ATTACHMENT-7-1-3-2

AIR EMISSIONS IMPACT ASSESSMENT, ADSIL, DROGHEDA IDA BUSINESS & TECHNOLOGY PARK, CO. MEATH

Technical Report Prepared For

Amazon Data Services Ireland Limited

Technical Report Prepared By

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EXECUTIVE SUMMARY

This report presents the assessment of air quality impacts as a result of the operation of the Amazon Data Services Ireland Ltd. ("ADSIL" or 'the applicant') data storage facility located at Drogheda IDA Business & Technology Park, Drogheda, Co. Meath. The existing Installation (comprising Building A, along with ancillary elements) currently operates under IE Licence 1181-01. This air quality impact assessment supports a review of the Licence to accommodate the extension of the Installation to include a second data storage facility building (Building B). Operations for the extended Installation will be herein referred to as 'Proposed Operations'.

The installation requires a continuous supply of electricity to operate. During normal operations, the Installation is supplied electricity from the national grid. Outside of normal operations, the Installation is first supplied electricity by some or all of the Uninterrupted Power Supply (UPS) systems (the UPS systems are contained in small Backup Battery Units (BBUs)) and then by some or all of the onsite back-up 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 the scheduled testing and maintenance, and potential emergency operation of the back-up generators at the Installation, in line with the requirements of the *Industrial Emissions Directive (IED) (Directive 2010/75/EU)* 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), carbon monoxide (CO), particulate matter (PM_{10} and $PM_{2.5}$) and sulphur dioxide (SO_2) at a variety of locations beyond the site boundary. The impact of emissions of NO_X, SO_2 and nutrient and acid deposition from the Installation, alone and in combination with other facilities, on European and nationally designated habitat sites within 20 km of the facility was also assessed.

The assessment has included emission points associated with Building A and Building B. Building A has 26 no. 6.82 MW_{th} back-up generators and 1 no. 1.55 MW_{th} back-up generator. Building B has 26 no. 6.79 MW_{th} back-up generators and 1 no. 2.02 MW_{th} back-up generator. A total of 54 back-up generators were included in the modelling assessment.

The assessment has determined the ambient air quality impact of the site and any air quality constraints that may be present. The back-up generators will be used solely for emergency operation and thus the emission limit values outlined in the Medium Combustion Plant Directive (which are only required for operation of combustion plant for more than 500 hours per year per generator) are not applicable to the back-up generators on site.

The Proposed Operations scenario involved the emergency operation of 50 no. of the 54 no. back-up generators (the remaining 4 no. generators serving as a "catcher" generator for Building A and Building B) for 100 hours per generator per year. The scenario also included the scheduled testing and maintenance of all 54 no. generators.

The modelling assessment also included the cumulative impact of the Proposed Operations, as well as the existing & proposed IED licenced sites of Irish Cement (P0030-06), Indaver Ireland Carranstown WTE facility (P0167-03) and SSE Generation Ireland Ltd. (P1225-01) in the vicinity of the site.

The results indicate that ambient ground level concentrations of pollutants are below the relevant air quality standards for all pollutants modelled (NO_2, CO, PM_{10}, $PM_{2.5}$ and SO_2) for all modelled scenarios.

Assessment Summary

Proposed Operations Scenario

This scenario involved the emergency operation of 50 no. of the 54 no. back-up generators (the remaining 4 no. generators serving as a "catcher" generator for Building A and Building B) for 100 hours per generator per year. The scenario also included the scheduled testing and maintenance of all 54 no. generators.

<u>Human Health Impacts</u>

Emissions of NO_2, CO, PM_{10}, $PM_{2.5}$ and SO_2 in this scenario are in compliance with the relevant ambient air quality standards. The maximum Predicted Environmental Concentration (PEC) results for each pollutant, as a percentage of the relevant ambient air quality standard, at the worst-case receptor modelled are as follows for each pollutant:

- NO_2 annual mean: 61%
- NO_2 maximum 1-hour (measured as 99.8^{th}%ile): 57%
- CO maximum 8-hour: 21%
- PM_{10} annual mean: 33%
- PM_{10} maximum 24-hour (measured as 90.4^{th}%ile): 44%
- $PM_{2.5}$ annual mean: 33%
- SO_2 maximum 1-hour (measured as 99.7^{th}%ile): 9%
- SO_2 maximum 24-hour (measured as 99.2^{nd}%ile): 11%

In addition, for NO_2, the UK EA assessment methodology determined that in the worst-case year, the Installation could operate for 104 hours per year without a likelihood of an exceedance of the ambient air quality standard at the nearest residential receptor (at a 98^{th} percentile confidence level).

<u>Ecological Impacts</u>

The Air Impact Assessment has evaluated the impact of emissions to air from the Installation on ecological receptors within a 20 km distance from the Installation. The assessment has included emissions of NO_X, SO_2, nitrogen and acid deposition. For the purposes of this assessment, the 'most impacted' ecological site is identified as the site where the highest modelled process contributions (PCs) occur, the River Boyne and River Blackwater SAC in the case of this assessment. Modelled PCs at all other ecological sites within 20 km of the Installation are lesser than those within the River Boyne and River Blackwater SAC. The River Boyne and River Blackwater SAC is also the closest ecological site to the Installation. Additionally, in order to inform the AA Screening / Natura Impact Statement (NIS), modelling results have been presented for the following designated sites:

- Boyne Coast and Estuary SAC (site code: 001957)
- Clogher Head SAC (site code: 001459)

- River Boyne and River Blackwater SAC (site code: 002299)
- Boyne Estuary SPA (site code: 004080)
- North-west Irish Sea SPA (site code: 004236)
- River Boyne and River Blackwater SPA (site code: 004232)
- River Nanny Estuary and Shore SPA (site code: 004158)

The results of the air modelling assessment indicate that there is no potential for these airborne pollutants to adversely affect the conservation objectives of any qualifying interests (QIs) at the modelled sites. This confirms that the direct air emissions from the Installation will not have significant effects on these designated habitats.

Under the Proposed Operations Scenario, the modelling assessment determined that Predicted Environmental Concentrations (PECs) of NO_X, SO_2 and nitrogen and acid deposition from the Installation at the Boyne Coast and Estuary SAC (site code: 001957), Boyne Estuary SPA (site code: 004080), North-west Irish Sea SPA (site code: 004236), and River Nanny Estuary and Shore SPA (site code: 004158) do not exceed the relevant critical levels and critical load ranges for the sensitive QI habitats.

Under the Proposed Operations Scenario, the modelling assessment determined that PEC of NO_X, SO_2, nitrogen deposition and acid deposition (as S) from the Installation at Clogher Head SAC (site code: 001459) do not exceed the relevant critical levels and critical load ranges for the sensitive QI habitats. The PEC acid deposition (as N) is above the minimum critical load range for the relevant QI habitat but is within the upper critical load range and therefore, is not considered significant. Background acid deposition levels are the most contributing factor to the PEC with the PC from the Installation contributing a minor amount.

In the Proposed Operations Scenario, the modelling assessment determined that PEC of NO_X, SO_2, nitrogen deposition and acid deposition (as N) from the Installation at the River Boyne and River Blackwater SAC (site code: 002299) and the River Boyne and River Blackwater SPA (site code: 004232) do not exceed the relevant critical levels and critical load ranges for the sensitive QI habitats. The PEC acid deposition (as S) is above the minimum critical load range for the relevant QI habitat but is within the upper critical load range and is therefore, not considered significant. Background acid deposition levels are the most contributing factor to the PEC with the PC from the Installation contributing a minor amount.

There are no significant impacts predicted for any other Natura 2000 SPAs and SACs than those presented within this report.

Under the Proposed Operations Scenario the dispersion modelling has determined that concentrations of all pollutants are in compliance with the relevant ambient air quality standards. Therefore, no significant impacts to the ambient air quality environment are predicted.

Cumulative Assessment

The cumulative assessment involved modelling the proposed operations of the Installation under the Proposed Operations scenario, as well as emissions from the IED licensed sites of Irish Cement, Indaver and SSE Generation Ireland Ltd.

Human Health Impacts

Emissions of NO_2, CO, PM_{10}, $PM_{2.5}$ and SO_2 in this scenario are in compliance with the relevant ambient air quality standards. The maximum PEC results for each pollutant, as a percentage of the relevant ambient air quality standard, at the worst-case receptor modelled are as follows for each pollutant:

- NO_2 annual mean: 63%
- NO_2 maximum 1-hour (measured as 99.8th%ile): 57%
- PM_{10} annual mean: 33%
- PM_{10} maximum 24-hour (measured as 90.4th%ile): 44%
- $PM_{2.5}$ annual mean: 33%
- SO_2 maximum 1-hour (measured as 99.7th%ile): 9%
- SO_2 maximum 24-hour (measured as 99.2nd%ile): 11%

In addition, for NO_2, the UK EA assessment methodology determined that in the worst-case year, the Installation could operate for 104 hours per year without a likelihood of an exceedance of the ambient air quality standard at the nearest residential receptor (at a 98th percentile confidence level).

Ecological Impacts

The Air Impact Assessment has evaluated the impact of emissions to air from the Installation and cumulative sites of Irish Cement, Indaver and SSE Generation Ireland Ltd. on ecological receptors within a 20 km distance from the Installation. The assessment has included emissions of NO_X, SO_2, nitrogen and acid deposition. For the purposes of this assessment, the 'most impacted' ecological site is identified as the site where the highest modelled process contributions (PCs) occur, the River Boyne and River Blackwater SAC in the case of this assessment. Modelled PCs at all other ecological sites within 20 km of the Installation are lesser than those within the River Boyne and River Blackwater SAC. The River Boyne and River Blackwater SAC is also the closest ecological site to the Installation. Additionally, in order to inform the AA Screening and NIS, modelling results have been presented for the following designated sites:

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The results of the air modelling assessment indicate that there is no potential for these airborne pollutants to adversely affect the conservation objectives of any qualifying interests (QIs) at the modelled sites. This confirms that the direct air emissions from the Installation will not have significant effects on these designated habitats.

Under the Cumulative Scenario, the modelling assessment determined that Predicted Environmental Concentrations (PECs) of NO_X, SO_2, nitrogen and acid deposition from the Installation at the Boyne Coast and Estuary SAC (site code: 001957), Boyne Estuary SPA (site code: 004080), North-west Irish Sea SPA (site code: 004236), and River Nanny Estuary and Shore SPA (site code: 004158) do not exceed the relevant critical levels and critical load ranges for the sensitive QI habitats.

Under the Cumulative Scenario, the modelling assessment determined that PEC of NO_X, SO_2, nitrogen deposition and acid deposition (as S) from the Installation at Clogher Head SAC (site code: 001459) do not exceed the relevant critical levels and critical load ranges for the sensitive QI habitats. The PEC acid deposition (as N) is above the minimum critical load range for the relevant QI habitat but is within the upper critical load range and is therefore, not considered significant. Background acid deposition levels are the most contributing factor to the PEC, with the PC from the Installation contributing a minor amount.

In the Cumulative Scenario, the modelling assessment determined that PEC of NO_X, SO_2, nitrogen deposition and acid deposition (as N) from the Installation at the River Boyne and River Blackwater SAC (site code: 002299) and the River Boyne and River Blackwater SPA (site code: 004232) do not exceed the relevant critical levels and critical load ranges for the sensitive QI habitats. The PEC acid deposition (as S) is above the minimum critical load range for the relevant QI habitat but is within the upper critical load range and is therefore, not considered significant. Background acid deposition levels are the most contributing factor to the PEC with the PC from the Installation contributing a minor amount.

Under the Cumulative Scenario the dispersion modelling has determined that concentrations of all pollutants are in compliance with the relevant ambient air quality standards. Therefore, no significant impacts to the ambient air quality environment are predicted.

Contents

1.0 INTRODUCTION

This report presents the assessment of air quality impacts as a result of the operation of the Amazon Data Services Ireland Ltd. ("ADSIL" or 'the applicant') data storage Installation located at Drogheda IDA Business & Technology Park, Drogheda, Co. Meath. The existing Installation (comprising Building A, along with ancillary elements) currently operates under IE Licence 1181-01. This air quality impact assessment supports a review of the Licence to accommodate the extension of the Installation to include a second data storage facility building (Building B). Operations for the extended Installation will be herein referred to as 'Proposed Operations'.

The installation requires a continuous supply of electricity to operate. During normal operations, the Installation is supplied electricity from the national grid. Outside of normal operations, the Installation is first supplied electricity by some or all of the UPS systems (the UPS systems are contained in small Backup Battery Units (BBUs)) and then by some or all of the onsite back-up 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 the scheduled testing and maintenance and potential emergency operation of the back-up generators at the Installation, in line with the requirements of the *Industrial Emissions Directive (IED) (Directive 2010/75/EU)* 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), carbon monoxide (CO), particulate matter (PM_{10} and $PM_{2.5}$) and sulphur dioxide (SO_2) at a variety of locations beyond the site boundary. The impact of emissions of NO_X, SO_2 and nutrient and acid deposition from the Installation, alone and in combination with other facilities, on European and nationally designated habitat sites within 20 km of the Installation was also assessed.

The assessment has included emission points associated with Building A and Building B. Building A has 26 no. 6.82 MW_{th} back-up generators and 1 no. 1.55 MW_{th} back-up generator. Building B has 26 no. 6.79 MW_{th} back-up generators and 1 no. 2.02 MW_{th} back-up generator. A total of 54 back-up generators were included in the modelling assessment.

The assessment has determined the ambient air quality impact of the site and any air quality constraints that may be present. The back-up generators will be used solely for emergency operation and thus the emission limit values outlined in the Medium Combustion Plant Directive (which are only required for operation of combustion plant for more than 500 hours per year per generator) are not applicable to the back-up generators on site.

In line with Appendix K of the EPA document *AG4 Guidance for Air Dispersion Modelling*(4). The modelling assessment also included the cumulative impact of the proposed operations scenario, as well as other existing and proposed IED licenced sites in the vicinity of the Installation. There are no IED licenced sites within 1 km of the subject site; the closest IED licenced site is over 2 km to the south of the Installation. At a distance of between 2 - 3 km are two licenced facilities, Irish Cement (P0030-06) and Indaver Ireland Carranstown WTE facility (P0167-03). These two facilities have been included in the cumulative assessment as these facilities have emissions to air (NO_x, CO, PM_{10}, $PM_{2.5}$ or SO_2) with the potential for cumulative impact with the emissions associated with the installation. Additionally, at a distance of c.3 km to the south of the Installation is SSE Generation Ireland Ltd., for which an IE licence has been applied for from the Agency (Application P1225-01). SSE Generation Ltd has emissions of NO_X, SO_2, CO, PM_{10} and $PM_{2.5}$ and has been included in the cumulative impact assessment.

In relation to cumulative CO emissions, these are likely to be negligible relative to the ambient air quality standard (i.e. the CO emission level is likely to be of a similar magnitude to NO_X emissions whilst the CO ambient air quality standard is 10,000 $\mu g/m^3$ compared to the NO_2 limit of 200 $\mu g/m^3$) and thus CO emissions have been screened out of the cumulative assessment.

The purpose of the air impact assessment was to determine to contribution of air pollutant emissions from the Installation to ambient pollutant concentrations and to identify the location and maximum of the worst-case ground level concentrations for each compound assessed. The dispersion model study consisted of the following components:

- Review of proposed emission data and other relevant information needed for the modelling study;
- Summary of background NO_2, CO, PM_{10}, $PM_{2.5}$ and SO_2 levels;
- Dispersion modelling of released substances under the following scenarios:
  - <u>Proposed Operations Scenario</u>, which includes the scheduled testing of the back-up generators as well as the potential emergency operation of the back-up generators for 100 hours per generator per year;
  - <u>Cumulative Assessment</u>, which includes the Proposed Operations as described above, as well as the existing and proposed IED licenced sites, in the vicinity of the Installation;
- Presentation of predicted ground level concentrations of released substances; and
- Evaluation of the significance of these predicted concentrations, including consideration of whether these ground level concentrations are likely to exceed the relevant ambient air quality limit values.

The site is located in Drogheda IDA Business & Technology Park, Drogheda, Co. Meath, which is approximately 2 km west of Drogheda town centre. The site is bounded to the west by the M1 motorway and to the north by agricultural lands. There are large residential housing estates located further to the north and to the east of the Installation (see Figure 1 and Figure 2). The closest designated habitat is the River Boyne and River Blackwater Special Area of Conservation (SAC) (site code 002299), which is approx. 1 km to the north of the Installation.

The modelling assessment has been based on 100 hours of potential emergency operations for each of the back-up generators, this provides a worst-case assessment. It is understood that the back-up generators will each be permitted to operate for a maximum of 100 emergency hours per year as per the existing IE licence 1181-01 and granted planning permission for the Installation.

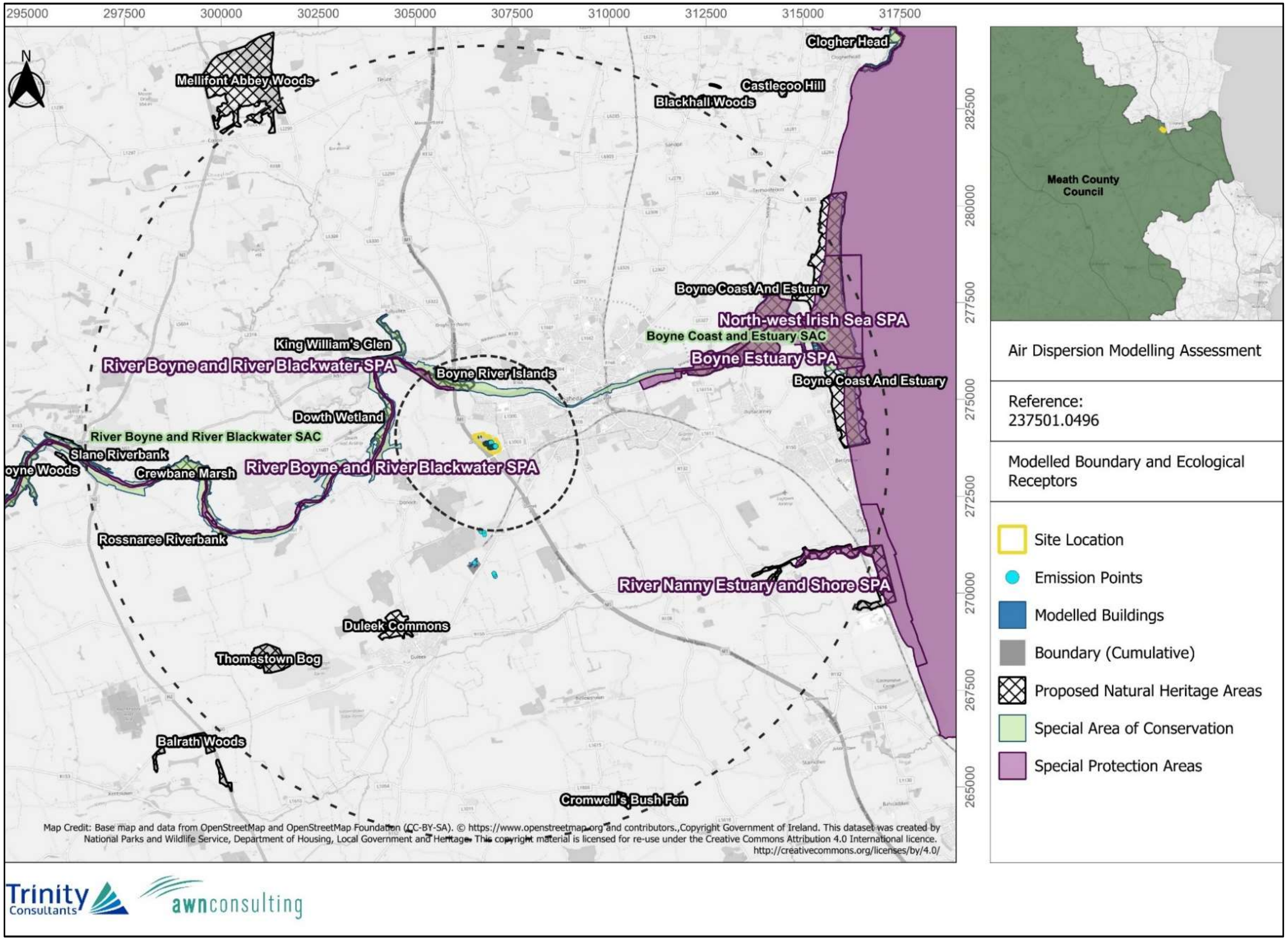

Figure 1. Map of land-use in the vicinity of the Installation.

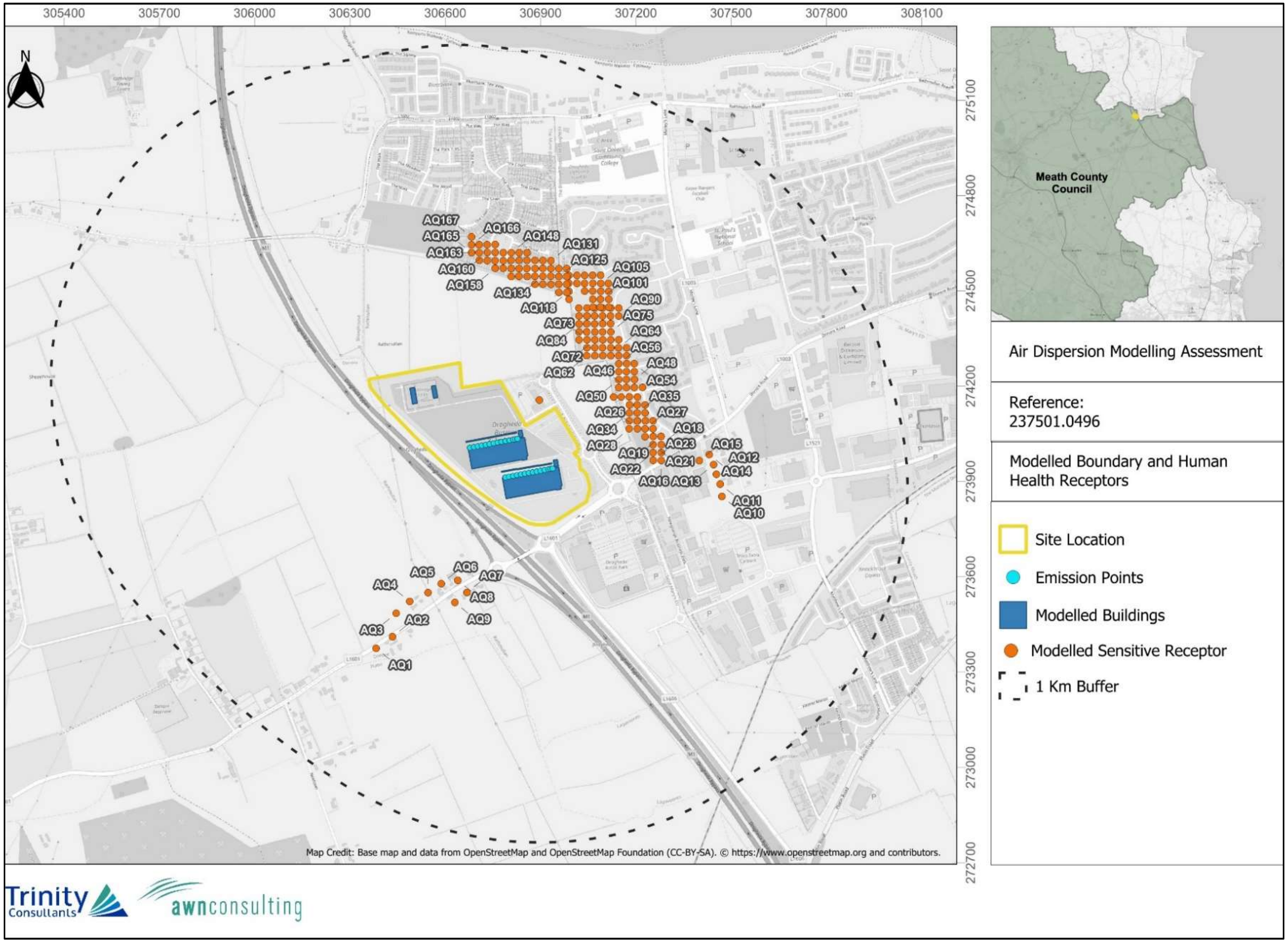

Figure 2. Modelled Boundary and Discrete Receptors

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 2022 (S.I. 739 of 2022), which incorporate EU Directive 2008/50/EC (see Table 1). The ambient air quality standards applicable for NO_2, CO, PM_{10}, $PM_{2.5}$ and SO_2 and are outlined in this Directive. Directive 2008/50/EC has been superseded by Directive (EU) 2024/2881. Table 2 of Annex I in Directive (EU) 2024/2881 sets out the current air quality standards for assessment purposes which are the same as those under Directive 2008/50/EC.

Ambient air quality legislation designed to protect human health and the environment is generally based on assessing ambient air quality at locations where the exposure of the population is significant relevant to the averaging time of the pollutant. However, in the current assessment, ambient air quality legislation has been applied to all locations within 20km of the Installation regardless of whether any sensitive receptors (such as residential locations) are present. This represents a worst-case approach and an examination of the corresponding concentrations at the nearest sensitive receptors relative to the actual quoted maximum concentration indicates that these receptors generally experience ambient concentrations significantly lower than that reported for the worst-case location.

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, CO, PM_{10}, $PM_{2.5}$ and SO_2 emissions from the Installation on ambient air quality.

Table 1. Air Quality Limit Values

Pollutant	Regulation/ Guideline	Limit Type	Value
Nitrogen Dioxide (NO_2)	2024/2881 Note 1	Hourly limit for protection of human health - not to be exceeded more than 18 times/year	200 $\mu g/m^3$ Note 1
		Annual limit for protection of human health	40 $\mu g/m^3$
Nitrogen Oxides (NO_X)	2024/2881	Annual limit for protection of vegetation	30 $\mu g/m^3$
Carbon Monoxide (CO)	2024/2881	8-hour limit (on a rolling basis) for protection of human health	10,000 $\mu g/m^3$
Particulate Matter (as PM_{10})	2024/2881	24-hour limit for protection of human health - not to be exceeded more than 35 times/year	50 $\mu g/m^3$
		Annual limit for protection of human health	40 $\mu g/m^3$
Particulate Matter (as $PM_{2.5}$) Stage 1	2024/2881	Annual limit for protection of human health	25 $\mu g/m^3$
Sulphur Dioxide (SO_2)	2024/2881	Hourly limit for protection of human health - not to be exceeded more than 24 times/year	350 $\mu g/m^3$

Pollutant	Regulation/ Guideline	Limit Type	Value
		24-Hourly limit for protection of human health - not to be exceeded more than 3 times/year	125 µg/m^3
		Critical level for protection of vegetation (annual and winter)	20 µg/m^3

Note 1 µg/m^3 (micrograms per cubic metre)

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 back-up generators considered in this assessment are 6.82 MW_{th} and 1.55 MW_{th} for Building A, and 6.79 MW_{th} and 2.02MW_{th} for Building B, therefore the Medium Combustion Plant (MCP) Regulations (S.I No. 595 of 2017), which transposed the Medium Combustion Plant Directive ((EU) 2015/2193) is a relevant consideration in respect of the individual plant.

