# 12.

# Appendices

# Appendix 12.1 Noise Perception and Terminology

## Noise Perception and Terminology

Between the quietest audible sound and the loudest tolerable sound there is a million to one ratio in sound pressure (measured in pascals, Pa). Because of this wide range a noise level scale based on logarithms is used in noise measurement called the decibel (dB) scale. Audibility of sound covers a range of approximately 0 to 140 dB.

The human ear system does not respond uniformly to sound across the detectable frequency range and consequently instrumentation used to measure noise is weighted to represent the performance of the ear. This is known as the 'A weighting' and annotated as dB (A) or $L_{pA}$ dB. Table 10.1 below lists the sound pressure level in dB (A) for common situations.

The noise level at a measurement point is rarely steady, even in rural areas, and varies over a range dependent upon the effects of local noise sources. Close to a busy road, the noise level may vary over a range of 5 dB(A), whereas in a suburban area this may increase up to 40 dB(A) and more due to the multitude of noise sources in such areas (cars, dogs, aircraft etc.) and their variable operation. Furthermore, the range of night-time noise levels will often be smaller and the levels significantly reduced compared to daytime levels.

***Table 10.1 Noise Levels for Common Situations***

| Typical noise level, dB(A) | Example |
|---|---|
| **0** | Threshold of hearing |
| **30** | Rural area at night, still air |
| **40** | Public library, refrigerator humming at 2m |
| **50** | Quiet office, no machinery |
| **60** | Normal conversation |
| **70** | Telephone ringing at 2m |
| **80** | General factory noise level |
| **90** | Heavy goods vehicle from pavement |
| **100** | Pneumatic Drill at 5m |
| **120** | Discotheque – 1m in front of loud speaker |
| **140** | Threshold of pain |

The equivalent continuous A-weighted sound pressure level, $L_{Aeq}$ dB (or $L_{eq}$ dBA), is the single number that represents the average sound energy measured over that period. The $L_{Aeq}$ is the sound level of a notionally steady sound having the same energy as a fluctuating sound over a specified measurement period.

When considering environmental noise, it is necessary to consider how to quantify the existing noise (the ambient noise) to account for these second-to-second variations. A parameter that is widely accepted as reflecting human perception of the ambient noise is the background noise level, $L_{A90}$. This is the noise level exceeded for 90% of the measurement period and generally reflects the noise level in the lulls between individual noise events. Over a one-hour period, the $L_{A90}$ will be the noise level exceeded for 54 minutes.

