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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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EXECUTIVE SUMMARY

Amazon Data Services Ireland Limited ('ADSIL') operate three data storage facilities on a site off the Greenhills Road, Tallaght, Dublin 24. 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 full 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 noise levels at all NSL's for new mechanical plant and the levels of existing plant noise 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 located off the Greenhills Road, Tallaght, Dublin 24. 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.

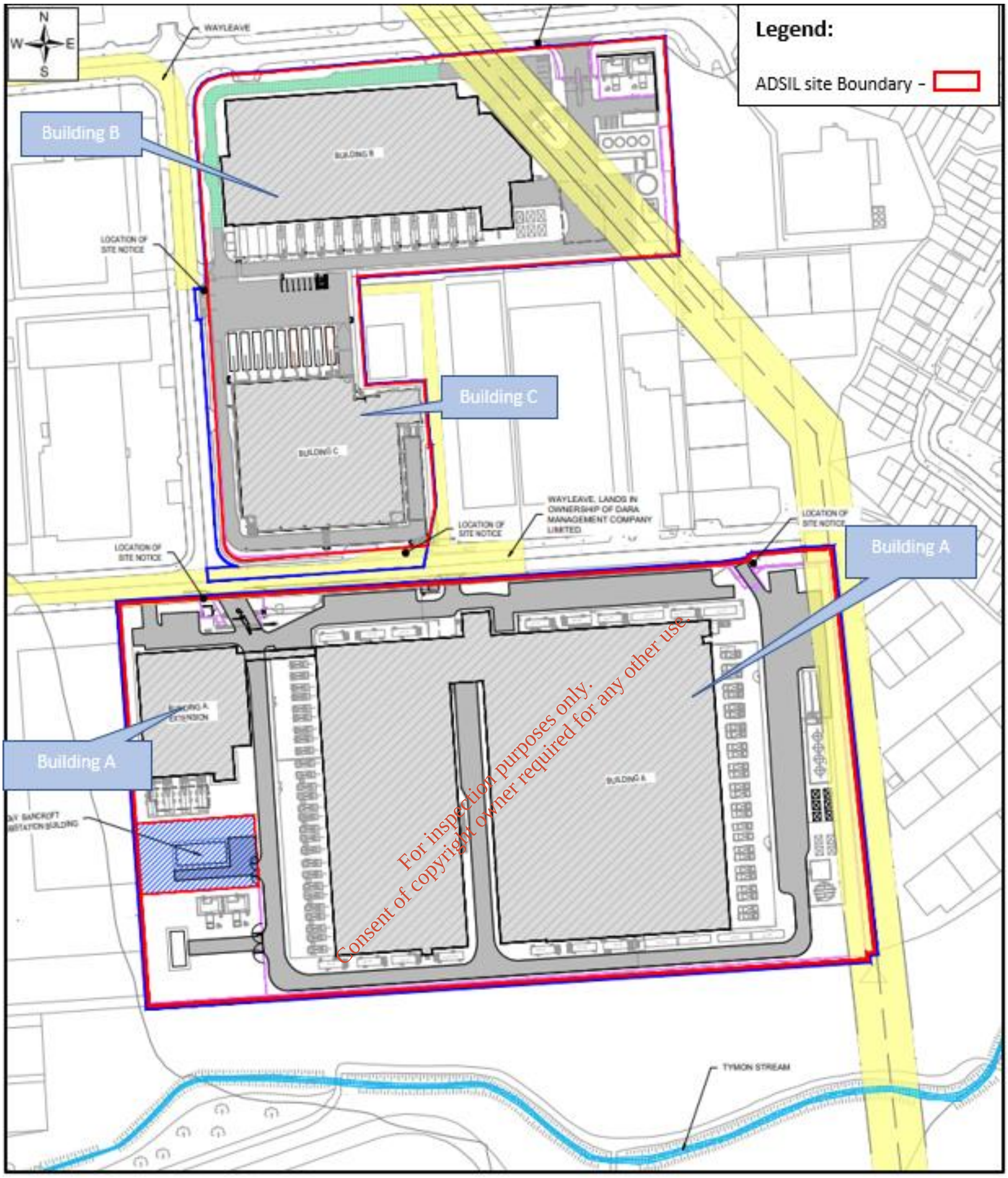


Figure 1 Site Location & Context (indicative site location in red)

Figure 1 illustrates the proposed site location in the context of the surrounding environment. The nearest residential locations are located to the north east of the development at the Tymon Green estate and to the north along Tymonville Road. A secondary school is located to the south west of the site beyond the operational Building A facility. A number of commercial operations are located on lands to the north, west and south of the lands in question. Public park space, including various sports facilities, share a common boundary with the existing Building A along its southern aspect of the overall site under consideration here.

