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

Technical Report Prepared For

Amazon Data Services Ireland Limited

Prepared By

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Our Reference

DK/21/12148NR01

Date of Issue

6 August 2021

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Document History

Document Reference		Original Issue Date	
DK/21/12148NR01		6 August 2021	
Revision Level	Revision Date	Description	Sections Affected

Record of Approval

Details	Written by	Approved by
Signature		
Name	Damian Kelly	Mike Simms
Title	Director (Acoustics)	Senior Acoustic Consultant
Date	6 August 2021	6 August 2021

EXECUTIVE SUMMARY

Amazon Data Services Ireland Limited (‘**ADSIL**’) will operate a series of data centres on their site at Grange Castle International Business Park, Clondalkin, Dublin 22. 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 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 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.

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1.0 INTRODUCTION

Amazon Data Services Ireland Limited (‘**ADSIL**') will operate a series of data centres on their site at Grange Castle International Business Park, Clondalkin, Dublin 22. 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 facility 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 illustrates the proposed site location in the context of the surrounding environment with the approximate site boundary outlined in red.

Figure 1 *Site Location & Context*

The nearest occupied residential noise sensitive locations are located to the south and south west of the site and consist of single dwelling private properties. The nearest commercial units are located to the east, north and south of the site. A section of the northern and eastern boundaries of the site abuts the Old Nangor Road.

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.

