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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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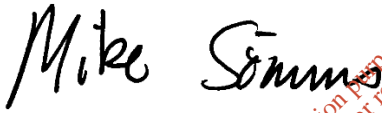

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EXECUTIVE SUMMARY

Amazon Data Services Ireland Limited ('ADSIL') operate two data storage facilities on a site off the Belgard 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.

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1.0 INTRODUCTION

Amazon Data Services Ireland Limited ('ADSIL') operate two data storage facilities on a site located off the Belgard 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 illustrates the proposed site location in the context of the surrounding environment.



Figure 1 Site Location & Context (indicative red line shown)

The nearest residential noise sensitive locations are located to the west of the development along the Belgard Road at a distance of approximately 45m from the nearest site buildings. There are also residential dwellings to the north east of the site at some 300m distance in Mayberry Park with Redwood View and other properties in the Redwood estate beyond. A number of residential locations are also noted to the west of the site in Colbert's Fort at a distance of some 90m. In addition, there are a number of commercial and industrial operations located on lands to the north, east and south. The western boundary of the site abuts a section of the Belgard Road.

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

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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 text¹.

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

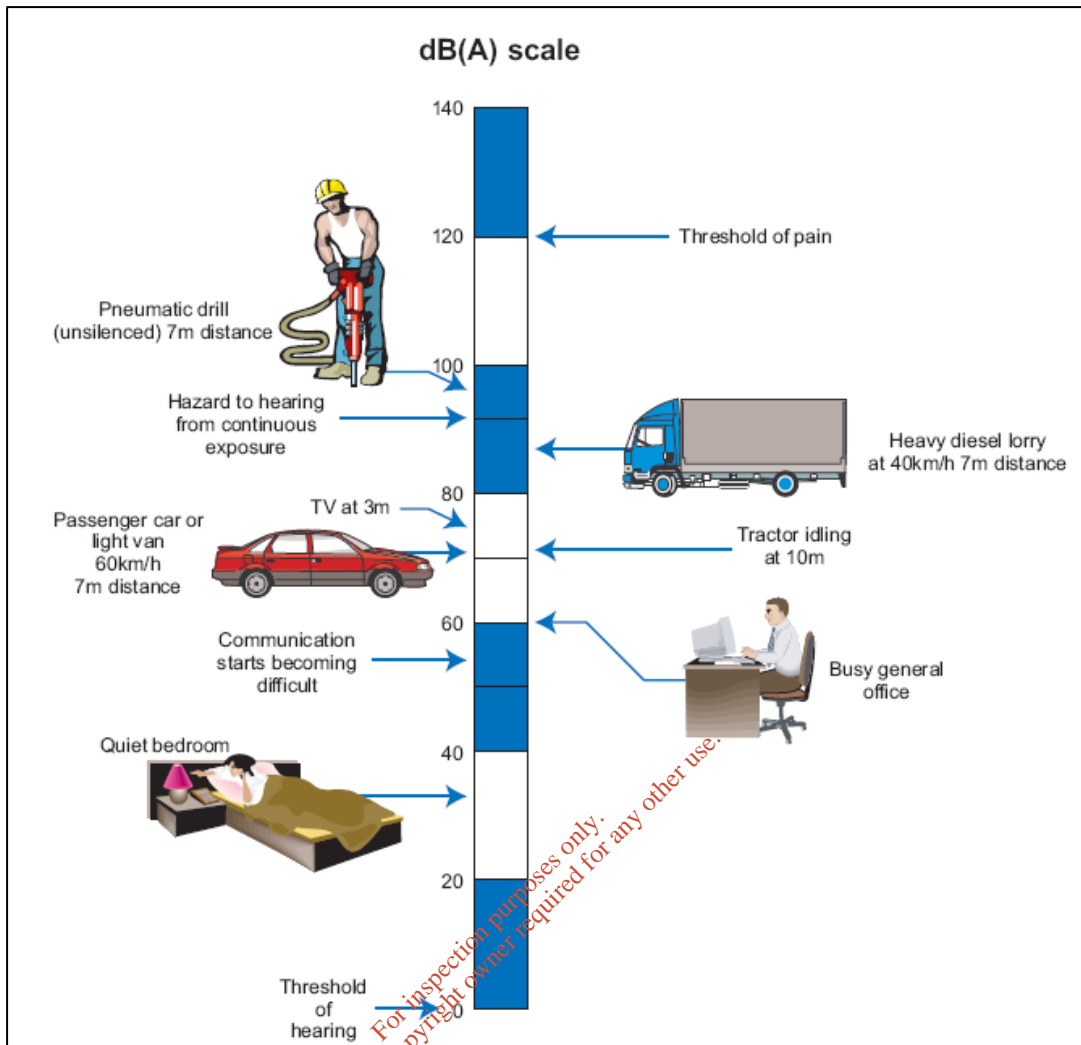


Figure 2 Level of Typical Sounds on the dB(A) Scale – (TII – Good Practice Guidance for the Treatment of Noise during the Planning of National Road Schemes)

