.12 With respect to the L_{Amax} (night), ProPG states that "*the initial site noise risk assessment should include the consideration of the individual noise events when the external $L_{Amax,F}$ exceeds 60 dB. A*

site should not be regarded as negligible risk if the $L_{Amax,F}$ exceeds, or is likely to exceed 60 dB more than 10 times a night. A site should be regarded as high risk if the $L_{Amax,F}$ exceeds, or is likely to exceed 80 dB more than 20 times a night."

2.13 Therefore, taking this into account and with reference to the LOAEL and SOAEL thresholds for the L_{Amax} presented in **Table 2**, for the purposes of this assessment:

- a 'negligible' risk is deemed to occur where the 10th highest measured $L_{Amax\ (night)}$ is less than 60 dB;
- a 'high' risk is deemed to occur where the 20th highest measured $L_{Amax\ (night)}$ is greater than 80 dB.

2.14 Based on the above a 'low' risk is deemed to occur where the 10th highest measured $L_{Amax\ (night)}$ is less than 70 dB.

ProPG Stage 2: Full Assessment

2.15 Where the ProPG Stage 1 assessment indicates that the site is at low, medium or high risk of adverse noise effects, a ProPG Stage 2 assessment should be carried out. The following subsections outline the relevant internal and external noise guidelines considered in the assessment.

Internal Noise Guidelines

2.16 For the purpose of considering internal noise levels, the assessment will be undertaken with reference to the internal noise guidelines set out in BS 8233:2014 as advocated by ProPG. These target internal noise levels are presented in **Table 3**.

Table 3: Target Internal Noise Levels

Location	Activity	Daytime Noise Level (0700-2300hrs)	Night-time Noise Level (2300-0700hrs)
Living Room	Resting	35 dB $L_{Aeq,16hr}$	-
Dining Room	Dining	40 dB $L_{Aeq,16hr}$	-
Bedroom	Sleeping (daytime resting)	35 dB $L_{Aeq,16hr}$	30 dB $L_{Aeq,16hr}$ 45 dB L_{AFmax} (normally less than 10 times a night)

2.17 Where possible, these target internal noise levels should be achieved with open windows but will otherwise be achievable with closed windows and an appropriate means of ventilation with respect to the Building Regulations Approved Document F (ADF). Adherence to these guidelines will be considered in the design of the building envelope.

2.18 However, open windows are normally assumed as part of the overheating mitigation strategy and an assessment has been carried out with reference to The Building Regulations Approved Document O.

External Noise Amenity

2.19 External noise amenity will be considered with reference to the guidance provided within BS 8233:2014. As the proposed development is likely to include 'traditional external areas' such as gardens and patios, as well as balconies, the assessment will consider adherence with external noise levels below 55 dB $L_{Aeq, 16hr}$ as an upper guideline value, and 50 dB $L_{Aeq, 16hr}$ as a design target.

Derivation of Assessment Levels

Internal Noise Levels from External Sources

2.20 In order to consider internal noise levels, the assessment has followed guidance provided within the Acoustics Ventilation and Overheating: Residential Design Guide (AVO Guide, 2020) which describes a method of calculating internal noise levels based on external free-field levels.

2.21 For a partially open window, Appendix B of the AVO Guide states that the noise insulation can be assumed to be approximately 13 dB and applied to an external free-field level. It is also noted that the value of 13 dB is not appropriate for all situations, however it does enable a ProPG Stage 2 assessment to be undertaken.

2.22 When windows are closed the sound insulation performance is determined by the building's façade construction including the performance of glazing and ventilation components and their respective areas.

3 Noise Survey

Noise Survey Results

Survey Observations

3.1 Generally, the acoustic environment within the site was noted to be dominated by natural sources, in particular birdsong and rustle of the vegetation. Distant road traffic noise also contributed to the noise environment.

3.2 At noise monitoring location LT1, daytime road traffic noise from Cumberworth Lane is dominant. Road traffic noise was also audible whilst monitoring at LT2 during the daytime, as well as footsteps from people using the PRoW, and the bleating of the sheep at the farm to the northwest. There was no other noise measured or observed from the existing industrial and farm buildings to the north and northwest of the site.

3.3 Some construction noise from the development site to the southeast (intermittent hammering) and road traffic noise from the A636 Wakefield Road were captured during daytime at monitoring locations LT3 and LT4 with natural sources being the most prevalent.

Measured Baseline Noise Levels

3.4 Results of the noise survey at each of the monitoring locations are summarised in **Table 4**, rounded to the nearest decibel, with full details presented in **Appendix A3**.

Table 4: Summary of Measured Levels – Unattended Locations

Location	Period of Representation	$L_{Aeq,T}$ (dB)	10th highest $L_{Amax,15min}$ (dB)	$L_{A10,T}$ (dB)	$L_{A90,T}$ Mean (dB)	$L_{A90,T}$ Mode (dB)
LT1	Daytime (07:00 – 23:00)	61	84	64	44	46
	Night-time (23:00 – 07:00)	53	74	47	34	33
LT2	Daytime (07:00 – 23:00)	49	71	50	40	40
	Night-time (23:00 – 07:00)	46	61	45	34	32
LT3	Daytime (07:00 – 23:00)	52	78	52	40	40
	Night-time (23:00 – 07:00)	51	69	46	35	33
LT4	Daytime (07:00 – 23:00)	49	70	50	44	44
	Night-time (23:00 – 07:00)	47	57	45	36	34

