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TECHNICAL NOTE

Project	**Hugh Lane Gallery**
Subject	**Noise Impact of Building Services Plant to Hugh Lane Gallery Roof**
Author	**Dr Stephen Smyth**
Date	**8 November 2023**
Ref.	**237501.0008NT01**

1.0 INTRODUCTION

AWN Consulting Limited has been requested to review the potential noise impact of new mechanical plant items located on the flat roof above the Francis Bacon Gallery, which lies to the rear (north) of the existing 1930's wing of the Hugh Lane Gallery.

The development will involve removal and replacement of AHU plant items and the addition of air source heat pumps and condenser units.

The roof area under consideration is situated in close proximity to residential dwellings along Frederick Street to the north and Bethesda Place to the west. The following has been undertaken to determine the potential impact of the proposed development on the adjacent noise sensitive buildings:

- A baseline noise survey previously undertaken for a similar study has been reused to characterise the prevailing noise environment representative of the nearest noise sensitive locations;
- A review of the relevant standards and guidelines has been undertaken to set appropriate noise levels;
- Operational plant noise levels have been calculated at the nearest noise sensitive locations;
- Calculated noise levels have been compared against the adopted criteria and noise control measures have been incorporated, where necessary to reduce operational noise levels.

This technical note provides a summary of the noise assessment undertaken.

2.0 ASSESSMENT CRITERIA

In the absence of statutory documents for control of environmental noise from fixed plant items, reference is made to the typical conditions that would be applied by DCC to the development of this nature:

> *"Noise levels from the proposed development should not be so loud, so continuous, so repeated, of such duration or pitch or occurring at such times as to give reasonable cause for annoyance to a person in any premises in the neighbourhood or to a person lawfully using any public space. In particular the rated noise levels from the proposed development shall not constitute reasonable grounds for complaint as provided for in B.S. 4142. Method for rating industrial noise affecting mixed residential and industrial area.*
>
> *Reason: In order to ensure a satisfactory standard of development, in the interests of residential amenity."*

Guidance from DCC on noise emissions from mechanical plant items makes reference to the British Standard BS 4142: 2014 +A1 2019: *Methods for Rating and Assessing Industrial and Commercial Sound*. This document is the industry standard method for analysing building services plant noise emissions to residential receptors and is the document used by DCC in their standard planning conditions and also in complaint investigations.

BS 4142 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.

For an appropriate BS 4142 assessment it is necessary to compare the measured external background noise level (i.e. the $L_{A90,T}$ level measured in the absence of plant items) to the rating level ($L_{Ar,T}$) of the various plant items, when operational. Where noise emissions are found to be tonal, impulsive in nature or irregular enough to attract attention, BS 4142 also advises that a penalty be applied to the specific level to arrive at the rating level.

The subjective method for applying a penalty for tonal noise characteristics outlined in BS 4142 recommends the application of a 2dB penalty for a tone which is just perceptible at the noise receptor, 4dB where it is clearly perceptible, and 6dB where it is highly perceptible.

The following definitions as discussed in BS 4142 as summarised below:

"ambient noise level, $L_{Aeq,T}$"	is the noise level produced by all sources including the sources of concern, i.e. the residual noise level plus the specific noise of mechanical plant, in terms of the equivalent continuous A-weighted sound pressure level over the reference time interval [T].
"residual noise level, $L_{Aeq,T}$"	is the noise level produced by all sources excluding the sources of concern, in terms of the equivalent continuous A-weighted sound pressure level over the reference time interval [T].

"specific noise level, $L_{Aeq,\ T}$"	is the sound level associated with the sources of concern, i.e. noise emissions solely from the mechanical plant, in terms of the equivalent continuous A-weighted sound pressure level over the reference time interval [T].
"rating level, $L_{Ar,T}$"	is the specific sound level plus any adjustments for the characteristic features of the sound (e.g. tonal, impulsive or irregular components);
"background noise level, $L_{A90,T}$"	is the sound pressure level of the residual noise that is exceeded for 90% of the time period T.

If the rated plant noise level is +10dB or more above the pre-existing background noise level then this indicates that complaints are likely to occur and that there will be a significant adverse impact. A difference of around +5dB is likely to be an indication of an adverse impact, depending on the context.

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.