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, as set out in Section 3.2, has been conducted in order to quantify the existing noise environment. The survey was conducted in general accordance with ISO 1996: 2007: *Acoustics – Description, measurement and assessment of environmental noise*². Specific details are set out below.

3.1 Choice of Measurement Locations

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

Table 1 Measurement Locations & Descriptions




Location	Description	Photo
A	Located at the nearest residential noise sensitive locations to the south east of the proposed development. It is located in the Bancroft Estate which is on the far side of the Institute of Technology campus. The location is some 700m from the site boundary.	
B	Located to the north of the site at the nearest noise sensitive locations within the Redwood estate off the Mayberry Road. The location is some 180m from the site under review here. The noise environment here is representative of other residential locations in the area.	
C	Located in the vicinity of residences in the Colbert’s Fort residential area. The location is some 80m from the site boundary on the opposite side of the Belgard Road.	

Figure 3 details the approximate location of the measurement positions identified below.

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

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

potential impact during night time periods is the critical issue. The survey was conducted during the following periods:

- Daytime 10:00hrs to 12:25hrs 24 February 2016
- Night-time 22:55hrs on 25 February to 02:00hrs on 26 February 2016

Baseline noise surveys used for the original planning associated with the development 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.

3.3 Personnel & Instrumentation

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

3.4 Procedure

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

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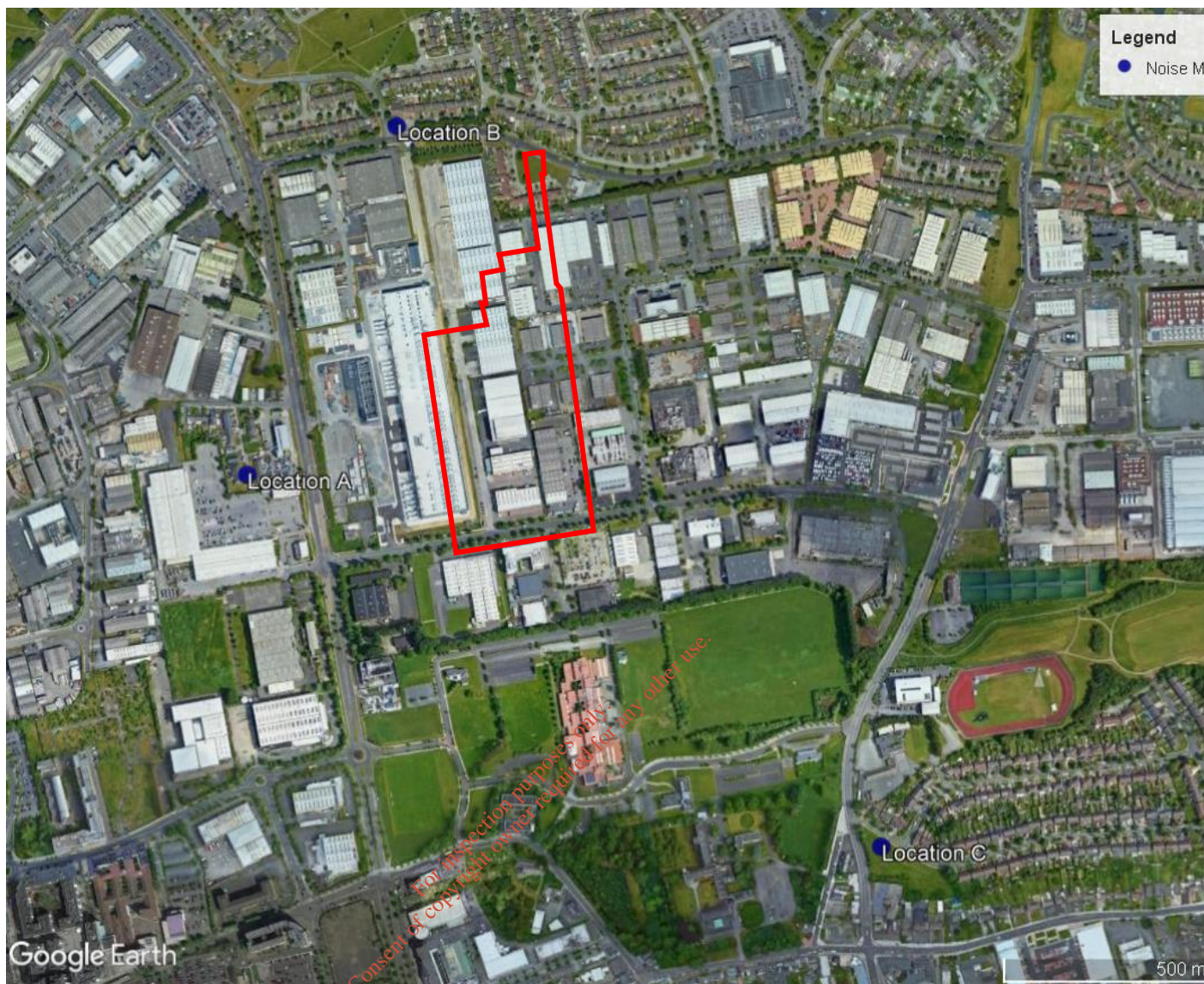