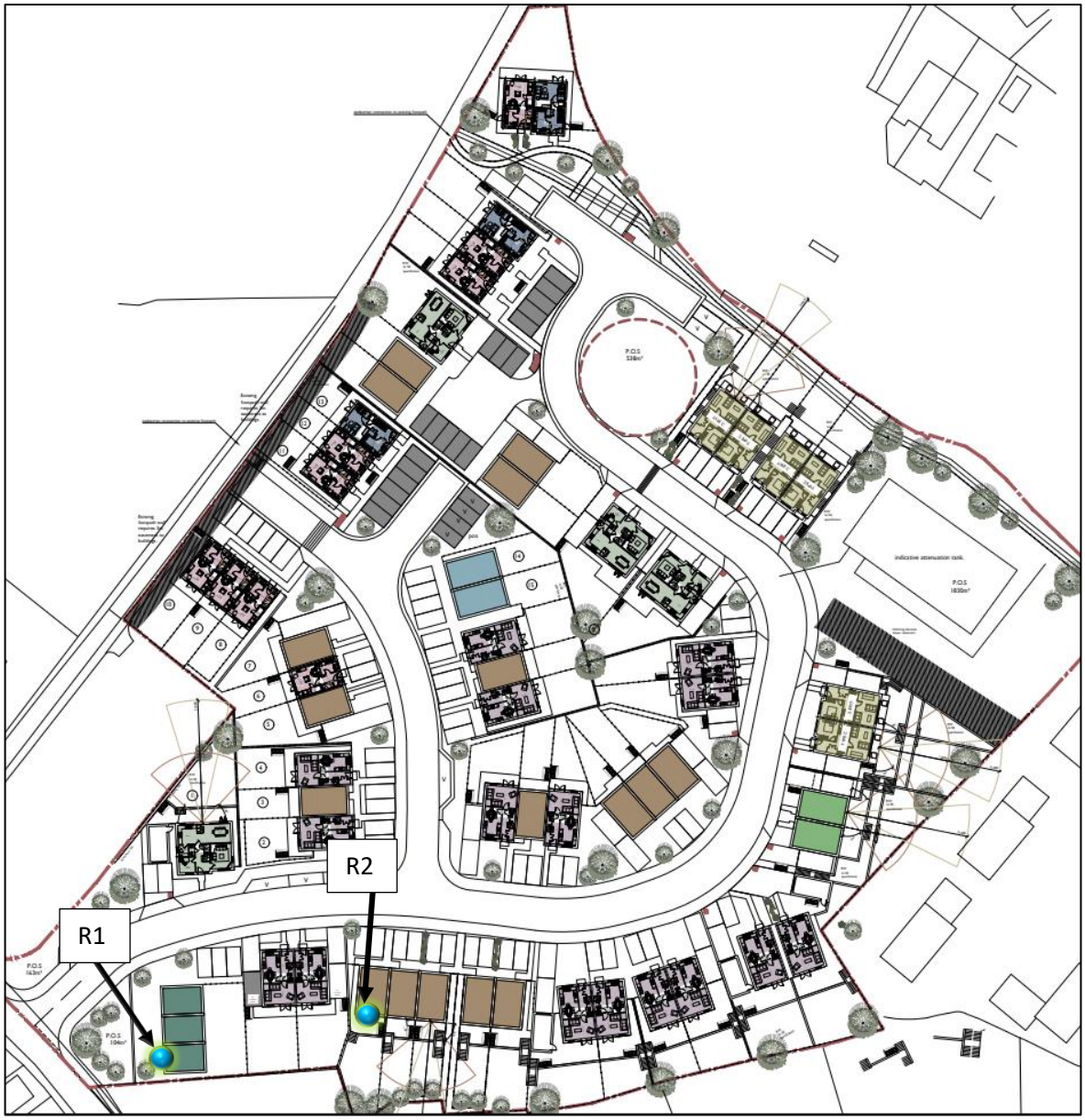
4 ProPG Stage 1 Initial Site Noise Risk Assessment

4.1 An initial site noise risk assessment has been undertaken to provide an indication of the likely risk of adverse effects and the suitability of the site for residential development, excluding any subsequent mitigation measures which may be included as part of the development proposals.

Site Suitability Assessment

4.2 The external noise levels presented in **Table 4** have been used for this assessment as well as predicted noise levels at the closest building façades to Cumberworth Lane (R1 and R2) based on the measurements obtained at LT1. R1 and R2 are identified in **Figure 3**.

Figure 3: Proposed Site Layout



4.3 With reference to the assessment criteria, the advice provided in ProPG Stage 1, and the site risk noise exposure thresholds set out in **Table 2**, **Table 5** presents the initial site noise risk assessment for the site.

Table 5: ProPG Initial Site Noise Risk Assessment (External Noise Levels)

Location	Dominant Source	Daytime $L_{Aeq,16hr}$ (dB)	Night-time $L_{Aeq,8hr}$ (dB)	Night-time L_{Amax} (dB)	ProPG Outcome
LT2	Road traffic, Natural sources	49	46	61	Indication of Negligible to Low Risk
LT3	Natural sources	52	51	69	Indication of Negligible to Low Risk
LT4	Natural sources	49	47	57	Indication of Negligible to Low Risk
R1(1)	Road traffic, Natural sources	55	47	62	Indication of Low Risk
R2(1)	Road traffic, Natural sources	51	42	53	Indication of Low Risk

Note (1): A line source distance correction (from 0.5 m from the kerb of Cumberworth Lane at LT1 to approximately 12 m at the façade at R1 and to approximately 40 m for rear façade at R2) has been used to predict the noise levels at the location of façade of the nearest proposed buildings to Cumberworth Lane.

4.4 It is considered that the site generally presents a 'Negligible to Low' risk of adverse noise effect, without mitigation measures in place and when considering the predicted noise levels at the façades close to Cumberworth Lane. As a result, a Stage 2 full assessment is required incorporating an Acoustic Design Statement (ADS) to demonstrate a good acoustic design process.

5 Acoustic Design Statement (ADS)

5.1 All recommendations in this ADS are given for acoustic reasons only and should be reviewed by the design team to ensure co-ordination with other disciplines.

Internal Noise Levels: Acoustics and Ventilation

Windows Closed

5.2 The following assessment of noise levels within habitable rooms aims to demonstrate that the target internal noise levels set out in **Table 3** are achievable.

5.3 The sound insulation performance afforded by the building envelope on a 'closed window' basis is informed by the combination of the building façade construction, including the sound insulation performance of glazing and cladding and their respective areas as well as acoustic conditions in the receiving room.

5.4 For the purposes of this assessment, the following assumptions have been made for the 'closed window' scenario:

- The glazed areas of bedrooms and living rooms at 50% of the façade area;
- The wall and room constructions of the dwellings are of a standard nature i.e. brick and block wall construction as per the standard assumptions made within BS 8233:2014; and
- Installation of standard in/over-frame trickle ventilators.

5.5 For the purposes of assessing internal noise levels for standard thermal double glazing, the following SRI data as provided in **Table 6**.

Table 6: Assumed Sound Reduction Index (R) for Cladding and Glazing

Element	Sound Reduction Index (SRI) at Octave Centre Band Frequency (Hz)						R_w (C; C_{tr})
	125	250	500	1K	2K	4K	
Double Glazing 6mm/ (6-16 mm)/ 6mm	20	18	28	38	34	38	31 (-1; -4)
Brick and Block External Wall	40	44	45	51	56	56	52 (-2; -5)

5.6 Based on the noise levels in **Table 5**, standard thermal double glazing (for example a 6 mm glass/ 6-16 mm air gap/ 6 mm glass construction) would be suitable for all habitable rooms in the development.

5.7 The suggested acoustic performance and example type of glazing demonstrate that suitable internal noise levels, compliant with the target noise levels set out in **Table 3**, can be achieved throughout the development.

Windows Open

Purge Ventilation

5.8 With regards to openable windows, it should be noted that Building Regulations Approved Document F – Ventilation (ADF) advises that "*purge ventilation*" is required "*for rapidly diluting indoor air pollutants and extracting water vapour where necessary*". Therefore "purge ventilation" is intermittent i.e., required only when such occasional activities occur, and open windows are suitable for this purpose.

Control of Overheating

5.9 The Building Regulations Approved Document O – Overheating (ADO) requires that windows are assumed to be closed where the internal noise levels will exceed:

- 40 dB $L_{Aeq,8hr}$ (2300 hrs to 0700 hrs); and
- 55 dB L_{AFmax} more than 10 times a night (between 2300 hrs and 0700 hrs).

5.10 The Draft *Guide to Demonstrating Compliance with the Noise Requirements of Approved Document O*[1] calculates that in a moderate risk area[2] the minimum free areas required to achieve the requirements of ADO provide an external to internal sound level difference of 9 dB(A). This results in equivalent external noise levels of 49 dB $L_{Aeq,8hr}$ and 64 dB L_{AFmax} as a guide to whether windows are likely to be closed during the night-time.

