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ATTACHMENT-7-1-3-2-AIR EMISSIONS IMPACT ASSESSMENT

Technical Report Prepared For

Amazon Data Services Ireland Limited

Prepared By

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EXECUTIVE SUMMARY

This revision includes the response to the Environmental Protection Agency (EPA) decision to request additional information dated 27 October 2022. In the interest of clarity and transparency, the additional information and any updates to this report since the submission is shown as tracked changes to this document (including deletions).

This report presents the assessment of air quality impacts as a result of the operation of the data storage facility, Grange Castle Business Park South, Co. Dublin. The installation requires a continuous supply of electricity to operate. During normal operations, the facility is supplied electricity from the national grid. Outside of normal operations, the facility is first supplied electricity by some or all of the onsite battery installations and then by some or all of the onsite backup generators. Outside of routine testing and maintenance, the operation of these back-up generators is typically only required under the following emergency circumstances:

- 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

The air dispersion modelling has been carried out using the United States Environmental Protection Agency's regulated model AERMOD. The AERMOD model has USEPA regulatory status and is one of the advanced models recommended within the air modelling guidance document 'Air Dispersion Modelling from Industrial Installations Guidance Note (AG4)' published by the EPA in Ireland (EPA, 2020). The modelling of air emissions from the site was carried out to assess concentrations of nitrogen dioxide (NO_2) at a variety of locations beyond the site boundary. The modelling was undertaken to assess the impact to ambient air quality from the testing of the emergency back-up generators and the infrequent emergency operation of the standby generators. The modelling assessment also included the cumulative impact of the standby generators and the existing IED licenced sites in the vicinity of the site and a second data storage facility to the south of the site under the applicant's control.

~~There are 70 no. 6.49 MW_{th} diesel powered emergency back-up generators on site and 3 no. 2.19 MW_{th} diesel powered 'house' generators. There are also 3.03 MWth diesel powered emergency back-up generators and 2 no. 0.57450 MW_{th} diesel powered emergency back-up fire pumps on site in addition to the emergency back-up generators. These fire pumps have been scoped out of this air modelling assessment as it is not expected that they would cause any significant impacts on ambient air quality considering their smaller scale (compared to the data hall back-up generators) and the low number required for use at any one time.~~

There are 70 no. 6.49 MW_{th} diesel powered emergency back-up generators on site and 3 no. 2.19 MW_{th} diesel powered 'house' generators. There are also 2 no. 0.57 MW_{th} diesel powered emergency back-up fire pumps on site in addition to the emergency back-up generators. These fire pumps have been scoped out of this air modelling assessment as it is not expected that they would cause any significant impacts on ambient air quality considering their smaller scale (compared to the data hall back-up generators) and the low number required for use at any one time.

In total, the air dispersion modelling includes 70 no. 6.49 MW_{th} emergency back-up generators on the Facility campus. Building A: 26 no. emergency back-up generators, Building B: 18 no. emergency back-up generators; Building C: 26 no. 6.49 MW_{th} emergency back-up generators. Each of these 70 no. 6.49 MW_{th} emergency back-up generators stacks will have a minimum height of 25m above ground level. In addition, each building A, B and C will also include 1 no. 2.19 MW_{th} 'house' generator which will have an associated 19.7 m stack. These 3 no. 2.19 MW_{th} generators have also been included in the modelling assessment and will operate under the same conditions and frequency as the larger 6.49 MW_{th} standby generators.

USEPA Guidance suggests that for emergency operations, an average hourly emission rate should be used rather than the maximum hourly rate. As a result, the maximum hourly emission rates from the standby generators were reduced by $\frac{72}{8760}$ and the generators were modelled over a period of one full year. In reality, the standby generators are likely to run during maintenance and testing only.

A second methodology has been published by the UK Environment Agency and is based on considering the statistical likelihood of an exceedance of the NO_2 hourly limit value (18 exceedances are allowable per year before the air standard is deemed to have been exceeded). The assessment assumes a hypergeometric distribution to assess the likelihood of exceedance hours coinciding with the operational hours of the standby generators. The guidance also states that there should be no running time restrictions on standby generators when providing power on site during an emergency. Both the methodology advised in USEPA guidance as well as the approach described in the UK Environment Agency guidance have been applied in this study to ensure a robust assessment of predicted air quality impacts from the standby generators.

Assessment Summary

The USEPA methodology modelling results (based on 72 hours of operation) indicate that ambient ground level concentrations are below the relevant air quality standards for NO_2 for all scenarios modelled. Emissions associated with the ~~70~~ 73 no. standby generators lead to an ambient NO_2 concentration that is 65% of the ambient 1-hour limit value (measured as a 99.8^{th} percentile) and ~~84~~84% of the ambient annual mean limit value at the worst-case off-site receptor for the worst-case year.

In addition, the NO_2 emissions associated with the cumulative assessment of the data storage facility and the IED licenced sites and second data storage facility to the south of the site are also in compliance with the air quality standards. Emissions under this scenario lead to an ambient NO_2 concentration that is 66% of the ambient 1-hour limit value (measured as a 99.8^{th} percentile) and ~~92~~93% of the ambient annual mean limit value at the worst-case off-site receptor for the worst-case year.

The UK Environment Agency assessment methodology determined that the standby generators could operate for ~~138~~ 251 hours before there is a likelihood of an exceedance of the ambient air quality standard (at a 98^{th} percentile confidence level). Cumulatively the standby generators, in conjunction with the IED licenced sites and a second data storage facility to the south, can operate for 76 hours before there is a likelihood of an exceedance of the ambient air quality standard (at a 98^{th} percentile confidence level). However, the UK guidance recommends that there should be no running time restrictions placed on standby generators which provide power on site only during an emergency power outage.

In summary, emissions to atmosphere of NO_2, as the main polluting substance (as defined in the Schedule of EPA (Industrial Emissions) (Licensing) Regulations 2013, S.I. No. 137 of 2013) from the standby generators, will be in compliance with the ambient air quality standards which are based on the protection of the environment and human health. Therefore, no significant impacts to the ambient air quality environment are predicted.

In terms of impacts in the nearby ecologically sensitive areas, the ambient level of NO_X in the Grand Canal Proposed NHA (002104); c. 1.4km north, due to emissions from the site, will be a small fraction of the ambient air quality standard for the protection of vegetation. Similarly, cumulative emissions will lead to ambient NO_X levels which will be a small fraction of the ambient air quality standard for the protection of vegetation.

CONTENTS

1.0 INTRODUCTION

This report presents the assessment of air quality impacts as a result of the operation of the data storage facility, Grange Castle Business Park South, Co. Dublin.

The installation requires a continuous supply of electricity to operate. During normal operations, the facility is supplied electricity from the national grid. Outside of normal operations, the facility is first supplied electricity by some or all of the onsite battery installations and then by some or all of the onsite backup generators. Outside of routine testing and maintenance, the operation of these back-up generators is typically only required under the following emergency circumstances:

- 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

Air dispersion modelling of operational stage emissions from 70 no. 6.49 MW_{th} standby diesel generators and 3 no. 2.19 MW_{th} generators was carried out using the United States Environmental Protection Agency's regulated model AERMOD. The modelling of air emissions from the site was carried out to assess concentrations of nitrogen dioxide (NO_2) at a variety of locations beyond the site boundary. The modelling was undertaken to assess the impact to ambient air quality from the testing of the standby generators and the infrequent emergency operation of the standby generators. The modelling assessment also included the cumulative impact of the standby generators and the existing IED licenced sites in the vicinity of the site.

The site is located in Grange Castle Business Park South which is approximately 12km to the west of Dublin city centre. Most of the land surrounding the site is occupied by industrial campuses including pharmaceutical, data centre, manufacturing and commercial uses (see Figure 1). The site is bounded to the north by the R134, to the west by Baldonnel Road and to the south by Grange Castle South Business Park access road. The Pfizer and Takeda IED licenced sites are located further to the north. In terms of sensitive residential receptors, there are a small number of once off residential properties, in linear development along the roads further to the south, west and north of the site (see Figure 1).

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Figure 1
Land use in the vicinity of ADSIL Grange Castle site

2.0 ASSESSMENT CRITERIA

2.1 Ambient Air Quality Standards

In order to reduce the risk to health from poor air quality, national and European statutory bodies have set limit values in ambient air for a range of air pollutants. These limit values or "Air Quality Standards" are health or environmental-based levels for which additional factors may be considered. The applicable standards in Ireland include the Air Quality Standards Regulations 2011, implement the obligations under Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe (see Table 1). The ambient air quality standards applicable for NO_2 are outlined in this Directive. ~~Directive 2008/50/EC which has set limit values for the pollutants NO_2, PM_{10}, and $PM_{2.5}$ relevant to this assessment.~~ Levels of SO_2 emitted from the facility will be insignificant and have been screened out of the assessment.

Air quality significance criteria are assessed on the basis of compliance with the appropriate standards or limit values. These standards have been used in the current assessment to determine the potential impact of NO_2 emissions from the facility on ambient air quality.

Table 1 *Air Quality Standards 2011 (Based on Directive 2008/50/EC)*

Pollutant	Regulation Note 1	Limit Type	Value
Nitrogen Dioxide (NO_2)	2008/50/EC	Hourly limit for protection of human health - not to be exceeded more than 18 times/year	200 $\mu g/m^3$
		Annual limit for protection of human health	40 $\mu g/m^3$
Nitrogen Oxides (NO_X)	2008/50/EC	Critical level for protection of vegetation (Annual)	30 $\mu g/m^3$ NO + NO_2
Sulphur Dioxide (SO_2)	2008/50/EC	Critical level for protection of vegetation (Annual & Winter)	20 $\mu g/m^3$ SO_2

Note 1 EU 2008/50/EC – Clean Air For Europe (CAFÉ) Directive replaces the previous Air Framework Directive (1996/30/EC) and daughter directives 1999/30/EC and 2000/69/EC

2.2 Industrial Emissions Directive and Medium Combustion Plant Directive

The Industrial Emissions Directive (IED) (Directive 2010/75/EU) was adopted on 7 January 2013 and is the key European Directive which covers the regulation of the majority of processes in the EU. As part of the IED Article 15, paragraph 2, requires that Emissions Limit Values (ELVs) are based on best available techniques (BAT) and the relevant sector Reference Document of Best Available Techniques (BREF documents).

