MAX FORDHAM

Scottish Opera New Rotterdam Wharf

Noise Impact Assessment

19th February 2024

Rev P03

J7374-MXF-XX-XX-RP-Y-10000

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ISSUE HISTORY

Issue	Date	Description
P01	09/02/2024	For comment
P02	16/02/2024	For comment
P03	19/02/2024	For Planning

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1.0 EXECUTIVE SUMMARY

Max Fordham LLP has been appointed to carry out a noise impact assessment in relation to the proposed mixed-use development at Scottish Opera Production Studios, Glasgow. The development is to incorporate two blocks of purpose-built student accommodation as well as a rehearsal space, studio and café.

As part of the noise impact assessment, an environmental noise survey was required to establish the existing ambient noise levels in the vicinity of the nearby noise sensitive receptor.

To establish baseline noise conditions, a set of short-term spot measurements and a long-term noise survey were carried out on-site. Results of the representative existing ambient noise levels and background noise levels are used to set out targets in compliance with relevant planning conditions and guidance.

The representative existing ambient noise levels on-site were found to be:

- 52 dBA – Daytime (07:00 to 23:00)
- 46 dBA – Night-time (23:00 to 07:00)

The representative existing background noise levels on-site were found to be:

- 44 dBA – Daytime (07:00 to 23:00)
- 38 dBA – Night-time (23:00 to 07:00)

Façade elements (windows and external walls) need to provide appropriate noise reduction to meet the BS 8233:2014 indoor ambient noise level limits.

Façade noise levels have been predicted by using 3D acoustic modelling software. The outcomes have been used to assess required acoustic specification of the façade elements.

Good practice is to design noise emissions such that the combined noise from all new primary items of plant equipment result in a “low impact” at the nearby noise sensitive receptor when assessed in accordance with BS 4142:2014+A1:2019.

As such, if the combined plant noise rating was below the representative background noise level, then a low impact is likely.

Similarly, for the combined noise emissions from emergency plant equipment, the noise rating level limit should be no greater than 10 dB above the representative background noise level at the nearest noise sensitive receptor.

It was found that daytime plant noise emissions are expected to comply with the proposed noise rating level limit and therefore represent a low impact at the nearest noise sensitive receptor.

Night-time plant noise emissions and daytime emergency plant noise emissions will be kept within the proposed noise rating level limit by being provided with a degree of acoustic intervention. This will include high performance acoustic enclosures for emergency generators and pump sets and either attenuating screens or acoustic louvred enclosures for heat pumps.

2.0 INTRODUCTION

This noise impact assessment is to form part of the planning application documents and presents the method and results of the noise survey as well the anticipated noise levels affecting the proposed development and from the development itself once in operation.

The report addresses the following aspects:

- Reviewing relevant policies and standards
- Undertaking an on-site noise survey
- Creating a 3D noise model to predict external noise levels affecting the proposed development
- Establishing internal noise level limits and providing façade sound insulation requirements
- Assessing plant noise emissions with initial advice regarding mitigation measures for plant noise
- Assessing activity noise from external events with advice regarding proposed limitations of events

A glossary of the acoustic terminology used in this report is included in the Appendix.

This report does not assess the following:

- Traffic noise: there is not expected to be a significant change in traffic as a result of the development
- Vibration: there are no significant existing sources of vibration affecting the development and the plant equipment associated with the development will be mounted on appropriate vibration mounts where required

3.0 RELEVANT POLICIES AND STANDARDS

3.1 National Planning Policy

Scottish Planning Policy
The purpose of the Scottish Planning Policy (SPP) is to set out national policies which reflect Scottish Ministers' priorities for operation of the planning system and for the development and use of land.

Planning should take a positive approach to enabling high-quality development and making efficient use of land to deliver long-term benefits for the public while protecting and enhancing natural and cultural resources.

The SPP promotes consistency in the application of policy across Scotland whilst allowing sufficient flexibility to reflect local circumstances.

The SPP sits alongside the following Scottish Government planning policy documents:

- National Planning Framework (NPF), which provides a statutory framework for Scotland's long-term spatial development. The NPF sets out the Scottish Government's spatial development priorities for the next 20 to 30 years. The SPP sets out policy that will help to deliver the objectives of the NPF
- Creating Places, the policy statement on architecture and place, which contains policies and guidance on the importance of architecture and design
- Designing Streets, which is a policy statement putting street design at the centre of placemaking. It contains policies and guidance on the design of new or existing streets and their construction, adoption and maintenance
- Circulars, which contain policy on the implementation of legislation or procedures

Where development plans and proposals accord with the SPP, their progress through the planning system should be smoother.

National Planning Framework
Scotland's fourth National Planning Framework (NPF4) was adopted by the Scottish Ministers on 13 February 2023, following approval by the Scottish Parliament in January.

NPF4 is a long-term plan looking to 2045 that guides spatial development, sets out national planning policies, designates national developments and highlights regional spatial priorities; as part of the development plan, it also influences planning decisions across Scotland.

NPF4 replaces National Planning Framework 3 and incorporates updated Scottish Planning Policy, with specific policy on a number of planning topics.

Policy 23, under the Health and Safety requirement, intends to protect people and places from environmental harm, mitigate risks arising from safety hazards and encourage, promote and facilitate development that improves health and wellbeing (see Figure 1).

Figure 1: Policy principles of policy 23

Part e) of the policy states that "development proposals that are likely to raise unacceptable noise issues will not be supported. The agent of change principle applies to noise sensitive development. A Noise Impact Assessment may be required where the nature of the proposal or its location suggests that significant effects are likely".

3.2 Local Planning Policy

Planning Advice Note
The Scottish Government issued Planning Advice Note (PAN) 1/2011: planning and noise in March 2011. The aim of the of the PAN is to provide advice on the role of the planning system in helping to prevent and limit the adverse effects of noise. It supersedes Circular 10/1999 Planning and Noise and PAN 56 Planning and Noise. Information and advice on noise impact assessment (NIA) methods is provided in the associated Technical Advice Note. It includes details of the legislation, technical standards and codes of practice for specific noise issues.

The PAN promotes the principles of good acoustic design and a sensitive approach to the location of new development. It promotes the appropriate location of new potentially noisy development and a pragmatic approach to the location of new development within the vicinity of existing noise generating uses, to ensure that quality of life is not unreasonably affected and that new development continues to support sustainable economic growth.

Technical Advice Note
The Technical Advice Note (TAN) that accompanies PAN 1/2011 states in paragraph 1.2 that "good acoustic design and a sensitive and pragmatic approach to the location of new development needs to be actively promoted to ensure that quality of life is not unreasonably affected and that new development continues to support sustainable economic growth in Scotland".

Paragraph 3.5 of the TAN discusses appropriate design criteria for noise levels in relation to NSDs and advises that consideration should be given to the avoidance of the adverse effects of noise including non-auditory effects such as annoyance, sleep disturbance and possibly health effects such as cardio-vascular disease. Guidance noise levels issued by authoritative organisations such as WHO and relevant planning and health guidance issued by Government should be sought in applying appropriate criteria levels, although context is important.

Paragraph 3.8 of the TAN states that "the choice of appropriate criteria noise levels and relevant time periods are the responsibility of the local authority. Although this may lead to inconstancies between different Local Authorities and, indeed, across areas within a given Local Authority, it does provide flexibility, allowing particular circumstances to be taken into account and the use of the latest guideline values to be included where appropriate".

Glasgow City Development Plan
Glasgow's City Development Plan (The Plan) was adopted in March 2017, replacing City Plan 2 (2009). The Plan sets out the Council's vision and strategy for land use whilst also providing the basis for assessing planning applications along with its associated Supplementary Guidance.

The Plan was prepared during a period when both NPF 2 and SPP 2010 were under review. The new City Development Plan 4 SPP (2014) and NPF3 were finalised in mid2014, post-production of the Proposed Plan. The Plan has attempted, where possible, to reflect the overall direction of policy and spatial priorities of the Scottish Government. It has also taken cognisance of other relevant planning, environmental and legislative requirements.

Policy CDP 1: The Placemaking Principle aims to ensure that new activity does not introduce unacceptable additional noise particularly in, or adjacent to, Noise Management Areas nor have an adverse effect on Quiet Areas.

3.3 British Standards

BS 8233:2014
BS 8233:2014 Guidance on sound insulation and noise reduction for buildings provides guidance on internal ambient noise levels, resulting from break-in of external environmental noise that should not be exceeded in various locations within dwellings.

