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ATTACHMENT-7-1-3-2 NOISE IMPACT ASSESSMENT FOR EPA LICENCE APPLICATION

Technical Report Prepared For

Amazon Data Services Ireland Limited

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Our Reference

217501/1055NR01

Date of Issue

23 March 2022

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Document History

Document Reference		Original Issue Date	
217501/1055NR01		23 March 2022	
Revision Level	Revision Date	Description	Sections Affected

Record of Approval

Details	Written by	Approved by
Signature		
Name	Mike Simms	Stephen Smyth
Title	Senior Acoustic Consultant	Associate (Acoustics)
Date	23 March 2022	23 March 2022

EXECUTIVE SUMMARY

Amazon Data Services Ireland Limited ('**ADSIL'**) operate three data storage facilities on a site in the IDA Business & Technology Park, Clonshaugh, Dublin 17. AWN Consulting has been commissioned to prepare a noise impact assessment for the operation of the facility to be compiled and submitted as part of the Industrial Emissions (IE) licence application process.

This technical report has been prepared to provide details in relation to the noise impact assessment for the licence application. The assessment is based on the most up-to-date design details available for development and has been prepared with due consideration of the guidance contained within the Environmental Protection Agency (EPA) document *Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4) 2016*.

Section 6 of the EPA's NG4 Guidance outlines the following assessment stages for the noise impact assessment for licence applications.

- Stage 1 – Baseline Noise Survey / Monitoring Locations;
- Stage 2 – Derivation of Noise Criteria;
- Stage 3 – Assessment of Noise Impact; and,
- Stage 4 – Reporting / Licence Application Form.

This report has been prepared with consideration of the four assessment stages outlined above.

An environmental noise survey was conducted to quantify the existing noise environment in the vicinity of nearest Noise Sensitive Receivers (NSL's) to the site. The survey was conducted in general accordance with the EPA's NG4 Guidance.

Appropriate operational noise criteria have been derived for the site following review of noise survey data and receiving environment, in accordance with the relevant NG4 Guidance. The applicable noise criteria identified are in line with the typical limit values for noise from licensed sites.

To assess the impact of noise from new mechanical plant at nearby NSL's, a detailed computer-based noise model has been prepared using a proprietary noise modelling software package. Noise prediction calculations have carried out in accordance with ISO 9613-2:1996 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation*. The predicted cumulative (Building W, Z and Y)noise levels at all NSL's for mechanical plant from the facility are within the day, evening and night-time noise criteria for site operations.

CONTENTS

1.0 INTRODUCTION

Amazon Data Services Ireland Limited (‘**ADSIL’**) operate three data storage facilities on a site in the IDA Business & Technology Park, Clonshaugh, Dublin 17. AWN Consulting has been commissioned to prepare a noise impact assessment for the operation of the facility to be compiled and submitted as part of the Industrial Emissions (IE) licence application process.

This assessment is based on the predicted noise emissions from the installation and the most up-to-date design details available for the development and has been prepared with due consideration to the guidance contained within the Environmental Protection Agency (EPA) document *Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4) 2016.* This report has been prepared in accordance with the four noise impact assessment stages outlined in Section 6 of NG4, which are as follows:

- Stage 1 – Baseline Noise Survey / Monitoring Locations;
- Stage 2 – Derivation of Noise Criteria;
- Stage 3 – Assessment of Noise Impact; and,
- Stage 4 – Reporting / Licence Application Form.

Figure 1 Site Location & Context (Source: Google Maps)

Figure 1 presents the proposed site location in the context of the surrounding environment. The nearest residential noise sensitive locations are to the east of the development along the Clonshaugh Road at a distance of approximately 200m from the site boundary. There are also residential dwellings to the west of the site within the Larch Hill development at a distance of approximately 300m from the site boundary, and within the Cromcastle Estate to the south of the site at a distance of approximately 250m from the site boundary. In addition, there are a number of commercial and industrial operations located on lands to the north, east, south and west of the site.

Appendix A to this report presents a glossary of the acoustic terminology referred to in this document.

2.0 FUNDAMENTALS OF ACOUSTICS

In order to provide a broader understanding of some of the technical discussion in this report, this section provides a brief overview of the fundamentals of acoustics and the basis for the preparation of this noise assessment.

A sound wave travelling through the air is a regular disturbance of the atmospheric pressure. These pressure fluctuations are detected by the human ear, producing the sensation of hearing. In order to take account of the vast range of pressure levels that can be detected by the ear, it is convenient to measure sound in terms of a logarithmic ratio of sound pressures. These values are expressed as Sound Pressure Levels (SPL) in decibels (dB).

The audible range of sounds expressed in terms of Sound Pressure Levels is 0dB (for the threshold of hearing) to 120dB (for the threshold of pain). In general, a subjective impression of doubling of loudness corresponds to a tenfold increase in sound energy which conveniently equates to a 10dB increase in SPL. It should be noted that a doubling in sound energy (such as may be caused by a doubling of traffic flows) increases the SPL by 3dB.

The frequency of sound is the rate at which a sound wave oscillates and is expressed in Hertz (Hz). The sensitivity of the human ear to different frequencies in the audible range is not uniform. For example, hearing sensitivity decreases markedly as frequency falls below 250Hz. In order to rank the SPL of various noise sources, the measured level has to be adjusted to give comparatively more weight to the frequencies that are readily detected by the human ear. Several weighting mechanisms have been proposed but the ‘A-weighting’ system has been found to provide one of the best correlations with perceived loudness. SPL’s measured using ‘A-weighting’ are expressed in terms of dB(A). An indication of the level of some common sounds on the dB(A) scale is presented in Figure 2.

The established prediction and measurement techniques for the dB(A) parameter are well developed and widely applied. For a more detailed introduction to the basic principles of acoustics, reference should be made to an appropriate standard text[1].

1 For example, *Woods Practical Guide to Noise Control* by Ian Sharland.

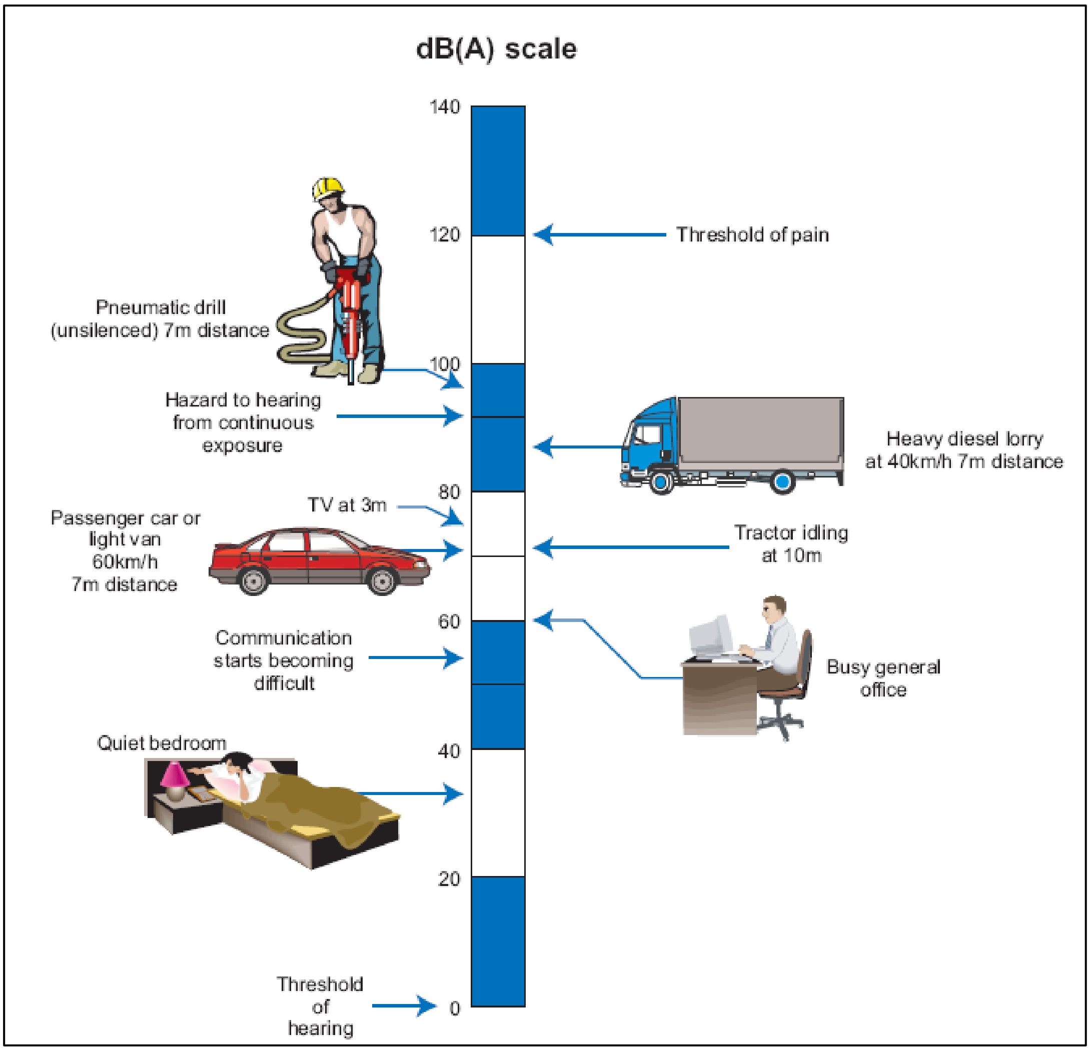

Figure 2 Level of Typical Sounds on the dB(A) Scale – (TII – Good Practice Guidance for the Treatment of Noise during the Planning of National Road Schemes)

3.0 RECEIVING ENVIRONMENT

This section deals with 'Stage 1' of the noise impact assessment as outlined in the EPA's NG4 Guidance. Note this section has been based on baseline noise surveys completed for the planning applications for the original buildings on the site (i.e. prior to the construction of any of the projects considered here) and is considered representative of the environment at this stage in time.