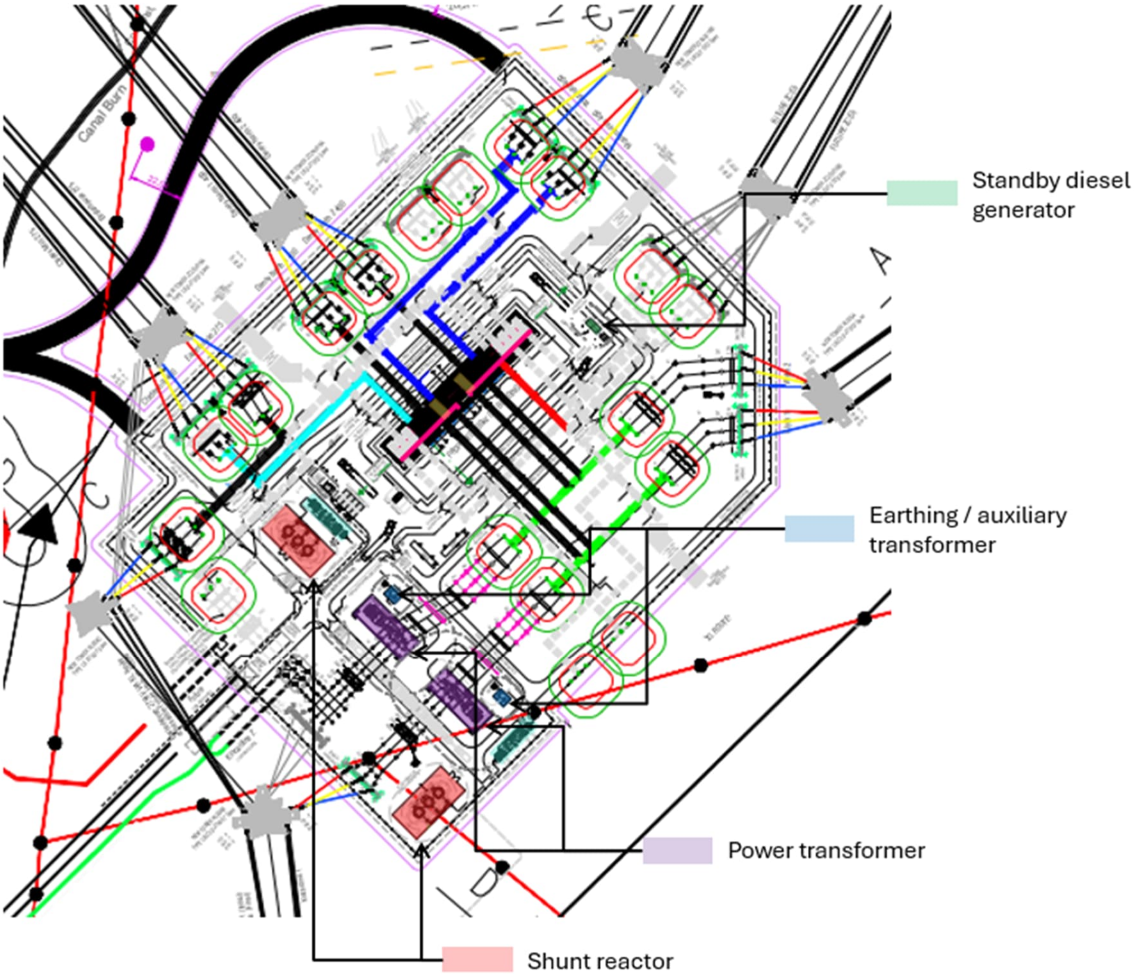
Human subjects are generally only capable of noticing changes in steady levels of no less than 3 dB(A). It is generally accepted that a change of 10 dB(A) in an overall, steady noise level is perceived to the human ear as a doubling (or halving) of the noise level. (These findings do not necessarily apply to transient or non-steady noise sources such as changes in noise due to changes in road traffic flow, or intermittent noise sources).

# Appendix 12.2 Baseline Survey Measurement Locations

## Figure12.1. Noise Measurement Locations

# Appendix 12.3 Proposed Substation Layout

## Figure12.2 Proposed Substation Layout



# Appendix 12.4 Baseline Survey Measurements

*Table 1 ML1 Survey Location Details*

| ML1 | Description |
|---|---|
| **Location description, what 3 words location and OS grid reference (Easting/Northing)** | ///dolphins.calibrate.focal<br>292973, 689210 |
| **Monitoring date and time** | 01/08/2024 12:35 to 05/08/2024 12:35 |
| **Monitoring height above ground** | 1.5m |
| **Distance to nearest building façade** | Greater than 3.5m |
| **Sound Level Meter and Serial No.** | Rion NL-52<br>00386766 |
| **Field Calibrator and Serial No.** | Brüel & Kjær 4231<br>2217876 |
| **Weather station used** | Davis Vantage Vue<br>DAV 6250 |
| **Daytime description of the sound climate** | The dominant sound source was birdsong and intermittent road traffic noise. |