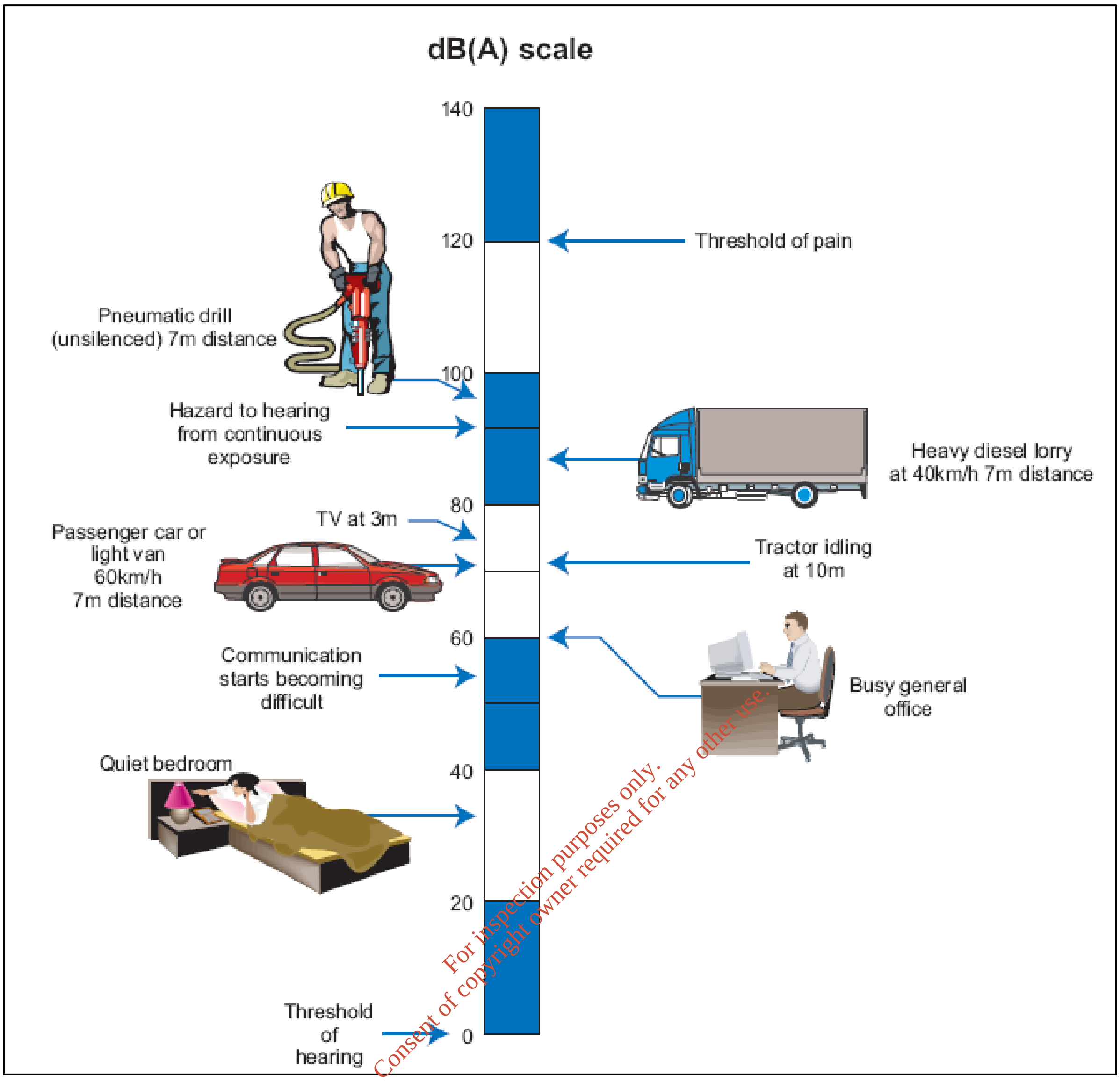

Figure 2 Level of Typical Sounds on the dB(A) Scale – (TII – *Good Practice Guidance for the Treatment of Noise during the Planning of National Road Schemes*)

3.0 RECEIVING ENVIRONMENT

This section deals with 'Stage 1' of the noise impact assessment as outlined in the EPA's NG4 Guidance.

An environmental noise survey was conducted by AWN in support of various planning applications for the development before any works commenced on site. One of the purposes of the survey was to quantify the existing noise environment at nearby noise sensitive locations in light of existing site noise emissions. The surveys were conducted in general accordance with guidance contained in the EPA NG4 publication and ISO 1996: 2017: *Acoustics – Description, measurement and assessment of environmental noise*. Details of this survey are presented in the following sections.

3.1 Choice of Measurement Locations

Noise measurements were conducted at three positions in the vicinity of the site.

Table 1 Measurement Locations & Descriptions

Location	Description
A	Located in the vicinity of the nearest noise sensitive locations to the south west of the development site.
B	Located midway along the southern boundary of the site. The lands to the immediate south are currently being developed with construction ongoing at the time of survey work completed here. This located is chosen to be representative of those noise sensitive locations further south. A review of the planning assessment completed for the development under construction has been completed in order to inform expected levels of noise in the absence of these activities at this location.
C	Located in the vicinity of the nearest residential noise sensitive location to the east of the proposed development site.
D	Located in the vicinity of an existing structure associated with the existing pitch and putt course.

Plate 1 Location A

Plate 2 Location B

Plate 3 Location C

Plate 4 Location D

These locations are shown on Figure 3.