An environmental noise survey has been conducted in order to quantify the existing noise environment. The survey was conducted in general accordance with ISO 1996: 2007: *Acoustics – Description, measurement and assessment of environmental noise*[2]. Specific details are set out below.

3.1 Choice of Measurement Locations

Noise measurements were conducted at seven positions in the vicinity of the site. The location of these measurements is shown on Figure 3.

Table 1 Measurement Locations & Descriptions

Location	Description	Photo
A (Oct 2015)	Located within the Turnapin housing estate to the west of the development. This location is considered representative of the nearest residential dwellings to the west of the site. These properties are c. 475m from the western site boundary.	
B (May 2019)	Located in the vicinity of the Clayton Hotel Dublin Airport located on the northern side of the R139 to the north of the development. This property has some 8 storeys. These properties are c.135m from the northern site boundary.	
C (May 2019)	Located on a grass verge in front of residential units located off the roundabout on the R139. These properties are c. 250m from the northern site boundary.	
D (May 2019)	Located on a point midway along the eastern boundary of the development site. This location is considered to be representative of background noise levels at the noise sensitive location located c. 65m to the east of the site.	N/A
E (Oct 2011& April 2013)	Located at the boundary of the IDA Business Park that adjoins the Larch Hill development to the west of the site. These properties are some 440m from the southern site boundary of the development. This location is considered to be indicative of the noise environment experienced at residences within the Larch Hill estate.	

2 Note this is the relevant version of the standard at the time of the survey being reported here.

Location	Description	Photo
F (Oct 2011& April 2013)	Located within the Woodlawn residential housing estate located to the south of the development site. The location is representative of dwellings in the vicinity. These properties are some 350m from the southern boundary of the development.	
G (Oct 2011& April 2013)	Located along the Clonshaugh Road adjacent to the entrance to Newbury Wood development. This location is considered representative of the nearest residential dwellings to the east of the site. These properties are some 200m from the eastern site boundary of the development.	

3.2 Survey Periods

Noise measurements were conducted during a daytime period and a typical night-time period that represents the time of night that provides a measure of existing background noise levels during a period where people are attempting to go to sleep or are sleeping. Due to the fact that the units in question here will operate on a 24-hour basis, their potential impact during night time periods is the critical issue. The surveys were conducted during the following periods:

- Daytime – 11:00 to 22:00hrs on 15 May 2019.
- Night-time – 23:00hrs on 15 May to 01:55hrs on 16 May 2019.
- Unattended – 13:10hrs on 17 May to 11:40hrs on 22 May 2019.
- Night-time – 23:40hrs on 4 October to 02:49hrs on 5 October 2011.
- Night-time – 23:00hrs on 25 April to 02:30hrs on 26 April 2013.
- Night-time – 23:00hrs on 12 October to 01:15hrs on 13 October 2015.
- Night-time – 22:45hrs on 19 October to 01:00hrs on 20 October 2015.

3.3 Personnel & Instrumentation

James Mangan (AWN) conducted the noise level measurements in 2011. Leo Williams conducted the noise level measurements in 2015. Donogh Casey (AWN) conducted the noise level measurements in 2019.

The noise measurements were performed using a Brüel & Kjær Type 2260 Sound Level Analyzer. Before and after the survey the measurement apparatus was check calibrated using a Brüel & Kjær Type 4231 Sound Level Calibrator. The unattended noise monitoring was completed used a RION NL-52 sound level meter.

3.4 Procedure

Measurements were conducted at the boundary location noted above. Sample periods for the noise measurements were typically 15 minutes. The results were noted onto a Survey Record Sheet immediately following each sample and were also saved to the instrument memory for later analysis if required. Survey personnel noted the primary noise sources contributing to noise build-up.

Figure 3 Noise Monitoring Locations

3.5 Measurement Parameters

The survey results are presented in terms of the following parameters:

L_{Aeq} is the equivalent continuous sound level. It is a type of average and is used to describe a fluctuating noise in terms of a single noise level over the sample period.

L_{A10} is the sound level that is exceeded for 10% of the sample period. It is typically used as a descriptor for traffic noise.

L_{A90} is the sound level that is exceeded for 90% of the sample period. It is typically used as a descriptor for background noise.

The "A" suffix denotes the fact that the sound levels have been "A-weighted" in order to account for the non-linear nature of human hearing. All sound levels in this report are expressed in terms of decibels (dB) relative to $2x10^{-5}$ Pa.

Another parameter that will be commented upon in this report is the L_{ArT}.

$L_{Ar\,T}$ The L_{Aeq} during a specified time interval, plus specified adjustments for tonal character and impulsiveness of the sound.

It should be noted for this assessment it has been assumed that detailed design will be carried out in order that there will be not tonal or impulsive noise emissions for the development. Therefore, in this instance L_{Aeq} is equal to $L_{Ar\,T}$.

3.6 Survey Results

3.6.1 Location A

The survey results for Location A are given in Table 2 below.

Table 2 Summary of Results for Location A

Time		Measured Noise Levels (dB re. $2x10^{-5}$ Pa)		
		L_{Aeq}	L_{AF10}	L_{AF90}
Day	11:16 – 11:31	67	68	64
	12:43 – 12:58	67	69	63
	14:39 – 14:54	64	65	62
	21:00 – 21:15	64	66	61
Night	23:40 – 00:05	65	61	55
	00:51 – 01:06	66	61	55

Daytime ambient and background noise levels at this location were dictated by road traffic noise from the M50 and M1. Other sources of noise included aircraft activity associated with Dublin Airport and some agricultural machinery. Ambient noise levels ranged from 64 to 67dB $L_{Aeq,15min}$ with background noise levels in the range of 61 to 64dB $L_{A90,15min}$.

During the night-time period road traffic noise was again the dominant noise source at this location with levels decreasing as the volume of traffic on the network deceased into the early hours of the morning. Noise levels were in the range of 65 to 66dB $L_{Aeq,15min}$ and the order of 55dB $L_{A90,15min}$.

3.6.2 Location B

The survey results for Location B are given in Table 3 below.

Table 3 Summary of Results for Location B

Time		Measured Noise Levels (dB re. $2x10^{-5}$ Pa)		
		L_{Aeq}	L_{AF10}	L_{AF90}
Day	11:54 – 12:09	62	64	59
	13:42 – 13:57	63	65	59
	15:12 – 15:27	63	64	59
	21:36 – 21:51	61	63	58
Night	00:09 – 00:24	57	57	52
	01:16 – 01:31	54	56	46

Daytime ambient and background noise levels at this location were dictated by road traffic noise from the R139, M50 and M1. Other sources of noise included aircraft activity associated with Dublin Airport and some agricultural machinery. Ambient noise levels ranged from 61 to 63dB $L_{Aeq,15min}$ with background noise levels in the range of 58 to 59dB $L_{A90,15min}$.

During the night-time period again road traffic noise was the dominant noise source at this location with levels decreasing as the volume of traffic on the network deceased into the early hours of the morning. Noise levels were in the range of 54 to 57dB $L_{Aeq,15min}$ and 46 to 52dB $L_{A90,15min}$.

3.6.3 Location C

The survey results for Location C are given in Table 4.

Table 4 Summary of Results for Location C

Time		Measured Noise Levels (dB re. $2x10^{-5}$ Pa)		
		L_{Aeq}	L_{AF10}	L_{AF90}
Day	12:18 – 12:33	65	68	56
	14:11 – 14:26	66	69	56
	15:36 – 15:51	65	69	57
	21:56 – 22:09	61	64	54
Night	00:28 – 00:42	59	60	48
	01:35 – 01:50	52	55	42

Daytime ambient and background noise levels at this location were dictated by road traffic noise from the R139, M50 and M1. Other sources of noise included aircraft activity associated with Dublin Airport and some agricultural machinery. Ambient noise levels ranged from 65 to 66dB $L_{Aeq,15min}$ with background noise levels in the range of 56 to 57dB $L_{A90,15min}$.

During the night-time period road traffic noise was again the dominant noise source at this location with levels decreasing as the volume of traffic on the network deceased into the early hours of the morning. Noise levels were in the range of 52 to 59dB $L_{Aeq,15min}$ and 42 to 48dB $L_{A90,15min}$

3.6.4 Location D

The profile of the ambient (i.e. $L_{Aeq,15min}$) and background noise levels (i.e. $L_{A90,15min}$) measured during the survey undertaken at Location D are presented in Figure 4.

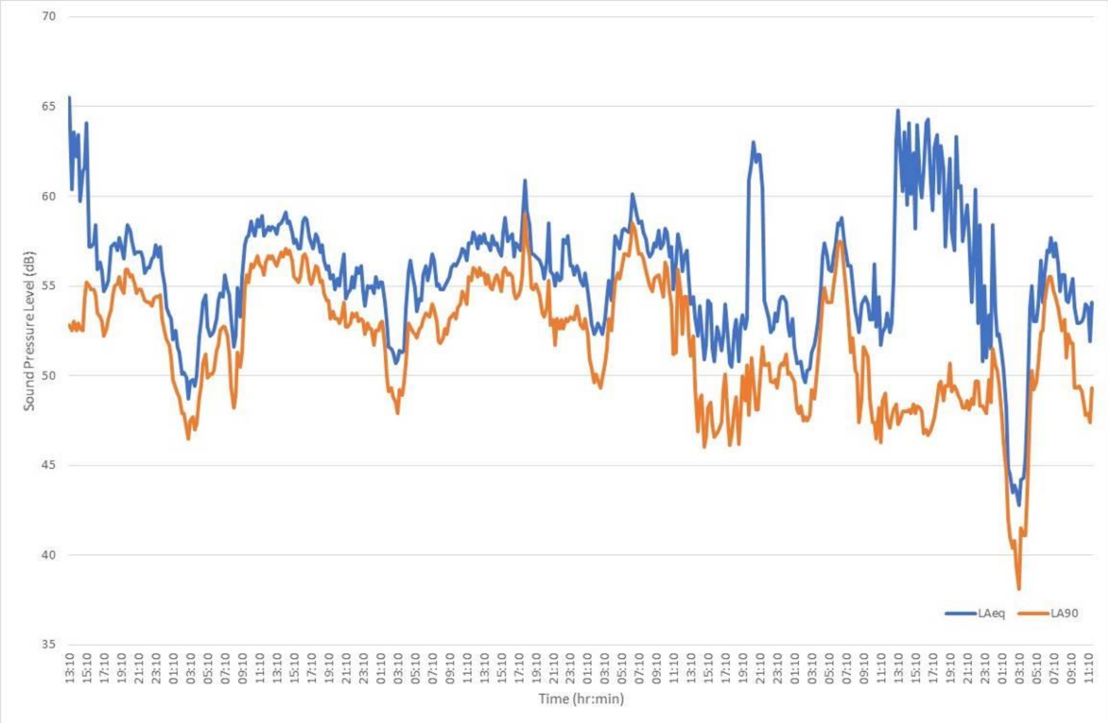

Figure 4 Noise Profile at Location D

The survey results for Location D are given in Table 5.