The Medium Combustion Plant (MCP) Regulations require that any combustion plant operating in excess of 500 hours complies with the relevant ELVs set out in the MCP Directive subject to Section 13(3) of the MCP Regulations. However, the back-up generators are for emergency operations only and are not anticipated to operate in excess of 500 hours per generator per annum (they will only operate up to 100 hours per generator per annum). Therefore, the back-up generators as proposed are exempt from complying with the relevant ELVs.

The UK Environment Agency assessment methodology in Section 6.2 below determined that the standby generators could operate for 104 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 Ecological Assessment Criteria

2.3.1 Critical Levels

The Air Quality Standards Regulations 2022 outline an annual critical level of 30 µg/m^3 for NO_X and a level of 20 µg/m^3 for SO_2 (Table 1) for the protection of vegetation and natural ecosystems in general. The CAFE Directive (2008/50/EC) defines 'Critical Levels' as "*a level fixed on the basis of scientific knowledge, above which direct adverse effects may occur on some receptors, such as trees, other plants or natural ecosystems but not on humans*".

2.3.2 Critical Loads

A ‘Critical Load’ is defined by the United Nations Economic Commission for Europe (UNECE) as *“a quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge”* (UNECE, 2003).

Critical loads are presented as a range, within which there is the potential for effects on sensitive ecological receptors. Critical load ranges for N deposition and acid deposition were derived from the Air Pollution Information System (APIS) website (APIS, 2025) and are reproduced as shown in Table 2 and Table 3. Also shown in these tables are the site feature code and name (i.e. the qualifying feature the site is designated for), the corresponding critical load class and EUNIS codes (European Nature Information System (EUNIS) by the European Environment Agency).

In order to determine the appropriate nitrogen deposition critical load, in addition to APIS, the EPA publication *Research 390: Nitrogen-Sulfur Critical Loads: Assessment of the Impacts of Air Pollution on Habitats* (EPA, 2021) was consulted. In Table 3.2 of the publication empirical critical loads of nutrient nitrogen are outlined with a worst-case range of 5-10 kg/ha/yr for most habitat types. In addition, for most habitat types, the EPA publication recommends the midpoint is used to define the critical load (e.g. 7.5 kg/ha/yr). Thus, for the habitat types listed in the EPA publication the mid-range critical load for the worst-case habitat type within the relevant sites have been used to compare with modelled process contributions or the lower end of the range was used where required as per the EPA publication criteria. Where the habitat types were not listed within Table 3.2 of the EPA publication, the lower end of the critical load range has been used as a conservative approach.

Acid deposition critical loads are further categorised by nitrogen (N) or sulphur (S) components. Modelled acid deposition process contributions are therefore calculated in terms of both nitrogen (N) and sulphur (S) (see Section 3.8).

Deposition of sulphur (as sulphate (SO_4^{2-})) and nitrogen (as nitrate (NO_3^-), ammonium (NH_4^+) and nitric acid (HNO_3^-)), can cause acidification and both sulphur and nitrogen compounds must be taken into account when assessing acidification of soils. For the purposes of determining links between critical loads and atmospheric emissions of sulphur and nitrogen, critical loads are further derived to produce a maximum critical load for sulphur (CLmaxS), a minimum critical load for nitrogen (CLminN) and a maximum critical load for nitrogen (CLmaxN). These components define the critical load function and when compared with deposition data for sulphur and nitrogen, they can be used to assess critical load exceedances.

The modelled acid deposition process contributions (as S) have been compared to the minimum critical load (S) (MinCLmaxS).

The modelled acid deposition process contributions (as N) have been compared to the minimum critical load (N) (MinCLminN). Where a process contribution is greater than 1% of this minimum critical load, the predicted environmental concentration (PEC) should then be calculated by adding the acid deposition background concentration to the process contribution. The PEC should then be compared to the lower end of the maximum critical load (N) range i.e. MaxCLminN. This is in line with the *Screening Acidity Critical Loads* approach taken by APIS (available as a tab in the APIS app) for designated sites. Notably, APIS does not consider the critical load function to be exceeded unless the PEC is larger than the maximum critical load, not the minimum (which is typically considered worst case).

Table 2. Critical Loads – Nitrogen Deposition

Ecological Receptor		Feature Code	Feature Name	Critical loads for most sensitive feature*			Nitrogen Critical Load Class	EUNIS code	Is species sensitive due to nutrient nitrogen impacts on broad habitat?	Reason
Site Name	**Site Code**			**Min. Critical Load for N (kg N/ha/yr)**	**Max. Critical Load for N (kg N/ha/yr)**	**Assessment Criteria**				
Boyne Coast and Estuary SAC	001957	H1130	Estuaries	5	10	7.5	Pioneer, low-mid, mid-upper saltmarshes	A2.54; A2.55; A2.53	No	-
Clogher Head SAC	001459	H4030	European dry heaths	5	10	7.5	Dry heaths	F4.2	Yes	-
River Boyne and River Blackwater SAC	002299	H7230	Alkaline fens	5	10	7.5	Rich fens	D4.1	Yes	-
Boyne Estuary SPA	004080	A048	Tadorna tadorna (North-western Europe)	5	10	7.5	Pioneer, low-mid, mid-upper saltmarshes	A2.54; A2.55; A2.53	-	No expected negative impact on species due to impacts on the species' broad habitat.
North-west Irish Sea SPA	004236	A141	Pluvialis apricaria [North-western Europe]	5	10	7.5	Pioneer, low-mid, mid-upper saltmarshes	A2.54; A2.55; A2.53	-	1. Potential negative impact on species due to impacts on the species' broad habitat. 2. Potential positive impact on species due to impacts on the species' food supply.
River Boyne and River Blackwater SPA	004232	n/a	n/a	n/a	n/a	n/a	n/a	n/a	-	-
River Nanny Estuary and Shore SPA	004158	A130	Haematopus ostralegus (Europe & Northern/Western Africa)	5	10	7.5	Pioneer, low-mid, mid-upper saltmarshes	A2.54; A2.55; A2.53	-	1. No expected negative impact on species due to impacts on the species' broad habitat. 2. Potential positive impact on species due to impacts on the species' food supply.

Table 3. Critical Loads – Acid Deposition

Ecological Receptor		Feature Code	Feature Name	Acidity Critical Load Class	Max. Critical Load Range (N) (keq/ha/yr)		Max. Critical Load (S) (keq/ha/yr)	Min. Critical Load Range (N) (keq/ha/yr)		Min. Critical Load (S) (keq/ha/yr)	Is species sensitive due to acidity impacts on broad habitat?	Reason
Site Name	**Site Code**				**MaxCL minN**	**MaxCL maxN**	**MaxCL maxS**	**MinCL minN**	**MinCL maxN**	**MinCL maxS**		
Boyne Coast and Estuary SAC	001957	H2130	Fixed coastal dunes with herbaceous vegetation ("grey dunes")	Acid grassland	0.714	5.066	4.352	0.143	4.285	4.142	-	-
Clogher Head SAC	001459	H4030	European dry heaths	Dwarf shrub heath	0.143	4.535	4.392	0.143	4.535	4.392	-	-
River Boyne and River Blackwater SAC	002299	S1099	Lampetra fluviatilis	Freshwater	0.714	5.463	4.748	0.143	0.336	0.193	Yes	Potential negative impact on species due to impacts on the species' broad habitat.
Boyne Estuary SPA	004080	A130	Haematopus ostralegus (Europe & Northern/Western Africa)	Acid grassland	0.714	5.066	4.352	0.143	4.285	4.142	No	No expected negative impact on the species due to impacts on the species' broad habitat.
North-west Irish Sea SPA	004236	A054	Anas acuta (North-western Europe)	Freshwater	0.714	4.956	4.241	0.143	4.249	4.107	No	No expected negative impact on the species due to impacts on the species' broad habitat.
River Boyne and River Blackwater SPA	004232	A229	Alcedo atthis	Freshwater	0.714	5.439	4.724	0.143	0.359	0.216	Yes	Potential negative impact on species due to impacts on the species' broad habitat.
River Nanny Estuary and Shore SPA	004158	A137	Charadrius hiaticula (Europe/Northern Africa - wintering)	Acid grassland	0.714	5.143	4.429	0.143	4.328	4.185	No	No expected negative impact on the species due to impacts on the species' broad habitat.

3.0 ASSESSMENT METHODOLOGY

Emissions from the Installation have been modelled using the AERMOD dispersion model (Version 24142) which has been developed by the U.S. Environmental Protection Agency (USEPA)[1] and following guidance issued by the EPA[4]. The model is a steady-state Gaussian plume model used to assess pollutant concentrations associated with industrial sources and has replaced ISCST3[5] as the regulatory model by the USEPA for modelling emissions from industrial sources in both flat and rolling terrain[6][8]. The model has more advanced algorithms and gives better agreement with monitoring data in extensive validation studies[8]-[12]. 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 aims to achieve compliance with the guidance outlined within the EPA document *AG4 Guidance for Air Dispersion Modelling*[4] for the maximum permissible process contribution: "*When modelling a facility, the uncertainty in the model should be considered. If the facility is operated continually at close to the maximum licenced mass emission rate (i.e. maximum concentration and maximum volume flow) the process contribution (PC) should be less than 75% of the ambient air quality standard and less than this where background levels account for a significant fraction of the ambient air quality standard*".

This approach allows for inherent uncertainty in air dispersion modelling to be taken into account in order to avoid a risk of exceeding the air quality standards. However, in terms of the emergency scenario emissions cannot be quantified accurately. The emergency hours of operation for the Installation are not known, this will depend on whether an emergency event occurs initiating the requirement for the back-up generators to run. it is likely that in any given year the back-up generators may operate for 24 – 48 hours in total (plus testing/maintenance). For the purposes of this assessment a total of 100 emergency hours per back-up generator has been assumed to provide a worst-case, robust approach. As these are estimated hours of operation and may not actually occur the requirement for the modelling results to be below 75% of the air quality standard is overly restrictive and unnecessary. As per Appendix K of AG4[4] this states that gas engines/energy centres should be modelled using the standard methodology for continuous emission sources in line with the general AG4 guidance but it does not state that this is applicable to emergency operations. Therefore, compliance with the 75% is considered overly conservative in relation to the current assessment as any potential emergency operations will be infrequent in nature, if occurring at all.

Throughout this study a conservative approach was taken. This will most likely lead to an over-estimation of the levels that will arise in practice. The conservative assumptions are outlined below:

- Maximum predicted concentrations were reported in this study, even if no residential receptors were near the location of this maximum;
- Conservative background concentrations were used in the assessment;
- The effects of building downwash, due to on-site buildings, has been included in the model;
- Emergency operations of the 50 no. back-up generators were assumed to occur for 100 hours per generator per year under the Proposed Operations Scenario, calculated according to USEPA methodology;
- Licensed emission points were assumed to be in operation 24 hours per day, 365 days per year.

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:

- Modelling was conducted at gridded receptors as well as individual discrete receptors. Receptors are discussed in detail below in Section 3.2.
- 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 relatively simple terrain. All terrain features have been mapped in detail into the model using the terrain pre-processor AERMAP(13).
- Hourly-sequenced meteorological information has been used in the model. Meteorological data over a five year period (Dublin Airport 2020 – 2024) was used in the model (see Figure 3 and Appendix II).
- The source and emissions data, including stack dimensions, gas volumes and emission temperatures have been incorporated into the model.

3.2 Modelled Receptors

The modelling has incorporated a variety of receptors, including a gridded receptor network, site boundary receptors, and individual discrete receptors representing specific residential properties or sensitive ecological sites. All receptors were modelled at 1.5 m to represent breathing height.

The gridded receptor network was based on a Cartesian grid with the site at the centre. Three 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 large outer grid measured 18 x 18 km with the site at the centre and concentrations calculated at 1 km intervals. The middle 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 are also placed along the boundary of the site, at 25m intervals, giving a total of 2,591 calculation points for the model.

The impact of the emission sources was also measured at nearby residential receptors (ASR) which were added to the model as discrete receptors (shown in Table 4 and Figure 2).

Table 4. Modelled Discrete Receptors

Discrete Receptors								
Receptor	Co-Ordinates (UTM Zone 29 N)			Co-Ordinates (UTM Zone 29 N)			Co-Ordinates (UTM Zone 29 N)	
	X	Y	Receptor	X	Y	Receptor	X	Y
ASR1	672765	5954018	ASR61	672873	5954240	ASR121	672748	5954440
ASR2	672757	5954068	ASR62	672898	5954240	ASR122	672773	5954440
ASR3	673123	5953840	ASR63	672923	5954240	ASR123	672798	5954440
ASR4	673148	5953840	ASR64	672948	5954240	ASR124	672823	5954440
ASR5	673123	5953865	ASR65	672973	5954240	ASR125	672848	5954440
ASR6	673148	5953865	ASR66	672873	5954265	ASR126	672873	5954440
ASR7	673123	5953890	ASR67	672898	5954265	ASR127	672898	5954440
ASR8	673148	5953890	ASR68	672923	5954265	ASR128	672923	5954440
ASR9	673098	5953915	ASR69	672948	5954265	ASR129	672948	5954440
ASR10	673123	5953915	ASR70	672973	5954265	ASR130	672973	5954440
ASR11	673148	5953915	ASR71	672873	5954290	ASR131	672573	5954465
ASR12	673048	5953940	ASR72	672898	5954290	ASR132	672598	5954465
ASR13	673073	5953940	ASR73	672923	5954290	ASR133	672623	5954465
ASR14	673098	5953940	ASR74	672948	5954290	ASR134	672648	5954465
ASR15	673123	5953940	ASR75	672973	5954290	ASR135	672673	5954465
ASR16	673048	5953965	ASR76	672998	5954290	ASR136	672698	5954465
ASR17	673073	5953965	ASR77	672873	5954315	ASR137	672723	5954465
ASR18	673098	5953965	ASR78	672898	5954315	ASR138	672748	5954465
ASR19	673123	5953965	ASR79	672923	5954315	ASR139	672773	5954465
ASR20	673048	5953990	ASR80	672948	5954315	ASR140	672798	5954465
ASR21	673073	5953990	ASR81	672973	5954315	ASR141	672548	5954490
ASR22	673098	5953990	ASR82	672998	5954315	ASR142	672573	5954490
ASR23	673048	5954015	ASR83	672948	5954340	ASR143	672598	5954490
ASR24	673073	5954015	ASR84	672973	5954340	ASR144	672623	5954490
ASR25	673098	5954015	ASR85	672998	5954340	ASR145	672648	5954490
ASR26	672998	5954040	ASR86	672823	5954365	ASR146	672673	5954490
ASR27	673023	5954040	ASR87	672848	5954365	ASR147	672698	5954490
ASR28	673048	5954040	ASR88	672873	5954365	ASR148	672723	5954490
ASR29	673073	5954040	ASR89	672948	5954365	ASR149	672548	5954515
ASR30	672998	5954065	ASR90	672973	5954365	ASR150	672573	5954515
ASR31	673023	5954065	ASR91	672998	5954365	ASR151	672598	5954515
ASR32	673048	5954065	ASR92	672748	5954390	ASR152	672623	5954515
ASR33	673073	5954065	ASR93	672773	5954390	ASR153	672548	5954540
ASR34	672998	5954090	ASR94	672798	5954390	ASR154	673284	5953857
ASR35	673023	5954090	ASR95	672823	5954390	ASR155	673355	5953744
ASR36	673048	5954090	ASR96	672848	5954390	ASR156	673350	5953783
ASR37	672998	5954115	ASR97	672873	5954390	ASR157	673338	5953814

Discrete Receptors								
Receptor	Co-Ordinates (UTM Zone 29 N)		Receptor	Co-Ordinates (UTM Zone 29 N)		Receptor	Co-Ordinates (UTM Zone 29 N)	
	X	Y		X	Y		X	Y
ASR38	673023	5954115	ASR98	672923	5954390	ASR158	673328	5953845
ASR39	673048	5954115	ASR99	672948	5954390	ASR159	673315	5953876
ASR40	672998	5954140	ASR100	672973	5954390	ASR160	672523	5953481
ASR41	673023	5954140	ASR101	672998	5954390	ASR161	672552	5953443
ASR42	673048	5954140	ASR102	672673	5954415	ASR162	672514	5953411
ASR43	672898	5954165	ASR103	672698	5954415	ASR163	672472	5953470
ASR44	672923	5954165	ASR104	672723	5954415	ASR164	672430	5953441
ASR45	672948	5954165	ASR105	672748	5954415	ASR165	672372	5953414
ASR46	672973	5954165	ASR106	672773	5954415	ASR166	672330	5953377
ASR47	672998	5954165	ASR107	672798	5954415	ASR167	672318	5953304
ASR48	673023	5954165	ASR108	672823	5954415	ASR168	672266	5953267
ASR49	672898	5954190	ASR109	672848	5954415	ASR169	672202	5954596
ASR50	672923	5954190	ASR110	672873	5954415			
ASR51	672948	5954190	ASR111	672898	5954415			
ASR52	672973	5954190	ASR112	672923	5954415			
ASR53	672998	5954190	ASR113	672948	5954415			
ASR54	673023	5954190	ASR114	672973	5954415			
ASR55	672873	5954215	ASR115	672998	5954415			
ASR56	672898	5954215	ASR116	672623	5954440			
ASR57	672923	5954215	ASR117	672648	5954440			
ASR58	672948	5954215	ASR118	672673	5954440			
ASR59	672973	5954215	ASR119	672698	5954440			
ASR60	672998	5954215	ASR120	672723	5954440			

3.3 Methodology for Modelling of Emergency Operations

Regarding emergency operations, USEPA Guidance suggests an average hourly emission rate should be used rather than the maximum hourly rate[25]. As a result, the maximum hourly emission rates from the back-up generators were reduced by, for example, *x no. hours / 8760* and the emissions were modelled over a period of one full year. A total of 100 emergency hours per generator have been included in the assessment for the back-up generators, therefore the relevant emissions rates were reduced by a factor of 100/8760.

The modelling assessment has been based on 100 hours of potential emergency operations per generator for the back-up generators, this provides a worst-case assessment. It is understood that the back-up generators will be permitted to operate for a maximum of 100 emergency hours per generator per year as per the existing IE licence 1181-01 and granted planning permission for the Installation.

A second assessment methodology has been published by the UK Environment Agency. The consultation document is entitled "*Diesel Generator Short-Term NO_2 Impact Assessment*"[26]. 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, as per S.I. 739 of 2022 and Directive 2008/50/EC). The assessment assumes a hypergeometric distribution to assess the likelihood of exceedance hours coinciding with the emergency operational hours of the 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 98^{th} 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 Installation. This also follows the guidance outlined in Appendix K of the EPA AG4 guidance(4).

3.4 Terrain

The AERMOD air dispersion model has a terrain pre-processor AERMAP(13) 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, H_{crit}, 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 (H_c). As outlined in the AERMOD model formulation(1) a plume embedded in the flow below H_c tends to remain horizontal; it might go around the hill or impact on it. A plume above H_c 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”(6).

3.5 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. Dublin Airport meteorological station, which is located approximately 31 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 Dublin Airport meteorological station provide an indication of the prevailing wind conditions for the region (see Figure 3 and Appendix II)[14]. Results indicate that the prevailing wind direction is westerly to south-westerly in direction over the period 2020 – 2024.

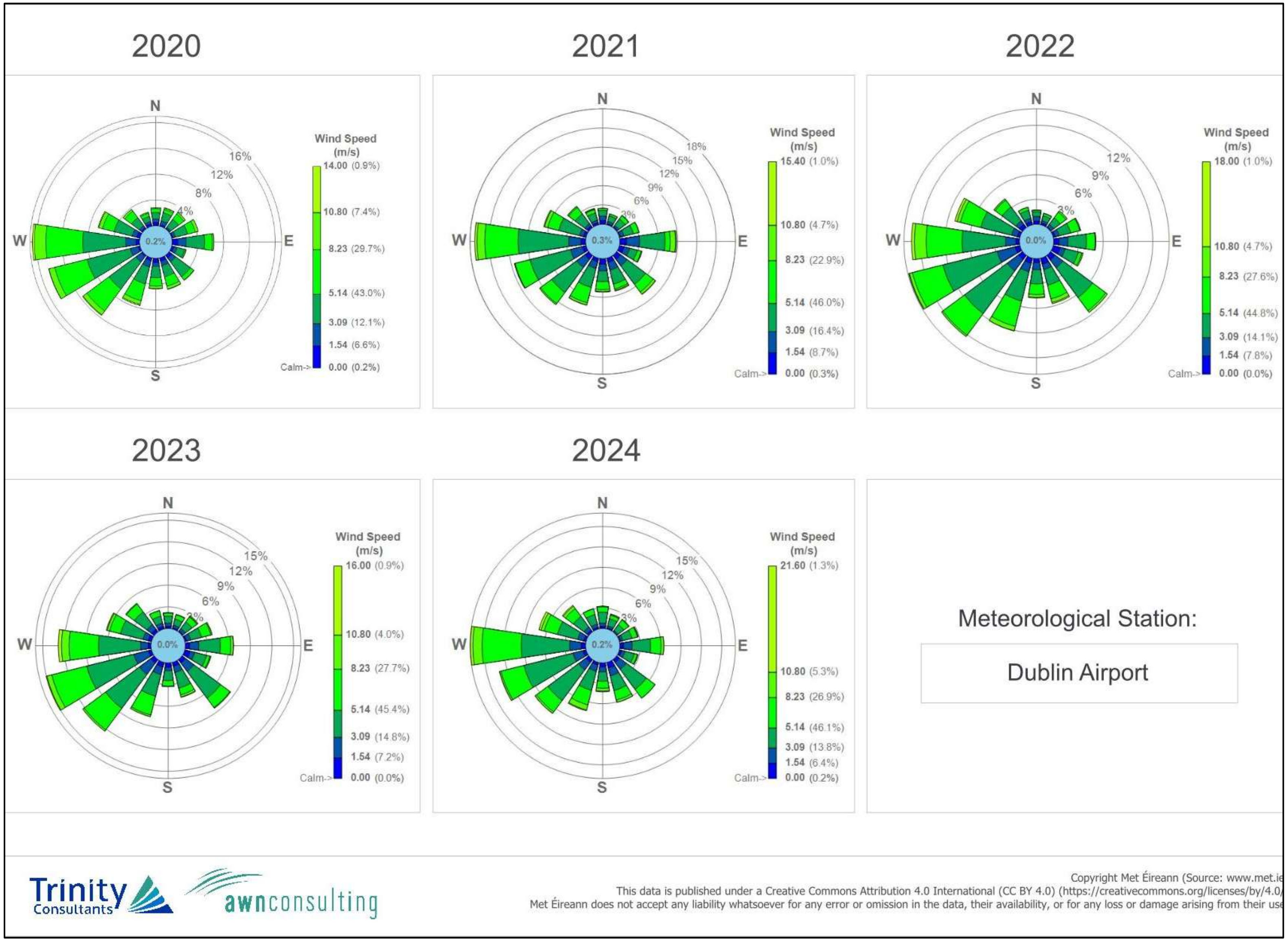

Figure 3. Dublin Airport Windrose 2020 – 2024

3.6 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[15] to enable the calculation of the appropriate parameters. The AERMET meteorological pre-processor 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 10 km from the meteorological station for Bowen Ratio and albedo and to a distance of 1 km for surface roughness in line with USEPA recommendations[15][16] 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 (Dublin Airport) rather than the installation;
- Surface roughness should use a default 1 km 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 10 km 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[16] 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[17]. This approach has been applied to the current site with full details provided in Appendix II.

3.7 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 800 m).

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[18].

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)[11][12] 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[11].

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. Shown in Figure 4 is an example of the buildings (in blue) which influence the building downwash for stack D72G01. The dominant building for each relevant stack will vary as a function of wind direction and relative building heights.