The most relevant BAT sector document for the activities at the installation is the Best Available Techniques (BAT) Reference Document for Large Combustion Plants LCP. There are no ELVs set out in the LCP BAT that are applicable to the individual emergency back-up generators.

The individual emergency back-up generators are ~~6.41~~ 6.49 MW_{th} and the Medium Combustion Plant (MCP) Regulations (S.I No. 595 of 2017), which transposed the Medium Combustion Plant Directive ((EU) 2015/2193), applies to the individual plant.

The installation requires a continuous supply of electricity to operate. During normal operations, the facility is supplied electricity from the national grid. Outside of normal operations, the facility is first supplied electricity by some or all of the onsite battery installations and then by some or all of the onsite backup generators. Outside of routine testing and maintenance, the operation of these back-up generators is typically only required under the following emergency circumstances:

- 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.

The diesel generators are for emergency back-up only and are not anticipated to operate in excess of 500 hours per annum. Therefore, the emergency generators as proposed are exempt from complying with the ELVs subject to Section 13(3) of the Medium Combustion Plant (MCP) Regulations.

The UK Environment Agency assessment methodology in Section 6.2 below determined that the standby generators could operate for ~~138~~ 214 hours before there is a likelihood of an exceedance of the ambient air quality standard (at a 98th percentile confidence level). However, the UK guidance recommends that there should be no running time restrictions placed on standby generators which provide power on site only during an emergency power outage.

2.3 Sensitive areas or areas of special interest

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.

The lands in which the installation is located have no formal designations. The nearest European site to the Proposed Development is the Rye Water Valley / Carton SAC; c. 5.2km north-west. The Baldonnell stream flows east-west through the Proposed Development site and acts as a pathway to European sites downstream in Dublin Bay c. 24km hydrological distance downstream to the east of the Proposed Development.

3.0 ASSESSMENT METHODOLOGY

Emissions from the facility have been modelled using the AERMOD dispersion model (Version ~~19191~~21112) which has been developed by the U.S. Environmental Protection Agency (USEPA)[(1)] and following guidance issued by the EPA[(2)]. The model is a steady-state Gaussian plume model used to assess pollutant concentrations associated with industrial sources and has replaced ISCST3[(3)] as the regulatory model by the USEPA for modelling emissions from industrial sources in both flat and rolling terrain[(4-6)]. The model has more advanced algorithms and gives better agreement with monitoring data in extensive validation studies[(6-10)]. An overview of the AERMOD dispersion model is outlined in Appendix I.

The air dispersion modelling input data consisted of information on the physical environment (including building dimensions and terrain features), design details from all emission points on-site and five years of appropriate hourly meteorological data. Using this input data the model predicted ambient ground level concentrations beyond the site boundary for each hour of the modelled meteorological years. The model post-processed the data to identify the location and maximum of the worst-case ground level concentration. This worst-case concentration was then added to the background concentration to give the worst-case predicted environmental concentration (PEC). The PEC was then compared with the relevant ambient air quality standard to assess the significance of the releases from the site.

The modelling has followed the approach outlined in Appendix K of the EPA guidance note *AG4 Guidance for Air Dispersion Modelling*(2). Throughout this study a worst-case approach was taken. This will most likely lead to an over-estimation of the levels that will arise in practice. The worst-case assumptions are outlined below:

- Maximum predicted concentrations were reported in this study, even if no residential receptors were near the location of this maximum;
- Worst-case background concentrations were used in the assessment;
- The effects of building downwash, due to on-site buildings, has been included in the model;
- Licenced emission points were assumed to be in operation 24 hours per day, 365 days per year;
- Emergency operations were assumed to occur for a maximum of 72 hours per year calculated according to USEPA methodology, in reality generators are likely to be used for maintenance and testing purposes only.

3.1 Air Dispersion Modelling Methodology

The United States Environmental Protection Agency (USEPA) approved AERMOD dispersion model has been used to predict the ground level concentrations (GLC) of compounds emitted from the principal emission sources on-site.

The modelling incorporated the following features:

- Two receptor grids were created at which concentrations would be modelled. Receptors were mapped with sufficient resolution to ensure all localised "hot-spots" were identified without adding unduly to processing time. The outer grid measured 5 x 5 km with the site at the centre and with concentrations calculated at 250m intervals. The inner grid measured 2 x 2 km with the site at the centre and with concentrations calculated at 50m intervals. Boundary receptor locations were also placed along the boundary of the site, at 25m intervals, giving a total of 2,395 calculation points for the model.
- Discrete receptors were also added to the model to represent nearby residential receptors. All receptors were modelled at 1.8m to represent breathing height.
- All on-site buildings and significant process structures were mapped into the computer to create a three dimensional visualisation of the site and its emission points. Buildings and process structures can influence the passage of airflow over the emission stacks and draw plumes down towards the ground (termed building downwash). The stacks themselves can influence airflow in the same way as buildings by causing low pressure regions behind them (termed stack tip downwash). Both building and stack tip downwash were incorporated into the modelling.
- Detailed terrain has been mapped into the model using SRTM data with 30m resolution. The site is located in an area of complex terrain. All terrain features have been mapped in detail into the model using the terrain pre-processor AERMAP(11).
- Hourly-sequenced meteorological information has been used in the model. Meteorological data over a five year period (Casement Aerodrome 2015 – 2019) was used in the model (see Figure 2 and Appendix II).
- The source and emissions data, including stack dimensions, gas volumes and emission temperatures have been incorporated into the model.

3.2 Terrain

The AERMOD air dispersion model has a terrain pre-processor AERMAP[11] which was used to map the physical environment in detail over the receptor grid. The digital terrain input data used in the AERMAP pre-processor was obtained from SRTM. This data was run to obtain for each receptor point the terrain height and the terrain height scale. The terrain height scale is used in AERMOD to calculate the critical dividing streamline height, Hcrit, for each receptor. The terrain height scale is derived from the Digital Elevation Model (DEM) files in AERMAP by computing the relief height of the DEM point relative to the height of the receptor and determining the slope. If the slope is less than 10%, the program goes to the next DEM point. If the slope is 10% or greater, the controlling hill height is updated if it is higher than the stored hill height.

In areas of complex terrain, AERMOD models the impact of terrain using the concept of the dividing streamline (Hc). As outlined in the AERMOD model formulation[1] a plume embedded in the flow below Hc tends to remain horizontal; it might go around the hill or impact on it. A plume above Hc will ride over the hill. Associated with this is a tendency for the plume to be depressed toward the terrain surface, for the flow to speed up, and for vertical turbulent intensities to increase.

AERMOD model formulation states that the model “captures the effect of flow above and below the dividing streamline by weighting the plume concentration associated with two possible extreme states of the boundary layer (horizontal plume and terrain-following). The relative weighting of the two states depends on: 1) the degree of atmospheric stability; 2) the wind speed; and 3) the plume height relative to terrain. In stable conditions, the horizontal plume "dominates" and is given greater weight while in neutral and unstable conditions, the plume traveling over the terrain is more heavily weighted”[4].

3.3 Meteorological Data

The selection of the appropriate meteorological data has followed the guidance issued by the USEPA[1]. A primary requirement is that the data used should have a data capture of greater than 90% for all parameters. Casement Aerodrome meteorological station, which is located approximately 1 km south of the site, collects data in the correct format and has a data collection of greater than 90%. Long-term hourly observations at Casement Aerdrome meteorological station provide an indication of the prevailing wind conditions for the region (see Figure 2 and Appendix II)[12]. Results indicate that the prevailing wind direction is westerly to south-westerly in direction over the period 2015 - 2019. The mean wind speed was approximately 5.5 m/s over the period 1981 - 2010. Calm conditions account for only a small fraction of the time in any one year peaking at 69 hours in 2018 (0.8% of the time). There are also no missing hours over the period 2015 – 2019.