Table 5 Summary of Results for Location D

Location	Period	Time	Measured Noise Levels (dB re. 2x10^{-5} Pa)	
			L_{Aeq} (Ambient)	L_{AF90} (Background)
D	Day	Average	57	53
	Night	Average	54	51

Daytime ambient and background noise levels at this location were dictated by road traffic noise from the R139, M50 and M1. Other sources of noise included aircraft activity associated with Dublin Airport and some commercial machinery. Ambient noise levels were the order of 57dB $L_{Aeq,16hr}$ with background noise levels the order of 53dB $L_{A90,16hr}$.

During the night-time period again road traffic noise was the dominant noise source at this location with levels decreasing as the volume of traffic on the network deceased into the early hours of the morning. Noise levels were in the order of 54dB $L_{Aeq,8hr}$ and 51dB $L_{A90,8hr}$.

3.6.5 Location E

The survey results for Location E are given in Table 6 below.

Table 6 Summary of Results for Location E

Time		Measured Noise Levels (dB re. $2x10^{-5}$ Pa)		
		L_{Aeq}	L_{AF10}	L_{AF90}
Night-time	23:10 – 23:25	51	50	46
	00:31 – 00:46	49	51	46
	01:35 – 01:50	49	51	45

Night time noise levels were influenced by distant road traffic movements along the Oscar Traynor Road, M1 and M50 motorways, occasional local vehicle movements and wind generated noise on nearby foliage. Ambient noise levels were in the range of 49 to 51dB L_{Aeq}. Background noise levels were in the range 45 to 46dB L_{AF90}.

3.6.6 Location F

The survey results for Location F are given in Table 7.

Table 7 Summary of Results for Location F

Time		Measured Noise Levels (dB re. $2x10^{-5}$ Pa)		
		L_{Aeq}	L_{AF10}	L_{AF90}
Night-time	22:56 – 23:09	52	54	51
	23:45 – 00:00	51	53	49
	00:23 – 00:38	50	52	47

Traffic noise from the M1 and the distant M1/M50 junction dictated noise levels at this location during the period both in terms of overall ambient noise and background levels. Levels reduced slightly as the survey period progressed due to a reduction in traffic volumes on the nearby and distant road network. Ambient noise levels were in the range of 51 to 52dB $L_{Aeq,15min}$. Background noise levels which were dictated by traffic noise were in the range 47 to 51dB $L_{AF90,15min}$.

3.6.7 Location G

The survey results for Location G are given in Table 8.

Table 8 Summary of Results for Location G

Time		Measured Noise Levels (dB re. $2x10^{-5}$ Pa)		
		L_{Aeq}	L_{AF10}	L_{AF90}
Night-time	00:06 – 00:21	57	58	49
	01:14 – 01:29	56	56	50

Night time noise levels were influenced by occasional road traffic movements along Clonshaugh Road, plant noise from a nearby industrial facility (i.e. an industrial facility not associated with the subject site) and wind generated noise on nearby foliage. Ambient noise levels were in the range of 56 to 57dB L_{Aeq}. Background noise levels were in the range 49 to 50dB L_{AF90}.

3.6.8 Updated Noise Survey

An additional noise survey was carried out over a typical night time period in 2013 prior to the development of Buildings B and C. The survey was carried out primarily to confirm the existing noise environment with Phase 1 of the development operational. Appendix C outlines the details of this noise survey. Monitoring was carried out at the same locations considered in the 2011 work.

Table 9 reviews the results of the recent noise survey. In general, a similar noise environment to that observed previously was noted again with the exception of reduced wind generated noise and as a result slightly lower L_{AF90} levels.

Table 9 Review of 2013 Noise Monitoring

Location	Time	Measured Noise Levels (dB re. 2x10^{-5} Pa)			Comments
		L_{Aeq}	L_{AF10}	L_{AF90}	
E	23:34 – 23:49	50	43	41	Traffic on Oscar Traynor Road. Distant traffic. Plant not audible.
	00:52 – 01:07	51	51	41	As above.
	02:08 – 02:23	50	54	43	Road traffic reduced. Distant plant just audible but not significant.
F	23:10 – 23:25	49	51	44	Distant plant from a number of sites. Not possible to distinguish specific sources. Distant traffic and occasional local traffic movements.
	00:31 – 00:46	47	47	42	As above. Reduced traffic.
	01:35 – 01:50	45	46	42	As above. Reduced traffic.
G	00:06 – 00:21	52	51	40	Distant traffic and plant audible. Source of plant noise not obvious. L_{Aeq} dictated by movements on local roads.
	01:14 – 01:29	41	41	40	As above. No vehicle movements local road.

3.7 Ecologically sensitive areas or areas of special interest

The AA Screening identifies that the lands in which the installation is located have no formal designations, and that the nearest European site to the Installation are the Dublin Bay sites, with the nearest being South Dublin Bay and River Tolka Estuary SPA (Site Code 004024) situated almost 4km to the south. Other nearby sites are the North Dublin Bay SAC (000206) and North Bull Island SPA (Site Code 004006); these are located over 4km to the east of the Project.

An Appropriate Assessment (AA) Screening Report (Attachment 6-3-4) has been prepared by Moore Group and have been submitted as part of the licence application for the site.

Based on the separation distance from the facility to the nearest ecologically sensitive area and European site, it is highly unlikely that noise arising from the facility under any scenario would have any impact on these sites. Therefore, the noise impact on ecologically sensitive area has been scoped out of any further assessment.

4.0 REVIEW OF RELEVANT GUIDANCE

This section deals with ‘Stage 2’ of the noise impact assessment as outlined in the EPA’s NG4 Guidance.

The discussion of appropriate IE Licence noise emission criteria for the overall facility will be conducted in accordance with the NG4 document. This approach is summarised below in accordance with guidance detailed in Section 4 of the NG4 document.

4.1 Quiet Area Screening

The proposed development is not considered a quiet area in this instance as it fails to meet any of the criteria outlined in EPA’s Guidance. The most stringent of these criteria are noted in bullet point and commented on below.

- At least 3km from urban area with a population >1,000 people;

The site is within the jurisdiction of Dublin City Council and is located less than 3km from a population significantly greater than 1,000.

- At least 3km away from any local industry;

Other industrial sites operate within 3km of the site.

- At least 5km away from any National Primary Route;

A section of the M50 and N81 national roads are located within 0.9 and 0.7km respectively.

4.2 Low Background Noise Area Screening

In order to establish whether the noise sensitive locations in the vicinity of the site would be considered ‘low background noise’ areas, the noise levels measured during the environmental noise survey need to satisfy all three of the following criteria:

- Arithmetic Average of L_{A90} During Daytime Period ≤40dB L_{A90}, and;
- Arithmetic Average of L_{A90} During Evening Period ≤35dB L_{A90}, and;
- Arithmetic Average of L_{A90} During Night-time Period ≤30dB L_{A90}.

The arithmetic average L_{A90} results at each location are compared against the criteria in Table 10. As can be seen, none of the locations would be considered ‘Areas of Low Background Noise’ as the measured noise levels do not satisfy the criteria.

Table 10 Comparison of Measurement Results with NG4 Low Background Noise Area Criteria

Location	Period	$L_{A90,T}$ (dB)	NG4 Screening (dB $L_{A90,T}$)	Satisfies All Criteria for Low Background Noise Area?
A	Daytime	60	≤40	No
	Evening	61	≤35	
	Night-time	55	≤30	
B	Daytime	59	≤40	No
	Evening	58	≤35	
	Night-time	46	≤30	

Location	Period	$L_{A90,T}$ (dB)	NG4 Screening (dB $L_{A90,T}$)	Satisfies All Criteria for Low Background Noise Area?
C	Daytime	46	≤40	No
	Evening	54	≤35	
	Night-time	42	≤30	
D	Daytime	53	≤40	No
D	Evening	52	≤35	No
	Night-time	51	≤30	
E	Night-time	42	≤30	No
F	Night-time	43	≤30	No
G	Night-time	40	≤30	No

4.3 Determining Appropriate Noise Criteria

Based on the EPA NG4 guidance, the following noise criteria are appropriate at the nearest NSL's to the facility:

- Daytime (07:00 to 19:00hrs) 55dB $L_{Ar,15min}$
- Evening (19:00 to 23:00hrs) 50dB $L_{Ar,15min}$
- Night time (23:00 to 07:00hrs) 45dB $L_{Aeq,15min}$

During the night period, no tonal or impulsive noise from the facility should be clearly audible or measurable at any NSL. The applicable noise criteria identified are in line with the typical limit values for noise from licensed sites.

There are certain plant items proposed for the development site that are designed to be used in emergency situations, for example, when grid power supplies fail. It is common practice to allow a relaxation of noise limits associated with emergency plant operations. Section 4.4.1 of EPA NG4 contains the following comments in relation to emergency plant items:

> *"In some instances, licensed sites will have certain items of emergency equipment (e.g. standby generators) that will only operate in urgent situations (e.g. grid power failure). Depending upon the context, it may be deemed permissible for such items of equipment to give rise to exceedances in the noise criteria/limits during limited testing and emergency operation only. If such equipment is in regular use for any purposes other than intermittent testing, it is subject to the standard limit values for the site".*

It is therefore considered that the proposed noise criterion of 55dB $L_{Aeq,(15mins)}$ is appropriate in emergency scenarios for daytime, evening and night-time periods.