Additional guidance on recommended internal noise levels for dwellings is contained within BS 8233:2014 *Guidance on Sound Insulation and Noise Reduction for Buildings*. This British Standard sets out recommended noise limits for indoor ambient noise levels in dwellings as presented in Table 2.

Typical situations	Design Range, $L_{Aeq,T}$ dB	
	Daytime $L_{Aeq,16hr}$ (07:00 to 23:00hrs)	Night-time $L_{Aeq,\ 8hr}$ (23:00 to 07:00hrs)
Living / Dining Rooms	35 - 40	n/a
Bedrooms	35	30

Table 1 Recommended Indoor Ambient Noise Levels from BS 8233:2014

In order to determine an external noise level based on the internal criteria noted in Table 1 above, a correction factor across a partially open window of 15dB is typical. The following external noise levels would, therefore, achieve the internal noise levels noted in Table 1 above.

- Daytime / Evening (07:00 to 23:00 hours) 50 - 55dB $L_{Aeq,1hr}$
- Night-time (23:00 to 07:00 hours) 45dB $L_{Aeq,15min}$

The absolute noise levels referred to above are a useful guide to assessing the overall potential noise impact in addition to the relative change assessment used in BS 4142. The overall noise impact from the plant area will therefore be assessed taking account of both standards.

3.0 BASELINE NOISE ENVIRONMENT

As part of a previous study into replacement roof plant at the Gallery, an unattended logging monitor was installed on the roof close to where the new plant area is proposed and directly opposite the nearest residents along Bethesda Place. Figure 1 below indicates the monitoring location, the nearest noise sensitive receivers indicated in orange, and the approximate proposed plant area indicated in red. The survey was carried out between the 21 March and 25 March 2019. The noise environment in the area is not expected to have changed significantly in the interim period and the data is considered suitable for reuse in this instance.

The noise survey was conducted in general accordance with ISO 1996-2: 2017: *Acoustics – Description, measurement and assessment of environmental noise Part 2: Determination of sound pressure levels.*