5.11 **Table 7** presents a comparison of the measured noise levels against the equivalent external noise levels.

Table 7: Noise Level Assessment for Overheating (Internal Noise Levels)

Location	Dominant Source	Night-time $L_{Aeq,8hr}$ (dB)	Night-time L_{Amax} (dB)	Commentary
LT2	Road traffic, Natural sources	37	52	ADO internal noise levels achievable with open windows
LT3	Natural sources	42	60	ADO internal noise levels not achieved with open windows; however, the primary sources of noise are natural (i.e., birdsong)
LT4	Natural sources	38	48	ADO internal noise levels achievable with open windows
R1(1)	Road traffic, Natural sources	38	53	ADO internal noise levels achievable with open windows

[1] Association of Noise Consultants (ANC) and Institute of Acoustics (IoA)

[2] A moderate risk location is defined in ADO as all of "*England, excluding high risk parts of London*".

Location	Dominant Source	Night-time $L_{Aeq,8hr}$ (dB)	Night-time L_{Amax} (dB)	Commentary
R2(1)	Road traffic, Natural sources	33	44	ADO internal noise levels achievable with open windows

5.12 Generally, the proposed development is at low risk in the context of acoustics and overheating. When windows are open for overheating mitigation, reasonable internal noise conditions should be achieved.

5.13 It is noted that the marginally higher noise levels at LT3 are likely to be due to birdsong during the dawn chorus rather than transportation noise due to the distance of this location from the nearest roads. Birdsong will vary from day-to-day throughout the year and these noise levels are not considered to be unreasonable given the rural context of the site.

External Amenity Noise Levels

5.14 **Table 8** provides a summary of the predicted daytime external noise levels at the noise measurement positions and identified receptors with respect to noise levels in external amenity areas (private gardens) within the proposed development. This assessment is based on an open site and further noise reduction is likely to be experienced where proposed dwellings provide screening of road traffic noise sources.

Table 8: External Noise Levels in Amenity Areas on an Open Site Basis

Location	$L_{Aeq,T}$ (dB)
LT2	49
LT3	52
LT4	49
R1	55
R2	51

5.15 It is expected that daytime road traffic exposure levels in the majority of amenity areas will be below the 50 dB $L_{Aeq,16hr}$ advocated in BS 8233. With reference to **Table 8**, the marginal exceedance at LT3 is due to noise from natural sources such as birdsong due to the distances between this location and the road traffic noise sources.

5.16 At R1, the proposed site layout (**Figure 3**) shows that the main garden area is further away from Cumberworth Lane and partially screened by the proposed residential property itself. Therefore, it is assumed that the noise exposure level in this amenity area will be lower than shown in **Table 8**. The predicted noise level at R1 is equal to the upper external noise guideline level of 55 dB $L_{Aeq,16hr}$ which is considered to be reasonable. However, a boundary treatment is recommended around this plot, with a minimum height of 1.8 m and with a surface density in excess of 10 kg/m^2 to provide some further noise screening.

6 Road Traffic Noise Impact Assessment

6.1 Following the traffic survey carried out in May 2022, the Transport Consultants, Via Solutions, have confirmed that Cumberworth Lane has a daily traffic flow of approximately 3500 vehicles. This is based on the counted average weekday, daily flows.

6.2 The proposed development is expected to generate an additional 222 vehicles a day. This equates to approximately 6% increase in traffic volume on Cumberworth Lane. A 6% increase in traffic volume equates to an increase in noise level of less than 0.3 dB which is not significant by reference to the Design Manual for Roads and Bridges *LA111 Noise & Vibration* (May 2020).

6.3 It is therefore concluded that there will be a negligible road traffic noise impact on existing receptors as a result of the proposed development.

7 Conclusion

7.1 NCL have undertaken a noise impact assessment for the proposed residential development (the 'proposed development') at Land at Cliff Hill, Denby Dale, Huddersfield (the 'site').

7.2 This noise impact assessment assesses the proposed development site in terms of suitability for residential use based on baseline noise monitoring and observations. The report evaluates the potential impacts upon the proposed development and specifies design measures, including the building envelope performance required to achieve suitable noise levels within habitable rooms.

7.3 An initial site noise risk assessment was undertaken in accordance with ProPG. The risk assessment demonstrated that there is a likely 'Negligible' to 'Low' risk of adverse effects from noise without the implementation of noise mitigation. The highest areas of risk are closest to Cumberworth Lane.

7.4 For habitable rooms in the proposed development, it has been demonstrated that the BS 8233:2014 guideline internal noise levels can be achieved with windows closed using a standard double glazed window system and an appropriate non-acoustic means of ventilation installed in accordance with the Building Regulations Approved Document F.

7.5 With windows open, reasonable internal noise conditions would be achievable across the site, therefore noise constraints in relation to the potential for overheating are considered to be negligible.

7.6 Noise levels in the garden areas across the majority of the site are predicted to be below the target noise level of 50 dB $L_{Aeq,16hr}$ with exceedances in some areas that are below the upper guideline noise level of 55 dB $L_{Aeq,16hr}$. A boundary treatment is recommended around the plot closest to Cumberworth Lane, comprising a1.8 m high noise barrier with a minimum surface density of 10 kg/m^2.

7.7 The assessment has demonstrated that the proposed development achieves the relevant target noise levels with standard noise mitigation measures. The site is therefore considered acceptable from a noise perspective provided that the recommendations of this report are implemented to mitigate and minimise noise.

7.8 On the basis of this assessment, the development is not considered to give rise to a significant adverse impact on health and quality of life in relation to noise, in accordance with paragraphs 174 and 185 of the NPPF.

8 Glossary

dB	Decibel. The logarithmically scaled measurement unit of sound.
A-weighting	Frequency weighting applied to measured sound in order to account for the relative loudness perceived by the human ear.
$L_{Aeq,T}$	A-weighted equivalent continuous sound level over a given time period. It is the sound level of a steady sound that has the same energy as a fluctuating sound over the same time period.
$L_{A10,T}$	The A-weighted sound level exceeded for 10% of the measurement period. It is widely used as a descriptor of road traffic noise.
$L_{A90,T}$	The A-weighted sound level exceeded for 90% of the measurement period. Often referred to as the background sound level.
L_{Amax}	The A-weighted maximum recorded noise level during a measurement period.
R_w	The weighted Sound Reduction Index which characterises the airborne sound insulation of a building element over a range of frequencies with a single number quantity.
C and C_{tr}	Spectrum adaption terms that use a standard reference curves to determine the weighted value of airborne sound insulation. C and C_{tr} take into account different source spectra, where C considers the A-weighted pink noise spectrum and C_{tr} considers the A-weighted urban traffic noise spectrum.
g-value	The coefficient commonly used to measure the solar energy transmittance of windows.

A1 National Policy and Guidance

National Noise Policy

Noise Policy Statement for England (NPSE, 2010)

A1.1 The Noise Policy Statement for England (NPSE, 2010) sets out the Government's Noise Policy Vision to:

"Promote good health and a good quality of life through the effective management of noise within the context of Government policy on sustainable development".