4.4 Compliance Noise Monitoring

See Attachment 7.5 of the Licence application for further details on the noise sensitive locations. Given there may be potential access constraints at some noise sensitive locations and the presence of extraneous noise sources in the vicinity, it may be necessary to undertake compliance noise monitoring (if required) at the site boundary or at a suitable proxy location and assess to the nearest NSL's. Any such assessment should be undertaken in accordance with the guidance outlined in the EPA NG4 document and supported by a sufficiently detailed noise report outlining the calculation methods used to determine the noise emission levels at the NSL's.

5.0 ASSESSMENT

This section deals with 'Stage 3' of the noise impact assessment as outlined in the EPA's NG4 Guidance.

The noise levels expected at nearest NSL's, due to the operation of the facility, must be considered and presented as part of the licence application.

The following sections present details of the assessment and the findings. Further information in relation to the noise prediction model, inputs, calculation settings and assessment assumptions are provided in Appendix B to this report.

It should be noted that noise impact assessment has been completed using information obtained from the design team for significant items of plant which in turn were procured from vendors.

5.1 Noise Sensitive Locations

Noise prediction calculations have been carried out at the representative nearest noise sensitive locations (NSL's) surrounding the site. Details of the NSL's used for the prediction calculations are presented in Table 11. Free field noise emission levels have been predicted at a height stated in Table 11.

Table 11 Coordinates of Noise Sensitive Receivers

Noise Sensitive Location	Calculation Height (m)	National Grid Reference	
		North	East
R01	4	718,674	740,333
R02	4	718,707	740,261
R03	4	718,733	740,124
R04	4	718,559	739,929
R05	4	718,392	740,023
R06	4	718,315	740,044
R07	4	718,197	740,073
R08	4	717,951	740,175
R09	4	717,958	740,250
R10	4	717,878	740,322
R11	4	717,815	740,409
R12	4	717,700	740,464
R13	4	717,604	740,495
R14	4	717,569	740,567
R15	4	717,656	741,184
R16	4	717,639	741,274
R17	4	717,632	741,373
R18	4	718,629	741,031
R19	4	718,726	740,857
R20	4	718,739	740,764
R21	4	718,680	740,684
R22	4	718,646	740,649
R23	4	718,607	740,563
R24	4	718,645	740,422

5.2 Noise Source Data

Details of the noise source data assumed in the noise model are presented in Appendix C and D of this document.

Figure 4 Noise Assessment Locations

5.3 Calculation Methodology

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

5.3.1 *DGMR iNoise*

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

DGMR iNoise is a proprietary noise calculation package for computing noise levels in the vicinity of noise sources. Predictor 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).

5.3.2 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, L_{AT}(DW), for the following conditions:

- wind direction at an angle of ±45° to the direction connecting the centre of the dominant sound source and the centre of the specified receiver region with the wind blowing from source to receiver, and;
- wind speed between approximately 1ms^{-1} and 5ms^{-1}, measured at a height of 3m to 11m above the ground.

The equations and calculations also hold for average propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs on clear calm nights. The basic formula for calculating $L_{AT}(DW)$ from any point source at any receiver location is given by:

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

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 12 below:

Table 12 Estimated Accuracy for Broadband Noise of $L_{AT}(DW)$

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

* *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.*

5.3.3 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 Clifton Scannell Emerson.

Local Area The location of noise sensitive locations has been obtained from a combination of site drawings provided by Clifton Scannell Emerson and others obtained from Ordinance Survey Ireland (OSI).

Heights The heights of buildings on site have been obtained from site drawings forwarded by Clifton Scannell Emerson. Off-site buildings have been assumed to be 8m high for houses and 16m for apartments with the exception of industrial buildings where a default height of 15m has been assumed.

Contours Site ground contours/heights have been obtained from site drawings forwarded by Clifton Scannell Emerson where available.

5.4 Predicted Noise Levels

This section presents the predicted noise levels at the nearest noise sensitive locations. The cumulative (Building W, Z and Y) impact of all modelled noise sources on the site has been assessed for two distinct operational scenarios.

Scenario A would be considered to be the most representative of the day to day operation.

Scenario B is representative of emergency situation; a loss, reduction or instability of grid power supply, critical maintenance to power systems, a request from the utility supplier (or third party acting on its behalf) to reduce grid electricity load. It should be noted that such an event is an extremely rare occurrence.

Figures 5 and 6 presents the predicted noise contour plot for mechanical services and process plant associated with the development for Scenarios A and B receptively.

The predicted cumulative (Building W, Z and Y)noise levels from mechanical plant at Buildings W and X are tabulated in Table 13 for each NSL.

Table 13 Predicted Cumulative Operational Noise Levels at NSL's for Mechanical Plant Items at Building W, X, and Y

Location	Plant Predicted Level (dB)	
	Scenario A	Scenario B
R01	38	46
R02	38	46
R03	34	42
R04	35	44
R05	39	47
R06	39	47
R07	38	48
R08	37	48
R09	38	48
R10	38	49
R11	36	48
R12	35	47
R13	35	46
R14	34	45
R15	31	34
R16	31	34
R17	31	34
R18	35	38
R19	40	43
R20	42	45
R21	41	44
R22	42	54
R23	41	49
R24	38	46

Table 14 presents the predicted plant noise emission levels at the nearest NSL's and compares the results against the relevant criteria that have been derived for the site for Scenario A.

Table 14 Predicted Operational Noise Levels vs Criteria – Scenario A

Receptor	Predicted $L_{Aeq,T}$	Day (07:00 – 19:00hrs)		Evening (19:00 – 23:00hrs)		Night (23:00 – 07:00hrs)	
		Criterion dB $L_{Ar,T}$	Complies?	Criterion dB $L_{Ar,T}$	Complies?	Criterion dB $L_{Aeq,T}$	Complies?
R01	38	55	Yes	50	Yes	45	Yes
R02	38		Yes		Yes		Yes
R03	34		Yes		Yes		Yes
R04	35		Yes		Yes		Yes
R05	39		Yes		Yes		Yes
R06	39		Yes		Yes		Yes
R07	38		Yes		Yes		Yes
R08	37		Yes		Yes		Yes
R09	38		Yes		Yes		Yes
R10	38		Yes		Yes		Yes
R11	36		Yes		Yes		Yes
R12	35		Yes		Yes		Yes
R13	35		Yes		Yes		Yes
R14	34		Yes		Yes		Yes
R15	31		Yes		Yes		Yes
R16	31		Yes		Yes		Yes
R17	31		Yes		Yes		Yes
R18	35		Yes		Yes		Yes
R19	40		Yes		Yes		Yes
R20	42		Yes		Yes		Yes
R21	41		Yes		Yes		Yes
R22	42		Yes		Yes		Yes
R23	41		Yes		Yes		Yes
R24	38		Yes		Yes		Yes
R25	35		Yes		Yes		Yes
R26	33		Yes		Yes		Yes
R27	31		Yes		Yes		Yes
R28	35		Yes		Yes		Yes

Table 15 presents the predicted plant noise emission levels at the nearest NSL's and compares the results against the relevant criteria that have been derived for the site for Scenario B.

Table 15 Predicted Operational Noise Levels vs Criteria – Scenario B

Receptor	Predicted $L_{Aeq,T}$	Day (07:00 – 19:00hrs)		Evening (19:00 – 23:00hrs)		Night (23:00 – 07:00hrs)	
		Criterion dB $L_{Ar,T}$	Complies?	Criterion dB $L_{Ar,T}$	Complies?	Criterion dB $L_{Aeq,T}$	Complies?
R01	46	55	Yes	55	Yes	55	Yes
R02	46		Yes		Yes		Yes
R03	42		Yes		Yes		Yes
R04	44		Yes		Yes		Yes
R05	47		Yes		Yes		Yes
R06	47		Yes		Yes		Yes
R07	48		Yes		Yes		Yes
R08	48		Yes		Yes		Yes
R09	48		Yes		Yes		Yes
R10	49		Yes		Yes		Yes
R11	48		Yes		Yes		Yes
R12	47		Yes		Yes		Yes
R13	46		Yes		Yes		Yes
R14	45		Yes		Yes		Yes
R15	34		Yes		Yes		Yes
R16	34		Yes		Yes		Yes
R17	34		Yes		Yes		Yes
R18	38		Yes		Yes		Yes
R19	43		Yes		Yes		Yes
R20	45		Yes		Yes		Yes
R21	44		Yes		Yes		Yes
R22	54		Yes		Yes		Yes
R23	49		Yes		Yes		Yes
R24	46		Yes		Yes		Yes
R25	46		Yes		Yes		Yes
R26	41		Yes		Yes		Yes
R27	42		Yes		Yes		Yes
R28	47		Yes		Yes		Yes

Figure 5 Operational Noise Prediction Contours – Scenario A

Figure 6 Operational Noise Prediction Contours – Scenario B

6.0 CONCLUSION

A detailed noise survey has been completed at seven noise sensitive locations surrounding the site to establish the existing noise environment. This work has demonstrated that the existing noise environment is dictated by road traffic noise and noise associated with aircraft movements and some existing industry plant noise.

In accordance with the relevant NG4 Guidance, appropriate operational noise criteria have been derived for the site which are based on consideration of the existing licence noise conditions and the existing noise environment at the nearest NSL's.

A noise impact assessment has been completed using information obtained from the design team for significant items of mechanical plant. A detailed computer-based noise model has been prepared using proprietary noise modelling software in accordance with the calculation method outlined in ISO 9613-2:1996.

The predicted noise levels at all NSL's are below the day, evening and night-time noise criteria that are applicable to the site operations.