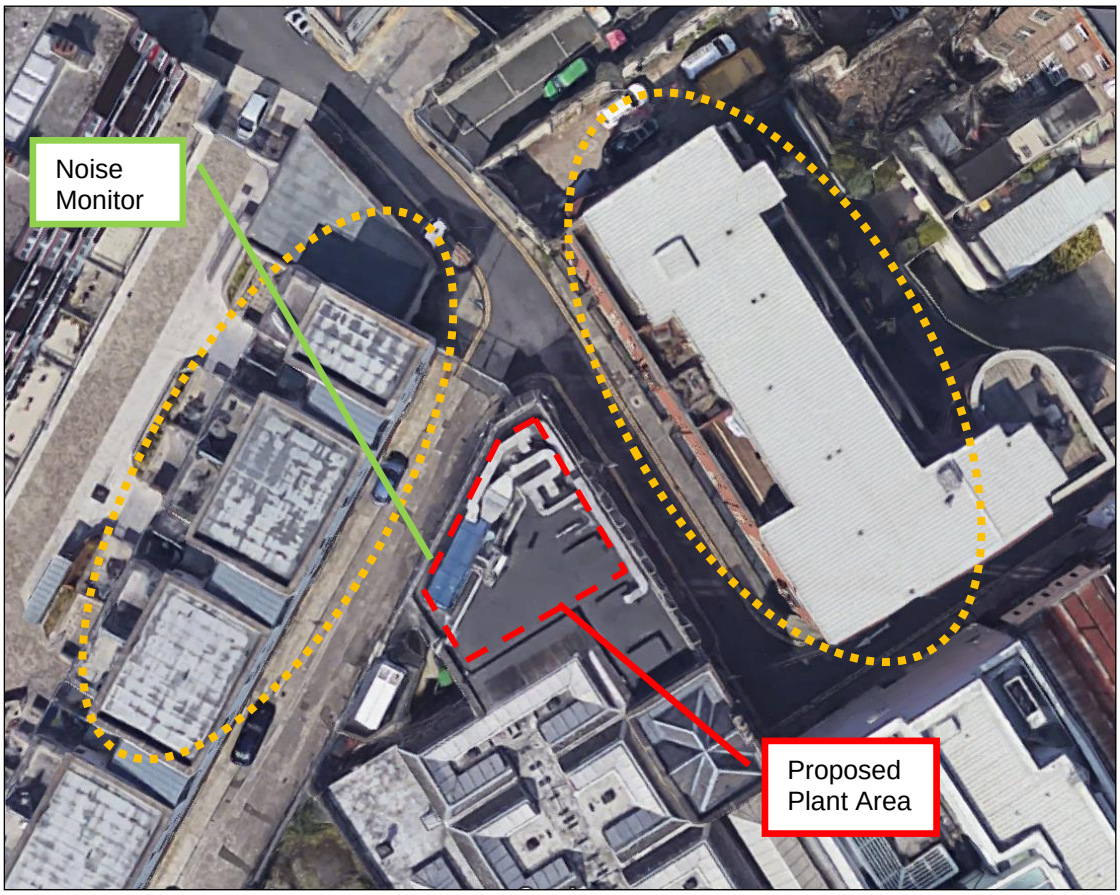

Figure 1 Site Location and Context

The main sources of noise noted in the vicinity of the monitoring position was from existing plant items serving the Hugh Lane Gallery and traffic on the surrounding local road network. The same plant items are still in operation at roof level.

3.1 Survey Results

Following analysis of the baseline noise monitoring data the average noise levels surrounding the site have been determined. For the assessment of plant noise, the most important parameter is the L_{A90} which represents the steady background noise.

Table 1 presents the measured average ambient and background noise levels for daytime (07:00 – 19:00hrs), evening (19:00 – 23:00hrs) and night-time (23:00 – 07:00hrs)

Date	Period	Measured Noise Levels (dB re. $2x10^{-5}$ Pa)	
		L_{Aeq}	L_{A90}
21st March 2019	Day	53	58
	Evening	59	58
22nd March 2019	Day	59	59
	Evening	61	58
	Night	59	58
23rd March 2019	Day	59	58
	Evening	59	58
	Night	59	58
24th March 2019	Day	60	59
	Evening	59	58
	Night	59	58
25th March 2019	Day	59	58
	Night	59	58
Average	Day	59	58
	Evening	58	58
	Night	59	58

Table 2 Summary of Measured Baseline Noise Levels

Noise levels throughout the survey period were steady over day, evening and night time period. As can be seen in the table above the ambient and background noise levels are almost identical indicating that measured noise levels are dominated by a continuous non-varying source, i.e. the AHU on this roof. This was also observed while the monitor was being installed and collected on site.

The average ambient noise level was 59dB $L_{Aeq,1hr}$ for both the day and night time period which relates to the boundary of the plant area, opposite the residential apartments. The average background noise level was 58dB $L_{Aeq,1hr}$ for both the day and night time period.

Correcting for distance attenuation, the calculated noise level at the nearest noise sensitive properties along Bethesda Place based on the data captured in the baseline noise survey is of the order of 45dB L_{A90} which remains constant over day and night-time periods.

4.0 PREDICTED IMPACT FROM PROPOSED BUILDING SERVICES

4.1 Plant Items and Layout

4.1.1 Site Layout

Figure 2 illustrates the preliminary roof plant layout for the development that has been adopted for the assessment.