A1.2 This long-term vision is supported by three Noise Policy Aims that can be delivered through effective management and control of environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development. These aims are to:

1. *avoid significant adverse impacts on health and quality of life;*
2. *mitigate and minimise adverse impacts on health and quality of life; and*
3. *where possible, contribute to the improvement of health and quality of life.*

A1.3 The explanatory note to the NPSE sets out 'effect levels' which are aligned to the Policy Aims. Drawing upon established concepts from toxicology, the NPSE defines the following noise effect levels:

- NOEL - 'No Observed Effect Level';
- LOAEL - 'Lowest Observed Adverse Effect Level'; and
- SOAEL - 'Significant Observed Adverse Effect Level'.

A1.4 The explanatory note describes SOAEL as the effect level above which significant adverse effects on health and quality of life occur, aligning this level with the first policy aim.

A1.5 LOAEL is described as the level at which adverse effects begin and the second aim of the NPSE refers to a situation where the effect lies somewhere between LOAEL and SOAEL. It requires that all reasonable steps should be taken to mitigate and minimise adverse effects on health and quality of life while also taking into account the guiding principles of sustainable development (paragraph 1.8 of the NPSE) however this does not mean that such adverse effects cannot occur.

A1.6 NOEL is described as a level of noise exposure below which no effect can be detected. In simple terms, below this level, there is no detectable effect on health and quality of life.

A1.7 The third aim seeks, where possible, to positively improve health and quality of life through the pro-active management of noise while also taking into account the guiding principles of sustainable development, recognising that there will be opportunities for such measures to be taken and that they will deliver potential benefits to society.

A1.8 The protection of quiet places and quiet times as well as the enhancement of the acoustic environment will assist with delivering this aim.

A1.9 NPSE states that it is not possible have a single, numerical definition of the SOAEL that is applicable to all sources of noise in all situations, since the SOAEL is likely to be different for different noise sources, for different receptors and at different times.

A1.10 The setting of LOAELs and SOAELs for transportation sources has however reached a form of consensus following a number of high-profile infrastructure projects in England, namely HS2 and a series of Highways England road schemes which have been successful through the Government's Hybrid Bill and Development Consent Order (DCO) consenting processes.

A1.11 In these projects, the setting of SOAEL has been aligned to Government policy and legislation in relation to the provision of noise insulation where it has been argued that significant adverse effects can be avoided through these means. **Table A.1.1** provides a summary of the LOAEL and SOAEL values applied on these projects.

Table A.1.1: LOAELs and SOAELs for Road and Railway Infrastructure Projects

Source/Project	Period	LOAEL	SOAEL
Road Traffic (Highway Agency A14 DCO)	Daytime	50 dB $L_{Aeq, 16hr}$	63 dB $L_{Aeq, 16hr}$
	Night-time	40 dB $L_{Aeq, 8hr}$	55 dB $L_{Aeq, 8hr}$
Rail (HS2)	Daytime	50 dB $L_{Aeq, 16hr}$	63 dB, $L_{Aeq\ 16hr}$
	Night-time	40 dB $L_{Aeq, 8hr}$ 60 dB L_{Amax}	55 dB $L_{Aeq, 8hr}$ 80/85 dB L_{Amax}

Planning Policy

National Planning Policy Framework (NPPF, 2021)

A1.12 The National Planning Policy Framework (NPPF, 2021) sets out the Government's planning policies for England and how these should be applied. The NPPF provides a framework within which locally prepared plans for housing and other development can be produced.

A1.13 In relation to noise, it states:

> *"174. Planning policies and decisions should contribute to and enhance the natural local environment by: …*
>
> - *preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability. Development should, wherever possible, help to improve local*

environmental conditions such as air and water quality, taking into account relevant information such as river basin management plans; and…"

A1.14 The NPPF includes policy which makes reference to 'significant adverse impacts on health and quality of life', as per the NPSE. NPPF policy states:

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

- *mitigate and reduce to a minimum potential adverse impacts resulting from noise from new development – and avoid noise giving rise to significant adverse impacts on health and the quality of life;*
- *identify and protect tranquil areas which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason; and…"*

A1.15 NPPF has also recently introduced the agent of change principle as follows:

"187. 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."

Planning Practice Guidance – Noise (PPG-Noise, 2019)

A1.16 The Planning Practice Guidance (PPG-Noise, 2019) provides further detail about how the effects of noise can be described in terms of perception and outcomes. It aligns this to increasing effect levels as defined in the NPSE. In addition, the PPG-Noise adds a fourth term and corresponding effect level:

- UAEL – 'Unacceptable Adverse Effect Level'.

This effect level is higher than the significant adverse effect on health and quality of life (SOAEL) and requires that unacceptable adverse effects are to be prevented. In PPG-Noise, prevention is not in the context of Government policy on sustainable development. **Table A.1.2** presents the noise exposure hierarchy described in PPG-Noise.

Table A.1.2: Planning Practice Guidance – Noise Exposure Hierarchy

Perception	Examples of Outcomes	Increasing Effect Level	Action
No Observed Effect Level			
Not present	No Effect	No Observed Effect	No specific measures required
No Observed Adverse Effect Level			
Present 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			
Present and intrusive	Noise can be heard and causes small changes in behaviour and/or attitude, e.g. turning up 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. 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
Significant Observed Adverse Effect Level			
Present and disruptive	The noise causes a material change in behaviour and/or attitude, e.g. 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. 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.	Significant Observed Adverse Effect	Avoid
Present and very disruptive	Extensive and regular changes in behaviour and/or an inability to mitigate effect of noise leading to psychological stress or physiological effects, e.g. regular sleep deprivation/awakening; loss of appetite, significant, medically definable harm, e.g. auditory and non-auditory	Unacceptable Adverse Effect	Prevent

A1.17 This noise exposure hierarchy is based on the principle that once noise or vibration becomes perceptible, the effect on people and other receptors increases as the level increases. PPG-Noise presents example outcomes to help characterise these effects using non-technical language. In general terms, an observed adverse effect is characterised as a perceived change in quality of life for occupants of a building or a perceived change in the acoustic character of an area, whereas a significant observed adverse effect disrupts activities.

A1.18 PPG-Noise also provides guidance in terms of what factors may influence whether noise could become a concern, and how adverse effects of noise can be mitigated. Examples of mitigation provided include:

- *"engineering: reducing the noise generated at source and/or containing the noise generated;*
- *layout: where possible, optimising the distance between the source and noise-sensitive receptors and/or incorporating good design to minimise noise transmission through the use of screening by natural or purpose built barriers, or other buildings;*
- *using planning conditions/obligations to restrict activities allowed on the site at certain times and/or specifying permissible noise levels differentiating as appropriate between different times of day, such as evenings and late at night, and;*
- *mitigating the impact on areas likely to be affected by noise including through noise insulation when the impact is on a building".*

A1.19 In the case of residential development, PPG-Noise also states that the impact of noise can be "*partially off-set*" if occupants have access to:

- *"a relatively quiet façade (containing windows to habitable rooms) as part of their dwelling, and/or;*
- *a relatively quiet external amenity space for their sole use, (e.g. a garden or balcony). Although the existence of a garden or balcony is generally desirable, the intended benefits will be reduced with increasing noise exposure and could be such that significant adverse effects occur, and/or;*
- *a relatively quiet, protected, nearby external amenity space for sole use by a limited group of residents as part of the amenity of their dwellings, and/or;*
- *a relatively quiet, protected, external publicly accessible amenity space (e.g. a public park or a local green space designated because of its tranquility) that is nearby (e.g. within 5 minutes walking distance)".*

A2 Residential Development Guidance

Professional Practice Guidance (ProPG, 2017) on Planning & Noise – '*New Residential Development*'

A2.1 Professional Practice Guidance: Planning & Noise – '*New Residential Development'* (ProPG, 2017) is a joint publication by the Chartered Institute of Environmental Health (CIEH), the Association of Noise Consultants (ANC) and the Institute of Acoustics (IoA).

