



Azymuth Acoustics UK

Professional Acoustic Services

Acoustic Review of Proposed External Plant

Ref: AA0449.2RevA

AO Arena Mezzanine Extension Manchester

On behalf of

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1.0 Introduction

Azymuth Acoustics UK (henceforth Azymuth) has been appointed by Galliford Try Plc. to provide acoustic design advice for the proposed mezzanine extension at Manchester's AO Arena. The extension will consist of:

1. A new VIP bar and restaurant located on a new mezzanine floor within the building.
2. A viewing platform extending from the VIP area through the existing terracing.
3. Extensive MEP alterations and diversions.
4. High end finishes.
5. Demolition
6. New toilets and ancillary areas.

This report considers the proposed external plant noise and impact on surrounding noise receptors.

The location of the proposed external roof plant can be seen in the figure below.



Figure 1 – Location of proposed external roof plant

2.0 Guidance and Criteria

In order to assess the extent of any measures required in order to comply with suitable conditions relating to potential noise sources, Azymuth Acoustics UK has reviewed various guidance documents and standards, these include:

- National Planning Policy Framework (NPPF 2021)
- World Health Organisation Guidelines on Community Noise
- British Standard 4142:2014
- Manchester City Council Planning and Noise Guidance 2022

2.1 National Planning Policy Framework (NPPF) 2021

The NPPF provides guidance to local authorities taking into account noise in making planning decisions. Paragraph 185 of the National Planning Policy Framework (NPPF) states that planning policies and decisions should aim to:

- Avoid noise giving rise to significant adverse impacts on health and quality of life as a result of new development
- Mitigate and reduce to a minimum other adverse impacts on health and quality of life arising from noise from new development, including through the use of conditions

The National Planning Policy Framework states that the planning system should ‘prevent both new and existing development from contributing to or being put at unacceptable risk from, or being adversely affected by unacceptable levels of soil, air, water or noise pollution or land instability’.

2.2 World Health Organisation Environmental Noise Guidelines (ENG) 2018

The main purpose of the 2018 WHO guidelines is to provide recommendations for protecting human health from exposure to environmental noise originating from the following sources: transportation (road traffic, railway and aircraft), wind turbines and leisure activities.

The guidelines set out to define recommended exposure levels for environmental noise in order to protect population health. Exposure limits are average levels defined over a period of one year, measured outdoors in free field at the most exposed façade. It should be noted that the document does not provide guideline limit values for multiple noise sources in combination.

The 2018 guidelines supersede the Community Noise Guidelines from 1999. Nevertheless, the document recommends that all CNG indoor guideline values and any values not covered by the current guidelines should remain valid. As such, the following guidance would remain appropriate:

For protection against sleep disturbance inside dwellings, night-time noise levels should not exceed 30dB L_{Aeq} for continuous noise and 45dB L_{Amax} for typical single sound events (which are exceeded 15 times or more per night – see ProPG Appendix A.12 for more details). To protect the majority of people from being seriously annoyed during the daytime, the outdoor sound level from steady, continuous noise (interpreted as noise from all sources combined) should not exceed 55dB L_{Aeq} on balconies, terraces and in outdoor living areas.

It should be noted that exposure levels defined in ENG and CNG are for guidance purposes as relates potential adverse health impacts and should not be interpreted as absolute limits or regulations.

2.3 British Standard 4142:2014

British Standard 4142: 2014 “Methods for assessing and rating industrial sound” describes methods for rating and assessing sound of an industrial and/or commercial nature. The methods described in this British Standard use outdoor sound levels to assess the likely effects of sound on people who might be inside or outside a dwelling or premises used for residential purposes upon which sound is incident.

- Typically, the greater the difference between background sound and industrial/commercial noise, the greater the magnitude of the impact.
- 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. Where the rating level does not exceed the background sound level, this is an indication of the specific sound source having a low impact, depending on the context.
- A difference of around +5dB is likely to be an indication of an adverse impact, depending on the context.
- A difference of around +10dB or more is likely to be an indication of a significant adverse impact, depending on the context.

BS 4142 notes that: “Adverse impacts include, but are not limited to, annoyance and sleep disturbance. Not all adverse impacts will lead to complaints and not every complaint is proof of an adverse impact.”

2.4 Manchester City Council Planning and Noise Guidance 2022

For Industrial & Commercial developments, Manchester City Council (MCC) suggests an assessment based upon BS 4142 is performed. From this, rating level relative to the background sound level can be used to indicate the adverse impact of the development. The lower the rating level (L_{Aeq}) relative to the background sound level (L_{A90}), the lower the likelihood of an adverse impact. The objective with regards to industrial development is as follows:

The development should be designed so as to achieve a rating level of 5dB (L_{Aeq}) below the typical background (L_{A90}) level at the nearest noise sensitive location.

A similar criterion for plant noise is also outlined:

Externally mounted ancillary plant, equipment and servicing shall be selected and/or acoustically treated in accordance with a scheme designed so as to achieve a rating level of 5dB (L_{Aeq}) below the typical background (L_{A90}) level at the nearest noise sensitive location.

3.0 Assessment of External Plant

3.1 Noise Survey of Existing Plant

Ambient noise measurements were undertaken on the roof where the external plant is proposed as well as on the upper roof where the existing external plant resides. The existing external plant typically consists of condensing units serving air handling units and air conditioning systems within the arena. Additional measurements were undertaken at the locations of the nearest residential receptors located on Breslyn / Mirabel Street as well as the committed development situated directly opposite the roof plant location at the former Boddingtons Brewery site. These local measurements are in addition to the measurements undertaken by OR Consulting in 2022.

The instrumentation used for the measurements consisted of a SvanTek 977/971 type 1 precision sound level meter. The equipment was calibrated before and after measurements. The sound level meter measured A-weighted (fast response) noise levels as well as octave bands noise levels for all measurement record.