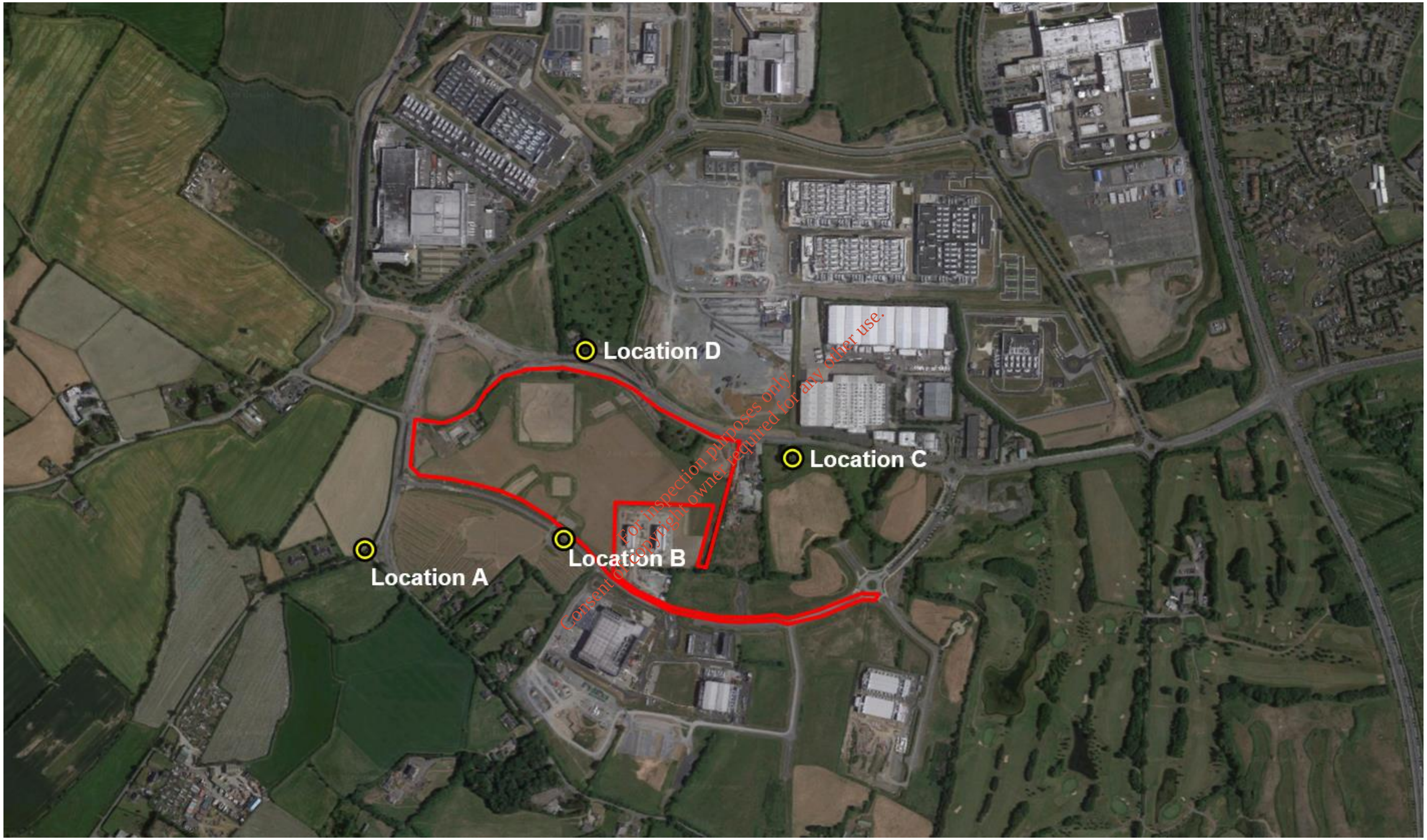

Figure 3 Noise Monitoring Locations

3.2 Survey Periods

The surveys were conducted at Locations A to D during the following periods:

Table 2 Survey Details

Period	Start Time/Date	End Time/Date
Day	10:50hrs 9 January 2020	14:40hrs 9 January 2020
Evening	21:30hrs 9 January 2020	23:00hrs 9 January 2020
Night	23:00hrs 9 January 2020	01:25hrs 10 January 2020

3.3 Personnel & Instrumentation

AWN Consulting conducted the noise level measurements during the various survey periods. The measurements were performed using Brüel & Kjær Type 2228 Modular Precision Sound Analysers. Before and after the survey the measurement apparatus was check calibrated using a Brüel & Kjær Type 4231 Sound Level Calibrator.

3.4 Procedure

During each of the day, evening and night-time periods, measurements were conducted on a continuous basis over the stated time periods. Sample periods were 15 minutes during all surveys. The results were saved to the instrument memory for later analysis where appropriate. Survey personnel noted all primary noise sources contributing to noise build-up.

