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Air Emissions Impact Assessment For Indaver Ireland Ltd, Carranstown Duleek, County Meath

Technical Report Prepared For

Indaver Ireland Ltd
Carranstown
Duleek
County Meath

Technical Report Prepared By

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Our Reference

EP/247501.0044AR01a

Date Of Issue

1 March 2024

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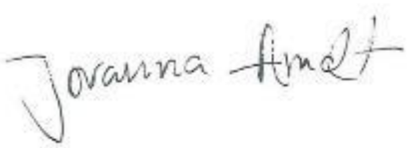
Document History

Document Reference		Original Issue Date	
247501.0044AR01		7 February 2024	
Revision Level	Revision Date	Description	Sections Affected
247501.0044AR01a	1 March 2024	Minor Updates	All Sections

Record of Approval

Details	Written by	Checked by
Signature		
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EXECUTIVE SUMMARY

The assessment was modelled on the maximum emission concentrations outlined in the Industrial Emissions Directive (2010/75/EU) and based on a maximum flue gas flow rate of 200,000 Nm^3/hr and also assumed 100% availability of the plant for 8760 hours per year. This assessment has found that the impact on air quality would not be significant.

Air dispersion modelling was carried out using the United States Environmental Protection Agency's (USEPA) regulatory model AERMOD. The aim of the study was to assess the impact in the ambient environment of emissions from the facility at the maximum emission limits outlined in Council Directive 2010/50/EC and also at a maximum stack emission flowrate (and at 75% of the maximum flow rate). Modelling was also conducted under abnormal operating conditions to assess any short-term impact due to these infrequent events. The study demonstrates that all substances which will be emitted from the facility will be at levels that are well below even the most stringent ambient air quality standards and guidelines. The dispersion model study consisted of the following components:

- Review of design emission levels and other relevant information needed for the modelling study;
- Identification of the significant substances which are released from the site;
- Review of background ambient air quality in the vicinity of the facility;
- Air dispersion modelling of significant substances released from the site;
- Identification of predicted ground level concentrations of released substances beyond the site boundary and at sensitive receptors in the immediate environment;
- A cumulative assessment of significant releases from the site taking into account the releases from all other significant industry in the area;
- Evaluation of the significance of these predicted concentrations, including consideration of whether these ground level concentrations are likely to exceed the most stringent ambient air quality standards and guidelines which have been set for the protection of human health;
- Impact on public health and the environment in the unlikely event of “abnormal” operating conditions.

Modelling and a subsequent impact assessment was undertaken for the following substances released from the site:

- Nitrogen dioxide (NO_2)
- Sulphur Dioxide (SO_2)
- Total Dust (as PM_{10} and $PM_{2.5}$)
- Gaseous and vaporous organic substances expressed as total organic carbon (TOC)
- Hydrogen Chloride (HCl)
- Hydrogen Fluoride (HF)
- Ammonia (NH_3)
- PCDD/PCDFs (Dioxins/Furans)
- Mercury (Hg)
- Cadmium (Cd) and Thallium (Tl)
- And the sum of Antimony (Sb), Arsenic (As), Lead (Pb), Chromium (Cr), Cobalt (Co), Copper (Cu), Manganese (Mn), Nickel (Ni) and Vanadium (V).

Assessment Approach

Emissions from the site have been assessed firstly under maximum operating conditions, secondly under abnormal operating conditions. Maximum operations are based on the facility operating at 200,000 Nm^3/hr and with emission levels at the limits defined in EU Directive 2010/75/EU and at maximum volume flow. Abnormal operating conditions refer to short-term periods in which the limits detailed in EU Directive 2010/75/EU are exceeded at maximum volume flow.

This is a conservative approach as the facility will typically operate to emission values well within emission limits defined in the EU Directive. Predicted ambient air concentrations have also been identified at the most sensitive residential receptors in Carranstown and the surrounding geographical area as far away as Duleek, Drogheda and Newgrange.

Modelling Under Maximum & Abnormal Operating Conditions

In order to assess the possible impact from the facility under maximum and abnormal operations, a conservative approach was adopted that is designed to over-predict ground level concentrations. This cautious approach will ensure that an over-estimation of impacts will occur and that the resultant emission standards adopted are protective of ambient air quality. The approach incorporated several conservative assumptions regarding operating conditions at the facility. This approach incorporated the following features:

- For the maximum operating scenario, it has been assumed that the emission point is continuously operating at its maximum operating volume flow. This will over-estimate the actual mass emissions from the site.

- For maximum operating scenario, it has been assumed that the emission point is operating for 24-hrs/day over the course of the full year. This will over-estimate the actual mass emissions.

- Abnormal operating emissions were pessimistically assumed to occur every Monday of the year with the exception of metals (2 days every month) and dioxins (5 weeks/annum):

    - NO_X - 400 mg/m^3 for 2 hours every Monday for a full year
    - Total Dust - 30 mg/m^3 for 8 hours every Monday for a full year
    - TOC - 30 mg/m^3 for 8 hours every Monday for a full year
    - HCl - 60 mg/m^3 for 4 hours every Monday for a full year
    - SO_2 - 200 mg/m^3 for 6 hours every Monday for a full year
    - HF - 4 mg/m^3 for 6 hours every Monday for a full year
    - CO - 200 mg/m^3 for 24 hours every Monday for a full year
    - Dioxins - 0.5 ng/m^3 for 5 weeks per year & 0.5 ng/m^3 for 2 days per month
    - Heavy Metals - 30 mg/m^3 for 2 days every month
    - Cd - 1 mg/m^3 for 2 days every month
    - Hg - 1 mg/m^3 for 2 days every month.

- The worst-case meteorological conditions for Dublin Airport over the five year period 2018 - 2022 have been used for each individual pollutant and averaging period. The worst-case year with regard to annual average concentrations was 2019, with annual average concentrations 8% higher than the five-year average. With regard to the 1-hour averaging period and limit values (i.e. maximum 1-hour, 99.8^{th}%ile, 99.7^{th}%ile), the worst-case year (2021) ranges from 3-35% higher than the five-year average. For the 8-hour period and 24-hour averaging period and limit values (i.e. 90.4^{th}%ile, 99.2nd%ile), the worst-case year is 6% - 26% higher respectively than the five year average.

As a result of these conservative assumptions, there will be an over-estimation of the emissions from the site and the impact of the facility on human health and the surrounding environment.

Modelled Locations

In relation to the spatial assessment of emissions from the site, modelling has been carried out to cover locations at the boundary of the site and beyond, regardless of whether any sensitive receptors are located in the area. Ambient air quality legislation designed to protect human health (i.e. by setting ambient limit values for a range of pollutants) 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 regardless of whether any sensitive receptors (such as residential locations) are present for significant periods of time. Thus, again, this represents a worst-case approach. 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 maximum value.

Cumulative Assessment

As the region around Carranstown is partly industrialised and thus has several other potentially significant sources of pollutants, a detailed cumulative assessment has been carried out using the methodology outlined by the USEPA. A cumulative assessment of all significant releases from nearby sites was carried out based on an analysis of their IE Licences.

Study Conclusions

The main study conclusions are presented below for each substance in turn:

NO_2

NO_2 modelling results indicate that the ambient ground level concentrations are below the relevant air quality standards for the protection of human health for nitrogen dioxide under maximum and abnormal operation of the site. Thus, no adverse impact on public health or the environment is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient NO_2 concentrations (including background concentrations) which are 29% of the maximum ambient 1-hour limit value (measured as a 99.8th%ile) and 39% of the annual average limit value at the worst-case receptor.

SO_2, CO, PM_{10} & $PM_{2.5}$

Modelling results indicate that ambient ground level concentrations are below the relevant air quality standards for the protection of human health for sulphur dioxide, CO and PM_{10} and $PM_{2.5}$ under maximum and abnormal operation of the site. Thus, no adverse impact on public health or the environment is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient concentrations (including background concentrations) ranging from 5% - 70% of the respective limit values at the worst-case receptors.

TOC, NH_3, HCl & HF

Modelling results indicate that the ambient ground level concentrations are below the relevant air quality guidelines for the protection of human health for TOC (assumed pessimistically to consist solely of benzene), ammonia and HCl under maximum and abnormal operation of the site. Thus, no adverse impact on public health or the environment is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient concentrations (including background concentrations) for HCl, NH_3 and TOC of only 3%, 0.2% and 21% respectively of the ambient limit values.

HF modelling results indicate that emissions at maximum operations equate to ambient HF concentrations (including background concentrations) which are 1% of the maximum ambient 1-hour limit value and 6% of the annual limit value.

PCDD / PCDFs (Dioxins/Furans)

Currently, no internationally recognised ambient air quality concentration or deposition standards exist for PCDD/PCDFs (Dioxins/Furans). Both the USEPA and WHO recommended approach to assessing the risk to human health from Dioxins/Furans entails a detailed risk assessment analysis involving the determination of the impact of Dioxins/Furans in terms of the TDI (Tolerable Daily Intake) approach. The WHO currently proposes a maximum TDI of between 1-4 pgTEQ/kg of body weight per day.

Background levels of Dioxins/Furans occur everywhere and existing levels in the surrounding area have been extensively monitored as part of this study. Previous monitoring results indicate that the existing levels are significantly lower than urban areas and typical of rural areas in the UK and Continental Europe. The contribution from the site in this context is minor, with levels at the worst-case receptor to the east of the site, under maximum and abnormal operation, remaining significantly below levels which would be expected in urban areas. Levels at the nearest residential receptor will be minor, with the annual contribution from the facility accounting for less than 1% of the existing background concentration under maximum operating conditions.

Hg

Hg modelling results indicate that the ambient ground level concentrations are below the relevant air quality standards for the protection of human health under maximum and abnormal operation of the site. Thus, no adverse impact on public health or the environment is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient mercury concentrations (including background concentrations) which are only 0.1% of the annual average limit value at the worst-case receptor.

Cd and Tl

Modelling results indicate that the ambient ground level concentrations will be below the relevant air quality standard for the protection of human health for cadmium under maximum and abnormal operation of the site. Emissions at maximum levels equate to ambient Cd and Tl concentrations (excluding background concentrations) which are no more than 7% of the EU annual target value for Cd close to the site boundary (the comparison is made with the Cd limit value as this is more stringent than that for Tl).

Hg

Modelling results indicate that the ambient ground level concentrations will be below the relevant air quality standards for the protection of human health for mercury under maximum and abnormal operations of the site. Emissions at maximum operations equate to an ambient Hg concentration (excluding background concentration) which is 0.03% of the annual target value for Cd close to the site boundary.

Sum of As, Sb, Pb, Cr, Co, Cu, Ni, Mn and V

Modelling results indicate that the ambient ground level concentrations are below the relevant air quality standards for the protection of human health for arsenic (As) and antimony (Sb) (the metals with the most stringent limit values) under maximum, average and abnormal operation of the site (based on the ratio of metals released from a similar facility in Belgium). Thus, no adverse impact on public health or the environment is envisaged to occur under these conditions at or beyond the site boundary. Ambient concentrations have been compared to the annual target value for As and the maximum 1-hour limit value for Sb as these represent the most stringent limit values for the suite of metals. Emissions at maximum operations equate to ambient As concentrations (excluding background concentrations) which are only 6% of the EU annual target value at the worst-case receptor whilst emissions at maximum operations equate to ambient Sb concentrations (excluding background concentrations) which are only 0.4% of the maximum 1-hour limit value at the worst-case receptor. Emissions under abnormal operations equate to ambient As concentrations (excluding background concentrations) which are only 34% of the annual limit value at the worst-case receptor whilst emissions at maximum operations equate to ambient Sb concentrations (excluding background concentrations) which are only 6% of the maximum 1-hour limit value at the worst-case receptor.

Summary

Modelling results indicate that the ambient ground level concentrations are below the relevant air quality standards or guidelines for the protection of human health for all compounds under maximum and abnormal operation of the site. The modelling results indicate that this maximum occurs near the site's boundary. Maximum operations are based on the emission concentrations outlined in EU Directive 2010/75/EU.

Concentrations fall off rapidly away from this maximum and the short-term limit values at the nearest residential receptor (not including background concentrations) are less than 11% of the short-term limit values. The annual average concentration has an even more dramatic decrease in maximum concentration away from the site with concentrations from emissions at the facility accounting for less than 5% of the limit value (not including background concentrations) at worst case sensitive receptors near the site. Thus, the results indicate that the impact from the facility is minor and limited to the immediate environs of the site.

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1.0 INTRODUCTION

The assessment was modelled on the maximum emission concentrations outlined in the Industrial Emissions Directive (2010/75/EU) and based on a maximum flue gas flow rate of 200,000 Nm^3/hr and also assumed 100% availability of the plant for 8760 hours per year. Modelling has been undertaken in line with EPA publication "*Air Dispersion Modelling From Industrial Installations Guidance Document*"(1).

Air dispersion modelling was carried out using the United States Environmental Protection Agency's (USEPA) regulatory model AERMOD. The aim of the study was to assess the impact in the ambient environment of emissions from the facility at the maximum emission limits outlined in Council Directive 2010/50/EC and also at a maximum stack emission flowrate (and at 75% of the maximum flow rate). Modelling was also conducted under abnormal operating conditions to assess any short-term impact due to these infrequent events. The study demonstrates that all substances which will be emitted from the facility will be at levels that are well below even the most stringent ambient air quality standards and guidelines. The dispersion model study consisted of the following components:

- Review of design emission levels and other relevant information needed for the modelling study;
- Identification of the significant substances which are released from the site;
- Review of background ambient air quality in the vicinity of the facility;
- Air dispersion modelling of significant substances released from the site;
- Identification of predicted ground level concentrations of released substances beyond the site boundary and at sensitive receptors in the immediate environment;
- A cumulative assessment of significant releases from the site taking into account the releases from all other significant industry in the area;
- Evaluation of the significance of these predicted concentrations, including consideration of whether these ground level concentrations are likely to exceed the most stringent ambient air quality standards and guidelines which have been set for the protection of human health;
- Impact on public health and the environment in the unlikely event of "abnormal" operating conditions.