Guidelines for internal noise levels are reported in Table 1.

Table 1: Indoor ambient noise levels for dwellings from BS 8233:2014

Activity	Location	Daytime (07:00 to 23:00)	Night-time (23:00 to 07:00)
Resting	Living room	35 dB $L_{Aeq,16hour}$	N/A
Dining	Dining room	40 dB $L_{Aeq,16hour}$	N/A
Sleeping (daytime, resting)	Bedroom	35 dB $L_{Aeq,16hour}$	30 dB $L_{Aeq,8hour}$

The standard clarifies that these values are based on the existing guidelines issued by the World Health Organisation (WHO). In addition, it states that the internal noise levels may be relaxed by up to 5 dB whilst maintaining a reasonable living condition. In relation to the WHO Guideline for Community Noise (2000), individual noise events should not normally exceed 45 dB L_{AFmax} more than 10 times a night in bedroom to avoid sleeping disturbance.

Furthermore, BS 8233:2014 provides guidance on desirable noise levels in areas that are intended to be used for external amenity space, such as gardens, balconies and roof gardens which are intended to be used for relaxation. For these spaces it is desirable that the external noise level does not exceed 50 dB $L_{Aeq,T}$ up to a level of 55 dB $L_{Aeq,T}$ for noisier environments.

BS 4142:2014+A1:2019
BS 4142:2014+A1:2019 Methods for rating and assessing industrial and commercial sound provides a method of assessing the impact of a source of industrial or commercial sound including sound from fixed installations, such as electrical and mechanical plant equipment.

In BS 4142:2014+A1:2019, a noise rating is determined and compared with the existing local background sound level based on several more cumulative acoustic feature corrections to apply where appropriate. For example, if the noise includes a distinguishable tone, impulse, intermittency or other readily distinguishable sound characteristic, then additional cumulative penalties individually ranging from 0 to 9 dB may be applied depending on the type of noise.

BS 4142:2014+A1:2019 seeks to determine a "representative" background sound level, stating that "…the objective is not simply to ascertain a lowest measured background sound level, but rather to quantify what is typical during particular time periods".

The assessment of the impact depends upon the margin by which the rating level of the specific sound source exceeds the background sound level (i.e. as before) but also promotes a consideration of the context in which the sound occurs when making an assessment. BS 4142:2014 states that an initial estimate of the impact of the specific sound is made by subtracting the measured background sound level from the rating level, while considering the following points:

a) Typically, the greater this difference, the greater the magnitude of the impact
b) A difference of around +10 dB or more is likely to be an indication of a significant adverse impact, depending on the context
c) A difference of around +5 dB is likely to be an indication of an adverse impact, depending on the context
d) 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

Note then, a BS 4142:2014+A1:2019 assessment may deduce a low impact where the rating level is below the background sound level.

3.4 The Code of Practice on Environmental Noise Control at Concerts

The Code of Practice on Environmental Noise Control at Concerts ("CoP"), produced by the Noise Council in 1990, is a design and management guide intended to minimise the impact of music noise from music venues. Within the introduction, its purpose is described thus:

Various guidelines and criteria are described in this document covering a range of events from the single occasional concert to a full season. It is believed that compliance with the guidelines and the other advice given here will enable successful concerts to be held whilst keeping to a minimum the disturbance caused by noise.

[…]

This Code is designed to assist those planning a music event, those responsible for licensing such events and those responsible for enforcing the nuisance provisions of the Environmental Protection Act 1990.

A-Weighted Noise Levels
Table 1 within the document (reproduced below in Figure 2) provides guideline noise levels for different venues for events before 2300 hours, based on the predicted number of concert days per calendar year. The maximum number of concert days listed in Figure 2 is 12.

Concert days per calendar year, per venue	Venue Category	Guideline
1 to 3	Urban Stadia or Arenas	The MNL should not exceed 75 dB(A) over a 15 minute period
1 to 3	Other Urban and Rural Venues	The MNL should not exceed 65 dB(A) over a 15 minute period
4 to 12	All Venues	The MNL should not exceed the background noise level by more than 15 dB(A) over a 15 minute period

Figure 2: Table 1 of the Code of Practice on Environmental Noise Control at Concerts

In the notes attached to Figure 2, however, the following clause is included.

For indoor venues used for up to about 30 events per calendar year an MNL not exceeding the background noise by more than 5 dBA over a fifteen-minute period is recommended for events finishing no later than 2300 hours.

Low Frequency Noise Levels
The document also contains this commentary on low frequency noise:

Assessment of noise in terms of dB(A) is very convenient but it can underestimate the intrusiveness of low frequency noise. Furthermore, low frequency noise can be very noticeable indoors. Thus, even if the dB(A) guideline is being met, unreasonable disturbance may be occurring because of the low frequency noise. With certain types of events, therefore, it may be necessary to set an additional criterion in terms of low frequency noise or apply additional control measures.

[…]

A level of up to 70dB in either of the 63Hz or 125Hz octave frequency band is satisfactory; a level of 80dB or more in either of those octave frequency bands causes significant disturbance.

4.0 NOISE SURVEY

4.1 Site Context

The site is located within the Garscube industrial estate (G4 9RD) immediately to the north of Glasgow city centre. The site comprises of the existing production studios belonging to the Royal Conservatoire of Scotland, service yards to either end of this building and a vacant site that lies to the east of the existing building that is within Scottish Opera's ownership.

The 'platform' site is approx. 3 m above the level of the production studios. The majority of the adjacent site is of concrete slab construction with a level change of approx. 8 m from the platform site to the Forth and Clyde canal above. The canal is a Scheduled Monument and is within the ownership of Scottish Canals. To the east of the canal basin lies listed buildings, Speirs Wharf, the Wheatsheaf building and the Canal House.

Access to the site is possible via Sawmillfield Street with evidence of a historic access point from Corn Street which has been bricked up and is proposed to reopen to gain access to a new south yard area.

Figure 3 shows an arial view of the existing site showing the location of the spot measurements and long-term noise survey.