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 no 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 3 below.

Table 3 Summary of Results for Location A

Start Time		Measured Noise Levels (dB re. $2x10^{-5}$ Pa)		
		L_{Aeq}	L_{AF10}	L_{AF90}
Daytime	11:48	71	68	53
	12:59	66	69	56
	14:23	63	66	54
Evening	21:30	55	57	48
Night-time	23:55	44	42	35
	01:09	37	38	35

Ambient daytime noise levels at this location were dominated by the road traffic noise on local roads and to a lesser extent by construction noise from nearby sites. Other noise sources noted included occasional aircraft movements overhead and birdsong. Distant road traffic noise typically dictated background noise levels along with a contribution from distant construction noise. Ambient (i.e. $L_{Aeq,15min}$) levels were in the range of 63 to 71dB with background noise levels in the range of 53 to 56dB.

Night-time noise levels were influenced by distant road traffic movements along with occasional local vehicle movements on the nearby road and wind generated noise on a nearby structure. Ambient noise levels were in the range of 37 to 44dB with

3.6.2 Location B

The survey results for Location B are given in Table 4 below.

Table 4 Summary of Results for Location B

Start Time		Measured Noise Levels (dB re. $2x10^{-5}$ Pa)		
		L_{Aeq}	L_{AF10}	L_{AF90}
Daytime	11:31	66	69	61
	12:42	65	67	61
	14:06	64	65	59
Evening	21:48	52	55	48
Night-time	23:36	45	41	36
	00:51	40	42	39

Ambient daytime noise levels at this location were dominated construction noise and to a lesser extent by traffic movements on local and nearby roads. Other noise sources noted included occasional aircraft movements overhead and birdsong. Construction noise and distant road traffic noise typically dictated background noise levels. Ambient (i.e. $L_{Aeq,15min}$) levels were in the range of 64 to 66dB with background noise levels in the range of 59 to 61dB.

Night-time noise levels were influenced by distant road traffic movements along with occasional local vehicle movements. Background noise levels included distant plant noise from existing operations. Ambient noise levels were in the range of 40 to 45dB with background noise levels were in the range 36 to 39dB.

3.6.3 Location C

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

Table 5 Summary of results for Location C

Start Time		Measured Noise Levels (dB re. $2x10^{-5}$ Pa)		
		L_{Aeq}	L_{AF10}	L_{AF90}
Daytime	10:51	71	76	49
	12:07	71	76	51
	13:25	72	77	54
Evening	22:15	68	69	48
Night-time	23:00	66	68	39
	00:14	61	57	40

Ambient daytime noise levels at this location were dominated by traffic on the Nangor Road. Other noise sources noted including dogs barking, occasional aircraft movements overhead and construction noise in the distance. Distant road traffic noise typically dictated background noise levels. Ambient (i.e. $L_{Aeq,15min}$) levels were in the range of 71 to 72dB with background noise levels in the range of 49 to 51dB.

Night-time noise levels were influenced by distant road traffic movements along with occasional local vehicle movements. Background noise levels included distant plant noise from existing operations. Ambient noise levels were in the range of 61 to 66dB with background noise levels were in the range 39 to 40dB.

3.6.4 Location D

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

Table 6 Summary of results for Location D

Start Time		Measured Noise Levels (dB re. $2x10^{-5}$ Pa)		
		L_{Aeq}	L_{AF10}	L_{AF90}
Daytime	11:08	72	76	54
	12:24	71	75	47
	13:43	71	76	50
Evening	22:37	63	62	45
Night-time	23:17	60	59	36
	00:32	60	55	39

Ambient daytime noise levels at this location were dominated by traffic on the Nangor Road. Other noise sources noted including dogs barking, occasional aircraft movements overhead and construction noise in the distance. Distant road traffic noise typically dictated background noise levels. Ambient (i.e. $L_{Aeq,15min}$) levels were in the range of 71 to 72dB with background noise levels in the range of 47 to 54dB.