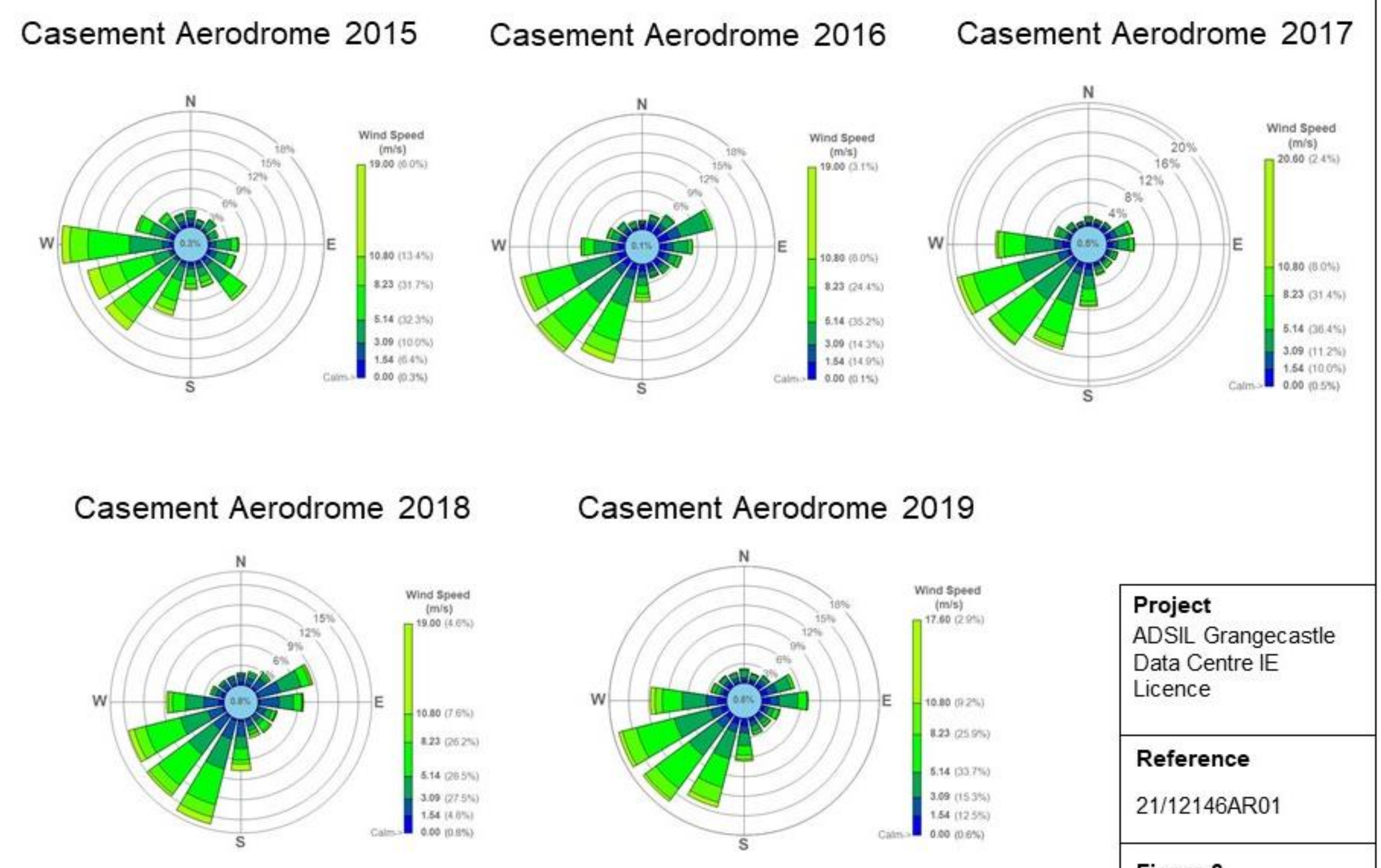

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Figure 2
Casement Aerodrome Windrose 2015 - 2019

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3.4 Geophysical Considerations

AERMOD simulates the dispersion process using planetary boundary layer (PBL) scaling theory[1]. PBL depth and the dispersion of pollutants within this layer are influenced by specific surface characteristics such as surface roughness, albedo and the availability of surface moisture. Surface roughness is a measure of the aerodynamic roughness of the surface and is related to the height of the roughness element. Albedo is a measure of the reflectivity of the surface whilst the Bowen ratio is a measure of the availability of surface moisture.

AERMOD incorporates a meteorological pre-processor AERMET[13] to enable the calculation of the appropriate parameters. The AERMET meteorological preprocessor requires the input of surface characteristics, including surface roughness (z_0), Bowen Ratio and albedo by sector and season, as well as hourly observations of wind speed, wind direction, cloud cover, and temperature. The values of albedo, Bowen Ratio and surface roughness depend on land-use type (e.g., urban, cultivated land etc) and vary with seasons and wind direction. The assessment of appropriate land-use type was carried out to a distance of 10km from the meteorological station for Bowen Ratio and albedo and to a distance of 1km for surface roughness in line with USEPA recommendations[13,14] as outlined in Appendix II.

In relation to AERMOD, detailed guidance for calculating the relevant surface parameters has been published[15]. The most pertinent features are:

- The surface characteristics should be those of the meteorological site (Casement Aerodrome) rather than the installation;
- Surface roughness should use a default 1km radius upwind of the meteorological tower and should be based on an inverse-distance weighted geometric mean. If land use varies around the site, the land use should be sub-divided by sectors with a minimum sector size of 30º;
- Bowen ratio and albedo should be based on a 10km grid. The Bowen ratio should be based on an un-weighted geometric mean. The albedo should be based on a simple un-weighted arithmetic mean.

AERMOD has an associated pre-processor, AERSURFACE[14] which has representative values for these parameters depending on land use type. The AERSURFACE pre-processor currently only accepts NLCD92 land use data which covers the USA. Thus, manual input of surface parameters is necessary when modelling in Ireland. Ordnance survey discovery maps (1:50,000) and digital maps such as those provided by the EPA, National Parks and Wildlife Service (NPWS) and Google Earth® are useful in determining the relevant land use in the region of the meteorological station. The Alaska Department of Environmental Conservation has issued a guidance note for the manual calculation of geometric mean for surface roughness and Bowen ratio for use in AERMET[15]. This approach has been applied to the current site with full details provided in Appendix II.

3.5 Building Downwash

When modelling emissions from an industrial installation, stacks which are relatively short can be subjected to additional turbulence due to the presence of nearby buildings. Buildings are considered nearby if they are within five times the lesser of the building height or maximum projected building width (but not greater than 800m).

The USEPA has defined the “Good Engineering Practice” (GEP) stack height as the building height plus 1.5 times the lesser of the building height or maximum projected building width. It is generally considered unlikely that building downwash will occur when stacks are at or greater than GEP[16].

When stacks are less than this height, building downwash will tend to occur. As the wind approaches a building it is forced upwards and around the building leading to the formation of turbulent eddies. In the lee of the building these eddies will lead to downward mixing (reduced plume centreline and reduced plume rise) and the creation of a cavity zone (near wake) where re-circulation of the air can occur. Plumes released from short stacks may be entrained in this airflow leading to higher ground level concentrations than in the absence of the building.

The Plume Rise Model Enhancements (PRIME)[9,10] plume rise and building downwash algorithms, which calculates the impact of buildings on plume rise and dispersion, have been incorporated into AERMOD. The building input processor BPIP-PRIME produces the parameters which are required in order to run PRIME. The model takes into account the position of each stack relative to each relevant building and the projected shape of each building for 36 wind directions (at 10º intervals). The model determines the change in plume centreline location with downwind distance based on the slope of the mean streamlines and coupled to a numerical plume rise model[9].

Given that the proposed stacks are less than 2.5 times the lesser of the building height or maximum projected building width, building downwash will need to be taken into account and the PRIME algorithm run prior to modelling with AERMOD. The dominant building for each relevant stack will vary as a function of wind direction and relative building heights.

4.0 BACKGROUND CONCENTRATIONS OF POLLUTANTS

Air quality monitoring programs have been undertaken in recent years by the EPA and Local Authorities[18,19]. The most recent annual report on air quality “Air Quality in Ireland 2019”[20], details the range and scope of monitoring undertaken throughout Ireland. As part of the implementation of the Framework Directive on Air Quality (1996/62/EC), four air quality zones have been defined in Ireland for air quality management and assessment purposes[18]. Dublin is defined as Zone A and Cork as Zone B. Zone C is composed of 23 towns with a population of greater than 15,000. The remainder of the country, which represents rural Ireland but also includes all towns with a population of less than 15,000 is defined as Zone D. In terms of air monitoring, Grange Castle is categorised as Zone A[18].

With regard to NO_2, continuous monitoring data from the EPA[18], at suburban Zone A background locations in Rathmines, Swords and Ballyfermot show that current levels of NO_2 are below both the annual and 1-hour limit values, with annual average levels ranging from 15 - 22 µg/m^3 in 2019 (see Table 2). Sufficient data is available for the station in Ballyfermot to observe long-term trends over the period 2015 – 2019[18], with annual average results ranging from 16 – 20 µg/m^3. Based on these results, an estimate of the current background NO_2 concentration in the region of the facility is 17 µg/m^3.

Modelling of NO_X emissions from the facility was based on the ozone-limiting method (OLM) based on the “OLMGROUP ALL” option. For the OLM method, it has been assumed that 10% of the NO_X in the stack gas is already in the form of NO_2 before the gas leaves the stack (in reality the levels are usually closer to 5% based on the USEPA database of NO_2/NO_X ratios). A background ozone concentration of 60 µg/m^3 was used in the modelling assessment, based on a review of worst case background ozone data for Zone A sites.

In relation to the annual average background, the ambient background concentration was added directly to the process concentration with the short-term peaks assumed to have an ambient background concentration of twice the annual mean background concentration.

Table 2 *Annual Mean and 99.8th Percentile 1-Hour NO_2 Concentrations In Zone A Locations (µg/m^3)*

Station	Averaging Period	Year				
		2015	2016	2017	2018	2019
Rathmines	Annual Mean NO_2 (µg/m^3)	18	20	17	20	22
	99.8th%ile 1-hr NO_2 (µg/m^3)	105	88	86	87	102
Swords	Annual Mean NO_2 (µg/m^3)	13	16	14	16	15
	99.8th%ile 1-hr NO_2 (µg/m^3)	93	96	79	85	80
Ballyfermot	Annual Mean NO_2 (µg/m^3)	16	17	17	17	20
	99.8th%ile 1-hr NO_2 (µg/m^3)	127	90	112	101	101

5.0 PROCESS EMISSIONS

The installation has no major emissions to air and only has minor (emergency generators) emissions that will generate quantities of air pollutants listed as a Principle Pollution Substance (*S.I. No. 137/2013 - Environmental Protection Agency (Industrial Emissions) (Licensing) Regulations 2013*).

The data storage facility will have 70 no. 6.49 MW_{th} standby diesel generators. Building A includes 26 no. back-up generators, Building B includes 18 no. back-up generators and Building C includes 26 no. back-up generators. Each generator has an associated stack which is 25m above ground level to provide for adequate dispersion of pollutants. In addition, each building A, B and C will also include 1 no. 2.19 MW_{th} 'house' generator which will have an associated 19.7 m stack. These 3 no. 2.19 MW_{th} generators have also been included in the modelling assessment and will operate under the same conditions and frequency as the larger 6.49 MW_{th} standby generators.

Two of the standby diesel generators associated with each Building A, B and C have been modelled as "catcher" generators to provide redundancy to the remaining generators on site. Therefore, in the event of a power failure at the site 64 of the 70 no. 6.49 MW_{th} backup generators will be operational plus the 3 no. 2.19 MW_{th} generators.