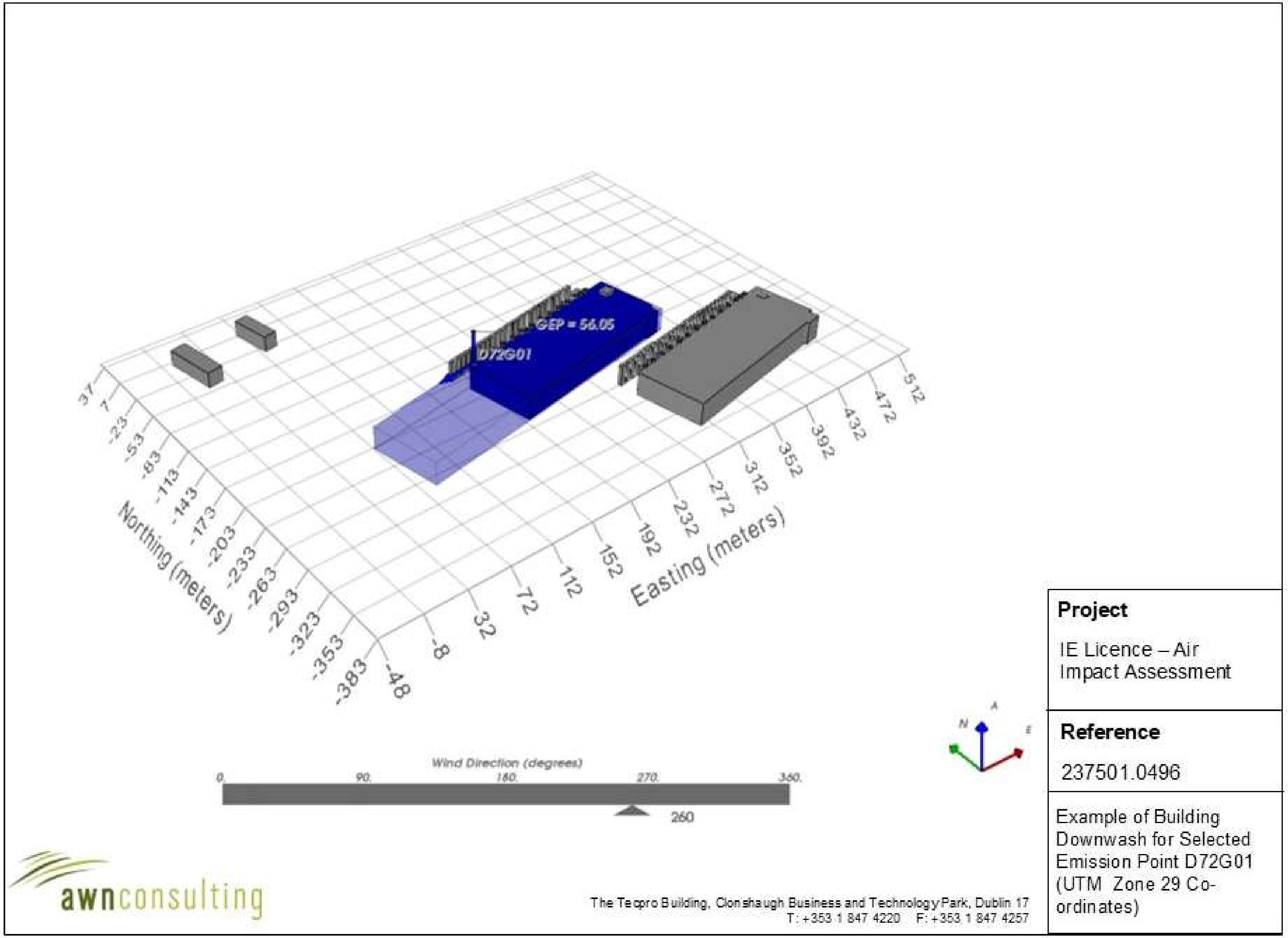

Figure 4. Example of building downwash at the Installation, Drogheda, Co. Meath

3.8 Designated Habitat Sites

3.8.1 Modelled Ecological Habitat Sites

The impact of emissions of NO_X, SO_2 and nutrient and acid deposition was assessed at the following designated habitat sites that are within 20 km of the Installation. The 20 km distance was selected based on maximum extent of the impact zone from the air emissions onsite. After 20 km, the ambient air concentration of NO_X, SO_2 and nutrient and acid deposition due to emissions from the Installation are imperceptible. Modelling was undertaken at the following designated habitat sites:

- **Proposed Natural Heritage Areas (pNHA)** – Balrath Woods pNHA, Barmeath Woods pNHA, Blackhall Woods pNHA, Bog Of The Ring pNHA, Boyne Coast And Estuary pNHA, Boyne River Islands pNHA, Boyne Woods pNHA, Castlecoo Hill pNHA, Clogher Head pNHA, Crewbane Marsh pNHA, Cromwell's Bush Fen pNHA, Dowth Wetland pNHA, Duleek Commons pNHA, Dunany Point pNHA, Dundalk Bay pNHA, Kildemock Marsh pNHA, King William's Glen pNHA, Knock Lake pNHA, Laytown Dunes/Nanny Estuary pNHA, Mellifont Abbey Woods pNHA, Rossnaree Riverbank pNHA, Slane Riverbank pNHA, Stabannan-Braganstown pNHA, Thomastown Bog pNHA.
- **Special Areas of Conservation (SAC) –** Boyne Coast and Estuary SAC, Clogher Head SAC, Dundalk Bay SAC, River Boyne And River Blackwater SAC.
- **Special Protection Area (SPA) –** Boyne Estuary SPA, Dundalk Bay SPA, River Boyne and River Blackwater SPA, River Nanny Estuary and Shore SPA, Stabannan-Braganstown SPA, North-west Irish Sea SPA.

The closest ecological habitat site, and Natura 2000 designated habitat, to the Installation is the River Boyne And River Blackwater SAC (site code 002299), which is approx. 1 km to the north of the Installation, this is the most impacted (i.e. where the highest predicted concentrations are) ecological site based on the results of the modelling assessment. While modelling has been undertaken for all the above listed designated sites, in order to align with and inform the AA Screening / Natura Impact Statement (NIS) the results of the modelling have been presented for the following designated sites:

- River Boyne and River Blackwater SAC (Site Code: 002299)
- Boyne Coast and Estuary SAC (Site Code: 001957)
- Clogher Head SAC (Site Code: 001459)
- River Boyne and River Blackwater SPA (Site Code: 004232)
- Boyne Estuary SPA (Site Code: 004080)
- River Nanny Estuary and Shore SPA (Site Code: 004158)
- North-west Irish Sea SPA (Site Code: 004236)

An annual limit value of 30 μg/m^3 for NO_X and 20 μg/m^3 for SO_2 is specified within Directive (EU) 2024/2881 for the protection of ecosystems. The NO_X limit value is applicable only in highly rural areas away from major sources of NO_X such as large conurbations, factories and high road vehicle activity such as a dual carriageway or motorway. Annex IV of Directive (EU) 2024/2881 identifies that monitoring to demonstrate compliance with the NO_X limit value for the protection of vegetation should be carried out distances greater than:

- 5 km from the nearest motorway or dual carriageway;
- 5 km from the nearest major industrial installation;
- 20 km from a major urban conurbation.

There are sections of designated sites which are near the Installation that are close to industrial facilities, the M1 motorway and Drogheda town, so the limit value for NO_X for the protection of ecosystems is not technically applicable at these sites. Regardless, the annual average concentrations for NO_X from all emission points at the Installation were predicted at receptors within the designated sites for all five years of meteorological data modelled (2020 – 2024). With receptor spacing of 500 m, 967 discrete receptors were modelled in total within the sensitive ecosystems. Ecological receptors were modelled at 0m.

3.8.2 *Methodology for Nitrogen and Acid Deposition*

In order to consider the effects of nitrogen and acid deposition owing to emissions from the Installation on the designated habitat sites, the maximum annual mean NO_2 and SO_2 predicted environmental concentrations must be converted firstly into a dry deposition flux using the equation below which is taken from UK Environment Agency publication "AGTAG06 – Technical Guidance On Detailed Modelling Approach For An Appropriate Assessment For Emissions To Air"(30):

Dry deposition flux (μg/m^2/s) = ground-level concentration (μg/m^3) x deposition velocity (m/s)

The deposition velocities for NO_2 and SO_2 are outlined in AQTAG06(30) and shown below in Table 5. The dry deposition flux is then multiplied by conversion factors shown in Table 5 (taken from AQTAG06(30)) to convert it to a nitrogen (N) and sulphur (S) deposition flux (kg/ha/yr), and to an acid deposition flux (keq/ha/yr).

Table 5. Dry Deposition Fluxes for NO_2 and SO_2

Chemical Species	Habitat Type	Recommended Deposition Velocity (m/s)	Nitrogen Deposition Conversion factor μg/m^2/s to kg/ha/yr	Acid Deposition Conversion factor μg/m^2/s to keq/ha/yr
NO_2	Grassland	0.0015	95.9	6.84
SO_2	Grassland	0.012	157.7	9.84

3.9 Concentration Contours

Modelled predicted ambient ground level concentrations beyond the site boundary are presented as concentration contours in Section 6.0. The purpose of the concentration contour plots is to show the extent and location of the emission plume.

The air dispersion model (AERMOD) produces numerical output files which contain predicted pollutant concentrations at a large number of discrete receptor points across the modelling domain domain (defined by the gridded receptors discussed in Section 3.2). These results are typically exported in tabular format, listing the predicted value (e.g. annual mean NO_2 in μg/m³) for each receptor location defined by its X and Y coordinates.

To aid interpretation, these tabular results can be imported into contouring software (e.g. Breeze 3D Analyst, Surfer, ArcGIS, or QGIS) where an interpolation algorithm is applied. The software estimates values between the discrete receptor points, allowing the creation of concentration contours. These are graphical representations that join locations of equal concentration with smooth lines, giving a clear picture of concentration gradients and the spatial extent of impact.

The primary differences between concentration contours and tabular results are:

- Tabular results provide the exact model predictions at defined receptor points and identify the receptor where the maximum model concentration is predicted. These are the values to be relied upon for compliance assessment and reporting against air quality standards or guidelines.

- Contours provide a visual interpretation of how pollutant concentrations vary across the site and surrounding area. They are useful for communicating results, identifying zones of higher or lower impact, and for inclusion in planning documents. However, since contours involve interpolation between points over a large study area (defined by the gridded receptors discussed in Section 3.2), they are approximate representations and should not be used in place of the tabulated receptor results for regulatory comparison. The maximum model concentration presented by concentration contours will always be less than the maximum concentration predicted at an individual receptor, due to the interpolation process of concentrations over a larger area.

4.0 BACKGROUND CONCENTRATIONS OF POLLUTANTS

A background concentration is typically added to the modelled process contribution to account for emission sources not included in the dispersion model.

Background concentrations representative of the area of the Installation are derived from ambient air quality monitoring undertaken in recent years by the EPA and Local Authorities(19). The most recent annual report on air quality "*Air Quality in Ireland 2023*"(19), 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(19). 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, the area of the Installation is categorised as Zone C(19).

Continuous monitoring by the EPA is carried out at a number of monitoring stations within Zone C; these include urban background sites, roadside (traffic) sites and suburban background sites.

It is necessary to select monitoring stations that are representative of the site location. Not all monitoring stations are considered suitable for determining background pollutant concentrations and must be reviewed on a case-by-case basis to determine the most appropriate EPA monitoring sites for the current assessment.

The EPA, on their website(19), state that background sites generally represent overall area-wide exposure more closely than roadside sites. Roadside monitoring sites are heavily influenced by traffic emissions and are not considered representative of area-wide pollutant levels. The purpose of this assessment, and particularly the cumulative assessment, is to determine the predicted pollutant concentrations over a wide area, therefore roadside monitoring stations were not considered appropriate.

Due to the location of the Installation and the above information, it was considered appropriate to use the EPA suburban background monitoring stations to determine background pollutant levels, in so far as possible. The full suite of EPA Zone C suburban background monitoring stations were therefore reviewed to determine those that were most appropriate to estimate background pollutant levels for the area of the Installation.

4.1 NO_2

With regard to NO_2, continuous monitoring by the EPA[19] is carried out at a number of monitoring stations within Zone C. The following Zone C monitoring stations of Kilkenny, Portlaoise and Dundalk were considered representative of the site location.

The selected monitoring sites are suburban background monitoring locations which are not heavily influenced by traffic or other major air emission sources and can provide an indicative estimate of the background NO_2 concentrations in the vicinity of the Installation. Road traffic is a significant contributor to NO_2 concentrations with concentrations of the pollutant decreasing rapidly with increasing distance from the road source. As mentioned by the EPA on their website[19], background sites generally represent overall area-wide exposure more closely than roadside sites. However, the M1 motorway is located directly to the east of the Installation boundary, and this has been taken into consideration when estimating the background concentrations.

NO_2 concentrations at the representative Zone C locations of Dundalk, Kilkenny and Portlaoise show that levels of NO_2 are below both the annual and 1-hour limit values, with concentrations ranging from 4 – 14 µg/m^3 over the period 2018 – 2023 (see Table 6). The 1-hour mean concentrations were also in compliance with the 1-hour limit of 200 µg/m^3, with at most 1 exceedance in Dundalk in any year (18 no. exceedances are allowable per year). Data for Dundalk indicates that annual mean concentrations ranged from 9 – 14 µg/m^3 over the 2018 – 2023 period. Additionally, long term trends in ambient NO_2 concentrations indicate either reductions or relatively stable levels over time, with significant increases unlikely in the future. *Ireland's Air Pollutant Emissions 2022* (1990-2030) report also demonstrates that Ireland's emissions of NO_X have been generally decreasing since 1990, with a reduction of 53.8% over the period 2005-2021 observed[32].

Based on the above results a reasonably conservative estimate of the background NO_2 concentration in the region of the Installation is **14 µg/m^3**.

Table 6. Background NO_2 Concentrations In Zone C Locations (µg/m^3)

Station	Averaging Period	Year					
		2018	2019	2020	2021	2022	2023
Kilkenny (Seville Lodge)	Annual Mean NO_2 (µg/m^3)	6	5	4	4	5	4
	1-hr Mean NO_2 values >200 µg/m^3	-	-	0	0	0	0
Portlaoise	Annual Mean NO_2 (µg/m^3)	11	11	8	8	9	8
	1-hr Mean NO_2 values >200 µg/m^3	-	-	0	0	0	0
Dundalk	Annual Mean NO_2 (µg/m^3)	14	12	10	11	10	9
	1-hr Mean NO_2 values >200 µg/m^3	-	-	1	0	1	1

The Ozone-Limited Method (OLM) was used to model NO_2 concentrations. The OLM is a regulatory option in AERMOD[22][23] which assumes that the amount of NO converted to NO_2 is proportional to the ambient ozone (O_3) concentration. The concentration is usually limited by the amount of ambient O_3 that is entrained in the plume. Thus, the ratio of the moles of O_3 to the moles of NO_X gives the ratio of NO_2/NO_X that is formed after the NO_X leaves the stack. In addition, it has been assumed that 10% of the NO_X in the stack gas from back-up generators is already in the form of NO_2 before the gas leaves the stack. The equation used in the algorithm to derive the ratio of NO_2/NO_X is:

$$NO_2/NO_X = (\text{moles } O_3 / \text{ moles } NO_X) + 0.10$$

A background ozone concentration of 58 µg/m^3 was used in the modelling assessment, based on a review of worst case background ozone data for Zone C sites(19).

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.

4.2 CO

In terms of CO, monitoring has been conducted at the suburban background Zone C sites of Portlaoise and Dundalk over the period 2019 – 2023. Monitored concentrations are significantly below the ambient limit value of 10 mg/m^3. Maximum 8-hour concentrations at the Portlaoise site ranged from 0.7 mg/m^3 – 1.3 mg/m^3 over the period 2019 – 2023(19). Maximum 8-hour concentrations at the Dundalk site over the 2019 – 2023 period ranged from 0.7 mg/m^3 – 2.0 mg/m^3. Based on these results a background 8-hour CO concentration of **2.0 mg/m^3** has been used in the modelling assessment.

This estimated background concentration has been added directly to the modelled 8-hour maximum result to produce the predicted environmental concentration in terms of CO.

4.3 PM_{10}

Continuous PM_{10} monitoring carried out at the suburban background locations of Drogheda, Dundalk, Ennis, Portlaoise and Kilkenny showed annual mean concentrations ranging from 11 – 16 µg/m^3 in 2023 (Table 7). There have been at most 21 exceedances (in Ennis) of the daily limit value of 50 µg/m^3 (35 exceedances are permitted per year)(19). Sufficient data is available for Dundalk, Ennis and Portlaoise to observe trends over the period 2018 – 2023. Average annual mean PM_{10} concentrations ranged from 11 – 20 µg/m^3 over this period. Data for the monitoring station at Drogheda, which is located approximately 4.8 km from the Installation, on the northern outskirts of Drogheda town and can be considered representative of the site location, indicated that concentrations ranged from 11 – 12 µg/m^3 over the 2021 – 2023 period. Based on these results, a conservative estimate of the background PM_{10} concentration in the region of the Installation is **13 µg/m^3**.

Table 7. Background PM_{10} Concentrations In Zone C Locations (µg/m^3)

Station	Averaging Period	Year					
		2018	2019	2020	2021	2022	2023
Drogheda	Annual Mean PM_{10} (µg/m^3)	-	-	-	11	12	11
	24-hr Mean > 50 µg/m^3 (days)	-	-	-	0	0	-

Station	Averaging Period	Year					
		2018	2019	2020	2021	2022	2023
	90th%ile of 24-hr Means	-	-	-	17	18	-
Dundalk	Annual Mean PM_{10} (µg/m^3)	15	14	13	12	12	13
	24-hr Mean > 50 µg/m^3 (days)	0	2	2	0	2	-
	90th%ile of 24-hr Means	24	-	23	19	21	-
Ennis	Annual Mean PM_{10} (µg/m^3)	16	18	20	19	20	16
	24-hr Mean > 50 µg/m^3 (days)	4	12	19	17	21	-
	90th%ile of 24-hr Means	27	34	34	35	39	-
Portlaoise	Annual Mean PM_{10} (µg/m^3)	11	15	12	11	12	11
	24-hr Mean > 50 µg/m^3 (days)	1	0	0	1	0	-
	90th%ile of 24-hr Means	18	27	21	20	22	-
Kilkenny (Seville Lodge)	Annual Mean PM_{10} (µg/m^3)	-	18	18	17	18	14
	24-hr Mean > 50 µg/m^3 (days)	-	7	1	2	2	-
	90th%ile of 24-hr Means	-	-	29	28	30	-

Note 1 Annual average limit value of 40 µg/m^3 and daily limit value of 50 µg/m^3 (EU Council Directive 2008/50/EC & S.I. No. 739 of 2022)

In relation to the annual averages, the ambient background concentration is added directly to the process concentration. However, in relation to the short-term peak concentration, concentrations due to emissions from elevated sources cannot be combined in the same way. Guidance from the UK DEFRA[21] and the EPA[2] advises that for PM_{10} an estimate of the maximum combined pollutant concentration can be obtained as shown below:

PM_{10} - The 90.4th%ile of total 24-hour mean PM_{10} is equal to the maximum of either A or B below:

a) 90.4th%ile of 24-hour mean background PM_{10} + annual mean process contribution PM_{10}

b) 90.4th%ile 24-hour mean process contribution PM_{10} + annual mean background PM_{10}

A 90.4th percentile 24-hour background concentration of **22 µg/m^3** was used in the assessment, based on average concentrations for Drogheda, Dundalk, Portlaoise and Kilkenny over the period 2018 – 2023.

4.4 $PM_{2.5}$

Continuous $PM_{2.5}$ monitoring carried out at the Zone C suburban background locations of Drogheda, Ennis, Portlaoise and Bray showed annual mean concentrations ranging from 6 – 12 µg/m^3 in 2023 (see Table 8). Sufficient data is available for Ennis and Bray to observe trends over the period 2018 – 2023. Average annual mean $PM_{2.5}$ concentrations ranged from 6 – 16 µg/m^3 over this period. Data from the monitoring station in Drogheda shows that annual average $PM_{2.5}$ concentrations were 6 µg/m^3 – 7 µg/m^3 over the 2021 to 2023 period. Based on this information, a conservative estimate of the background $PM_{2.5}$ concentration in the region of the Installation is **8 µg/m^3**.

In relation to the annual average background, the ambient background concentration was added directly to the process concentration.

Table 8. Background $PM_{2.5}$ Concentrations In Zone C Locations (µg/m^3)

Station	Averaging Period	Year					
		2018	2019	2020	2021	2022	2023
Drogheda	Annual Mean $PM_{2.5}$ (µg/m^3)	-	-	-	6	7	6
Ennis	Annual Mean $PM_{2.5}$ (µg/m^3)	10	14	14	15	16	12
Portlaoise	Annual Mean $PM_{2.5}$ (µg/m^3)	-	-	12	8	8	7
Bray	Annual Mean $PM_{2.5}$ (µg/m^3)	6	7	5	6	6	6

Note 1 Annual average limit value of 25 µg/m^3 (EU Council Directive 2008/50/EC & S.I. No. 739 of 2022)

4.5 SO_2

Continuous SO_2 monitoring carried out at the Zone C suburban background locations of Ennis, Portlaoise and Dundalk showed annual mean concentrations ranging from 2 – 5 µg/m^3 in 2023 (see Table 9). Sufficient data is available for all stations to observe trends in annual mean concentrations over the period 2018 – 2023. Average annual mean SO_2 concentrations ranged from 1 – 6 µg/m^3 over this period, suggesting an upper average concentration of no more than 6 µg/m^3. Based on this information, a conservative estimate of the background SO_2 concentration in the region of the Installation is **4 µg/m^3**.

Table 9. Background SO_2 Concentrations In Zone C Locations (µg/m^3)

Station	Averaging Period	Year					
		2018	2019	2020	2021	2022	2023
Ennis	Annual Mean SO_2 (µg/m^3) Note 1	3	4	4	6	5	5
	99.7th%ile of 1-hour mean SO_2 (µg/m^3) Note 2	27	36	61	-	68	-
	99.2th%ile of 24-hour mean SO_2 (µg/m^3) Note 3	13	16	21	31	27	-
Portlaoise	Annual Mean SO_2 (µg/m^3)	3	1	2	2	3	4
	99.7th%ile of 1-hour mean SO_2 (µg/m^3) Note 2	-	-	17	-	11	-

Station	Averaging Period	Year					
		2018	2019	2020	2021	2022	2023
	99.2th%ile of 24-hour mean SO_2 (µg/m^3) Note 3	-	-	7	4	6	-
Dundalk	Annual Mean SO_2 (µg/m^3)	4	2	2	2	4	2
	99.7th%ile of 1-hour mean SO_2 (µg/m^3) Note 2	-	-	15	-	18	-
	99.2th%ile of 24-hour mean SO_2 (µg/m^3) Note 3	-	-	6	7	9	-

Note 1 Annual average limit value of 20 µg/m^3 (EU Council Directive 2008/50/EC & S.I. No. 739 of 2022)

Note 2 24 hour limit value of 125 µg/m^3 not to be exceeded more than 3 times per year (EU Council Directive 2008/50/EC & S.I. No. 739 of 2022)

Note 3 Hourly limit value of 350 µg/m^3 not to be exceeded more than 24 times per year (EU Council Directive 2008/50/EC & S.I. No. 739 of 2022)

When calculating the short-term peak results, concentrations due to emissions from stacks cannot be combined by directly adding the annual background level to the modelling results. Guidance from the UK DEFRA(21) and EPA(4) advises that for SO_2 an estimate of the maximum combined pollutant concentrations can be obtained as shown below:

99.7th%ile of 1-hour mean SO_2 is equal to the maximum of either Method A or Method B below:

a) [Annual mean process contribution SO_2 (x2)] + [99.7th%ile hourly background SO_2]
b) [99.7th%ile hourly process contribution SO_2] + [annual mean background SO_2 (x2)]

99.2nd%ile of 24-hour mean SO_2 is equal to the maximum of either Method A or Method B below:

a) [Annual mean process contribution SO_2 (x2)] + [99.2nd%ile of 24-hour mean background SO_2]
b) [99.2nd%ile 24-hour mean process contribution SO_2] + [annual mean background SO_2 (x2)]

A 99.2nd percentile 24-hour background concentration of **13 µg/m^3** and a 99.7th percentile 1-hour background concentration of **30 µg/m^3** were used in the assessment, based on average concentrations for Ennis, Portlaoise and Dundalk over the period 2018 – 2023.

4.6 Sensitive Designated Habitats

Background concentrations for NO_X, SO_2, and nitrogen and acid deposition at the relevant designated habitats for the purposes of the AA Screening / NIS were derived from the 1 km grid square concentrations provided on the Air Pollution Information System (APIS) website(31), in line with UKEA(30) and UK Defra(21) guidance, and are shown in Table 10. The background concentrations are added directly to the modelled process contributions to give a total predicted environmental concentration.

Table 10. Background Concentrations for NO_X, SO_2, Nitrogen and Acid Deposition[31]

Relevant Sensitive Designated Habitat	NO_x (µg/m³)	SO_2 (µg/m³)	Nitrogen Deposition (kg/ha/yr)	Acid Deposition (keq/ha/yr)
River Boyne & River Blackwater SAC	6.662	0.753	7.276	0.568
Boyne Coast and Estuary SAC	5.780	0.738	6.089	0.472
Clogher Head SAC	6.300	0.700	6.500	0.500
Boyne Estuary SPA	6.899	0.877	7.276	0.568
North-west Irish Sea SPA Note 1	5.200	0.500	5.800	0.400
River Boyne and River Blackwater SPA	6.261	0.699	8.238	0.593
River Nanny Estuary and Shore SPA	5.029	0.434	5.694	0.405
Note 1: No background concentration information available on APIS for the North-west Irish Sea SPA. Appropriate backgrounds derived from 1km grid squares along Irish coastline in proximity to project area.				

5.0 PROCESS EMISSIONS

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

Building A has 26 no. 6.82 MW_{th} back-up generators and 1 no. 1.55 MW_{th} back-up generator. Building B has 26 no. 6.79 MW_{th} back-up generators and 1 no. 2.02 MW_{th} back-up generator. A total of 54 no. back-up generators were considered in this assessment. Each generator has an associated stack, the heights of which were designed in an iterative fashion to provide for adequate dispersion of pollutants. All stacks are vertical and are 25m above ground level.

Two of the 6.82 MW_{th} back-up generators associated with Building A and two of the 6.79 MW_{th} back-up generators associated with Building B 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 50 of the 54 no. back-up generators will be operational.

In addition to the 54 no. emergency back-up generators which will power the site in an emergency scenario, the site also includes 2 no. fire sprinkler pump generators (0.37 MW_{th}). The fire sprinkler pump generators 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 stationary data hall back-up generators) and the low number required for use at any one time.

Two testing regimes for the back-up generators have 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 54 no. back-up generators on the campus at 25% load for a maximum of 30 minutes each, one generator at a time, sequentially.
- **Test 2:** All 54 no. back-up generators will be periodically tested for a maximum of four hours. This was modelled as one generator operating, at 90% load, for 4 consecutive hours, once per quarter. Under the Test 2 operations, the generators will operate for a maximum of 16 hours per generator over a one year period.

5.1 Diesel / Hydrotreated Vegetable Oil Fuel

The air impact assessment has been based on the emissions from standard diesel fuel, as an approach to conservatively assesses the environmental impact, ensuring that the highest potential emissions levels are considered. By using the emissions associated with diesel in this worst-case scenario, the assessment ensures that when operating on HVO (likely to be lower or equivalent emissions) are appropriately accounted for.

The emissions from combustion plant (such as emergency generators) when operating on hydrotreated vegetable oil (HVO) fuel are no higher than those produced when using standard diesel fuel. While HVO has been shown to significantly reduce CO_2 emissions, its impact on other pollutants – such as nitrogen oxides (NO_X), sulphur oxides (SO_X), particulate matter (PM), and carbon monoxide (CO) – is guaranteed by equipment suppliers to be comparable to or less than that of standard diesel fuel.

5.2 Emergency Operations

The back-up generators will operate in an emergency scenario as per the criteria in Section 2.2. In addition, testing of the generators will be required as outlined above.

There are two methodologies used to determine the impact from the operation of the back-up generators on ambient air quality as set out in Section 3.3. Both methodologies from the USEPA and UK Environment Agency have been used in this assessment, this follows the guidance outlined in Appendix K of the Irish EPA document AG4(2).

5.3 Cumulative Assessment

A review of sites with relevant emissions within a 1 km radius of the subject site was conducted to determine the potential for cumulative impacts. Sites which hold an IED licence from the EPA were assessed for relevant air emissions. There are no IED licenced sites within 1 km of the subject site. At a distance of between 2 – 3 km are two licenced facilities, Irish Cement (P0030-06) and Indaver Ireland Carranstown WTE facility (P0167-03). These two facilities have been included in the cumulative assessment as outlined in Table 13.

SSE Generation Ireland Ltd is located c.3 km to the south of the Installation, for which an IE Licence has been applied for from the Agency (Licence Reg. No. P1225-01). This facility has also been included in the cumulative assessment as outlined in Table 13.