Night-time noise levels were influenced by distant road traffic movements along with occasional local vehicle movements. Background noise levels included distant plant noise from existing operations. Ambient noise levels were in the order of 60dB with background noise levels were in the range 36 to 39dB.

3.7 Sensitive Areas or Areas of Special Interest

The lands in which the installation is located have no formal designations. The nearest ecologically sensitive area to the facility is the Grand Canal Proposed NHA (002104) which is approximately 1.4km north of the facility. The nearest European site to the facility is the Rye Water Valley / Carton SAC; c. 5.2km north-west

An Appropriate Assessment (AA) Screening Reports (Attachment 6-3-4) have been prepared by Scott Cawley Ltd and have been submitted as part of the planning 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 all 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 South Dublin County Council and is located less than 3km from a population significantly greater than 1,000.

- At least 3km away from any local industry;

Numerous other industrial sites operate within 3km of the site.

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

The N7 is located some 2.5 km to the south east of the development site.

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 7.

Table 7 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	54	≤40	No
	Evening	48	≤35	
	Night-time	35	≤30	
B	Daytime	60	≤40	No
	Evening	48	≤35	
	Night-time	37	≤30	
C	Daytime	51	≤40	No
	Evening	48	≤35	
	Night-time	40	≤30	
D	Daytime	50	≤40	No
	Evening	45	≤35	
	Night-time	37	≤30	

As outlined in Tables 4, 5 and 6, none of the locations would be considered 'Areas of Low Background Noise' as the measured noise levels do not satisfy the criteria.

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 some 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 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 8. Free field noise emission levels have been predicted at a height stated in Table 8.

Table 8 Coordinates of Noise Sensitive Receivers

Ref	Comment	National Grid Reference	
		North	East
R01	Located at a private residence to the south west of the proposed site at a distance of some 300m from the site boundary.	702,552	730,654
R02	Located at a private residence to the south west of the proposed site at a distance of some 250m from the site boundary.	702,609	730,672
R03	Located at a private residence along the Baldonnel Road, to the south of the site, on the opposite side of the Cyrus One facility under construction, some 220m from the site boundary.	702,848	730,614
R04	Located at a private residence along the Baldonnel Road, to the south of the site, on the opposite side of the Cyrus One facility under construction, some 230m from the site boundary.	702,869	730,601
R05	Located at a private residence along the Baldonnel Road, to the south of the site, on the opposite side of the Cyrus One facility under construction, some 250m from the site boundary.	702,896	730,571
R06	Located at a private residence along the Baldonnel Road, to the south of the site, on the opposite side of the Cyrus One facility under construction, some 270m from the site boundary.	703,016	730,481
R07	Located at a private residence along the Baldonnel Road, to the south of the site, on the opposite side of the Cyrus One facility under construction, some 375m from the site boundary.	702,961	730,388

Ref	Comment	National Grid Reference	
		North	East
R08	Located at a private residence along the Baldonnel Road, to the south of the site, on the opposite side of the Cyrus One facility under construction, some 380m from the site boundary.	703,020	730,336
R09	Located at a private residence, adjoining a nearby pitch and putt course on the opposite side of the New Nangor Road, to the north of the site, some 50m from the northern site boundary.	703,134	731,133
R10	Located at nearby commercial site, on the opposite side of the Old Nangor Road, some 55m from the northern site boundary.	703,262	731,102
R11	Located at nearby commercial site, opposite the eastern boundary of the site.	703,492	730,900
R12	Located at nearby commercial site, opposite the eastern boundary of the site.	703,490	730,877
R13/14	Located at a private residence located off the Old Nangor Road, to the east of the site some 120m from the eastern site boundary. It is understood this property is abandoned and is unlikely to be reoccupied going forward.	703,599	730,907

Figure 4 Noise Assessment Locations

5.2 Noise Source Data

The noise modelling competed indicates the following limits in relation to various items of plant associated with the overall site development. Plant items will be selected in order to achieve the stated noise levels and or appropriate attenuation will be incorporated into the design of the plant/building in order that the plant noise emission levels are achieved on site (including any system regenerated noise).