*Figure 1 ML1 Equipment Setup*

*Table 2 ML1 Summary of Each Measurement Period*

| Period | Date | $L_{Aeq}$ (logarithmic mean) | $L_{AFmax}$ (maximum) | $L_{A90}$ (mean) |
|---|---|---|---|---|
| Day (12:35-19:00) | 01/08/2024 | 50 | 85 | 44 |
| Day (07:00-19:00) | 02/08/2024 | 55 | 82 | 44 |
| Day (07:00-19:00) | 03/08/2024 | 48 | 74 | 43 |
| Day (07:00-19:00) | 04/08/2024 | 49 | 73 | 43 |
| Day (07:00-12:35) | 05/08/2024 | 51 | 73 | 45 |
| Day-Evening (07:00 – 23:00) | 01/08/2024 | 49 | 85 | 42 |
| Day-Evening (07:00 – 23:00) | 02/08/2024 | 54 | 82 | 43 |
| Day-Evening (07:00 – 23:00) | 03/08/2024 | 48 | 75 | 42 |
| Day-Evening (07:00 – 23:00) | 04/08/2024 | 49 | 73 | 43 |
| Day-Evening (07:00 – 23:00) | 05/08/2024 | 51 | 73 | 45 |
| Evening (19:00-23:00) | 01/08/2024 | 47 | 67 | 40 |
| Evening (19:00-23:00) | 02/08/2024 | 45 | 70 | 40 |
| Evening (19:00-23:00) | 03/08/2024 | 46 | 75 | 39 |
| Evening (19:00-23:00) | 04/08/2024 | 48 | 73 | 42 |
| Night (23:00-07:00) | 01/08/2024 | 45 | 78 | 33 |
| Night (23:00-07:00) | 02/08/2024 | 44 | 76 | 32 |
| Night (23:00-07:00) | 03/08/2024 | 42 | 69 | 31 |
| Night (23:00-07:00) | 04/08/2024 | 46 | 70 | 38 |

*Table 3 ML1 Overall Summary*

| Period | $L_{Aeq}$ (logarithmic average) | $L_{AFmax}$ (maximum) | $L_{A90}$ (mean) | $L_{A90}$ (mode) |
|---|---|---|---|---|
| **Day** | 51 | 85 | 44 | 45 |
| **Day-Evening** | 51 | 85 | 43 | 45 |
| **Evening** | 46 | 75 | 40 | 38 |
| **Night** | 44 | 78 | 33 | 32 |