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.

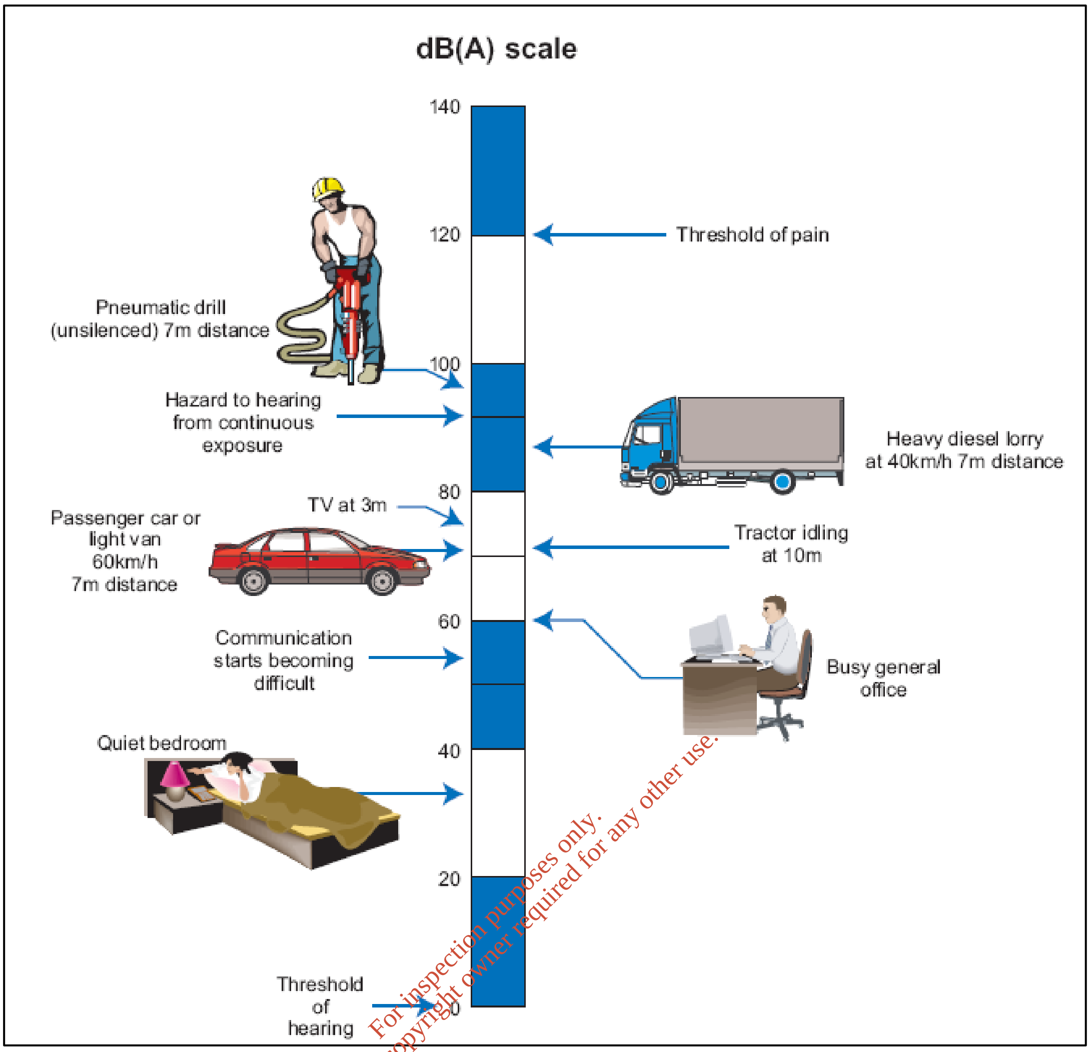


Figure 2 Level of Typical Sounds on the dB(A) Scale – (TII – Good Practice Guidance for the Treatment of Noise during the Planning of National Road Schemes)

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 survey details are set out in the below sections.

3.1 Choice of Measurement Locations

Noise measurements were conducted at five 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
1	Located on a section of open ground to the rear of Tymon North Lawn to the north east of Building A being assessed here. This location is considered to be indicative of the noise environment experienced at the rear of the properties in this estate that are the closest to the Building A development.	
2	Located in the public park adjacent to the boundary with the nearest houses on Bancroft Road. These properties are some 190m from the southern Building A boundary of the development.	
3	Located in the public park adjacent to the boundary with the nearest houses on Bancroft Grove. These properties are some 150m from the southern Building A boundary of the development.	
4	Located on a section of open ground to the rear of Tymon North Green to the north eastern side of the Greenhills Business Park. This location is considered to be indicative of the noise environment experienced at the rear of the properties in this estate.	