5.4 Modelled Operational Scenarios

The modelling is undertaken to assess the impact to ambient air quality from the following two operational scenarios:

- **Proposed Operations Scenario:** This includes the emergency operation of 50 no. of the 54 no. back-up generators (the remaining 4 no. generators serving as a "catcher" generator for Building A and Building B). The scenario also included testing and maintenance of all 54 no. generators as described above. The process emissions are outlined in Table 11 and Table 12;

- **Cumulative Assessment:** This scenario included emissions associated with the Installation as per the Proposed Operations Scenario as well as cumulative emissions from the licenced facilities, Irish Cement (P0030-06), Indaver Ireland Carranstown WTE facility (P0167-03) and SSE Generation Ireland Ltd. (P1225-01). The emissions associated with these three facilities have been included in the cumulative assessment as outlined in Table 13.

Table 11. Summary of Process Emission Information for the Installation

Stack Reference	Height Above Ground Level (m)	Exit Diameter (m)	Scenario	Temp (K)	Volume Flow (Nm^3/hr) Note 1	Exit Velocity (m/sec actual)
Building A: 6.82 MWth Back-up Generators (A3-1 to A3-26)	25	0.35	Emergency operations and Test 2 (90% load)	760.75	17,466	90.0
			Test 1 (25% load)	716.75	6,116	28.9
Building A: 1.55 MWth Back-up Generator (A3-27)	25	0.3	Emergency operations and Test 2 (90% load)	770.15	4,490	28.5
			Test 1 (25% load)	632.15	1,610	12.1
Building B: 6.79 MWth Back-up Generators (A3-28 to A3-53)	25	0.6	Emergency operations and Test 2 (90% load)	760.75	17,466	30.6
			Test 1 (25% load)	716.75	6,116	9.8
Building B: 2.02 MWth Back-up Generator (A3-54)	25	0.3	Emergency operations and Test 2 (90% load)	824.15	4,111	23.9
			Test 1 (25% load)	646.65	1,304	8.7

Note 1 Emissions referenced to 273.15 K, 101.3 Pa, 15% O_2, dry gas

Table 12. Summary of Emission Concentrations and Mass Emission Rates for the Installation

Stack Ref.	Operations	Hours of Operations	NO_X		CO		SO_X		PM_{10}	
			Conc. (mg/ Nm^3) Note 1	Mass Emission (g/s)	Conc. (mg/ Nm^3) Note 1	Mass Emission (g/s)	Conc. (mg/ Nm^3) Note 1	Mass Emission (g/s)	Conc. (mg/ Nm^3) Note 1	Mass Emission (g/s)
Building A: A3-1 to A3-26	Test 1	30 minutes per week	815.3	1.39	95.0	0.16	18.6	0.03	7.8	0.01
	Test 2	4 hours per quarter (16 hours per year)	612.3	2.97	145.8	0.71	18.6	0.09	8.3	0.04
	Emergency	100	612.3	0.034	145.8	0.008	18.6	0.001	8.3	0.0005
Building A: A3-27	Test 1	30 minutes per week	661.4	0.30	74.8	0.03	18.6	0.01	5.2	0.002

Stack Ref.	Operations	Hours of Operations	NO_x		CO		SO_x		PM_{10}	
			Conc. (mg/ Nm^3) Note 1	Mass Emission (g/s)	Conc. (mg/ Nm^3) Note 1	Mass Emission (g/s)	Conc. (mg/ Nm^3) Note 1	Mass Emission (g/s)	Conc. (mg/ Nm^3) Note 1	Mass Emission (g/s)
	Test 2	4 hours per quarter (16 hours per year)	814.2	1.02	46.6	0.06	18.6	0.02	3.8	0.005
	Emergency	100	814.2	0.012	46.6	0.001	18.6	0.0003	3.8	0.0001
Building B: A3-28 to A3-53	Test 1	30 minutes per week	815.3	1.39	95.0	0.16	18.6	0.03	7.8	0.01
	Test 2	4 hours per quarter (16 hours per year)	612.3	2.97	145.8	0.71	18.6	0.09	8.3	0.04
	Emergency	100	612.3	0.034	145.8	0.008	18.6	0.001	8.3	0.0005
Building B: A3-54	Test 1	30 minutes per week	1518.4	0.55	110.9	0.04	18.6	0.01	5.2	0.002
	Test 2	4 hours per quarter (16 hours per year)	1210.4	1.38	151.1	0.17	18.6	0.02	3.8	0.004
	Emergency	100	1210.4	0.016	151.1	0.002	18.6	0.0002	3.8	0.0001

Note 1 Emissions referenced to 273.15 K, 101.3 Pa, 15% O_2, dry gas

Table 13. Process Emission Details for Cumulative Facilities

Stack Reference Note 1	Stack Height Above Ground Level (m)	Exit Diameter (m)	Temp (K)	Exit Velocity (m/sec actual)	NO_x		PM		SO_2	
					Conc. (mg/Nm^3)	Mass Emission (g/s)	Conc. (mg/Nm^3)	Mass Emission (g/s)	Conc. (mg/Nm^3)	Mass Emission (g/s)
Indaver Ireland – A1-1	65.00	2.20	423.15	29.10	200	10.21	10	0.51	50	2.55
Irish Cement – A2-01	98.01	2.38	360.15	5.86	500	6.81	20	0.27	50	0.68
Irish Cement – Kiln 2 (A2-02)	103.04	3.70	394.15	26.96	500	90.28	20	3.61	50	9.03

Stack Reference Note 1	Stack Height Above Ground Level (m)	Exit Diameter (m)	Temp (K)	Exit Velocity (m/sec actual)	NO_x		PM		SO_2	
					Conc. (mg/Nm^3)	Mass Emission (g/s)	Conc. (mg/Nm^3)	Mass Emission (g/s)	Conc. (mg/Nm^3)	Mass Emission (g/s)
Irish Cement – A2-03	48.09	1.00	354.15	18.88	500	4.31	20	0.17	50	0.43
Irish Cement – Kiln 3 (A2-08)	123.00	3.75	381.15	30.72	500	90.28	20	3.61	50	9.03
SSE Generation Ireland Ltd. – OCGT1, OCGT2, OCGT3	25.00	3.54	727.15	34.52	50	6.38	5	0.64	5	0.64

Note 1 All licensed emission points assumed to operate continuously

6.0 RESULTS

6.1 Proposed Operations (USEPA Methodology)

This section presents modelling results for the Proposed Operations Scenario, based on the USEPA methodology[21].

This scenario involved the emergency operation of 50 no. of the 54 no. back-up generators (the remaining 4 no. generators serving as a "catcher" generator for Building A and Building B) for 100 hours per generator per year. The scenario also included the scheduled testing of all 54 no. generators.

6.1.1 NO_2

The NO_2 modelling results at the worst-case receptor (considers boundary, gridded and sensitive receptors) are detailed in Table 14. 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 ambient NO_2 concentrations (including background) which are at most 57% of the maximum ambient 1-hour limit value (measured as a 99.8th percentile) at the worst-case receptor (offsite gridded receptor, location shown in Figure 5) and 61% of the annual limit value at the worst-case receptor (boundary receptor, location shown in Figure 6). The locations of the maximum concentrations for NO_2 are close to the boundary of the site with concentrations decreasing with distance from the Installation.

The geographical variations in ground level NO_2 predicted environmental concentrations (PEC) beyond the Installation boundary for the worst-case year modelled are illustrated as concentration contours in Figure 5 and Figure 6, to demonstrate the direction and extent of the emission plume.

Table 14. Proposed Operations – Dispersion Model Results for Nitrogen Dioxide (NO_2)

Pollutant/ Year	Averaging Period	Worst Case Receptor Type	Worst Case Receptor X,Y (UTM Zone 29 N)	PC (µg/m³)	Background (µg/m³)	PEC (µg/m³)	Limit Values (µg/Nm³)	PEC as a % of Limit Value
NO_2 / 2020	Annual Mean	Boundary	672738, 5953967	10.6	14	24.6	40	61%
	1-hr Mean (as 99.8th%ile)	Grid	672750, 5954000	84.2	28	112.2	200	56%
NO_2 / 2021	Annual Mean	Boundary	672738, 5953967	9.5	14	23.5	40	59%
	1-hr Mean (as 99.8th%ile)	Boundary	672753, 5953976	81.9	28	109.9	200	55%
NO_2 / 2022	Annual Mean	Boundary	672738, 5953967	10.5	14	24.5	40	61%
	1-hr Mean (as 99.8th%ile)	Boundary	672753, 5953976	83.4	28	111.4	200	56%
NO_2 / 2023	Annual Mean	Boundary	672738, 5953967	10.4	14	24.4	40	61%
	1-hr Mean (as 99.8th%ile)	Grid	672750, 5954000	82.2	28	110.2	200	55%

Pollutant/ Year	Averaging Period	Worst Case Receptor Type	Worst Case Receptor X,Y (UTM Zone 29 N)	PC ($\mu g/m^3$)	Background ($\mu g/m^3$)	PEC ($\mu g/m^3$)	Limit Values ($\mu g/Nm^3$)	PEC as a % of Limit Value
NO_2 / 2024	Annual Mean	Boundary	672738, 5953967	10.0	14	24.0	40	60%
	1-hr Mean (as 99.8th%ile)	Boundary	672584, 5953762	85.4	28	113.4	200	57%

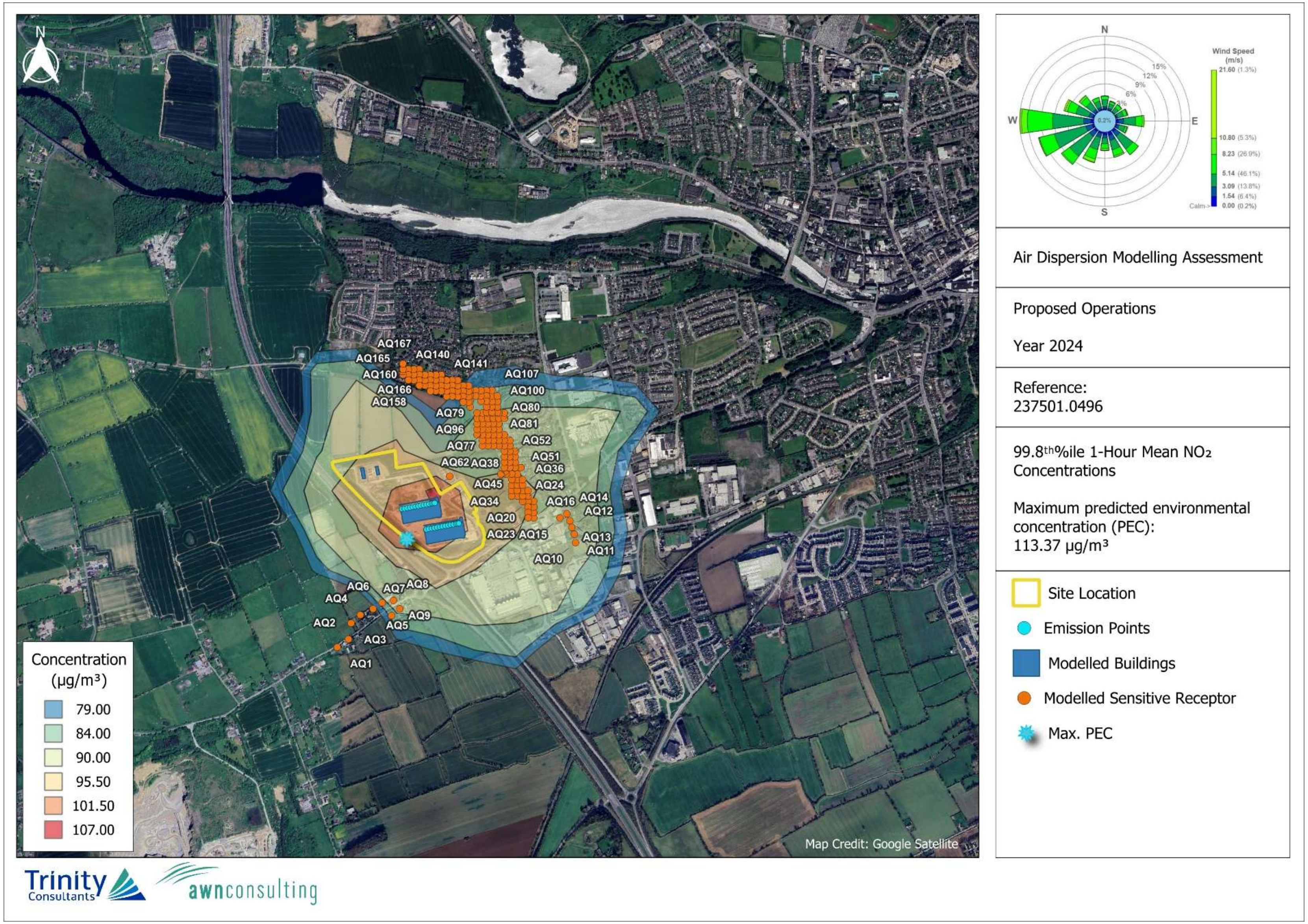

Figure 5. Proposed Operations – Maximum 1-Hour NO_2 Concentrations (as 99.8th%ile) (µg/m^3)

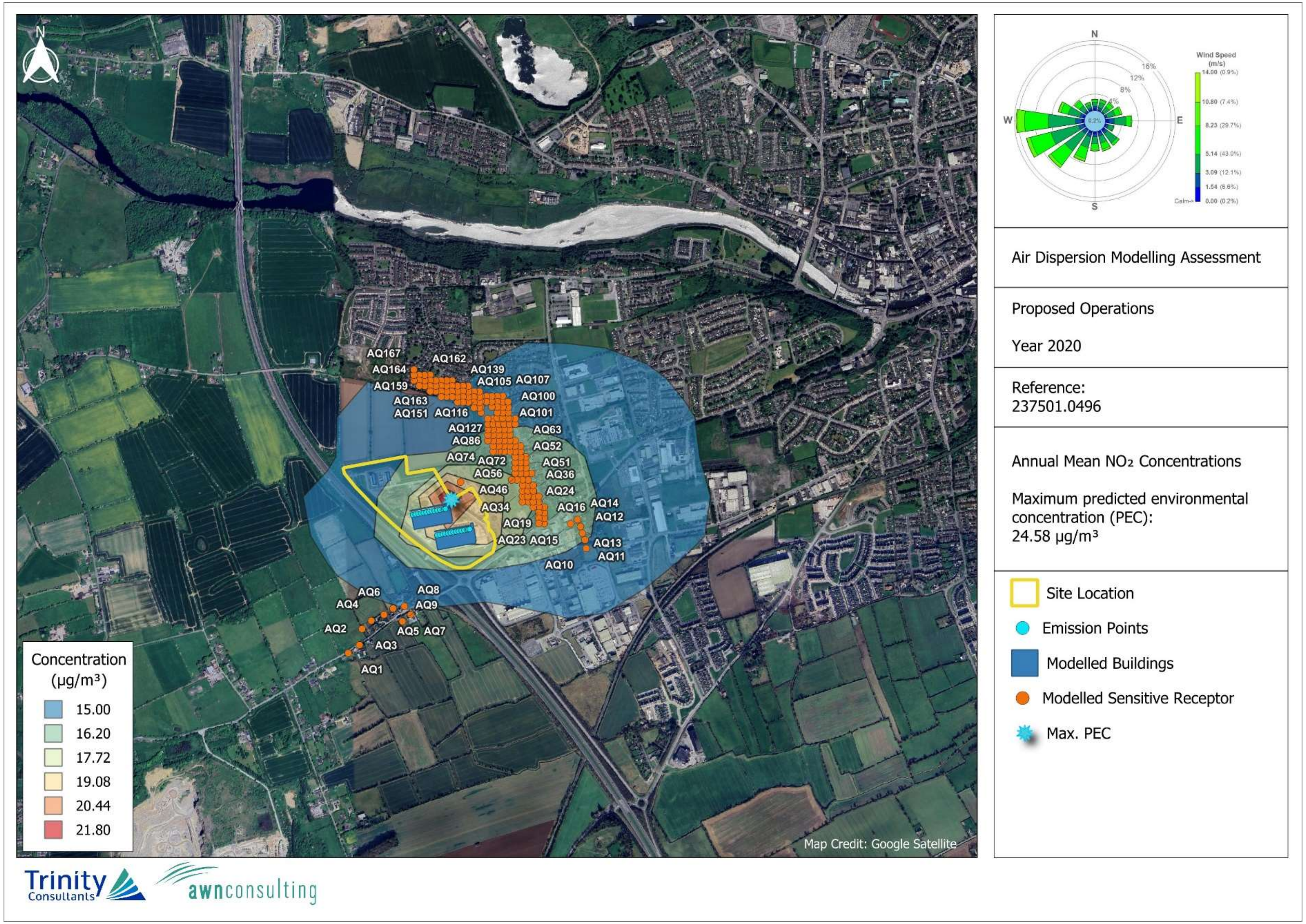

Figure 6. Proposed Operations – Annual Mean NO_2 Concentrations (µg/m^3)

6.1.2 CO

The CO modelling results at the worst-case receptor (considers boundary, gridded and sensitive receptors) are detailed in Table 15. The results indicate that the ambient ground level concentrations are in compliance with the relevant air quality standards for CO. For the worst-case year, emissions from the site lead to an ambient CO concentration (including background) which is 21% of the maximum ambient 8-hour limit value at the worst-case receptor (boundary receptor, location shown in Figure 7). The locations of the maximum concentrations for CO are close to the boundary of the site with concentrations decreasing with distance from the Installation.

The geographical variations in ground level CO predicted environmental concentrations (PEC) beyond the Installation boundary for the worst-case year modelled are illustrated as concentration contours in Figure 7, to demonstrate the direction and extent of the emission plume.

Table 15. Proposed Operations – Dispersion Model Results for Carbon Monoxide (CO)

Pollutant / Year	Averaging Period	Worst Case Receptor Type	Worst Case Receptor X, Y (UTM Zone 29 N)	PC (µg/m^3)	Back-ground (µg/m^3)	PEC (µg/m^3)	Limit Value (µg/m^3)	PEC as a % of Limit Value
CO / 2020	Maximum 8-Hour	Boundary	672584, 5953762	70.67	2000	2070.67	10000	21%
CO / 2021	Maximum 8-Hour	Boundary	672709, 5954017	59.35	2000	2059.35	10000	21%
CO / 2022	Maximum 8-Hour	Boundary	672753, 5953976	65.04	2000	2065.04	10000	21%
CO / 2023	Maximum 8-Hour	Boundary	672568, 5953774	65.91	2000	2065.91	10000	21%
CO / 2024	Maximum 8-Hour	Boundary	672584, 5953762	78.57	2000	2078.57	10000	21%

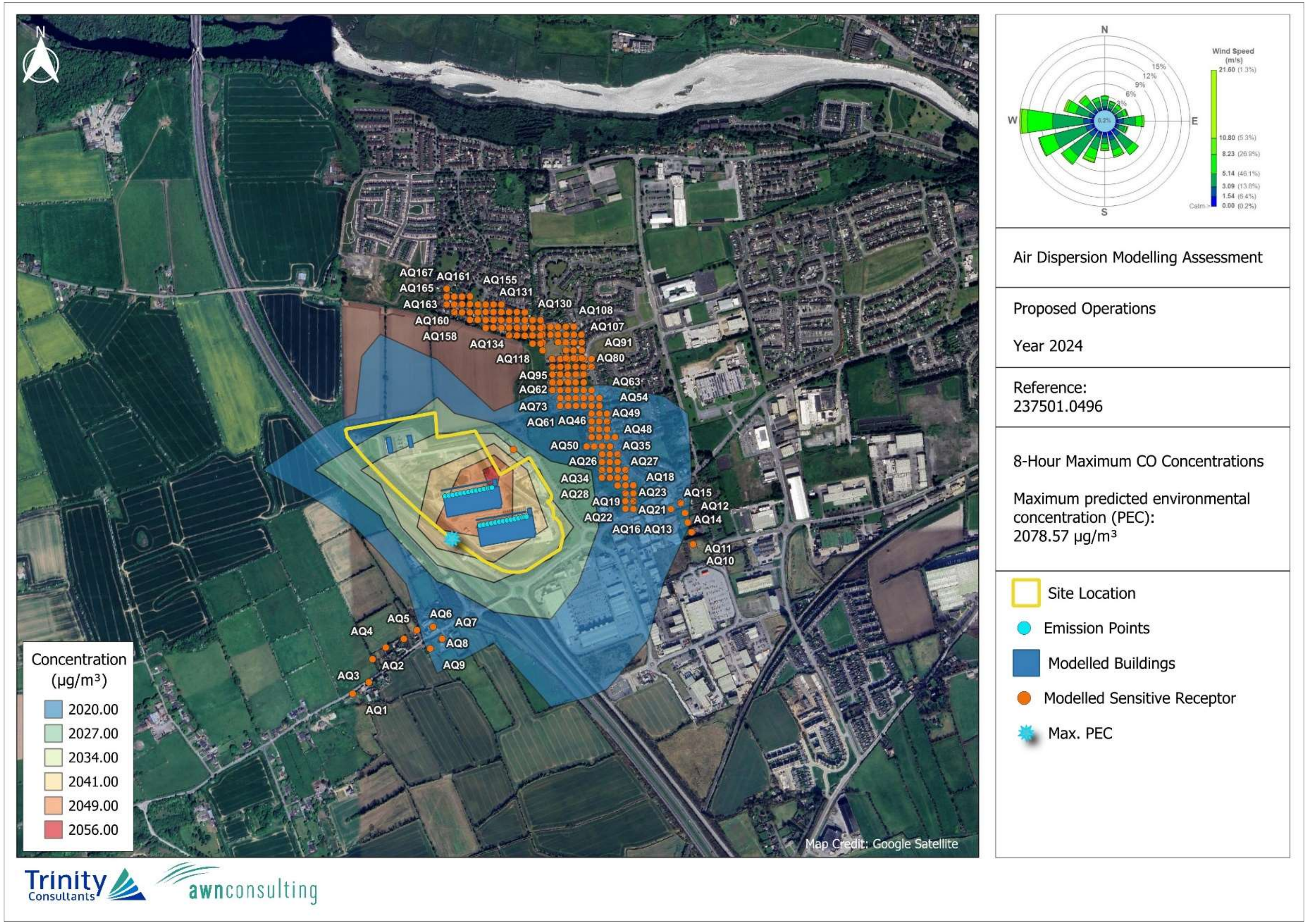

Figure 7. Proposed Operations – Maximum 8-Hour CO Concentrations (µg/m^3)

6.1.3 PM_{10}

Ambient Ground Level Concentrations (GLCs) of PM_{10} have been predicted below in Table 16. The results indicate that the ambient ground level concentrations are below the relevant air quality standards for all modelled years for PM_{10}. For the worst-case year, emissions from the site lead to an ambient PM_{10} concentration (including background) which is 44% of the maximum ambient 24-hour limit value (measured as a 90.4^{th}%ile) at the worst-case receptor (boundary receptor, location shown in Figure 8) and 33% of the annual limit value at the worst-case receptor (boundary receptor, location shown in Figure 9).

Calculating the maximum 24-hour mean PM_{10} (90.4^{th}%ile) PEC is not a simple addition of background concentration to process contribution but is instead calculated in line with guidance from the UK DEFRA (UK DEFRA, 2022) and the EPA (EPA, 2020), as explained in Section 4.3, which states that for PM_{10} an estimate of the maximum PEC can be obtained from the methods shown below:

a) 90.4^{th}%ile of 24-hour mean background PM_{10} + annual mean process contribution PM_{10}

b) 90.4^{th}%ile 24-hour mean process contribution PM_{10} + annual mean background PM_{10}

The results of this calculation process are shown in Table 16 as "PEC Method A" and "PEC Method B", and determined that the maximum 24-hour mean PM_{10} (90.4^{th}%ile) PEC is based on method A ("PEC Method A").

The geographical variation in the 24-hour mean (90.4^{th}%ile) and annual mean PM_{10} ground level predicted environmental concentrations (PEC) beyond the Installation boundary for the worst-case years modelled are illustrated as concentration contours in Figure 8 and Figure 9, to demonstrate the direction and extent of the emission plume.