Table 9 L_{wA} levels Utilised in Noise Model

Source	L_{wA} - Octave Band Centre Frequency								dB (A)
	63	125	250	500	1k	2k	4k	8k	
Roof Fan Note A	56	59	67	71	69	66	62	62	75
AHU & CRAH Louvres Note B	55	61	55	51	46	44	41	32	54
Condensers	55	63	68	72	72	67	61	52	77
Generator Intake Note C	88	90	82	83	83	80	78	76	94
Generator Rear Note C	88	90	82	83	83	80	78	76	94
Generator Stack Note D	84	77	77	73	69	74	71	71	86
Generator Sides & Roof Note C	82	93	92	94	94	93	88	75	101

Note A Roof exhaust with attenuator – as advised by client.
Note B Per m^2
Note C Assuming generator housing dimensions of 17m (L) x 4m (W) x 4m (H). Data based on CAT data supplied in relation to previous sites.
Note D Additional attenuation due to 20m stack and additional bends assumed.

Note E The following extract from the "EirGrid Evidence Based Environmental Studies Study 8: Noise – Literature review and evidence-based field study on the noise effects of high voltage transmission development (May 2016) states the following in relation to noise impacts associated with 110KvA transformer installations:

"The survey on the 110kV substation at Dunfirth indicated that measured noise levels (L_{Aeq}) were less than 40dB(A) at 5m from each of the boundaries of the substation. This is below the WHO night-time free-field threshold limit of 42dB for preventing effects on sleep and well below the WHO daytime threshold limits for serious and moderate annoyance in outdoor living areas (i.e. 55dB and 50dB respectively). Spectral analysis of the data recorded at this site demonstrated that there were no distinct tonal elements to the recorded noise level. To avoid any noise impacts from 110kV substations at sensitive receptors, it is recommended that a minimum distance of 5m is maintained between 110kV substations and the land boundary of any noise sensitive property."

Assuming the proposed substation installation has comparable noise emissions to the 110kV unit discussed above and considering the distance between the 110kV substation and the nearest off site i.e. >250m) noise from this installation is not predicted to be an issue off site.

Considering the above, it is concluded that there will be no significant noise emissions from the operation of the cable installations or substation. Consequently, there is no requirement to assess any operational noise emissions.

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:

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

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 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

*Note ** *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 HJL Architects.

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

Heights The heights of buildings on site have been obtained from site drawings forwarded by HJL 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 HJL 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 four distinct operational scenarios.

- Scenario A – Proposed Data Storage Facility – Day to Day
- Scenario B – Proposed Data Storage Facility – Emergency
- Scenario C1 – Proposed Data Storage Facility – Generator Testing Building A
- Scenario C2 – Proposed Data Storage Facility – Generator Testing Building C

Figures 5, 6, 7 and 8 presents the predicted noise contour plot for mechanical services and process plant associated with the development for Scenarios A, B, C1 and C2 receptively.

The predicted noise levels from new mechanical plant at each NSL are tabulated in Table 11.