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

Location	Description	Photo
5	Location to the nearest residence locations to the north of the Building B some 210m beyond the Building B boundary. The location on Tymonville Road is considered to be representative of the noise environment at the various noise sensitive locations that share a common northern boundary with the Greenhills Business Park.	

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 – 15:40 to 19:30hrs on 27 April 2011;
- Night-time – 23:15hrs on 27 April 2011 to 03:00hrs on 28 April 2011;
- Daytime – 10:00 to 14:30hrs on 7 August 2014, and;
- Night-time – 23:10hrs on 6 August 2014 to 01:30hrs on 7 August 2014.

Baseline noise surveys used for the planning associated with the initial stages of the development and focused on the period when the potential noise impact was most significant (i.e. night-time). Day and night-time noise levels (in particular background noise levels) would be expected to be some 5 to 10 dB higher than those reported for night-time periods due to increased road traffic noise in with wider study areas during these periods when compared to night-time hours.

The weather during the 2011 daytime survey period was cool with wind speeds of the order of 2m/s. Temperatures were of the order of 12°C. The weather during the night-time survey period was dry and calm with wind speeds of the order of 2m/s. Temperatures were of the order of 5°C.

The weather during the 2014 daytime survey period was mild with wind speeds of the order of 1m/s. Temperatures were of the order of 19°C. The weather during the night-time survey period was dry and calm with wind speeds of the order of 1m/s. Temperatures were of the order of 12°C.

3.3 Personnel & Instrumentation

Terry Donnelly (AWN) conducted the noise level measurements in 2011 and Jennifer Harmon (AWN) attended site for the 2014 survey work. The noise measurements were performed using Brüel & Kjær Type 2260 Sound Level Analysers. Before and after the survey the measurement apparatus was check calibrated using a Brüel & Kjær Type 4231 Sound Level Calibrator.

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 (indicative site location shown in red)

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_{AFmax} is the instantaneous maximum sound level measured during the sample period.

L_{AFmin} is the instantaneous minimum sound level measured during 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 1

The survey results for Location 1 are given in Table 2 below.

Table 2 Summary of Results for Location 1

Time (hrs)		Measured Noise Levels (dB re. $2x10^{-5}$ Pa)				
		$L_{Aeq,15mn}$	L_{AFmax}	L_{AFmin}	$L_{A10,15min}$	$L_{A90,15min}$
Daytime	15:43 – 16:02	58	71	45	61	47
	17:32 – 17:47	50	67	45	52	47
	18:45 – 19:00	52	72	45	52	46
Night-time	23:15 – 23:30	47	60	44	48	45
	00:41 – 00:56	46	58	42	47	43

Daytime ambient noise levels were heavily influenced by works associated with the site including a road sweeper at work and generator noise (associated with construction activities). Other sources of noise included other vehicle activity associated with units within the industrial estate. This activity reduced as the survey progressed and the normal working day finished. Distant road traffic noise was also noted at this location while on site. Noise levels were in the range of 50 to 58 dB $L_{Aeq,15min}$ and 46 to 47dB $L_{A90,15min}$.

Night time noise levels were influenced by generator plant noise from the site under consideration here (associated with construction activities), activities from other units in the industrial estate and occasional estate road vehicle movements. Noise levels were in the range of 46 to 47dB $L_{Aeq,15min}$ and 43 to 45dB $L_{A90,15min}$.

3.6.2 Location 2

The survey results for Location 2 are given in Table 3 below.

Table 3 Summary of Results for Location 2

Time (hrs)		Measured Noise Levels (dB re. 2x10^{-5} Pa)				
		$L_{Aeq,15mn}$	L_{AFmax}	L_{AFmin}	$L_{A10,15min}$	$L_{A90,15min}$
Daytime	16:36 – 16:56	52	61	45	54	47
	17:58 – 18:13	48	66	44	50	45
Evening	19:09 – 19:24	51	71	44	52	45
Night-time	23:46 – 00:01	46	61	43	48	45
	01:59 – 02:14	48	64	41	48	43

Daytime noise levels were influenced by local road activities, activities within the nearby park and a low level of generator plant noise. Noise levels were in the range of 48 to 52dB $L_{Aeq,15min}$ and 45 to 47dB $L_{A90,15min}$.

During the night time noise survey, the most significant source of noise at this location was related to a generator associated with the site under consideration here. Noise levels were in the range of 46 to 48dB $L_{Aeq,15min}$ and 43 to 45dB $L_{A90,15min}$.