The noise measurements were undertaken using the sound level meter at the roof position(s) shown in Figure 2:

- Position 1: Proposed plant roof (circa 4-5m lower than positions 2/3 and circa 5m above ground level)
- Position 2: Existing plant roof (highest roof level)
- Position 3: External roof plant measurement (highest roof level)
- Position 4: Car park plant measurement 1 (circa 3m lower than positions 2/3)
- Position 5: Car park plant measurement 2 (circa 3m lower than positions 2/3)

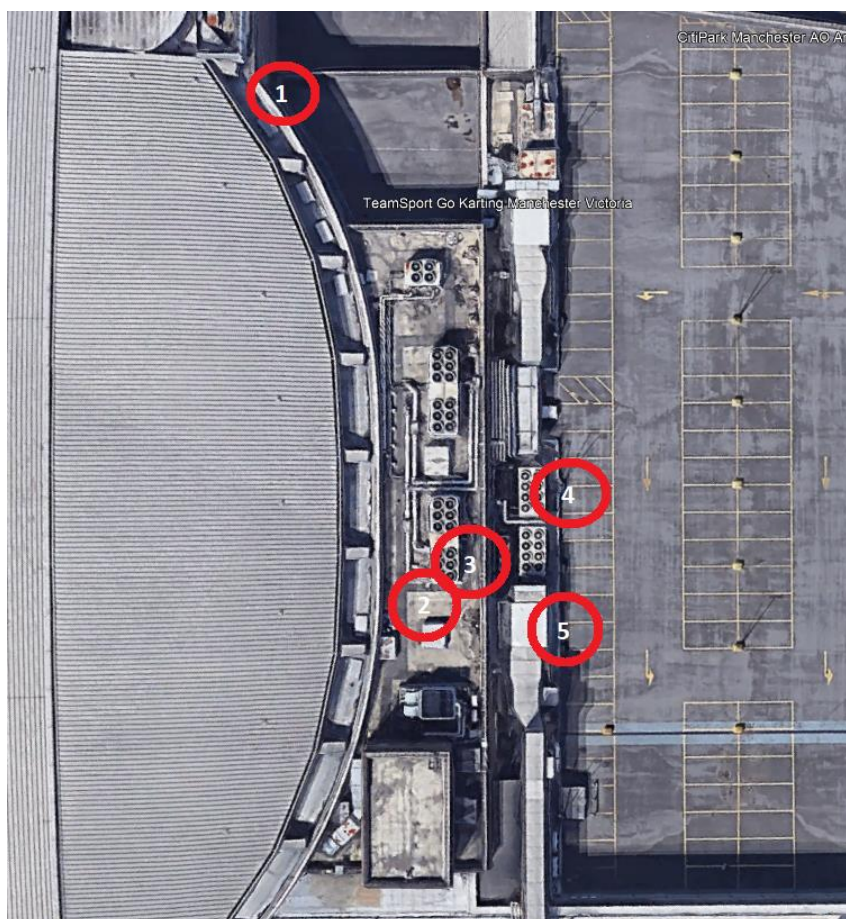


Figure 2 – Noise measurement locations

Location	Time	L _{AFmax}	L _{Aeq}	L _{A10}	L _{A50}	L _{A90}
1) Proposed plant roof	00:15:00	66.2	62.8	63.8	62.7	61.8
2) Existing plant roof	00:10:00	60.5	55.8	56.7	55.5	54.3
3) External roof plant measurement	00:01:30	65.5	64.6	65.3	64.5	64.0
4) Car park plant measurement 1	00:01:30	84.4	72.3	62.0	61.3	60.4
5) Car park plant measurement 2	00:01:30	69.0	67.6	68.4	67.5	67.0

Table 1 – Noise measurement data for roof plant measurements

3.2 Environmental Noise Survey

The environmental noise survey focussed on measurements close to the existing and potential / proposed residential properties or location and these measurements were undertaken using the sound level meter at the position(s) shown in Figure 3:

- Position 1: Corner of Dutton Street
- Position 2: Breslyn / Mirabel Street



Figure 3 – Residential measurement locations

Location	Time	L _{AFmax}	L _{Aeq}	L _{A10}	L _{A50}	L _{A90}
1) Corner of Dutton Street	Day	83.7	70.3	73.2	67.1	62.5
1) Corner of Dutton Street	Night	75.0	59.0	68.7	62.6	54.9
2) Breslyn Street / Mirabel Street	Day	72.0	57.2	58.8	54.0	47.2
2) Breslyn Street / Mirabel Street	Night	66.2	52.8	59.1	53.2	47.6

Table 2 – Noise measurement data for residential measurements

3.3 Proposed Extension External Plant Layout (Revised)

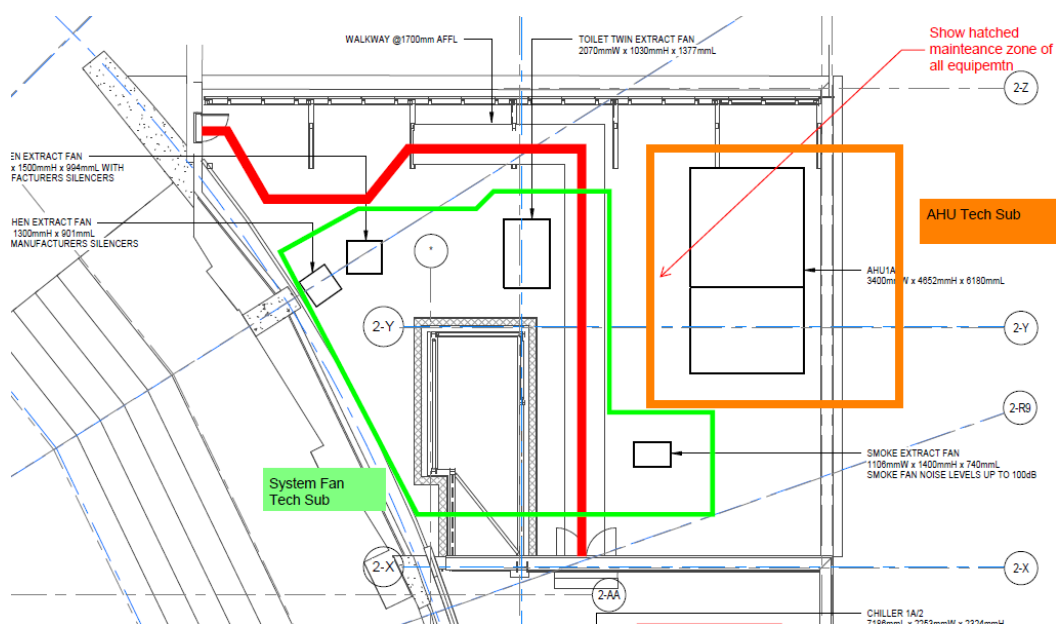


Figure 3 – Proposed lower roof plant locations

The proposed 'lower roof' external plant area shall be noise screened along the East, West and South facing orientations by the existing buildings which are at least 2m higher than where the external plant is located.