Modelling and a subsequent impact assessment was undertaken for the following substances released from the site:

- Nitrogen dioxide (NO_2) and Nitrogen Oxides (NO_X)
- Sulphur Dioxide (SO_2)
- Total Dust (as PM_{10} and $PM_{2.5}$)
- Gaseous and vaporous organic substances expressed as total organic carbon (TOC)
- Hydrogen Chloride (HCl)
- Hydrogen Fluoride (HF)
- Ammonia (NH_3)
- PCDD/PCDFs (Dioxins/Furans)
- Mercury (Hg)
- Cadmium (Cd) and Thallium (Tl)
- And the sum of Antimony (Sb), Arsenic (As), Lead (Pb), Chromium (Cr), Cobalt (Co), Copper (Cu), Manganese (Mn), Nickel (Ni) and Vanadium (V).

2.0 ASSESSMENT METHODOLOGY

The air dispersion modelling input data consists of detailed information on the physical environment (including building dimensions and terrain features), design details from all emission points on-site and a full year of worst-case meteorological data. Using this input data, the model predicts ambient ground level concentrations beyond the site boundary for each hour of the modelled meteorological year. The model post-processes the data to identify the location and maximum of the worst-case ground level concentration in the applicable format for comparison with the relevant limit values. This worst-case concentration is then added to the existing background concentration to give the worst-case predicted ambient concentration. The worst-case ambient concentration is then compared with the relevant ambient air quality standard for the protection of human health to assess the significance of the releases from the site.

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

- Emissions from all emission points in the cumulative assessment were assumed to be operating at their maximum emission level, 24 hours/day over the course of a full year. This represents a very conservative approach as typical emission from the facility will be well within the emission limit values set out in the Industrial Emissions Directive.

- For the maximum scenario, emission points were assumed to be operating at their maximum volume flow, 24 hours/day over the course of a full year.

- For maximum operating scenario, it has been assumed that the emission point is operating for 24-hrs/day over the course of the full year and at the maximum levels allowed by the Industrial Emissions Directive.

- Abnormal operating emissions (above the emission limits of the Industrial Emissions Directive) were pessimistically assumed to occur every Monday of the year with the exception of metals (2 days every month) and dioxins (5 weeks/annum) and at maximum volume flow.

- Maximum predicted ambient concentrations for all pollutants measured within a 9 km radius of the site were reported in this study even though, in most cases, no residential receptors were near the location of this maximum ambient concentration. Concentrations at the nearest residential receptors are generally significantly lower than the maximum ambient concentrations reported.

- Worst-case background concentrations were used to assess the baseline levels of substances released from the site.

- The worst-case meteorological conditions for Dublin Airport over the five year period 2018 - 2022 have been used for each individual pollutant and averaging period. The worst-case year with regard to annual average concentrations was 2019, with annual average concentrations 8% higher than the five-year average. With regard to the 1-hour averaging period and limit values (i.e. maximum 1-hour, 99.8th%ile, 99.7th%ile), the worst-case year (2021) ranges from 3-35% higher than the five-year average. For the 8-hour period and 24-hour averaging period and limit values (i.e. 90.4th%ile, 99.2nd%ile), the worst-case year is 6% - 26% higher respectively than the five year average.

- A nested receptor grid was 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 inner receptor grid was based on Cartesian grids with the site at the centre. The grid extended over a distance of 2000m with concentrations calculated at 25m intervals. The middle receptor grid was also based on Cartesian grids with the site at the centre. The grid extended over a distance of 5000m with concentrations calculated at 50m intervals. The outer receptor grid was also based on Cartesian grids with the site at the centre. The grid extended over a distance of 18000m with concentrations calculated at 1000m intervals. Boundary receptor locations were also placed along the boundary of the site, at 25m intervals. Discrete sensitive receptors were created to represent residential homes in close proximity to the site. In total, 17044 calculation points were input into the air dispersion model.

- 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 gentle terrain. This takes account of all significant features of the terrain. All terrain features have been mapped in detail into the model using the terrain pre-processor AERMAP(11). The terrain in the region of the facility is complex in the sense that the maximum terrain in the modelling domain peaks at 179m which is above the stack top of all emission points onsite. However, the region of the site has moderate terrain in the immediate vicinity of the facility.

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.

In terms of ammonia (NH_3) emissions, the following standards in relation to human health have been applied for this assessment in the absence of EU or Irish standards for ammonia. An ambient air quality limit for ammonia by the UK Environment Agency (EA) entitled "*Air Emissions Risk Assessment For Your Environmental Permit*"(2) has outlined both short-term and long-term environmental assessment levels (EAL) for ammonia for the protection of human health as outlined in

Table 1.

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

Table 1 Air Quality Standards 2022 (Based on Directive 2008/50/EC)

Pollutant	Regulation/ Guideline	Limit Type	Value
Nitrogen Dioxide (NO_2)	2008/50/EC Note 1	Hourly limit for protection of human health - not to be exceeded more than 18 times/year	200 μg/m^3 Note 2
		Annual limit for protection of human health	40 μg/m^3
Carbon Monoxide (CO)	2008/50/EC	8-hour limit (on a rolling basis) for protection of human health	10,000 μg/m^3
Ammonia (NH_3)	UK Environment Agency (2003)	1-Hour	2,500 μg/m^3
		Annual	180 μg/m^3
	UNECE (2010)	Critical level for protection of vegetation (annual)	1-3 μg/m^3 Note 3
Particulate Matter (as PM_{10})	2008/50/EC	24-hour limit for protection of human health - not to be exceeded more than 35 times/year	50 μg/m^3
		Annual limit for protection of human health	40 μg/m^3
Particulate Matter (as $PM_{2.5}$) Stage 1	2008/50/EC	Annual limit for protection of human health	25 μg/m^3
Particulate Matter (as $PM_{2.5}$) Stage 2	2008/50/EC	Annual limit for protection of human health	20 μg/m^3 Note 4
Sulphur Dioxide (SO_2)	2008/50/EC	Hourly limit for protection of human health - not to be exceeded more than 24 times/year	350 μg/m^3
		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)	10-30 μg/m^3 Note 3
Lead	2008/50/EC	Annual limit for protection of human health	5 μg/m^3
Arsenic	2004/107/EC	Annual limit for protection of human health	6 ng/m^3
Cadmium	2004/107/EC	Annual limit for protection of human health	5 ng/m^3
Nickel	2004/107/EC	Annual limit for protection of human health	20 ngm^3

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

Note 2 μg/m^3 (micrograms per cubic metre)

Note 3 WHO (2000) 'Air quality guidelines for Europe'

Note 4 Stage 2 indicative limit value to be reviewed by the European Commission in 2013. Due to come into force in January 2020, however, no update from the Commission has been published.

2.2 Meteorological Data

Meteorological data is an important input into the air dispersion model. The local airflow pattern will be greatly influenced by the geographical location. Important features will be the location of hills and valleys or land-water-air interfaces and whether the site is located in simple or complex terrain.

The selection of the appropriate meteorological data has followed the guidance issued by the USEPA[(3)]. A primary requirement is that the data used should have a data capture of greater than 90% for all parameters. Two meteorological stations were identified near the site – Casement Aerodrome and Dublin Airport. Data collection of greater than 90% for all parameters is required for air dispersion modelling. Both Casement Aerodrome and Dublin Airport fulfil this requirement.

The additional requirements of the selection process depend on the representativeness of the data. The representativeness can be defined as "the extent to which a set of measurements taken in a space-time domain reflects the actual conditions in the same or different space-time domain taken on a scale appropriate for a specific application"[(4)]. The meteorological data should be representative of conditions affecting the transport and dispersion of pollutants in the area of interest as determined by the location of the sources and receptors being modelled.

The representativeness of the data is dependent on[(3)]:

1) the proximity of the meteorological monitoring site to the area under consideration,

2) the complexity of the terrain,

3) the exposure of the meteorological monitoring site (surface characteristics around the meteorological site should be similar to the surface characteristics within the modelling domain),

4) the period of time during which data is collected.

In the region of the site, Dublin Airport is the nearest suitable meteorological station to the site and due to its proximity the weather pattern experienced would be expected to be similar. On account of the modest terrain features to the north of the site, some channelling of wind may be expected to occur along the direction of the Boyne Valley. However, this would not be expected to be significant at stack height due to the modest nature and shallow gradient of this terrain feature.

The windrose from Dublin Airport for the years 2018-2022 is shown in Figure 1. The windrose indicates the prevailing wind speed and direction over the five-year period. The prevailing wind direction is generally from the W-SW direction with wind speeds averaging around 4-6 m/s.

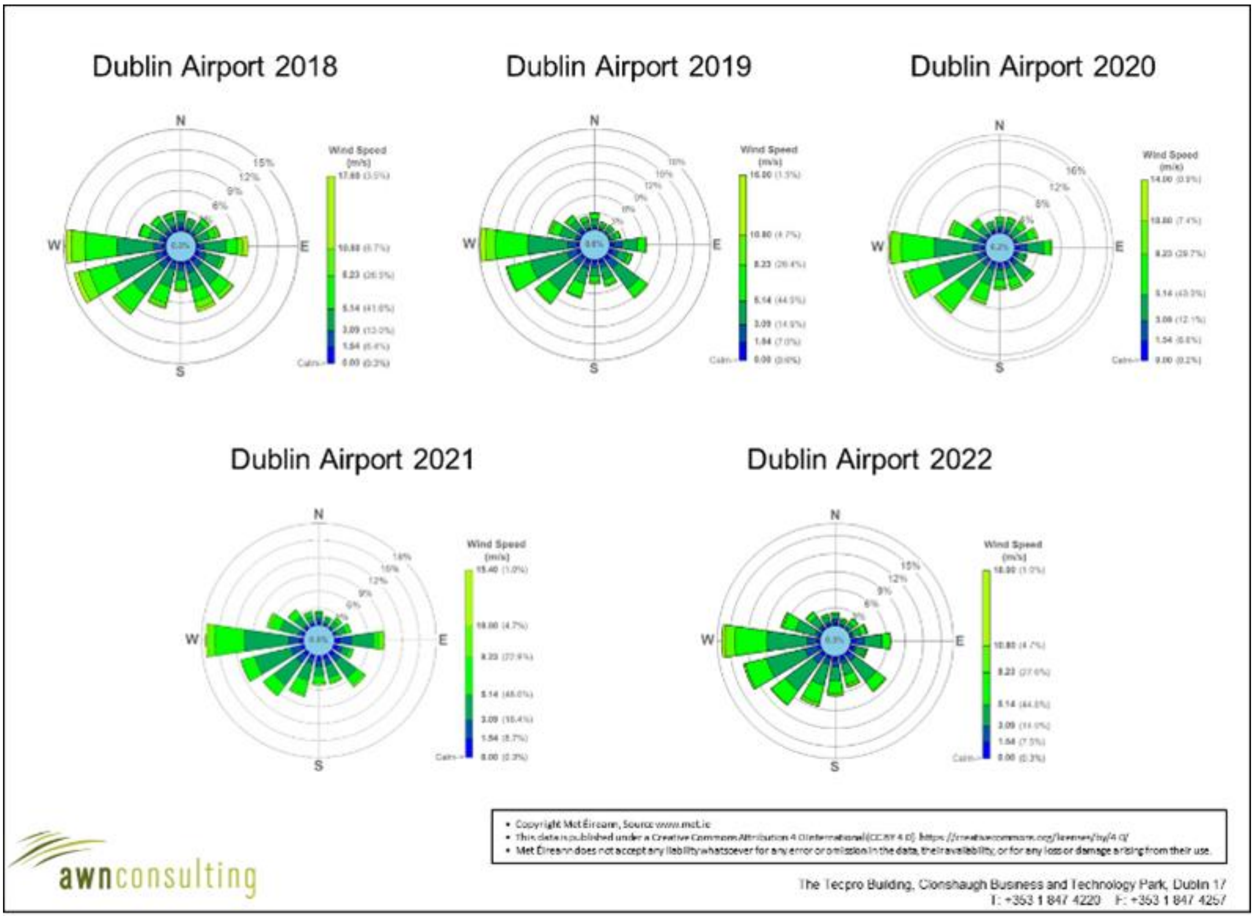

Figure 1 Dublin Airport Windrose 2018-2022

2.3 Modelling Methodology

Emissions from the site have been modelled using the AERMOD dispersion model (Version 22112) in conjunction with the AERMET pre-processor which has been developed by the U.S. Environmental Protection Agency (USEPA)[5]. The model is a steady-state Gaussian plume model used to assess pollutant concentrations associated with industrial sources. The model has been designated the regulatory model by the USEPA for modelling emissions from industrial sources in both flat and complex terrain[3]. An overview of the model is outlined in Appendix I with details on the input data to AERMET outlined in Appendix II.

The assessment methodology used in the current study was developed following the recommendations outlined in Council Directive 2010/75/EU. The Directive has outlined air emission limit values, which are to be complied with as set out in Table 2. The Directive has also outlined stringent operating conditions in order to ensure sufficient combustion of waste thus ensuring that dioxin formation is minimised. Specifically, the combustion gases must be maintained at a temperature of 850°C for at least two seconds under normal operating conditions for non-hazardous waste whilst for hazardous waste containing more than 1% halogenated organic substances, the temperature should be raised to 1100°C for at least two seconds. These measures will ensure that dioxins/furans and polychlorinated biphenyls (PCBs) are minimised through complete combustion of waste.

Specific emission measurement requirements have been outlined in the directive for each pollutant:

1) continuous measurements of the following substances; NO_x, CO, total dust, TOC, HCl, and SO_2.

2) bi-annual measurements of heavy metals, dioxins and furans.

Indaver Ireland is committed, as a minimum, to meeting all the requirements of Council Directive 2010/75/EU. Indeed, due to the advanced post-combustion flue gas cleaning technology employed, expected average emission values will be significantly lower than the values used in this study. The maximum and abnormal emission concentrations and mass emission rates have been detailed in Table 3.