3.6.3 Location 3

The survey results for Location 3 are given in Table 4.

Table 4 Summary of Results for Location 3

Time (hrs)		Measured Noise Levels (dB re. 2x10^{-5} Pa)				
		$L_{Aeq,15mn}$	L_{AFmax}	L_{AFmin}	$L_{A10,15min}$	$L_{A90,15min}$
Daytime	17:01 – 17:16	49	62	45	50	46
	18:19 – 18:34	48	66	45	49	46
Night-time	00:14 – 00:29	42	47	40	43	41
	02:21 – 02:36	42	47	39	43	41

Pedestrian and park activities and a degree of generator noise from the site were noted as the significant sources of noise at this location during the daytime period. Noise levels were in the range of 48 to 49dB $L_{Aeq,15min}$ and the order of 46dB $L_{A90,15min}$.

During the night time period the noise levels at this location were dictated by plant noise emissions form the site (i.e. generators). Noise levels were in the order of 42dB $L_{Aeq,15min}$ and 41dB $L_{A90,15min}$.

Alternative Location – During the period when the noise survey detailed above was carried out noise levels at the nearest locations were influenced by activity on the site under consideration here. During this period temporary generators (associated with construction activities) were in use. In order to gain a clear indication of background noise levels expected in the vicinity of the noise sensitive locations in the absence of these noise sources, an additional noise monitoring period was undertaken at a location along Bancroft Park, where subjectively, Site B activities were inaudible. The results of this monitoring period are detailed in Table 5.

Table 5 Summary of Results for Bankcroft Park

Time (hrs)		Measured Noise Levels (dB re. 2x10^{-5} Pa)				
		$L_{Aeq,15mn}$	L_{AFmax}	L_{AFmin}	$L_{A10,15min}$	$L_{A90,15min}$
Night	02:43 – 02:48	35	46	28	38	32

3.6.4 Location 4

The survey results for Location 4 are given in Table 6.

Table 6 Summary of Results for Location 4

Time (hrs)		Measured Noise Levels (dB re. 2x10^{-5} Pa)				
		$L_{Aeq,15mn}$	L_{AFmax}	L_{AFmin}	$L_{A10,15min}$	$L_{A90,15min}$
Daytime	10:01 – 10:16	43	62	36	44	38
	10:42 – 10:57	46	65	36	47	39
	14:10 – 14:25	47	75	38	49	41
Night-time	23:11 – 23:26	41	59	34	42	37
	00:25 – 00:40	39	58	33	41	36
	01:08 – 01:23	38	51	33	40	35

Daytime ambient noise levels were heavily influenced by local estate traffic movements, distant traffic noise and a degree of birdsong. A low level of aircraft noise overhead was also noted on occasion. Distant road traffic noise typically dictated background levels in the area. Noise levels were in the range of 43 to 47dB $L_{Aeq,15min}$ and 38 to 41dB $L_{A90,15min}$.

Night time noise levels were influenced by distant road traffic. Noise levels were in the range of 38 to 41dB $L_{Aeq,15min}$ and 35 to 37dB $L_{A90,15min}$.

3.6.5 Location 5

The survey results for Location 5 are given in Table 7.

Table 7 Summary of Results for Location 5

Time (hrs)		Measured Noise Levels (dB re. 2x10^{-5} Pa)				
		$L_{Aeq,15mn}$	L_{AFmax}	L_{AFmin}	$L_{A10,15min}$	$L_{A90,15min}$
Daytime	10:21 – 10:36	49	66	41	51	43
	11:33 – 11:48	58	77	43	60	48
	13:44 – 13:59	54	74	41	56	43
Night-time	23:16 – 23:31	42	57	39	44	40
	00:04 – 00:19	40	55	37	41	38
	00:46 – 01.01	42	55	39	43	40

Daytime ambient noise levels were heavily influenced by local traffic movements, distant traffic noise and a degree of birdsong. The second measurement period was influenced by noise associated with the use of a lawnmower in a nearby garden. Distant road traffic noise typically dictated background levels in the area. Noise levels were in the range of 49 to 58dB $L_{Aeq,15min}$ and 43 to 48dB $L_{A90,15min}$.

Night time noise levels were influenced by distant road traffic. Noise levels were in the range of 40 to 42dB $L_{Aeq,15min}$ and 38 to 40dB $L_{A90,15min}$.

3.7 Ecologically sensitive areas or areas of special interest

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

The lands in which the installation is located have no formal designations. The nearest ecologically sensitive area to the subject site is the Dodder Valley Proposed Natural Heritage Area (pNHA) (site code 000991) which is located c. 850 m south-east of the subject site. The nearest European sites to the facility are the South Dublin Bay and River Tolka Estuary SPA c. 9.8 km east.