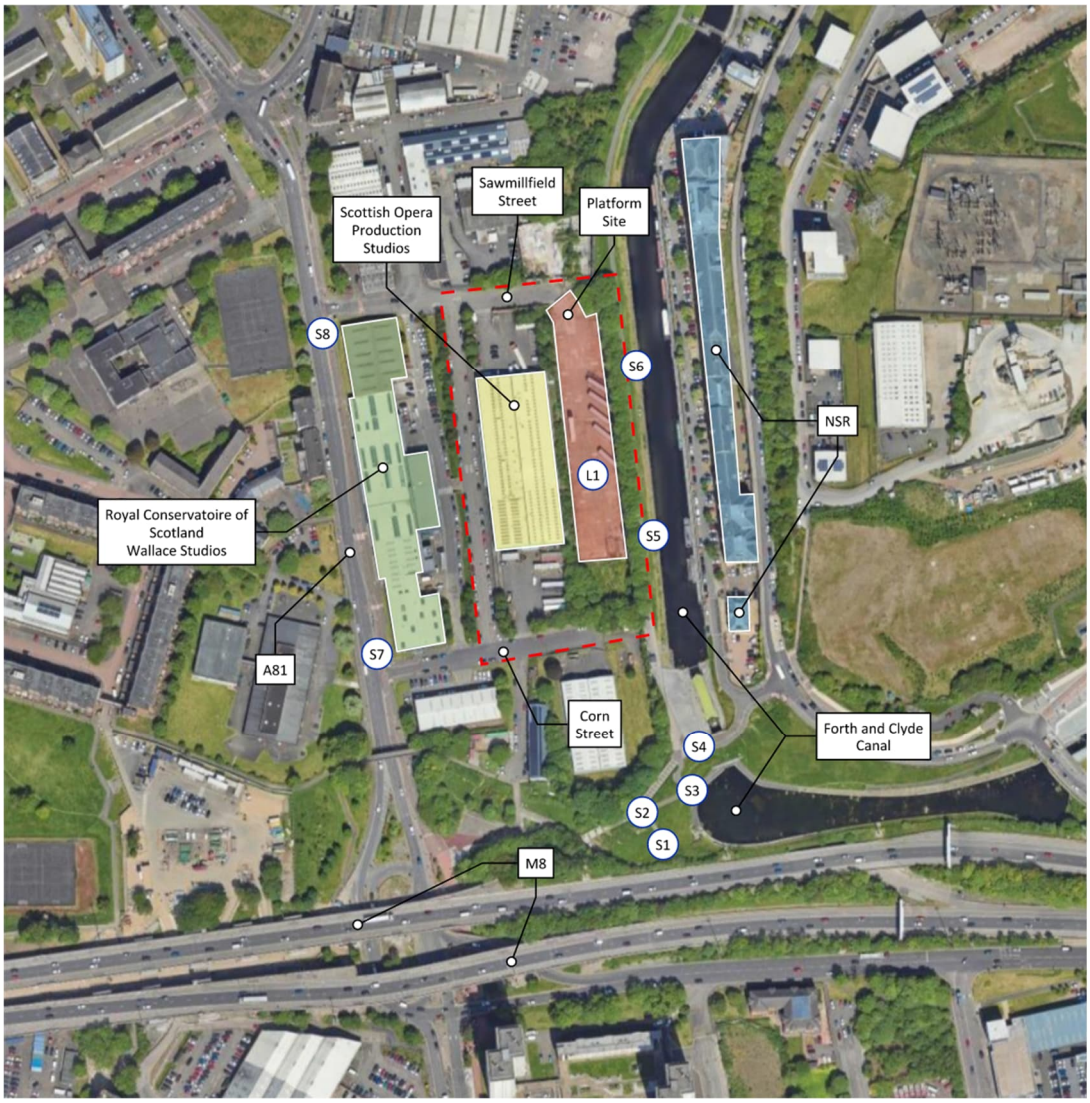

Figure 3: Aerial view of the existing site showing the location of spot measurements and long-term noise survey

4.2 Environmental Noise Survey

To establish baseline noise conditions on-site, a set of short-term (attended) 'spot' measurements were carried out on 25th October 2023. A long-term (unattended) noise survey was also carried out from 25th to 31st October 2023 on-site to establish representative existing noise levels.

The results of the survey were used to assess the ambient and background noise levels on-site.

Methodology

Both surveys were carried out in accordance with BS 7445-1 Description and measurement of environmental noise – Part 1: Guide to quantities and procedures.

The measurement equipment, a class 1 sound level meter, was field calibrated with a portable sound calibrator prior to and after the survey. No significant deviation from the calibrated level was observed.

Weather Conditions

The weather conditions during the survey were consistent. Weather data taken from Glasgow Airport (GLA) weather station reported an average wind speed of 11 mph (or 5 m/s) with occasional light rain over the 6-day time period (from 25 October 2023 to 31 October 2023). Therefore, on-site weather conditions had minimal effect on the overall results of the survey.

Noise Sources

Particular attention was paid to the nearby M8 which dominates the acoustic environment of the site. It was noted that traffic flow on the M8 was atypical due to a two-lane closure and reduced speed limit. Therefore, it is expected that daytime and night-time noise levels are 6 dB and 4 dB greater than measured during the noise survey, respectively. This was calculated following guidance in the Calculation of Road Traffic Noise (CRTN), published in 1988 by the Department for Transport.

Measurement Equipment

Noise measurements S1, S2, S6 and S8 (see Table 2) were taken using a hired Norsonic 140 sound level analyser (see Table 13). Similarly, noise measurements S3, S4, S5, S7 and L1 (see Table 3) were taken using a Norsonic 140 sound level analyser (see Table 14). The NOR 140 is a class 1 sound level meter as per the specification given in BS EN IEC 61672. The meter uses a Norsonic 1225 free field response microphone and a NOR 1209 microphone pre-amplifier. A Norsonic 1251 portable sound calibrator (complying with BS EN IEC 60942 class 1) was used to calibrate the instrument.

Measurement Locations

Spot measurements were taken at a total of eight locations around the site, including six measurements taken along the canal tow path and two measurements taken kerbside of the A81 (see Figure 3). The long-term noise survey was centrally located on the platform site.

4.3 Noise Survey Results

Spot Measurements
Table 2 shows the results (rounded to the nearest decibel) of the eight spot measurements taken around the site on 25th October 2023.

Table 2: Summary of data from spot measurements

Measurement position	Date/Time	Duration (minutes)	$L_{Aeq,T}$ (dBA)
S1	25/10/2023 @ 09:35	5	72
S2	25/10/2023 @ 09:41	5	70
S3	25/10/2023 @ 09:34	5	67
S4	25/10/2023 @ 09:41	5	66
S5	25/10/2023 @ 09:50	5	55
S6	25/10/2023 @ 09:52	5	51
S7	25/10/2023 @ 10:09	5	67
S8	25/10/2023 @ 10:11	5	71

Long-term Noise Survey
The long-term noise survey started on 25th October 2023 and was running until 31st October 2023 with consecutive 15-minute measurements being recorded for a total of 147 hours over the 6-day period.

For the purpose of this survey, daytime and night-time hours are considered to be as follows:

- Daytime: 07:00 to 23:00 hours
- Night-time: 23:00 to 07:00 hours

Table 3, with reference to Figure 4, shows the single figure results (rounded to the nearest decibel) of the following parameters:

- $L_{Aeq,T}$ is an indication of the ambient noise level over the stated period of time, T, obtained as a logarithmic average over the duration of the survey
- L_{A90} is an indication of the representative background noise level, obtained here by the 40th percentile of the $L_{A90,15min}$ data values gathered over the duration of the survey
- L_{AFmax} is an indication of the maximum noise level, obtained here by the 90th percentile of the $L_{AFmax,15min}$ data values gathered over the duration of the survey

Table 3: Summary of data from long-term noise survey

Measurement position	Time period	$L_{Aeq,T}$ (dBA)[1]	$L_{AF90,15min}$ (dBA)[2]	$L_{AFmax,15min}$ (dBA)[3]	$L_{AFmax,2min}$ (dBA)[4]
L1	Daytime (07:00 to 23:00)	52	44	69	N/A
	Night-time (23:00 to 07:00)	46	38	65	64

[1] logarithmic average of the noise levels during the entire duration of the survey
[2] the 40th percentile value of the $L_{AF90,15min}$ data values
[3] the 90th percentile value of the $L_{AFmax,15min}$ data values
[4] the highest value that is not exceeded more than 10 times per night

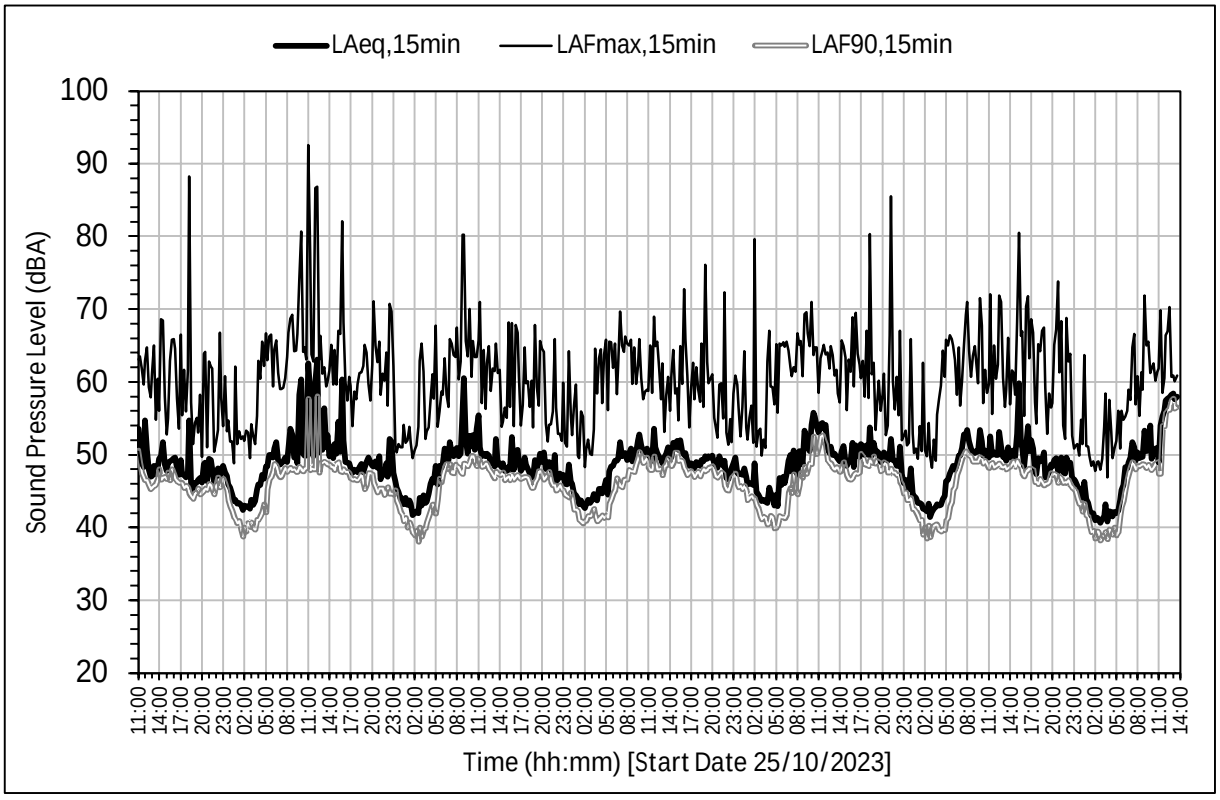

Figure 4: Long-term noise survey data

5.0 SITE SUITABILITY

In this section, the suitability of the site for the proposed development was considered in the context of the measured acoustic environment.