***Table** 2* Council Directive 2010/75/EU, Air Emission Limit Values

Daily Average Values	**Concentration**	
Total Dust	10 mg/m^3	
Gaseous & vaporous organic substances expressed as total organic carbon (TOC)	10 mg/m^3	
Hydrogen Chloride (HCl)	10 mg/m^3	
Hydrogen Fluoride (HF)	1 mg/m^3	
Sulphur Dioxide (SO_2)	50 mg/m^3	
Nitrogen Oxides (as NO_2)	200 mg/m^3	
Half-hourly Average Values	**Concentration**	
	(100%)	**(97%)**
Total Dust(1)	30 mg/m^3	10 mg/m^3
Gaseous & vaporous organic substances expressed as total organic carbon (TOC)	20 mg/m^3	10 mg/m^3
Hydrogen Chloride (HCl)	60 mg/m^3	10 mg/m^3
Hydrogen Fluoride (HF)	4 mg/m^3	2 mg/m^3
Sulphur Dioxide (SO_2)	200 mg/m^3	50 mg/m^3
Nitrogen Oxides (as NO_2)	400 mg/m^3	200 mg/m^3
Average Value Over 30 mins to 8 Hours	**Concentration(2)**	
Cadmium and its compounds, expressed as Cd	Total 0.05 mg/m^3	
Thallium and its compounds, expressed as Tl		
Mercury and its compounds, expressed as Hg	0.05 mg/m^3	
Antimony and its compounds, expressed as Sb	Total 0.5 mg/m^3	
Arsenic and its compounds, expressed as As		
Lead and its compounds, expressed as Pb		
Chromium and its compounds, expressed as Cr		
Cobalt and its compounds, expressed as Co		
Copper and its compounds, expressed as Cu		
Manganese and its compounds, expressed as Mn		
Nickel and its compounds, expressed as Ni		
Vanadium and its compounds, expressed as V		
Average Values Over 6 – 8 Hours	**Concentration**	
Dioxins and furans	0.1 ng/m^3	
Average Value	**Concentration(3)**	
	Daily Average Value	**30 Min Average Value**
Carbon Monoxide	50 mg/m^3	100 mg/m^3

(1) Total dust emission may not exceed 150 mg/m^3 as a half-hourly average under any circumstances
(2) These values cover also the gaseous and vapour forms of the relevant heavy metals as well as their compounds
(3) Exemptions may be authorised for incineration plants using fluidised bed technology, provided that emission limit values do not exceed 100 mg/m^3 as an hourly average value.

Table 3 Air Emission Values From Waste-to-Energy Facility, Carranstown, Co. Meath

Daily Average Values Unless Stated Otherwise	**EU Maximum Emission Concentration**	**Maximum Operating Values Emission Rate (g/s)**	**Abnormal Emission Concentration**	**Abnormal Operating Values Emission Rate (g/s)**
Total Dust	10 mg/m^3	0.56	30 mg/m^3	1.67
Total Dust (Maximum Half-hour Average)	30 mg/m^3	1.67	30 mg/m^3	1.67
Total organic carbon (TOC)	10 mg/m^3	0.56	30 mg/m^3	1.67
Total organic carbon (TOC) (Maximum Half-hour Average)	20 mg/m^3	1.11	30 mg/m^3	1.67
Hydrogen Chloride (HCl)	10 mg/m^3	0.56	60 mg/m^3	3.33
Hydrogen Chloride (HCl) (Maximum Half-hour Average)	60 mg/m^3	3.33	60 mg/m^3	3.33
Hydrogen Fluoride (HF)	1 mg/m^3	0.056	4 mg/m^3	0.22
Hydrogen Fluoride (HF) (Maximum Half-hour Average)	4 mg/m^3	0.22	4 mg/m^3	0.22
Sulphur Dioxide (SO_2)	50 mg/m^3	2.78	200 mg/m^3	11.1
Sulphur Dioxide (SO_2) (Maximum Half-hour Average)	200 mg/m^3	11.1	200 mg/m^3	11.1
Nitrogen Oxides (as NO_2)	200 mg/m^3	11.1	400 mg/m^3	22.2
Nitrogen Oxides (as NO_2) (Maximum Half-hour Average)	400 mg/m^3	22.2	400 mg/m^3	22.2
Cadmium and its compounds, expressed as Cd	Total 0.05 mg/m^3	0.0028	Total 1 mg/m^3	0.056
Thallium and its compounds, expressed as Tl				
Mercury and its compounds, expressed as Hg	0.05 mg/m^3	0.0028	1 mg/m^3	0.056
Antimony, Arsenic, Lead, Chromium, Cobalt, Copper, Manganese, Nickel, Vanadium and their compounds, expressed as the relevant metal	Total 0.5 mg/m^3	0.028	Total 30 mg/m^3	1.67
Dioxins and furans	0.1 ng/m^3	5.6×10^{-9}	0.5 ng/m^3	2.8×10^{-8}
Carbon Monoxide	50 mg/m^3	2.8	200 mg/m^3	11.1
Carbon Monoxide (Maximum Half-hour Average)	100 mg/m^3	5.6	200 mg/m^3	11.1

2.4 Background Concentrations of Pollutants

Air quality monitoring programmes have been undertaken in recent years by the EPA and Local Authorities[6]. The most recent annual report on air quality at the time of this assessment, "*Air Quality in Ireland 2021*"[7], 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[7]. 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, Carranstown is at the boundary of Zone C and Zone D and thus as a worst-case Zone C baseline data has been assumed[7].

With regard to NO_2, continuous monitoring data from the EPA[7], at suburban Zone C background locations in Kilkenny, Portlaoise and Dundalk show that current levels of NO_2 are below both the annual and 1-hour limit values, with annual average levels ranging from 4 - 11 µg/m^3 in 2021 (see Table 4). Sufficient data is available for the stations in Kilkenny, Portlaoise and Dundalk and to observe the long-term trend over the period 2018 – 2021 with annual average results ranging from 4 – 14 µg/m^3. Based on these results, a conservative estimate of the background NO_2 concentration in the region of the proposed development in 2021 is 14 µg/m^3.

Table 4 Annual Mean and 99.8th Percentile 1-Hour NO_2 Concentrations In Zone C Locations (µg/m^3)

Station	Averaging Period	Year				
		2017	2018	2019	2020	2021
Kilkenny	Annual Mean NO_2 (µg/m^3)	5	6	5	4	4
	99.8th%ile 1-hr NO_2 (µg/m^3)	41	44	41	45	42
Portlaoise	Annual Mean NO_2 (µg/m^3)	11	11	11	11	8
	99.8th%ile 1-hr NO_2 (µg/m^3)	60	68	60	52	49
Dundalk	Annual Mean NO_2 (µg/m^3)	-	14	12	10	11
	99.8th%ile 1-hr NO_2 (µg/m^3)	-	67	69	73	67

Note 1 Annual average limit value of 40 µg/m^3 and hourly limit value of 200 µg/m^3 (EU Council Directive 2008/50/EC & S.I. No. 739 of 2022)

The Plume Volume Molar Ratio Method (PVMRM) was used to model NO_2 concentrations. The PVMRM is currently a non-regulatory option in AERMOD which assumes that the amount of NO converted to NO_2 is proportional to the ambient ozone concentration[8,9]. The PVMRM uses both plume size and O_3 concentration to derive the amount of O_3 available for the reaction between NO and O_3. NO_X moles are determined by emission rate and travel time through the plume segment. 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 20% of the NO_X in the stack gas is already in the form of NO_2 before the gas leaves the stack (in reality the levels are usually closer to 5%). The model has also assumed a final equilibrium ratio for NO_2/NO_X of 0.90 which again is pessimistic and more likely to be in the range 0.7 – 0.8. The equation used in the algorithm to derive the ratio of NO_2/NO_X gas combustion is:

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

A background ozone concentration of 57 µg/m^3 was used in the modelling assessment, based on a review of worst case background ozone data for Zone C sites[7].

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.

CO

In terms of CO, monitoring has been conducted at the suburban traffic Zone C sites of Portlaoise and Dundalk over the period 2017 – 2021. Monitored concentrations are significantly below the ambient limit value of 10 mg/m^3. Maximum 8-hour concentrations at the Dublin Airport site ranged from 0.1 mg/m^3 – 0.5 mg/m^3 over the period 2017 – 2021(7) Based on these results a background 8-hour CO concentration of 0.5 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.

NH_3

An EPA research study entitled “Ambient Atmospheric Ammonia in Ireland, 2013-2014”(10) has been used to inform background ammonia concentrations. A background value of 1 µg/m^3 has been added to the annual mean modelled process concentration for ammonia.

PM_{10}

Continuous PM_{10} monitoring carried out at the Zone C suburban background locations of Galway, Ennis, Portlaoise and Dundalk showed annual mean concentrations ranging from 11–19 µg/m^3 in 2021 (see Table 5) with at most 17 exceedances (in Ennis) of the daily limit value of 50 µg/m^3 (35 exceedances are permitted per year)(7). Sufficient data is available for Galway, Ennis, Portlaoise and Dundalk to observe trends over the period 2018 – 2021. Average annual mean PM_{10} concentrations ranged from 10 – 19 µg/m^3 over the period of 2018–2021, suggesting an upper average concentration of no more than 19 µg/m^3. Based on these results, a conservative estimate of the background PM_{10} concentration in the region of the proposed development is 19 µg/m^3.

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(11) and the EPA(1) 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 35 µg/m^3 was used in the assessment, based on average concentrations for Galway, Ennis, Portlaoise and Dundalk over the period 2018 – 2021.

Table 5 Annual Mean and 24-Hour Mean PM_{10} Concentrations In Zone C Locations (µg/m^3)

Station	Averaging Period	Year				
		2017	2018	2019	2020	2021
Galway	Annual Mean PM_{10} (µg/m^3)	-	15	13	13	11
	24-hr Mean > 50 µg/m^3 (days)	-	0	0	1	1
	90th%ile of 24-hr Means	24	-	-	20	19
Ennis	Annual Mean PM_{10} (µg/m^3)	16	16	18	20	19
	24-hr Mean > 50 µg/m^3 (days)	9	4	12	19	17
	90th%ile of 24-hr Means	29	27	34	34	35
Portlaoise	Annual Mean PM_{10} (µg/m^3)	10	11	15	12	11
	24-hr Mean > 50 µg/m^3 (days)	0	1	0	0	1
	90th%ile of 24-hr Means	17	18	27	21	20
Dundalk	Annual Mean PM_{10} (µg/m^3)	-	15	14	13	12
	24-hr Mean > 50 µg/m^3 (days)	-	0	2	2	0
	90th%ile of 24-hr Means	-	24	-	23	19

Note 1 Annual average limit value of 40 µg/m^3 and hourly limit value of 200 µg/m^3 (EU Council Directive 2008/50/EC & S.I. No. 739 of 2022)

$PM_{2.5}$

Continuous $PM_{2.5}$ monitoring carried out at the Zone C suburban background locations of Ennis and Bray showed annual mean concentrations ranging from 6 – 15 µg/m^3 in 2021 (see Table 6)[(7)]. Sufficient data is available for Ennis and Bray to observe trends over the period 2017 – 2021. Average annual mean $PM_{2.5}$ concentrations ranged from 5 – 15 µg/m^3 over the period of 2017–2021, suggesting an upper average concentration of no more than 15 µg/m^3. Based on this information, a conservative estimate of the background $PM_{2.5}$ concentration in the region of the proposed development is 15 µg/m^3.

Table 6 Annual Mean $PM_{2.5}$ Concentrations In Zone C Locations (µg/m^3)

Station	Averaging Period	Year				
		2017	2018	2019	2020	2021
Ennis	Annual Mean $PM_{2.5}$ (µg/m^3)	11	10	14	14	15
Bray	Annual Mean $PM_{2.5}$ (µg/m^3)	5	6	7	5	6

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

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 2.2 – 4.0 µg/m^3 in 2021 (see Table 7)[(7)]. Sufficient data is available for Ennis, Portlaoise and Dundalk to observe trends over the period 2017 – 2021. Average annual mean SO_2 concentrations ranged from 1.3 – 5.9 µg/m^3 over the period of 2017–2021, 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 proposed development is 6 µg/m^3. Over the period 2017 – 2021, the 99.7th%ile of the 1-hour mean at Ennis ranged from 32 – 67 µg/m^3, and the 99.2nd%ile of the 24-hour mean ranged from 15 – 33 µg/m^3. A conservative estimate of the 99.7th%ile 1-hour mean background in the region of the proposed development is 67 µg/m^3 and a 99.2nd%ile 24-hour mean background is 33 µg/m^3.

Table 7 Annual Mean, 1-Hour and 24-Hour Mean SO_2 Concentrations In Zone C Locations (μg/m^3)

Station	Averaging Period	Year				
		2017	2018	2019	2020	2021
Ennis	Annual Mean SO_2 (μg/m^3) Note 1	3.4	3.2	3.6	4.4	5.9
Portlaoise	Annual Mean SO_2 (μg/m^3)	2.4	3.0	1.3	1.6	1.9
Dundalk	Annual Mean SO_2 (μg/m^3)	-	3.8	1.5	2.0	2.3

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)

2.5 Process Emissions

Indaver Ireland has one main process emission point (Stack A1-1). The operating details of this major emission point has been taken from information supplied by Indaver Ireland and are outlined in Table 8 with buildings model input data is shown in Table 9.

Table 8 Process Emission Design Details

Stack Reference	Stack Co-ordinates (ITM)	Stack Height (m O.D.)	Exit Diameter (m)	Cross-Sectional Area (m^2)	Temp (K)	Volume Flow (Nm^3/hr)$^{(1)}$	Actual Volume Flow (m^3/s)$^{(1)}$	Exit Velocity (m/sec actual)
A1-1 Maximum Operation	E 706260 N 770982	95.5	2.2	3.80	413	200,000	73.6	19.4$^{(2)}$
A1-1 - 75% Of Maximum Flow		95.5	2.2	3.80	413	150,000	55.2	14.5$^{(2)}$

(1) Normalised to 273K, 11% Oxygen, dry gas.
(2) Actual - 413K, 6.5% Oxygen, 21.5% H_2O

Table 9 Building Model Input Data

Building / Tier Reference	Base Elevation (m O.D.)	Height (m)	Length (m)	Width	Angle (°)
Tipping Hall	30.5	21	36.4	35.2	144.2
Furnace / Boiler Room	30.5	40	70.7	25.8	144.2
Cranelift	30.5	34	27.0	44.3	144.2
Flue Gas Cleaning	30.5	29.6	34.3	30.4	144.2
Warehouse	30.5	12	25.0	45.0	52.3

Emissions from the site have been assessed for maximum, 75% of maximum and at abnormal operating conditions. The AERMOD model was run using a unitised emission rate of 1 g/s. The unitised concentration output has then been adjusted for each substance based on the specific emission rate of each.