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 8. 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 8 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?
1	Daytime	47	≤40	No
	Evening	45	≤35	
	Night-time	44	≤30	
2	Daytime	47	≤40	No
	Evening	45	≤35	
	Night-time	44	≤30	

Location	Period	$L_{A90,T}$ (dB)	NG4 Screening (dB $L_{A90,T}$)	Satisfies All Criteria for Low Background Noise Area?
3	Daytime	46	≤40	No
	Evening	45	≤35	
	Night-time	41	≤30	
4	Daytime	39	≤40	No
	Evening	39	≤35	
	Night-time	36	≤30	
5	Daytime	43	≤40	No
	Evening	40	≤35	
	Night-time	39	≤30	

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 9. Free field noise emission levels have been predicted at a height stated in Table 9.

Table 9 Coordinates of Noise Sensitive Receivers

Noise Sensitive Location	Calculation Height (m)	National Grid Reference	
		North	East
R01	4	310,166	228,086
R02	4	310,178	228,099
R03	4	310,201	228,107
R04	4	310,310	228,178
R05	4	310,358	228,255
R06	4	310,319	228,342
R07	4	310,286	228,386
R08	4	310,251	228,412
R09	4	310,241	228,422
R10	4	310,230	228,431
R11	4	309,730	227,928
R12	4	309,828	227,942
R13	4	309,876	227,949
R14	4	309,914	227,994
R15	4	309,962	228,025
R16	4	310,000	228,050
R17	4	309,737	228,716
R18	4	309,837	228,704
R19	4	309,884	228,698
R20	4	309,920	228,732
R21	4	310,003	228,729
R22	4	310,058	228,726
R23	4	310,168	228,728
R24	4	310,182	228,628

Noise Sensitive Location	Calculation Height (m)	National Grid Reference	
		North	East
R25	4	310,190	228,608
R26	4	310,250	228,586
R27	4	310,251	228,517
R28	4	310,229	228,461

5.2 Noise Source Data

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

Figure 4 Noise Assessment Locations (indicative site location shown in red)

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 2×10^{-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 10 below:

Table 10 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 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.

5.4 Predicted Noise Levels

This section presents the predicted noise levels at the nearest noise sensitive locations. The cumulative 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 noise levels from mechanical plant at Buildings A and B are tabulated in Table 11 for each NSL.

Table 11 Predicted Cumulative Operational Noise Levels at NSL's for Mechanical Plant Items at Building A and B

Location	Plant Predicted Level (dB)	
	Scenario A	Scenario B
R01	33	48
R02	33	48
R03	33	48
R04	33	46
R05	28	44
R06	24	41
R07	30	39
R08	36	43
R09	37	44
R10	37	45
R11	30	40
R12	31	41
R13	31	40
R14	32	46
R15	33	46
R16	34	47
R17	28	35
R18	32	38
R19	33	38
R20	33	43
R21	34	38
R22	33	38
R23	27	36
R24	36	42
R25	35	46
R26	33	41
R27	31	42
R28	35	47

Table 12 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 12 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	33	55	Yes	50	Yes	45	Yes
R02	33		Yes		Yes		Yes
R03	33		Yes		Yes		Yes
R04	33		Yes		Yes		Yes
R05	28		Yes		Yes		Yes
R06	24		Yes		Yes		Yes
R07	30		Yes		Yes		Yes
R08	36		Yes		Yes		Yes
R09	37		Yes		Yes		Yes
R10	37		Yes		Yes		Yes
R11	30		Yes		Yes		Yes
R12	31		Yes		Yes		Yes
R13	31		Yes		Yes		Yes
R14	32		Yes		Yes		Yes
R15	33		Yes		Yes		Yes
R16	34		Yes		Yes		Yes
R17	28		Yes		Yes		Yes
R18	32		Yes		Yes		Yes
R19	33		Yes		Yes		Yes
R20	33		Yes		Yes		Yes
R21	34		Yes		Yes		Yes
R22	33		Yes		Yes		Yes
R23	27		Yes		Yes		Yes
R24	36		Yes		Yes		Yes
R25	35		Yes		Yes		Yes
R26	33		Yes		Yes		Yes
R27	31		Yes		Yes		Yes
R28	35		Yes		Yes		Yes