Figure 3 Noise Monitoring Locations (indicative red line shown)

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 2×10^{-5} Pa.

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

L_{ArT} 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_{ArT} .

3.6 Survey Results

3.6.1 Location A

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

Table 2 Summary of Results for Location A

Time (hrs)		Measured Noise Levels (dB re. 2×10^{-5} Pa)				
		$L_{Aeq,15mn}$	L_{AFmax}	L_{AFmin}	$L_{A10,15min}$	$L_{A90,15min}$
Daytime	10:08	56	68	44	59	48
	12:07	56	74	44	58	51
Night-time	23:41	52	63	40	57	43
	00:42	52	66	37	56	41
	01:45	50	63	36	56	38

During the daytime period, measured levels were dominated by traffic on the Greenhills Road. Other noise sources included dogs barking, pedestrians and noise from a nearby schoolyard. Ambient noise levels were the order of 56dB $L_{Aeq,15min}$ with background noise levels in the range 48 to 51dB $L_{A90,15min}$.

During the night-time period levels were again dominated by the reduced traffic volumes moving along the Greenhills Road. As with the daytime survey, dogs barking were also noted. A faint plant noise to the west and south was also noted. A loud screeching event during the second measurement was audible from the west. Ambient noise levels were in the range of 50 to 52dB $L_{Aeq,15min}$ with background noise levels in the range of 38 to 43dB $L_{A90,15min}$.

3.6.2 Location B

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

Table 3 Summary of Results for Location B

Time (hrs)		Measured Noise Levels (dB re. 2×10^{-5} Pa)				
		$L_{Aeq,15mn}$	L_{AFmax}	L_{AFmin}	$L_{A10,15min}$	$L_{A90,15min}$
Daytime	10:39	65	82	45	67	51
	11:44	61	75	45	65	51
Night-time	23:19	61	76	41	65	44
	00:21	62	80	40	64	42

Time (hrs)		Measured Noise Levels (dB re. 2×10^{-5} Pa)				
		L _{Aeq,15mn}	L _{AFmax}	L _{AFmin}	L _{A10,15min}	L _{A90,15min}
	01:23	58	79	39	55	41

During the daytime period noise levels were dominated by frequent traffic on Mayberry Road. During lulls activity from the warehouses to the south was audible at the monitoring locations. Background noise levels were dictated by general traffic noise typical of urban areas. Ambient noise levels were in the range 61 to 65dB L_{Aeq,15min} with background noise levels of the order of 51dB L_{A90,15min}.