SoundPLAN (version 8.2), an industry standard noise modelling software package, was used to map noise propagation across the site with road traffic noise calibrated to the results of the noise survey.

Daytime and night-time plots of the noise contour levels across the site were used to inform the suitability of the proposed development.

5.1 Noise Map

A 3D noise model of the site was created using a satellite map from Google Maps and the surrounding area informed using Google Earth Pro. The proposed development was created with reference to the architect's latest drawings. The results of the noise surveys were used to calibrate the model by appropriately adjusting the noise sources (i.e. roads M8 and A81 modelled as line sources) so that they accurately represented the noise survey data. It should be noted that the noise map images do not include the CRTN corrections previously mentioned but do so within the results used for analysis.

The noise maps in Figure 5 and Figure 6 show the predicted daytime and night-time noise levels, respectively, across the site at 1.5 m above ground level.

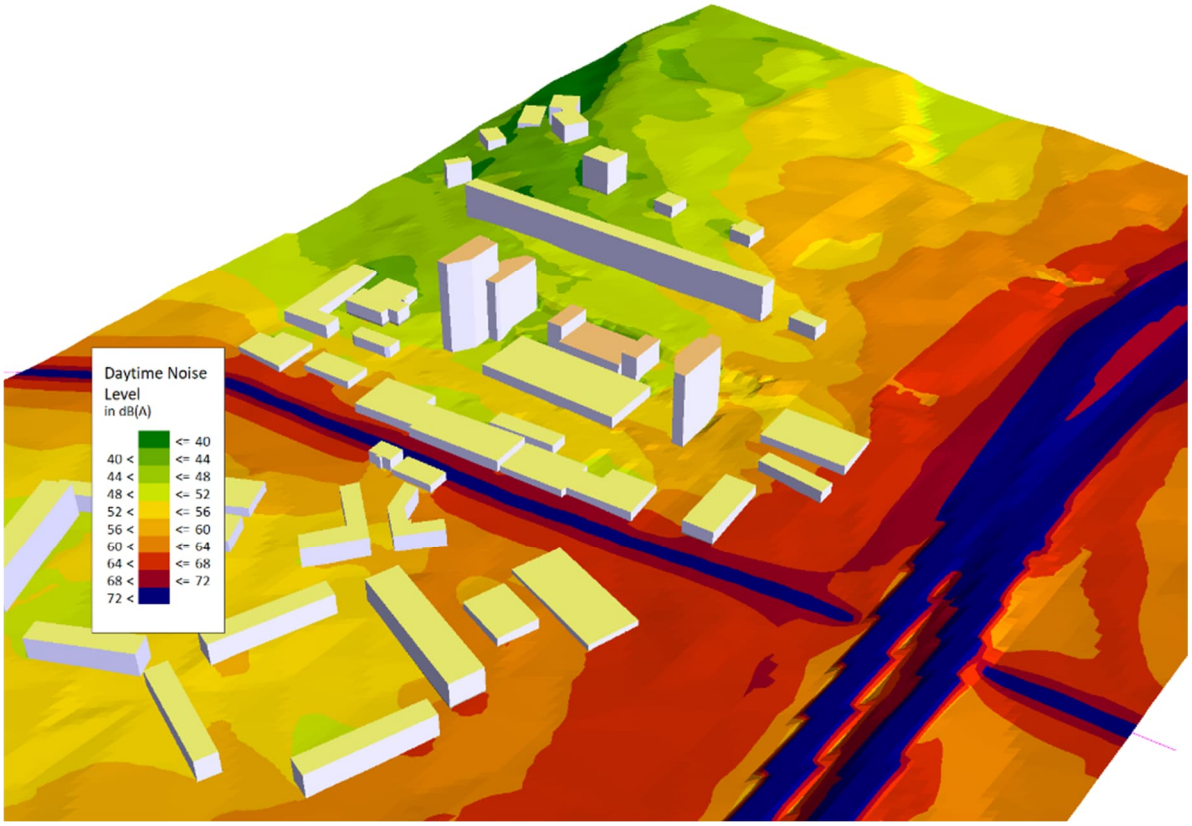

Figure 5: Daytime noise map of the proposed development at 1.5 m above ground level

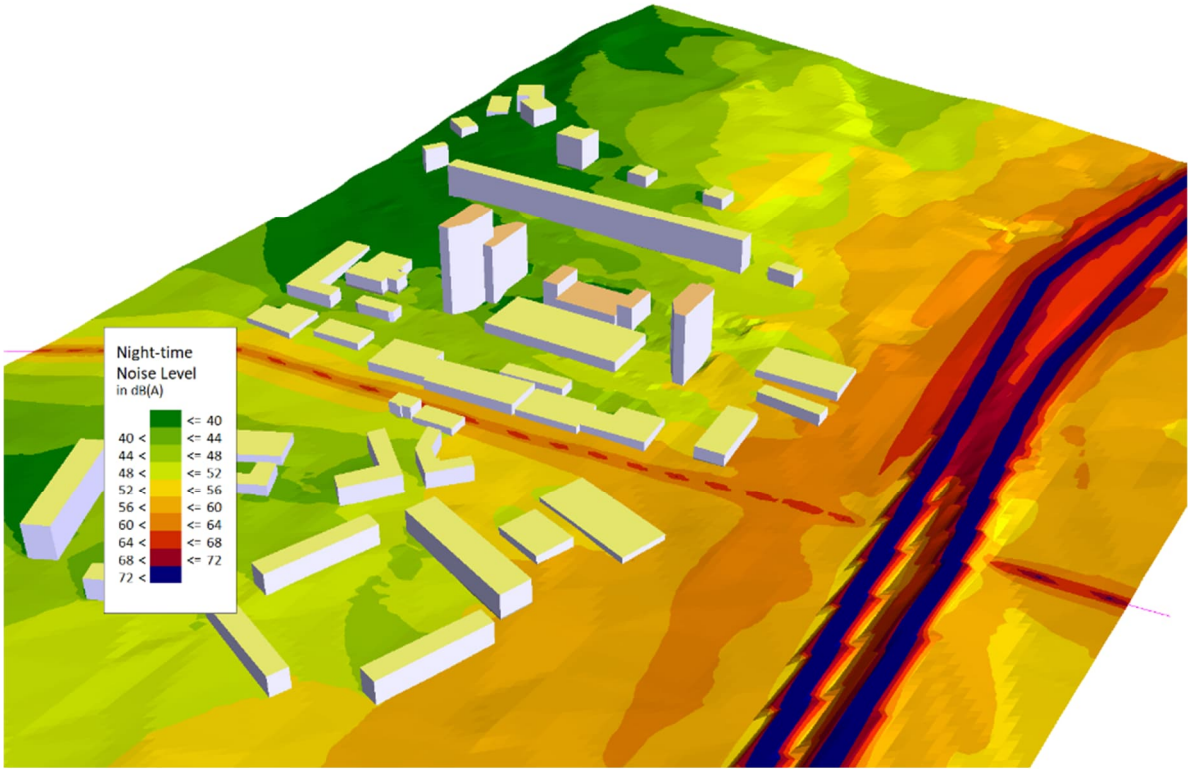

Figure 6: Night-time noise map of the proposed development at 1.5 m above ground level

As it can be seen, the acoustic environment of the site is dominated by the nearby M8 which lies perpendicular to the site and runs east to west. Running north to south, the A81 also contributes to the acoustic environment of the site and lies parallel to the west side of the proposed development.

5.2 Building Envelope Design

To control internal ambient noise from the external noise sources, façades must provide a minimum sound insulation under background ventilation conditions capable of meeting the internal ambient noise levels as given in the BS 8233:2014 standard (shown below).