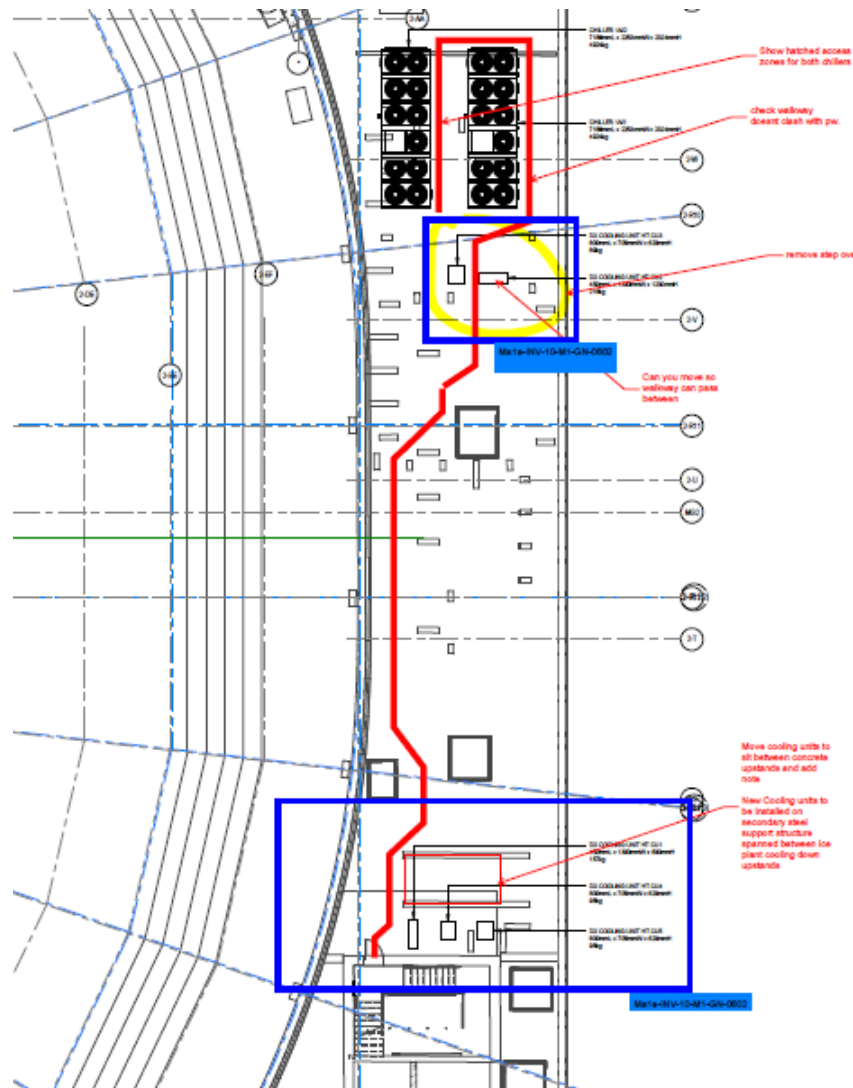


Figure 4 – Proposed upper roof plant locations

The noise levels for each individual item of plant has been provided by RPS in conjunction with the relevant data sheets. The Airtech Air Handling Unit (AHU) located on the lower roof has 6 sections. Azymuth have modelled the AHU using the sound power data for both the supply and extract sections of the unit.

Operational information for the proposed plant has been provided, this information includes the various modes for operation and their associated start/stop times. To emulate a worst-case possible scenario the roof plant has been modelled so that it starts at the earliest 'start' time, 08:00hrs in Conference Mode, and ends at the latest 'stop' time, 02:00hrs in VIP Mode.

The noise impact shall be less if the plant is not in use or is operating in a reduced capacity when the venue is not operational. Therefore, the predictions from the SoundPLAN model can be deemed representative of the worst case for periods up to approx. 2300hrs, it is likely that noise levels from the plant would decrease after 2300hrs.



The octave band sound power data used for the noise model is as follows:

Plant	Octave Band Centre Frequency (Hz)								~LwA (dB)
	63	125	250	500	1000	2000	4000	8000	
AHU Airtech Ciat 600	82	83	96	92	91	88	75	72	96
VIP Kitchen Extract Fan	86	94	84	82	76	74	71	59	84
Mezz Kitchen Extract Fan	78	86	74	69	65	67	60	45	75
Smoke Extract Fan	79	84	81	78	68	69	65	47	79
Toilet Twin Extract Fan 01	94	81	90	84	80	74	65	59	86
Chillers (1A/1 and 1A/2)	92	87	95	89	87	84	79	78	93
DX Cooling Unit HT-CU 1	72	80	68	63	59	61	54	39	69
DX Cooling Unit HT-CU 2	74	82	70	65	61	63	56	41	71
DX Cooling Unit HT-CU 3, 4 & 5	74	83	70	65	62	63	65	41	72

Table 3 – Octave band sound power data for each item of plant

The sound power levels tabulated above are the rated values at full output.

3.4 SoundPLAN Noise Modelling

Azymuth has undertaken noise modelling in SoundPLAN 8.2 to predict and visualise the (typical worst case) effect of plant noise on the surrounding environment. The nearest noise sensitive receptor is the committed residential development being constructed at the former Boddingtons Brewery site located on Trinity Way / Dutton Street. This development is directly opposite the AO Arena roof plant at a distance of ~30m.

3.4.1 Grid Noise Map (GNM)

The following grid noise maps represent the daytime (up to 2300hrs) noise levels at 3 different heights above local ground i.e. 1.5m representing pavement or ground floor level, 15m which would be level with the lower plant platform and ~30m to represent the upper floors of the development for all plant operating simultaneously. GNMs for both daytime and night-time noise levels have been computed.



Figure 5 – GNM of noise propagation at ground floor level during the daytime (1.5m)



Figure 6 – GNM of noise propagation at ground floor level during the night-time (1.5m)

Figures 7 and 8 show the noise propagation from the roof plant at a height of ~15m.