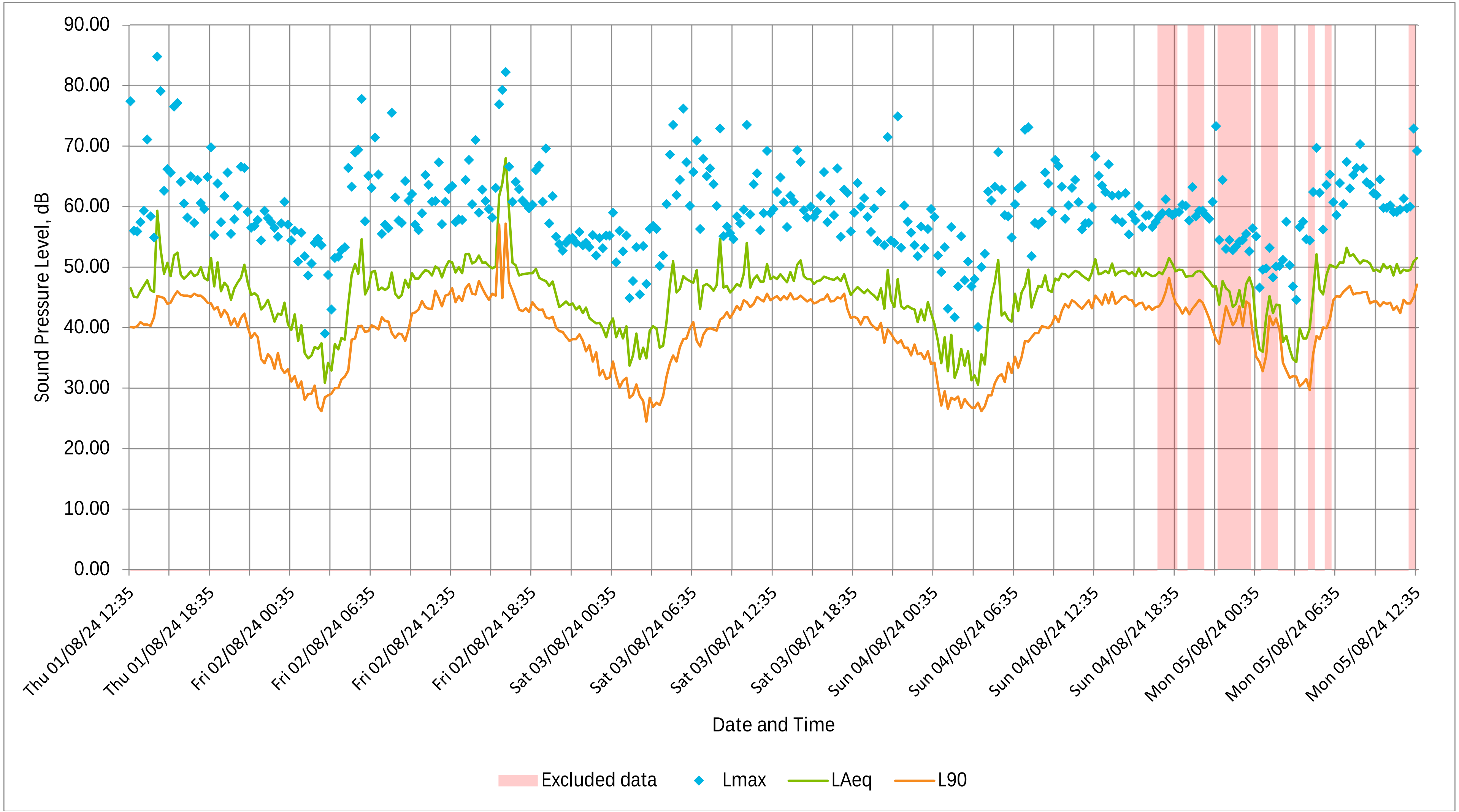



*Figure 2 ML1 Time Series Data*

*Table 4 ML2 Survey Location Details*

| ML2 | Description |
|---|---|
| **Location description, what 3 words location and OS grid reference (Easting/Northing)** | ///fattening.hems.share<br>292973, 689210 |
| **Monitoring date and time** | 01/08/2024 14:15 – 05/08/2024 13:45 |
| **Monitoring height above ground** | 1.5m |
| **Distance to nearest building façade** | Greater than 3.5m |
| **Sound Level Meter and Serial No.** | Rion NL-52<br>00386764 |
| **Field Calibrator and Serial No.** | Brüel & Kjær 4231<br>2217876 |
| **Weather station used** | Davis Vantage Vue<br>DAV 6250 |
| **Daytime description of the sound climate** | Distant, intermittent road traffic noise. |

*Figure 3 ML2 Equipment Setup*

*Table 5 ML2 Summary of Each Measurement Period*

| Period | Date | $L_{Aeq}$ (logarithmic mean) | $L_{AFmax}$ (maximum) | $L_{A90}$ (mean) |
|---|---|---|---|---|
| Day (14:15-19:00) | 01/08/2024 | 48 | 72 | 44 |
| Day (07:00-19:00) | 02/08/2024 | 48 | 80 | 45 |
| Day (07:00-19:00) | 03/08/2024 | 51 | 74 | 46 |
| Day (07:00-19:00) | 04/08/2024 | 48 | 66 | 44 |
| Day (07:00-13:45) | 05/08/2024 | 49 | 84 | 46 |
| Day-Evening (07:00 – 23:00) | 01/08/2024 | 47 | 72 | 41 |
| Day-Evening (07:00 – 23:00) | 02/08/2024 | 47 | 80 | 43 |
| Day-Evening (07:00 – 23:00) | 03/08/2024 | 50 | 74 | 44 |
| Day-Evening (07:00 – 23:00) | 04/08/2024 | 47 | 70 | 44 |
| Day-Evening (07:00 – 23:00) | 05/08/2024 | 49 | 84 | 46 |
| Evening (19:00-23:00) | 01/08/2024 | 43 | 64 | 38 |
| Evening (19:00-23:00) | 02/08/2024 | 45 | 59 | 40 |
| Evening (19:00-23:00) | 03/08/2024 | 44 | 70 | 38 |
| Evening (19:00-23:00) | 04/08/2024 | 46 | 70 | 43 |
| Night (23:00-07:00) | 01/08/2024 | 41 | 67 | 33 |
| Night (23:00-07:00) | 02/08/2024 | 40 | 66 | 32 |
| Night (23:00-07:00) | 03/08/2024 | 39 | 61 | 31 |
| Night (23:00-07:00) | 04/08/2024 | 46 | 73 | 40 |