A2.2 The primary goal of ProPG is "*to assist the delivery of sustainable development by promoting good health and wellbeing through the effective management of noise*".

A2.3 The guidance has been produced to assist practitioners in matters relating to noise and new residential development. It focuses on existing transportation noise sources and has been developed to consider the Government's overarching noise policy, planning policy and policy guidance. It has also been developed to take into account other authoritative sources of guidance such as British Standard 8233:2014 '*Guidance on Sound Insulation and Noise Reduction for Buildings*' (BS 8233:2014).

A2.4 The guidance provides advice for Local Planning Authorities (LPAs) and developers, and practitioners. ProPG aims to:

- *Advocate the full consideration of the acoustic environment from the earliest possible stage of the development control process;*
- *Promote and encourage the process of good acoustic design in and around new residential developments;*
- *Set out the considerations which should be taken into account in deciding planning applications for new noise-sensitive developments;*
- *Promoting the use of appropriate noise exposure standards and policies in assessment; and*
- *Provide assistance in the delivery of sustainable development.*

A2.5 ProPG advocates a two-stage assessment approach:

- **Stage 1** – an initial noise risk assessment of the proposed development site; and
- **Stage 2** – a systematic assessment considering four key elements.

A2.6 ProPG is underpinned by the preparation and delivery of an Acoustic Design Statement (ADS).

Stage 1 – Initial Risk Assessment

A2.7 Stage 1 of ProPG provides guidance to practitioners as to whether the site poses a risk in terms of noise for any future site occupants. To identify this, ProPG sets out a number of considerations for

inclusion within an 'initial risk assessment'. **Table A.2.1** reproduces Figure 1 from ProPG, which describes the initial site risk assessment.

Table A.2.1: ProPG – Stage 1 Initial Site Risk Assessment

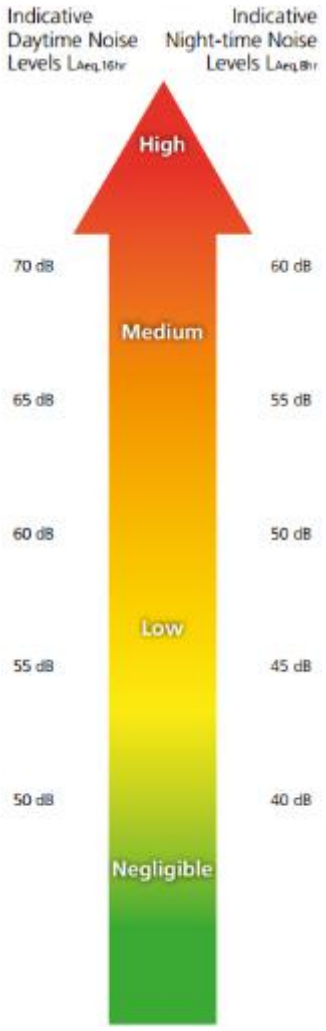
Noise Risk Assessment	Potential Effect Without Noise Mitigation	Pre-Planning Application Advice
	Increasing risk of adverse effect	High noise levels indicate that there is an increased risk that development may be refused on noise grounds. This risk may be reduced by following a good acoustic design process that is demonstrated in a detailed ADS. Applicants are strongly advised to seek expert advice. As noise levels increase, the site is likely to be less suitable from a noise perspective and any subsequent application may be refused unless 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, and which clearly demonstrate that a significant adverse noise impact will be avoided in the finished development. 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.
	No adverse effect	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.

Figure 1 Notes:

a. Indicative noise levels should be assessed without inclusion of the acoustic effect of any scheme specific noise mitigation measures.

b. Indicative noise levels are the combined free-field noise level from all sources of transport noise and may also include industrial/commercial noise where this is present but is "not dominant".

c. $L_{Aeq,16hr}$ is for daytime 07:00 – 23:00, $L_{Aeq,8hr}$ is for night-time 23:00 – 07:00.

d. An indication that there may be more than 10 noise events at night (23:00 – 07:00) with $L_{Amax,F}$ > 60 dB means the site should not be regarded as negligible risk.

A2.8 ProPG is clear that an Acoustic Design Statement should be included as part of a planning application where the risk is anything above 'negligible'.

Stage 2 – Full Assessment

A2.9 Stage 2 of ProPG describes four elements required for a full assessment. These are:

- **Element 1** – demonstrating a "Good Acoustic Design Process"
- **Element 2** – observing internal "Noise Level Guidelines"
- **Element 3** – undertaking an "External Amenity Area Noise Assessment"; and
- **Element 4** – the consideration of "Other Relevant Issues".

A2.10 A summary of the considerations required in each of the four elements is provided in **Table A.2.2**.

Table A.2.2: ProPG Stage 2 – Summary of Four Key Elements

Element	Potential Effect Without Noise Mitigation
Element 1 Good Acoustic Design Process	Considerations include: • Good acoustic design is not just compliance with recommended internal and external noise exposure standards. Good acoustic design should provide an integrated solution whereby the optimum acoustic outcome is achieved, without design compromises that will adversely affect living conditions and the quality of life of the inhabitants or other sustainable design objectives and requirements. • Using fixed unopenable glazing for sound insulation purposes is generally unsatisfactory and should be avoided. Any reliance upon building envelope insulation with closed windows should be justified in supporting documents The Planning Application MUST: • Check the feasibility of relocating, or reducing noise levels from relevant sources. • Consider options for planning the site or building layout. • Consider the orientation of proposed building(s). • Select construction types and methods for meeting building performance requirements. • Examine the effects of noise control measures on ventilation, fire regulation, • health and safety, cost, CDM (construction, design and management) etc. • Assess the viability of alternative solutions. • Assess external amenity area noise.