Table 13 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 13 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	48	55	Yes	55	Yes	55	Yes
R02	48		Yes		Yes		Yes
R03	48		Yes		Yes		Yes
R04	46		Yes		Yes		Yes
R05	44		Yes		Yes		Yes
R06	41		Yes		Yes		Yes
R07	39		Yes		Yes		Yes
R08	43		Yes		Yes		Yes
R09	44		Yes		Yes		Yes
R10	45		Yes		Yes		Yes
R11	40		Yes		Yes		Yes
R12	41		Yes		Yes		Yes
R13	40		Yes		Yes		Yes
R14	46		Yes		Yes		Yes
R15	46		Yes		Yes		Yes
R16	47		Yes		Yes		Yes
R17	35		Yes		Yes		Yes
R18	38		Yes		Yes		Yes
R19	38		Yes		Yes		Yes
R20	43		Yes		Yes		Yes
R21	38		Yes		Yes		Yes
R22	38		Yes		Yes		Yes
R23	36		Yes		Yes		Yes
R24	42		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

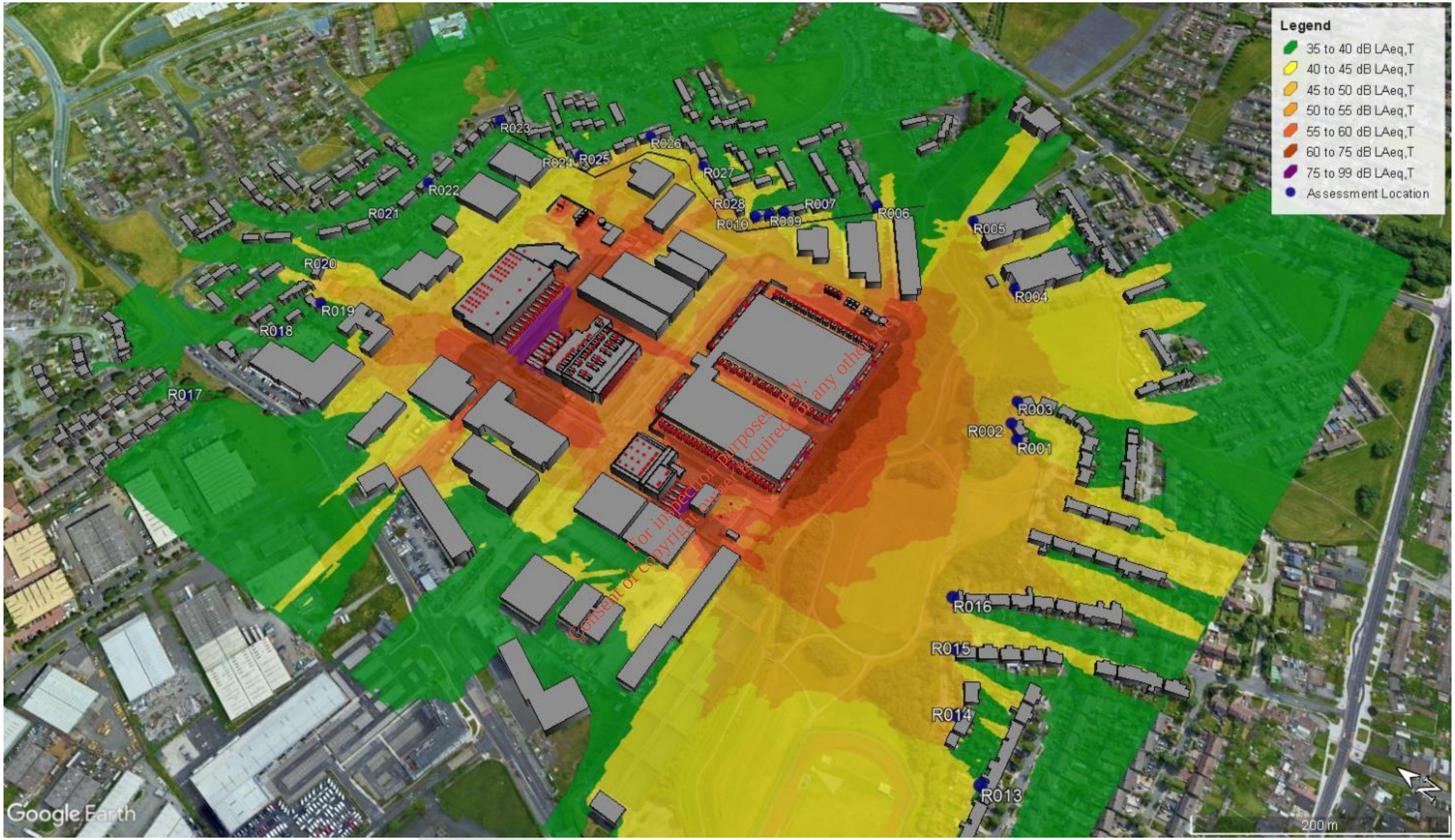


Figure 6 Operational Noise Prediction Contours – Scenario B

6.0 CONCLUSION

A detailed noise survey has been completed at five 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 new 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) per m^2 where:

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

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:

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

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
NOISE SOURCE DATA

In relation to Building A each noise source was input as sound power in octave bands. The sound power of each source was measured in accordance with *BS4196:1991: Determination of sound power levels using sound pressure*. This standard involves the measurement of sound pressure at a set of points on an enveloping surface around the source, and applying a correction to the measured level to obtain the sound power of the source. Predictor accepts sound power levels in octave bands from 63Hz to 8kHz. Table C1 details the A-Weighted sound power levels and associated spectra for the various noise sources associated with the ventilation plant on site. In terms of the noise model this bank of nine AHU plant have been reproduced in order to represent the full development of the site considering 81 units in total.

Source	Height (m)	L_{WA} - Octave Band Centre Frequency							
		63	125	250	500	1k	2k	4k	8k
Intake 01	3	62.8	71.9	82.3	84.3	83.5	82	75.1	66.7
Intake 02	3	62.8	71.9	82.3	84.3	83.5	82	75.1	66.7
Intake 03	3	62.8	71.9	82.3	84.3	83.5	82	75.1	66.7
Intake 04	3	62.8	71.9	82.3	84.3	83.5	82	75.1	66.7
Intake 05	3	62.8	71.9	82.3	84.3	83.5	82	75.1	66.7
Intake 06	3	62.8	71.9	82.3	84.3	83.5	82	75.1	66.7
Intake 07	3	62.8	71.9	82.3	84.3	83.5	82	75.1	66.7
Intake 08	3	62.8	71.9	82.3	84.3	83.5	82	75.1	66.7
Intake 09	3	62.8	71.9	82.3	84.3	83.5	82	75.1	66.7
Exha N 01	6.5	60.6	77	82.7	86.2	85.6	83.5	76.9	68.4
Exha N 02	6.5	60.6	77	82.7	86.2	85.6	83.5	76.9	68.4
Exha N 03	6.5	60.6	77	82.7	86.2	85.6	83.5	76.9	68.4
Exha N 04	6.5	60.6	77	82.7	86.2	85.6	83.5	76.9	68.4
Exha N 05	6.5	60.6	77	82.7	86.2	85.6	83.5	76.9	68.4
Exha N 06	6.5	60.6	77	82.7	86.2	85.6	83.5	76.9	68.4
Exha N 07	6.5	60.6	77	82.7	86.2	85.6	83.5	76.9	68.4
Exha N 08	6.5	60.6	77	82.7	86.2	85.6	83.5	76.9	68.4
Exha N 09	6.5	60.6	77	82.7	86.2	85.6	83.5	76.9	68.4
Exha S 01	6.5	61.6	75.6	80.6	85.5	84.8	83.1	76.5	67.9
Exha S 02	6.5	61.6	75.6	80.6	85.5	84.8	83.1	76.5	67.9
Exha S 03	6.5	61.6	75.6	80.6	85.5	84.8	83.1	76.5	67.9
Exha S 04	6.5	61.6	75.6	80.6	85.5	84.8	83.1	76.5	67.9
Exha S 05	6.5	61.6	75.6	80.6	85.5	84.8	83.1	76.5	67.9
Exha S 06	6.5	61.6	75.6	80.6	85.5	84.8	83.1	76.5	67.9
Exha S 07	6.5	61.6	75.6	80.6	85.5	84.8	83.1	76.5	67.9
Exha S 08	6.5	61.6	75.6	80.6	85.5	84.8	83.1	76.5	67.9
Exha S 09	6.5	61.6	75.6	80.6	85.5	84.8	83.1	76.5	67.9

Table C1 L_{WA} levels Utilised in Noise Model – Building A

Acoustic louvres have been installed on intake and exhaust of the AHU plant installed on site. Table C2 outlines the required minimum sound reduction index values, as offered by the double bank louvres.

Louvre	Sound Reduction Index (SRI) dB – Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
Double	7	8	11	20	29	31	29	26

Table C2 Sound Reduction Index Associated with Louvres – Building A

Noise source data for additional plant associated with Building A extension consists of some 19 additional roof mounted fans and other supporting items of plant.

Table B3 presents the noise data associated with these plant items. During the detailed design process plant items will be designed in order to achieve these guidelines or suitable levels such that the adopted noise criterion is achieved. Note it is assumed that 7 out of 10 units are operational at any one time and applies a correction for directivity associated with the vertical exhaust on roof fans. It is also assumed fans will be operating at 70% duty.