In order to obtain the predicted environmental concentration (PEC), background data was added to the process emissions. In relation to the annual averages, the ambient background concentration was added directly to the process concentration. However, in relation to the short-term peak concentrations, concentrations due to emissions from elevated sources cannot be combined in the same way. Guidance from the UK DEFRA(10) advises that for SO_2 and PM_{10} an estimate of the maximum combined pollutant concentration can be obtained as shown below:

SO_2 - The 99.7th%ile of total 1-hour SO_2 is equal to the maximum of either A or B below:
a) 99.7th%ile hourly background SO_2 + (2 x annual mean process contribution SO_2)

b) 99.7th%ile hourly process contribution SO_2 + (2 x annual mean background contribution SO_2)

SO_2 - The 99.2th%ile of total 24-hour SO_2 is equal to the maximum of either A or B below:
a) 99.2th%ile of 24-hour mean background SO_2 + (2 x annual mean process contribution SO_2)
b) 99.2th%ile 24-hour mean process contribution SO_2 + (2 x annual mean background contribution SO_2).

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}

The above formulae were used along with EPA monitoring data[7] to derive the appropriate background concentrations which were subsequently used in the assessment of the impact of the facility in the surrounding environment.

3.0 MODELLING RESULTS

Emissions from the site has been modelled using the AERMOD dispersion model which is the USEPA's regulatory model used to assess pollutant concentrations associated with industrial sources[1,3]. Emissions have been assessed, firstly under the maximum emissions limits of the EU Directive 2010/75/EU and secondly under abnormal operating conditions. Results for the worst-case year are presented below. Data for all five years of normal operation at 100% volume flow are outlined in Appendix III.

3.1 Nitrogen Dioxide Emissions and Results

Nitrogen oxides (NO_X), containing both nitrogen oxide (NO) and nitrogen dioxide (NO_2) are emitted from the combustion process on-site, although it is the latter which is considered the more harmful to human health. These combustion processes lead to emissions which are mainly in the form of nitrogen oxide (NO) (typically 95%) with small amounts of the more harmful nitrogen dioxide.

Ambient Ground Level Concentrations (GLCs) of Nitrogen Dioxide have been predicted for the following scenarios in Table 10.

Table 10 Emission Scenario for Nitrogen Dioxide

Pollutant	Scenario	Concentration	Emission Rate (g/s)
NO_2	Maximum 1-Hour Operation	400 mg/m^3	22.2
	Maximum 24-Hour Operation	200 mg/m^3	11.1
	Abnormal Operation(1)	400 mg/m^3	22.2

(1) Abnormal operation scenario based on an emission level of 400 mg/m^3 for two hours every Monday for a full year.

Abnormal Operation

Elevated levels of NO_X may occur due to the malfunctioning of the de-NOx system. Such conditions will be detected immediately from an elevation in the NO_2 emission value which will be continuously observed on the computerised control system in the control room. An automatic alarm will be activated well in advance of exceedance of the emission limit value to allow adequate time for intervention. Therefore for the purpose of the air modelling study the following abnormal operation conditions were used: 2hrs of operation at an emission value of 400 mg/Nm^3.

Modelling was carried out for the scenarios described above. Table 11 details the predicted annual average and maximum one-hour NO_2 GLC for each scenario at the worst-case locations.

Table 11 Dispersion Model Results – Nitrogen Dioxide

Pollutant / Scenario	Background (μg/m^3)(1)	Averaging Period	Process Contribution (μg/m^3)	Predicted Emission Concentration (μg/Nm^3)	Standard(2) (μg/Nm^3)
NO_2 / Maximum Operation	14	Annual Mean	0.78	14.8	40
	28	99.8th%ile of 1-hr means	27.2	55.2	200
NO_2 / Abnormal Operation	14	Annual Mean	0.79	14.9	40
	28	99.8th%ile of 1-hr means	27.2	55.2	200
NO_x / Maximum Operation	20	Annual Mean	1.4	21.4	30
NO_x / Abnormal Operation	20	Annual Mean	1.4	21.4	30

(1) Directive 2008/50/EC

Concentration Contours

The geographical variation in NO_2 ground level concentrations beyond the site boundary are illustrated as concentration contours in Figures 2 to 3.

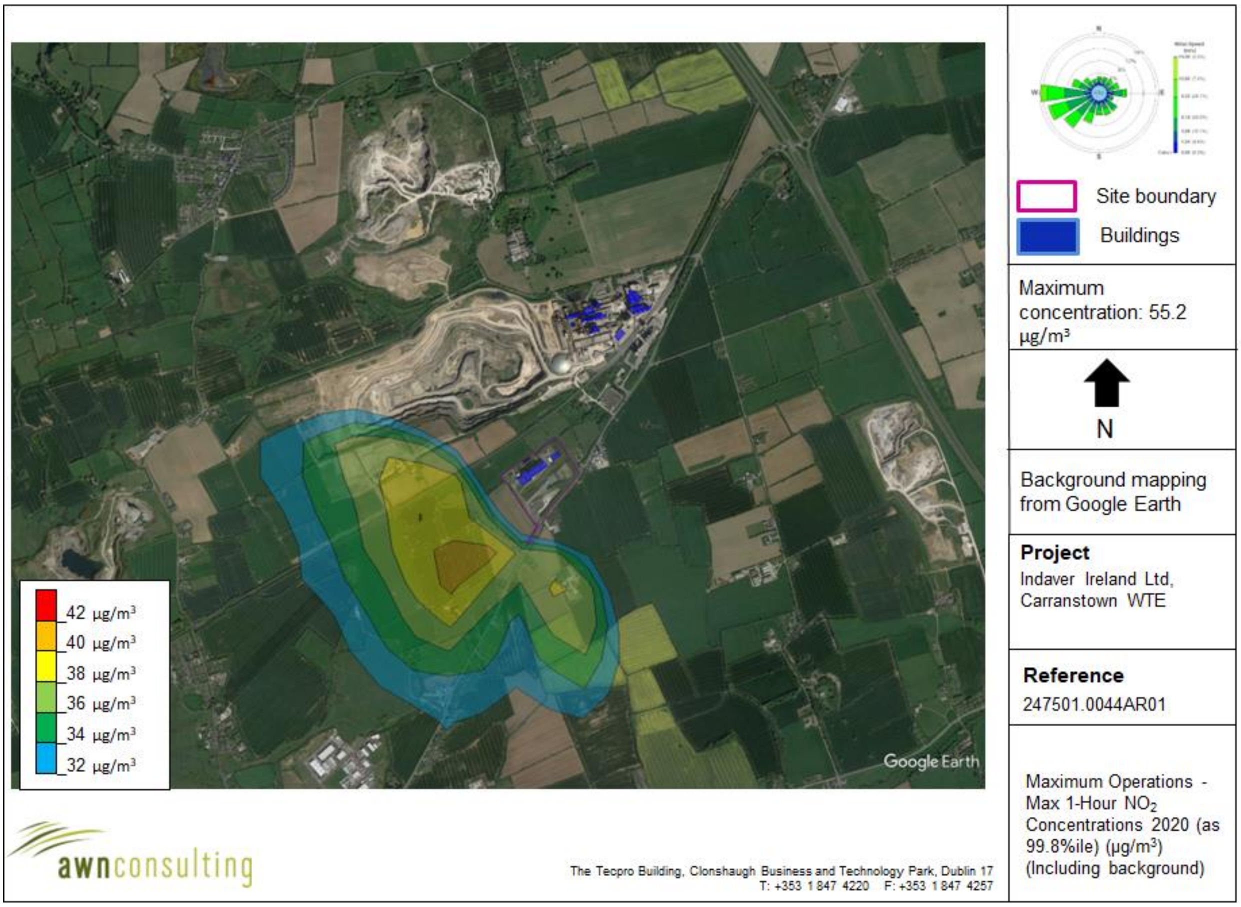

Figure 2 Maximum Operations: Predicted NO_2 99.8th Percentile Concentration (Year 2020)

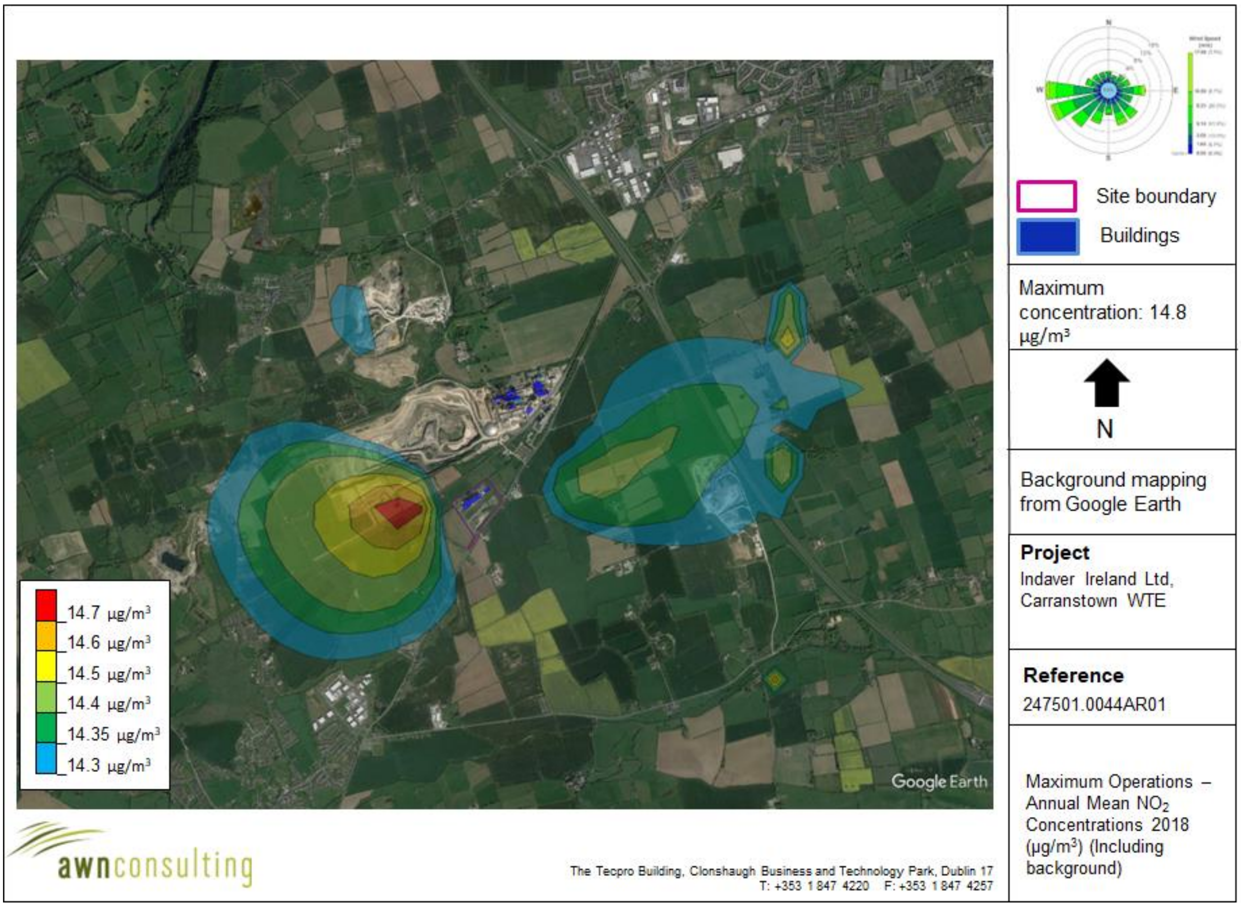

Figure 3 Maximum Operations: Predicted NO_2 Annual Average Concentration (Year 2018)

Result Findings

In relation to the maximum one-hour limit value, NO_2 modelling results indicate that the ambient ground level concentrations are below these ambient standards for the protection of human health under 75% volume flow, maximum and abnormal operation of the site. Thus, no adverse impact on public health or the environment is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient NO_2 concentrations (including background concentrations) which are 28% of the maximum ambient 1-hour limit value (measured as a 99.8th%ile) at the worst-case receptor (500m south-west of the site-boundary). The annual average concentration (including background concentration) is also significantly below the limit value for the protection of human health accounting for 36% of the annual limit value at the worst-case receptor which is located 600m west of the site. The impact under abnormal operation is essentially unchanged compared to normal operation due to the infrequent nature of the occurrence (approximately 1% of the time in any one week).

The modelling results indicate that the maximum 1-hour and annual average concentrations occur at or near the site's north-west to eastern boundaries. Concentrations fall off rapidly away from this maximum and for the maximum 1-hour concentration (as a 99.8th%ile) will be only 11% of the limit value (not including background concentrations) at the nearest sensitive receptor to the site.

In relation to the annual limit value for the protection of ecosystems, NO_x modelling results indicate that the ambient ground level concentrations are below these ambient standards for the protection of ecologically sensitive areas under maximum and abnormal operation of the site. Thus, no adverse impact on public health or the environment is envisaged to occur under these conditions at or beyond the site boundary. At the closest SAC/SPA, the River Boyne and River Blackwater SAC/SPA which at the closest point is 3.3km north of the facility, levels will be imperceptible.

3.2 Sulphur Dioxide and Total Dust (as PM_{10} and $PM_{2.5}$) Emissions and Results

Ambient Ground Level Concentrations (GLC's) of Sulphur Dioxide (SO_2) and Total Dust (as PM_{10} and $PM_{2.5}$) have been predicted for the following scenarios in Table 12.

Table 12 Emission Scenario for Sulphur Dioxide and Total Dust (as PM_{10} and $PM_{2.5}$)

Pollutant	Scenario	Concentration	Emission Rate (g/s)
SO_2	Maximum 1-Hour Operation	200 mg/m^3	11.1
	Maximum 24-Hour Operation	50 mg/m^3	2.78
	Abnormal Operation(1)	200 mg/m^3	11.1
Total Dust	Maximum 24-Hour Operation	10 mg/m^3	0.56
	Abnormal Operation(2)	30 mg/m^3	1.67

(1) Abnormal operation scenario based on an emission level of 200 mg/m^3 for six hours every Monday for a full year.
(2) Abnormal operation scenario based on an emission level of 30 mg/m^3 for eight hours every Monday for a full year.

Comparison with Standards And Guidelines

The relevant air quality standards for Sulphur Dioxide, PM_{10} and $PM_{2.5}$ have been detailed in Table 13. In this report the ambient air concentrations for SO_2 and PM_{10} have been referenced to Council Directive 2008/50/EC and S.I. 739 of 2022.