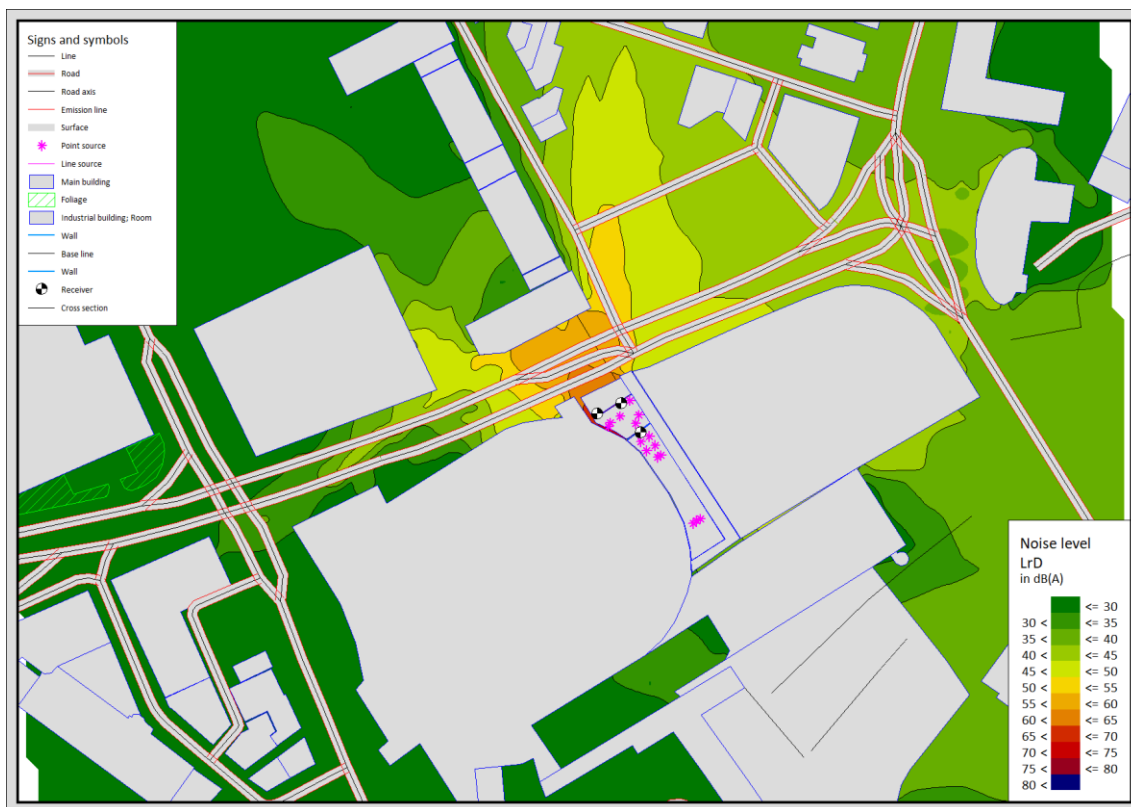


Figure 7 – GNM of noise propagation at a height of 15m during the daytime



Figure 8 – GNM of noise propagation at a height of 15m during the night-time

Figures 9 and 10 shows the noise propagation from the roof plant at a height of ~30m.



Figure 9 – GNM of noise propagation at a height of 30m during the daytime



Figure 10 – GNM of noise propagation at a height of 30m during the night-time

3.4.2 Façade Noise Maps (FNM)

The façade noise maps below show the effect of noise on the facades of the nearest residential and education receptors. The external plant has been modelled as a set of point sources and is indicated as an 'Asterix' (magenta colour) on each FNM below.

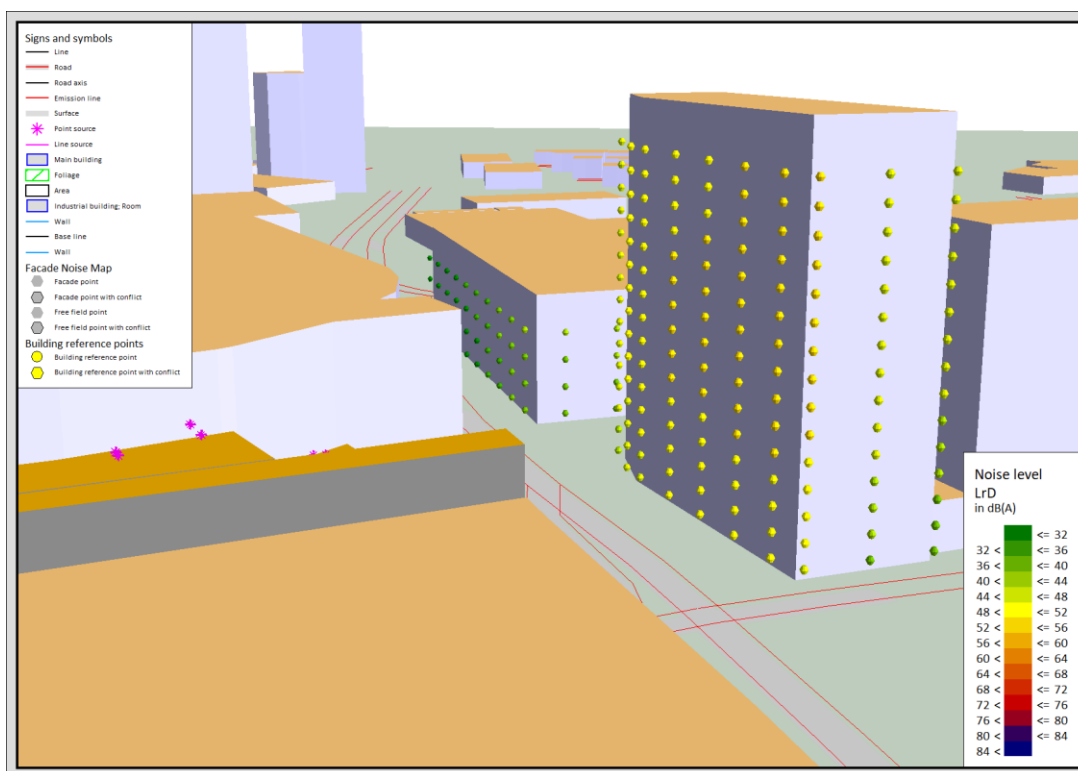


Figure 11 – FNM of the effect of noise on adjacent development and Manchester College