During the night-time period ambient levels were again dominated by traffic on the Mayberry Road. Activity in the warehouses and yards to the south was more discernible (truck engines revving, reverse alarms, shusher alarms, intermittent bangs and air brakes) for the whole survey period. Again loud screeching was audible one or twice over the survey period. HGV's were observed entering and exiting the yard further down the road, for the duration of the survey. Ambient noise levels were in the range of 58 to 62dB L_{Aeq,15min}. Background noise levels were in the range of 41 to 44dB L_{A90,15min}.

3.6.3 Location C

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

Table 4 Summary of Results for Location C

Time (hrs)		Measured Noise Levels (dB re. 2×10^{-5} Pa)				
		L _{Aeq,15mn}	L _{AFmax}	L _{AFmin}	L _{A10,15min}	L _{A90,15min}
Daytime	11:05	46	68	40	47	42
	12:07	51	75	41	51	43
Night-time	22:58	51	73	37	53	40
	00:02	48	67	39	49	42
	01:04	46	66	37	47	39

During the daytime period ambient noise levels were dominated by traffic on the Belgard Road with levels in the range of 46 to 51dB L_{Aeq,15min}. Other noise sources included pedestrians and activity in the car park to the south of the location. Background noise levels were dictated by general traffic noise typical of urban areas. Background levels were in the range of 42 to 43dB L_{A90,15min}.

During the night-time survey moderate traffic on the Belgard Road influenced the measurements. Other noise sources included faint plant noise, pedestrian light beeping and faint activity in the yard to west. Ambient noise levels are in the range of 46 to 51dB L_{Aeq,15min} and background noise levels in the range of 39 to 42dB L_{A90,15min}.

It is also to be noted that the noise criteria applied for this development are based on noise data before Building A was operational and this therefore addresses any concern of 'background creep'.

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 have been submitted as part of the licence application for the site.

This analysis found that the nearest European sites to the Project are Glenasmole Valley SAC, approximately 3.82 km to the south, and the two Wicklow Mountains sites, Wicklow Mountains SAC and SPA, both over 6 km to the south.

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.

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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 1.4 and 1km 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 ≤ 40 dB L_{A90} , and;
- Arithmetic Average of L_{A90} During Evening Period ≤ 35 dB L_{A90} , and;
- Arithmetic Average of L_{A90} During Night-time Period ≤ 30 dB L_{A90} .

Table 5 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	49	≤ 40	No
	Evening	45	≤ 35	
	Night-time	41	≤ 30	
B	Daytime	51	≤ 40	No
	Evening	45	≤ 35	
	Night-time	42	≤ 30	
C	Daytime	42	≤ 40	No
	Evening	40	≤ 35	
	Night-time	40	≤ 30	

The arithmetic average L_{A90} results at each location are compared against the criteria in Table 5. As outlined in Table 5, 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 55 dB $L_{Aeq,(15mins)}$ 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 6. Free field noise emission levels have been predicted at a height stated in Table 6.

Table 6 Coordinates of Noise Sensitive Receivers

Noise Sensitive Location	Calculation Height (m)	National Grid Reference	
		North	East
NSL01	4	308,720	228,770
NSL02	4	308,786	228,785
NSL03	4	308,845	228,799
NSL04	4	308,900	228,816
NSL05	4	308,953	228,822
NSL06	4	309,003	228,829
NSL07	4	309,053	228,815
NSL08	4	309,034	228,762
NSL09	4	309,045	228,705
NSL10	4	309,060	228,694
NSL11	4	309,092	228,698
NSL12	4	309,125	228,705
NSL13	4	309,200	228,769
NSL14	4	309,254	228,772
NSL15	4	309,313	228,785
NSL16	3	308,704	228,381
NSL17	3	308,709	228,357
NSL18	3	308,718	228,324
NSL19	3	308,722	228,304
NSL20	3	308,638	228,383
NSL21	4	308,547	227,992
NSL22	4	309,587	227,855