Table 11 Predicted Operational Noise Levels at NSL's for New Mechanical Plant Items

Location	Plant Predicted Level (dB)			
	Scenario A	Scenario B	Scenario C1	Scenario C2
R01	23	34	24	24
R02	25	35	26	26
R03	28	38	29	29
R04	29	38	30	30
R05	30	39	31	31
R06	33	45	33	35
R07	32	43	32	34
R08	31	43	32	33
R09	36	54	38	44
R10	36	53	36	46
R11	35	41	35	36
R12	35	41	35	35
R13	33	40	33	35

5.4.1 Scenario A

Table 12 present 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

Ref	Description	Predicted Noise Level dB(A) for Scenario A	Period	Criterion dB $L_{Aeq,T}$	Complies?
R01	--	23	Day	55	✓
			Evening	50	✓
			Night	45	✓
R02	--	25	Day	55	✓
			Evening	50	✓
			Night	45	✓
R03	--	28	Day	55	✓
			Evening	50	✓
			Night	45	✓
R04	--	29	Day	55	✓
			Evening	50	✓
			Night	45	✓
R05	--	30	Day	55	✓
			Evening	50	✓
			Night	45	✓
R06	--	33	Day	55	✓
			Evening	50	✓
			Night	45	✓
R07	--	32	Day	55	✓
			Evening	50	✓
			Night	45	✓
R08	--	31	Day	55	✓
			Evening	50	✓
			Night	45	✓
R09	--	36	Day	55	✓
			Evening	50	✓
			Night	45	✓
R10	Commercial	36	Day	55	✓
			Evening	n/a	n/a
			Night	n/a	n/a
R11	Commercial	35	Day	55	✓
			Evening	n/a	n/a
			Night	n/a	n/a
R12	Commercial	35	Day	55	✓
			Evening	n/a	n/a
			Night	n/a	n/a
R13	--	33	Day	55	✓
			Evening	50	✓
			Night	45	✓

Review of the predicted noise levels conclude the adopted criteria are satisfied based on the assumptions outlined in this document.

5.4.2 Scenario B

Table 13 present 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

Ref	Description	Predicted Noise Level dB(A) for Scenario C	Period	Criterion dB $L_{Aeq,T}$	Complies?
R01	--	34	Emergency	55	✓
R02	--	35		55	✓
R03	--	38		55	✓
R04	--	38		55	✓
R05	--	39		55	✓
R06	--	45		55	✓
R07	--	43		55	✓
R08	--	43		55	✓
R09	--	54		55	✓
R10	Commercial	53		55	✓
R11	Commercial	41		55	✓
R12	Commercial	41		55	✓
R13	--	40		55	✓

Review of the predicted noise levels conclude the adopted criteria are satisfied based on the assumptions outlined in this document.

5.4.3 Scenario C1

Table 13 present 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 C1. Note generator testing will only take place during daytime periods.

Table 14 Predicted Operational Noise Levels vs Criteria – Scenario C1

Ref	Description	Predicted Noise Level dB(A) for Scenario C	Period	Criterion dB $L_{Aeq,T}$	Complies?
R01	--	24	Emergency	55	✓
R02	--	26		55	✓
R03	--	29		55	✓
R04	--	30		55	✓
R05	--	31		55	✓
R06	--	33		55	✓
R07	--	32		55	✓
R08	--	32		55	✓
R09	--	38		55	✓
R10	Commercial	36		55	✓

Ref	Description	Predicted Noise Level dB(A) for Scenario C	Period	Criterion dB $L_{Aeq,T}$	Complies?
R11	Commercial	35		55	✓
R12	Commercial	35		55	✓
R13	--	33		55	✓

Review of the predicted noise levels conclude the adopted criteria are satisfied based on the assumptions outlined in this document.

5.4.4 Scenario C2

Table 15 present 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 C2. Note generator testing will only take place during daytime periods.

Table 15 Predicted Operational Noise Levels vs Criteria – Scenario C2

Ref	Description	Predicted Noise Level dB(A) for Scenario C	Period	Criterion dB $L_{Aeq,T}$	Complies?
R01	--	24	Emergency	55	✓
R02	--	26		55	✓
R03	--	29		55	✓
R04	--	30		55	✓
R05	--	31		55	✓
R06	--	35		55	✓
R07	--	34		55	✓
R08	--	33		55	✓
R09	--	44		55	✓
R10	Commercial	46		55	✓
R11	Commercial	36		55	✓
R12	Commercial	35		55	✓
R13	--	35		55	✓

Review of the predicted noise levels conclude the adopted criteria are satisfied based on the assumptions outlined in this document.