APPENDIX A
GLOSSARY OF ACOUSTIC TERMINOLOGY

ambient noise The totally encompassing sound in a given situation at a given time, usually composed of sound from many sources, near and far.

background noise The steady existing noise level present without contribution from any intermittent sources. The A-weighted sound pressure level of the residual noise at the assessment position that is exceeded for 90 per cent of a given time interval, T ($L_{AF90,T}$).

broadband Sounds that contain energy distributed across a wide range of frequencies.

dB Decibel - The scale in which sound pressure level is expressed. It is defined as 20 times the logarithm of the ratio between the RMS pressure of the sound field and the reference pressure of 20 micro-pascals (20 μPa).

dB L_{pA} An ‘A-weighted decibel’ - a measure of the overall noise level of sound across the audible frequency range (20 Hz – 20 kHz) with A-frequency weighting (i.e. ‘A’–weighting) to compensate for the varying sensitivity of the human ear to sound at different frequencies.

Hertz (Hz) The unit of sound frequency in cycles per second.

impulsive noise A noise that is of short duration (typically less than one second), the sound pressure level of which is significantly higher than the background.

$L_{Aeq,T}$ This is the equivalent continuous sound level. It is a type of average and is used to describe a fluctuating noise in terms of a single noise level over the sample period (T).The closer the L_{Aeq} value is to either the L_{AF10} or L_{AF90} value indicates the relative impact of the intermittent sources and their contribution. The relative spread between the values determines the impact of intermittent sources such as traffic on the background.

L_{AFN} The A-weighted noise level exceeded for N% of the sampling interval. Measured using the “Fast” time weighting.

L_{AFmax} is the instantaneous slow time weighted maximum sound level measured during the sample period (usually referred to in relation to construction noise levels).

$L_{Ar,T}$ The Rated Noise Level, equal to the L_{Aeq} during a specified time interval (T), plus specified adjustments for tonal character and impulsiveness of the sound.

L_{AF90} Refers to those A-weighted noise levels in the lower 90 percentile of the sampling interval; it is the level which is exceeded for 90% of the measurement period. It will therefore exclude the intermittent features of traffic and is used to estimate a background level. Measured using the “Fast” time weighting.

APPENDIX A
GLOSSARY OF ACOUSTIC TERMINOLOGY (Continued)

L_{AT}(DW) equivalent continuous downwind sound pressure level.

L_{fT}(DW) equivalent continuous downwind octave-band sound pressure level.

low frequency noise LFN - noise which is dominated by frequency components towards the lower end of the frequency spectrum.

noise Any sound, that has the potential to cause disturbance, discomfort or psychological stress to a person exposed to it, or any sound that could cause actual physiological harm to a person exposed to it, or physical damage to any structure exposed to it, is known as noise.

noise sensitive location NSL – Any dwelling house, hotel or hostel, health building, educational establishment, place of worship or entertainment, or any other facility or other area of high amenity which for its proper enjoyment requires the absence of noise at nuisance levels.

octave band A frequency interval, the upper limit of which is twice that of the lower limit. For example, the 1,000Hz octave band contains acoustical energy between 707Hz and 1,414Hz. The centre frequencies used for the designation of octave bands are defined in ISO and ANSI standards.

rating level See $L_{Ar,T}$.

sound power level The logarithmic measure of sound power in comparison to a referenced sound intensity level of one picowatt (1pW) where:

$$Lw = 10 Log \frac{P}{P_0} \text{ dB}$$

Where: p is the rms value of sound power in pascals; and

P_0 is 1 pW.

sound pressure level The sound pressure level at a point is defined as:

$$Lp = 20 Log \frac{P}{P_0} \text{ dB}$$

specific noise level A component of the ambient noise which can be specifically identified by acoustical means and may be associated with a specific source. In BS 4142, there is a more precise definition as follows: 'the equivalent continuous A-weighted sound pressure level at the assessment position produced by the specific noise source over a given reference time interval ($L_{Aeq, T}$)'.

APPENDIX A
GLOSSARY OF ACOUSTIC TERMINOLOGY (Continued)

tonal Sounds which cover a range of only a few Hz which contains a clearly audible tone i.e. distinguishable, discrete or continuous noise (whine, hiss, screech, or hum etc.) are referred to as being 'tonal'.

$^{1}/_{3}$ octave analysis Frequency analysis of sound such that the frequency spectrum is subdivided into bands of one–third of an octave each.

APPENDIX B
NOISE MODELLING DETAILS

Noise Model

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

DGMR iNoise

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

DGMR iNoise is a proprietary noise calculation package for computing noise levels in the vicinity of noise sources. Predictor 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, $L_{AT}(DW)$, for the following conditions:

- wind direction at an angle of ±45° to the direction connecting the centre of the dominant sound source and the centre of the specified receiver region with the wind blowing from source to receiver, and;
- wind speed between approximately $1ms^{-1}$ and $5ms^{-1}$, measured at a height of 3m to 11m above the ground.

The equations and calculations also hold for average propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs on clear calm nights.

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 B.1 below:

Table B.1 Estimated Accuracy for Broadband Noise of L_{AT}(DW)

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

* 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 Kavanagh Tuite Architects.

Local Area The location of noise sensitive locations has been obtained from a combination of site drawings provided by Kavanagh Tuite Architects and others obtained from Ordinance Survey Ireland (OSI).

Heights The heights of buildings on site have been obtained from site drawings forwarded by Kavanagh Tuite Architects. Off-site buildings have been assumed to be 8m high for houses and 16m for apartments with the exception of industrial buildings where a default height of 15m has been assumed.

Contours Site ground contours/heights have been obtained from site drawings forwarded by Kavanagh Tuite Architects where available.

Figure B1 presents a 3D render of the developed site noise model for the current proposals.

Modelling Calculation Parameters[3]

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 1.0 have been assumed. No metrological corrections were assumed for the calculations. The atmospheric attenuation outlined in Table B.3 has been assumed for all calculations.

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

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

3 See Appendix D for further discussion of calculation parameters.

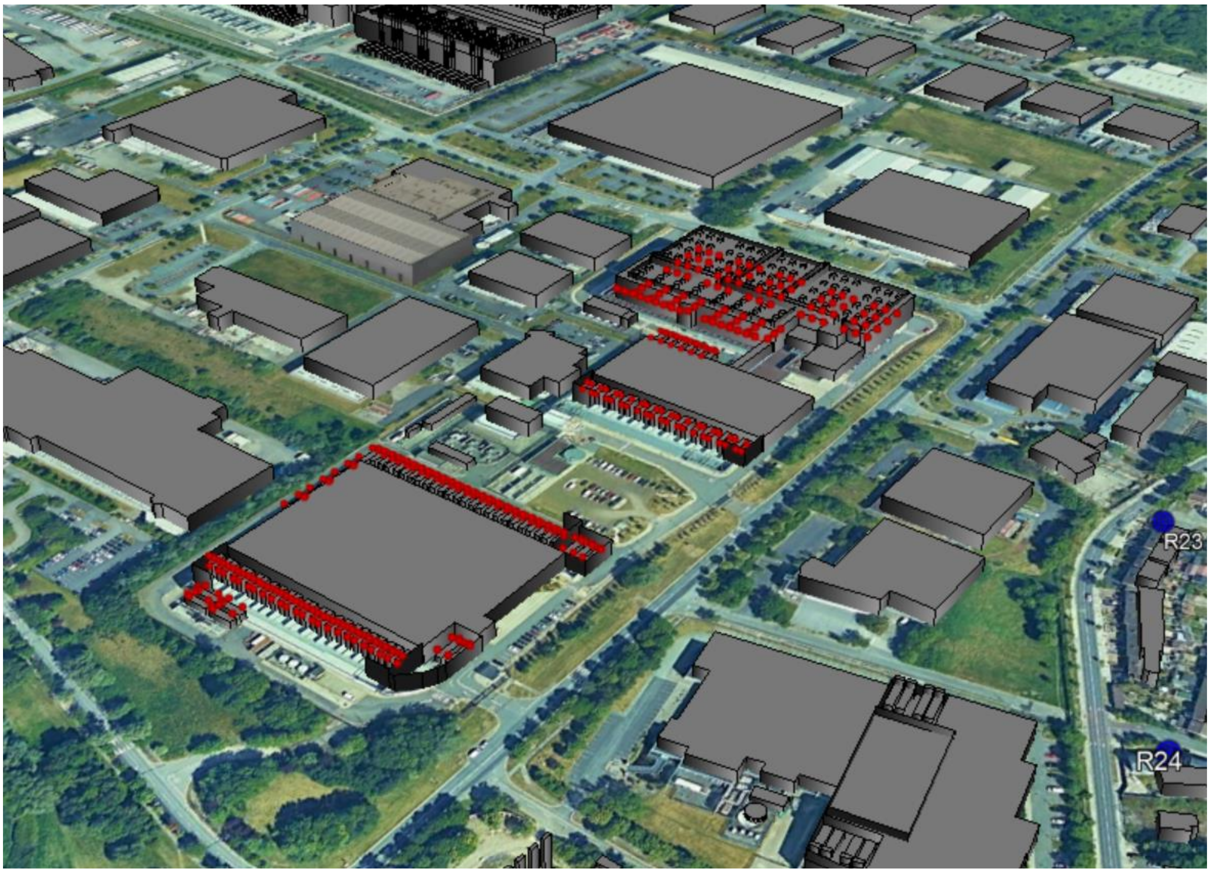

Figure B1 Images of Developed Noise Model – View of Site

APPENDIX C
BUILDING W – NOISE SOURCE DATA (MEASURED)