Modelling for NO_2 was undertaken in detail. In relation to CO, PM_{10} and $PM_{2.5}$ no detailed modelling was undertaken. Emissions of these pollutants are significantly lower than the NO_X emissions from the generators relative to their ambient air quality standards and thus ensuring compliance with the NO_2 ambient limit value will ensure compliance for all other pollutants. For example, the emission of CO from the generators is at least eight times lower than NO_X whilst the CO ambient air quality standard is 10,000 µg/m^3 compared to the 1-hour NO_2 standard of 200 µg/m^3. Similarly, levels of PM_{10}/$PM_{2.5}$ emitted from the generators will be significantly lower than NO_X emissions whilst the ambient air quality standards are comparable.

The scenarios modelled for this assessment include emergency operation of the generators for 72 hours per year calculated according to USEPA protocol. Emergency operations have been overestimated as it is unlikely that the generators would be used other than during routine testing and maintenance. Two testing regimes have also been included in the model as outlined below, all testing was assumed to occur from 8am to 5pm, Monday to Friday only.

- **Test 1**: testing once per week of all ~~70~~ 73 no. back-up generators at 25% load for a maximum of 30 minutes each, one generator at a time, sequentially;
- **Test 2**: each generator will be periodically tested at up to 90% load for a maximum of 4 hours per year.

USEPA Guidance suggests that for emergency operations, an average hourly emission rate should be used rather than the maximum hourly rate[(19)]. As a result, the maximum hourly emission rates from the emergency generators were reduced by $\frac{72}{8760}$ and the generators were modelled over a period of one full year. However, in reality, and based on recent experience over the past number of years, generators are rarely used other than during testing and maintenance described above.

A second methodology has been published by the UK Environment Agency. The consultation document is entitled "*Diesel Generator Short-Term NO_2 Impact Assessment*"[(20)]. The methodology is based on considering the statistical likelihood of an exceedance of the NO_2 hourly limit value (18 exceedances are allowable per year before the air standard is deemed to have been exceeded). The assessment assumes a hypergeometric distribution to assess the likelihood of exceedance hours coinciding with the emergency operational hours of the standby generators. The cumulative hypergeometric distribution of 19 and more hours per year is computed and the probability of an exceedance determined. The guidance suggests that the 98th percentile confidence level should be used to indicate if an exceedance is likely. The guidance suggests that the assessment should be conducted at the nearest residential receptor or at locations where people are likely to be exposed and that there should be no running time restrictions on these generators when providing power on site during an emergency.

Both the methodology advised in the USEPA guidance as well as the approach described in the UK EA guidance have been applied for the scenarios modelled in this study to ensure a robust assessment of predicted air quality impacts from the standby generators.

A cumulative impact assessment of the facility and nearby sites within a 1km radius was also conducted. Sites which hold an IED licence from the EPA and emit air pollutants on an essentially continuous basis over the course of a year were included in the modelling assessment. There are 2 no. IE licenced sites within 1km of the facility, these are Takeda and Pfizer to the north of the facility within the Grange Castle Business Park. Additionally, the Applicant operates a separate data storage facility to the direct south of the subject site, which is owned by Cyrus One. Once fully built, the Cyrus One facility will have 3 buildings and 32 no. standby diesel generators. The Operator leases one of these buildings, which is supported by 9 emergency back-up generators. Because the Operator has sufficient information about the emissions associated with emergency back-up generator testing, maintenance and emergency operations at this second building, these have been included in the cumulative assessment in addition to emissions from the IE licenced sites Takeda and Pfizer.

In addition to the nearby IE licenced sites and existing data storage facility operated by the Applicant, there are a number of data storage facilities operated by third parties within 1km of the facility boundary, these include Microsoft, Google and EdgeConneX. However, because the emergency back-up generator emissions associated with these sites occur on an infrequent basis and public data about these emissions and related site operations is limited, it is not possible to include these sites in the modelling assessment. In any event, according to Appendix E of the EPA guidance note AG4[(2)], cumulative assessments are only required for facilities that will emit over 100 tonnes of a regulated pollutant per annum; due to the infrequent usage of the emergency back-up generators, it is unlikely that 100 tonnes/annum of NO_2 or any other regulated pollutant would be emitted from any individual site. Thus, as per the EPA guidance, a cumulative impact assessment of the subject site and the nearby data storage facilities is not required.

Table 3 *ADSIL Grange Castle Data Storage Facility, Emergency Back-Up Diesel Generator Emission Details*

Stack Reference	Stack Height Above Ground Level (m)	Exit Diameter (m)	Cross-Sectional Area (m^2)	Temp (K)	Volume Flow (Nm^3/hr at 15% Ref. O_2)	Exit Velocity (m/sec actual)	NO_x	
							Concentration (mg/Nm^3 at 15% Ref. O_2)	Mass Emission (g/s)
Emergency Operation and Test 2 for 6.49 MWth Back-up Diesel Generators (90% load) Note 1	25m	0.5	0.20	754.2	20,382	46.01	775.9	0.036 Note 2 / 4.393 Note 3
Test 1 for 6.49 MWth Diesel Generators (25% load) Note 1	25m	0.5	0.20	720.1	7,760	18.40	860.6	0.927 Note 4
Emergency Operation of 2.19 MWth Back-up Diesel Generators (90% load) Note 1	19.7m	0.3	0.07	816.2	5,012	34.8	1,301	0.015 Note 2 / 1.81 Note 3
Testing of 2.19 MWth Diesel Generators (25% load) Note 1	19.7m	0.3	0.07	709.0	2,246	13.6	1,007	0.314 Note 4

Note 1 For the purposes of this assessment normalised conditions are 273K, 101.3 kPa, dry gas, 15% O_2.

Note 2 Reduced emission rates based on USEPA protocol (assuming 72 hours / annum) used to model emissions during emergency operation of generators (90% load)

Note 3 Maximum emission rates for diesel generators (based on 90% load) used to model emissions during emergency operation of generators for UK EA assessment methodology and for Test 2 assumptions for USEPA assessment methodology

Note 4 Emission rates used to model emissions during Test 1 at 25% load assumed to occur once per week, per generator

6.0 RESULTS

6.1 Emergency Operation (USEPA Methodology)

This assessment involved modelling the continuous operation of ~~64~~ 67 of the ~~70~~ 73 standby diesel generators for 72 hours per year based on the USEPA methodology(19) and also considering the two types of scheduled testing of the 73~~0~~ no. diesel generators. The NO_2 modelling results at the worst-case off-site receptor are detailed in Table 4. The results indicate that the ambient ground level concentrations are in compliance with the relevant air quality standards for NO_2. For the worst-case year, emissions from the site lead to an ambient NO_2 concentration (including background) which is 65% of the maximum ambient 1-hour limit value (measured as a 99.8th percentile) and ~~84~~ 85% of the annual limit value at the worst-case off-site receptor.

The geographical variations in ground level NO_2 concentrations beyond the facility boundary for the worst-case years modelled are illustrated as concentration contours in Figures 3 and 4. The locations of the maximum concentrations for NO_2 are close to the boundary of the site with concentrations decreasing with distance from the facility.

Table 4 *Dispersion Model Results for Nitrogen Dioxide (NO_2) – Emergency Operations & Scheduled Testing*

Pollutant / Meteorological Year	Background (µg/m^3)	Averaging Period	Process Contribution NO_2 (µg/m^3)	Predicted Emission Concentration NO_2 (µg/m^3)	Standard (µg/m^3) Note 1
NO_2 / 2015	34	99.8th%ile of 1-Hr Means	93.2 ~~93.0~~	127.2 ~~127.0~~	200
	17	Annual mean	14.6 ~~14.2~~	31.6 ~~31.2~~	40
NO_2 / 2016	34	99.8th%ile of 1-Hr Means	96.9 ~~96.9~~	130.9 ~~130.9~~	200
	17	Annual mean	14.7 ~~14.4~~	31.7 ~~31.4~~	40
NO_2 / 2017	34	99.8th%ile of 1-Hr Means	90.8 ~~90.7~~	124.8 ~~124.7~~	200
	17	Annual mean	17.1 ~~16.8~~	34.1 ~~33.8~~	40
NO_2 / 2018	34	99.8th%ile of 1-Hr Means	93.4 ~~93.1~~	127.4 ~~127.1~~	200
	17	Annual mean	14.4 ~~14.1~~	31.4 ~~31.1~~	40
NO_2 / 2019	34	99.8th%ile of 1-Hr Means	94.5 ~~94.4~~	128.5 ~~128.4~~	200
	17	Annual mean	15.5 ~~15.2~~	32.5 ~~32.2~~	40

Note 1 Air Quality Standards 2011 (from EU Directive 2008/50/EC and S.I. 180 of 2011)

6.2 Emergency Operation (UK Environment Agency Methodology)

Emissions from ~~64~~ 67 of the ~~70~~ 73 no. standby generators were assessed using the UK Environment Agency methodology. The methodology, based on considering the statistical likelihood of an exceedance of the NO_2 hourly limit value assuming a hypergeometric distribution, has been undertaken at the worst-case residential receptor. The cumulative hypergeometric distribution of 19 and more hours per year was computed and the probability of an exceedance determined as outlined in Table 5. The results have been compared to the 98th percentile confidence level to indicate if an exceedance is likely at various operational hours for the standby diesel generators. The results indicate that in the worst-case year, the emergency generators can operate for up to ~~138~~ 251 hours per year before there is a likelihood of an exceedance of the ambient air quality standard (at a 98th percentile confidence level). Figure 5 shows the statistical distribution predicted for the 98th percentile (based on ~~138~~ 251 hours of operation per year). However, the UK guidance recommends that there should be no running time restrictions placed on back-up generators which provide power on site only during an emergency power outage.