Table 13 EU Ambient Air Quality Standards

Pollutant	Regulation	Limit Type	Value
Sulphur Dioxide	2008/50/EC	Hourly limit for protection of human health - not to be exceeded more than 24 times/year	350 µg/m^3
		Daily limit for protection of human health - not to be exceeded more than 3 times/year	125 µg/m^3
		Annual & Winter limit for the protection of ecosystems	20 µg/m^3
PM_{10}	2008/50/EC	24-hour limit for protection of human health - not to be exceeded more than 35 times/year	50 µg/m^3
		Annual limit for protection of human health	40 µg/m^3
$PM_{2.5}$	2008/50/EC	Annual limit for protection of human health	25 µg/m^3

Modelling Results

Tables 14 - 16 details the predicted SO_2, PM_{10} and $PM_{2.5}$ GLC for each scenario.

Table 14 Dispersion Model Results – Sulphur Dioxide

Pollutant / Scenario	Background (µg/m^3)	Averaging Period	Process Contribution (µg/m^3)	PEC (µg/Nm^3)(2)	Standard(1) (µg/Nm^3)
SO_2 / Maximum Operation	67	99.7th%ile of 1-hr means	29.2	67.7	350
	33	99.2th%ile of 24-hr means	2.7	33.7	125
	6	Annual Mean	0.34	6.3	20
SO_2 / Abnormal Operation	67	99.7th%ile of 1-hr means	29.2	67.8	350
	33	99.2th%ile of 24-hr means	3.1	33.8	125
	6	Annual Mean	0.38	6.4	20

(1) Directive 2008/50/EC
(2) PEC determined using UK DEFRA guidance.

Table 15 Dispersion Model Results – Total Dust (referenced to PM_{10})

Pollutant / Scenario	**Annual Mean Background (µg/m³)**	**Averaging Period**	**Process Contribution (µg/m³)**	**PEC (µg/Nm³) (2)**	**Standard(1) (µg/Nm³)**
PM_{10} / Maximum	35	90.4th%ile of 24-hr means	0.23	35.1	50
	19	Annual mean	0.07	19.1	40
PM_{10} / Abnormal Operation	35	90.4th%ile of 24-hr means	0.27	39.1	50
	19	Annual mean	0.08	20.1	40

(1) Directive 2008/50/EC
(2) PEC determined using UK DEFRA guidance.

Table 16 Dispersion Model Results – Total Dust (referenced to $PM_{2.5}$)

Pollutant / Scenario	**Annual Mean Background (µg/m³)**	**Averaging Period**	**Process Contribution (µg/m³)**	**PEC (µg/Nm³)**	**Limit Value(1) (µg/Nm³)**
$PM_{2.5}$ / Maximum	15	Annual mean	0.07	15.1	25
$PM_{2.5}$ / Abnormal Operation	15	Annual mean	0.08	15.1	25

(1) 2008/50/EC
(2) PEC determined using UK DEFRA guidance.

Concentration Contours

The geographical variation in SO_2, PM_{10} and $PM_{2.5}$ ground level concentrations beyond the site boundary are illustrated as concentration contours in Figures 4 - 7.

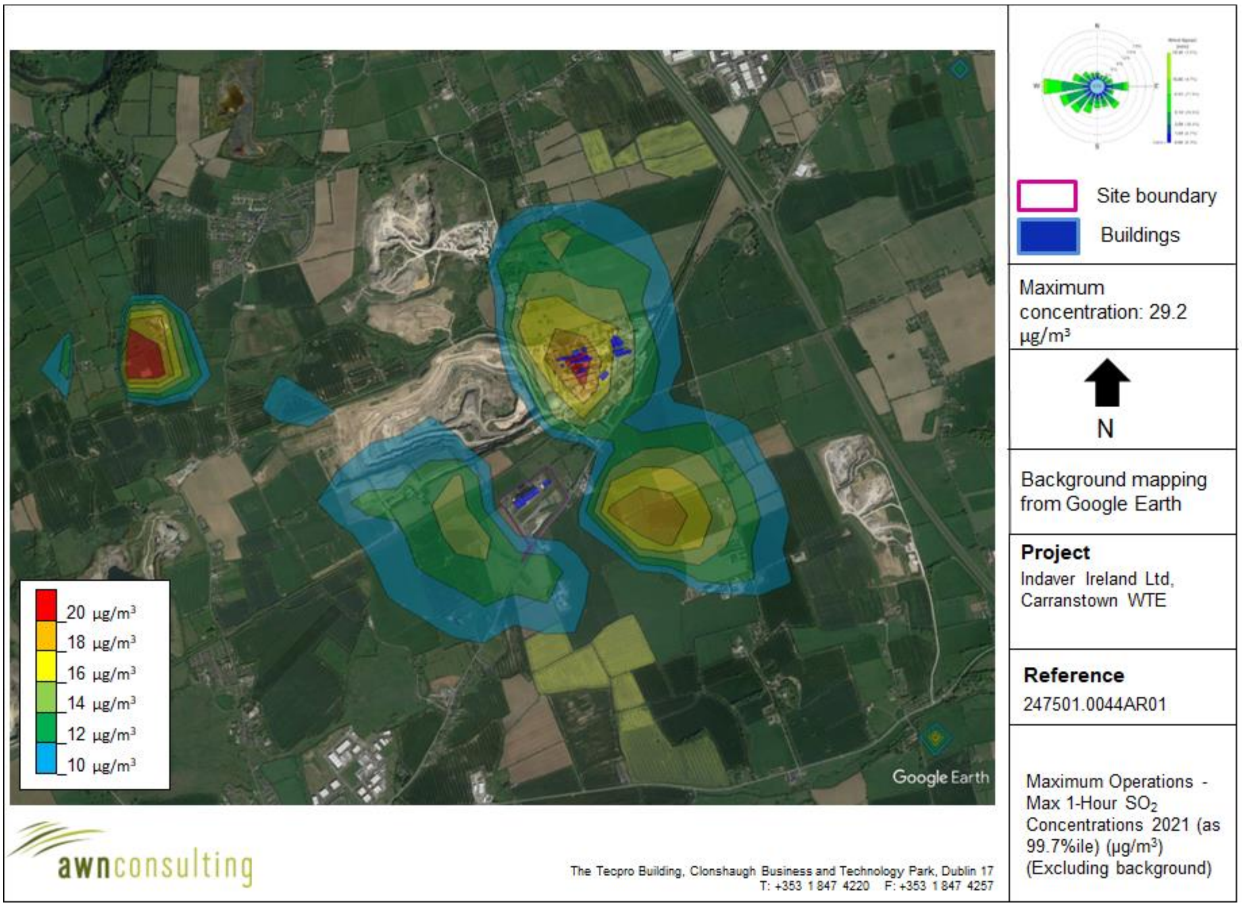

Figure 4 Maximum Operations: Predicted SO_2 99.7th Percentile of Hourly Concentrations (Year 2021)

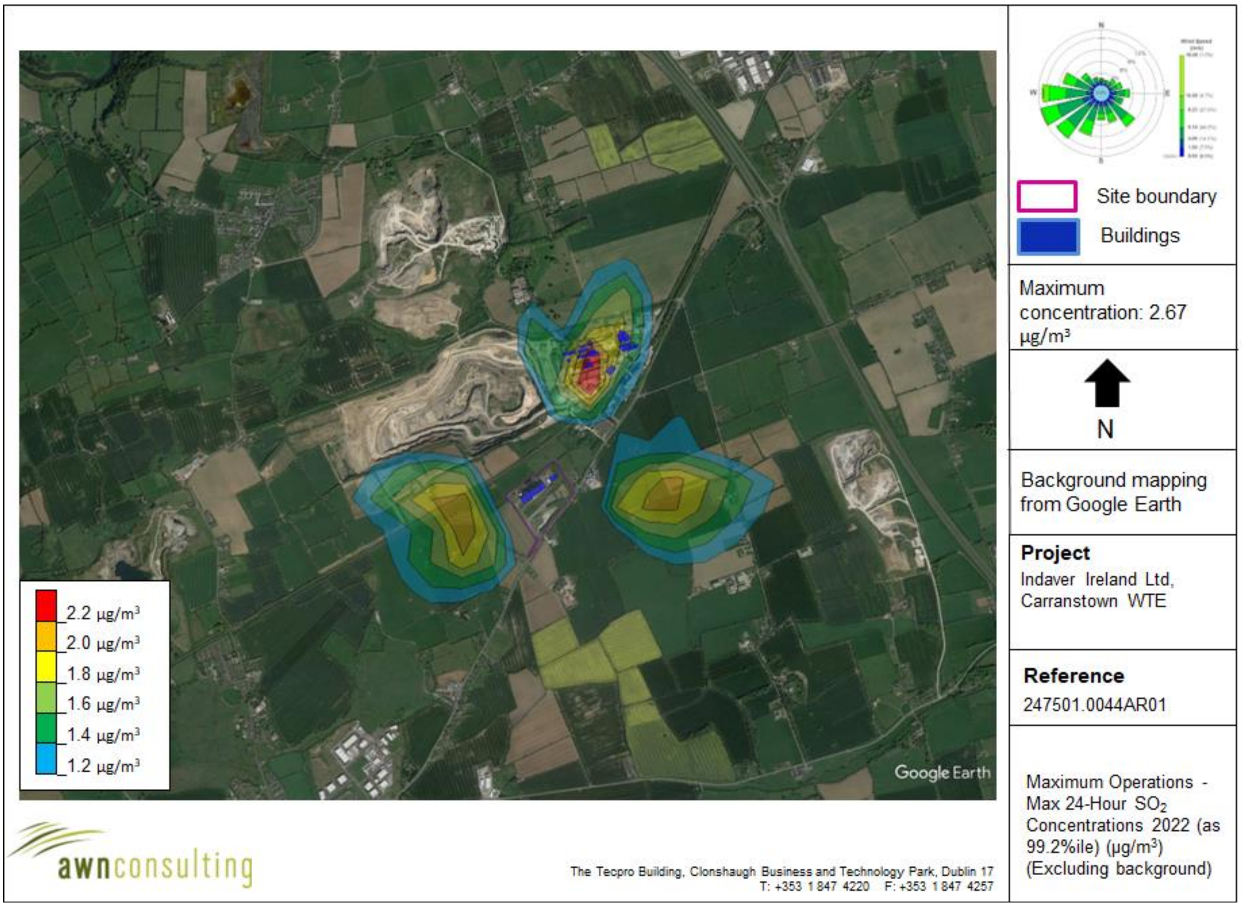

Figure 5 Maximum Operations: Predicted SO_2 99.2nd %ile of 24-Hourly Concentrations (Year 2022)

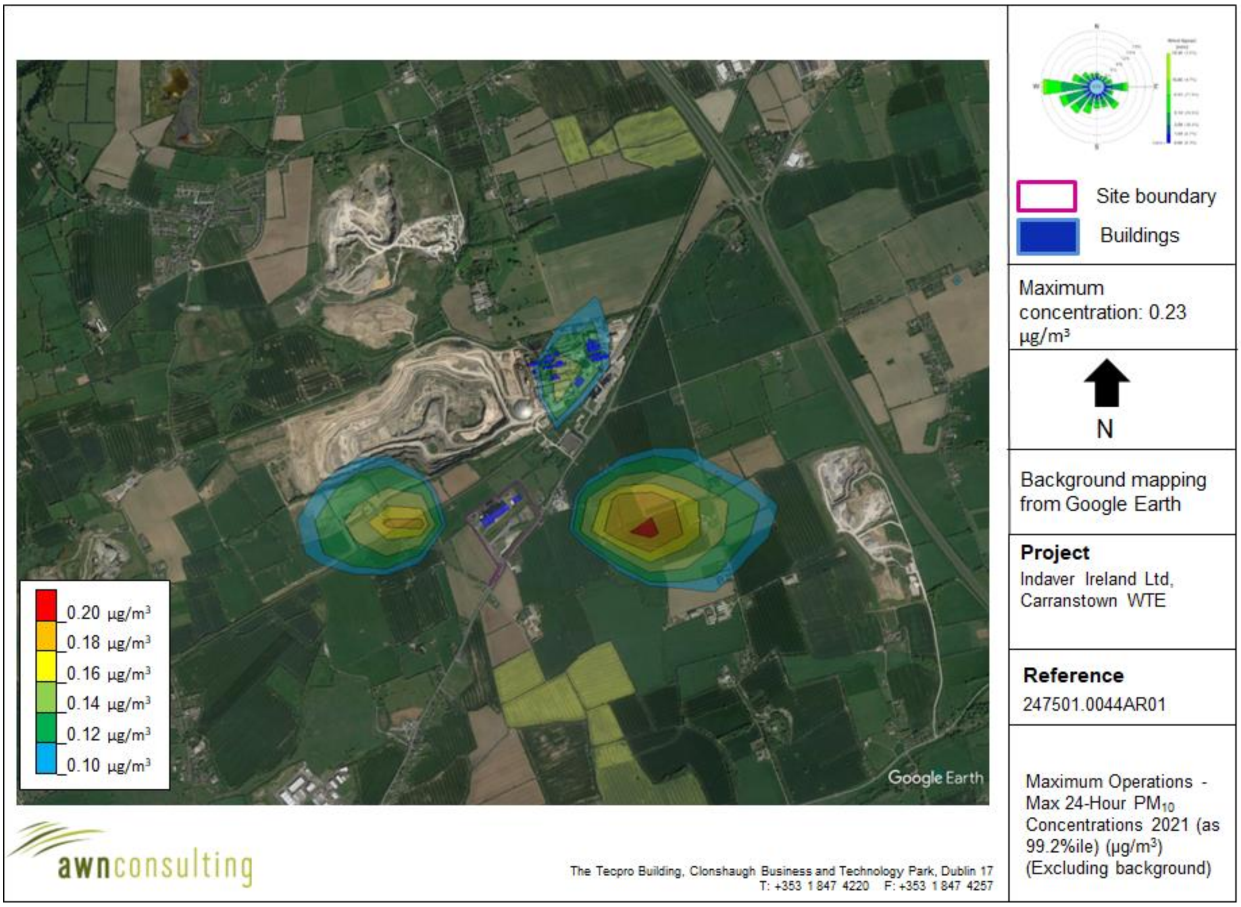

Figure 6 Maximum Operations: Predicted PM_{10} 90.4th %ile of 24-Hourly Concentrations (Year 2021)