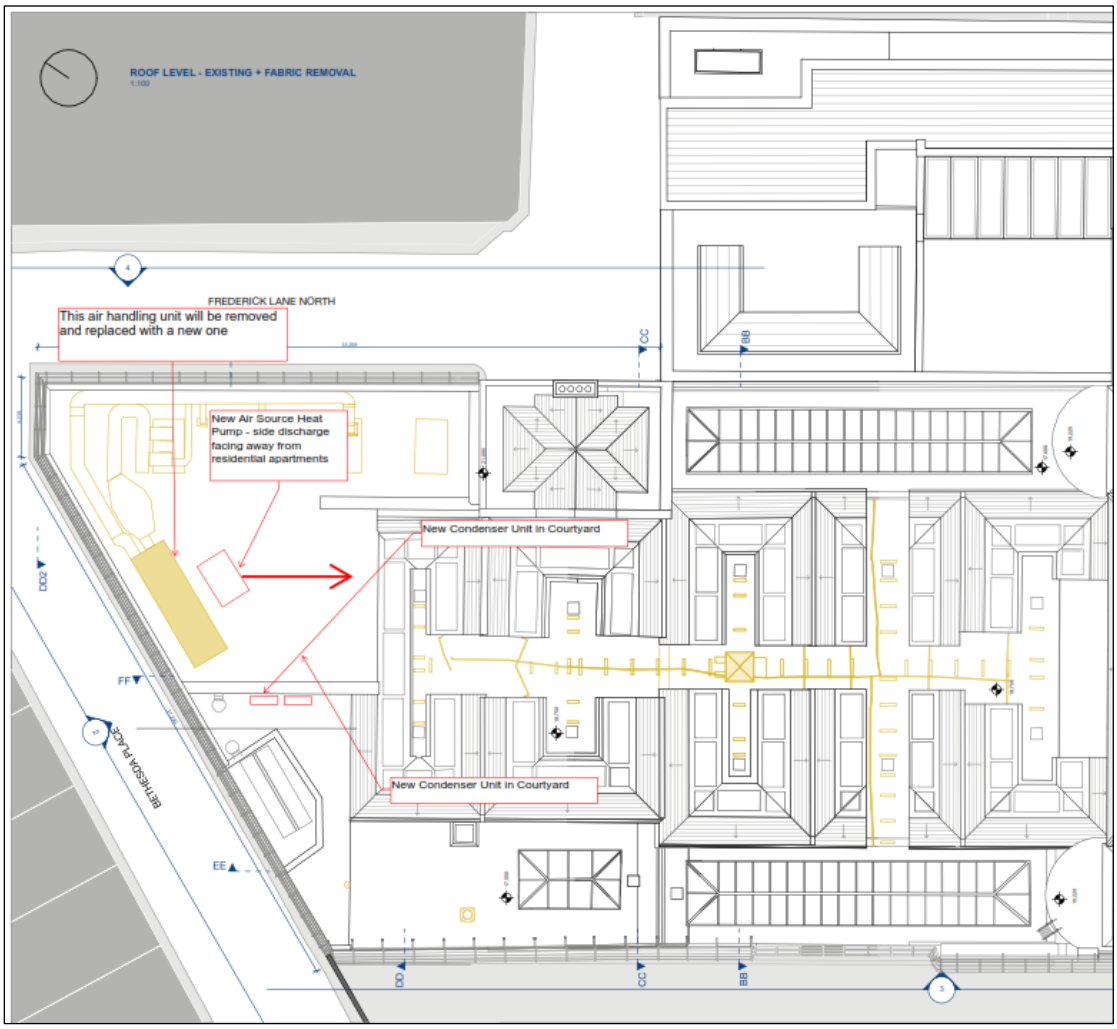

Figure 2 Roof Plant Layout and Context

4.1.2. Source Data

Table 3 lists the rooftop plant items required to serve the new development and the associated overall sound power noise level from each item. Note that the sound power levels quoted are estimated based on the equipment schedules. During detailed design the noise emission data associated with the equipment to be installed will be used to verify that the installation achieves a cumulative noise level that is not significantly greater than the prevailing background noise level.

Item	Description	Sound Power Level dB(A)
AHU	AHU Supply	66
	AHU extract	66
Condenser Units	Serving Francis Bacon	70 each
Air Source Heat Pump	2 no. side discharge units	76 each

Table 3 Summary of Plant Noise Levels

The existing AHU along the west of the roof area along Bethesda Place will be removed and replaced with the AHU listed above. As the existing AHU was the dominant contributor to prevailing background noise levels along this boundary, once this is removed and replaced, there are no expected cumulative noise impacts from existing and proposed plant items.

Using the data from Table 3 that has been provided by the design team and manufacturers technical datasheets, calculations have been applied in line with appropriate guidance to predict the noise level of the proposed mechanical plant at the façade of the nearest NSL's.

For the purposes of this assessment we have assumed that all plant items are operational simultaneously, at full load and on a 24/7 basis.

4.1.3 Plant Screening

The assessment has been completed without any noise screening in place to present a conservative assessment. This matches the current situation where there is no noise screening present.

4.1.4 Noise Model

A 3D computer-based prediction model has been prepared in order to quantify the noise level associated with the proposed plant items in accordance with *ISO 9613: Acoustics – Attenuation of sound during propagation outdoors, Part 2: General method of calculation, 1996*. Details of the model development area included in Appendix A.

Noise levels have been calculated at the apartments to the north along Frederick Street (R1 – R4) at heights of first to third floor level and along Bethesda Place (R5 – R11) at heights of first and second floor level representative of the most exposed windows of the apartment buildings.

Figure 3 illustrates the noise assessment locations.