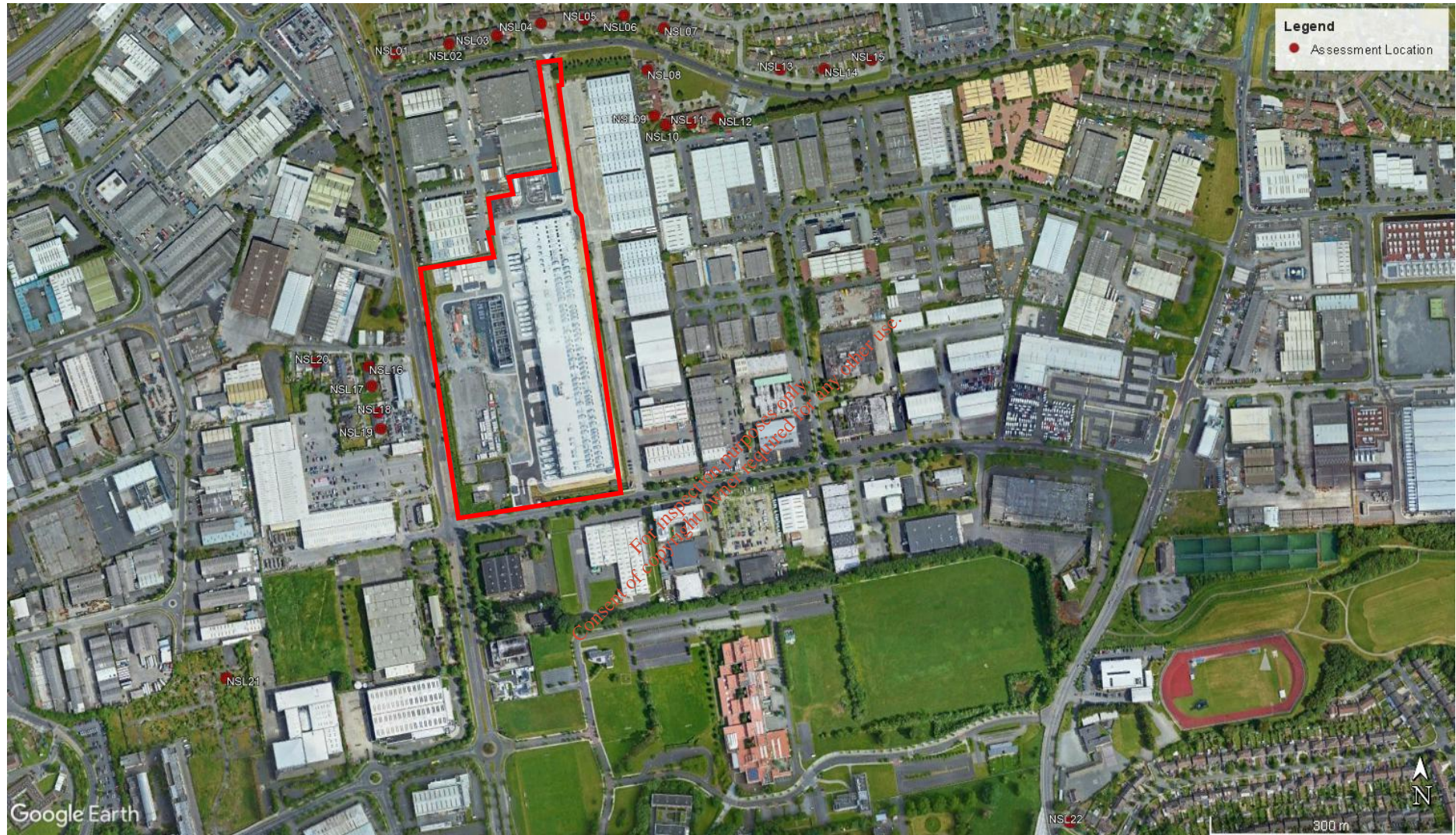


Figure 4 Noise Assessment Locations (*indicative red line shown*)

5.2 Noise Source Data

The noise modelling completed indicates the following limits in relation to the sound power levels of 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 7 *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}	61	70	78	81	77	77	75	68	86
Roof Fan ^{Note B}	65	69	77	79	75	69	67	62	83
AHU Louvres	43	59	60	62	60	59	56	45	68
Electrical Room Extract Fan ^{Note C}	43	63	62	62	50	46	29	17	67
Catcher Room Extract Fan	43	63	62	62	50	46	29	17	67
Generator Roof	75	88	88	90	93	90	89	82	98
Generator Side (x2)	74	93	89	91	92	91	87	75	99
Generator Front	88	90	82	83	83	80	78	76	94
Generator Rear	80	91	86	87	84	81	78	68	95
Generator Stack	84	77	77	74	70	75	72	72	87

Note A Building A - SAE-DUB064 sound source Noise Test Ext.PDF. For the purposes of this assessment it has been assumed that all fans are operating on 80% duty.