*Table 6 ML2 Overall Summary*

| Period | $L_{Aeq}$ (logarithmic average) | $L_{AFmax}$ (maximum) | $L_{A90}$ (mean) | $L_{A90}$ (mode) |
|---|---|---|---|---|
| **Day** | 49 | 84 | 45 | 46 |
| **Day-Evening** | 48 | 84 | 44 | 46 |
| **Evening** | 44 | 70 | 39 | 41 |
| **Night** | 41 | 73 | 33 | 34 |

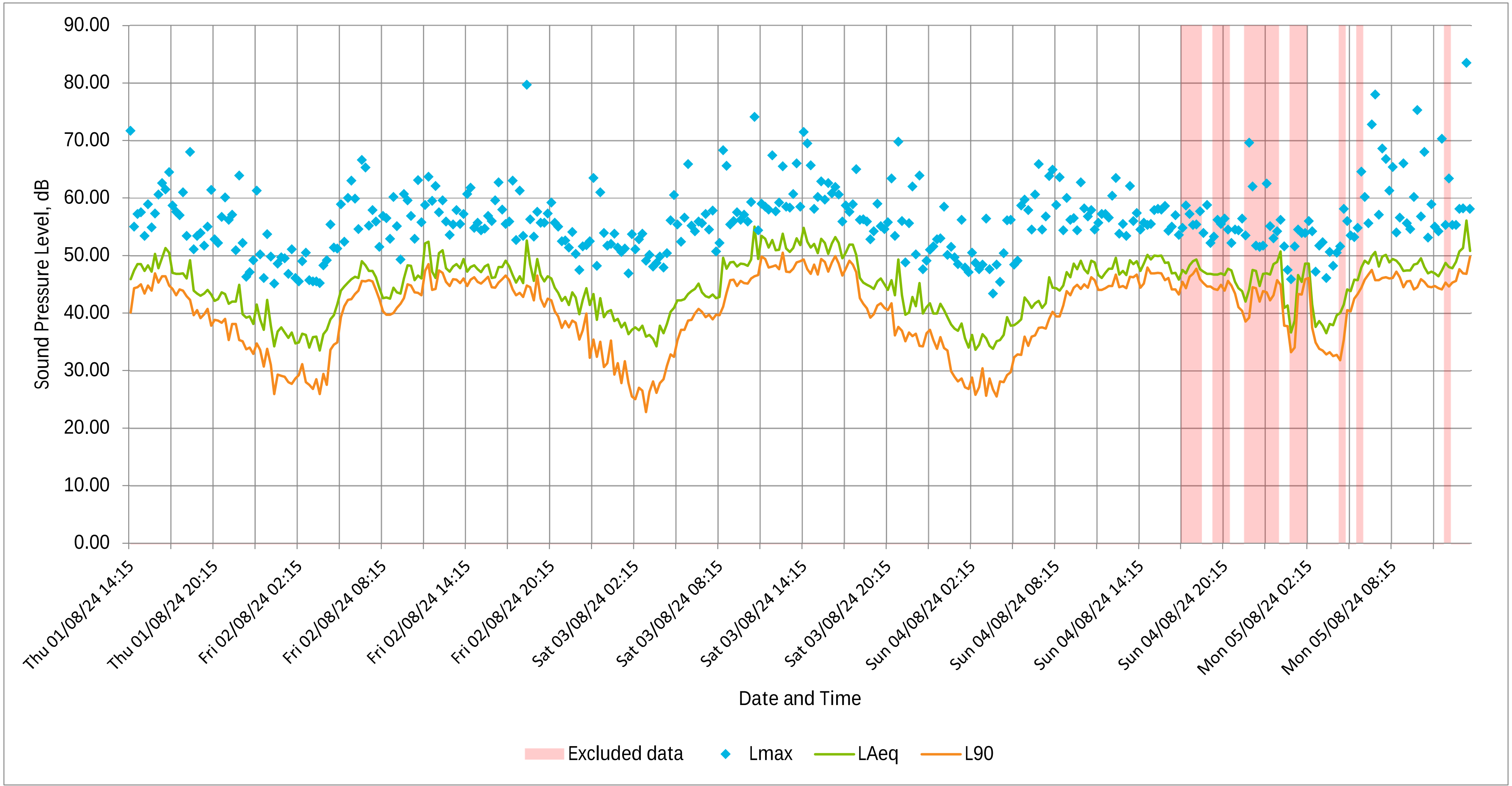



*Figure 4 ML2 Time*

# Appendix 12.5 Acoustic Modelling Details

## Prediction Methodology

Modelling of sound levels from the Proposed Development has been undertaken using CadnaA acoustic modelling software. This software implements the sound propagation calculation methodology set out in the ISO 9613-2:2024 – *'Attenuation of sound during propagation outdoors'*. The propagation model described in this standard provides for the prediction of sound pressure levels based on either short-term downwind (i.e. worst case) conditions or long-term overall averages. The highest sound levels at NSRs occur under down wind conditions (wind blowing 1 to 5 m/s from the site towards the nearby receptors), and these have been adopted within the model. When the wind is blowing in the opposite direction, sound levels may be significantly lower than those predicted. The ISO propagation model calculates the predicted sound pressure level by taking the source sound power level for each source and subtracting a number of attenuation factors according to the following:

$$\text{Predicted Sound Level} = L_{WA} + D - A_{geo} - A_{atm} - A_{gr} - A_{bar} - A_{misc}$$

These factors are discussed in detail below.

The Sound Power Level ($L_{WA}$) defines the total acoustic power radiated by a noise source expressed in decibels (dB re 1 pW).

The directivity factor (D) allows for an adjustment to be made where the sound radiated in the direction of interest is higher than that for which the sound power level is specified. No directivity factor is considered within this assessment.