Predictor Ref	Danann AHU Type	Duty / Pressure	Octave Bands (Hz) Sound Power Levels dB (A-weighted) per band									L_{wA}
			31.5	63	125	250	500	1000	2000	4000	8000	
1 S Int	DA55.45.	26.7m^3/s at 725pa Supply.	55.0	62.7	69.7	79.4	77.2	75.9	73.6	68.3	62.0	83.4
1 S Exh 2	DA55.45.	25.37m^3/s at 600pa Return	56.8	64.0	73.8	80.0	79.4	78.1	76.4	71.0	62.9	85.3
1 S Exh 1	DA55.45.	25.37m^3/s at 600pa Return	56.5	64.8	76.7	83.7	82.7	81.2	79.1	72.8	65.6	88.5
2 S Int	DA55.45.	26.7m^3/s at 725pa Supply.	55.4	63.2	69.4	80.4	78.1	76.3	73.9	68.7	59.3	84.2
2 S Exh 2	DA55.45.	25.37m^3/s at 600pa Return	58.7	67.1	74.7	79.4	79.1	76.5	75.2	70.2	61.6	84.7
2 S Exh 1	DA55.45.	25.37m^3/s at 600pa Return	56.8	64.0	73.8	80.0	79.4	78.1	76.4	71.0	62.9	85.3
3 S Int	DA55.45.	26.7m^3/s at 725pa Supply.	55.8	62.9	70.1	80.1	78.6	77.1	74.6	69.4	62.2	84.4
3 S Exh 2	DA55.45.	25.37m^3/s at 600pa Return	56.1	64.7	72.2	76.7	76.7	75.7	74.1	69.5	61.9	82.7
3 S Exh 1	DA55.45.	25.37m^3/s at 600pa Return	58.7	67.1	74.7	79.4	79.1	76.5	75.2	70.2	61.6	84.7
4 S Int	DA55.45.	26.7m^3/s at 725pa Supply.	55.8	62.9	70.1	80.1	78.6	77.1	74.6	69.4	62.2	84.4
4 S Exh 2	DA55.45.	25.37m^3/s at 600pa Return	53.9	61.3	74.2	76.4	74.9	74.2	72.0	67.9	64.4	81.9
4 S Exh 1	DA55.45.	25.37m^3/s at 600pa Return	56.1	64.7	72.2	76.7	76.7	75.7	74.1	69.5	61.9	82.7
5 S Int	DA55.45.	26.7m^3/s at 725pa Supply.	55.2	62.8	69.8	79.6	77.9	76.4	73.7	68.6	64.7	83.8
5 S Exh 2	DA55.45.	25.37m^3/s at 600pa Return	55.4	62.8	72.0	75.1	75.6	72.9	70.6	66.3	61.3	80.9
5 S Exh 1	DA55.45.	25.37m^3/s at 600pa Return	53.9	61.3	74.2	76.4	74.9	74.2	72.0	67.9	64.4	81.9
6 S Int	DA55.45.	26.7m^3/s at 725pa Supply.	54.3	61.9	67.9	74.8	75.1	73.4	70.1	65.1	55.6	80.3
6 S Exh 2	DA55.45.	25.37m^3/s at 600pa Return	54.2	62.5	74.7	80.2	75.9	74.6	72.8	68.1	59.5	83.7
6 S Exh 1	DA55.45.	25.37m^3/s at 600pa Return	55.4	62.8	72.0	75.1	75.6	72.9	70.6	66.3	61.3	80.9
7 S Int	DA55.45.	26.7m^3/s at 725pa Supply.	55.5	63.3	69.1	78.0	77.6	75.9	73.0	67.9	57.4	82.9
7 S Exh 2	DA55.45.	25.37m^3/s at 600pa Return	55.7	63.0	73.2	78.9	78.1	75.2	74.0	68.8	59.9	83.7
7 S Exh 1	DA55.45.	25.37m^3/s at 600pa Return	54.2	62.5	74.7	80.2	75.9	74.6	72.8	68.1	59.5	83.7
8 S Int	DA55.45.	26.7m^3/s at 725pa Supply.	54.4	62.5	69.4	79.4	78.0	77.0	73.8	68.6	59.2	83.9
8 S Exh 2	DA55.45.	25.37m^3/s at 600pa Return	53.7	61.2	69.1	73.4	76.0	73.4	71.5	66.7	58.9	80.6
8 S Exh 1	DA55.45.	25.37m^3/s at 600pa Return	55.7	63.0	73.2	78.9	78.1	75.2	74.0	68.8	59.9	83.7
9 S Int	DA55.45.	26.7m^3/s at 725pa Supply.	55.0	62.7	69.7	79.4	77.2	75.9	73.6	68.3	62.0	83.4
9 S Exh 2	DA55.45.	25.37m^3/s at 600pa Return	56.8	64.0	73.8	80.0	79.4	78.1	76.4	71.0	62.9	85.3
9 S Exh 1	DA55.45.	25.37m^3/s at 600pa Return	56.5	64.8	76.7	83.7	82.7	81.2	79.1	72.8	65.6	88.5
10 S Int	DA55.45.	26.7m^3/s at 725pa Supply.	55.4	63.2	69.4	80.4	78.1	76.3	73.9	68.7	59.3	84.2
10 S Exh 2	DA55.45.	25.37m^3/s at 600pa Return	58.7	67.1	74.7	79.4	79.1	76.5	75.2	70.2	61.6	84.7

Predictor Ref	Danann AHU Type	Duty / Pressure	Octave Bands (Hz) Sound Power Levels dB (A-weighted) per band									L_{wA}
			31.5	63	125	250	500	1000	2000	4000	8000	
10 S Exh 1	DA55.45.	25.37m^3/s at 600pa Return	56.8	64.0	73.8	80.0	79.4	78.1	76.4	71.0	62.9	85.3
11 S Int	DA55.45.	26.7m^3/s at 725pa Supply.	55.8	62.9	70.1	80.1	78.6	77.1	74.6	69.4	62.2	84.4
11 S Exh 2	DA55.45.	25.37m^3/s at 600pa Return	56.1	64.7	72.2	76.7	76.7	75.7	74.1	69.5	61.9	82.7
11 S Exh 1	DA55.45.	25.37m^3/s at 600pa Return	58.7	67.1	74.7	79.4	79.1	76.5	75.2	70.2	61.6	84.7
12 S Int	DA55.45.	26.7m^3/s at 725pa Supply.	55.8	62.9	70.1	80.1	78.6	77.1	74.6	69.4	62.2	84.4
12 S Exh 2	DA55.45.	25.37m^3/s at 600pa Return	53.9	61.3	74.2	76.4	74.9	74.2	72.0	67.9	64.4	81.9
12 S Exh 1	DA55.45.	25.37m^3/s at 600pa Return	56.1	64.7	72.2	76.7	76.7	75.7	74.1	69.5	61.9	82.7
13 S Int	DA55.45.	26.7m^3/s at 725pa Supply.	55.2	62.8	69.8	79.6	77.9	76.4	73.7	68.6	64.7	83.8
13 S Exh 2	DA55.45.	25.37m^3/s at 600pa Return	55.4	62.8	72.0	75.1	75.6	72.9	70.6	66.3	61.3	80.9
13 S Exh 1	DA55.45.	25.37m^3/s at 600pa Return	53.9	61.3	74.2	76.4	74.9	74.2	72.0	67.9	64.4	81.9
14 S Int	DA55.45.	26.7m^3/s at 725pa Supply.	54.3	61.9	67.9	74.8	75.1	73.4	70.1	65.1	55.6	80.3
14 S Exh 2	DA55.45.	25.37m^3/s at 600pa Return	54.2	62.5	74.7	80.2	75.9	74.6	72.8	68.1	59.5	83.7
14 S Exh 1	DA55.45.	25.37m^3/s at 600pa Return	55.4	62.8	72.0	75.1	75.6	72.9	70.6	66.3	61.3	80.9
15 S Int	DA55.45.	26.7m^3/s at 725pa Supply.	55.5	63.3	69.1	78.0	77.6	75.9	73.0	67.9	57.4	82.9
15 S Exh 2	DA55.45.	25.37m^3/s at 600pa Return	55.7	63.0	73.2	78.9	78.1	75.2	74.0	68.8	59.9	83.7
15 S Exh 1	DA55.45.	25.37m^3/s at 600pa Return	54.2	62.5	74.7	80.2	75.9	74.6	72.8	68.1	59.5	83.7
16 S Int	DA55.45.	26.7m^3/s at 725pa Supply.	54.4	62.5	69.4	79.4	78.0	77.0	73.8	68.6	59.2	83.9
16 S Exh 2	DA55.45.	25.37m^3/s at 600pa Return	53.7	61.2	69.1	73.4	76.0	73.4	71.5	66.7	58.9	80.6
16 S Exh 1	DA55.45.	25.37m^3/s at 600pa Return	55.7	63.0	73.2	78.9	78.1	75.2	74.0	68.8	59.9	83.7
17 S Int	DA55.45.	26.7m^3/s at 725pa Supply.	55.0	62.7	69.7	79.4	77.2	75.9	73.6	68.3	62.0	83.4
17 S Exh 2	DA55.45.	25.37m^3/s at 600pa Return	56.8	64.0	73.8	80.0	79.4	78.1	76.4	71.0	62.9	85.3
17 S Exh 1	DA55.45.	25.37m^3/s at 600pa Return	56.5	64.8	76.7	83.7	82.7	81.2	79.1	72.8	65.6	88.5
18 S Int	DA55.45.	26.7m^3/s at 725pa Supply.	55.4	63.2	69.4	80.4	78.1	76.3	73.9	68.7	59.3	84.2
18 S Exh 2	DA55.45.	25.37m^3/s at 600pa Return	58.7	67.1	74.7	79.4	79.1	76.5	75.2	70.2	61.6	84.7
18 S Exh 1	DA55.45.	25.37m^3/s at 600pa Return	56.8	64.0	73.8	80.0	79.4	78.1	76.4	71.0	62.9	85.3
19 S Int	DA55.45.	26.7m^3/s at 725pa Supply.	55.8	62.9	70.1	80.1	78.6	77.1	74.6	69.4	62.2	84.4
19 S Exh 2	DA55.45.	25.37m^3/s at 600pa Return	56.1	64.7	72.2	76.7	76.7	75.7	74.1	69.5	61.9	82.7
19 S Exh 1	DA55.45.	25.37m^3/s at 600pa Return	58.7	67.1	74.7	79.4	79.1	76.5	75.2	70.2	61.6	84.7
20 S Int	DA55.45.	26.7m^3/s at 725pa Supply.	55.8	62.9	70.1	80.1	78.6	77.1	74.6	69.4	62.2	84.4
20 S Exh 2	DA55.45.	25.37m^3/s at 600pa Return	53.9	61.3	74.2	76.4	74.9	74.2	72.0	67.9	64.4	81.9
20 S Exh 1	DA55.45.	25.37m^3/s at 600pa Return	56.1	64.7	72.2	76.7	76.7	75.7	74.1	69.5	61.9	82.7
21 S Int	DA55.45.	26.7m^3/s at 725pa Supply.	55.2	62.8	69.8	79.6	77.9	76.4	73.7	68.6	64.7	83.8