Note B Building B – measured on site 80% duty.

Note C 6054-DUB064-CRAH UNITS - SOUND CALCS - 250Pa ESP - REV A - 23-03-2018

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 $\pm 45^\circ$ 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:

$$L_{IT}(DW) = L_W + D_c - A \tag{Eqn. A}$$

Where:

- $L_{IT}(DW)$ is an octave band centre frequency component of $L_{AT}(DW)$ in dB relative to $2 \times 10^{-5}\text{Pa}$;
- 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 8 below:

Table 8 Estimated Accuracy for Broadband Noise of $L_{AT}(DW)$

Height, h^*	Distance, d^\dagger	
	$0 < d < 100\text{m}$	$100\text{m} < d < 1,000\text{m}$
$0 < h < 5\text{m}$	$\pm 3\text{dB}$	$\pm 3\text{dB}$
$5\text{m} < h < 30\text{m}$	$\pm 1\text{dB}$	$\pm 3\text{dB}$

* h is the mean height of the source and receiver. $^\dagger d$ 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 an 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 9 for each NSL.

Table 5 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
NSL01	25	40
NSL02	29	52
NSL03	25	41
NSL04	35	42
NSL05	38	44
NSL06	26	40
NSL07	28	39
NSL08	26	39
NSL09	26	40
NSL10	27	41
NSL11	29	41
NSL12	29	41
NSL13	30	40
NSL14	30	40
NSL15	30	39
NSL16	39	47
NSL17	36	47
NSL18	38	46
NSL19	40	47
NSL20	37	49
NSL21	34	45
NSL22	29	39

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Table 10 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 10 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?
NSL01	25	55	Yes	50	Yes	45	Yes
NSL02	29		Yes		Yes		Yes
NSL03	25		Yes		Yes		Yes
NSL04	35		Yes		Yes		Yes
NSL05	38		Yes		Yes		Yes
NSL06	26		Yes		Yes		Yes
NSL07	28		Yes		Yes		Yes
NSL08	26		Yes		Yes		Yes
NSL09	26		Yes		Yes		Yes
NSL10	27		Yes		Yes		Yes
NSL11	29		Yes		Yes		Yes
NSL12	29		Yes		Yes		Yes
NSL13	30		Yes		Yes		Yes
NSL14	30		Yes		Yes		Yes
NSL15	30		Yes		Yes		Yes
NSL16	39		Yes		Yes		Yes
NSL17	36		Yes		Yes		Yes
NSL18	38		Yes		Yes		Yes
NSL19	40		Yes		Yes		Yes
NSL20	37		Yes		Yes		Yes
NSL21	34		Yes		Yes		Yes
NSL22	29		Yes		Yes		Yes

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Table 11 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 6 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?
NSL01	40	55	Yes	55	Yes	55	Yes
NSL02	52		Yes		Yes		Yes
NSL03	41		Yes		Yes		Yes
NSL04	42		Yes		Yes		Yes
NSL05	44		Yes		Yes		Yes
NSL06	40		Yes		Yes		Yes
NSL07	39		Yes		Yes		Yes
NSL08	39		Yes		Yes		Yes
NSL09	40		Yes		Yes		Yes
NSL10	41		Yes		Yes		Yes
NSL11	41		Yes		Yes		Yes
NSL12	41		Yes		Yes		Yes
NSL13	40		Yes		Yes		Yes
NSL14	40		Yes		Yes		Yes
NSL15	39		Yes		Yes		Yes
NSL16	47		Yes		Yes		Yes
NSL17	47		Yes		Yes		Yes
NSL18	46		Yes		Yes		Yes
NSL19	47		Yes		Yes		Yes
NSL20	49		Yes		Yes		Yes
NSL21	45		Yes		Yes		Yes
NSL22	39		Yes		Yes		Yes

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Figure 5 Operational Noise Prediction Contours – Scenario A