- 35 dBA daytime (living room)
- 40 dBA daytime (dining room)
- 30 dBA night-time (bedroom)

As assumed in the standard, the L_{Aeq} levels are assessed under the condition of closed windows and with background ventilation provided by mechanical ventilation.

Façade Design Element Assessment
The sound insulation performance of the windows has been assessed based on the predicted façade noise level results from SoundPLAN (version 8.2) (see Figure 7-Figure 10).

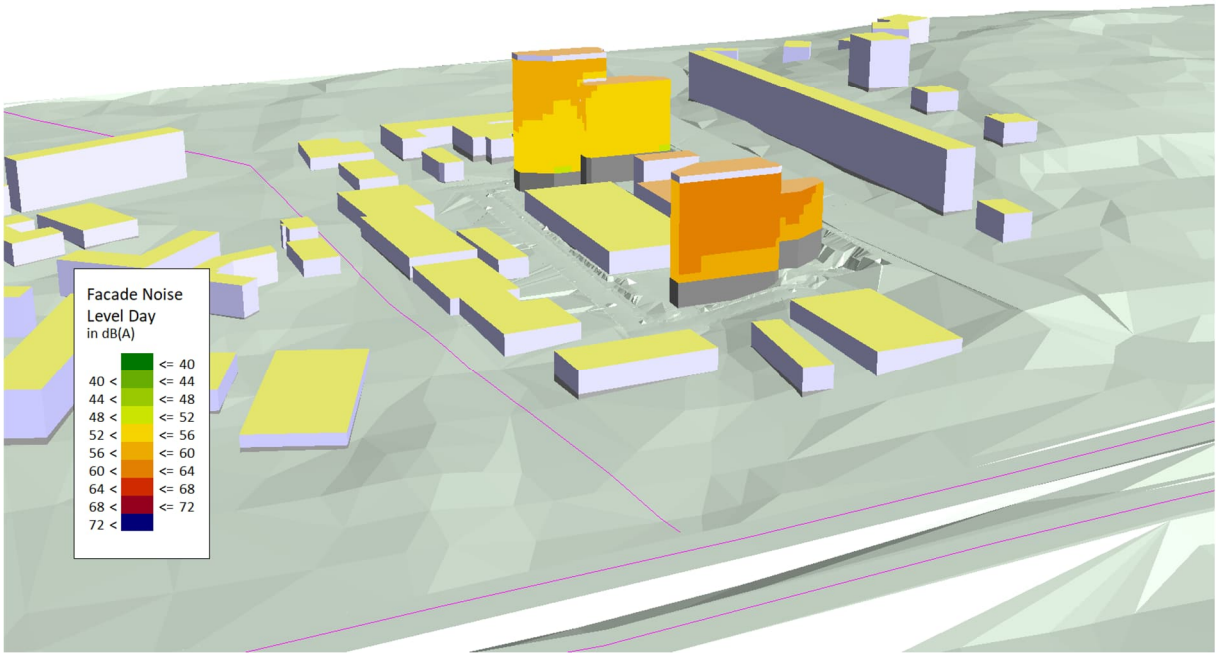

Figure 7: Daytime façade noise levels of the proposed development (south to north)

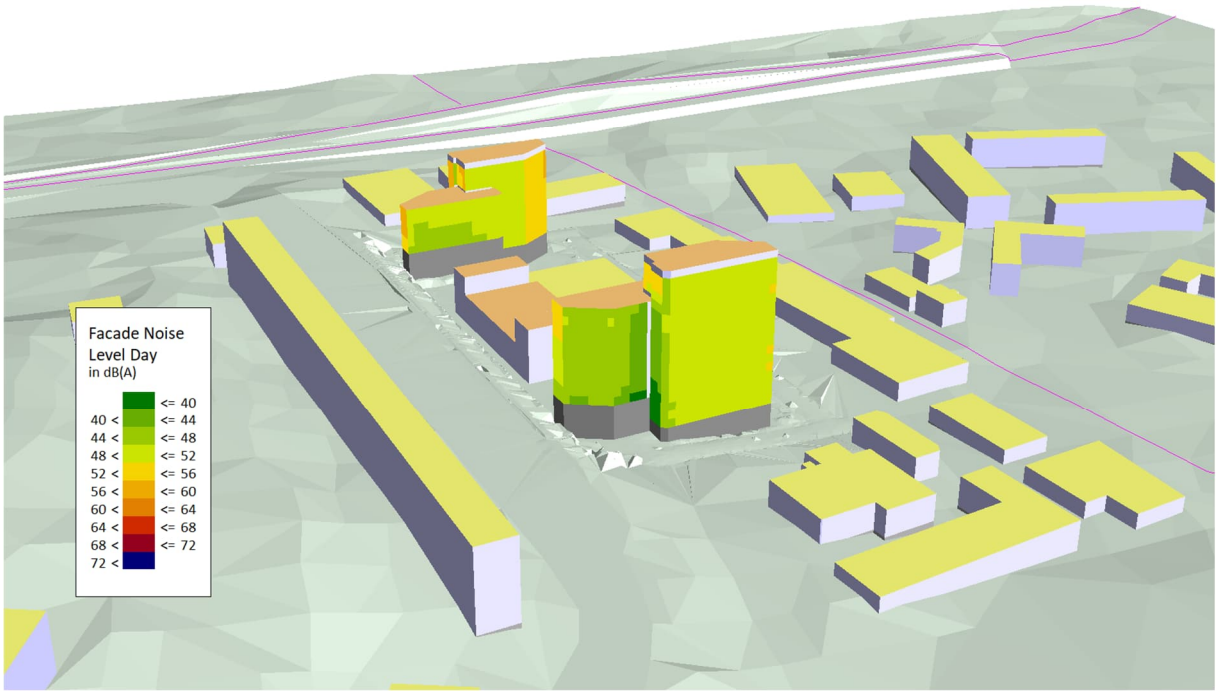

Figure 8: Daytime façade noise levels of the proposed development (north to south)

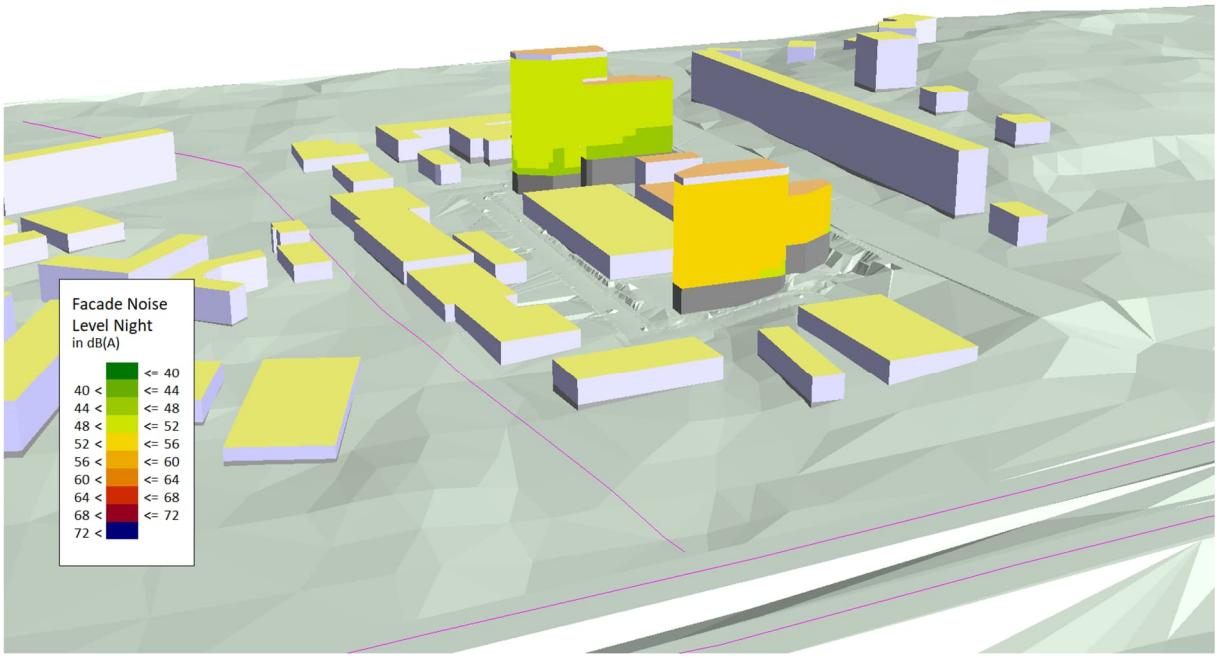

Figure 9: Night-time façade noise levels of the proposed development (south to north)