Table 5 *Hypergeometric Statistical Results at Worst-Case Residential Receptor – NO_2*

Pollutant / Meteorological Year	Hours of operation (Hours) (98th%ile) Allowed Prior To Exceedance Of Limit Value	UK Guidance – Probability Value = 0.02 (98th%ile) Note 1
NO_2 / 2015	361 ~~239~~	0.02
NO_2 / 2016	269 ~~304~~	
NO_2 / 2017	514 ~~238~~	
NO_2 / 2018	251 ~~138~~	
NO_2 / 2019	362 ~~212~~	

Note 1 Guidance Outlined In UK EA publication "Diesel Generator Short-Term NO_2 Impact Assessment"(20)

6.3 Cumulative Assessment (USEPA Methodology)

The cumulative assessment involved modelling the emergency operation of ~~64~~ 67 of the ~~70~~ 73 standby generators and scheduled testing of the ~~70~~ 73 no. standby generators in addition to the emissions from the EPA licenced sites, Takeda and Pfizer and emissions from 32 no. standby generators at a separate data storage facility to the direct south of the subject site. The NO_2 modelling results at the worst-case off-site receptor are detailed in Table 6. The results indicate that the ambient ground level concentrations are below the relevant air quality standards for NO_2. For the worst-case year, emissions from the site lead to an ambient NO_2 concentration (including background) which is 66% of the maximum ambient 1-hour limit value (measured as a 99.8th percentile) and ~~92~~ 93% of the annual limit value at the worst-case off-site receptor.

The geographical variations in ground level NO_2 concentrations beyond the facility boundary for the worst-case years modelled are illustrated as concentration contours in Figures 6 and 7.

Table 6 *Dispersion Model Results for Nitrogen Dioxide (NO_2) – Cumulative Assessment*

Pollutant / Meteorological Year	Background ($\mu g/m^3$)	Averaging Period	Process Contribution NO_2 ($\mu g/m^3$)	Predicted Emission Concentration NO_2 ($\mu g/m^3$)	Standard ($\mu g/m^3$) Note 1
NO_2 / 2015	34	99.8th%ile of 1-Hr Means	93.4 ~~93.3~~	127.4 ~~127.3~~	200
	17	Annual mean	17.3 ~~17.0~~	34.3 ~~34.0~~	40
NO_2 / 2016	34	99.8th%ile of 1-Hr Means	97.2 ~~97.2~~	131.2 ~~131.2~~	200
	17	Annual mean	17.6 ~~17.3~~	34.6 ~~34.3~~	40
NO_2 / 2017	34	99.8th%ile of 1-Hr Means	91.6 ~~91.5~~	125.6 ~~125.5~~	200
	17	Annual mean	20.1 ~~19.7~~	37.1 ~~36.7~~	40
NO_2 / 2018	34	99.8th%ile of 1-Hr Means	93.7 ~~93.4~~	127.7 ~~127.4~~	200
	17	Annual mean	17.2 ~~16.9~~	34.2 ~~33.9~~	40
NO_2 / 2019	34	99.8th%ile of 1-Hr Means	94.6 ~~94.5~~	128.6 ~~128.5~~	200
	17	Annual mean	18.3 ~~18.0~~	35.3 ~~35.0~~	40

Note 1 Air Quality Standards 2011 (from EU Directive 2008/50/EC and S.I. 180 of 2011)

6.4 Cumulative Assessment (UK Environment Agency Methodology)

The cumulative assessment using the UK Environment Agency methodology involved emissions from 67~~4~~ of the 73~~0~~ no. standby generators and emissions from the EPA licenced sites Takeda and Pfizer and emissions from 32 no. standby generators at a separate data storage facility to the direct south of the subject site. The methodology, based on considering the statistical likelihood of an exceedance of the NO_2 hourly limit value assuming a hypergeometric distribution, has been undertaken at the worst-case residential receptor. The cumulative hypergeometric distribution of 19 and more hours per year was computed and the probability of an exceedance determined. The results have been compared to the 98th percentile confidence level to indicate if an exceedance is likely at various operational hours for the standby diesel generators. The results indicate that in the worst-case year, the emergency generators in combination with the Takeda and Pfizer sites can operate for up to 76 hours per year before there is a likelihood of an exceedance of the ambient air quality standard (at a 98th percentile confidence level).

6.5 Air Quality Impact On Ecologically Sensitive Area And European Sites

The modelling of air emissions from the site was carried out to assess the concentrations of nitrogen dioxide (NO_x) beyond the site boundary at the nearest European Site. The modelling undertaken has been reviewed and compared with the limit values in Table 1.

The lands in which the installation is located have no formal designations. The nearest ecologically sensitive area to the subject site is the Grand Canal Proposed NHA (site code 002104) which is approximately 1.4km north of the facility.

The results shown in Table 7 indicate that the ambient ground level concentrations at the nearest ecologically sensitive areas are within the relevant air quality standard for NO_x. For the worst-case year the modelled process emissions from the site lead to an ambient NO_x concentration which is less than ~~3.5~~8% of the annual limit value at the worst-case ecological receptor as shown in Table 7.

Table 7 *NO_x Dispersion Model Results In Ecologically Sensitive Areas*

Pollutant / Year	Averaging Period	Process Contribution NO_x (µg/m^3)	NO_x Limit Value (µg/m^3)	NO_x As % Of Limit Value
NO_x / 2015	Annual Mean	2.39 ~~0.97~~	30	7.98% ~~3.2%~~
NO_x / 2016	Annual Mean	2.27 ~~0.90~~	30	7.57% ~~3.0%~~
NO_x / 2017	Annual Mean	2.32 ~~0.94~~	30	7.72% ~~3.1%~~
NO_x / 2018	Annual Mean	2.16 ~~0.91~~	30	7.18% ~~3.0%~~
NO_x / 2019	Annual Mean	2.10 ~~0.83~~	30	6.99% ~~2.8%~~

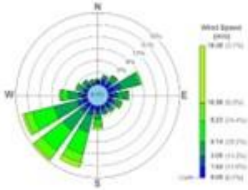
The results shown in Table 8 indicate that for the cumulative modelling of air emissions from the from ~~64~~ 67 of the ~~70~~ 73 no. standby generators and emissions from the EPA licenced sites Takeda and Pfizer and emissions from 32 no. standby generators at a separate data storage facility to the direct south of the subject site that the ambient ground level concentrations at the nearest ecologically sensitive areas are within the relevant air quality standard for NO_x. For the worst-case year modelled, emissions from the site and the EPA licenced sites Takeda and Pfizer combined lead to an ambient NO_x concentration which is less than 20% of the annual limit value at the worst-case ecological receptor as shown in Table 8.

Table 8 *Cumulative NO_x Dispersion Model Results In Ecologically Sensitive Areas*

Pollutant / Year	Averaging Period	Process Contribution NO_x (µg/m^3)	NO_x Limit Value (µg/m^3)	NO_x As % Of Limit Value
NO_x / 2015	Annual Mean	5.70 ~~5.69~~	30	19.0% ~~19.0%~~
NO_x / 2016	Annual Mean	5.11 ~~5.09~~	30	17.0% ~~17.0%~~
NO_x / 2017	Annual Mean	5.60 ~~5.58~~	30	18.7% ~~18.6%~~
NO_x / 2018	Annual Mean	4.89 ~~4.88~~	30	16.3% ~~16.3%~~
NO_x / 2019	Annual Mean	5.15 ~~5.13~~	30	17.2% ~~17.1%~~

In terms of impacts in the nearby ecologically sensitive areas, the ambient level of NO_X in the Grand Canal Proposed NHA (002104); c. 1.4km north, due to emissions during operations, will be a small fraction of the ambient air quality standard for the protection of vegetation. Similarly, cumulative emissions will lead to ambient NO_X levels which will be a small fraction of the ambient air quality standard for the protection of vegetation.

The nearest European site to the installation is the Rye Water Valley / Carton SAC; c. 5.2km north-west. Based on the separation distance, and dispersion of pollutant from the site it is highly unlikely that airborne pollution from the facility would affect the nearest or any other European site.



Site boundary

Maximum concentration: 96.95µg/m³

N

Background mapping from Google Earth

Project
ADSIL Grangecastle Data Centre IE Licence

Reference
21/12146AR01

Figure 3
Max 1-Hour NO_2 Concentrations 2016 (as 99.8%ile) (µg/m³) (excluding background concentrations)