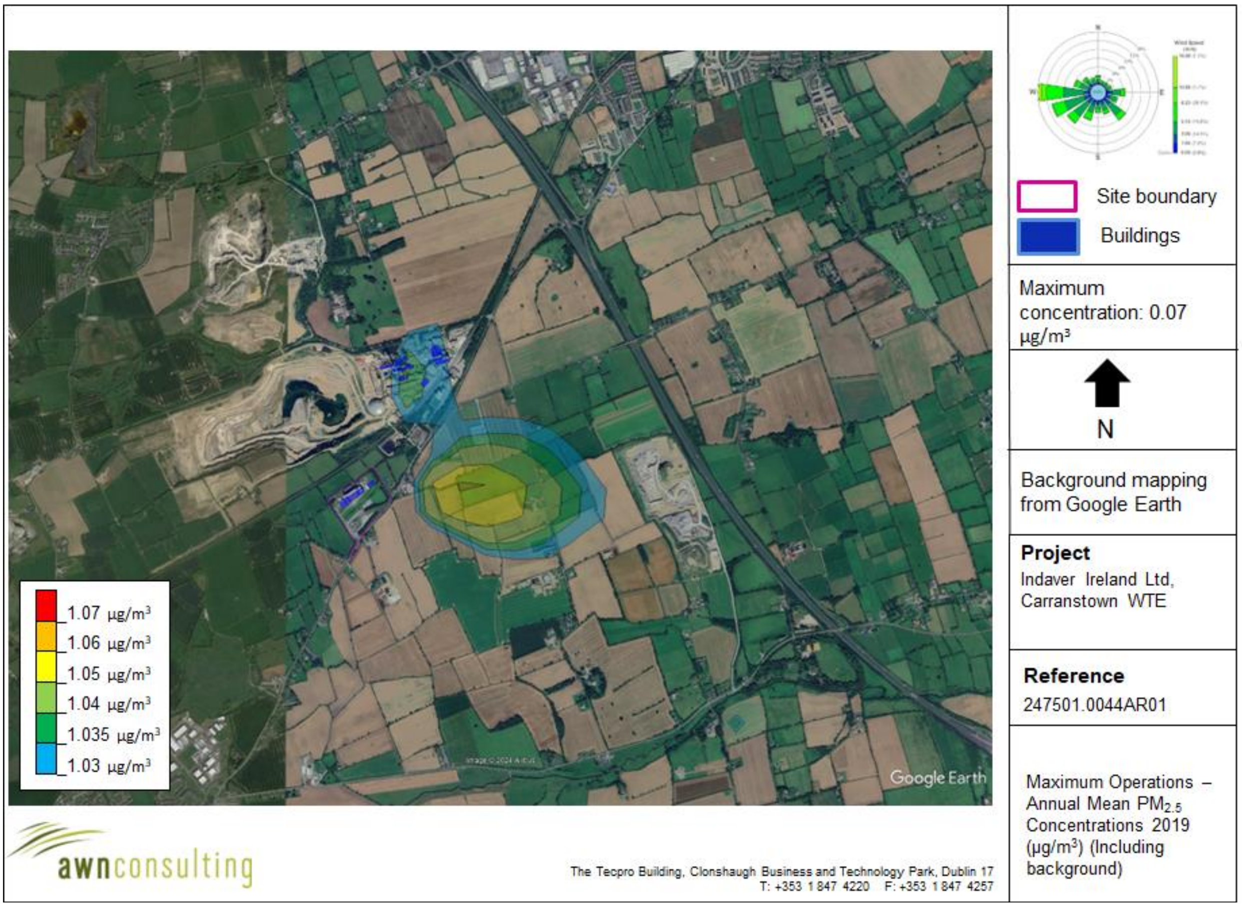

Figure 7 Maximum Operations: Predicted $PM_{2.5}$ Annual Average Concentration (Year 2019)

Result Findings

SO_2

SO_2 modelling results indicate that the ambient ground level concentrations are below the relevant air quality standards for the protection of human health for sulphur dioxide under maximum and abnormal operation of the site. Thus, no adverse impact on public health or the environment is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient SO_2 concentrations (including background concentrations) which are 19% of the maximum ambient 1-hour limit value (measured as a 99.7th%ile) and 27% of the maximum ambient 24-hour limit value (measured as a 99.2th%ile) at the worst-case receptor.

In relation to the annual limit value for the protection of ecosystems, SO_2 modelling results indicate that the ambient ground level concentrations are below these ambient standards for the protection of ecologically sensitive areas under maximum and abnormal operation of the site. Thus, no adverse impact on public health or the environment is envisaged to occur under these conditions at or beyond the site boundary. Levels will be imperceptible at the closest SAC/SPA, the River Boyne and River Blackwater SAC/SPA, which at the closest point is 3.3km north of the facility.

PM_{10}

PM_{10} modelling results indicate that the ambient ground level concentrations are below the relevant air quality standards for the protection of human health for PM_{10} under maximum and abnormal operation of the site. Thus, no adverse impact on public health or the environment is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient PM_{10} concentrations (including background concentrations) which are 70% of the maximum ambient 24-hour limit value (measured as a 90.4th%ile) and 48% of the annual average limit value at the worst-case receptor. The contribution from the facility equates to 0.5% and 0.2% of the 24-hour and annual limit values respectively under maximum operating conditions.

$PM_{2.5}$

$PM_{2.5}$ modelling results indicate that the ambient ground level concentrations are below the air quality standard for the protection of human health for $PM_{2.5}$ under average, maximum and abnormal operation of the site. Thus, no adverse impact on public health or the environment is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient $PM_{2.5}$ concentrations (including background concentrations) which are 60% of the annual average limit value at the worst-case receptor, with the contribution from the facility equating to 0.3% of the limit value.

3.3 Total Organic Carbon (TOC), Ammonia, Hydrogen Chloride and Hydrogen Fluoride Emissions and Results

Ambient Ground Level Concentrations (GLC's) of Total Organic Carbon (TOC), Ammonia (NH_3), Hydrogen Chloride (HCl) and Hydrogen Fluoride (HF) have been predicted for the following scenarios in Table 17.

Table 17 Emission Scenario for TOC, NH_3, HCl and HF

Pollutant	Scenario	Concentration	Emission Rate (g/s)
TOC	Maximum 1-Hour Operation	20 mg/m^3	1.11
	Maximum 24-Hour Operation	10 mg/m^3	0.56
	Abnormal Operation(1)	30 mg/m^3	1.67
HCl	Maximum 1-Hour Operation	60 mg/m^3	3.33
	Maximum 24-Hour Operation	10 mg/m^3	0.56
	Abnormal Operation(2)	60 mg/m^3	3.33
HF	Maximum 1-Hour Operation	4mg/m^3	0.222
	Maximum 24-Hour Operation	1 mg/m^3	0.056
	Abnormal Operation(3)	4 mg/m^3	0.222
NH_3	Maximum 24-Hour Operation	15 mg/m^3	0.833

(1) Abnormal operation scenario based on an emission level of 30 mg/m^3 for eight hours every Monday for a full year.
(2) Abnormal operation scenario based on an emission level of 60 mg/m^3 for four hours every Monday for a full year.
(3) Abnormal operation scenario based on an emission level of 4 mg/m^3 for six hours every Monday for a full year.

Comparison With Standards And Guidelines

The organic emissions from the site will consist of a range of aliphatic and aromatic compounds at low concentration. The toxicity of these compounds will vary by several orders of magnitude. Ambient benzene levels have been regulated by the EU (Council Directive 2008/50/EC) due to the higher toxicity of this compound compared to other common hydrocarbons. In this assessment, it has been assumed that all emissions from the site are composed of benzene. This is a very pessimistic assumption and thus will significantly overestimate the impact of TOC emissions from the site. Ambient air quality standards for HCl, HF and NH3 are also shown in Table 18.

Table 18 Air Standards for TOC, NH_3, HCl and HF

Pollutant	**Regulation**	**Limit Type**	**Value**
TOC (assumed to be benzene)	EU Directive 2008/50/EC	Annual Average	5 $\mu g/m^3$
HCl	UK EA (2016)	Hourly limit for protection of human health	750 $\mu g/m^3$
HCl	UK EA (2016)	Annual Mean	20 $\mu g/m^3$
HF	UK EA (2016)	Hourly limit for protection of human health	160 $\mu g/m^3$
HF	UK EA (2016)	Annual Mean	16 $\mu g/m^3$
NH_3	UK EA (2016)	Hourly limit for protection of human health	2500 $\mu g/m^3$
NH_3	UK EA (2016), UNECE (2010)	Annual Mean	180 $\mu g/m^3$

Tables 19 – 22 details the predicted TOC, NH_3, HCl and HF GLC for each scenario.

Table 19 Dispersion Model Results – TOC (assumed to be benzene)

Pollutant / Scenario	**Annual Mean Background ($\mu g/m^3$)**	**Averaging Period**	**Process Contribution ($\mu g/m^3$)**	**Predicted Emission Concentration ($\mu g/Nm^3$)**	**Standard(1) ($\mu g/Nm^3$)**
TOC / Maximum	1.0	Annual Average	0.07	1.1	5
TOC / Abnormal Operation	1.0	Annual Average	0.08	1.1	5

(1) Council Directive 2008/50/EC

Table 20 Dispersion Model Results – NH_3

Pollutant / Scenario	**Annual Mean Background ($\mu g/m^3$)(1)**	**Averaging Period**	**Process Contribution ($\mu g/m^3$)**	**Predicted Emission Concentration ($\mu g/Nm^3$)**	**Standard ($\mu g/Nm^3$)**
NH_3 / Maximum	1.8	Maximum 1-hr	5.2	8.8	2500(2)
		Annual Average	0.10	1.9	180(2), 3.0(3)

(1) Mean level in farmland near Navan 2013-14 (UCD, 2013)
(2) UK EA (2016)(2)
(3) UNECE (2010)(12)

Table 21 Dispersion Model Results – HCl

Pollutant / Scenario	**Annual Mean Background ($\mu g/m^3$)(1)**	**Averaging Period**	**Process Contribution ($\mu g/m^3$)**	**Predicted Emission Concentration ($\mu g/Nm^3$)**	**Standard(2) ($\mu g/Nm^3$)**
HCl / Maximum	0.5	Maximum 1-hr	20.8	21.8	750
		Annual Average	0.07	0.57	20
HCl / Abnormal Operation	0.5	Maximum 1-hr	20.8	21.8	750
		Annual Average	0.08	0.58	20

(1) Upper Limit Based On Onsite Monitoring 2004/05
(2) UK EA (2016)(2)

Table 22 Dispersion Model Results – HF

Pollutant / Scenario	Annual Mean Background (µg/m³)(1)	Averaging Period	Process Contribution (µg/m³)	Predicted Emission Concentration (µg/Nm³)	Standard (µg/Nm³)(2)
HF / Maximum	0.1	Maximum 1-hr Annual Average	1.38 0.007	1.58 0.11	160 16
HF / Abnormal Operation	0.1	Maximum 1-hr Annual Average	1.38 0.008	1.58 0.11	160 16

(1) Upper Limit Based On Onsite Monitoring 2004/05
(2) UK EA (2016)[2]

The geographical variation in TOC (as benzene), NH_3, HCl and HF ground level concentrations beyond the site boundary is illustrated as concentration contours in Figures 8 – 11.

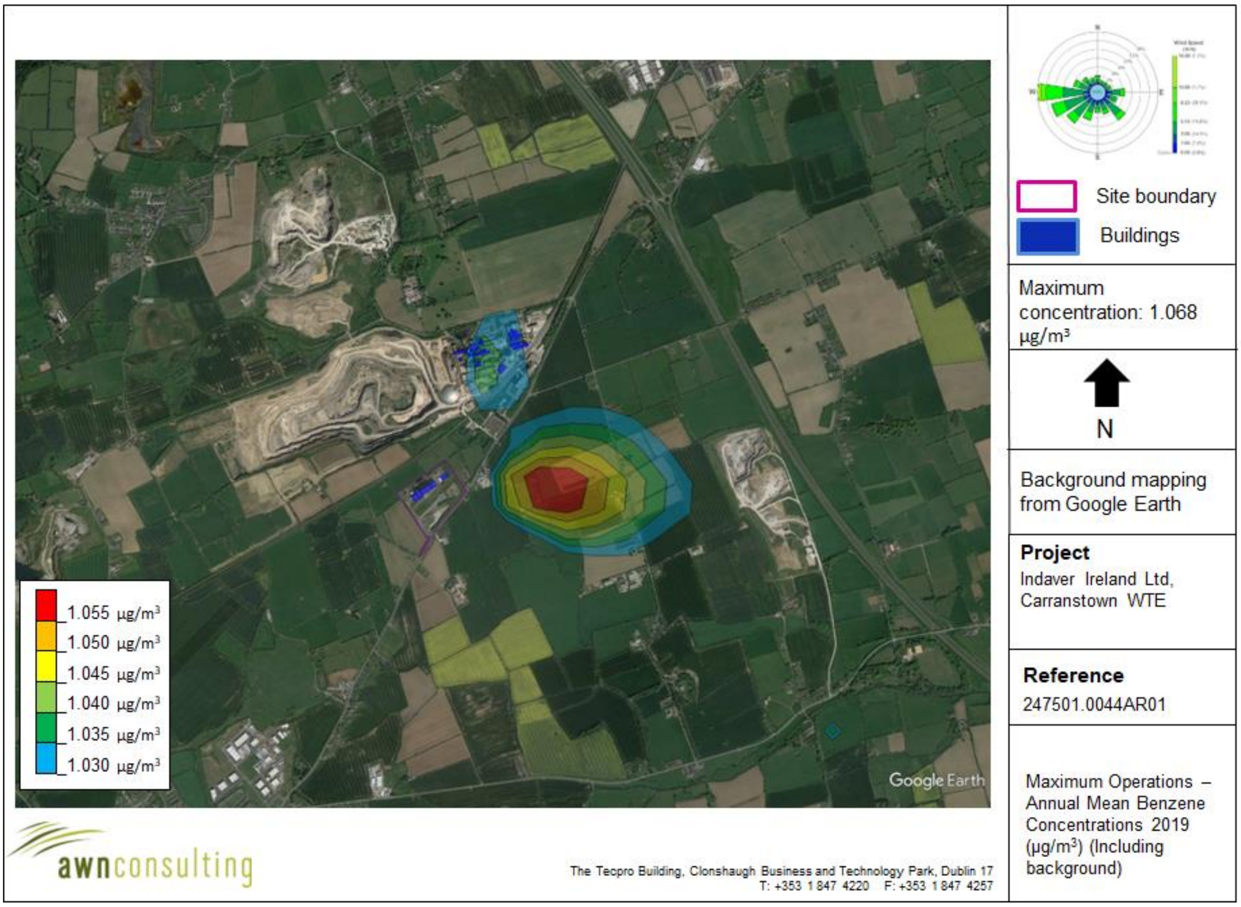

Figure 8 Maximum Operations: Predicted Benzene Annual Average Concentration (Year 2019)