Element	Potential Effect Without Noise Mitigation
Element 2 Internal Noise Level Guidelines	Considerations include: • Reference to BS 8233:2014 'Guidance on Sound Insulation and Noise Reduction for Buildings' for internal noise level guidelines • Most residents value the ability to open windows at will, for a variety of reasons, and LPAs should therefore normally request that designers principally aim, through the use of good acoustic design, to achieve the internal noise level guidelines in noise-sensitive rooms with windows open. Where internal noise levels are assessed with windows closed the justification for this should be included in the ADS. In the case of sites exposed to industrial and/or commercial noise: • Where industrial and/or commercial noise is present on the site and is considered to be "dominant" (i.e., where the impact would be rated as adverse or greater (subject to context)) then this is outside the scope of this ProPG and regard should be had to the guidance in BS 4142:2014. • In the special case where industrial and/or commercial noise is present on the site but is "not dominant" (i.e. where the impact would be rated as lower than adverse (subject to context) if a BS 4142:2014 assessment was to be carried out), its contribution may be included in the noise level used to establish the degree of risk in Stage 1 and may also be included in the consideration of Stage 2 Element 2 Internal Noise Level Guidelines (and if included, this should be clearly stated).
Element 3 External Amenity Area Noise Assessment	The assessment must provide and demonstrate: • Full details of the external amenity area noise assessment should be included in an Acoustic Design Statement. • The term "assessment" is deliberately used because this element concerns more than just the level of noise outside. • ProPG external amenity area noise assessment reflects and extends the advice contained in BS 8233:2014 and the current Government guidance in PPG-Noise In the case of sites exposed to industrial and/or commercial noise: • Where external amenity areas are exposed to "dominant" industrial and/or commercial noise, the impact of the noise should be assessed in accordance with BS 4142:2014 over the time period that the amenity area is likely to be used. • In the special case where industrial and/or commercial noise is present on the site but is "not dominant", its contribution may be included in the noise level used to establish the degree of risk in Stage 1 and may also be included in the consideration of Stage 2 Element 3 External Amenity Area Noise Assessment (and if included, this should be clearly stated).

Element	Potential Effect Without Noise Mitigation
Element 4 Assessment of Other Relevant Issues	Consideration should be given to: • Compliance with relevant national and local policy: i.e., NPSE, PPG-Noise and The Environmental Noise Regulations. • Magnitude and extent of compliance with ProPG • Likely occupants of the development • Acoustic design vs unintended adverse consequences: Examples include sealed up balconies that result in a lack of connection with the external environment, roadside barriers that remove views or prevent crossing roads, sealed facades that affect personal control over the internal environment etc. Wherever possible, such unintended adverse consequences should be obviated by good acoustic design. • Acoustic design vs wider planning objectives

Acoustic Design Statement (ADS)

A2.11 ProPG requires that the Acoustic Design Statement (ADS) provides sufficient evidence that the ProPG Stage 1 and Stage 2 Elements 1 – 4 have been followed. It also advises that the ADS should be proportionate to the scale of the development and the degree of noise risk at the proposed development site. In this context, ProPG states that the level of detail to be provided within the ADS should increase with the increasing level of risk.

Supporting Decision-Makers

A2.12 ProPG also provides advice and support to decision-makers when taking into account noise and new residential development. These recommendations are aligned to the outcomes of Stage 1 and Stage 2 of the assessment along with the considerations made within the Acoustic Design Statement. Section 3 of ProPG details the recommendations to decision-makers.

Sites Exposed to Industrial and/or Commercial Noise

A2.13 In the case of sites exposed to industrial and/or commercial noise, ProPG states that if the industrial and/or commercial noise is present but not dominant, then its contribution may be included in the noise level used to establish the degree of risk.

A2.14 If the industrial and/or commercial noise is considered to be dominant, then the risk assessment should not be applied to the industrial or commercial noise and instead the assessment should follow the methodology and guidance provided in British Standard 4142:2014+A1:2019 '*Methods for rating and assessing industrial and commercial sound*' (BS 4142:2014+A1:2019).

A2.15 ProPG states that *"[t]he judgement on whether or not to undertake a BS 4142:2014 assessment to determine dominance should be proportionate to the level of risk. In low risk cases a subjective judgement of dominance, based on audibility, would normally be sufficient.*"

British Standard 8233:2014 'Guidance on Sound Insulation and Noise Reduction for Buildings'

A2.16 BS 8233:2014 provides guidance for the control of noise in and around buildings. It is applicable to the design of new buildings, or refurbished buildings undergoing a change of use.

A2.17 BS 8233:2014 provides noise guidance for buildings of different uses, however in respect to dwellings and habitable residential spaces, Table 4 of BS 8233:2014 provides guideline values that it is desirable not to exceed during daytime and night-time periods. These guideline values are reproduced in **Table A.2.3**.

Table A.2.3: Indoor Ambient Noise Levels for Residential Dwellings

Activity	Location	Daytime Guideline (07:00-23:00hrs)	Night-time Guideline (23:00-07:00hrs)
Resting	Living Room	35 dB $L_{Aeq, 16hr}$	-
Dining	Dining Room / Area	40 dB $L_{Aeq, 16hr}$	-
Sleeping (Daytime Resting)	Bedroom	35 dB $L_{Aeq, 16hr}$	30 dB $L_{Aeq, 8hr}$

A2.18 The internal noise requirements are not intended to be met with open windows, although BS 8223:2014 states that the internal noise levels should take account of the proposed ventilation strategy.

A2.19 BS 8233:2014 also notes that: "*Where development is considered necessary or desirable, despite external noise levels above WHO guidelines, the internal target levels may be relaxed by up to 5 dB and reasonable internal conditions still achieved*". This sentence refers to the WHO '*Guidelines for Community Noise*' (WHO, 1999).

A2.20 BS 8233:2014 does not provide specific guidance on noise levels for regular individual noise events, such as passing trains, which can cause sleep disturbance. Guidance on suitable noise levels for individual events is provided in ProPG, which states:

'In most circumstances in noise-sensitive rooms at night (e.g. bedrooms) good acoustic design can be used so that individual noise events do not normally exceed 45 dB $L_{Amax, F}$ more than 10 times a night. However, where it is not reasonably practicable to achieve this guideline then the judgement of acceptability will depend not only on the maximum noise levels but also on factors such as source, number, distribution, predictability and regularity of noise events'.

A2.21 On this basis, it is considered appropriate to adopt the 10th highest $L_{Amax,F}$ noise event occurring in the night time period for the purposes of the assessment.

A2.22 With respect to external amenity spaces, BS 8233:2014 states 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*".

A2.23 BS 8233:2014 also states that it will not always be possible to achieve these guideline values for all circumstances where development may be desirable, and that development in higher noise areas, such as urban areas adjoining the strategic transport network or city centres, may warrant a compromise between elevated noise levels and other factors (for example the convenience of living in these locations). In these situations, BS 8233:2014 states that "*development should be designed to achieve the lowest practicable levels in these external amenity spaces, but should not be prohibited*". This approach is also advocated in PPG-Noise.

World Health Organization 'Environmental Noise Guidelines for the European Region' (WHO, 2018)

A2.24 The guidelines presented within the World Health Organization's (WHO) '*Environmental Noise Guidelines for the European Region*' (WHO, 2018) complement the WHO '*Guidelines for Community Noise*' (WHO, 1999) and the WHO '*Night Noise Guidelines for Europe*' (WHO NNG, 2009).

A2.25 The guidelines recommend noise exposure-response relationships that are mostly related to the noise exposure indicators L_{den} and L_{night}, with the aim of "*protecting human health from exposure to environmental noise originating from various sources: transportation (road traffic, railway, aircraft) noise, wind turbine noise and leisure noise*".