Table 16. Proposed Operations – Dispersion Model Results for Particulate Matter (PM_{10})

Pollutant/ Year	Averaging Period	Worst Case Receptor		PC (µg/m³)	Background (µg/m³)	PEC (µg/m³) Method A	PEC (µg/m³) Method B	Limit Values (µg/Nm³)	PEC as a % of Limit Value
		Type	X,Y (UTM Zone 29 N)						
PM_{10} / 2020	Annual Mean	Boundary	672738, 5953967	0.184	13	13.18	13.18	40	33%
	24-hr Mean (as 90.4th%ile)	Boundary	672738, 5953967	0.401	22	22.18	13.40	50	44%
PM_{10} / 2021	Annual Mean	Boundary	672738, 5953967	0.161	13	13.16	13.16	40	33%
	24-hr Mean (as 90.4th%ile)	Boundary	672738, 5953967	0.349	22	22.16	13.35	50	44%
PM_{10} / 2022	Annual Mean	Boundary	672738, 5953967	0.182	13	13.18	13.18	40	33%
	24-hr Mean (as 90.4th%ile)	Boundary	672738, 5953967	0.405	22	22.18	13.40	50	44%
PM_{10} / 2023	Annual Mean	Boundary	672738, 5953967	0.179	13	13.18	13.18	40	33%
	24-hr Mean (as 90.4th%ile)	Boundary	672738, 5953967	0.386	22	22.18	13.39	50	44%
PM_{10} / 2024	Annual Mean	Boundary	672738, 5953967	0.176	13	13.18	13.18	40	33%
	24-hr Mean (as 90.4th%ile)	Boundary	672738, 5953967	0.421	22	22.18	13.42	50	44%

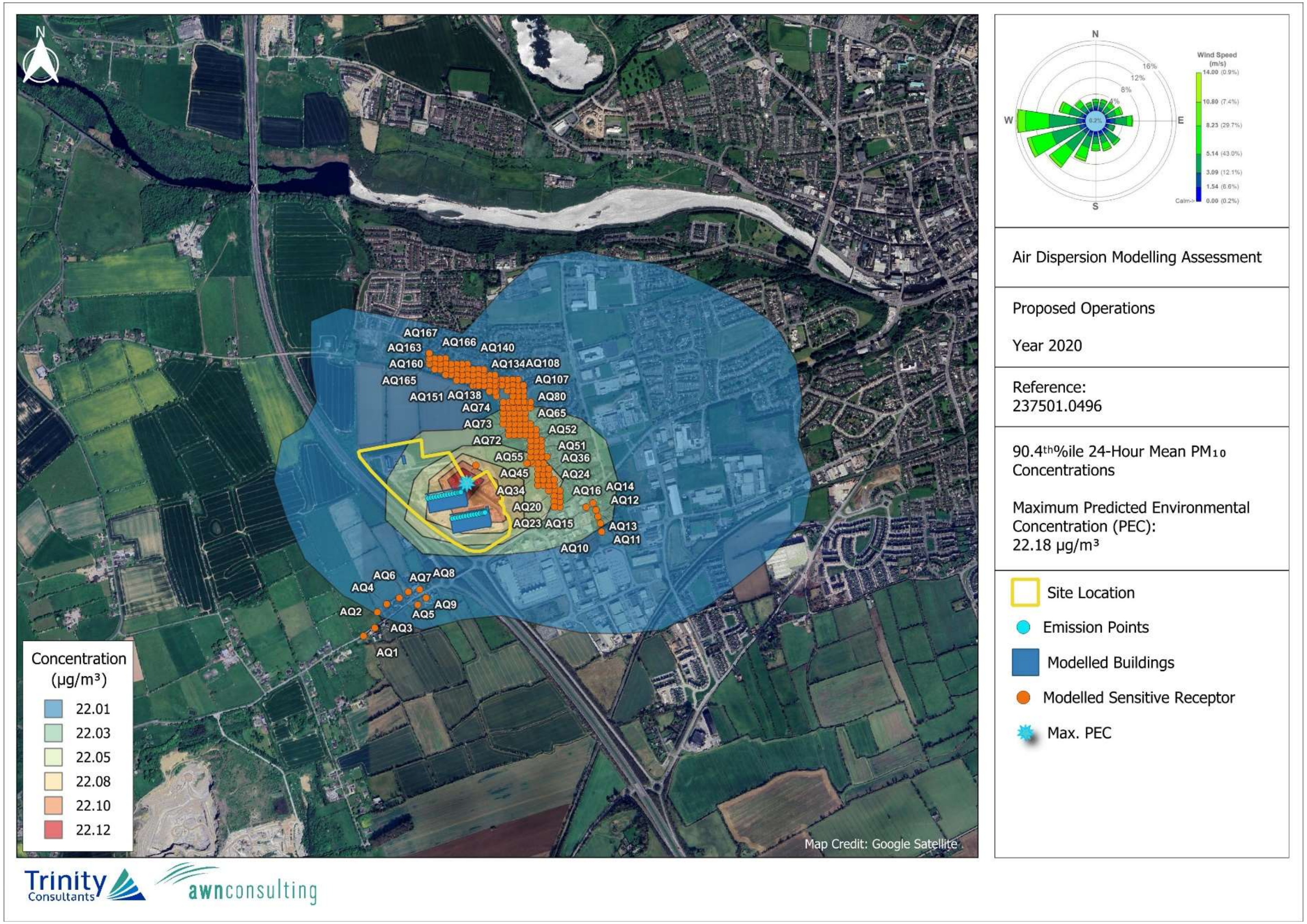

Figure 8. Proposed Operations – Maximum 24-Hour PM_{10} Concentration (μg/m^3)

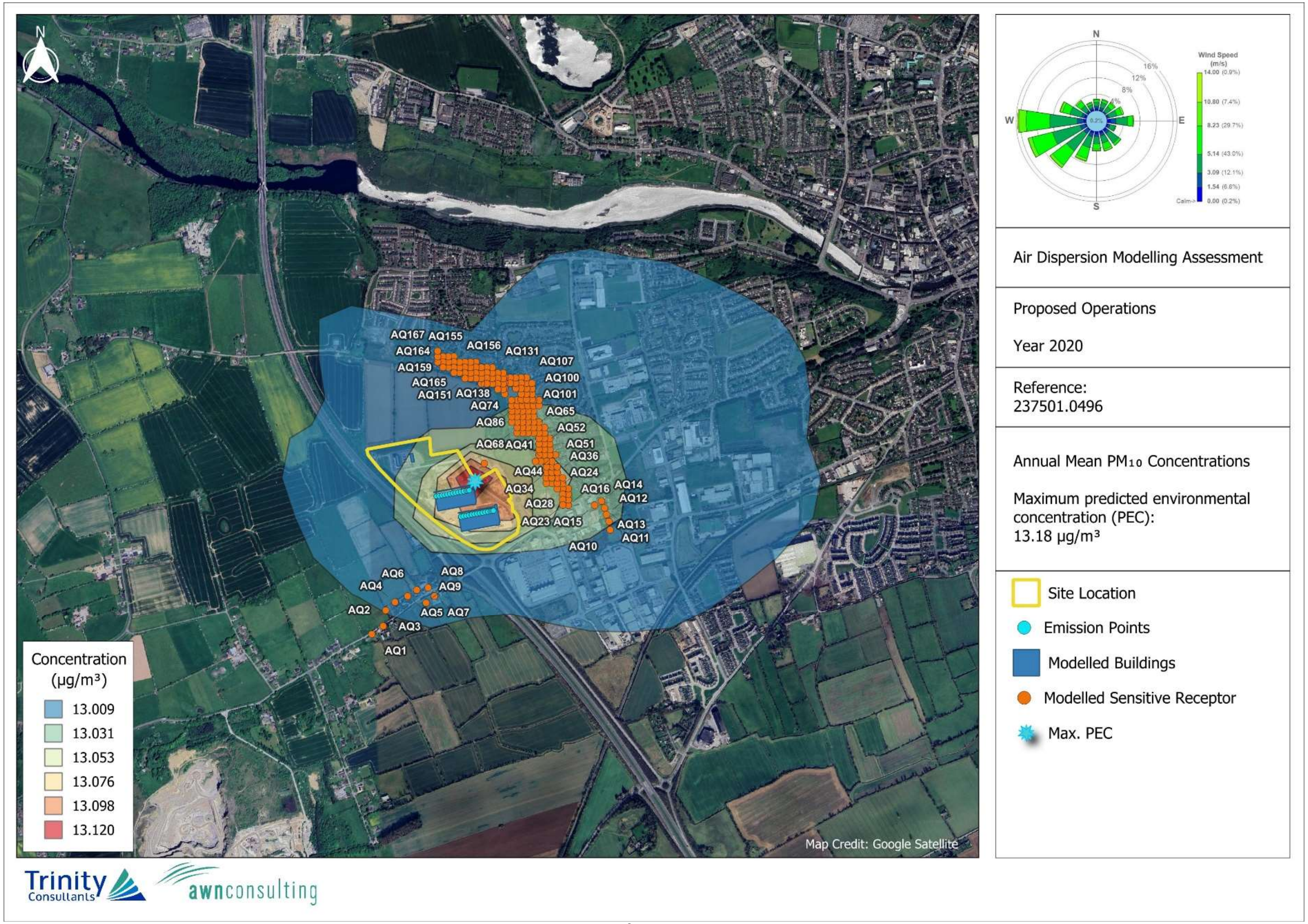

Figure 9. Proposed Operations – Annual Mean PM_{10} Concentration (µg/m^3)

6.1.4 PM2.5

The $PM_{2.5}$ modelling results are detailed in Table 17. These are derived from a worst-case assumption that all PM_{10} emissions from the Installation are of a particle size of 2.5 microns or less ($PM_{2.5}$). This assumption is necessitated due to the lack of availability of $PM_{2.5}$ emission concentration data for emission sources and therefore $PM_{2.5}$ emissions could not be directly modelled. In reality, particles greater than 2.5 microns will also be present and thus the mass of $PM_{2.5}$ released has been overestimated.

For the worst-case year, ambient concentrations (including background) will be 33% of the annual mean $PM_{2.5}$ limit value of 25 µg/m^3 at the worst-case receptor (boundary receptor, location shown in Figure 9). As the annual mean $PM_{2.5}$ concentrations have been conservatively assumed equal to the annual mean PM_{10} concentrations, the direction and extent of the emission plume is identical to that shown in Figure 9.

Table 17. Proposed Operations – Dispersion Model Results for Particulate Matter ($PM_{2.5}$)

Pollutant / Year	Averaging Period	Worst Case Receptor Type	Worst Case Receptor X, Y (UTM Zone 29 N)	PC (µg/m^3)	Back-ground (µg/m^3)	PEC (µg/m^3)	Limit Value (µg/m^3)	PEC as % of Limit Value
PM_{25} / 2020	Annual Mean	Boundary	672738, 5953967	0.14	8	8.14	25	33%
PM_{25} / 2021	Annual Mean	Boundary	672738, 5953967	0.30	8	8.30	25	33%
PM_{25} / 2022	Annual Mean	Boundary	672738, 5953967	0.12	8	8.12	25	32%
PM_{25} / 2023	Annual Mean	Boundary	672738, 5953967	0.26	8	8.26	25	33%
PM_{25} / 2024	Annual Mean	Boundary	672738, 5953967	0.14	8	8.14	25	33%

6.1.5 SO2

The SO_2 modelling results at the worst-case receptor (considers boundary, gridded and sensitive receptors) are detailed in Table 18. The results indicate that the ambient ground level concentrations are in compliance with the relevant air quality standards for SO_2. Emissions from the Installation lead to an ambient SO_2 concentration (including background) which is 9% of the maximum 1-hour limit value (measured as a 99.7th%ile) at the worst-case receptor (boundary receptor, location shown in Figure 10) and 11% of the maximum 24-hour limit value (measured as a 99.2nd%ile) at the worst-case receptor (boundary receptor, location shown in Figure 11). The locations of the maximum concentrations for SO_2 are close to the boundary of the site with concentrations decreasing with distance from the Installation.

Calculating the maximum 1-hour mean SO_2 (99.7th%ile) and 24-hour mean SO_2 (99.2nd%ile) PEC is not a simple addition of background concentration to process contribution but is instead calculated in line with guidance from the UK DEFRA (UK DEFRA, 2022) and the EPA (EPA, 2020), as explained in Section 4.5, which states that for SO_2 an estimate of the maximum PEC can be obtained from the methods shown below:

99.7th%ile of 1-hour mean SO_2 is equal to the maximum of either Method A or Method B below:

a) [Annual mean process contribution SO_2 (x2)] + [99.7th%ile hourly background SO_2]
b) [99.7th%ile hourly process contribution SO_2] + [annual mean background SO_2 (x2)]

99.2nd%ile of 24-hour mean SO_2 is equal to the maximum of either Method A or Method B below:

a) [Annual mean process contribution SO_2 (x2)] + [99.2nd%ile of 24-hour mean background SO_2]
b) [99.2nd%ile 24-hour mean process contribution SO_2] + [annual mean background SO_2 (x2)]

The results of this calculation process are shown in Table 18 as “PEC Method A” and “PEC Method B”, and determined that the maximum 1-hour mean SO_2 (99.7th%ile) PEC is based on method A (“PEC Method A”), and the maximum 24-hour mean SO_2 (99.2nd%ile) PEC is based on method A (“PEC Method A”).

The geographical variations in ground level SO_2 predicted environmental concentration (PEC) beyond the Installation boundary for the worst-case years modelled are illustrated as concentration contours in Figure 10 and Figure 11, to demonstrate the direction and extent of the emission plume.

Table 18. Proposed Operations – Dispersion Model Results for Sulphur Dioxide (SO_2)

Pollutant / Year	Averaging Period	Worst Case Receptor		PC (µg/m³)	Back-ground (µg/m³)	PEC (µg/m³) Method A	PEC (µg/m³) Method B	Limit Values (µg/Nm³)	PEC as a % of Limit Value
		Type	X,Y (UTM Zone 29 N)						
SO_2 / 2020	Annual Mean	Boundary	672738, 5953967	0.42	4	4.42	4.42	-	-
	99.7th%ile 1-hr Mean	Boundary	672738, 5953967	8.00	30	30.83	16.00	350	9%
	99.2nd%ile 24-hr Mean	Boundary	672738, 5953967	2.92	13	13.83	10.92	125	11%
SO_2 / 2021	Annual Mean	Boundary	672738, 5953967	0.36	4	4.36	4.36	-	-
	99.7th%ile 1-hr Mean	Boundary	672738, 5953967	7.72	30	30.73	15.72	350	9%
	99.2nd%ile 24-hr Mean	Boundary	672738, 5953967	2.47	13	13.73	10.47	125	11%
SO_2 / 2022	Annual Mean	Boundary	672738, 5953967	0.41	4	4.41	4.41	-	-
	99.7th%ile 1-hr Mean	Boundary	672738, 5953967	7.75	30	30.83	15.75	350	9%
	99.2nd%ile 24-hr Mean	Boundary	672738, 5953967	2.59	13	13.83	10.59	125	11%
SO_2 / 2023	Annual Mean	Boundary	672738, 5953967	0.41	4	4.41	4.41	-	-
	99.7th%ile 1-hr Mean	Boundary	672738, 5953967	7.90	30	30.81	15.90	350	9%
	99.2nd%ile 24-hr Mean	Boundary	672738, 5953967	2.64	13	13.81	10.64	125	11%
SO_2 / 2024	Annual Mean	Boundary	672738, 5953967	0.40	4	4.40	4.40	-	-
	99.7th%ile 1-hr Mean	Boundary	672738, 5953967	7.97	30	30.80	15.97	350	9%
	99.2nd%ile 24-hr Mean	Boundary	672738, 5953967	2.55	13	13.80	10.55	125	11%

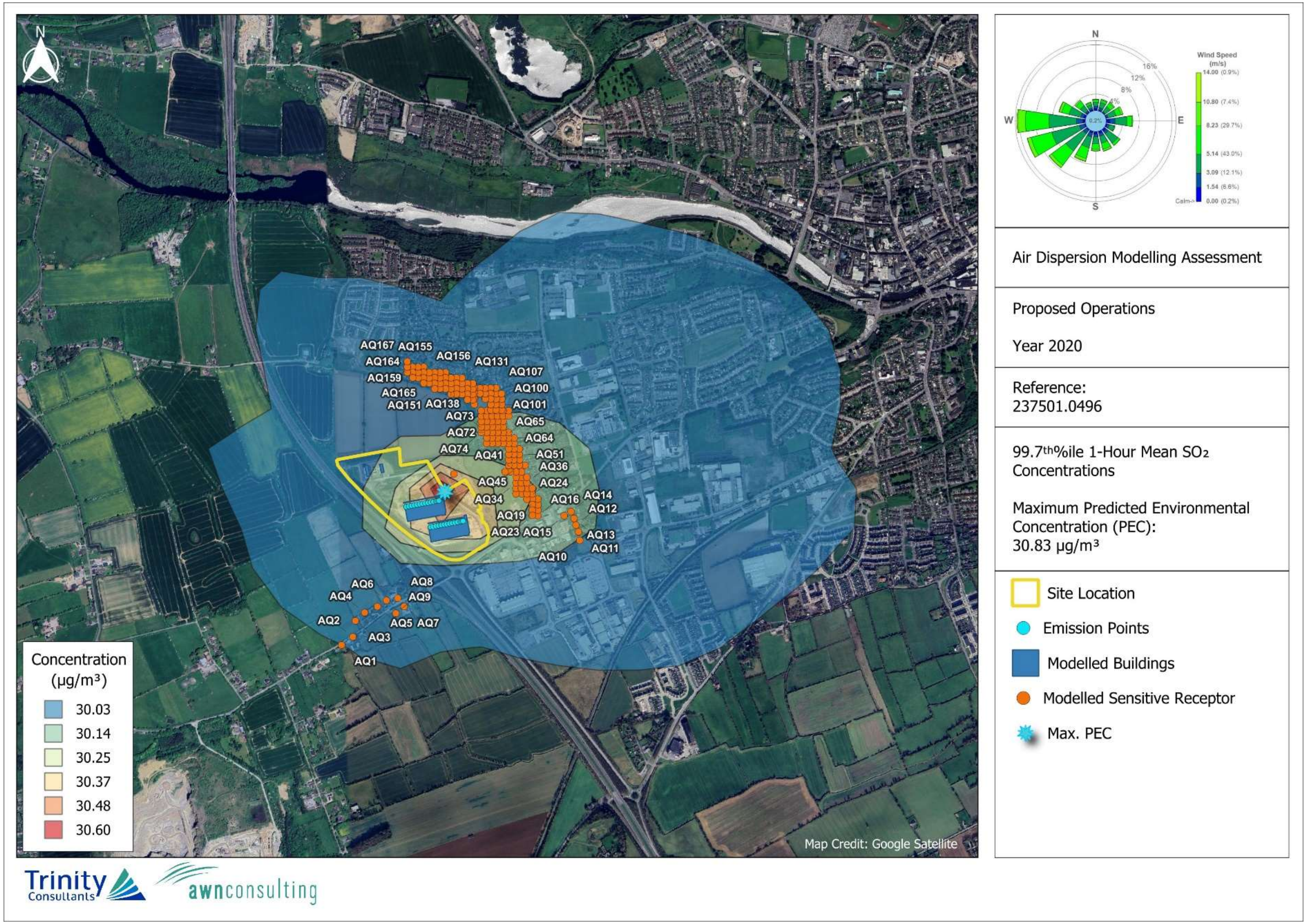

Figure 10. Proposed Operations – Maximum 1-Hour SO_2 Concentrations (as 99.7th%ile) (µg/m^3)

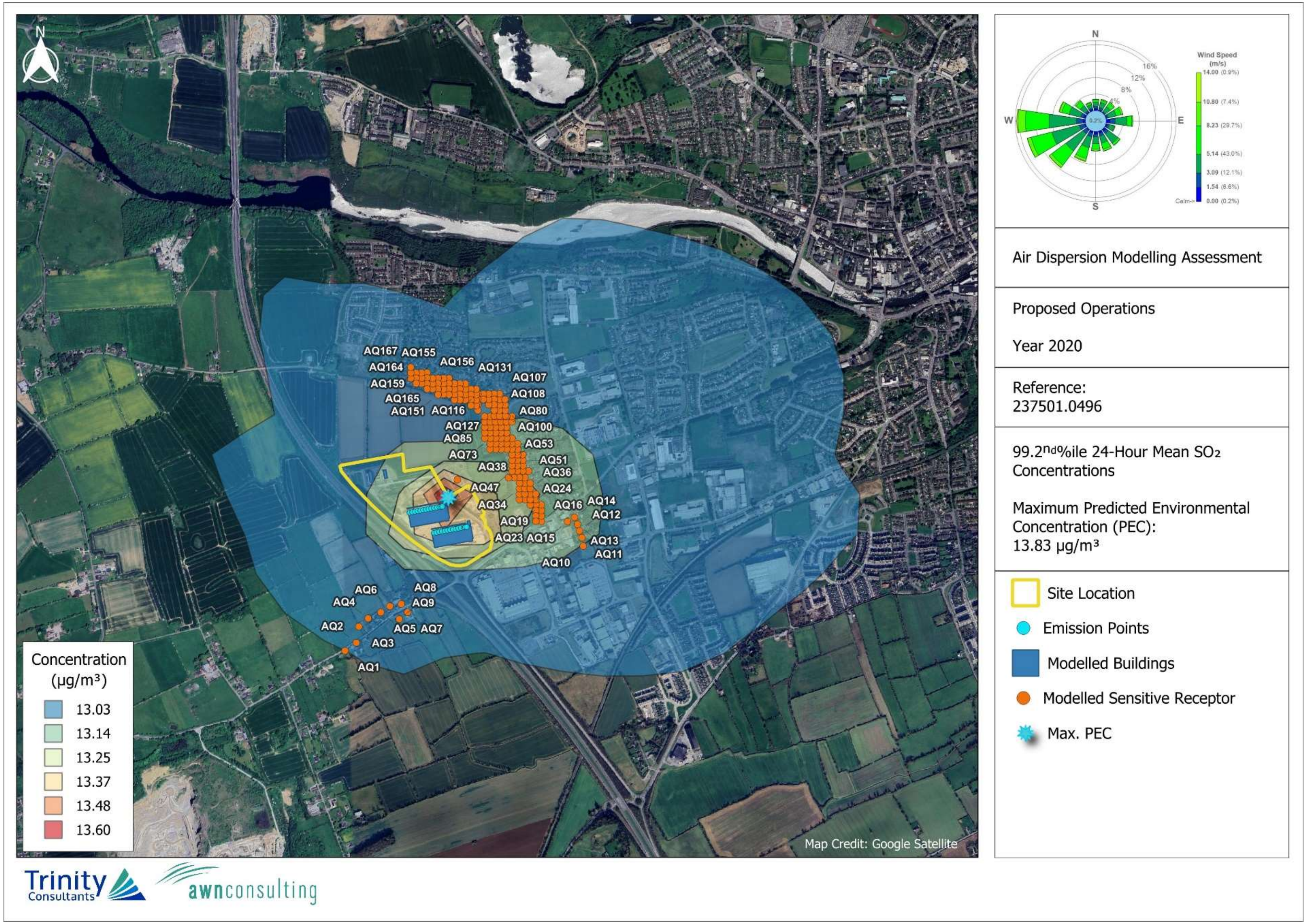

Figure 11. Proposed Operations – Maximum 24-Hour SO_2 Concentrations (as 99.2nd%ile) (µg/m^3)

6.1.6 *Sensitive Ecological Habitats*

The ecological habitat site most impacted by the Installation, and where the highest modelled concentrations are predicted, is the River Boyne & River Blackwater SAC, this is also the most impacted Natura 2000 designated habitat site. In order to align with and inform the AA Screening / NIS the results of the modelling have been presented for the following designated sites:

- River Boyne and River Blackwater SAC (Site Code: 002299)
- Boyne Coast and Estuary SAC (Site Code: 001957)
- Clogher Head SAC (Site Code: 001459)
- River Boyne and River Blackwater SPA (Site Code: 004232)
- Boyne Estuary SPA (Site Code: 004080)
- River Nanny Estuary and Shore SPA (Site Code: 004158)
- North-west Irish Sea SPA (Site Code: 004236)

For the purposes of this assessment, the ecological site considered most impacted is the ecological site where the highest modelled process contributions (PC) are predicted; i.e., the ecological site where the Installation is contributing the highest concentrations. Commentary has also been provided for the most impacted site in terms of overall impact, process contribution plus background concentration (i.e. PEC).

6.1.6.1 NO_X

The NO_X modelling results are detailed in Table 19. Within the most impacted (in terms of PC) ecological habitat site and Natura 2000 designated habitat site (River Boyne & River Blackwater SAC), at the worst-case location, emissions from the Installation lead to an ambient NO_X concentration (including background) which is at most 23% of the annual limit value over the five years of meteorological data modelled.

Within the most impacted (in terms of PEC) ecological habitat site and Natura 2000 designated habitat site (Boyne Estuary SPA), at the worst-case location, emissions from the Installation lead to an ambient NO_X concentration (including background) which is at most 24% of the annual limit value over the five years of meteorological data modelled.

NO_X emissions at all relevant designated Natura 2000 sites are in compliance with the NO_X critical level of 30 µg/m^3.

Table 19. Proposed Operations – NO_X Dispersion Model Results

Ecological Receptor	NO_X Process Contributions (µg/m^3)					Max PC % of Critical Level	Back-ground (µg/m^3)	PEC (µg/m^3)	Critical Level (µg/m^3)	PEC % of critical level
	2020	2021	2022	2023	2024					
Boyne Coast and Estuary SAC	0.11	0.10	0.10	0.12	0.11	0.4%	6.7	6.8	30	23%
Clogher Head SAC	0.04	0.04	0.04	0.03	0.04	0.1%	5.8	5.8	30	19%
River Boyne and River Blackwater SAC	0.60	0.54	0.58	0.50	0.52	2.0%	6.3	6.9	30	23%
Boyne Estuary SPA	0.15	0.13	0.13	0.17	0.14	0.6%	6.9	7.1	30	24%
North-west Irish Sea SPA	0.06	0.06	0.07	0.07	0.07	0.2%	5.2	5.3	30	18%

Ecological Receptor	NO_X Process Contributions (µg/m^3)					Max PC % of Critical Level	Back-ground (µg/m^3)	PEC (µg/m^3)	Critical Level (µg/m^3)	PEC % of critical level
	2020	2021	2022	2023	2024					
River Boyne and River Blackwater SPA	0.32	0.41	0.40	0.44	0.47	1.6%	6.3	6.7	30	22%
River Nanny Estuary and Shore SPA	0.04	0.04	0.04	0.04	0.04	0.1%	5.0	5.1	30	17%

6.1.6.2 SO_2

The SO_2 modelling results are detailed in Table 20. Within the most impacted (in terms of PC) ecological habitat site and Natura 2000 designated habitat site (River Boyne & River Blackwater SAC), at the worst-case location, emissions from the Installation lead to an ambient SO_2 concentration (including background) which is at most 4% of the annual limit value over the five years of meteorological data modelled.

Within the most impacted (in terms of PEC) ecological habitat site and Natura 2000 designated habitat site (Boyne Estuary SPA), at the worst-case location, emissions from the Installation lead to an ambient SO_2 concentration (including background) which is at most 4% of the annual limit value over the five years of meteorological data modelled.

SO_2 emissions at all relevant designated Natura 2000 sites are in compliance with the SO_2 critical level of 20 µg/m^3.

Table 20. Proposed Operations – SO_2 Dispersion Model Results

Ecological Receptor	SO_2 Process Contributions (µg/m^3)					Max PC % of Critical Level	Back-ground (µg/m^3)	PEC (µg/m^3)	Critical Level (µg/m^3)	PEC % of critical level
	2020	2021	2022	2023	2024					
Boyne Coast and Estuary SAC	0.0031	0.0028	0.0028	0.0035	0.0031	0.02%	0.75	0.757	20	4%
Clogher Head SAC	0.0011	0.0011	0.0012	0.0010	0.0010	0.01%	0.74	0.739	20	4%
River Boyne and River Blackwater SAC	0.0174	0.0156	0.0166	0.0145	0.0150	0.09%	0.70	0.717	20	4%
Boyne Estuary SPA	0.0042	0.0036	0.0036	0.0047	0.0039	0.02%	0.88	0.882	20	4%
North-west Irish Sea SPA	0.0018	0.0018	0.0019	0.0020	0.0020	0.01%	0.50	0.502	20	3%
River Boyne and River Blackwater SPA	0.0091	0.0117	0.0115	0.0127	0.0137	0.07%	0.70	0.713	20	4%
River Nanny Estuary and Shore SPA	0.0011	0.0012	0.0012	0.0011	0.0012	0.02%	0.43	0.435	20	2%

6.1.6.3 Nitrogen Deposition

In order to consider the effects of nitrogen deposition (as N) owing to emissions from the Installation on the most impacted ecological habitat site, the maximum annual mean NO_2 process contribution concentrations (PC) are converted into the dry deposition fluxes and then nitrogen deposition fluxes (as described in Section 3.8) and shown in Table 21 and Table 22.