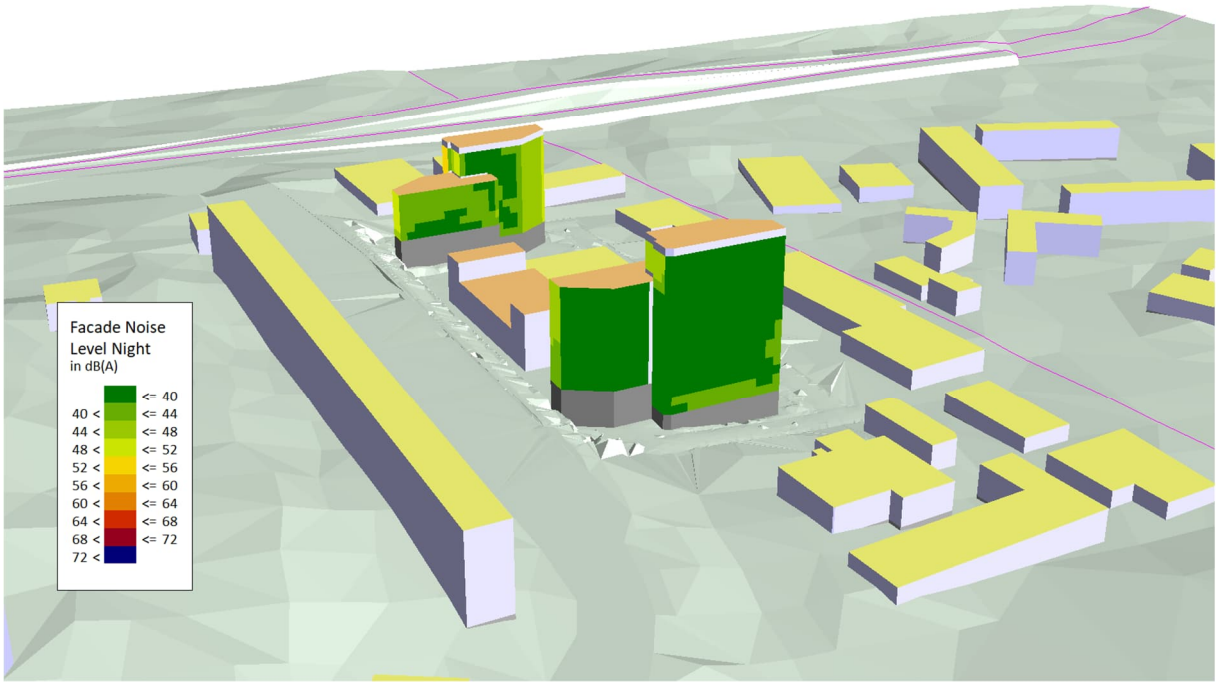

Figure 10: Night-time façade noise levels of the proposed development (north to south)

Whole dwelling ventilation will be provided by a mechanical ventilation with heat recovery (MVHR) system without the need to open windows. As such, mechanical ventilation systems, including both continuous and intermittent mechanical ventilation, should be designed and installed to meet the internal ambient noise levels as given in the BS 8233:2014 standard.

Under these conditions, the façade sound level difference is a function of the acoustic performance of the façade elements.

The following table (see Table 4) shows the minimum façade glazing acoustic requirements to achieve 35 dBA and 30 dBA ambient noise levels during daytime and night-time hours, respectively. The following assumes solid façade elements achieve at least 40 dB R_{w+Ctr}.

Table 4: Minimum façade glazing acoustic requirements

Tower	Façade	Façade level L_{Aeq} day	Façade level L_{Aeq} night	Glazing	
				R_{w+Ctr}	Example
North and South	N	60 dBA	52 dBA	25 dB	4/16/4
North	S	63 dBA	55 dBA	28 dB	6/16/4
South	S	67 dBA	60 dBA	36 dB	10/12/8.8 laminate

6.0 PLANT NOISE ASSESSMENT

Good practice would be to design noise emissions such that the combined noise from all new items of fixed plant equipment result in a "low impact" at nearby noise sensitive receptors when assessed in accordance with the methodology described in BS 4142:2014+A1:2019. As such, if the combined plant noise rating is below the representative background noise level (determined by the long-term noise survey), then a low impact is likely.

6.1 Representative Background Noise Levels

In selecting a background noise level, we note that BS 4142:2014+A1:2019 seeks to determine a representative background noise level, stating that "…the objective is not simply to ascertain a lowest measured background sound level, but rather to quantify what is typical during particular time periods". A definitive method of selecting a representative background noise level is not prescribed in BS 4142:2014+A1:2019, although an example is presented where the modal value is selected from a statistical analysis of L_{A90} data.

Based on experience, a reasonable approach to defining an overall representative value is to consider the 40th percentile value of the $L_{AF90,15min}$ data periods, which accounts for potentially unrepresentative high values and atypical events, while usually representing values near the median of the remaining distribution.

The representative existing background noise levels on-site were found to be:

- 44 dBA – Daytime (07:00 to 23:00)
- 38 dBA – Night-time (23:00 to 07:00)

6.2 Proposed Plant Noise Level Limits

In assessing plant noise emissions associated with the proposed development, the following considerations have been made:

- Plant equipment serving both the Scottish Opera building and residential development may be running at any time during daytime and night-time hours
- The emergency plant equipment will be in operation only in case of emergency. However, emergency equipment will need to be tested and thus may run for short periods of time (typically 30 minutes) at regular intervals throughout the year

On this basis, the following strategy has been proposed:

- The adoption of the representative background noise level to establish appropriate level limits for plant noise emissions. The representative background noise level has been defined by the 40th percentile of the $L_{A90,15min}$ data values gathered over the duration of the long-term noise survey for both daytime and night-time hours
- When testing the emergency plant equipment, the noise rating level limit should be no greater than 10 dB above the representative background noise level at the nearest noise sensitive receptor when assessed in accordance with BS 4142:2014+A1:2019. It is expected that occasional 30-minute testing of the generator will take place on weekdays (Monday to Friday) during daytime hours

As such, the adopted representative background noise level and resulting plant noise rating level limits are shown in Table 5.

Table 5: Plant noise level limits at the nearest noise sensitive receptor

	Representative background noise level (dBA)	Noise rating level limit for primary plant equipment ($L_{Ar,Tr}$ dBA)	Noise rating level limit for emergency plant equipment ($L_{Ar,Tr}$ dBA)
Daytime (07:00 to 23:00)	44[1]	≤ 44	≤ 54
Night-time (23:00 to 07:00)	38[1]	≤ 38	N/A[2]
[1] the 40th percentile value of the background noise level measured during the long-term noise survey [2] the emergency plant equipment is expected to only be operational during daytime hours			

6.3 Mechanical Services

The mechanical design strategy of the proposed development makes use of air handling units (AHUs), air source heat pumps (ASHPs), DX cooling units and substations.

Emergency plant equipment consists of diesel pump sets, generators and smoke fans.

Table 6 shows nominal selections for mechanical plant equipment for the proposed development with the associated sound power level for each item of plant. Final selections may be subject to change.

Table 6: List of plant equipment for the proposed development

Plant item	Model or indicative load requirement	Quantity	Location	Sound power level per unit (dBA)
ASHP	Ecodan CAHV-P500YB-HPB	4 (Scottish Opera building)	Ground level plant area (external)	70
DHW ASHP	Mitsubishi QAHV N560YA-HPB	7 north tower and 5 south tower	Level 2 plant area (internal)	67
DX Cooling unit	PUHZ-ZRP200YKA3	4 (Scottish Opera building)	Ground level plant area (external)	73
LTHW ASHP	Daikin EWYT050CZPBA2	3 per tower	Level 2 plant area (internal) (landlord amenity heating only)	81
Substation	1.5 MVA	1 per tower	Ground level plant area (internal)	67
Emergency plant equipment				
Diesel sprinkler pump set with acoustic enclosure	JU4H-LP24	1 (Scottish Opera building)	Basement level plant area (internal)	95
Generator with acoustic enclosure	275 kVA	1 per tower	Ground level plant area (enclosed)	95
Smoke fan	7.1 m³/s axial fan	1 per tower	Roof level plant area	110
Sprinkler pump set with acoustic enclosure	OH3-45 DE	1 per tower	Level 1 plant area (internal)	95
Wet riser pump set with acoustic enclosure	Hyrise 16DE	1 north tower only	Level 1 plant area (internal)	95

Mechanical ventilation units which are located internally are not assessed on the basis that they are located internally within rooms without openings and will have suitable attenuators on any external air ductwork connections. Therefore, the sound contribution from these units will be negligible.