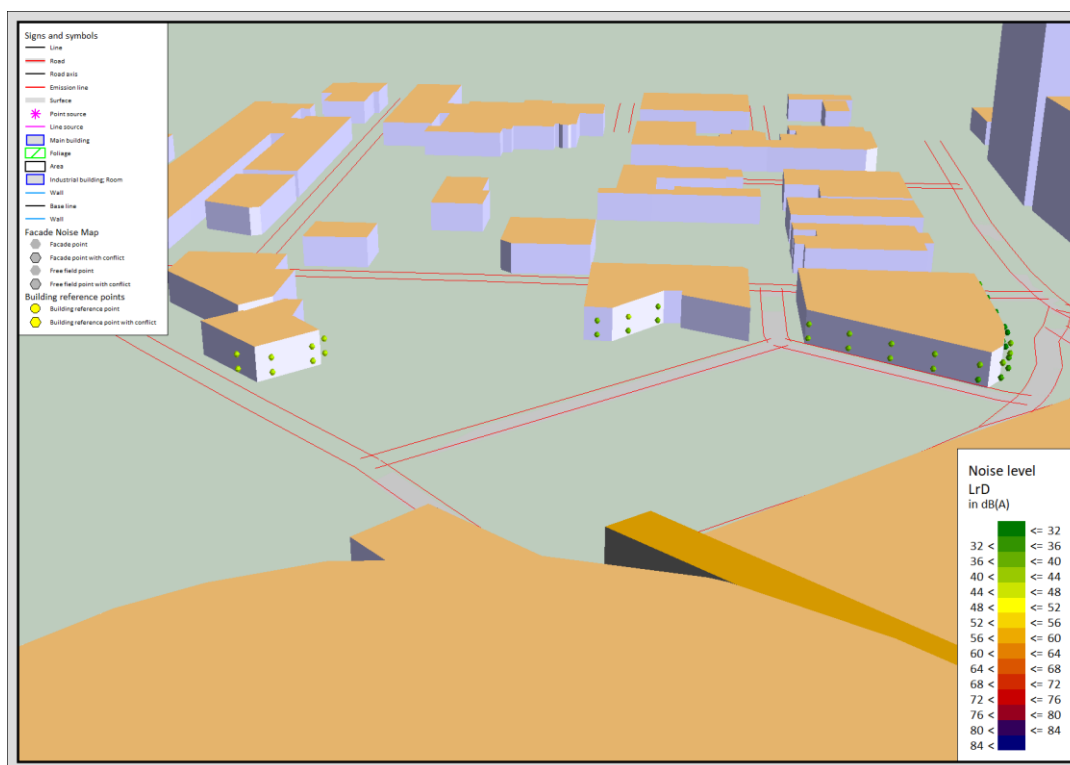


Figure 12 – FNM of the effect of noise on adjacent buildings

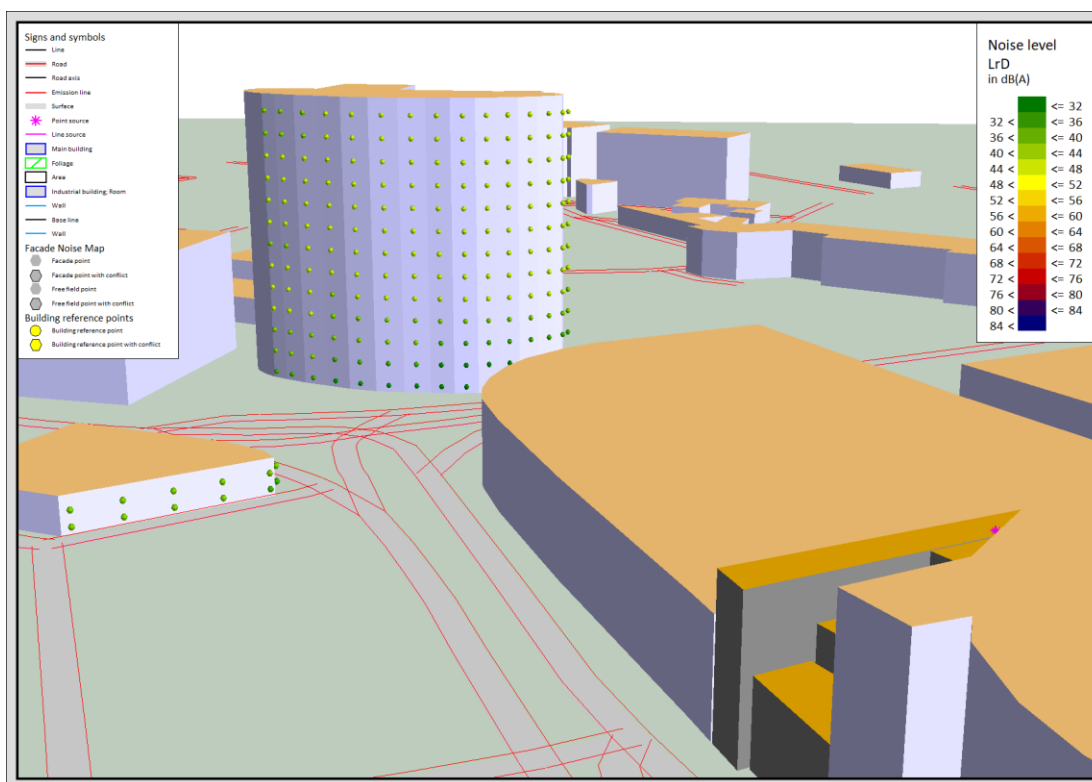


Figure 13 – FNM of the effect of noise on Peninsula office block

3.4.3 Cross Section Map (CSM)

Azymuth have produced the following Cross Section Maps to show how the potential worst case noise from the roof plant shall affect the committed development on Dutton Street.