Predictor Ref	Danann AHU Type	Duty / Pressure	Octave Bands (Hz) Sound Power Levels dB (A-weighted) per band									L_{wA}
			31.5	63	125	250	500	1000	2000	4000	8000	
21 S Exh 2	DA55.45.	25.37m³/s at 600pa Return	55.4	62.8	72.0	75.1	75.6	72.9	70.6	66.3	61.3	80.9
21 S Exh 1	DA55.45.	25.37m³/s at 600pa Return	53.9	61.3	74.2	76.4	74.9	74.2	72.0	67.9	64.4	81.9
22 S Int	DA55.45.	26.7m³/s at 725pa Supply.	54.3	61.9	67.9	74.8	75.1	73.4	70.1	65.1	55.6	80.3
22 S Exh 2	DA55.45.	25.37m³/s at 600pa Return	54.2	62.5	74.7	80.2	75.9	74.6	72.8	68.1	59.5	83.7
22 S Exh 1	DA55.45.	25.37m³/s at 600pa Return	55.4	62.8	72.0	75.1	75.6	72.9	70.6	66.3	61.3	80.9
23 S Int	DA55.45.	26.7m³/s at 725pa Supply.	55.5	63.3	69.1	78.0	77.6	75.9	73.0	67.9	57.4	82.9
23 S Exh 2	DA55.45.	25.37m³/s at 600pa Return	55.7	63.0	73.2	78.9	78.1	75.2	74.0	68.8	59.9	83.7
23 S Exh 1	DA55.45.	25.37m³/s at 600pa Return	54.2	62.5	74.7	80.2	75.9	74.6	72.8	68.1	59.5	83.7
24 S Int	DA55.45.	26.7m³/s at 725pa Supply.	54.4	62.5	69.4	79.4	78.0	77.0	73.8	68.6	59.2	83.9
24 S Exh 2	DA55.45.	25.37m³/s at 600pa Return	53.7	61.2	69.1	73.4	76.0	73.4	71.5	66.7	58.9	80.6
24 S Exh 1	DA55.45.	25.37m³/s at 600pa Return	55.7	63.0	73.2	78.9	78.1	75.2	74.0	68.8	59.9	83.7
25 S Int	DA45.55.	26.7m³/s at 800pa Supply.	44.9	56.8	65.5	71.8	74.0	73.1	68.8	64.0	51.5	78.7
25 S Exh 2	DA45.55.	26.0m³/s at 700pa Return	50.8	60.3	76.2	76.9	83.2	84.8	80.9	77.7	68.1	89.0
25 S Exh 1	DA45.55.	26.0m³/s at 700pa Return	46.9	56.2	72.8	75.0	79.7	81.2	77.2	73.6	61.6	85.5
26 S Int	DA45.55.	26.7m³/s at 800pa Supply.	44.9	56.8	65.5	71.8	74.0	73.1	68.8	64.0	51.5	78.7
26 S Exh 2	DA45.55.	26.0m³/s at 700pa Return	44.8	54.3	70.2	70.9	77.2	78.8	74.9	71.7	62.1	83.0
26 S Exh 1	DA45.55.	26.0m³/s at 700pa Return	46.9	56.2	72.8	75.0	79.7	81.2	77.2	73.6	61.6	85.5
27 S Int	DA45.55.	26.7m³/s at 800pa Supply.	44.8	56.3	66.2	71.3	74.3	73.5	69.1	64.4	54.1	79.0
27 S Exh 2	DA45.55.	26.0m³/s at 700pa Return	45.4	55.4	73.3	74.5	79.2	81.1	77.2	73.5	63.4	85.3
27 S Exh 1	DA45.55.	26.0m³/s at 700pa Return	44.8	54.3	70.2	70.9	77.2	78.8	74.9	71.7	62.1	83.0
28 S Int	DA45.55.	26.7m³/s at 800pa Supply.	45.5	56.4	66.6	71.9	74.3	73.5	68.7	64.2	53.0	79.0
28 S Exh 2	DA45.55.	26.0m³/s at 700pa Return	49.0	59.7	75.7	74.2	81.2	83.2	78.5	74.3	63.5	87.1
28 S Exh 1	DA45.55.	26.0m³/s at 700pa Return	45.4	55.4	73.3	74.5	79.2	81.1	77.2	73.5	63.4	85.3
29 S Int	DA45.55.	26.7m³/s at 800pa Supply.	45.5	56.4	66.6	71.9	74.3	73.5	68.7	64.2	53.0	79.0
29 S Exh 2	DA45.55.	26.0m³/s at 700pa Return	47.0	55.8	71.6	73.5	77.9	80.0	75.5	71.3	59.9	84.0
29 S Exh 1	DA45.55.	26.0m³/s at 700pa Return	49.0	59.7	75.7	74.2	81.2	83.2	78.5	74.3	63.5	87.1
30 S Int	DA45.55.	26.7m³/s at 800pa Supply.	45.8	57.1	67.0	72.4	74.7	74.1	69.6	65.2	54.8	79.6
30 S Exh 2	DA45.55.	26.0m³/s at 700pa Return	44.4	54.5	70.4	71.2	77.2	78.9	74.8	71.4	60.0	83.0
30 S Exh 1	DA45.55.	26.0m³/s at 700pa Return	47.0	55.8	71.6	73.5	77.9	80.0	75.5	71.3	59.9	84.0
31 S Int	DA45.55.	26.7m³/s at 800pa Supply.	45.6	57.2	66.3	71.5	74.2	73.6	68.8	65.2	52.2	79.0
31 S Exh 2	DA45.55.	26.0m³/s at 700pa Return	47.7	56.6	72.4	75.9	80.6	81.6	77.1	73.8	60.3	86.0
31 S Exh 1	DA45.55.	26.0m³/s at 700pa Return	44.4	54.5	70.4	71.2	77.2	78.9	74.8	71.4	60.0	83.0

Predictor Ref	Danann AHU Type	Duty / Pressure	Octave Bands (Hz) Sound Power Levels dB (A-weighted) per band									L_{wA}
			31.5	63	125	250	500	1000	2000	4000	8000	
32 S Int	DA45.55.	26.7m^3/s at 800pa Supply.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.5
32 S Exh 2	DA45.65.	25.6m^3/s at 500pa Return	49.3	57.6	72.7	77.8	82.3	83.6	78.5	75.4	64.0	87.7
32 S Exh 1	DA45.55.	26.0m^3/s at 700pa Return	47.7	56.6	72.4	75.9	80.6	81.6	77.1	73.8	60.3	86.0
33 S Int	DA45.65.	25.6m^3/s at 700pa Supply.	45.5	58.9	66.9	72.9	75.0	74.2	69.2	65.3	56.8	79.8
33 S Exh 2	DA45.65.	25.6m^3/s at 500pa Return	49.9	58.3	73.2	76.6	81.4	82.0	77.2	74.6	64.5	86.5
33 S Exh 1	DA45.65.	25.6m^3/s at 500pa Return	49.3	57.6	72.7	77.8	82.3	83.6	78.5	75.4	64.0	87.7
34 S Int	DA45.65.	25.6m^3/s at 700pa Supply.	46.8	58.7	67.7	73.1	75.6	74.1	69.0	64.5	52.3	80.0
34 S Exh 2	DA45.65.	25.6m^3/s at 500pa Return	51.5	61.8	77.0	77.7	84.1	85.1	80.3	77.8	68.1	89.4
34 S Exh 1	DA45.65.	25.6m^3/s at 500pa Return	49.9	58.3	73.2	76.6	81.4	82.0	77.2	74.6	64.5	86.5
35 S Int	DA45.65.	25.6m^3/s at 700pa Supply.	47.8	58.8	67.3	73.1	75.4	74.3	69.9	64.8	52.0	80.0
35 S Exh 2	DA45.65.	25.6m^3/s at 500pa Return	49.2	58.6	75.3	78.6	82.8	83.0	78.5	75.3	63.4	87.8
35 S Exh 1	DA45.65.	25.6m^3/s at 500pa Return	51.5	61.8	77.0	77.7	84.1	85.1	80.3	77.8	68.1	89.4
36 S Int	DA45.65.	25.6m^3/s at 700pa Supply.	47.8	58.8	67.3	73.1	75.4	74.3	69.9	64.8	52.0	80.0
36 S Exh 2	DA45.65.	25.6m^3/s at 500pa Return	48.6	57.4	72.6	74.5	80.0	80.4	76.0	73.5	63.7	85.1
36 S Exh 1	DA45.65.	25.6m^3/s at 500pa Return	49.2	58.6	75.3	78.6	82.8	83.0	78.5	75.3	63.4	87.8
37 S Int	DA45.65.	25.6m^3/s at 700pa Supply.	46.9	57.9	68.6	73.7	75.5	74.7	70.3	66.1	59.8	80.5
37 S Exh 2	DA45.65.	25.6m^3/s at 500pa Return	48.1	57.8	74.6	76.4	80.9	81.6	77.2	75.1	65.0	86.4
37 S Exh 1	DA45.65.	25.6m^3/s at 500pa Return	48.6	57.4	72.6	74.5	80.0	80.4	76.0	73.5	63.7	85.1
38 S Int	DA45.65.	25.6m^3/s at 700pa Supply.	48.8	59.1	70.0	74.2	76.4	75.6	71.2	66.7	55.4	81.3
38 S Exh 2	DA45.65.	25.6m^3/s at 500pa Return	50.1	60.5	77.3	76.9	81.7	82.2	77.7	75.5	62.3	87.1
38 S Exh 1	DA45.65.	25.6m^3/s at 500pa Return	48.1	57.8	74.6	76.4	80.9	81.6	77.2	75.1	65.0	86.4
39 S Int	DA45.65.	25.6m^3/s at 700pa Supply.	48.8	59.1	70.0	74.2	76.4	75.6	71.2	66.7	55.4	81.3
39 S Exh 2	DA45.65.	25.6m^3/s at 500pa Return	46.4	56.4	72.2	74.1	77.9	77.6	73.5	72.3	60.5	83.1
39 S Exh 1	DA45.65.	25.6m^3/s at 500pa Return	50.1	60.5	77.3	76.9	81.7	82.2	77.7	75.5	62.3	87.1
40 S Int	DA45.65.	25.6m^3/s at 700pa Supply.	46.4	58.1	69.7	73.5	76.8	75.9	71.0	66.5	55.0	81.4
40 S Exh 2	DA55.45 / DA45.65.	25.3m^3/s at 600pa Return / 25.6m^3/s at 500pa Return	48.3	56.6	73.4	75.1	79.7	79.3	74.8	72.3	61.2	84.5
40 S Exh 1	DA45.65.	25.6m^3/s at 500pa Return	46.4	56.4	72.2	74.1	77.9	77.6	73.5	72.3	60.5	83.1
41 S Int	DA55.45.	26.7m^3/s at 725pa Supply.	45.9	57.7	67.3	73.5	76.5	75.4	69.8	65.6	51.7	80.8
41 S Exh 2	DA55.45.	25.3m^3/s at 600pa Return	49.0	57.6	73.3	77.1	82.1	81.0	76.1	72.2	58.5	86.3
41 S Exh 1	DA55.45 / DA45.65.	25.3m^3/s at 600pa Return / 25.6m^3/s at 500pa Return	48.3	56.6	73.4	75.1	79.7	79.3	74.8	72.3	61.2	84.5
42 S Int	DA55.45.	26.7m^3/s at 725pa Supply.	47.3	58.6	68.7	74.0	77.5	76.3	69.7	64.5	53.1	81.6