6.4 Predicted Plant Noise Emissions

A plant noise assessment has been carried out based on the current design of the proposed development (RIBA Stage 2) to show the feasibility of meeting the adopted plant noise level limits.

The noise propagation of plant equipment was predicted using SoundPLAN (version 8.2), with all plant set to run at 100% duty. This is a situation unlikely to occur but represents a worst-case scenario. As the plant equipment represents a combined broadband noise contribution, a noise correction to account for tonality has not been applied.

It should be noted that although there are 4 ASHPs located external to the Scottish Opera building, it is unlikely that all four will run simultaneously. Therefore, following advice from the building services engineer, it is proposed that two ASHPs are to run during daytime hours and one ASHP during night-time hours (still all operating at 100% duty).

Similarly, emergency plant equipment will be tested one item at a time, therefore the maximum emergency plant noise level at the NSR represents the loudest single item of emergency plant equipment.

Table 7 shows the results of the plant noise model with the maximum façade noise levels of the nearest noise sensitive receptor. The nearest noise sensitive receptor being listed buildings, Speirs Wharf and the Canal House, which lie to the east of the canal basin.

Table 7: Difference between the plant noise level limits and the maximum noise level at the nearest noise sensitive receptor

	Primary plant level limit (dBA)	Maximum plant noise level at NSR (dBA)	Exceedance over level limit (dBA)
Daytime (07:00 to 23:00)	≤ 44	42	-2
Night-time (23:00 to 07:00)	≤ 38	42	4

Table 8: Difference between emergency plant noise level limits and the maximum noise level at the nearest noise sensitive receptor

	Emergency plant level limit (dBA)	Maximum emergency plant noise level at NSR (dBA)	Exceedance over level limit (dBA)
Daytime (07:00 to 23:00)	≤ 54	56	2

It can be seen from Table 7 that the façade noise levels of the nearest noise sensitive receptor are less than the required noise rating level limit of less than or equal to 44 dBA during daytime hours. During night-time hours, the façade noise levels of the nearest noise sensitive receptor were found to exceed the required noise rating level limit by 4 dBA. This is assuming that all fixed plant equipment has a duty of 100% during night-time hours.

The daytime noise propagation of emergency plant equipment (i.e. diesel pump sets, generators and smoke fans) was modelled separately using SoundPLAN (version 8.2). In this case, the façade noise levels of the nearest noise sensitive receptor should not exceed 10 dBA above the representative background noise level (i.e. ≤ 54).

It can be seen from Table 8 that the façade noise levels of the nearest noise sensitive receptor were found to exceed the required noise rating level limit by 2 dBA during daytime hours for emergency plant equipment.

In summary, it is expected that daytime plant noise emissions are to comply with the proposed noise rating level and therefore represent a low impact at the nearest noise sensitive receptor without any further mitigation required.

However, night-time plant noise emissions do not meet the proposed noise rating level limit; therefore, a degree of additional acoustic intervention is required. Similarly, daytime emergency plant noise emissions do not meet the proposed noise rating level limit, therefore a degree of acoustic intervention is also required for these items of plant. The acoustic mitigation required is discussed in the following section.

6.5 Plant Noise Mitigation Requirements

All items of plant (including emergency plant equipment) should be acoustically treated as necessary to achieve the noise level limits at the nearest noise sensitive receptor. This assumes all items of plant running at 100% duty (i.e. worst-case scenario).

Providing that the following, reasonably achievable, acoustic mitigation measures are implemented then it is expected that noise from plant equipment associated with the development should result in a "low impact" as per the guidance in BS 4142:2014+A1:2019.

Scottish Opera Building Diesel Pump
The diesel sprinkler pump with acoustic enclosure associated with the Scottish Opera building requires a sound power level of no more than 90 dBA to meet the proposed emergency plant level limit during daytime hours.

Residential Tower Smoke Fans
The smoke fans proposed to be located on the roof of the residential towers require 5 dB of attenuation per unit.

This amount of attenuation can be achieved by providing a suitable acoustic barrier around the smoke fans with a height of no less than 2 m along with an in-duct acoustic attenuator on the atmosphere side duct outlet.

It is understood that a parapet wall is to be constructed around the edge of the residential towers which could effectively act as an acoustic barrier and in turn provide the 5 dB of attenuation required, so long as the parapet has a minimum height of 2 m (i.e. 1 m above the height of the smoke fan).

Residential Tower Diesel Pump Sets
The sprinkler and wet riser pump sets associated with the residential towers are proposed to be located within internal plant rooms at level 1.

Similar to the diesel pump for the Scottish Opera building as above, these pumps require a sound power level of no more than 90 dBA to meet the proposed emergency plant level limit during daytime hours.

Residential Tower Air Source Heat Pumps
The DHW and LTHW ASHPs associated with the residential towers are proposed to be located within internal plant rooms at level 2. Due to the air flow required for these units, it is necessary for the façade of these plant rooms to be highly louvered.

The noise impact assessment made in the previous section assumed that simple weather louvres with no sound reduction would be used on the façade of the plant rooms and as such, that all the sound power from the ASHPs would emit from the façade louvres.

12 dB of acoustic attenuation is required for these ASHPs and as such, providing acoustic louvres to the façades of the ASHP plant rooms with an insertion loss of at least 12 dB would provide sufficient acoustic attenuation for these items of plant.

7.0 ENTERTAINMENT NOISE IMPACT ASSESSMENT

7.1 External Events

It is currently proposed that Studio 3 of the Scottish Opera building may occasionally be opened up onto the Roof Garden in order to facilitate informal community performances.

The noise impact of these events upon noise sensitive receptors depends upon the noise level, the frequency of occurrence throughout the year and whether or not the events occur during daytime or night-time hours.

It is currently understood that events would only occur during daytime hours (i.e. finishing before 11pm) and less than 12 times per year. Performances would consist of small classical ensembles with a combined sound power level assumed to be no more than 103 dBA, some examples are shown below with sound power level data taken from Table A.1. of BS ISO 23591:2021 Acoustic quality criteria for music rehearsal rooms and spaces. The sound power levels given are typical for instruments playing at forte.

Table 9: Unamplified instrument ensemble sound power level

Instrument	Sound power level (dBA)	No.	Total sound power level (dBA)
"Opera Highlight" – 4 Singers and Piano			
Singer	96	4	102
Piano	93	1	93
Total:		5	103
Woodwind Quartet			
Flute	91	1	91
Oboe	93	1	93
Clarinet	93	1	93
Bassoon	93	1	93
Total:		4	99
String Orchestra			
Violin	89	11	99
Viola	87	4	93
Cello	90	4	96
Double Bass	92	2	95
Total:		21	103
Brass Solo			
Trumpet	101	1	101
Total:		1	101

External Event Noise Level at NSR
The NSR most affected by entertainment noise emanating from Studio 3 if its façade is opened up onto the Roof Garden will be residents in the new residential block to the north of the site and the existing residents of Speirs Wharf and the Canal House to the east, both of which have clear line of sight to the Studio.

The south tower, although closer in absolute distance, will benefit to a greater degree from a barrier effect of the Studio building itself. The modelled noise levels at the NSR are shown in Table 10 and are compared to the representative daytime background noise level of 44 dBA.

Table 10: External event noise at NSR compared to representative background noise level

	North tower	South tower	Spiers Wharf and Canal House
Modelled sound pressure level at NSR	58 dBA	53 dBA	56 dBA
Comparison to representative daytime background noise level	+14 dBA	+9 dBA	+12 dBA

As can be seen from Table 10, the external event noise level is less than 15 dB above the representative background noise level at all NSRs and is consistent with the guidance in *The Code of Practice on Environmental Noise Control at Concerts*.

The Code of Practice goes on to state that "*It is believed that compliance with the guidelines and the other advice given here will enable successful concerts to be held whilst keeping to a minimum the disturbance caused by noise."*

The proposed restrictions for external events are summarised then as:

- No more than 12 events per year
- Events must not continue beyond 11pm
- Each event should consist of unamplified music from an ensemble with a total sound power no greater than 103 dBA which is approximately equal to one of the following numbers of each instrument category:
    - 1 Brass Instrument
    - 5 Adult Singers (and Piano)
    - 10 Woodwind Instruments
    - 21 String Instruments

7.2 Internal Activity Noise

There are 4 types of spaces within the proposed Scottish Opera building which may be considered to regularly have high internal activity noise levels:

- Main Rehearsal Studio
- Practice Rooms
- Studio 3
- Education Studio

In order to ensure that activity noise within these spaces has a low impact upon the existing and proposed noise sensitive receptor, it is proposed that the noise level at each receptor should be at least 10 dBA below the representative background noise level.