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The Tecpro Building, Clonshaugh Business and Technology Park, Dublin 17
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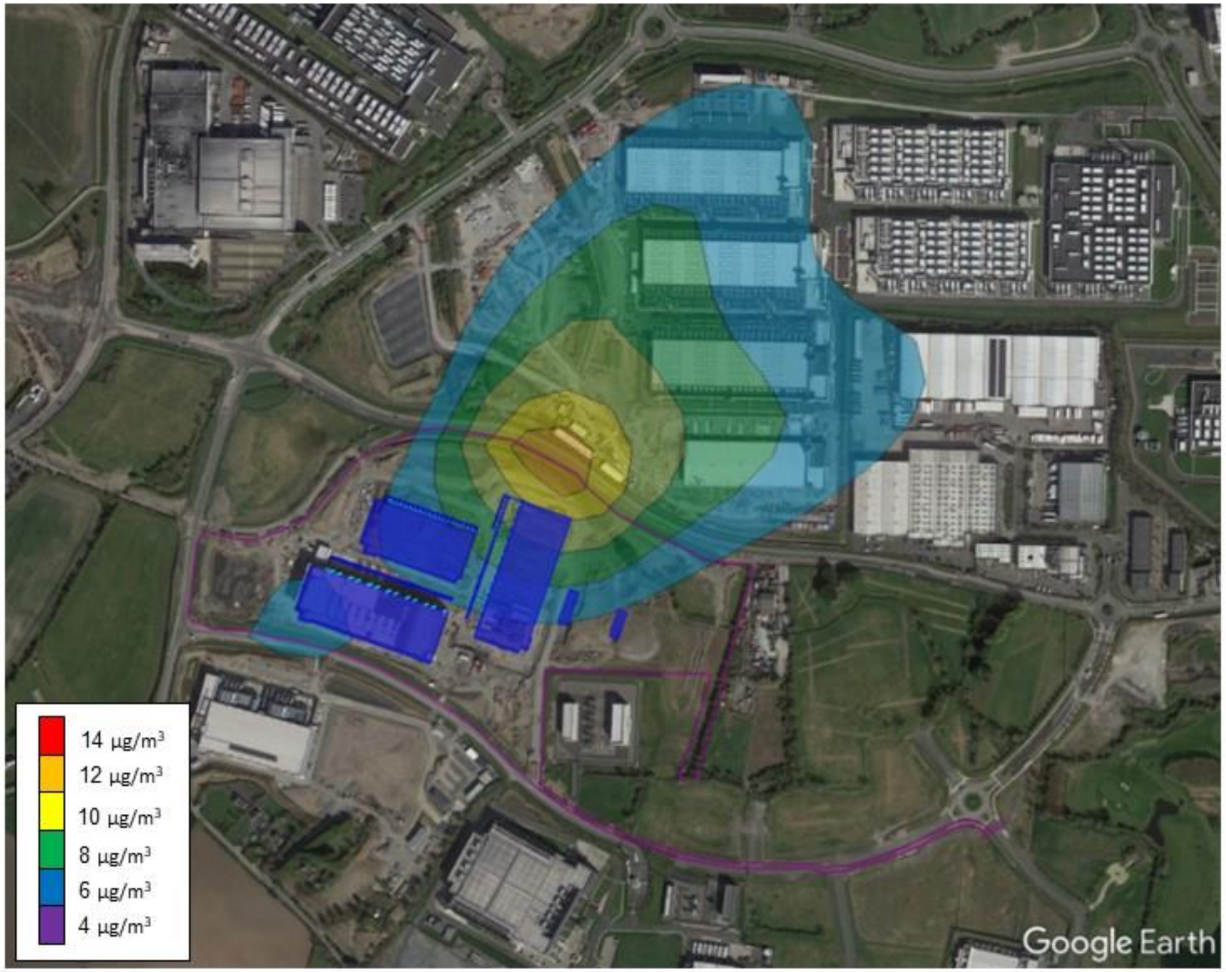

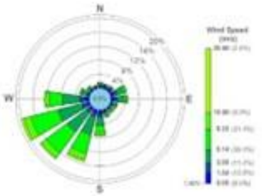

Site boundary

Maximum concentration: 17.13µg/m³

N

Background mapping from Google Earth

Project
ADSIL Grangecastle Data Centre IE Licence

Reference
21/1246AR01

Figure 4
Annual Mean NO_2 Concentrations 2017 (µg/m³) (excluding background concentrations)

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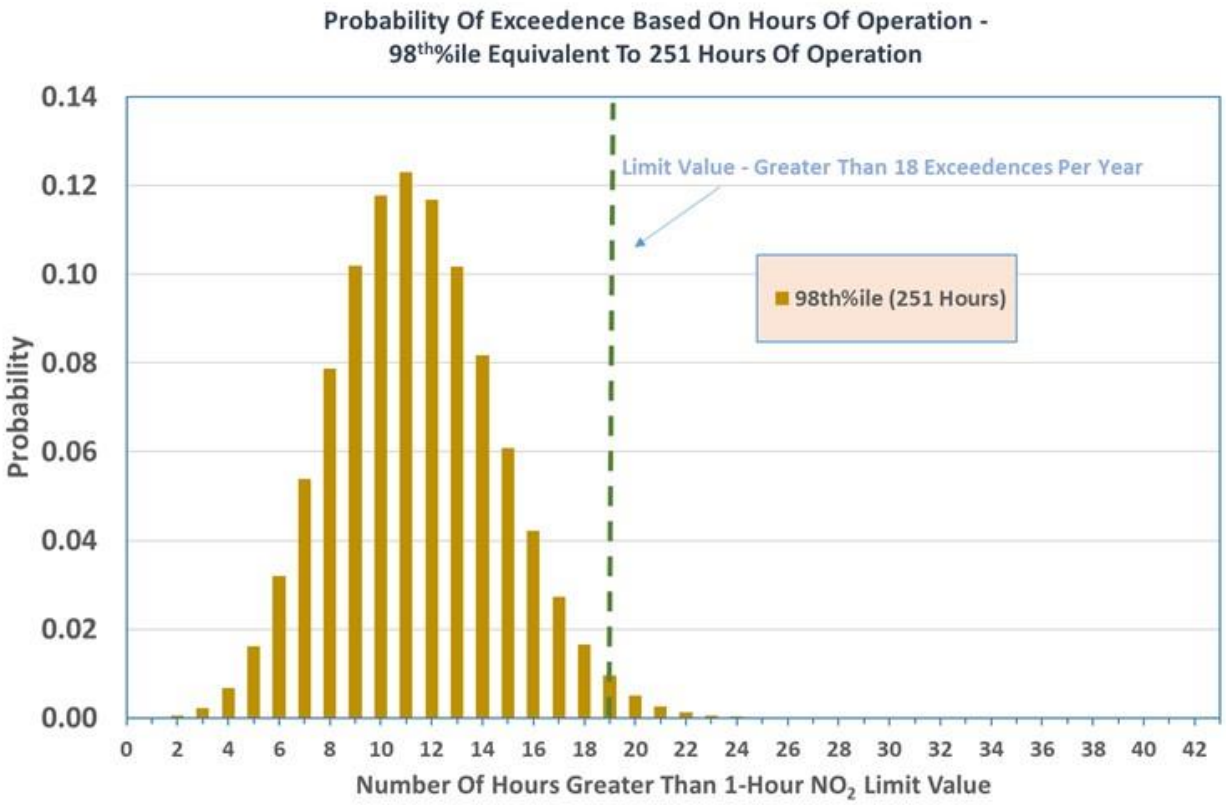

Project
ADSIL Grangecastle Data Centre IE Licence

Reference
21/12146AR01

Figure 5
Probability of Exceedance of 1-Hour NO_2 Ambient Air Quality Limit Value based on Hours of Operation for Emergency Generators