5.4.5 Summary

Scenario A All locations comply with the adopted criteria in relation to day to day operations. Figure 6 presents a noise contour for Scenario A.

Scenario B All locations comply with the adopted criteria in relation to day to day operations. Figure 7 presents a noise contour for Scenario B.

Scenario C1 All locations are within the relevant adopted emergency operation limit in the rare event that a power loss to the site occurs. Figure 8 presents a noise contour for Scenario C.

Scenario C2 All locations are within the relevant adopted daytime limits by a during periods when generators are undergoing routine testing. Figure 9 presents a noise contour for Scenario D.

Figure 5 Operational Noise Prediction Contours – Scenario A

Figure 6 Operational Noise Prediction Contours – Scenario B

Figure 7 Operational Noise Prediction Contours – Scenario C1

Figure 8 Operational Noise Prediction Contours – Scenario C2

6.0 CONCLUSION

A detailed noise survey has been completed at four 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 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 m² 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 Arup.

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

Heights The heights of buildings on site have been obtained from site drawings forwarded by Arup. 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 Arup where available.

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

Modelling Calculation Parameters[2]

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

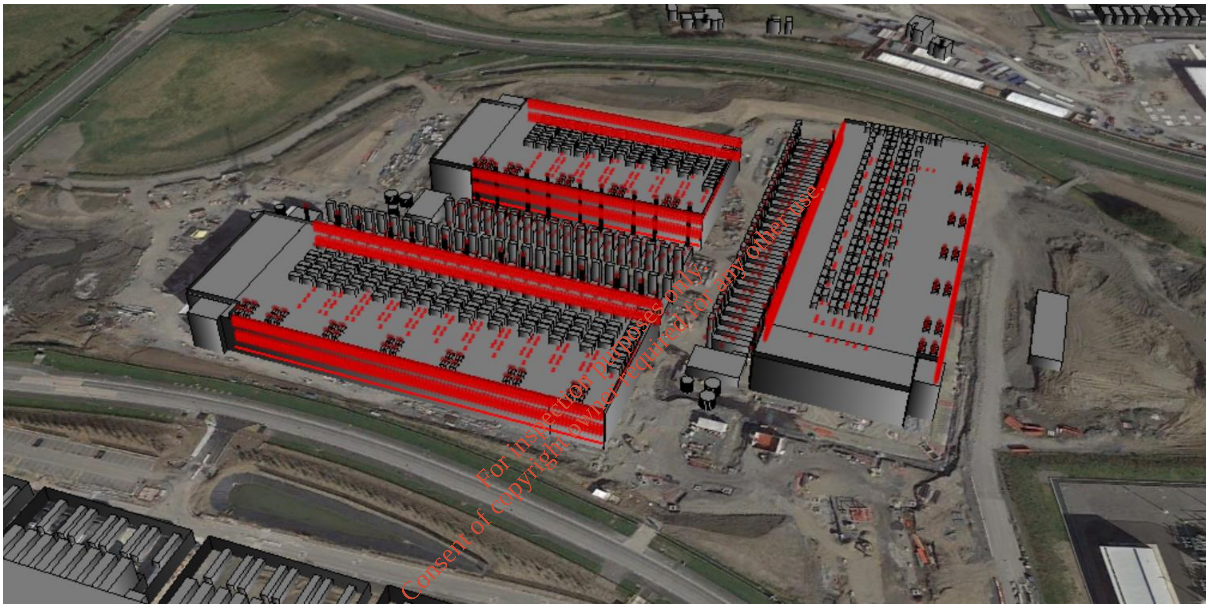

Figure B1 Images of Developed Noise Model – View of Site

2 See Appendix C for further discussion of calculation parameters.

APPENDIX C

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.

Table 10.6.1 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

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.