Figure 3 Noise assessment Locations

Table 4 details the highest calculated noise level at each NSL representative of the upper floors of the apartment buildings. The calculations assume the plant is operating at full load, which is a conservative assumption as plant will operate at quieter levels when demand is low. The relevant assessment level in accordance with the methodology outlined in BS4142:2014 is also included through comparison against the background noise level. Plant is to be specified to not have any tonal or impulsive characteristics and therefore no rating corrections are applied in Table 4.

Reference	Location	Background Level (dB L_{A90})	Rating Noise Level from New Plant dB $L_{Ar,T}$	BS 4142 Assessment Level, dB	BS 4142 Potential Impact
R1	Frederick St	45	44	-1	Low
R2	Frederick St		38	-7	Low
R3	Frederick St		46	+1	Adverse - low
R4	Frederick St		40	-5	Low
R5	Bethesda Place		40	-5	Low
R6	Bethesda Place		46	+1	Adverse - low
R7	Bethesda Place		48	+3	Adverse - low
R8	Bethesda Place		46	+1	Adverse - low
R9	Bethesda Place		42	-3	Low
R10	Bethesda Place		40	-5	Low
R11	Bethesda Place		39	-6	Low

Table 4 Summary of Predicted Noise Levels and BS4142 assessment level

The assessment has been conducted in accordance with BS4142:2014 where the predicted noise from mechanical plant at the nearest noise sensitive locations would

result in a low adverse noise impacts at the upper floors of some residential apartments nearby. A low noise impact is calculated at apartments south west of the plant area along Bethesda Place.

The results of the assessment have determined that operational noise levels have the potential to generate an adverse noise impact when the plant is operating under conditions at full load. The overall range of noise levels calculated at the nearest apartment facades are 38 to 48dB L_{Aeq} under this scenario.

During daytime periods, an operational noise level of up to 48dB L_{Aeq} would result in a small increase to the background noise environment. An external noise level of this magnitude is, however, within the design range of absolute noise levels for daytime periods of 50 to 55dB L_{Aeq} in order to achieve acceptable internal noise level within living spaces and bedrooms in accordance with BS 8233 2014.

During night-time periods, with the plant under full load, the calculated noise level of up to 48dB L_{Aeq} has the potential to marginally increase the background noise environment. However, the overall impact is not significant based on the methodology outlined in BS4142. Notwithstanding this, some discussion of mitigation options are presented in Section 5.0 to be considered during the detailed design which may further reduce the noise levels.

It is important to note, the noise levels calculated are considered a worst case analysis, assuming all plant items are operating at full load, particularly during night-time periods. In reality, the plant items are not expected to require full loading during night-time periods and will therefore result in lower noise emissions. The specific operational noise level for part load conditions is not available for the units assessed, therefore the conservative assessment assuming full load has been included only.

5.0 MITIGATION MEASURES

During detailed design, consideration of further noise mitigation measures can be investigated for the plant area to achieve reduced operational noise levels.

The options for mitigation measures that may be considered to reduce operational plant noise are as follows:

- Atmosphere side attenuation to all AHU discharge points
- Side discharge Air Source Heat Pump: Orientation to be optimised to point this highly directional noise source away from nearby sensitive dwellings
- Consideration of a night-time setback mode when demand is low which will reduce noise at source from all plant

These options have the potential to reduce noise output by up to 3dB at some locations which would reduce the operational noise level to at or below 45 dB $L_{A,r,T}$ at all locations, thus reducing the overall noise impact .

It is acknowledged that the selection of the specific plant items and their final location is subject to change during the detailed design stage. However, noise from any new plant items should be designed and/or controlled so as not to give rise to significant noise impacts at the nearest noise sensitive locations.

Furthermore, it is confirmed that any new plant items will not emit significant tonal or impulsive characteristics which may increase the potential for annoyance at the nearest noise sensitive locations. Note that the new plant will be required to avoid tonal or impulsive sources, particularly during night-time periods, and therefore no rating penalties have been applied.

6.0 CONCLUSION

A preliminary review of plant noise emissions has been carried out for the proposed development to assess the potential noise impact and the requirement for noise mitigation measures.

The calculated noise levels have been assessed against the relevant noise criteria within BS4142 and BS 8233 in order to ensure noise impact are controlled to avoid significant adverse noise impacts and to not give rise to reasonable grounds for complaint as provided for in BS 4142.

The assessment has been based on review of the information that has been provided to date for plant layout and noise emission data.