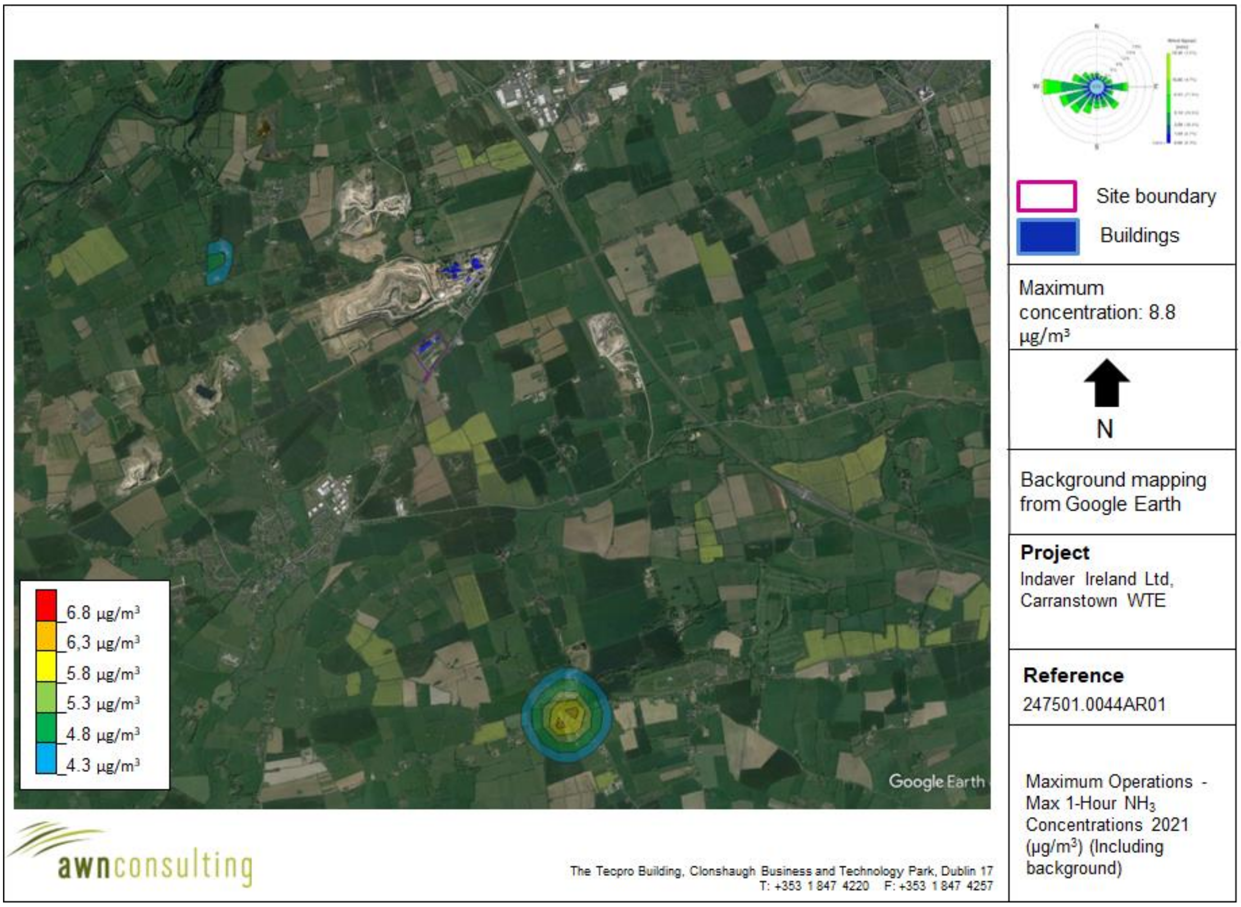

Figure 9 Maximum Operations: Predicted Maximum 1-Hour NH_3 Concentrations (Year 2021)

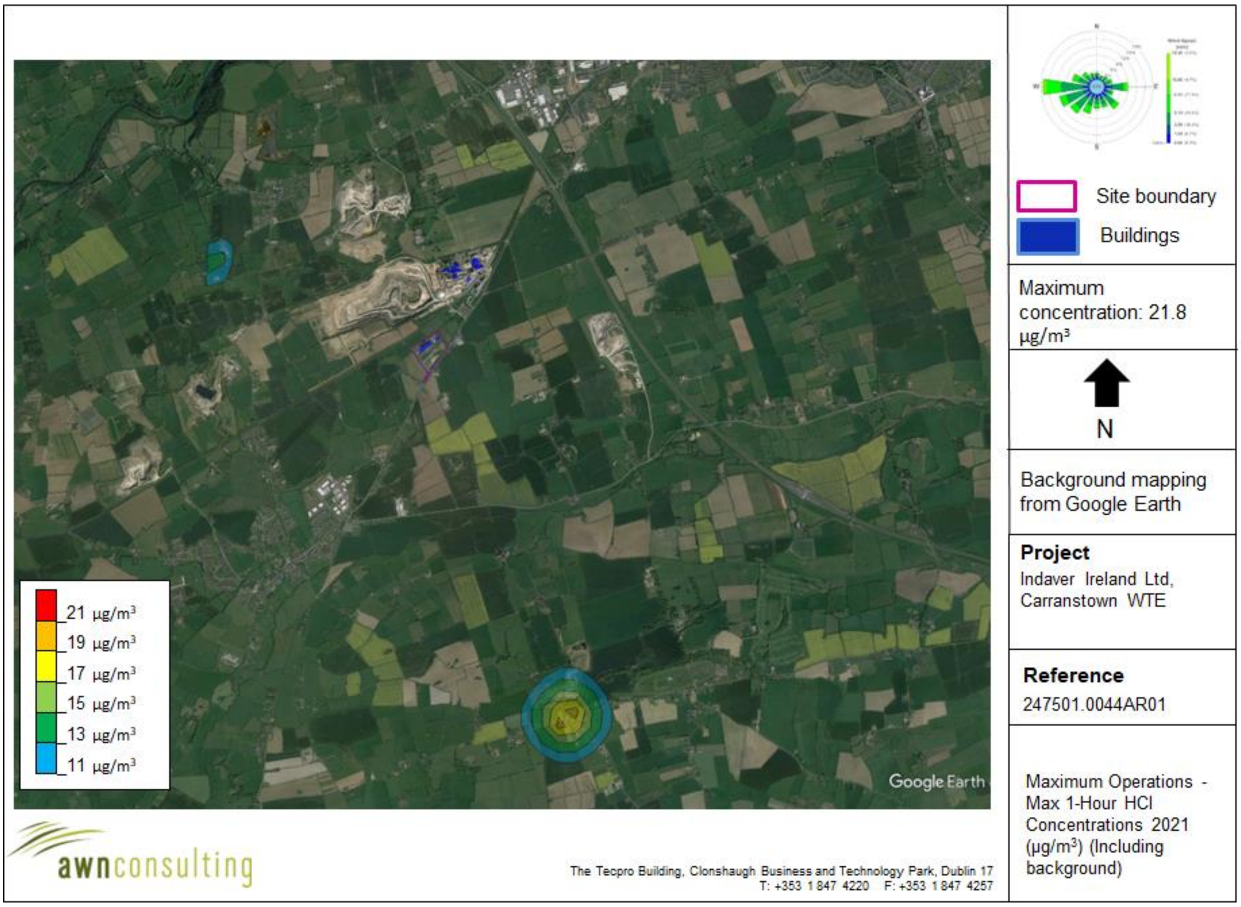

Figure 10 Maximum Operations: Predicted Maximum 1-Hour HCl Concentrations (Year 2021)

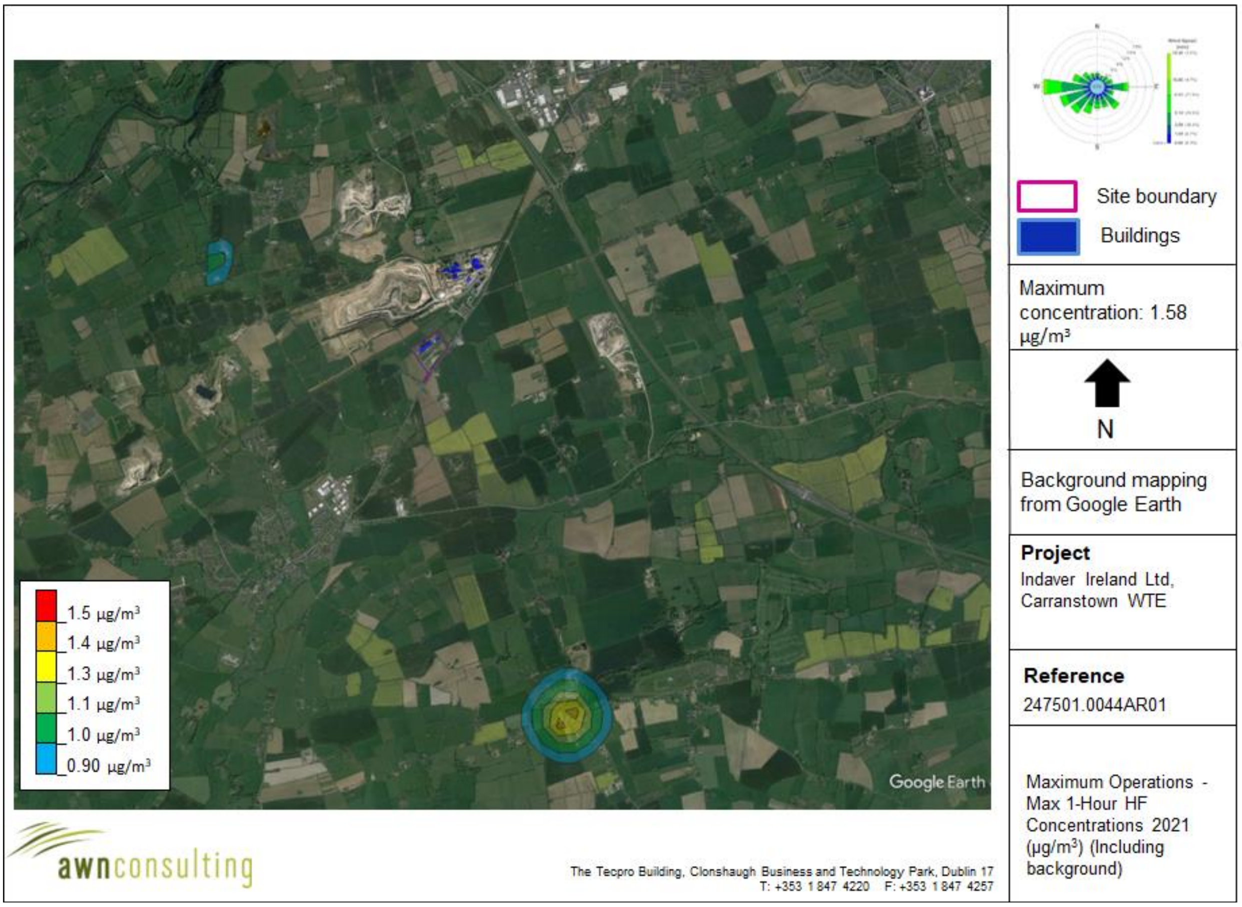

Figure 11 Maximum Operations: Predicted Maximum 1-Hour HF Concentrations (Year 2021)

TOC

TOC modelling results indicate that the ambient ground level concentrations are below the relevant air quality standard for the protection of human health for benzene under maximum and abnormal operation of the site. Thus, no adverse impact on public health or the environment is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to a maximum ambient TOC concentration (including background concentration) which is 21% of the benzene annual limit value.

NH_3

NH_3 modelling results indicate that the ambient ground level concentrations are below the relevant air quality guideline for the protection of human health for NH_3 under maximum operation of the site. Thus, no adverse impact on public health or the environment is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient NH_3 concentrations (including background concentrations) which is 0.4% of the maximum ambient 1-hour limit value. At the closest SAC/SPA, the River Boyne and River Blackwater SAC/SPA which at the closest point is 3.3km north of the facility, levels will be imperceptible relative to the ambient standard for the protection of Higher plants (including heathland, grassland and forest ground flora).

HCl

HCl modelling results indicate that the ambient ground level concentrations are below the relevant air quality guideline for the protection of human health for HCl under maximum and abnormal operation of the site. Thus, no adverse impact on public health or the environment is envisaged to occur under these conditions at or beyond the site boundary.

Emissions at maximum operations equate to ambient HCl concentrations (including background concentrations) which is 3% of the maximum ambient 1-hour limit value.

HF

HF modelling results indicate that the ambient ground level concentrations are below the relevant air quality standards and guidelines for HF for the protection of human health and vegetation under maximum and abnormal operation of the site. Thus, no adverse impact on public health or the environment is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient HF concentrations (including background concentrations) which is 1% of the maximum ambient 1-hour limit value and 1% of the annual limit value.

3.4 Dioxin/Furans Emissions and Results

Ambient Ground Level Concentrations (GLCs) of dioxins/furans have been predicted for the following scenarios in Table 23 based on a dioxin emission values of 0.1 ngTEQ/Nm^3 for the full year. While dioxin emissions are continuously sampled, emission values would be historic. It would typically take two weeks to analyse a dioxin filter which operates on a two-week cycle. Therefore for the purpose of the air modelling study the following two abnormal operation conditions were used: firstly, dioxin emission values of 0.5 ngTEQ/Nm^3 for two days per month and secondly, a dioxin emission values of 0.5 ngTEQ/Nm^3 for five weeks per year (based on a two week sampling period and three week analysis period).

Comparison with Standards And Guidelines

Currently, no internationally recognised ambient air quality concentration or deposition standards exist for PCDD/PCDFs (Dioxins/Furans). Both the USEPA and EU recommended approach to assessing the risk to human health from Dioxins/Furans entails a detailed risk assessment analysis involving the determination of the impact of Dioxins/Furans in terms of the TDI (Tolerable Daily Intake) approach[13,14]. A TDI has been defined by the EU as *"an estimate of the intake of a substance over a lifetime that is considered to be without appreciable health risk"*[14]. Occasional short term excursions above the TDI would have no health consequences provided the long-term average is not exceeded. The EU currently proposes a maximum TDI of between 1-4 pgTEQ/kg of body weight per day. A TDI of 4 pgTEQ/kg of body weight per day should be considered a maximal tolerable intake on a provisional basis and that the ultimate goal is to reduce human intake levels of below 1 pgTEQ/kg of body weight per day. This reflects the concept that guidance values for the protection of human health should consider total exposure to the substance including air, water, soil, food and other media sources.