A2.26 The guidelines provide source-specific recommendations on noise exposures. **Table A.2.4** presents the recommendations relating to transportation sources from the guidance.

Table A.2.4: Source Specific Recommendations on Noise Exposures

Source	Average Noise Exposure	Night Noise Exposure
Road traffic noise	Below 53 dB L_{den} strongly recommended	Below 45 dB L_{night} strongly recommended
Railway noise	Below 54 dB L_{den} strongly recommended	Below 44 dB L_{night} strongly recommended
Aircraft noise	Below 45 dB L_{den} strongly recommended	Below 40 dB L_{night} strongly recommended

A2.27 Notably, the L_{den} parameter is a compound noise indicator, and is representative of the average sound pressure level over all days, evenings and night in a year, subject to an evening penalty of 5 dB and a night penalty of 10 dB. Whilst the WHO guidelines (2018) adopt the L_{den} as an appropriate indicator for adverse health effects, the $L_{Aeq,\,T}$ parameter, as advocated in Government policy and legislation is deemed to be the appropriate parameter for the determination of likely adverse impacts on health and quality of life.

Building Regulations Approved Document O – Overheating mitigation (ADO, 2021)

A2.28 Importantly, ADO, which took effect on 15 June 2022, aims to protect the health and welfare of occupants of buildings by reducing the occurrence of high indoor temperatures. This is achieved by designing and constructing the building to achieve both of the following:

- Limiting unwanted solar gains in summer; and
- Providing an adequate means of removing excess heat from the indoor environment.

A2.29 Compliance is demonstrated via a simplified method or by way of dynamic thermal modelling. The simplified method is based upon limiting solar gains by limiting the percentage glazed area and providing shading for high-risk locations. The removal of excess heat is achieved by specifying minimum free areas of ventilation provision.

A2.30 The dynamic thermal modelling approach provides a standardised approach to predicting overheating risk and offers the designer additional design flexibility over mitigation solutions. The mitigation methods would be expected to be similar to those advocated in the simplified method. This approach also allows the use of a mechanical ventilation and/or cooling system however it advises using passive means (non-mechanical) as far as reasonably practicable.

A2.31 Regarding noise, ADO states that windows are likely to be closed during sleeping hours if noise within bedrooms exceeds the 40dB $L_{Aeq,T}$, averaged over 8 hours (between 11pm and 7am) and 55 dB L_{AFmax} no more than ten times a night.