The geometrical divergence ($A_{geo}$) accounts for spherical spreading of the sound from the source within free-field conditions. Different sources at the Installation have been modelled to take account of their geometry, as area, line or point sources. The divergence factor is calculated from the distance from the source to the receiver, and the relationship between the attenuation provided and distance is dependent on the type of sound source assumed.

The atmospheric absorption factor ($A_{atm}$) considers the attenuation offered by the atmosphere as a result of the conversion of sound to heat. The degree of attenuation is dependent on the relative humidity and temperature of the air through which the sound is travelling and is frequency dependent. Increasing attenuation occurs towards the higher frequencies of sound.

Modelling parameters have assumed an ambient temperature of 10 °C and 70% relative humidity which are found to result in worst case noise propagation. The corresponding atmospheric attenuation factors are summarised below in Table 1.

*Table 1 Atmospheric Attenuation (dB/km) at 10 °C and 70% Relative Humidity*

| Octave Band Centre Frequency / Hz | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k |
|---|---|---|---|---|---|---|---|---|
| **Atmospheric Absorption Coefficient dB / km** | 0.122 | 0.411 | 1.04 | 1.93 | 3.68 | 9.66 | 32.8 | 117 |

The ground effect ($A_{gr}$) is the result of sound reflected by the ground interfering with the sound propagating directly from source to receiver, and the interaction of the sound with porous and absorptive ground cover. The prediction of ground effects depends on the source height, receiver height, propagation height between the source and receiver and the ground conditions.

The ground conditions are described according to a variable defined as G, which varies between 0 for 'hard' ground (includes paving, water, ice, concrete and any locations with low porosity) and 1 for 'soft' ground (includes ground covered by grass, trees or other vegetation).