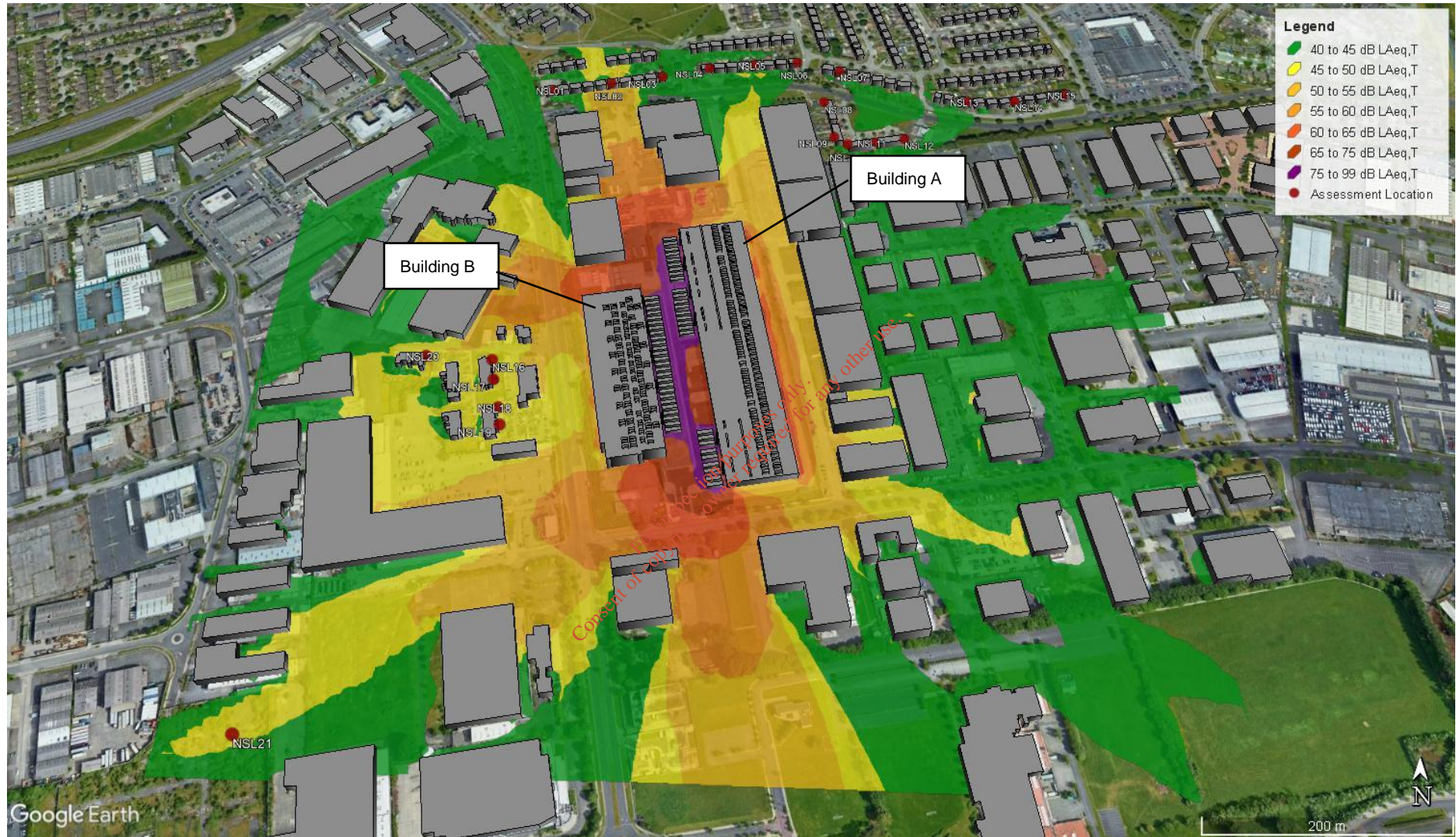


Figure 6 Operational Noise Prediction Contours – Scenario B

6.0 CONCLUSION

A detailed noise survey has been completed at three 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.

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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 μ Pa).
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 _{A,r,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:
	$L_w = 10 \log \frac{P}{P_0} \text{ dB}$
	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:
	$L_p = 20 \log \frac{P}{P_0} \text{ dB}$
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.