The following table (see Table 11) summarises the internal spaces along with their external façade area, proposed façade sound reduction specification, distance to the nearest noise sensitive receptor and the resulting level difference to the NSR. The nearest NSR is typically either the proposed north or south residential tower within the proposed development.

Table 11: Studio internal to NSR level difference

Space	External façade area (m²)	Façade sound reduction (Rw dB)	Distance to nearest NSR (m)	Level difference to nearest NSR (dB Dw)
Main Rehearsal Studio	1050	65	62	85
Studio 3	302	43	39	64
Education Studio	102	42	30	65
Practice Rooms	39.5	50	32	78

Studio 3 and the Education Studio are less formal performance spaces and it is anticipated that the maximum noise level that is likely to be produced in these rooms is 95 dBA and that these rooms would only be used during daytime hours (i.e. finishing before 11pm) for such uses.

The Main Rehearsal Studio is a formal orchestral and opera rehearsal and performance space and may also be used as a recording studio for a variety of activities. Therefore, it is anticipated that this space might produce up to 105 dBA internal noise levels and at any time of day or night.

The Practice Rooms are likely to be used by a small number of unamplified orchestral instruments and, as such it is anticipated that internal noise levels may reach up to 95 dBA on occasion and could potentially be used at any time of day or night.

The following table (see Table 12) summarises the maximum activity noise likely for each space, the resulting level at the nearest NSR and a comparison to the measured representative noise level for the relevant time period (day or night).

Table 12: Studio activity noise level at NSR compared to background noise level

Space	Max activity noise level (LAeq dB)	Level difference to nearest NSR (dB Dw)	Level at nearest NSR (dB LAeq)	Period	Representative background noise level (dB LA90)	Level below background noise level (dBA)
Main Rehearsal Studio	110	85	25	Day or night	38	13
Studio 3	95	64	31	Day	44	13
Education Studio	95	65	30	Day	44	14
Practice Rooms	95	78	17	Day or night	38	21

The activity noise level from these spaces is expected to be significantly below the representative background noise level for the relevant daytime and night-time hours at the nearest noise sensitive receptor. This is therefore an indication that the noise source will have a low impact.

It should also be noted that in the worst case of all 3 Studios being used simultaneously that the resulting noise level at the NSR is still 10 dBA below the representative background noise level and an indication of a low impact.

8.0 SUMMARY AND CONCLUSION

Max Fordham LLP has been appointed to carry out a noise impact assessment in relation to the proposed mixed-use development at Scottish Opera Production Studios in Glasgow. The development is to incorporate two blocks of purpose-built student accommodation as well as a rehearsal space, studio and café.

National policies, local policies and standards relevant to this project have been considered when assessing noise level limits.

Acoustic design basis has been given for the proposed development in line with British Standards, with respect to environmental policy outlined in Glasgow's City Development Plan.

An environmental noise survey at the site has been carried out to assess the local noise environment, mainly characterised by road traffic noise (M8 and A81).

Based on the predicted façade noise level outcomes obtained from the 3D noise modelling software, the external-to-internal noise level difference has been calculated and then minimum sound insulation performance requirement for the façade components (windows and external walls) have been assessed to meet the BS 8233:2014 indoor ambient noise level limits.

Proposed daytime and night-time plant noise level limits at the nearest noise sensitive receptor were said to be any value less than or equal to the representative background noise level for daytime and night-time hours, respectively, as shown below:

- ≤ 44 dBA $L_{Ar,Tr}$ – Daytime (07:00 to 23:00)
- ≤ 38 dBA $L_{Ar,Tr}$ – Night-time (23:00 to 07:00)

Similarly, proposed emergency plant noise level limits at the nearest noise sensitive receptor were said to be no greater than 10 dBA above the representative background noise level for daytime hours.

Additional acoustic mitigation measures for plant equipment were outlined for the plant noise emissions to meet the proposed level limits.

9.0 APPENDIX

9.1 Acoustic Glossary

SOUND PRESSURE LEVEL (SPL), L (dB). The sound level measured on a logarithmic scale, with unit decibel (dB). A free-field SPL refers to a level determined far enough from surfaces or façades, apart from the ground, so as not to be influenced by reflections from those surfaces.

A-WEIGHTED SOUND PRESSURE LEVEL (SPL), L_A (dBA). A-weighted SPL values (or noise levels) are weighted in a way that approximates the frequency response of the human ear and allows sound levels to be expressed as a single figure value.

EQUIVALENT CONTINUOUS A-WEIGHTED SPL, $L_{Aeq,T}$ (dBA). Energy weighted average of the A-weighted sound pressure level over a time period, T. The level of a notional continuous sound that would deliver the same A-weighted sound energy as the actual fluctuating sound over the course of the defined time period, T.

PLANT NOISE RATING LEVEL, $L_{Ar,Tr}$ (dBA). The specific sound level ($L_{Aeq,T}$) plus any adjustment for the characteristic features of the sound, following BS4142:2014, such as a penalty for tonality, impulsivity etc.

MAXIMUM A-WEIGHTED SPL, L_{Amax} (dBA). The maximum A-weighted sound pressure level measured. If not specified, usually assumed to mean L_{AFmax}, i.e. L_{Amax} determined with a 'fast' (F) sound level meter time constant of 125 ms.

PERCENTILE NOISE LEVELS $L_{A1,T}$, $L_{A10,T}$, $L_{A90,T}$ (dBA). The value of the A-weighted sound pressure level that is exceeded for N% of any given time interval, T. For example $L_{A1,T}$ is the value that is exceed for 1% of the measurement period. $L_{A90,T}$ is the level that is exceeded for 90% of the measurement period and is usually used to represent the ambient background noise level.

SOUND REDUCTION INDEX, R (dB). The sound reduction index of an element, such as a wall, floor, door or window describes proportion of incident sound that is not transmitted by that element. R varies with frequency and can be expressed either in terms of the fraction of incident sound energy that is transmitted or in terms of the difference in SPL on either side of the element.

WEIGHTED SOUND REDUCTION INDEX, RW (dB). A value calculated from the frequency dependent values of sound reduction index, measured in a laboratory and weighted according to a method described in BS EN ISO 717-1:1997. This allows the sound reduction of an element to be expressed in terms of a single value.

SOUND LEVEL DIFFERENCE, D (dB). The difference in sound pressure level between rooms on either side of a partition, D = L1 – L2 (where L1 and L2 are the sound pressure levels on either side of the partition). D varies with sound frequency.

9.2 Noise Monitoring Equipment

The equipment summarised in Table 13 and Table 14 has been calibrated by a United Kingdom Accreditation Service (UKAS) accredited laboratory in accordance with the laboratory requirements on the date shown.

Table 13: Hired noise monitoring equipment

Item	Make/Type (serial no.)	Calibration intervals	Last calibrated	Next due calibration	Certificate No.
Class 1 sound level meter	Norsonic/140 (1405219)	2 years	26/07/23	26/07/25	U44943
Microphone preamplifier	Norsonic/1209 (15278)	2 years	26/07/23	26/07/25	U44943
Microphone	Norsonic/1225 (142460)	2 years	26/07/23	26/07/25	44942
Calibrator	Norsonic/1251 (31313)	1 year	26/07/23	26/07/25	U43891

Table 14: Noise monitoring equipment

Item	Make/Type (serial no.)	Calibration intervals	Last calibrated	Next due calibration	Certificate No.
Class 1 sound level meter	Norsonic/140 (1406755)	2 years	28/10/20	28/10/24	U42262 U42263
Microphone preamplifier	Norsonic/1209 (21284)	2 years	28/10/20	28/10/24	U42262 U42263
Microphone	Norsonic/1225 (251518)	2 years	28/10/20	28/10/24	42261
Calibrator	Norsonic/1251 (34890)	1 year	17/03/23	17/03/24	U43710

9.3 Noise Survey Photos

Figure 11: View from S1 looking south onto the M8

Figure 12: View from S3 overlooking part of the Forth and Clyde canal and onto the M8

Figure 13: Location of L1 on the platform site