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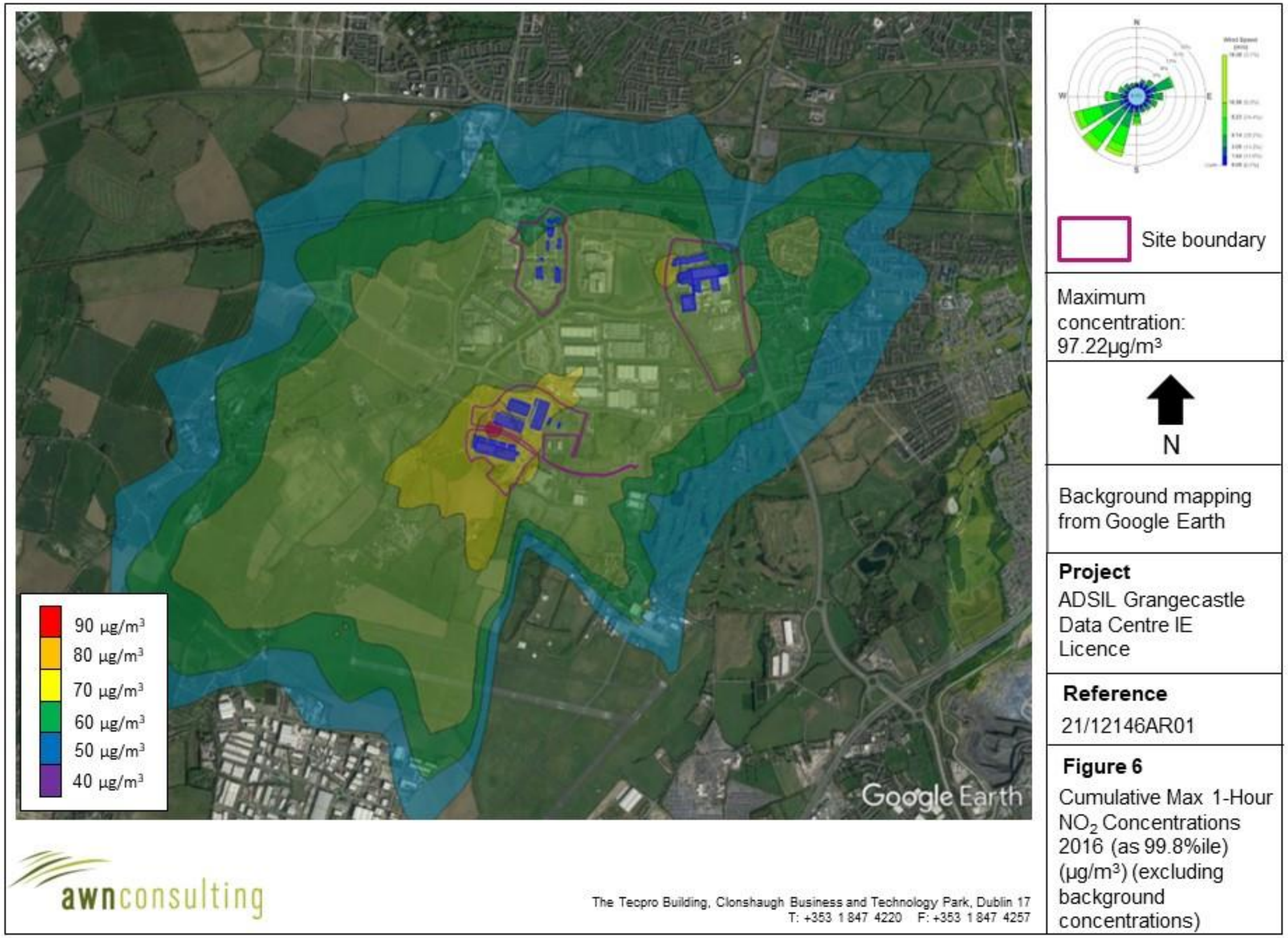
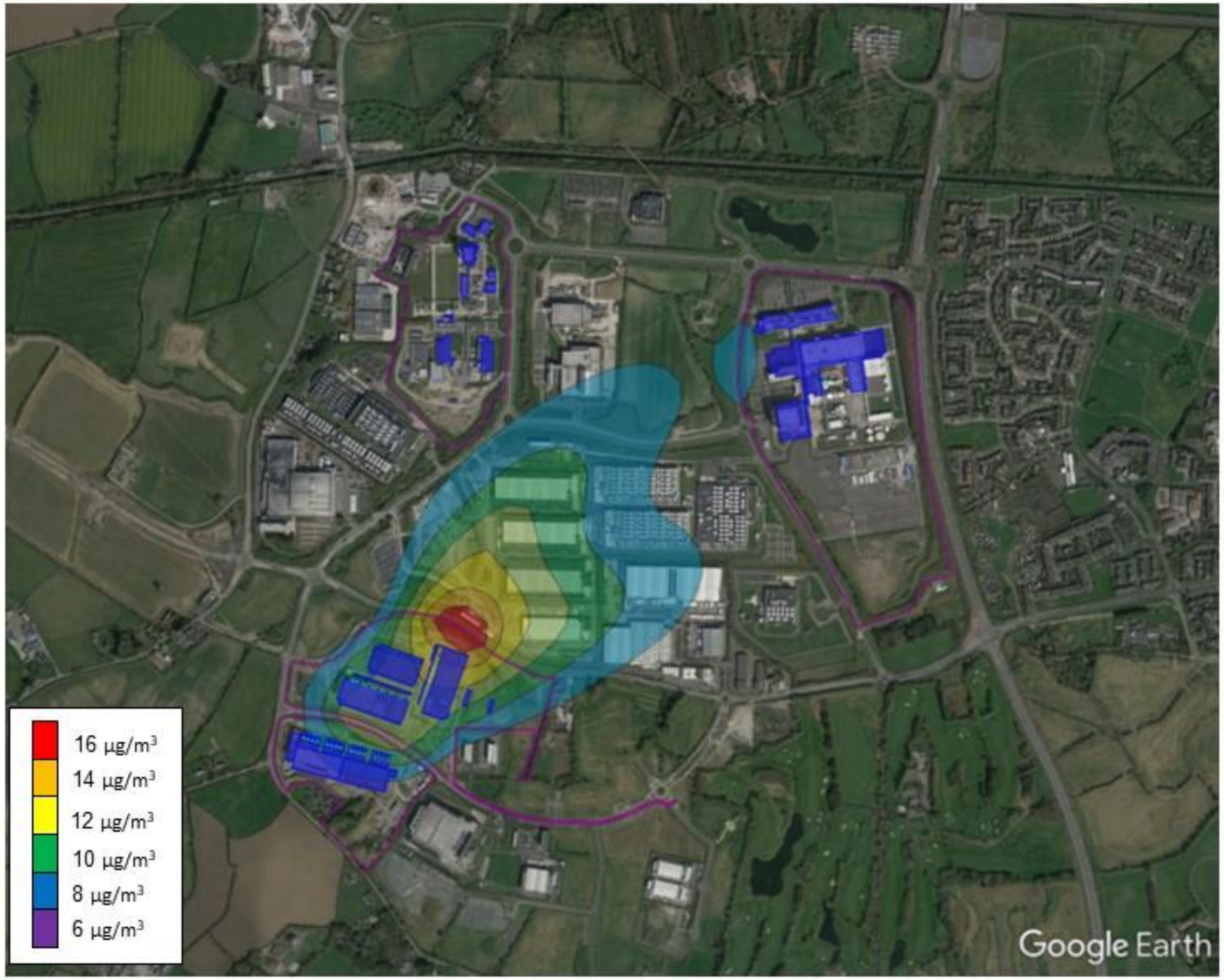
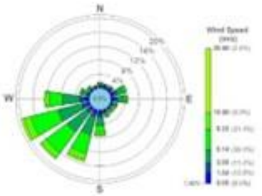

90 µg/m³
80 µg/m³
70 µg/m³
60 µg/m³
50 µg/m³
40 µg/m³
Google Earth
awnconsulting
The Tecpro Building, Clonshaugh Business and Technology Park, Dublin 17
T: +353 1 847 4220 F: +353 1 847 4257
Site boundary
Maximum concentration: 97.22µg/m³
N
Background mapping from Google Earth
Project
ADSIL Grangecastle Data Centre IE Licence
Reference
21/12146AR01
Figure 6
Cumulative Max 1-Hour NO2 Concentrations 2016 (as 99.8%ile) (µg/m³) (excluding background concentrations)





Site boundary

Maximum concentration: 20.10µg/m³

N

Background mapping from Google Earth

Project
ADSIL Grangecastle Data Centre IE Licence

Reference
21/1246AR01

Figure 7
Cumulative Annual Mean NO_2 Concentrations 2017 (µg/m³) (excluding background concentrations)

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7.0 ASSESSMENT SUMMARY

The USEPA methodology modelling results (based on 72 hours of operation) indicate that ambient ground level concentrations are below the relevant air quality standards for NO_2 for all scenarios modelled. Emissions associated with the ~~70~~ 73 no. standby generators lead to an ambient NO_2 concentration that is 65% of the ambient 1-hour limit value (measured as a 99.8th percentile) and ~~84~~ 85% of the ambient annual mean limit value at the worst-case off-site receptor for the worst-case year.

In addition, the NO_2 emissions associated with the cumulative assessment of the data storage facility and the IED licenced sites and second data storage facility to the south of the site are also in compliance with the air quality standards. Emissions under this scenario lead to an ambient NO_2 concentration that is 66% of the ambient 1-hour limit value (measured as a 99.8th percentile) and ~~92~~ 93% of the ambient annual mean limit value at the worst-case off-site receptor for the worst-case year.

The UK Environment Agency assessment methodology determined that the standby generators could operate for ~~138~~ 251 hours before there is a likelihood of an exceedance of the ambient air quality standard (at a 98th percentile confidence level). Cumulatively the standby generators, in conjunction with the IED licenced sites and a second data storage facility to the south, can operate for 76 hours before there is a likelihood of an exceedance of the ambient air quality standard (at a 98th percentile confidence level). However, the UK guidance recommends that there should be no running time restrictions placed on standby generators which provide power on site only during an emergency power outage.

In summary, emissions to atmosphere of NO_2, as the main polluting substance (as defined in the Schedule of EPA (Industrial Emissions) (Licensing) Regulations 2013, S.I. No. 137 of 2013) from the standby generators, will be in compliance with the ambient air quality standards which are based on the protection of the environment and human health. Therefore, no significant impacts to the ambient air quality environment are predicted.

In terms of impacts in the nearby ecologically sensitive areas, the ambient level of NO_X in the Grand Canal Proposed NHA (002104); c. 1.4km north, due to emissions from the site, will be a small fraction of the ambient air quality standard for the protection of vegetation. Similarly, cumulative emissions will lead to ambient NO_X levels which will be a small fraction of the ambient air quality standard for the protection of vegetation.

8.0 REFERENCES

(1) USEPA (2019) AERMOD Description of Model Formulation and Evaluation
(2) EPA (2020) Air Dispersion Modelling from Industrial Installations Guidance Note (AG4)
(3) USEPA (1995) User's Guide for the Industrial Source Complex (ISC3) Dispersion Model Vol I & II
(4) USEPA (2005) Guidelines on Air Quality Models, Appendix W to Part 51, 40 CFR Ch.1
(5) USEPA (2000) Seventh Conference on Air Quality Modelling (June 2000) Vol I & II
(6) USEPA (1998) Human Health Risk Assessment Protocol, Chapter 3: Air Dispersion and Deposition Modelling, Region 6 Centre for Combustion Science and Engineering
(7) USEPA (1999) Comparison of Regulatory Design Concentrations: AERMOD vs. ISCST3 vs. CTDM PLUS
(8) Schulman, L.L; Strimaitis, D.G.; Scire, J.S. (2000) Development and evaluation of the PRIME plume rise and building downwash model. Journal of the Air & Waste Management Association, 50, 378-390.
(9) Paine, R & Lew, F. "Consequence Analysis for Adoption of PRIME: an Advanced Building Downwash Model" Prepared for the EPRI, ENSR Document No. 2460-026-450 (1997).
(10) Paine, R & Lew, F. "Results of the Independent Evaluation of ISCST3 and ISC-PRIME" Prepared for the EPRI, ENSR Document No. 2460-026-3527-02 (1997).
(11) USEPA (2018) AERMAP Users Guide
(12) Met Éireann (2021) Met Éireann Website: www.met.ie
(13) USEPA (201) User's Guide to the AERMOD Meteorological Preprocessor (AERMET)
(14) USEPA (2008) AERSURFACE User's Guide
(15) Alaska Department of Environmental Conservation (2008) ADEC Guidance re AERMET Geometric Means (http://dec.alaska.gov/air/ap/modeling.htm)
(16) USEPA (1985) Good Engineering Practice Stack Height (Technical Support Document For The Stack Height Regulations) (Revised)
(17) EPA (2021) http://www.epa.ie/whatwedo/monitoring/air/
(18) Environmental Protection Agency (2020) Air Quality Monitoring Report 2019 (& previous reports)
(19) UK Environment Agency (2016) Air Quality Modelling and Assessment Unit – Diesel Generator Short Term NO_2 Impact Assessment
(20) USEPA (2011) Additional Clarification Regarding Application of Appendix W Modelling Guidance for the 1-Hour National Ambient Air Quality Standard

APPENDIX I

Description of the AERMOD Model

The AERMOD dispersion model has been developed in part by the U.S. Environmental Protection Agency (USEPA)[1,4]. The model is a steady-state Gaussian model used to assess pollutant concentrations associated with industrial sources. The model is an enhancement on the Industrial Source Complex-Short Term 3 (ISCST3) model which has been widely used for emissions from industrial sources.