A3 Measured Sound Levels

Figure A.3.1: Location LT1 Unattended Measurements

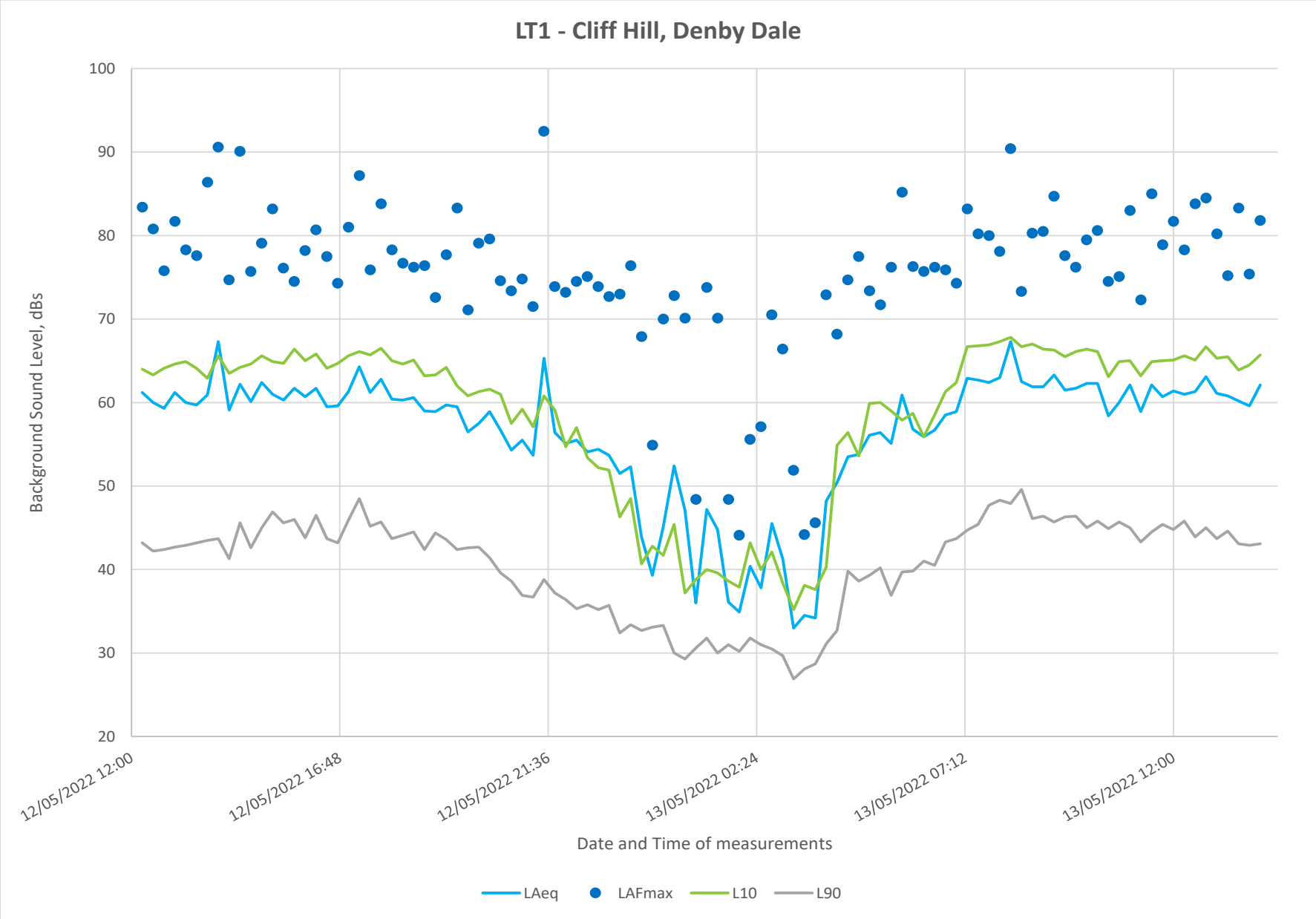


Figure A.3.2: Location LT2 Unattended Measurements

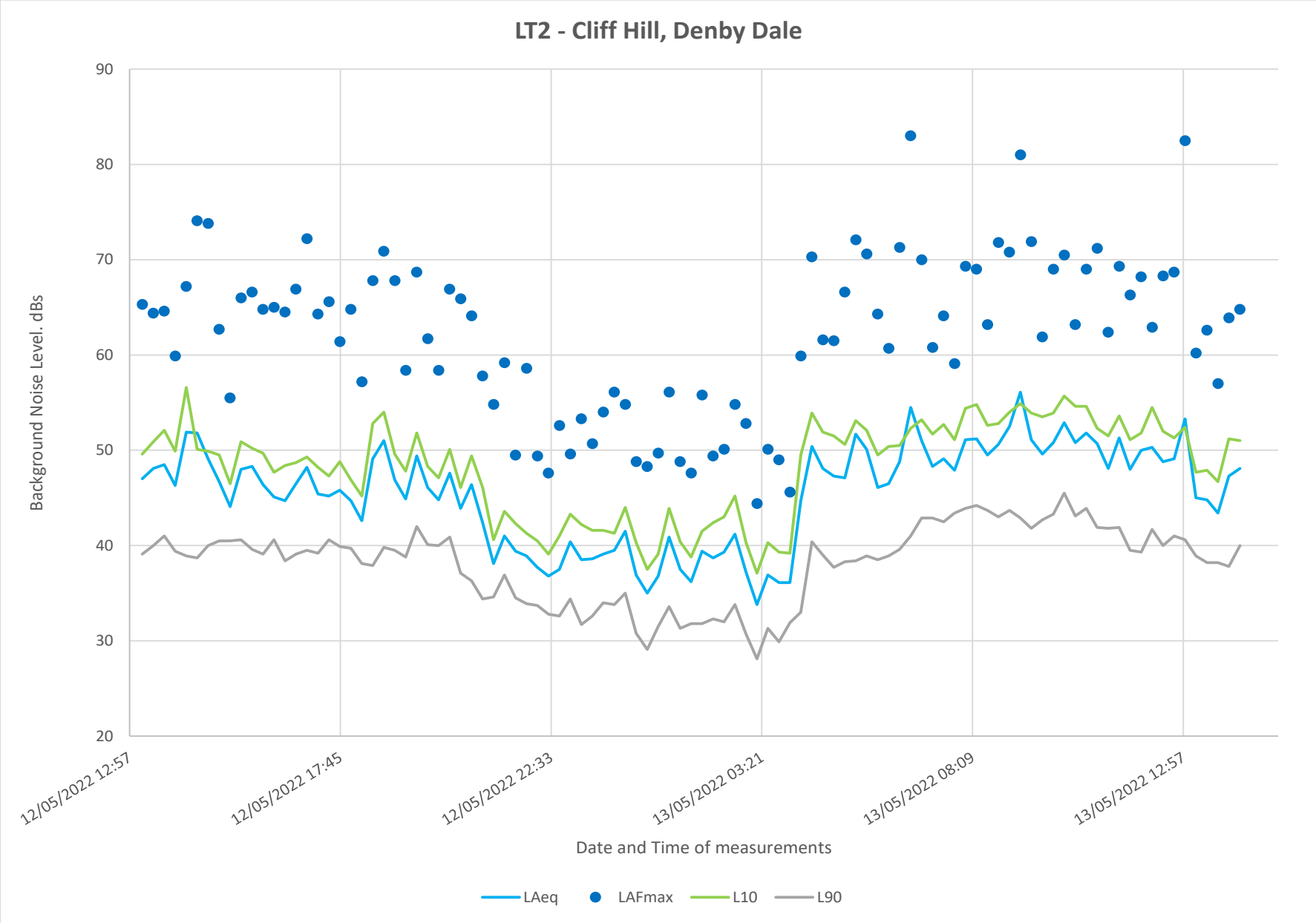


Figure A.3.3: Location LT3 Unattended Measurements

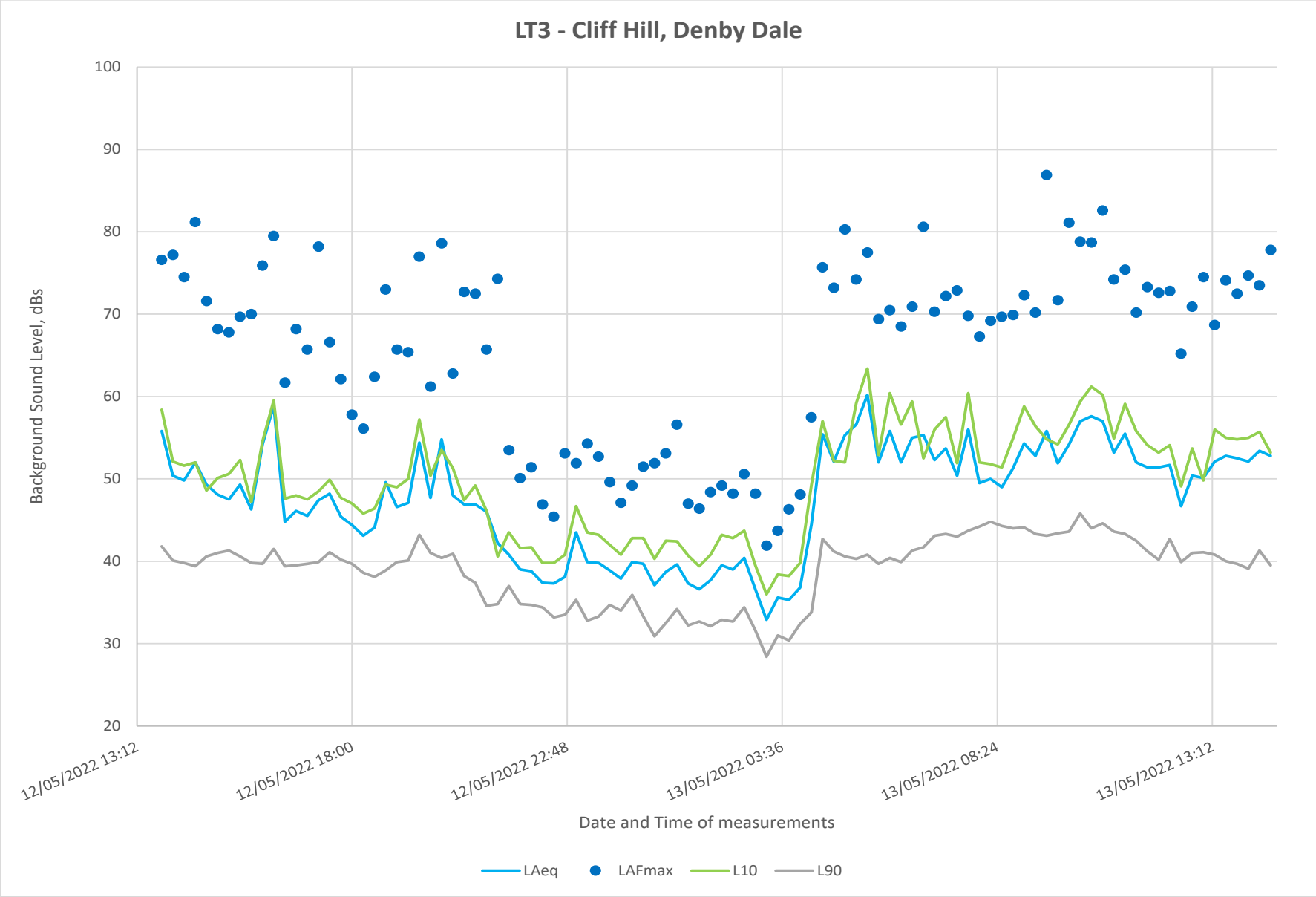


Figure A.3.4: Location LT4 Unattended Measurements