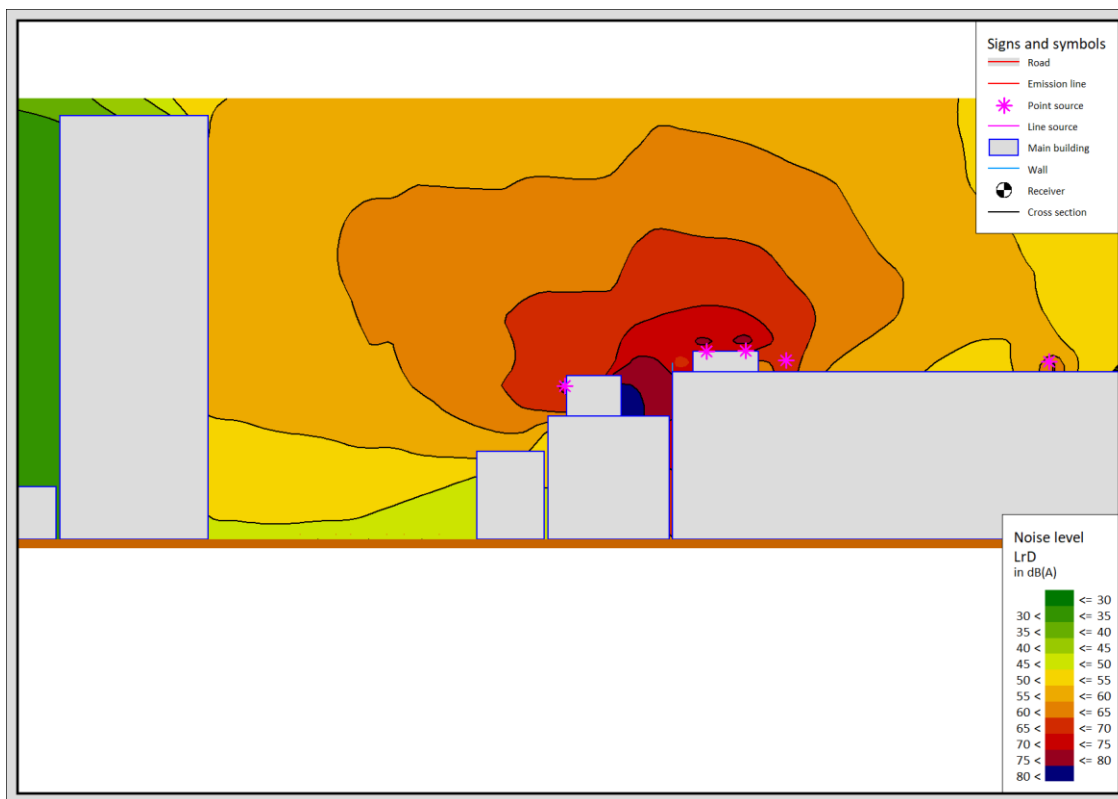


Figure 14 – CSM of effect of noise on committed development Dutton Street during the daytime

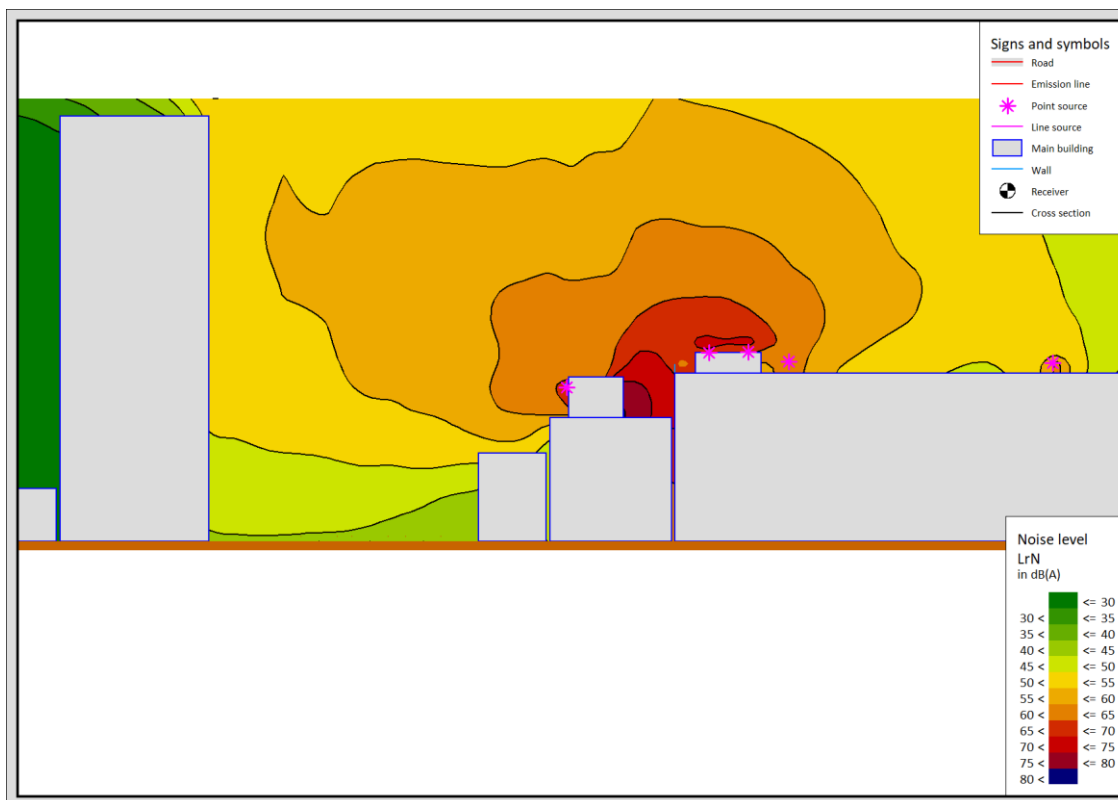


Figure 15 – CSM of effect of noise on committed development Dutton Street during the night-time



3.4.4 Noise Predictions

The below table provides the worst-case predicted noise levels at the nearest façade of each of the nearby receptors and how these levels relate to the lowest typical background sound level (night-time) at these receptors. The background sound levels used for assessment purposes are the levels measured by Azymuth in 2023 and OR Consulting in 2022.

Receptor Location	Distance from Source to Receiver (~m)	Time	Predicted Noise Level at Receptor (dBA)	Background Sound Level (dBA)	Penalty for Tonality, Impulsivity and/or Intermittency (dB)	Noise Rating Level (dBA)	Rating Level re. Background Sound Level
Residential Receptors							
Committed Development Dutton Street	30	Day	57.0	62.5	0 - 3*	57.0 - 60.0	-5.5 to -2.5
		Night	52.7	53.3		52.7 - 55.7	-0.6 to +2.4
Beaumont Building	180	Day	34.0	47.2	0 - 3*	34.0 - 37.0	-13.2 to -10.2
		Night	30.1	47.6		30.1 - 33.1	-17.5 to 14.5
Committed Development Mirabel Street / Great Ducie Street	180	Day	25.6	47.2	0 - 3*	25.6 - 28.6	-21.6 to -18.6
		Night	21.5	47.6		21.5 - 24.5	-26.1 to -23.1
Commercial Receptors (Daytime)							
8-10 Dutton Street	110	Day	40.7	53	0 - 3*	40.7 - 43.7	-12.3 to 9.3
Manchester College Building (60 Great Ducie Street)	72	Day	45	62.5	0 - 3*	45 - 48	-17.5 to -14.5
Peninsula Office (Victoria Place)	150	Day	36.3	62.5	0 - 3*	36.3 - 39.3	-26.2 to -23.2
*A penalty range of 0-3dB has been applied, this is due to the potential intermittency of plant changing ON/OFF state. It is unclear if this change in state shall be distinctive when compared to the residual acoustic environment. Azymuth have analysed their near-field measurements undertaken on the plant roof and do not deem any of the plant to have distinctive tonal qualities based on the data.							