The effect of any barrier or topographical obstruction ($A_{bar}$) between the sound source and the receiver position is that sound will be reduced according to the relative heights of the source, receiver and barrier and the frequency spectrum of the sound.

## Acoustic Modelling Input Data

All plant has been modelled as point sources which is considered appropriate due to the distance to noise sensitive receptors. The sound power levels for proposed new plant items assessed in this report are provided in the following table. Receiver points are modelled at 1.5 m for the ground floor and 4 m for the first floor. Point sources are positioned in the centre of the top of each item of plant. Heights are provided in the table below.

*Table 2 Sound Power Level of New Plant Items*

| New Plant Item | Sound Power Level LwA (dB) | Point Source Height (m) |
|---|---|---|
| **2x Power Transformer With Cooler Unit** | 87 | 7 |
| **2x Earthing / Auxiliary Transformer** | 70 | 1.5 |
| **2x Shunt Reactor** | 83 | 3.9 |
| **1x Standy Diesel Generator (Rural option)** | 102* | 1.6 |

*Note: *The standby diesel generator noise level was provided as a sound pressure level of 85 dBA at 1 m which was converted to a sound power level via the conformal surfaces method.*

***Table 0.1. Sound Power Levels (dB per unit) at Third-Octave Band Centre Frequency (Hz)***

| Unit | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 | 800 | 1k | 1.25k | 1.6k | 2k | 2.5k | 3.15k | 4k | 5k | 6.3k | 8k | 10k | Total (dB $L_A$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Power Transformer With Cooler Unit | 74 | 73 | 74 | 92 | 74 | 63 | 74 | 63 | 67 | 75 | 61 | 63 | 60 | 60 | 60 | 59 | 56 | 57 | 59 | 77 | 85 | 73 | 54 | 52 | *87* |
| Earthing / Auxiliary Transformer | 57 | 56 | 57 | 75 | 57 | 46 | 57 | 46 | 50 | 58 | 44 | 46 | 43 | 43 | 43 | 42 | 39 | 40 | 42 | 60 | 68 | 56 | 37 | 35 | *70* |
| Shunt Reactor | 70 | 69 | 70 | 88 | 70 | 59 | 70 | 59 | 63 | 71 | 57 | 59 | 56 | 56 | 56 | 55 | 52 | 53 | 55 | 73 | 81 | 69 | 50 | 48 | *83* |
| Standy Diesel Generator (rural option)* | - | 103 | - | - | 100 | - | - | 104 | - | - | 98 | - | - | 97 | - | - | 93 | - | - | 84 | - | - | 75 | - | *102* |

**Note: The standby diesel generator was modelled using octave bands.*

# Appendix 12.6 Predicted Internal Noise Levels

*Table 0.1 Predicted noise break in and noise ratings assuming the substation is operational with a rural standby diesel generator*

| NSR | Assessment Period | Predicted External Noise Break in $L_{eq}$ 63 Hz | 125 Hz | 250 Hz | 500 Hz | 1000 Hz | 2000 Hz | 4000 Hz | Predicted Internal Noise Level $L_{Aeq,T}$ (63 Hz – 4 kHz) | Predicted Internal Noise Rating | Meets NR 25 (and NR 35) (Y/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **NSR1 First Floor** | Day | 26 | 21 | 20 | 20 | 19 | 8 | -8 | 22 | NR 19 | Y |
| | Night | 26 | 24 | 23 | 21 | 20 | 9 | -6 | 23 | NR 20 | Y |
| **NSR2 First Floor** | Day | 26 | 22 | 20 | 20 | 20 | 9 | -7 | 23 | NR 20 | Y |
| | Night | 27 | 25 | 23 | 21 | 21 | 10 | -6 | 24 | NR 21 | Y |
| **NSR3 First Floor** | Day | 22 | 18 | 16 | 15 | 14 | 1 | -21 | 17 | NR 14 | Y |
| | Night | 23 | 21 | 19 | 16 | 16 | 3 | -19 | 19 | NR 15 | Y |