Predictor Ref	Danann AHU Type	Duty / Pressure	Octave Bands (Hz) Sound Power Levels dB (A-weighted) per band									L_{wA}
			31.5	63	125	250	500	1000	2000	4000	8000	
42 S Exh 2	DA55.45.	25.3m^3/s at 600pa Return	51.6	61.0	76.2	76.2	82.3	82.3	77.3	73.6	60.1	87.0
42 S Exh 1	DA55.45.	25.3m^3/s at 600pa Return	49.0	57.6	73.3	77.1	82.1	81.0	76.1	72.2	58.5	86.3
43 S Int	DA55.45.	26.7m^3/s at 725pa Supply.	47.3	58.6	68.7	74.0	77.5	76.3	69.7	64.5	53.1	81.6
43 S Exh 2	DA55.45.	25.3m^3/s at 600pa Return	47.8	56.7	72.4	74.8	79.9	79.7	74.4	70.5	58.0	84.5
43 S Exh 1	DA55.45.	25.3m^3/s at 600pa Return	51.6	61.0	76.2	76.2	82.3	82.3	77.3	73.6	60.1	87.0
44 S Int	DA55.45.	26.7m^3/s at 725pa Supply.	49.1	58.4	68.7	74.1	77.0	75.7	70.1	66.0	53.4	81.3
44 S Exh 2	DA55.45.	25.3m^3/s at 600pa Return	48.1	56.3	72.1	72.7	79.0	79.1	74.3	71.3	59.9	83.8
44 S Exh 1	DA55.45.	25.3m^3/s at 600pa Return	47.8	56.7	72.4	74.8	79.9	79.7	74.4	70.5	58.0	84.5
45 S Int	DA55.45.	26.7m^3/s at 725pa Supply.	47.4	57.9	68.0	74.4	77.3	76.3	71.0	66.3	53.3	81.7
45 S Exh 2	DA55.45.	25.3m^3/s at 600pa Return	48.1	57.3	72.7	75.1	79.8	80.1	75.2	71.4	57.9	84.8
45 S Exh 1	DA55.45.	25.3m^3/s at 600pa Return	48.1	56.3	72.1	72.7	79.0	79.1	74.3	71.3	59.9	83.8
46 S Int	DA55.45.	26.7m^3/s at 725pa Supply.	48.0	58.0	68.4	73.9	77.7	76.3	71.7	66.8	51.9	81.9
46 S Exh 2	DA55.45.	25.3m^3/s at 600pa Return	47.3	56.4	72.2	72.9	79.4	79.5	74.3	70.6	58.3	84.0
46 S Exh 1	DA55.45.	25.3m^3/s at 600pa Return	48.1	57.3	72.7	75.1	79.8	80.1	75.2	71.4	57.9	84.8
47 S Int	DA55.45.	26.7m^3/s at 725pa Supply.	50.1	60.9	71.6	78.5	80.5	79.7	73.8	68.5	55.1	85.1
47 S Exh 2	DA55.45.	25.3m^3/s at 600pa Return	49.2	57.7	73.6	76.1	81.0	80.6	75.2	71.1	58.5	85.5
47 S Exh 1	DA55.45.	25.3m^3/s at 600pa Return	47.3	56.4	72.2	72.9	79.4	79.5	74.3	70.6	58.3	84.0
48 S Int	DA55.45.	26.7m^3/s at 725pa Supply.	47.3	58.6	69.8	76.2	79.0	78.6	73.6	68.1	53.4	83.7
48 S Exh 2	DA55.45.	25.3m^3/s at 600pa Return	47.6	57.1	68.8	75.1	80.3	79.8	74.5	69.9	57.9	84.5
48 S Exh 1	DA55.45.	25.3m^3/s at 600pa Return	49.2	57.7	73.6	76.1	81.0	80.6	75.2	71.1	58.5	85.5

Table C1 Sound Power Levels Associated with Phase 1 Plant (Measured on Site)

APPENDIX D
NOISE SOURCE DATA – BUILDING X & Y

Noise emissions associated with the existing Building W AHU plant are detailed in Appendix C. Noise source data for additional plant associated with Building X consist of some 21 additional AHU installations and for Building Y some 86 roof mounted fans and other supporting items of plant.

Table D1 presents the noise data associated with these plant items.

Source	No. Units	L_{wA} - Octave Band Centre Frequency								dB (A)
		63	125	250	500	1k	2k	4k	8k	
AHU Air Intake	21	62	74	78	87	86	82	74	64	91
AHU Air Exhaust	21	69	77	85	91	90	86	82	69	95
Roof Fans	84	60	64	72	75	74	71	62	59	80
Roof Fans ($16m^3/s$)	22	60	64	72	75	74	71	62	59	80
Roof Fans ($33m^3/s$)	6	60	64	72	75	74	71	62	59	80
Dry Coolers	20	60	64	72	75	74	71	62	59	80
Trane Chillers	6	60	64	72	75	74	71	62	59	80

Table D1 L_{wA} levels Utilised in Noise Model

In terms of emergency generators the following source noise data has been assumed for the proposed units based on measurements obtained on site for generator units associated with the Building W facility.

Source	L_{wA} - Octave Band Centre Frequency								dB (A)
	63	125	250	500	1k	2k	4k	8k	
Sides	67	77	81	86	84	60	73	58	90
Intake	79	92	94	95	90	85	80	66	99
Exhaust	65	74	82	87	85	82	77	65	91

Table D2 L_{wA} levels Utilised in Noise Model – Generators – Building W & X

In relation to Building Y the emergency generators are located within the building. It is understood that exhausts and intakes associated with these units have been designed such that 85 dB(A) at 1m is not exceeded from them. This has been assumed for the assessment presented here.

APPENDIX E
NOISE MODELLING PARAMETERS

Prediction calculations for noise emissions have been conducted in accordance with *ISO 9613: Acoustics – Attenuation of sound during propagation outdoors, Part 2: General method of calculation, 1996*. The following are the main aspects that have been considered in terms of the noise predictions presented in this instance.

Directivity Factor: The directivity factor (D) allows for an adjustment to be made where the sound radiated in the direction of interest is higher than that for which the sound power level is specified. In this case the sound power level is measures in a down wind direction, corresponding to the worst-case propagation conditions and needs no further adjustment.

Ground Effect: Ground effect is the result of sound reflected by the ground interfering with the sound propagating directly from source to receiver. The prediction of ground effects is inherently complex and depend on source height receiver height propagation height between the source and receiver and the ground conditions. The ground conditions are described according to a variable defined as G, which varies between 0.0 for hard ground (including paving, ice concrete) and 1.0 for soft ground (includes ground covered by grass trees or other vegetation) Our predictions have been carried out using various source height specific to each plant item, a receiver heights of 1.6m for single storey properties and 4m for double. An assumed ground factor of G = 1.0 has been applied off site. Noise contours presented in the assessment have been predicted to a height of 4m in all instances. For construction noise predictions have been made at a level of 1.6m as these activities will not occur at night.

Geometrical Divergence This term relates to the spherical spreading in the free-field from a point sound source resulting in attenuation depending on distance according to the following equation:

$$A_{geo} = 20 \times \log \text{(distance from source in meters)} + 11$$

Atmospheric Absorption Sound propagation through the atmosphere is attenuated by the conversion of the sound energy into heat. This attenuation is dependent on the temperature and relative humidity of the air through which the sound is travelling and is frequency dependent with increasing attenuation towards higher frequencies. In these predictions a temperature of 10ºC and a relative humidity of 70% have been used, which give relativity low levels of atmosphere attenuation and corresponding worst case noise predictions.

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 E1 Atmospheric Attenuation Assumed for Noise Calculations (dB per km)

Barrier Attenuation The effect of any barrier between the noise source and the receiver position is that noise will be reduced according to the relative heights of the source, receiver and barrier and the frequency spectrum of the noise.