Source	No. Units	L_{WA} - Octave Band Centre Frequency								dB (A)
		63	125	250	500	1k	2k	4k	8k	
Roof Fans (16m^3/s)	12	60	64	72	75	74	71	62	59	80
Roof Fans (33m^3/s)	7	60	64	72	75	74	71	62	59	80

Table C3 L_{WA} levels Utilised in Noise Model – Building A Extension

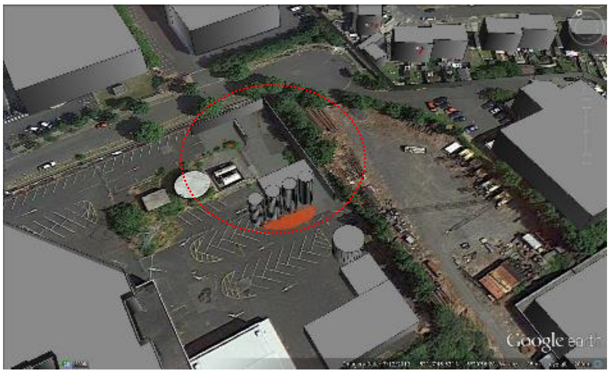
Table C4 details the A-Weighted sound power levels and associated spectra for the various noise sources associated with the ventilation plant on site in relation to the Building B building. In terms of the noise model this bank of 55 roof mounted plant has been considered. During the detailed design process plant items will be designed in order to achieve these guidelines or suitable levels such that the adopted noise criterion is achieved. If required appropriate acoustic louvres will be incorporated into the design of the units. Note it is assumed that 7 out of 10 units are operational at any one time and applies a correction for directivity associated with the vertical exhaust on roof fans. It is also assumed fans will be operating at 70% duty. This is considered a conservative assumption in terms of day to day operations.

Source	No. Units	L_{WA} - Octave Band Centre Frequency								dB (A)
		63	125	250	500	1k	2k	4k	8k	
Roof Fan	55	60	64	72	75	74	71	62	59	80
110 kV Substation	2	56	59	61	80	72	60	53	55	81

Table C4 L_{WA} levels Utilised in Noise Model – Building B

A 4m high boundary wall is proposed in the vicinity of the proposed sub stations as detailed in the graphic to the left.

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 A facility.



Source	No. Units	L_{WA} - Octave Band Centre Frequency								dB (A)
		63	125	250	500	1k	2k	4k	8k	
Exhaust	20	62.2	72.1	75.8	81.4	78.6	74.6	68.0	53.0	84.8
Intake	20	74.4	86.6	89.2	90.0	85.0	79.9	74.9	61.0	94.4
Stack	20	65.0	74.4	82.2	87.2	85.2	82.3	77.3	65.2	91.0

Table C5 L_{WA} levels Utilised in Noise Model – Generators – Building A & B

Table C6 details the A-Weighted sound power levels and associated spectra for the various noise sources associated with the ventilation plant on site in relation to Building C. In terms of the noise model this bank of 50 roof mounted plant have considered. During the detailed design process plant items will be designed in order to achieve these guidelines or suitable levels such that the adopted noise criterion is achieved. If required appropriate acoustic louvres will be incorporated into the design of the units. Note it is assumed that 7 out of 10 units are operational at any one time and applies a correction for directivity associated with the vertical exhaust on roof fans. It is also assumed fans will be operating at 70% duty. This is considered a conservative assumption in terms of day to day operations.

Table C6 outlines additional attenuation incorporated into the design in relation to the roof top fan exhausts.

Source	No. Units	L_{wA} - Octave Band Centre Frequency								dB (A)
		63	125	250	500	1k	2k	4k	8k	
Roof Fan Exhaust	50	58	64	73	81	79	76	72	62	85
AHU Intake	22	43	60	70	71	66	62	51	39	75

Table C5 L_{wA} levels Utilised in Noise Model – Building C

Item	Sound Reduction Index (SRI) dB – Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
Roof Fan Attenuation	2	5	7	10	10	10	10	10

Table C6 Sound Reduction to be Applied to Proposed Roof Fans – Building C

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 other facilities.

Source	No. Units	L_{wA} - Octave Band Centre Frequency								dB (A)
		63	125	250	500	1k	2k	4k	8k	
Front	9	96.6	90.4	95.7	89.8	87.1	89.0	82.9	77.0	94.5
Rear	9	94.8	88.6	93.9	88.0	85.3	87.2	81.1	75.2	92.7
Sides	9	98.3	92.1	97.4	91.5	88.8	90.7	84.6	78.7	96.3
Stack	9	83.5	76.5	76.5	72.8	69.1	73.9	70.7	71.2	79.2

Table C7 Additional L_{wA} levels Utilised in Noise Model – Generators

APPENDIX D
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 D.1 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.