Table 4 – BS 4142 noise assessment

Azymuth have calculated the cumulative noise level on the proposed lower plant roof to be ~70dBA at 5m from the AHU.

Due to the already relatively high ambient noise levels and the model based on a worst-case scenario where plant may run as late as 02:00hrs, Azymuth doesn't anticipate that the plant noise will have a significant impact on the nearby (proposed) residential receptors.

It is also currently unclear the extent in which the penalties in the BS 4142 assessment can or should be applied. From measurements taken of the existing plant, no obvious tonality was identified. The penalty for intermittency is what produces the exceedance at night, it is not currently known if any intermittent noise shall be audible against the residual acoustic environment during the night. It is quite likely that rather than being intermittent the combination of multiple items of plant operating at different cycles/duties will translate as

small fluctuations in noise level during operating hours with a gradual turn down in noise as the venue closes (ie the noise levels are likely to be relatively continuous and unobtrusive).

4.0 Noise Verification Criteria

In order to verify that the noise levels produced by externally roof mounted plant do not exceed the background sound levels at the nearest residential receptors, the accumulative noise level should not exceed $68\text{dB } L_{Aeq,5\text{min}}$ at $\sim 1\text{m}$ from the lower roof parapet shown in Figure 16 below.

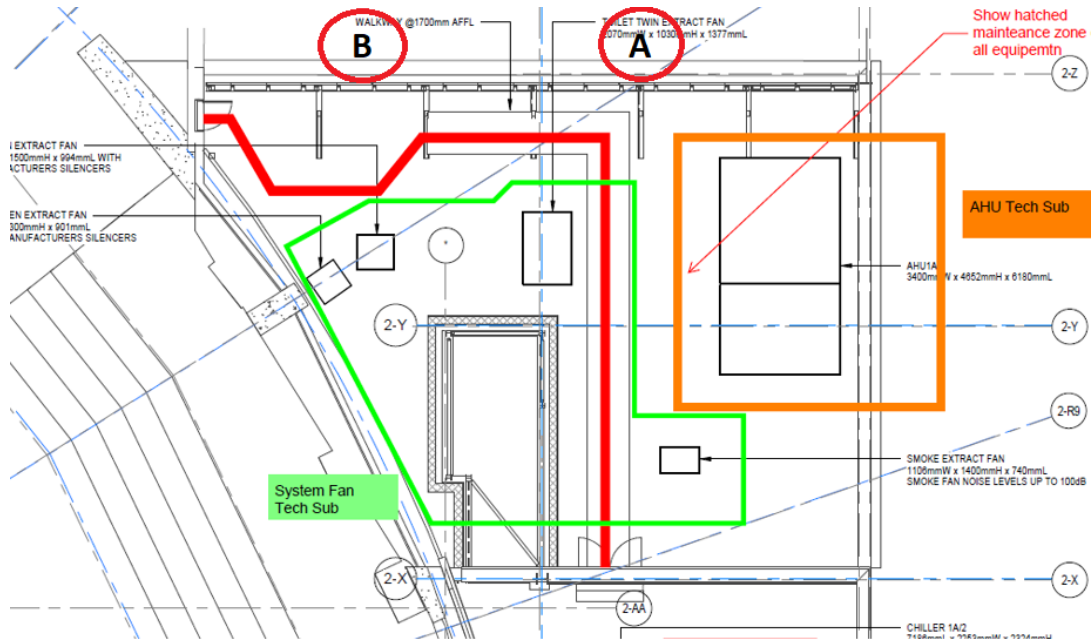


Figure 16 – Noise verification measurement positions

5.0 Summary

Azymuth has undertaken an acoustic design review in relation to predicted noise break out from the proposed external plant (revised) serving the new extension to the AO Arena. The extension involves the installation of a new Mezzanine Bar and VIP Lounge.

Azymuth has undertaken a baseline noise survey on the roof where the new external plant associated with the bar/lounge shall be located.

A noise model has been created in SoundPLAN 8.2 to predict the impact of noise associated with the proposed plant on the surrounding environment.

The predicted worst-case daytime noise level at the nearest residential receptor (Dutton Street committed development) is ~57dBA, this level is below the background sound level during the day. The predicted worst-case night-time noise level is ~53dBA, this level is below the background sound level if no penalties for intermittency or impulsivity are included. If there is a penalty to be included, then the noise level at this receptor may exceed the background sound level at night by up to 2.4dB.

It should be made clear that the model produced by Azymuth is based on a worst-case scenario in which the plant operates at full capacity starting during the earliest mode of operation (0800hrs) and ending at the latest mode of operation (0200hrs). Azymuth believes that after 2300hrs the plant shall operate in a reduced capacity, and it is therefore likely that the impact of noise on the nearest residential receptors shall be less than predicted. It would also be noted that the adjacent Manchester College Building and the Peninsula Building also have roof mounted plant that is likely to contribute as much or more to the local noise climate than the proposed new plant at the AO Arena.

It should also be noted that the nearest residential receptor (committed development Dutton Street) is not actually in existence / constructed at the present time and it is also very likely that the receptor in question will have significant noise mitigation of its own in the form of acoustic glazing and acoustically rated ventilation.

Azymuth have provided a verification criterion to identify whether the plant noise shall exceed the background sound level at the nearest receptor, the accumulative noise level at the positions marked in Figure 16 should not exceed 68dB $L_{Aeq,5min}$ at ~1m from the lower roof parapet. Compliance with this verification noise level would be deemed to satisfy the receptor noise limits.

In overall terms it is deemed that the impact of the plant will be minimal during operating hours and compliant with the planning guidance.

Appendix A – Glossary of Acoustic Terms

Decibel (dB)

This is the unit used to measure sound. The human ear has an approximately logarithmic response to acoustic pressure over a very large dynamic range (typically 20 micro Pascal to 100 Pascal).

dB (A)

This is a measure of the overall noise level of sound across the audible spectrum with a frequency weighting (i.e. A-weighting) to compensate for the sensitivity of the human ear to sound of different frequencies. The A-weighting curve is implemented in sound level meters using an electronic filter that approximately corresponds to the frequency response of the ear.

Octave Band Noise Level

The human ear is sensitive to sound over a range of frequencies between approximately 20Hz to 20kHz. The ear is also generally more sensitive to medium and high frequencies than to low frequencies. In order to define the frequency content of a noise, the spectrum can be divided into frequency bands. The most commonly used frequency bands are octave bands, in which the mid-frequency of each band is twice that of the band below it.