Within the most impacted (in terms of PC) ecological habitat site and Natura 2000 designated habitat site (River Boyne & River Blackwater SAC), at the worst-case location, the nitrogen deposition flux for the worst-case year is 6.58 kg/ha/yr, shown in Table 22. This is below the mid-point critical load of 7.5 kg/ha/yr for the habitat type "Alkaline fens" in the River Boyne & River Blackwater SAC, indicating that the effects of nitrogen deposition on ecological habitat sites due to the Installation are not significant.

Within the most impacted (in terms of PEC) ecological habitat site and Natura 2000 designated habitat site (River Boyne and River Blackwater SPA), at the worst-case location, the nitrogen deposition flux for the worst-case year is 8.30 kg/ha/yr, shown in Table 22. There are no comparable critical load levels for this designated site, indicating that the effects of nitrogen deposition are not a concern. The background deposition of 8.24 kg/ha/yr is contributing the most to the PEC.

Nitrogen deposition fluxes at all other relevant ecological sites are within the required critical load range indicating that the effects of nitrogen deposition on ecological habitat sites due to the Installation are not significant.

Table 21. Proposed Operations – Nitrogen Deposition

Ecological Receptor	NO_2 Process Contributions (µg/m^3)					NO_2 Dry Deposition (µg/m^2/s)	NO_2 Nitrogen Deposition (kg/ha/yr)
	2020	2021	2022	2023	2024		
Boyne Coast and Estuary SAC	0.10	0.09	0.09	0.11	0.10	0.0002	0.016
Clogher Head SAC	0.03	0.03	0.04	0.03	0.03	0.0001	0.005
River Boyne and River Blackwater SAC	0.52	0.49	0.52	0.45	0.46	0.0008	0.075
Boyne Estuary SPA	0.13	0.12	0.12	0.15	0.13	0.0002	0.022
North-west Irish Sea SPA	0.06	0.06	0.06	0.06	0.06	0.0001	0.009
River Boyne and River Blackwater SPA	0.29	0.36	0.35	0.39	0.42	0.0006	0.060
River Nanny Estuary and Shore SPA	0.04	0.04	0.04	0.04	0.04	0.0001	0.006

Table 22. Proposed Operations – Nitrogen Deposition contd.

Ecological Receptor	Total PC Nitrogen Deposition (kg/ha/yr)	APIS Background Nitrogen Deposition (kg/ha/yr)	Total PEC Nitrogen Deposition (kg/ha/yr)	Critical load (kg/ha/yr)
Boyne Coast and Estuary SAC	0.016	7.28	7.29	7.5
Clogher Head SAC	0.005	6.09	6.09	7.5
River Boyne and River Blackwater SAC	0.075	6.50	6.58	7.5
Boyne Estuary SPA	0.022	7.28	7.30	7.5
North-west Irish Sea SPA	0.009	5.80	5.81	7.5
River Boyne and River Blackwater SPA	0.060	8.24	8.30	n/a
River Nanny Estuary and Shore SPA	0.006	5.69	5.70	7.5

6.1.6.4 Acid Deposition

In order to consider the effects of acid deposition (as N and S) owing to emissions from the Installation on the relevant Natura 2000 designated habitat sites, the maximum annual mean NO_2 and SO_2 process contribution concentrations (PC) are converted into the dry deposition fluxes and then acid deposition fluxes (as described in Section 3.8) and shown in Table 23 – Table 26.

Within the most impacted (in terms of PC) ecological habitat site (River Boyne & River Blackwater SAC), at the worst-case location, the total acid deposition (as N) flux for the worst-case year is 0.505 keq/ha/yr, shown in Table 24. This is below the MaxCLminN of 0.714 keq/ha/yr for the sensitive species "*Lampetra fluviatilus*" in the River Boyne & River Blackwater SAC [31], indicating that the effects of acid deposition (as N) on ecological habitat sites due to the Installation are not significant.

Within the most impacted (in terms of PEC) ecological habitat site (River Boyne & River Blackwater SPA), at the worst-case location, the total acid deposition (as N) flux for the worst-case year is 0.597 keq/ha/yr, shown in Table 24. This is below the MaxCLminN of 0.714 keq/ha/yr for the sensitive species "*Alcedo atthis*" in the River Boyne and River Blackwater SPA[31], indicating that the effects of acid deposition (as N) on ecological habitat sites due to the Installation are not significant.

Within the Clogher Head SAC the total acid deposition (as N) flux for the worst-case year is 0.472 keq/ha/yr, shown in Table 24. This is above the MaxCLminN of 0.143 keq/ha/yr for the sensitive species "European Dry Heaths" in the Clogher Head SAC. However, the PEC acid deposition (as N) flux of 0.472 keq/ha/yr for the Clogher Head SAC is within the upper MaxCLmaxN range of 4.535 keq/ha/yr (see Table 3). APIS does not consider the critical load function to be exceeded unless the PEC is larger than the maximum critical load, not the minimum. Therefore it can be concluded that the predicted acid deposition (as N) is not significant. It should be noted that the background acid deposition level of 0.47 keq/ha/yr in this area is contributing the most to the PEC and the process contribution from the Installation is minor, at 0.0004 keq/ha/yr. It should also be noted that the maximum NO_2 process contributions from the Installation, from which nitrogen deposition levels are derived, are below the limit of detection of 0.5 µg/m^3 which must be achieved by chemiluminescence-based automated NO_X/NO_2 analysers (EN 14211). Limit of detection is defined as the smallest concentration that can be reliably measured by an analytical procedure. The EPA guidelines (EPA, 2022) define an imperceptible effect as *"an effect capable of measurement but without significant consequences".* NO_2 process contributions, and by extension nitrogen deposition levels, that are below a monitoring instrument's limit of detection are not measurable and will therefore have a less than imperceptible effect.

Acid deposition (as N) fluxes at all other relevant ecological sites are within the required critical load ranges indicating that the effects of nitrogen deposition (as N) on ecological habitat sites due to the Installation are not significant.

Within the most impacted (in terms of PC) ecological habitat site (River Boyne & River Blackwater SAC), at the worst-case location, the total acid deposition (as S) flux for the worst-case year is 0.502 keq/ha/yr, shown in Table 26. This is above the MinCLmaxS of 0.193 keq/ha/yr for the sensitive species "*Lampetra fluviatilus*" in the River Boyne & River Blackwater SAC. However, the PEC is within the upper MaxCLmaxS range of 4.748 keq/ha/yr (see Table 3). Therefore, it can be concluded that the predicted acid deposition (as S) within the River Boyne and River Blackwater SAC is not significant. The background acid deposition level of 0.50 keq/ha/yr in this area is contributing the most to the PEC and the process contribution from the Installation is minor, at 0.0021 keq/ha/yr. Additionally, the SO_2 PCs from the Installation, from which the acid deposition (as S) levels are derived are below the limit of detection of 0.14 µg/m^3 which must be achieved by fluorescence-based automated SO_2 analysers (Thermo Scientific, 2025).

Within the most impacted (in terms of PEC) ecological habitat site, the River Boyne and River Blackwater SPA, the total acid deposition (as S) flux for the worst-case year is 0.595 keq/ha/yr, shown in Table 26. This above the MinCLmaxS of 0.216 keq/ha/yr for the sensitive species "*Alcedo atthis*" in the River Boyne & River Blackwater SPA. However, the PEC is within the upper MaxCLmaxS range of 4.724 keq/ha/yr (see Table 3). Therefore, it can be concluded that the predicted acid deposition (as S) within the River Boyne and River Blackwater SPA is not significant. The background acid deposition level of 0.593 keq/ha/yr in this area is contributing the most to the PEC and the process contribution from the Installation is minor, at 0.0016 keq/ha/yr.

Acid deposition (as S) fluxes at all other relevant ecological sites are within the required critical load range indicating that the effects of acid deposition on ecological habitat sites due to the Installation are not significant.

Table 23. Proposed Operations – Acid Deposition (as N)

Ecological Receptor	NO_2 Process Contributions (µg/m^3)					NO_2 Dry Deposition (µg/m^2/s)	NO_2 Acid Deposition (keq/ha/year)
	2020	2021	2022	2023	2024		
Boyne Coast and Estuary SAC	0.10	0.09	0.09	0.11	0.10	0.00017	0.001
Clogher Head SAC	0.03	0.03	0.04	0.03	0.03	0.00006	0.0004
River Boyne and River Blackwater SAC	0.52	0.49	0.52	0.45	0.46	0.00078	0.005
Boyne Estuary SPA	0.13	0.12	0.12	0.15	0.13	0.00023	0.002
North-west Irish Sea SPA	0.06	0.06	0.06	0.06	0.06	0.00009	0.001
River Boyne and River Blackwater SPA	0.29	0.36	0.35	0.39	0.42	0.00063	0.004
River Nanny Estuary and Shore SPA	0.10	0.09	0.09	0.11	0.10	0.00017	0.001

Table 24. Proposed Operations – Acid Deposition (as N) contd.

Ecological Receptor	PC Acid Deposition (N) (keq/ha/yr)	APIS Background Acid Deposition (keq/ha/yr)	Total PEC Acid Deposition (N) (keq/ha/yr)	Critical load (MaxCLminN) for PEC (keq/ha/yr)
Boyne Coast and Estuary SAC	0.0011	0.57	0.569	0.714
Clogher Head SAC	0.0004	0.47	0.472	0.143
River Boyne and River Blackwater SAC	0.0054	0.50	0.505	0.714
Boyne Estuary SPA	0.0015	0.57	0.570	0.714
North-west Irish Sea SPA	0.0006	0.400	0.401	0.714
River Boyne and River Blackwater SPA	0.0043	0.59	0.597	0.714
River Nanny Estuary and Shore SPA	0.0004	0.41	0.405	0.714

Table 25. Proposed Operations – Acid Deposition (as S)

Ecological Receptor	SO_2 Process Contributions (µg/m^3)					SO_2 Dry Deposition (µg/m^2/s)	SO_2 Acid Deposition (S) (keq/ha/yr)
	2020	2021	2022	2023	2024		
Boyne Coast and Estuary SAC	0.003	0.003	0.003	0.004	0.003	0.00004	0.0004
Clogher Head SAC	0.001	0.001	0.001	0.001	0.001	0.00001	0.0001
River Boyne and River Blackwater SAC	0.017	0.016	0.017	0.014	0.015	0.00021	0.0021
Boyne Estuary SPA	0.004	0.004	0.004	0.005	0.004	0.00006	0.0006
North-west Irish Sea SPA	0.002	0.002	0.002	0.002	0.002	0.00002	0.0002
River Boyne and River Blackwater SPA	0.009	0.012	0.012	0.013	0.014	0.00016	0.0016

Ecological Receptor	SO_2 Process Contributions (µg/m^3)					SO_2 Dry Deposition (µg/m^2/s)	SO_2 Acid Deposition (S) (keq/ha/yr)
	2020	2021	2022	2023	2024		
River Nanny Estuary and Shore SPA	0.001	0.001	0.001	0.001	0.001	0.00001	0.0001

Table 26. Proposed Operations – Acid Deposition (as S) contd.

Ecological Receptor	PC Acid Deposition (S) (keq/ha/yr)	APIS Background Acid Deposition (keq/ha/yr)	Total PEC Acid Deposition (S) (keq/ha/yr)	Critical load (MinCLmaxS) (keq/ha/yr)
Boyne Coast and Estuary SAC	0.0004	0.568	0.568	4.142
Clogher Head SAC	0.0001	0.472	0.472	4.392
River Boyne and River Blackwater SAC	0.0021	0.500	0.502	0.193
Boyne Estuary SPA	0.0006	0.568	0.569	4.142
North-west Irish Sea SPA	0.0002	0.400	0.400	4.107
River Boyne and River Blackwater SPA	0.0016	0.593	0.595	0.216
River Nanny Estuary and Shore SPA	0.0001	0.405	0.405	4.185

6.2 Proposed Operations (UK Environment Agency Methodology)

Emissions from the proposed emergency operation of the 54 no. back-up generators were assessed using the UK Environment Agency methodology[22]. 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 or more hours per year was computed and the probability of an exceedance determined as outlined in Table 27 and Figure 12. The results have been compared to the 98th percentile confidence level to indicate if an exceedance is likely at various operational hours for the back-up generators. The results indicate that the Installation can operate for a maximum of 104 hours in a year without the likelihood of an exceedance of the ambient air quality standard (at a 98th percentile confidence level).

Table 27. Proposed Operations – 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 / 2020	108	**0.02**
NO_2 / 2021	115	
NO_2 / 2022	106	
NO_2 / 2023	104	
NO_2 / 2024	112	

Note 1 Guidance Outlined In UK EA publication "Diesel Generator Short-Term NO_2 Impact Assessment"[22]

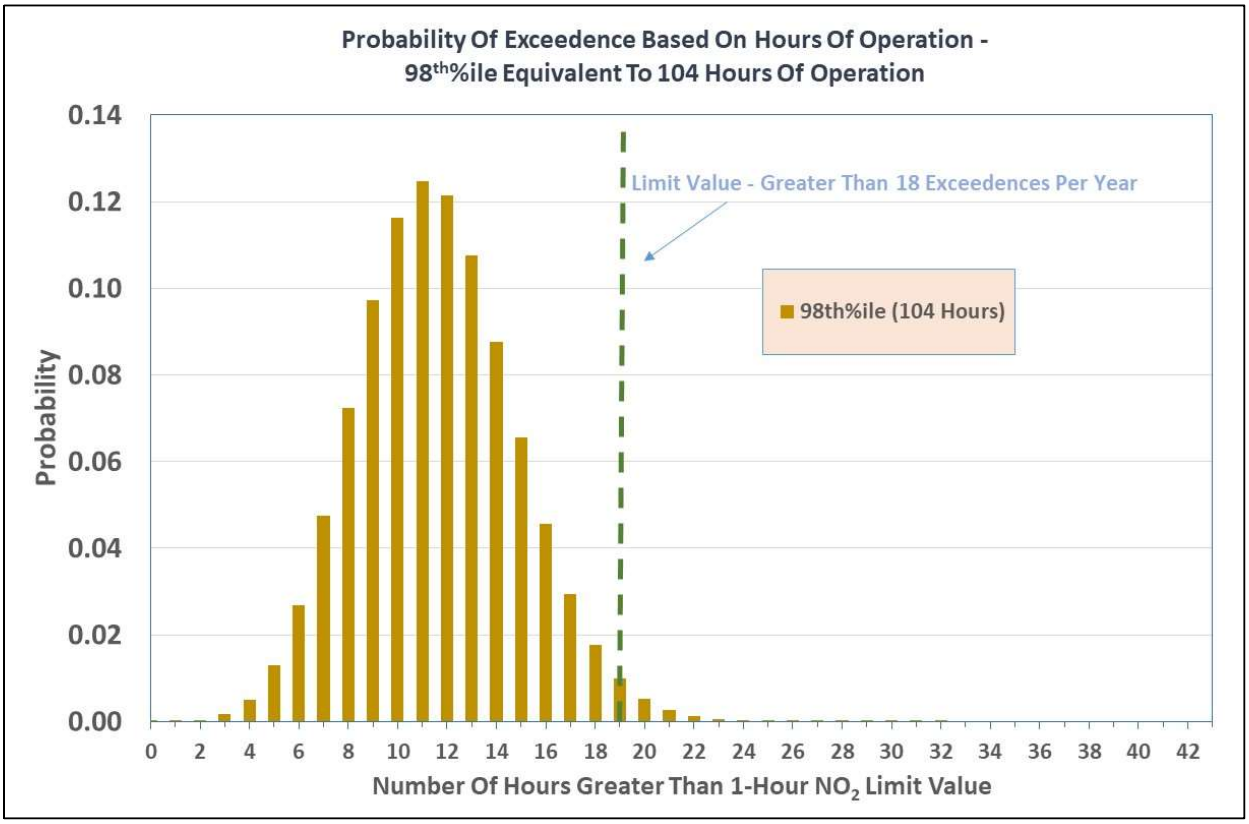

Figure 12. Proposed Operations Scenario – Probability of Exceedance based on Hours of Operation

6.3 Cumulative Assessment (USEPA Methodology)

The cumulative assessment involved the emergency operation of 50 no. of the 54 no. back-up generators (the remaining 4 no. generators serving as a “catcher” generator for Building A and Building B) for 100 hours per generator per year. The scenario also included the scheduled testing of all 54 no. generators, as well as emissions from the existing and proposed EPA licensed sites of Irish Cement, Indaver and SSE Generation Ireland Ltd. as listed in Table 13.

6.3.1 NO_2

The NO_2 modelling results at the worst-case receptor (considers boundary, gridded and sensitive receptors) are detailed in Table 28. The results indicate that the ambient ground level concentrations are below the relevant air quality standards for NO_2. For the worst-case year, cumulative emissions lead to an ambient NO_2 concentration (including background) which is 57% of the maximum ambient 1-hour limit value (measured as a 99.8th percentile) worst-case receptor (offsite gridded receptor, location shown in Figure 13) and 63% of the annual limit value at the worst-case receptor (boundary receptor, location shown in Figure 14).

The geographical variations in ground level NO_2 predicted environmental concentrations (PEC) concentrations beyond the Installation boundary for the worst-case years modelled are illustrated as concentration contours in Figure 13 and Figure 14, to demonstrate the direction and extent of the emission plume.

Table 28. Cumulative Assessment – Dispersion Model Results for Nitrogen Dioxide (NO_2)

Pollutant / Year	Averaging Period	Worst Case Receptor Type	Worst Case Receptor X, Y (UTM Zone 29 N)	PC (µg/m^3)	Back-ground (µg/m^3)	PEC (µg/m^3)	Limit Value (µg/m^3)	PEC as % of Limit Value
NO_2 / 2020	Annual Mean	Boundary	672738, 5953967	11.1	14	25.1	40	63%
	99.8th%ile of 1-hr means	Grid	672750, 5954000	84.4	28	112.4	200	56%
NO_2 / 2021	Annual Mean	Boundary	672738, 5953967	10.1	14	24.1	40	60%
	99.8th%ile of 1-hr means	Boundary	672753, 5953976	82.2	28	110.2	200	55%
NO_2 / 2022	Annual Mean	Boundary	672738, 5953967	11.3	14	25.3	40	63%
	99.8th%ile of 1-hr means	Boundary	672753, 5953976	83.4	28	111.4	200	56%
NO_2 / 2023	Annual Mean	Boundary	672738, 5953967	11.1	14	25.1	40	63%
	99.8th%ile of 1-hr means	Grid	672750, 5954000	82.2	28	110.2	200	55%
NO_2 / 2024	Annual Mean	Boundary	672738, 5953967	10.6	14	24.6	40	62%
	99.8th%ile of 1-hr means	Boundary	672584, 5953762	85.4	28	113.4	200	57%

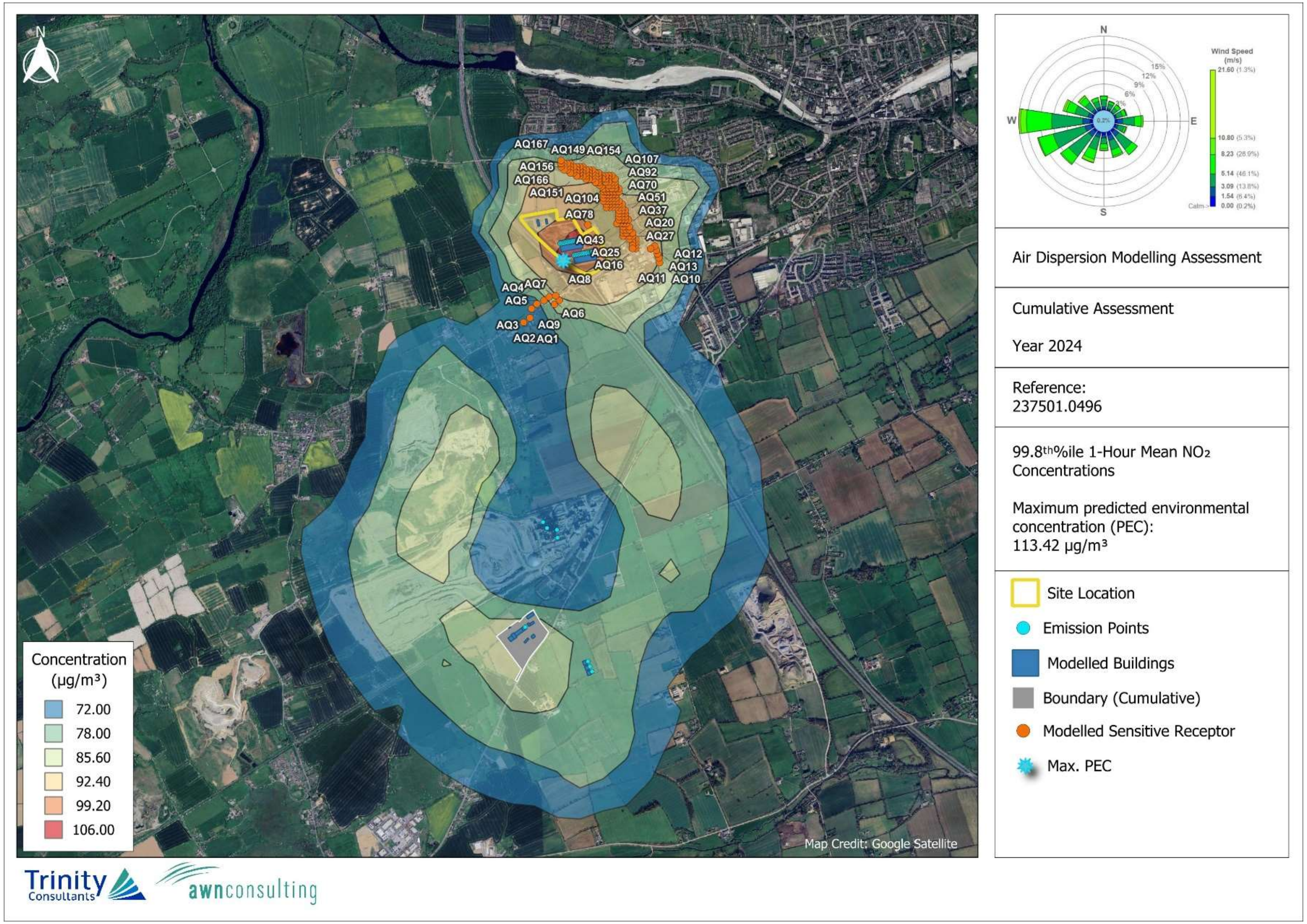

Figure 13. Cumulative Assessment - Maximum 1-Hour NO_2 Concentrations (as 99.8th%ile) (µg/m^3)

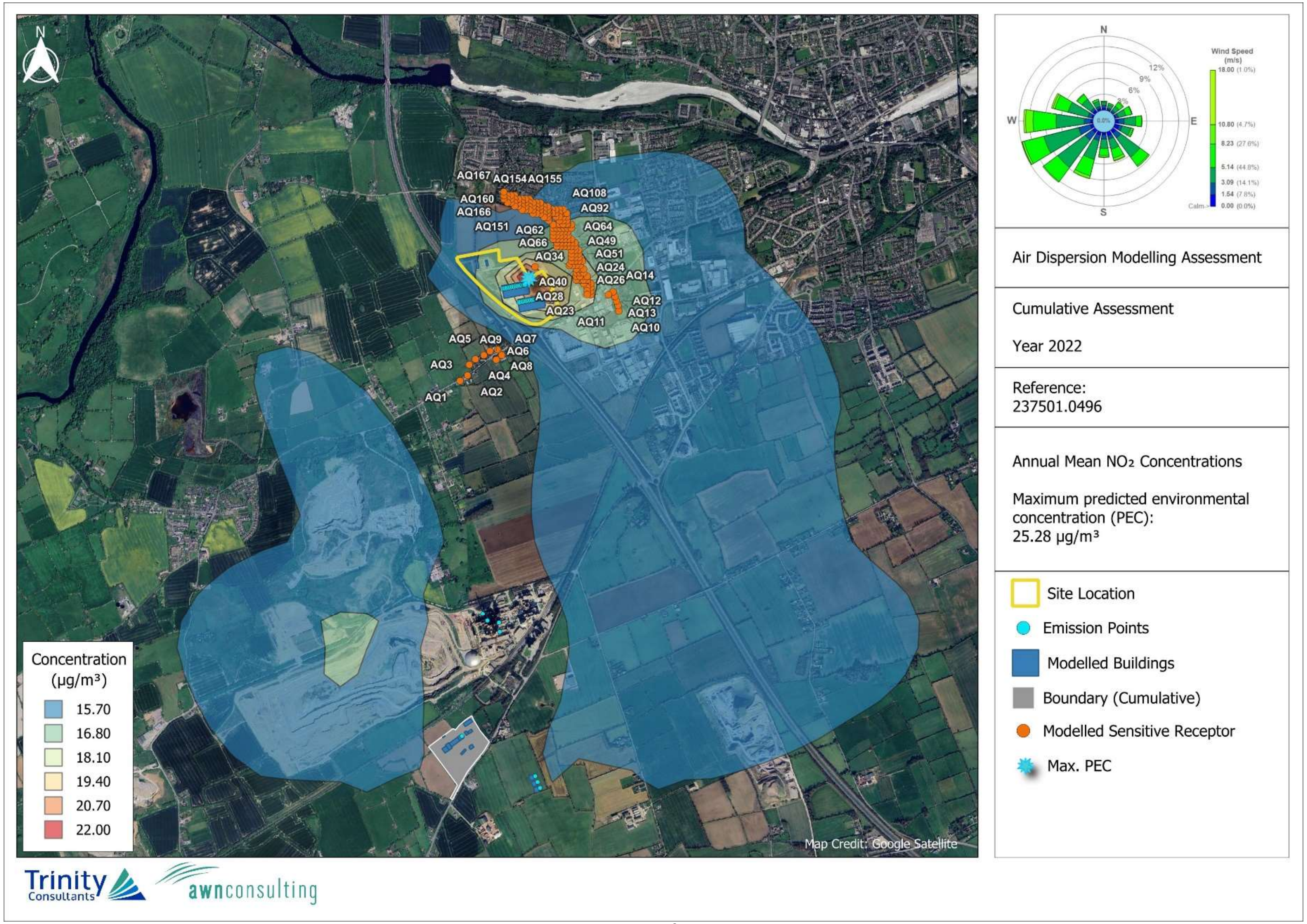

Figure 14. Cumulative Assessment - Annual Mean NO_2 Concentrations (µg/m^3)

6.3.2 PM_{10}

Ambient Ground Level Concentrations (GLCs) of PM_{10} modelling results at the worst-case receptor (considers boundary, gridded and sensitive receptors) are detailed in Table 29. The results indicate that the ambient ground level concentrations are below the relevant air quality standards for all modelled years for PM_{10}. For the worst-case year, cumulative emissions lead to an ambient PM_{10} concentration (including background) which is 44% of the maximum ambient 24-hour limit value (measured as a 90.4th%ile) (boundary receptor, location shown in Figure 15) and 33% of the annual limit value at the worst-case receptor (boundary receptor, location shown in Figure 16).