Improvements over the ISCST3 model include the treatment of the vertical distribution of concentration within the plume. ISCST3 assumes a Gaussian distribution in both the horizontal and vertical direction under all weather conditions. AERMOD with PRIME, however, treats the vertical distribution as non-Gaussian under convective (unstable) conditions while maintaining a Gaussian distribution in both the horizontal and vertical direction during stable conditions. This treatment reflects the fact that the plume is skewed upwards under convective conditions due to the greater intensity of turbulence above the plume than below. The result is a more accurate portrayal of actual conditions using the AERMOD model. AERMOD also enhances the turbulence of night-time urban boundary layers thus simulating the influence of the urban heat island.

In contrast to ISCST3, AERMOD is widely applicable in all types of terrain. Differentiation of the simple versus complex terrain is unnecessary with AERMOD. In complex terrain, AERMOD employs the dividing-streamline concept in a simplified simulation of the effects of plume-terrain interactions. In the dividing-streamline concept, flow below this height remains horizontal, and flow above this height tends to rise up and over terrain. Extensive validation studies have found that AERMOD (precursor to AERMOD with PRIME) performs better than ISCST3 for many applications and as well or better than CTDMPLUS for several complex terrain data sets[8].

Due to the proximity to surrounding buildings, the PRIME (Plume Rise Model Enhancements) building downwash algorithm has been incorporated into the model to determine the influence (wake effects) of these buildings on dispersion in each direction considered. The PRIME algorithm takes into account the position of the stack relative to the building in calculating building downwash. In the absence of the building, the plume from the stack will rise due to momentum and/or buoyancy forces. Wind streamlines act on the plume leads to the bending over of the plume as it disperses. However, due to the presence of the building, wind streamlines are disrupted leading to a lowering of the plume centreline.

When there are multiple buildings, the building tier leading to the largest cavity height is used to determine building downwash. The cavity height calculation is an empirical formula based on building height, the length scale (which is a factor of building height & width) and the cavity length (which is based on building width, length and height). As the direction of the wind will lead to the identification of differing dominant tiers, calculations are carried out in intervals of 10 degrees.

In PRIME, the nature of the wind streamline disruption as it passes over the dominant building tier is a function of the exact dimensions of the building and the angle at which the wind approaches the building. Once the streamline encounters the zone of influence of the building, two forces act on the plume. Firstly, the disruption caused by the building leads to increased turbulence and enhances horizontal and vertical dispersion. Secondly, the streamline descends in the lee of the building due to the reduced pressure and drags the plume (or part of) nearer to the ground, leading to higher ground level concentrations. The model calculates the descent of the plume as a function of the building shape and, using a numerical plume rise model, calculates the change in the plume centreline location with distance downwind.

The immediate zone in the lee of the building is termed the cavity or near wake and is characterised by high intensity turbulence and an area of uniform low pressure. Plume mass captured by the cavity region is re-emitted to the far wake as a ground-level volume source. The volume source is located at the base of the lee wall of the building, but is only evaluated near the end of the near wake and beyond. In this region, the disruption caused by the building downwash gradually fades with distance to ambient values downwind of the building.

AERMOD has made substantial improvements in the area of plume growth rates in comparison to ISCST3[3,5]. ISCST3 approximates turbulence using six Pasquill-Gifford-Turner Stability Classes and bases the resulting dispersion curves upon surface release experiments. This treatment, however, cannot explicitly account for turbulence in the formulation. AERMOD is based on the more realistic modern planetary boundary layer (PBL) theory which allows turbulence to vary with height. This use of turbulence-based plume growth with height leads to a substantial advancement over the ISCST3 treatment.

Improvements have also been made in relation to mixing height[1,3]. The treatment of mixing height by ISCST3 is based on a single morning upper air sounding each day. AERMOD, however, calculates mixing height on an hourly basis based on the morning upper air sounding and the surface energy balance, accounting for the solar radiation, cloud cover, reflectivity of the ground and the latent heat due to evaporation from the ground cover. This more advanced formulation provides a more realistic sequence of the diurnal mixing height changes.

AERMOD also has the capability of modelling both unstable (convective) conditions and stable (inversion) conditions. The stability of the atmosphere is defined by the sign of the sensible heat flux. Where the sensible heat flux is positive, the atmosphere is unstable whereas when the sensible heat flux is negative the atmosphere is defined as stable. The sensible heat flux is dependent on the net radiation and the available surface moisture (Bowen Ratio). Under stable (inversion) conditions, AERMOD has specific algorithms to account for plume rise under stable conditions, mechanical mixing heights under stable conditions and vertical and lateral dispersion in the stable boundary layer.

AERMOD also contains improved algorithms for dealing with low wind speed (near calm) conditions. As a result, AERMOD can produce model estimates for conditions when the wind speed may be less than 1 m/s, but still greater than the instrument threshold.

APPENDIX II

Meteorological Data - AERMET

AERMOD incorporates a meteorological pre-processor AERMET (version 16216)(12). AERMET allows AERMOD to account for changes in the plume behaviour with height. AERMET calculates hourly boundary layer parameters for use by AERMOD, including friction velocity, Monin-Obukhov length, convective velocity scale, convective (CBL) and stable boundary layer (SBL) height and surface heat flux. AERMOD uses this information to calculate concentrations in a manner that accounts for changes in dispersion rate with height, allows for a non-Gaussian plume in convective conditions, and accounts for a dispersion rate that is a continuous function of meteorology.

The AERMET meteorological preprocessor requires the input of surface characteristics, including surface roughness (z_0), Bowen Ratio and albedo by sector and season, as well as hourly observations of wind speed, wind direction, cloud cover, and temperature. A morning sounding from a representative upper air station, latitude, longitude, time zone, and wind speed threshold are also required.

Two files are produced by AERMET for input to the AERMOD dispersion model. The surface file contains observed and calculated surface variables, one record per hour. The profile file contains the observations made at each level of a meteorological tower, if available, or the one-level observations taken from other representative data, one record level per hour.

From the surface characteristics (i.e. surface roughness, albedo and amount of moisture available (Bowen Ratio)) AERMET calculates several boundary layer parameters that are important in the evolution of the boundary layer, which, in turn, influences the dispersion of pollutants. These parameters include the surface friction velocity, which is a measure of the vertical transport of horizontal momentum; the sensible heat flux, which is the vertical transport of heat to/from the surface; the Monin-Obukhov length which is a stability parameter relating the surface friction velocity to the sensible heat flux; the daytime mixed layer height; the nocturnal surface layer height and the convective velocity scale which combines the daytime mixed layer height and the sensible heat flux. These parameters all depend on the underlying surface.

The values of albedo, Bowen Ratio and surface roughness depend on land-use type (e.g., urban, cultivated land etc) and vary with seasons and wind direction. The assessment of appropriate land-use types was carried out in line with USEPA recommendations(4) and using the detailed methodology outlined by the Alaska Department of Environmental Conservation(14). AERMET has also been updated to allow for an adjustment of the surface friction velocity (u*) for low wind speed stable conditions based on the work of Qian and Venkatram (BLM, 2011). Previously, the model had a tendency to over-predict concentrations produced by near-ground sources in stable conditions.

Surface Roughness

Surface roughness length is the height above the ground at which the wind speed goes to zero. Surface roughness length is defined by the individual elements on the landscape such as trees and buildings. In order to determine surface roughness length, the USEPA recommends that a representative length be defined for each sector, based on geometric mean of the inverse distance area-weighted land use within the sector, by using the eight land use categories outlined by the USEPA. The area-weighted surface roughness length derived from the land use classification within a radius of 1km from Casement Aerodrome is shown in Table A1.

Table A1 Surface Roughness based on an inverse distance area-weighted average of the land use within a 1km radius of Casement Aerodrome

Sector	Area Weighted Land Use Classification	Spring	Summer	Autumn	Winter[Note 1]
0-360	100% Grassland	0.050	0.100	0.010	0.010

Note 1: Winter defined as periods when surfaces covered permanently by snow whereas autumn is defined as periods when freezing conditions are common, deciduous trees are leafless and no snow is present (Iqbal (1983)). Thus for the current location autumn more accurately defines "winter" conditions at the proposed facility.

Albedo

Noon-time Albedo is the fraction of the incoming solar radiation that is reflected from the ground when the sun is directly overhead. Albedo is used in calculating the hourly net heat balance at the surface for calculating hourly values of Monin-Obuklov length. The area-weighted arithmetic mean albedo derived from the land use classification over a 10km x 10km area centred on Casement Aerodrome is shown in Table A2.

Table A2 Albedo based on an area-weighted arithmetic mean of the land use over a 10km x 10km area centred on Casement Aerodrome

Area Weighted Land Use Classification	Spring	Summer	Autumn	Winter[Note1]
0.5% Water, 30% Urban, 0.5% Coniferous Forest 38% Grassland, 19% Cultivated Land	0.155	0.180	0.187	0.187

Note 1: For the current location autumn more accurately defines "winter" conditions at the proposed facility.

Bowen Ratio

The Bowen ratio is a measure of the amount of moisture at the surface of the earth. The presence of moisture affects the heat balance resulting from evaporative cooling which, in turn, affects the Monin-Obukhov length which is used in the formulation of the boundary layer. The area-weighted geometric mean Bowen ratio derived from the land use classification over a 10km x 10km area centered on Casement Aerodrome is shown in Table A3.

Table A3 Bowen Ratio based on an area-weighted geometric mean of the land use over a 10km x 10km area centred on Casement Aerodrome

Area Weighted Land Use Classification	Spring	Summer	Autumn	Winter[Note1]
0.5% Water, 30% Urban, 0.5% Coniferous Forest 38% Grassland, 19% Cultivated Land	0.549	1.06	1.202	1.202

Note 1: For the current location autumn more accurately defines "winter" conditions at the proposed facility.