L_{Aeq}

This is the equivalent steady sound level in dB (A) containing the same acoustic energy as the actual fluctuating sound level over a given time period.

Reverberation Time (RT or sometimes T_{30} or T_{60})

This is the time taken for the reverberant sound energy in an enclosure to decay one millionth of its equilibrium value, i.e. by 60dB, after the source has been switched off, is known as the reverberation time. The reverberation time is frequency dependent and it is customary to measure its value in octave or one-third octave bands. Reverberation occurs when sound waves are repeatedly reflected from each surface of the room.

Sound Reduction Index (SRI)

Difference measured between the amount of energy flowing towards the wall in the source room and the total amount of energy entering the receiving room (usual range 100 - 3150 Hz for one third octave band values). The SRI varies with frequency and is measured in a laboratory in either octave or one-third octave bands.

$SRI = L_1 - L_2 + 10 \log (S/A)$, where:

L_1 = Noise level in the source room

L_2 = Noise levels in the receiving room

S = Surface area of test specimen

A = Equivalent acoustic absorption area in the receiving room

Weighted Sound Reduction Index (R_w)

This is a weighted single figure descriptor of the sound insulation performance of a partition measured under laboratory conditions. The procedure used to quantify the R_w is to compare the sound reduction index (SRI) in each of the one-third octave bands from 100Hz to 3150Hz against a set of standard reference curves.



Appendix B – Noise Measurement Data

Start	Position	Time	L _{Amax}	L _{Aeq}	L _{A10}	L _{A50}	L _{A90}
Thursday 9 th December 2022							
09:55:00	1	00:05:00	67.4	62.7	63.7	62.6	61.7
10:00:00	1	00:05:00	65.7	62.9	63.8	62.7	62
10:05:00	1	00:05:00	65.5	62.9	63.8	62.7	61.8
11:04:00	3	00:00:30	65.7	64.8	65.6	64.7	64.1
11:04:30	3	00:00:30	65.4	64.5	64.9	64.4	64
11:05:00	3	00:00:30	65.5	64.6	65.4	64.5	64
11:07:00	2	00:01:00	63.1	55	56.2	54.6	53.6
11:08:00	2	00:01:00	68.5	56.3	57	56.1	54.2
11:09:00	2	00:01:00	59.5	55.6	56.7	55.3	54.2
11:10:00	2	00:01:00	60.1	57.3	58.7	57.2	55
11:11:00	2	00:01:00	58.4	55.9	56.9	55.8	55
11:12:00	2	00:01:00	57.9	55.4	56.4	55.3	54.2
11:13:00	2	00:01:00	57.5	55.7	56.7	55.6	54.6
11:14:00	2	00:01:00	62.9	55.2	55.9	55	53.9
11:15:00	2	00:01:00	59.7	54.9	55.8	54.7	54
11:16:00	2	00:01:00	57.4	55.7	56.6	55.6	54.7
11:31:32	4	00:00:30	90.5	67.9	61.9	61.2	60.2
11:32:02	4	00:00:30	99.7	76.4	61.9	61.3	60.3
11:32:32	4	00:00:30	62.9	61.5	62.1	61.4	60.7
11:33:40	5	00:00:30	68.5	67.6	68.4	67.5	67
11:34:10	5	00:00:30	68.8	67.6	68.4	67.5	67
11:34:40	5	00:00:30	69.8	67.6	68.5	67.5	66.9

Table B1 – AO Arena plant noise measurement data

Start	Position	Time	L _{Amax}	L _{Aeq}	L _{A10}	L _{A50}	L _{A90}
Thursday 13 th July 2023							
12:00:00	1	00:05:00	74.3	56.5	60	54.1	46.5
12:05:00	1	00:05:00	81.4	57.3	59.9	55.2	49
12:10:00	1	00:05:00	69.2	57.6	60.2	56.3	50.2
12:15:00	1	00:05:00	92.9	61.6	60.5	55.7	49.1
12:21:00	1	00:05:00	60.3	53.4	56.8	52.2	45.8
12:26:00	1	00:05:00	61.8	53.8	57.1	52.7	45.2
12:31:00	1	00:05:00	64.1	53.5	56.9	51.7	44.7
Monday 24 th July 2023							
12:10:00	2	00:05:00	83.3	68.1	71.4	66.1	62.3
12:15:00	2	00:05:00	77.0	68.3	71.3	67.1	62.5
12:20:00	2	00:05:00	84.9	69	71.9	66.8	62.5
12:25:00	2	00:05:00	84.0	71.1	74.9	67.8	62.7
12:30:00	2	00:05:00	84.9	71.6	75	67.7	63.9
12:35:00	2	00:05:00	84.9	70.5	73.9	66.8	62.6
12:40:00	2	00:05:00	84.3	70.7	73.9	65.8	61.8
12:45:00	2	00:05:00	86.3	71.7	75	68.1	62.2
12:50:00	2	00:05:00	84.6	70.9	73.7	67.2	62.8
12:55:00	2	00:05:00	79.1	68.2	71.2	66.2	62.6
13:00:00	2	00:05:00	87.5	70.8	73	68.1	61.8



Start	Position	Time	L _{Amax}	L _{Aeq}	L _{A10}	L _{A50}	L _{A90}
Tuesday 1 st August 2023							
23:05:00	1	00:05:00	73.3	65.8	69.4	64.3	56.6
23:10:00	1	00:05:00	76.7	64	67.9	60.9	53.1
23:15:00	1	00:05:00	73.1	64.6	69	61.9	51.8
23:20:00	1	00:05:00	73.6	64.5	68.6	61.4	54.1
23:25:00	1	00:05:00	75	64.5	68.7	59.2	51.8
23:30:00	1	00:05:00	73.5	62.4	66.7	58.2	52.1
23:44:00	2	00:05:00	64.9	56.5	59.7	55.1	49.3
23:49:00	2	00:05:00	63.2	55.1	59.1	52.3	47
23:54:00	2	00:05:00	67.8	55.9	59.3	54.3	48.6
23:59:00	2	00:05:00	70.7	57.2	60.7	54.8	47.9
Wednesday 2 nd August 2023							
00:04:00	2	00:05:00	63.5	53.3	57.4	50.2	45.5
00:09:00	2	00:05:00	67.3	55.6	58.5	52.7	47.5

Table B2 – AO Arena residential noise measurement data