Calculating the maximum 24-hour mean PM_{10} (90.4th%ile) PEC is not a simple addition of background concentration to process contribution but is instead calculated in line with guidance from the UK DEFRA (UK DEFRA, 2022) and the EPA (EPA, 2020), as explained in Section 4.3, which states that for PM_{10} an estimate of the maximum PEC can be obtained from the methods shown below:

a) 90.4th%ile of 24-hour mean background PM_{10} + annual mean process contribution PM_{10}

b) 90.4th%ile 24-hour mean process contribution PM_{10} + annual mean background PM_{10}

The results of this calculation process are shown in Table 29 as "PEC Method A" and "PEC Method B", and determined that the maximum 24-hour mean PM_{10} (90.4th%ile) PEC is based on method A ("PEC Method A").

The geographical variation in the 24-hour mean (90.4th%ile) and annual mean PM_{10} ground level predicted environmental concentrations (PEC) beyond the Installation boundary for the worst-case years modelled are illustrated as concentration contours in Figure 15 and Figure 16, to demonstrate the direction and extent of the emission plume.

Table 29. Cumulative Assessment – Dispersion Model Results for Particulate Matter (PM_{10})

Pollutant/ Year	Averaging Period	Worst Case Receptor		PC (µg/m^3)	Back-ground (µg/m^3)	PEC (µg/m^3) Method A	PEC (µg/m^3) Method B	Limit Values (µg/Nm^3)	PEC as a % of Limit Value
		Type	X,Y (UTM Zone 29 N)						
PM_{10} / 2020	Annual Mean	Boundary	672738, 5953967	0.209	13	13.21	13.21	40	33%
	24-hr Mean (as 90.4th%ile)	Boundary	672738, 5953967	0.526	22	22.21	13.53	50	44%
PM_{10} / 2021	Annual Mean	Boundary	672738, 5953967	0.194	13	13.19	13.19	40	33%
	24-hr Mean (as 90.4th%ile)	Boundary	672738, 5953967	0.622	22	22.19	13.62	50	44%
PM_{10} / 2022	Annual Mean	Boundary	672738, 5953967	0.221	13	13.22	13.22	40	33%
	24-hr Mean (as 90.4th%ile)	Boundary	672738, 5953967	0.536	22	22.22	13.54	50	44%
PM_{10} / 2023	Annual Mean	Boundary	672738, 5953967	0.214	13	13.21	13.21	40	33%
	24-hr Mean (as 90.4th%ile)	Boundary	672738, 5953967	0.637	22	22.21	13.64	50	44%

Pollutant/ Year	Averaging Period	Worst Case Receptor		PC (µg/m³)	Back-ground (µg/m³)	PEC (µg/m³) Method A	PEC (µg/m³) Method B	Limit Values (µg/Nm³)	PEC as a % of Limit Value
		Type	X,Y (UTM Zone 29 N)						
PM_{10} / 2024	Annual Mean	Boundary	672738, 5953967	0.207	13	13.21	13.21	40	33%
	24-hr Mean (as 90.4th%ile)	Boundary	672738, 5953967	0.594	22	22.21	13.59	50	44%

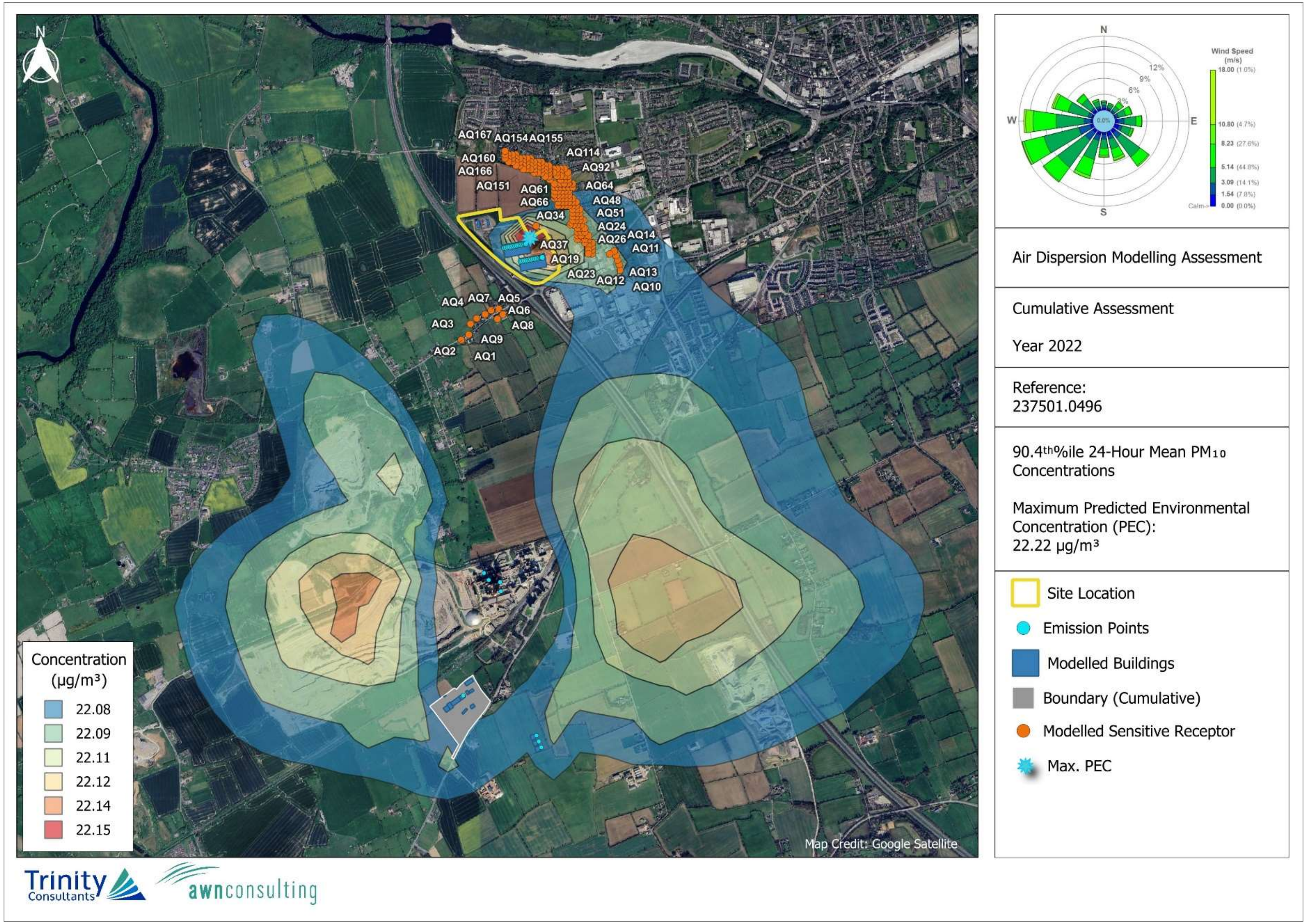

Figure 15. Cumulative Assessment - Maximum 24-Hour PM_{10} Concentration (µg/m³)

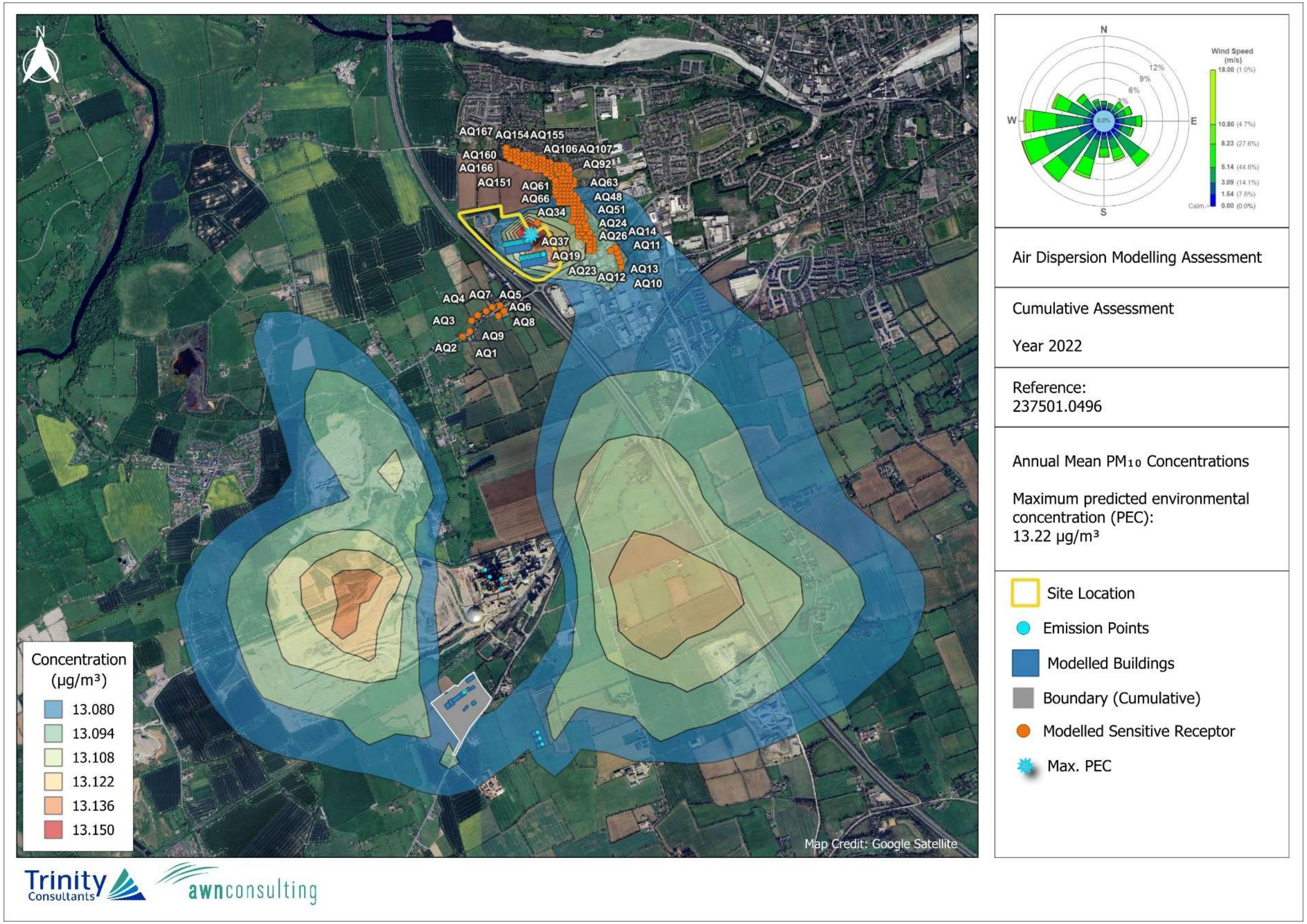

Figure 16. Cumulative Assessment - Annual Mean PM_{10} Concentration (µg/m^3)

6.3.3 $PM_{2.5}$

The $PM_{2.5}$ modelling results at the worst-case receptor (considers boundary, gridded and sensitive receptors) are detailed in Table 30. These are derived from a worst-case assumption that all PM_{10} emissions from the Installation are of a particle size of 2.5 microns or less ($PM_{2.5}$). This assumption is necessitated due to the lack of availability of $PM_{2.5}$ emission concentration data for emission sources and therefore $PM_{2.5}$ emissions could not be directly modelled. In reality, particles greater than 2.5 microns will also be present and thus the mass of $PM_{2.5}$ released has been overestimated.

For the worst-case year, ambient concentrations (including background) will be 33% of the annual mean $PM_{2.5}$ limit value of 25 µg/m^3 at the worst-case receptor (boundary receptor, location shown in Figure 16). As the annual mean $PM_{2.5}$ concentrations have been conservatively assumed equal to the annual mean PM_{10} concentrations, the direction and extent of the emission plume is identical to that shown in Figure 16.

Table 30. Cumulative Assessment – Dispersion Model Results for Particulate Matter ($PM_{2.5}$)

Pollutant / Year	Averaging Period	Worst Case Receptor Type	Worst Case Receptor X, Y (UTM Zone 29 N)	PC (µg/m^3)	Back-ground (µg/m^3)	PEC (µg/m^3)	Limit Value (µg/m^3)	PEC as % of Limit Value
PM_{25} / 2020	Annual Mean	Boundary	672738, 5953967	0.157	8	8.157	25	33%
PM_{25} / 2021	Annual Mean	Boundary	672738, 5953967	0.146	8	8.146	25	33%
PM_{25} / 2022	Annual Mean	Boundary	672738, 5953967	0.166	8	8.166	25	33%
PM_{25} / 2023	Annual Mean	Boundary	672738, 5953967	0.160	8	8.160	25	33%
PM_{25} / 2024	Annual Mean	Boundary	672738, 5953967	0.155	8	8.155	25	33%

6.3.4 SO_2

The SO_2 modelling results at the worst-case receptor (considers boundary, gridded and sensitive receptors) are detailed in Table 31. The results indicate that the ambient ground level concentrations are in compliance with the relevant air quality standards for SO_2. Cumulative emissions lead to an ambient SO_2 concentration (including background) which is 9% of the maximum 1-hour limit value (measured as a 99.7th%ile) at the worst-case receptor (boundary receptor, location shown in Figure 17) and 11% of the maximum 24-hour limit value (measured as a 99.2nd%ile) at the worst-case receptor (offsite gridded receptor, location shown in Figure 18). The locations of the maximum concentrations for SO_2 are close to the boundary of the site with concentrations decreasing with distance from the Installation.

Calculating the maximum 1-hour mean SO_2 (99.7th%ile) and 24-hour mean SO_2 (99.2nd%ile) PEC is not a simple addition of background concentration to process contribution but is instead calculated in line with guidance from the UK DEFRA (UK DEFRA, 2022) and the EPA (EPA, 2020), as explained in Section 4.5, which states that for SO_2 an estimate of the maximum PEC can be obtained from the methods shown below:

99.7th%ile of 1-hour mean SO_2 is equal to the maximum of either Method A or Method B below:

a) [Annual mean process contribution SO_2 (x2)] + [99.7th%ile hourly background SO_2]

b) [99.7th%ile hourly process contribution SO_2] + [annual mean background SO_2 (x2)]

99.2nd%ile of 24-hour mean SO_2 is equal to the maximum of either Method A or Method B below:

a) [Annual mean process contribution SO_2 (x2)] + [99.2nd%ile of 24-hour mean background SO_2]
b) [99.2nd%ile 24-hour mean process contribution SO_2] + [annual mean background SO_2 (x2)]

The results of this calculation process are shown in Table 31 as “PEC Method A” and “PEC Method B”, and determined that the maximum 1-hour mean SO_2 (99.7th%ile) PEC is based on method A (“PEC Method A”), and the maximum 24-hour mean SO_2 (99.2nd%ile) PEC is based on method A (“PEC Method A”).

The geographical variations in ground level SO_2 predicted environmental concentration (PEC) beyond the Installation boundary for the worst-case years modelled are illustrated as concentration contours in Figure 17 and Figure 18, to demonstrate the direction and extent of the emission plume.

Table 31. Cumulative Assessment – Dispersion Model Results for Sulphur Dioxide (SO_2)

Pollutant/ Year	Averaging Period	Worst Case Receptor		PC (µg/m^3)	Background (µg/m^3)	PEC (µg/m^3) Method A	PEC (µg/m^3) Method B	Limit Values (µg/Nm^3)	PEC as a % of Limit Value
		Type	X,Y (UTM Zone 29 N)						
SO_2 / 2020	Annual Mean	Boundary	672738, 5953967	0.48	4	4.48	4.48	-	-
	99.7th%ile 1-hr Mean	Boundary	672738, 5953967	8.50	30	30.96	16.50	350	9%
	99.2nd%ile 24-hr Mean	Boundary	672738, 5953967	3.69	13	13.96	11.69	125	11%
SO_2 / 2021	Annual Mean	Boundary	671550, 5951650	0.47	4	4.47	4.47	-	-
	99.7th%ile 1-hr Mean	Grid	671550, 5951650	8.14	30	30.94	16.14	350	9%
	99.2nd%ile 24-hr Mean	Grid	671550, 5951650	4.55	13	13.94	12.55	125	11%
SO_2 / 2022	Annual Mean	Boundary	672738, 5953967	0.51	4	4.51	4.51	-	-
	99.7th%ile 1-hr Mean	Boundary	672738, 5953967	8.64	30	31.03	16.64	350	9%
	99.2nd%ile 24-hr Mean	Boundary	672738, 5953967	3.63	13	14.03	11.63	125	11%
SO_2 / 2023	Annual Mean	Boundary	672738, 5953967	0.49	4	4.49	4.49	-	-
	99.7th%ile 1-hr Mean	Boundary	672738, 5953967	8.05	30	30.99	16.05	350	9%
	99.2nd%ile 24-hr Mean	Boundary	672738, 5953967	3.81	13	13.99	11.81	125	11%
SO_2 / 2024	Annual Mean	Boundary	672738, 5953967	0.48	4	4.48	4.48	-	-
	99.7th%ile 1-hr Mean	Boundary	672738, 5953967	8.85	30	30.96	16.85	350	9%
	99.2nd%ile 24-hr Mean	Boundary	672738, 5953967	3.78	13	13.96	11.78	125	11%

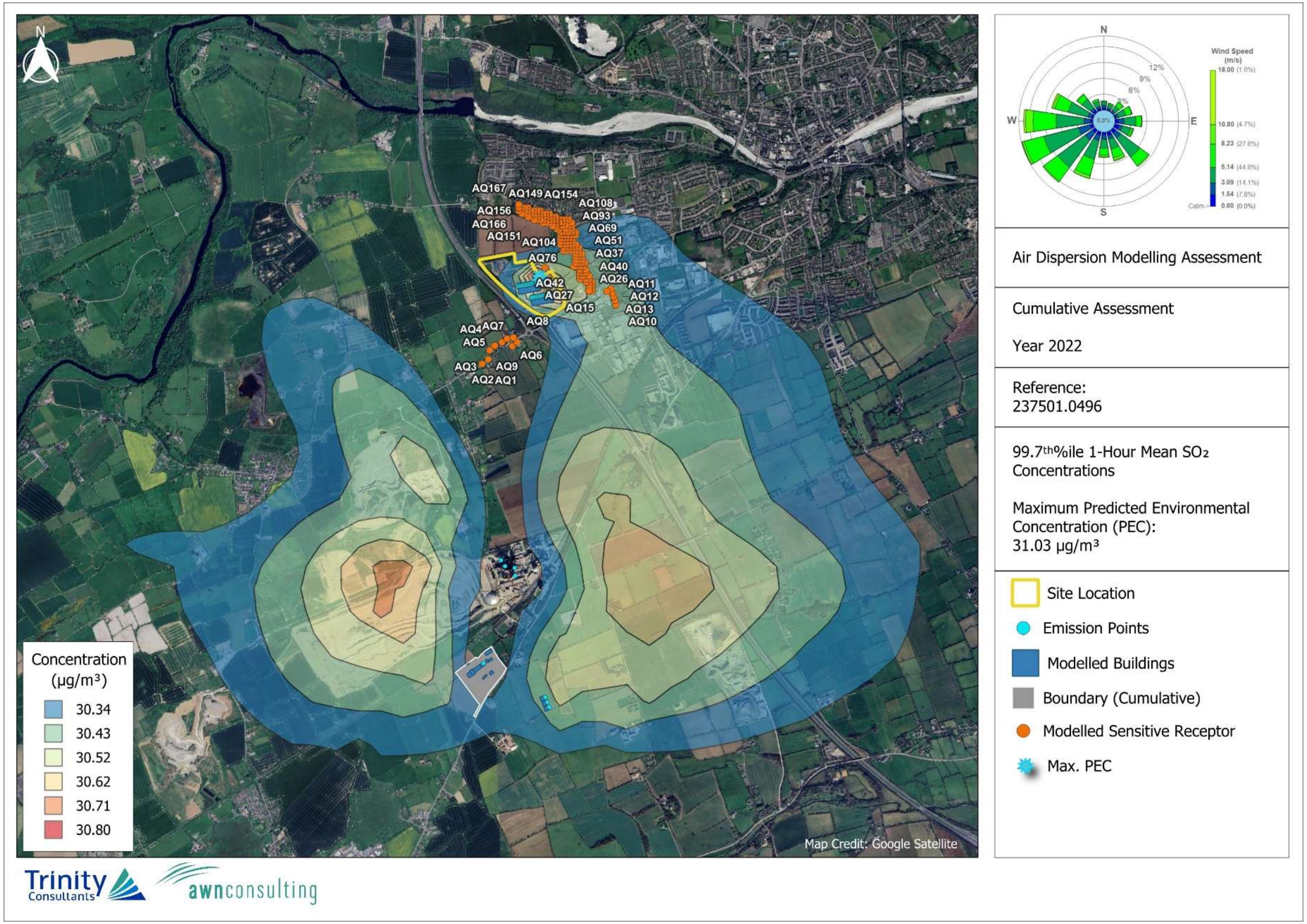

Figure 17. Cumulative Assessment - Maximum 1-Hour SO_2 Concentrations (as 99.7th%ile) ($\mu g/m^3$)

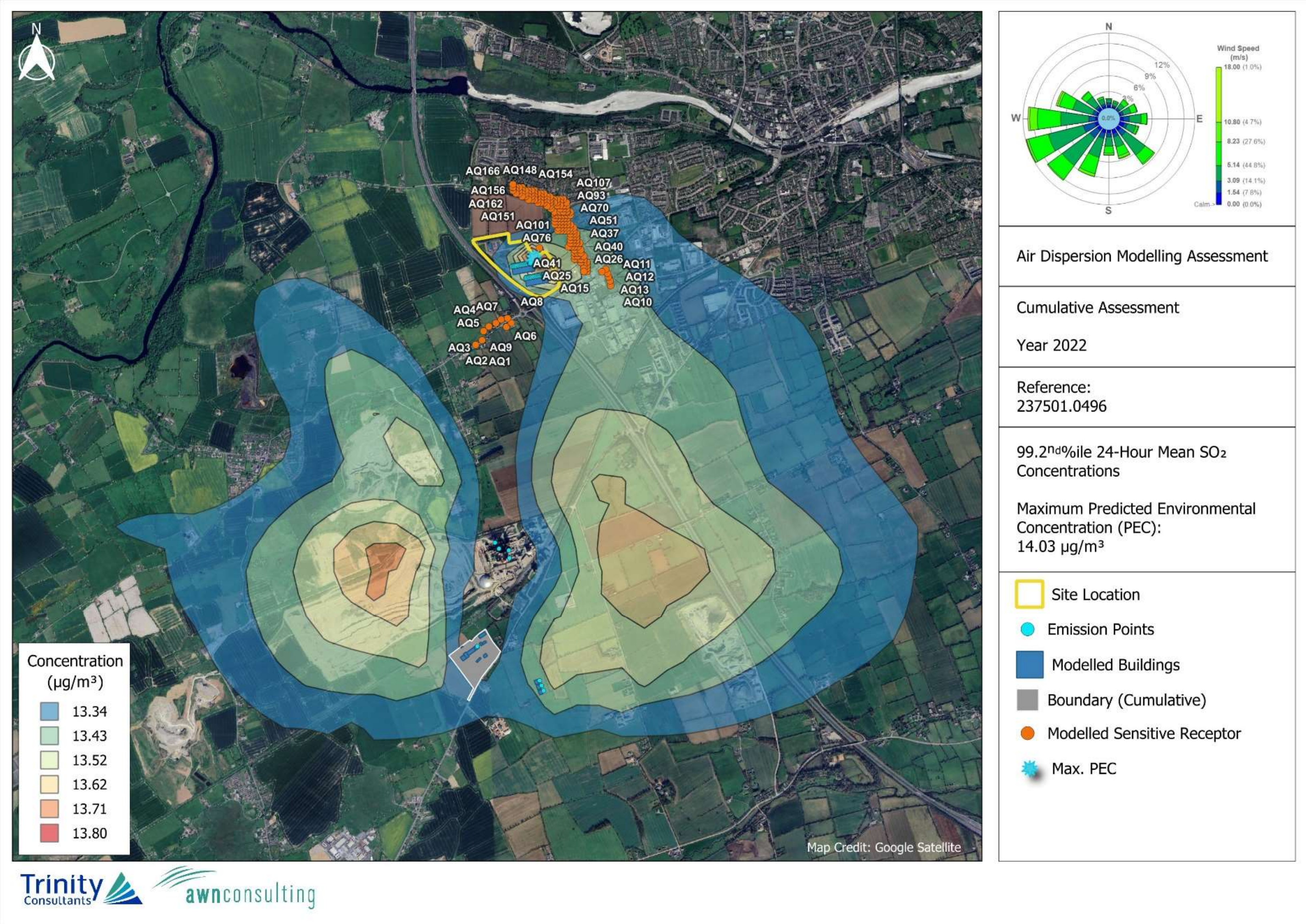

Figure 18. Cumulative Assessment - Maximum 24-Hour SO_2 Concentrations (as 99.2nd%ile) ($\mu g/m^3$)

6.3.5 *Sensitive Ecological Habitats*

The ecological habitat site most impacted by the Installation and cumulative sites, and where the highest modelled concentrations are predicted, is the River Boyne & River Blackwater SAC, this is also the most impacted Natura 2000 designated habitat site. In order to align with and inform the AA Screening / NIS, the results of the modelling have been presented for the following designated sites:

- River Boyne and River Blackwater SAC (Site Code: 002299)
- Boyne Coast and Estuary SAC (Site Code: 001957)
- Clogher Head SAC (Site Code: 001459)
- River Boyne and River Blackwater SPA (Site Code: 004232)
- Boyne Estuary SPA (Site Code: 004080)
- River Nanny Estuary and Shore SPA (Site Code: 004158)
- North-west Irish Sea SPA (Site Code: 004236)

For the purposes of this assessment, the ecological site considered 'most impacted' is the ecological site where the highest modelled process contributions (PC) are predicted; i.e., the ecological site where the Installation is contributing the highest concentrations. Commentary has also been provided for the most impacted site in terms of overall impact, process contribution plus background concentration (i.e. PEC).

6.3.5.1 NO_X

The NO_X modelling results are detailed in Table 32. Within the most impacted (in terms of PC) ecological habitat site (River Boyne & River Blackwater SAC), at the worst-case location, cumulative emissions lead to an ambient NO_X concentration (including background) which is at most 26% of the annual limit value over the five years of meteorological data modelled.

Within the most impacted (in terms of PEC) ecological habitat site (Boyne Estuary SPA), at the worst-case location, cumulative emissions lead to an ambient NO_X concentration (including background) which is at most 26% of the annual limit value over the five years of meteorological data modelled.

NO_X emissions at all relevant designated Natura 2000 sites are in compliance with the NO_X critical level of 30 µg/m^3.