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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 $\pm 45^\circ$ 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:

$$L_{rT}(DW) = L_W + D_c - A \quad \text{Eqn. A}$$

Where:

$L_{rT}(DW)$ is an octave band centre frequency component of $L_{AT}(DW)$ in dB relative to $2 \times 10^{-5} \text{Pa}$;

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^\dagger	
	$0 < d < 100\text{m}$	$100\text{m} < d < 1,000\text{m}$
$0 < h < 5\text{m}$	$\pm 3\text{dB}$	$\pm 3\text{dB}$
$5\text{m} < h < 30\text{m}$	$\pm 1\text{dB}$	$\pm 3\text{dB}$

* h is the mean height of the source and receiver. $\dagger d$ 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 Parameters³

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

Ground attenuation factors of 0.5 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 (°C)	% 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

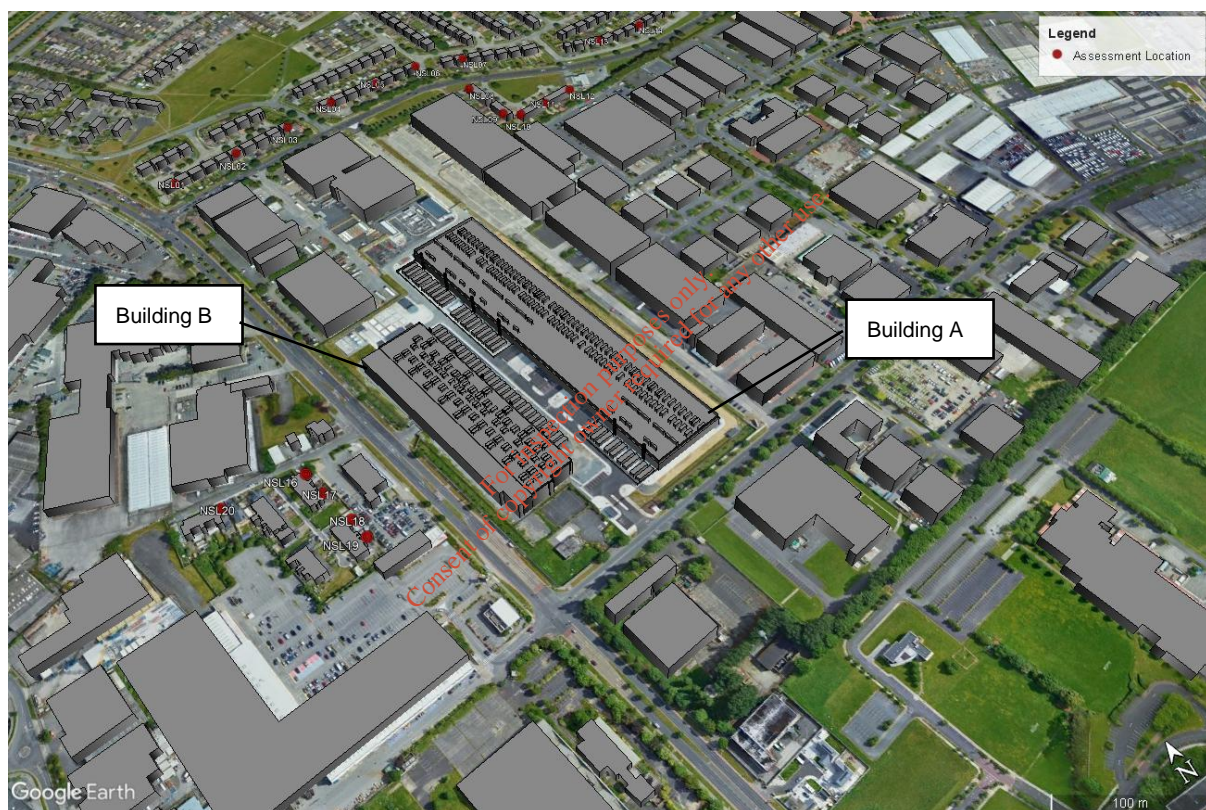


Figure B1 Images of Developed Noise Model – View of Site

³ 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 measured 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 10°C and a relative humidity of 70% have been used, which give relatively 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 (°C)	% 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.