Mitigation measures to the plant area such as atmosphere side attention to the AHU, orientation of the air source heat pump or restricting operational modes at night will be considered during detailed design. The specifics of the final options will be determined during the detail design stage of the plant area.

The findings indicate that once operational noise levels from plant noise emissions are controlled to the absolute noise limits outlined in this report, the noise impact will be acceptable.

APPENDIX A

NOISE MODEL INFORMATION

Noise Model

A 3D computer-based prediction model has been prepared in order to quantify the noise level associated with the proposed plant area This section discusses the methodology behind the noise modelling process.

Brüel & Kjær Type 7810 Predictor

Proprietary noise calculation software has been used for the purposes of this modelling exercise. The selected software, *Predictor,* calculates noise levels in accordance with *ISO 9613: Acoustics – Attenuation of sound during propagation outdoors, Part 2: General method of calculation, 1996*.

Predictor is a proprietary noise calculation package for computing noise levels in the vicinity of noise sources. The model calculates noise levels in different ways depending on the selected prediction standard. In general, however, the resultant noise level is calculated taking into account a range of factors affecting the propagation of sound, including:

- the magnitude of the noise source in terms of A weighted sound power levels (L_{WA});
- the distance between the source and receiver;
- the presence of obstacles such as screens or barriers in the propagation path;
- the presence of reflecting surfaces;
- the hardness of the ground between the source and receiver;
- Attenuation due to atmospheric absorption; and
- Meteorological effects such as wind gradient, temperature gradient and humidity (these have significant impact at distances greater than approximately 400m).

Brief Description of ISO9613-2: 1996

ISO9613-2:1996 calculates the noise level based on each of the factors discussed previously. However, the effect of meteorological conditions is significantly simplified by calculating the average downwind sound pressure level

The basic formula for calculating $L_{AT}(DW)$ from any point source at any receiver location is given by:

$$L_{fT}(DW) = LW + Dc - A \qquad \textbf{Eqn. A}$$

Where:

$L_{fT}(DW)$ is an octave band centre frequency component of $L_{AT}(DW)$ in dB relative to $2x10^{-5}$Pa;

L_W is the octave band sound power of the point source;

D_c is the directivity correction for the point source;

A is the octave band attenuation that occurs during propagation, namely attenuation due to geometric divergence, atmospheric absorption, ground effect, barriers and miscellaneous other effects.

The estimated accuracy associated with this methodology is shown in Table A1 below:

Height, h*	Distance, d†	
	0 < d < 100m	100m < d < 1,000m
0<h<5m	±3dB	±3dB
5m<h<30m	±1dB	±3dB

Table A1 Estimated Accuracy for Broadband Noise of L_{AT}(DW)

* h is the mean height of the source and receiver. † d is the mean distance between the source and receiver.
N.B. These estimates have been made from situations where there are no effects due to reflections or attenuation due to screening.

Input Data and Assumptions

The noise model has been constructed using data from various source as follows:

Site Layout The general site layout has been obtained from the drawings forwarded by Hawkins Brown Architects and plant layout drawings from Aecom.

Local Area The location of noise sensitive locations has been obtained from a combination of site drawings provided by the design team and reference to Google earth.

Heights The heights of buildings on site have been obtained from site drawings forwarded by the design team

Source Sound Power Data

The following noise source data was used for the key noise emission.

Item	Description	Sound Power Level dB(A)
AHU	AHU Supply	66
	AHU extract	66
Condenser Units	Serving Francis Bacon	70 each
Air Source Heat Pump	2 no. side discharge units	76 each

Table A.2 L_{wA} levels Utilised in Noise Model

Modelling Calculation Parameters

Prediction calculations for plant noise have been conducted in accordance with *ISO 9613: Acoustics – Attenuation of sound during propagation outdoors, Part 2: General method of calculation, 1996*.

Ground attenuation factors of 0 have been assumed for hard ground. No metrological corrections were assumed for the calculations. The atmospheric attenuation outlined in Table A.3 has been assumed for all calculations.

Temp (ºC)	% Humidity	Octave Band Centre Frequencies (Hz)							
		63	125	250	500	1k	2k	4k	8k
10	70	0.12	0.41	1.04	1.92	3.66	9.70	33.06	118.4

Table A.3 Atmospheric Attenuation Assumed for Noise Calculations (dB per km)