Table 32. Cumulative Assessment – NO_X Dispersion Model Results

Ecological Receptor	NO_X Process Contributions (µg/m^3)					Max PC % of Critical Level	Back-ground (µg/m^3)	PEC (µg/m^3)	Critical Level (µg/m^3)	PEC % of critical level
	2020	2021	2022	2023	2024					
Boyne Coast and Estuary SAC	0.82	0.67	0.74	0.81	0.74	2.7%	6.7	7.5	30	25%
Clogher Head SAC	0.40	0.35	0.39	0.39	0.35	1.3%	5.8	6.2	30	21%
River Boyne and River Blackwater SAC	1.30	1.43	1.46	1.41	1.38	4.9%	6.3	7.8	30	26%
Boyne Estuary SPA	0.94	0.78	0.88	0.95	0.88	3.2%	6.9	7.9	30	26%
North-west Irish Sea SPA	0.66	0.61	0.59	0.65	0.57	2.2%	5.2	5.9	30	20%
River Boyne and River Blackwater SPA	0.85	1.21	1.24	1.20	1.10	4.1%	6.3	7.5	30	25%
River Nanny Estuary and Shore SPA	0.67	0.71	0.68	0.65	0.65	2.4%	5.0	5.7	30	19%

6.3.5.2 SO_2

The SO_2 modelling results are detailed in Table 33. Within the most impacted (in terms of PC) ecological habitat site (River Boyne & River Blackwater SAC), at the worst-case location, cumulative emissions lead to an ambient SO_2 concentration (including background) which is at most 4% of the annual limit value over the five years of meteorological data modelled.

Within the most impacted (in terms of PEC) ecological habitat site (Boyne Estuary SPA), at the worst-case location, cumulative emissions lead to an ambient SO_2 concentration (including background) which is at most 5% of the annual limit value over the five years of meteorological data modelled.

SO_2 emissions at all relevant designated Natura 2000 sites are in compliance with the SO_2 critical level of 20 µg/m^3.

Table 33. Cumulative Assessment – SO_2 Dispersion Model Results

Ecological Receptor	SO_2 Process Contributions (µg/m^3)					Max PC % of Critical Level	Back-ground (µg/m^3)	PEC (µg/m^3)	Critical Level (µg/m^3)	PEC % of critical level
	2020	2021	2022	2023	2024					
Boyne Coast and Estuary SAC	0.083	0.065	0.073	0.079	0.072	0.41%	0.75	0.836	20	4%
Clogher Head SAC	0.042	0.036	0.041	0.040	0.036	0.21%	0.74	0.780	20	4%
River Boyne and River Blackwater SAC	0.106	0.148	0.153	0.148	0.131	0.76%	0.70	0.853	20	4%
Boyne Estuary SPA	0.091	0.075	0.085	0.090	0.085	0.46%	0.88	0.968	20	5%
North-west Irish Sea SPA	0.069	0.065	0.062	0.068	0.059	0.34%	0.50	0.569	20	3%
River Boyne and River Blackwater SPA	0.085	0.122	0.125	0.120	0.111	0.62%	0.70	0.824	20	4%
River Nanny Estuary and Shore SPA	0.072	0.076	0.073	0.071	0.070	0.38%	0.43	0.510	20	3%

6.3.5.3 Nitrogen Deposition

In order to consider the effects of nitrogen deposition (as N) owing to emissions from the Installation and cumulative sites on the most impacted ecological habitat site, the maximum annual mean NO_2 process contribution concentrations (PC) are converted into the dry deposition fluxes and then nitrogen deposition fluxes (as described in Section 3.8) and shown in Table 34 and Table 35.

Within the most impacted (in terms of PC) ecological habitat site (River Boyne & River Blackwater SAC), at the worst-case location, the nitrogen deposition flux for the worst-case year is 6.686 kg/ha/yr, shown in Table 35. This is below mid-point critical load of 7.5 kg/ha/yr for the habitat type "Alkaline fens" in the River Boyne & River Blackwater SAC, indicating that the effects of nitrogen deposition on ecological habitat sites due to the Installation and cumulative sites are not significant.

Within the most impacted (in terms of PEC) ecological habitat site (River Boyne & River Blackwater SPA), at the worst-case location, the nitrogen deposition flux for the worst-case year is 8.398 kg/ha/yr, shown in Table 35. There are no comparable critical load levels for this designated site, indicating that the effects of nitrogen deposition are not a concern. The background deposition of 8.24 kg/ha/yr is contributing the most to the PEC.

Nitrogen deposition fluxes at all other relevant ecological sites are within the required critical load range indicating that the effects of nitrogen deposition on ecological habitat sites due to the Installation and cumulative sites are not significant.

Table 34. Cumulative Assessment – Nitrogen Deposition

Ecological Receptor	NO_2 Process Contributions (µg/m^3)					NO_2 Dry Deposition (µg/m^2/s)	NO_2 Nitrogen Deposition (kg/ha/yr)
	2020	2021	2022	2023	2024		
Boyne Coast and Estuary SAC	0.74	0.60	0.67	0.73	0.67	0.0011	0.107
Clogher Head SAC	0.36	0.31	0.35	0.35	0.32	0.0005	0.052
River Boyne and River Blackwater SAC	1.17	1.29	1.29	1.27	1.24	0.0019	0.186
Boyne Estuary SPA	0.85	0.70	0.79	0.85	0.80	0.0013	0.123
North-west Irish Sea SPA	0.59	0.55	0.53	0.59	0.51	0.0009	0.085
River Boyne and River Blackwater SPA	0.76	1.09	1.11	1.08	0.99	0.0017	0.160
River Nanny Estuary and Shore SPA	0.60	0.64	0.61	0.58	0.59	0.0010	0.093

Table 35. Cumulative Assessment – Nitrogen Deposition contd.

Ecological Receptor	Total PC Nitrogen Deposition (kg/ha/yr)	APIS Background Nitrogen Deposition (kg/ha/yr)	Total PEC Nitrogen Deposition (kg/ha/yr)	Critical load (kg/ha/yr)
Boyne Coast and Estuary SAC	0.107	7.28	7.383	7.5
Clogher Head SAC	0.052	6.09	6.141	7.5
River Boyne and River Blackwater SAC	0.186	6.50	6.686	7.5
Boyne Estuary SPA	0.123	7.28	7.399	7.5
North-west Irish Sea SPA	0.085	5.80	5.885	7.5
River Boyne and River Blackwater SPA	0.160	8.24	8.398	n/a
River Nanny Estuary and Shore SPA	0.093	5.694	5.787	7.5

6.3.5.4 Acid Deposition

In order to consider the effects of acid deposition (as N and S) owing to emissions from the Installation and cumulative sites on the most impacted ecological habitat site, the maximum annual mean NO_2 and SO_2 process contribution concentrations (PC) are converted into the dry deposition fluxes and then acid deposition fluxes (as described in Section 3.8) and shown in Table 36 to Table 39.

Within the most impacted (in terms of PC) ecological habitat site (River Boyne & River Blackwater SAC), at the worst-case location, the total acid deposition (as N) flux for the worst-case year is 0.513 keq/ha/yr, shown in Table 37. This is below the MaxCLminN of 0.714 keq/ha/yr for the sensitive species "*Lampetra fluviatilus*" in the River Boyne & River Blackwater SAC [(31)], indicating that the effects of acid deposition (as N) on ecological habitat sites due to the Installation and cumulative sites are not significant.

Within the most impacted (in terms of PEC) ecological habitat site (River Boyne and River Blackwater SPA), at the worst-case location, the total acid deposition (as N) flux for the worst-case year is 0.604 keq/ha/yr, shown in Table 37. This is below the MaxCLminN of 0.714 keq/ha/yr for the sensitive species "*Alcedo atthis*" in the River Boyne and River Blackwater SPA[(31)], indicating that the effects of acid deposition (as N) on ecological habitat sites due to the Installation and cumulative sites are not significant.

Within the Clogher Head SAC the total acid deposition (as N) flux for the worst-case year is 0.476 keq/ha/yr, shown in Table 37. This is above the MaxCLminN of 0.143 keq/ha/yr for the sensitive species "European Dry Heaths" in the Clogher Head SAC. However, the PEC acid deposition (as N) flux of 0.476 keq/ha/yr for the Clogher Head SAC is within the upper MaxCLmaxN range of 4.535 keq/ha/yr (see Table 3). APIS does not consider the critical load function to be exceeded unless the PEC is larger than the maximum critical load, not the minimum. Therefore it can be concluded that the predicted acid deposition (as N) is not significant. It should be noted that the background acid deposition level of 0.47 keq/ha/yr in this area is contributing the most to the PEC and the process contribution from the Installation and cumulative sites is minor, at 0.0037 keq/ha/yr. It should also be noted that the maximum NO_2 process contributions from the Installation and cumulative sites, from which nitrogen deposition levels are derived, are below the limit of detection of 0.5 µg/m^3 which must be achieved by chemiluminescence-based automated NO_X/NO_2 analysers (EN 14211). Limit of detection is defined as the smallest concentration that can be reliably measured by an analytical procedure. The EPA guidelines (EPA, 2022) define an imperceptible effect as *"an effect capable of measurement but without significant consequences".* NO_2 process contributions, and by extension nitrogen deposition levels, that are below a monitoring instrument's limit of detection are not measurable and will therefore have a less than imperceptible effect.

Acid deposition (as N) fluxes at all other relevant ecological sites are within the required critical load range indicating that the effects of nitrogen deposition (as N) on ecological habitat sites due to the Installation and cumulative sites are not significant.

Within the most impacted (in terms of PC) ecological habitat site (River Boyne & River Blackwater SAC), at the worst-case location, the total acid deposition (as S) flux for the worst-case year is 0.518 keq/ha/yr, shown in Table 39. This is above the MinCLmaxS of 0.193 keq/ha/yr for the sensitive species "*Lampetra fluviatilus*" in the River Boyne & River Blackwater SAC. However, the PEC is within the upper MaxCLmaxS range of 4.748 keq/ha/yr (see Table 3). Therefore, it can be concluded that the predicted acid deposition (as S) within the River Boyne and River Blackwater SAC is not significant. The background acid deposition level of 0.500 keq/ha/yr in this area is contributing the most to the PEC and the process contribution from the Installation is minor, at 0.018 keq/ha/yr. Additionally, the SO_2 PCs from the Installation and cumulative sites, from which the acid deposition (as S) levels are derived are below the limit of detection of 0.14 µg/m^3 which must be achieved by fluorescence-based automated SO_2 analysers (Thermo Scientific, 2025).

Within the most impacted (in terms of PEC) ecological habitat site, the River Boyne and River Blackwater SPA, the total acid deposition (as S) flux for the worst-case year is 0.608 keq/ha/yr, shown in Table 39. This above the MinCLmaxS of 0.216 keq/ha/yr for the sensitive species "*Alcedo atthis*" in the River Boyne & River Blackwater SPA. However, the PEC is within the upper MaxCLmaxS range of 4.724 keq/ha/yr (see Table 3). Therefore, it can be concluded that the predicted acid deposition (as S) within the River Boyne and River Blackwater SPA is not significant. The background acid deposition level of 0.593 keq/ha/yr in this area is contributing the most to the PEC and the process contribution from the Installation and cumulative sites is minor, at 0.015 keq/ha/yr.

Acid deposition (as S) fluxes at all other relevant ecological sites are within the required critical load range indicating that the effects of nitrogen deposition on ecological habitat sites due to the Installation and cumulative sites are not significant.

Table 36. Cumulative Assessment – Acid Deposition (as N)

Ecological Receptor	NO_2 Process Contributions (µg/m³)					NO_2 Dry Deposition (µg/m²/s)	NO_2 Acid Deposition (keq/ha/year)
	2020	2021	2022	2023	2024		
Boyne Coast and Estuary SAC	0.74	0.60	0.67	0.73	0.67	0.0011	0.008
Clogher Head SAC	0.36	0.31	0.35	0.35	0.32	0.0005	0.004
River Boyne and River Blackwater SAC	1.17	1.29	1.29	1.27	1.24	0.0019	0.013
Boyne Estuary SPA	0.85	0.70	0.79	0.85	0.80	0.0013	0.009
North-west Irish Sea SPA	0.59	0.55	0.53	0.59	0.51	0.0009	0.006
River Boyne and River Blackwater SPA	0.76	1.09	1.11	1.08	0.99	0.0017	0.011
River Nanny Estuary and Shore SPA	0.60	0.64	0.61	0.58	0.59	0.0010	0.007

Table 37. Cumulative Assessment – Acid Deposition (as N) contd.

Ecological Receptor	PC Acid Deposition (N) (keq/ha/yr)	APIS Background Acid Deposition (keq/ha/yr)	Total PEC Acid Deposition (N) (keq/ha/yr)	Critical load (MaxCLminN) for PEC (keq/ha/yr)
Boyne Coast and Estuary SAC	0.0076	0.57	0.576	0.714
Clogher Head SAC	0.0037	0.47	0.476	0.143
River Boyne and River Blackwater SAC	0.0133	0.50	0.513	0.714
Boyne Estuary SPA	0.0088	0.57	0.577	0.714
North-west Irish Sea SPA	0.0061	0.40	0.406	0.714
River Boyne and River Blackwater SPA	0.0114	0.59	0.604	0.714
River Nanny Estuary and Shore SPA	0.0066	0.41	0.412	0.714

Table 38. Cumulative Assessment – Acid Deposition (as S)

Ecological Receptor	SO_2 Process Contributions (µg/m³)					SO_2 Dry Deposition (µg/m²/s)	SO_2 Acid Deposition (S) (keq/ha/yr)
	2020	2021	2022	2023	2024		
Boyne Coast and Estuary SAC	0.083	0.065	0.073	0.079	0.072	0.0010	0.010
Clogher Head SAC	0.042	0.036	0.041	0.040	0.036	0.0005	0.005
River Boyne and River Blackwater SAC	0.106	0.148	0.153	0.148	0.131	0.0018	0.018
Boyne Estuary SPA	0.091	0.075	0.085	0.090	0.085	0.0011	0.011
North-west Irish Sea SPA	0.069	0.065	0.062	0.068	0.059	0.0008	0.008
River Boyne and River Blackwater SPA	0.085	0.122	0.125	0.120	0.111	0.0015	0.015
River Nanny Estuary and Shore SPA	0.072	0.076	0.073	0.071	0.070	0.0009	0.009

Table 39. Cumulative Assessment – Acid Deposition (as S) contd.

Ecological Receptor	PC Acid Deposition (S) (keq/ha/yr)	APIS Background Acid Deposition (keq/ha/yr)	Total PEC Acid Deposition (S) (keq/ha/yr)	Critical load (MinCLmaxS) (keq/ha/yr)
Boyne Coast and Estuary SAC	0.010	0.568	0.578	4.142
Clogher Head SAC	0.005	0.472	0.477	4.392

Ecological Receptor	PC Acid Deposition (S) (keq/ha/yr)	APIS Background Acid Deposition (keq/ha/yr)	Total PEC Acid Deposition (S) (keq/ha/yr)	Critical load (MinCLmaxS) (keq/ha/yr)
River Boyne and River Blackwater SAC	0.018	0.500	0.518	0.193
Boyne Estuary SPA	0.011	0.568	0.579	4.142
North-west Irish Sea SPA	0.008	0.400	0.408	4.107
River Boyne and River Blackwater SPA	0.015	0.593	0.608	0.216
River Nanny Estuary and Shore SPA	0.009	0.405	0.414	4.185

6.4 Cumulative Assessment (UK Environment Agency Methodology)

Emissions from the emergency operation of the 50 no. back-up generators, as well as EPA licensed sites were assessed using the UK Environment Agency methodology[22]. 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 or more hours per year was computed and the probability of an exceedance determined as outlined in Table 40. The results have been compared to the 98th percentile confidence level to indicate if an exceedance is likely at various operational hours for the Installation. The results indicate that the Installation can operate for a maximum of 104 hours in any given year without the likelihood of an exceedance of the ambient air quality standard (at a 98th percentile confidence level).

Table 40. Cumulative Assessment – 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 / 2020	108	0.02
NO_2 / 2021	115	
NO_2 / 2022	106	
NO_2 / 2023	104	
NO_2 / 2024	112	

Note 1 Guidance Outlined In UK EA publication “Diesel Generator Short-Term NO_2 Impact Assessment”[22]

7.0 ASSESSMENT SUMMARY

The results indicate that ambient ground level concentrations are below the relevant air quality standards for all pollutants modelled (NO_2, CO, PM_{10}, $PM_{2.5}$ and SO_2) for the Proposed Operations scenario and the Cumulative scenario.

The modelling study has concluded that emissions from the back-up generators will be in compliance with the ambient air quality standards which are based on the protection of the environment and human health.

7.1 Proposed Operations Scenario

This scenario involved the emergency operation of 50 no. of the 54 no. back-up generators (the remaining 4 no. generators serving as a “catcher” generator for Building A and Building B) for 100 hours per generator per year. The scenario also included the scheduled testing of all 54 no. generators.

Human Health Impacts

Emissions of NO_2, CO, PM_{10}, $PM_{2.5}$ and SO_2 in this scenario are in compliance with the relevant ambient air quality standards. The maximum PEC results for each pollutant, as a percentage of the relevant ambient air quality standard, at the worst-case receptor modelled are as follows for each pollutant:

- NO_2 annual mean: 61%
- NO_2 maximum 1-hour (measured as 99.8th%ile): 57%
- CO maximum 8-hour: 21%
- PM_{10} annual mean: 33%
- PM_{10} maximum 24-hour (measured as 90.4th%ile): 44%
- $PM_{2.5}$ annual mean: 33%
- SO_2 maximum 1-hour (measured as 99.7th%ile): 9%
- SO_2 maximum 24-hour (measured as 99.2nd%ile): 11%

In addition, for NO_2, the UK EA assessment methodology determined that in the worst-case year, the Installation could operate for 104 hours per year without a likelihood of an exceedance of the ambient air quality standard at the nearest residential receptor (at a 98th percentile confidence level).

Ecological Impacts

The Air Impact Assessment has evaluated the impact of emissions to air from the Installation on ecological receptors within a 20 km distance from the Installation. The assessment has included emissions of NO_X, SO_2, nitrogen and acid deposition. For the purposes of this assessment, the 'most impacted' ecological site is identified as the site where the highest modelled process contributions (PCs) occur, the River Boyne and River Blackwater SAC in the case of this assessment. Modelled PCs at all other ecological sites within 20 km of the Installation are lesser than those within the River Boyne and River Blackwater SAC. The River Boyne and River Blackwater SAC is also the closest ecological site to the Installation. Additionally, in order to inform the AA Screening / NIS, modelling results have been presented for the following designated sites:

- Boyne Coast and Estuary SAC (site code: 001957)
- Clogher Head SAC (site code: 001459)
- River Boyne and River Blackwater SAC (site code: 002299)
- Boyne Estuary SPA (site code: 004080)
- North-west Irish Sea SPA (site code: 004236)
- River Boyne and River Blackwater SPA (site code: 004232)
- River Nanny Estuary and Shore SPA (site code: 004158)

The results of the air modelling assessment indicate that there is no potential for these airborne pollutants to adversely affect the conservation objectives of any qualifying interests (QIs) at the modelled sites. This confirms that the direct air emissions from the Installation will not have significant effects on these designated habitats.

Under the Proposed Operations Scenario, the modelling assessment determined that predicted environmental concentrations (PECs) of NO_X, SO_2 and nitrogen and acid deposition from the Installation at theBoyne Coast and Estuary SAC (site code: 001957), Boyne Estuary SPA (site code: 004080), North-west Irish Sea SPA (site code: 004236), and River Nanny Estuary and Shore SPA (site code: 004158) do not exceed the relevant critical levels and critical load ranges for the sensitive QI habitats.

Under the Proposed Operations Scenario, the modelling assessment determined that PEC of NO_X, SO_2, nitrogen deposition and acid deposition (as S) from the Installation at Clogher Head SAC (site code: 001459) do not exceed the relevant critical levels and critical load ranges for the sensitive QI habitats. The PEC acid deposition (as N) is above the minimum critical load range for the relevant QI habitat but is within the upper critical load range and is therefore, not considered significant. Background acid deposition levels are the most contributing factor to the PEC with the PC from the Installation contributing a minor amount.

In the Proposed Operations Scenario, the modelling assessment determined that PEC of NO_X, SO_2, nitrogen deposition and acid deposition (as N) from the Installation at the River Boyne and River Blackwater SAC (site code: 002299) and River Boyne and River Blackwater SPA (site code: 002299) do not exceed the relevant critical levels and critical load ranges for the sensitive QI habitats. The PEC acid deposition (as S) is above the minimum critical load range for the relevant QI habitat but is within the upper critical load range and is therefore, not considered significant. Background acid deposition levels are the most contributing factor to the PEC with the PC from the Installation contributing a minor amount.

There are no significant impacts predicted for any other Natura 2000 SPAs and SACs than those presented within this report.

Under the Proposed Operations Scenario the dispersion modelling has determined that concentrations of all pollutants are in compliance with the relevant ambient air quality standards. Therefore, no significant impacts to the ambient air quality environment are predicted.

7.2 Cumulative Assessment

The cumulative assessment involved modelling the proposed operations of the Installation under the Proposed Operations scenario, as well as emissions from the existing and proposed IED licensed sites of Irish Cement, Indaver and SSE Generation Ireland Ltd.

Human Health Impacts

Emissions of NO_2, CO, PM_{10}, $PM_{2.5}$ and SO_2 in this scenario are in compliance with the relevant ambient air quality standards. The maximum PEC results for each pollutant, as a percentage of the relevant ambient air quality standard, at the worst-case receptor modelled are as follows for each pollutant:

- NO_2 annual mean: 63%
- NO_2 maximum 1-hour (measured as 99.8^{th}%ile): 57%
- PM_{10} annual mean: 33%
- PM_{10} maximum 24-hour (measured as 90.4^{th}%ile): 44%
- $PM_{2.5}$ annual mean: 33%
- SO_2 maximum 1-hour (measured as 99.7^{th}%ile): 9%
- SO_2 maximum 24-hour (measured as 99.2^{nd}%ile): 11%

In addition, for NO_2, the UK EA assessment methodology determined that in the worst-case year, the Installation could operate for 104 hours per year without a likelihood of an exceedance of the ambient air quality standard at the nearest residential receptor (at a 98^{th} percentile confidence level).

Ecological Impacts

The Air Impact Assessment has evaluated the impact of emissions to air from the Installation and cumulative sites of Irish Cement, Indaver and SSE Generation Ireland Ltd. on ecological receptors within a 20 km distance from the Installation. The assessment has included emissions of NO_X, SO_2, nitrogen and acid deposition. For the purposes of this assessment, the 'most impacted' ecological site is identified as the site where the highest modelled process contributions (PCs) occur, the River Boyne and River Blackwater SAC in the case of this assessment. Modelled PCs at all other ecological sites within 20 km of the Installation are lesser than those within the River Boyne and River Blackwater SAC. The River Boyne and River Blackwater SAC is also the closest ecological site to the Installation. Additionally, in order to inform the AA Screening / NIS, modelling results have been presented for the following designated sites:

- Boyne Coast and Estuary SAC (site code: 001957)
- Clogher Head SAC (site code: 001459)
- River Boyne and River Blackwater SAC (site code: 002299)
- Boyne Estuary SPA (site code: 004080)
- North-west Irish Sea SPA (site code: 004236)
- River Boyne and River Blackwater SPA (site code: 004232)
- River Nanny Estuary and Shore SPA (site code: 004158)

The results of the air modelling assessment indicate that there is no potential for these airborne pollutants to adversely affect the conservation objectives of any qualifying interests (QIs) at the modelled sites. This confirms that the direct air emissions from the Installation will not have significant effects on these designated habitats.

Under the Cumulative Scenario, the modelling assessment determined that predicted environmental concentrations (PECs) of NO_X, SO_2, nitrogen and acid deposition from the Installation at the Boyne Coast and Estuary SAC (site code: 001957), Boyne Estuary SPA (site code: 004080), North-west Irish Sea SPA (site code: 004236), and River Nanny Estuary and Shore SPA (site code: 004158) do not exceed the relevant critical levels and critical load ranges for the sensitive QI habitats.

Under the Cumulative Scenario, the modelling assessment determined that PEC of NO_X, SO_2, nitrogen deposition and acid deposition (as S) from the Installation at Clogher Head SAC (site code: 001459) do not exceed the relevant critical levels and critical load ranges for the sensitive QI habitats. The PEC acid deposition (as N) is above the minimum critical load range for the relevant QI habitat but is within the upper critical load range and is therefore, not considered significant. Background acid deposition levels are the most contributing factor to the PEC with the PC from the Installation contributing a minor amount.

In the Cumulative Scenario, the modelling assessment determined that PEC of NO_X, SO_2, nitrogen deposition and acid deposition (as N) from the Installation at the River Boyne and River Blackwater SAC (site code: 002299) and River Boyne and River Blackwater SPA (site code: 002299) do not exceed the relevant critical levels and critical load ranges for the sensitive QI habitats. The PEC acid deposition (as S) is above the minimum critical load range for the relevant QI habitat but is within the upper critical load range and is therefore, not considered significant. Background acid deposition levels are the most contributing factor to the PEC with the PC from the Installation contributing a minor amount.

Under the Cumulative Scenario the dispersion modelling has determined that concentrations of all pollutants are in compliance with the relevant ambient air quality standards. Therefore, no significant impacts to the ambient air quality environment are predicted.

8.0 REFERENCES

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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)(6)]. 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[(10)].

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(5)(7). 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)(5). 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)[(15)]. 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[(6)] and using the detailed methodology outlined by the Alaska Department of Environmental Conservation[(17)]. 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. 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 1 km from Dublin Airport is shown in Table A1.

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

Sector	Area Weighted Land Use Classification	Spring	Summer	Autumn	Winter Note 1
340-100	0% Water, 100% Urban, 0% Grassland	1	1	1	1
100-340	0% Water, 0% Urban, 100% Grassland	0.05	0.1	0.01	0.01

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 Installation.

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 10 km x 10 km area centred on Dublin Airport is shown in Table A2.

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

Area Weighted Land Use Classification	Spring	Summer	Autumn	Winter Note 1
2% Water, 49% Urban, 31% Grassland, 19% Cultivated Land	0.152	0.173	0.185	0.185

Note 1 For the current location autumn more accurately defines “winter” conditions at the proposed Installation.

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 10 km x 10 km area centred on Dublin Airport is shown in Table A3.

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

Area Weighted Land Use Classification	Spring	Summer	Autumn	Winter Note 1
2% Water, 49% Urban, 31% Grassland, 19% Cultivated Land	0.63	1.23	1.36	1.36

Note 1 For the current location autumn more accurately defines “winter” conditions at the proposed Installation.