Table 23 Dispersion Model Summary of Concentrations – PCCD/PCDFs

Pollutant / Scenario	Annual Mean Background[1] (pg/m^3)	Averaging Period	Process Contribution (pg/m^3)	Predicted Emission Concentration (pg/Nm^3)
PCCD/PCDFs / Maximum Operation	0.028 0.046	Annual Average	0.00068	0.0287 0.0467
PCCD/PCDFs / Abnormal Operation A[2]	0.028 0.046	Annual Average	0.00091	0.0289 0.0469
PCCD/PCDFs / Abnormal Operation B[3]	0.028 0.046	Five weeks	0.046	0.0740 0.0920
PCCD/PCDFs / Abnormal Operation B[3]	0.028 0.046	Annual Average	0.0010	0.0290 0.0470

(1) Baseline results for dioxins recorded in 2004/05 for the site given as sum of cumulative impacts (in the absence of the proposed facility) and baseline monitoring data firstly as (i) Non-detects = zero, (ii) Non-detects = limit of detection.

(2) Abnormal operation A scenario based on an emission level of 0.5 ng/m^3 for 2 days per month.

(3) Abnormal operation B scenario based on an emission level of 0.5 ng/m^3 for five weeks in a full year.

Concentration Contours

The geographical variation in PCCD/PCDFs (Dioxins/Furans) ground level concentrations beyond the site boundary are illustrated as concentration contours in Figure 12.

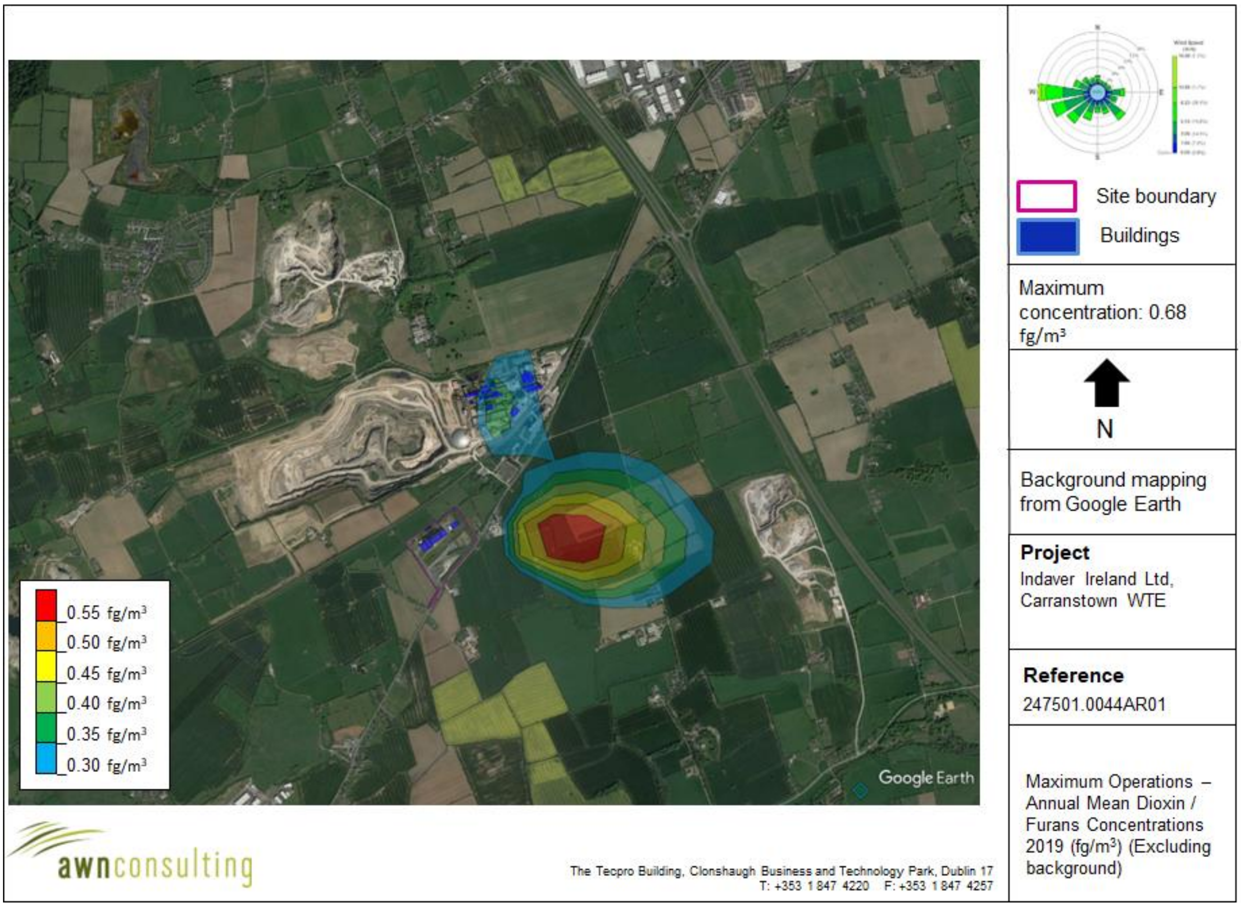

Figure 12 Maximum Operations: Predicted PCCD/PCDFs Annual Average Concentration (Year 2019)

Result Findings

Background levels of PCDD/PCDFs (Dioxins/Furans) occur everywhere and existing levels in the surrounding area have been extensively monitored as part of this study. Monitoring results indicate that the existing levels are significantly lower than urban areas and typical of rural areas in the UK and Continental Europe. The contribution from the site in this context is minor with levels under maximum and abnormal operations remaining significantly below levels which would be expected in urban areas even at the worst-case receptor to the east of the site (see Table 23). Levels at the nearest residential receptor will be minor, with the annual contribution from the proposed facility accounting for less than 1% of the existing background concentration under maximum operating conditions and accounting for less than 1.5% of the existing background concentration under abnormal operating conditions.

3.5 Heavy Metal Emissions and Results

Ambient ground level concentrations (GLCs) of Mercury (Hg), Cadmium & Thallium (Cd & Tl) and the Sum of antimony (Sb), arsenic (As), lead (Pb), chromium (Cr), cobalt (Co), copper (Cu), manganese (Mn), nickel (Ni) and vanadium (V) have been investigated using the concentration limits outlined in Council Directive 2010/75/EU (see Table 24) and also under abnormal operations at the site.

Data is available from a similar Indaver site in Beveren, Belgium (see Table 25) indicating the actual emission levels of these metals based on typical and maximum recorded levels over the period 2000 - 2004. This data has been used to identify the likely ratio of metals when emitting under maximum and abnormal operation conditions. It should be noted that modelled levels are significantly higher than that detected at this facility over this five year period.

Table 24 Emission Scenario for Heavy Metals Taken From Council Directive 2010/75/EU

Pollutant	Scenario	Concentration	Emission Rate (g/s)
Hg	Maximum Operation	0.05 mg/m^3	0.0028
	Abnormal Operation(1)	1 mg/m^3	0.056
Cd & Tl	Maximum Operations	0.05 mg/m^3	0.0028
	Abnormal Operation(12	1 mg/m^3	0.056
Sum of Sb, As, Pb, Cr, Co, Cu, Mn, Ni and V	Maximum Operation	0.50 mg/m^3	0.028
	Abnormal Operation(3)	30 mg/m^3	1.67

(1) Abnormal operation scenario based on an emission level of 1 mg/m^3 for two days every month for a full year.
(2) Abnormal operation scenario based on an emission level of 1 mg/m^3 for two days every month for a full year.
(3) Abnormal operation scenario based on an emission level of 30 mg/m^3 for two days every month for a full year.

Abnormal Operation

For the purpose of the air modelling study the following abnormal operation conditions were used: Cd: 1 mg/Nm^3 for two days, Tl: 1 mg/Nm^3 for two days and Heavy metals: 30 mg/Nm^3 for two days.

Table 25 Actual Measured Emission Data From An Indaver Site In Belgium Over The Period 2000 - 2004 (mg/Nm^3)

	Average(1)	**Maximum(1)**	**Maximum Operation(2)**	**Abnormal Operation(2)**
	2000 - 2004	2000 - 2004	0.50 mg/m^3	30 mg/m^3
As	0.012	0.020	0.054	3.23
Cd	0.001	0.008		
Co	0.008	0.040	0.037	2.23
Cr	0.014	0.059	0.062	3.71
Cu	0.011	0.070	0.049	2.95
Mn	0.018	0.200	0.081	4.84
Ni	0.005	0.036	0.023	1.38
Pb	0.013	0.042	0.058	3.50
Sb	0.012	0.020	0.053	3.18
Sn	0.011	0.057	0.049	2.96
Tl	0.011	0.020		
V	0.008	0.020	0.035	2.07
Sum Cd+Tl	0.008	0.030		
Hg	0.002	0.024		
Sum Sb/As/Pb/Cr/Co/ Cu/Mn/Ni/V/Sn	0.060	0.37	0.50	30.0

(1) Non-detects reported at the detection limit.

(2) Based on the ratio under average operation.

Comparison with Standards And Guidelines

Predicted GLCs have been compared with the applicable ambient air quality guidelines and standards for the protection of human health as set out in Table 26.

In the absence of statutory standards, ambient air quality guidelines can also be derived from occupational exposure limits (OEL). The OEL for each compound (where available) divided by an appropriate safety factor may be used. This factor accounts for increased exposure time and susceptibility of the general population in comparison to on-site personnel. The OEL can be expressed on the basis of two averaging periods; an eight-hour average and a fifteen-minute average (the short term exposure limit or STEL). The OEL (8-hour reference) divided by a factor of 100 may be applied to generate an ambient air quality guideline or Environmental Assessment Level (EAL) for comparison with predicted annual averages and the STEL divided by 40 may be applied for comparison with the one-hour concentrations.

A comparison of Table 26 indicates that Arsenic is the metal which is emitted at the most significant level relative to its annual average limit value and thus has been reported below. All other metals will have a lower impact on the ambient environment. Antimony has also been investigated as it is emitted at the most significant level relative to the short-term limit values.

Table 26 Hg, Cd, Tl, Sb, As, Pb, Cr, Co, Cu, Mn, Ni and V Ambient Air Quality Standards & Guidelines

Pollutant	Regulation	Limit Type	Value
Inorganic Mercury (as Hg)	WHO	Annual Average	1.0 μg/m^3
Cd	EU	Annual Average	0.005 μg/m^3(1)
Tl	UK EA EAL	Annual Average	1.0 μg/m^3
Sb (organic compounds)	UK EA EAL	Maximum One-Hour	5 μg/m^3
Sb (organic compounds)	UK EA EAL	Annual Average	1.0 μg/m^3
As	WHO	Annual Average	0.005 μg/m^3
As	EU	Annual Average	0.006 μg/m^3(1)
Pb	EU	Annual Average	0.5 μg/m^3
Cr (except VI)	UK EA EAL	Annual Average	5.0 μg/m^3
Cr (VI)	UK EA EAL	Annual Average	0.5 μg/m^3
Co	UK EA EAL	Annual Average	1.0 μg/m^3
Cu (fumes)	UK EA EAL	Annual Average	2.0 μg/m^3
Cu (dust & mists)	UK EA EAL	Annual Average	10 μg/m^3
Mn	WHO	Annual Average	0.15 μg/m^3
Mn (fume)	UK EA EAL	Maximum One-Hour	75 μg/m^3
Ni	EU	Annual Average	0.02 μg/m^3(1)
V (fume & respirable dust)	UK EA EAL	Annual Average	0.4 μg/m^3
V	WHO	24-Hour Average	1.0 μg/m^3

(1) Council Directive 2004/107/EC

Modelling Results

Air dispersion modelling was carried out for the scenarios described above. Table 27 outlines the maximum and abnormal emission levels for Cd and Tl.

Table 27 Cadmium Emission Concentration & Summary Of Ambient Standards

Pollutant / Scenario	Annual Mean Background (ng/m^3)(1)	Averaging Period	Process Contribution (ng/m^3)	Predicted Emission Concentration (ng/Nm^3)	Standard (ng/Nm^3)(2)
Cd / Maximum	1.0	Annual mean	0.34	1.34	5.0
Cd / Abnormal	1.0	Annual mean	0.82	1.82	5.0

(1) Background concentration for cadmium based on on-site monitoring in 2004/05
(2) Council Directive 2004/107/EC

Air dispersion modelling was carried out for the scenarios described above. Table 28 outlines the maximum and abnormal emission levels for Hg.

Table 28 Mercury Emission Concentration & Summary Of Ambient Standards

Pollutant / Scenario	Annual Mean Background (ng/m^3)(1)	Averaging Period	Process Contribution (ng/m^3)	Predicted Emission Concentration (ng/Nm^3)	Standard (ng/Nm^3)(2)
Hg / Maximum	1.0	Annual mean	0.34	1.34	1000
Hg / Abnormal	1.0	Annual mean	0.82	1.82	1000

(1) Background concentration based on EPA data for 2022
(2) Council Directive 2004/107/EC

Table 29 details the predicted GLC for each scenario for arsenic and antimony.

Table 29 Dispersion Model Results – Arsenic and Antimony

Heavy Metal / Scenario	Annual Mean Background (ng/m^3)	Averaging Period	Process Contribution (ng/m^3)	Predicted Emission Concentration (ng/Nm^3)	Standard (ng/Nm^3)
Arsenic / Maximum	1.0(1)	Annual mean	0.37	1.37	**6.0(3)**
Antimony / Maximum	1.0(2)	Maximum One-Hour	18.7	20.7	**5000(4)**
Arsenic / Abnormal	1.0(1)	Annual mean	2.04	3.04	**6.0(3)**
Antimony / Abnormal	1.0(2)	Maximum One-Hour	335	113	**5000(4)**

(1) Background concentration for arsenic based on on-site monitoring in 2004/05
(2) Background concentration for antimony based on on-site monitoring in 2004/05
(3) Ambient standard for arsenic which is the most stringent applicable limit value for this averaging period
(4) Ambient standard for antimony which is the most stringent applicable limit value for this averaging period.

Concentration Contours

The geographical variations in heavy metal ground level concentrations beyond the site boundary are illustrated as concentration contours in Figures 13 to 14.

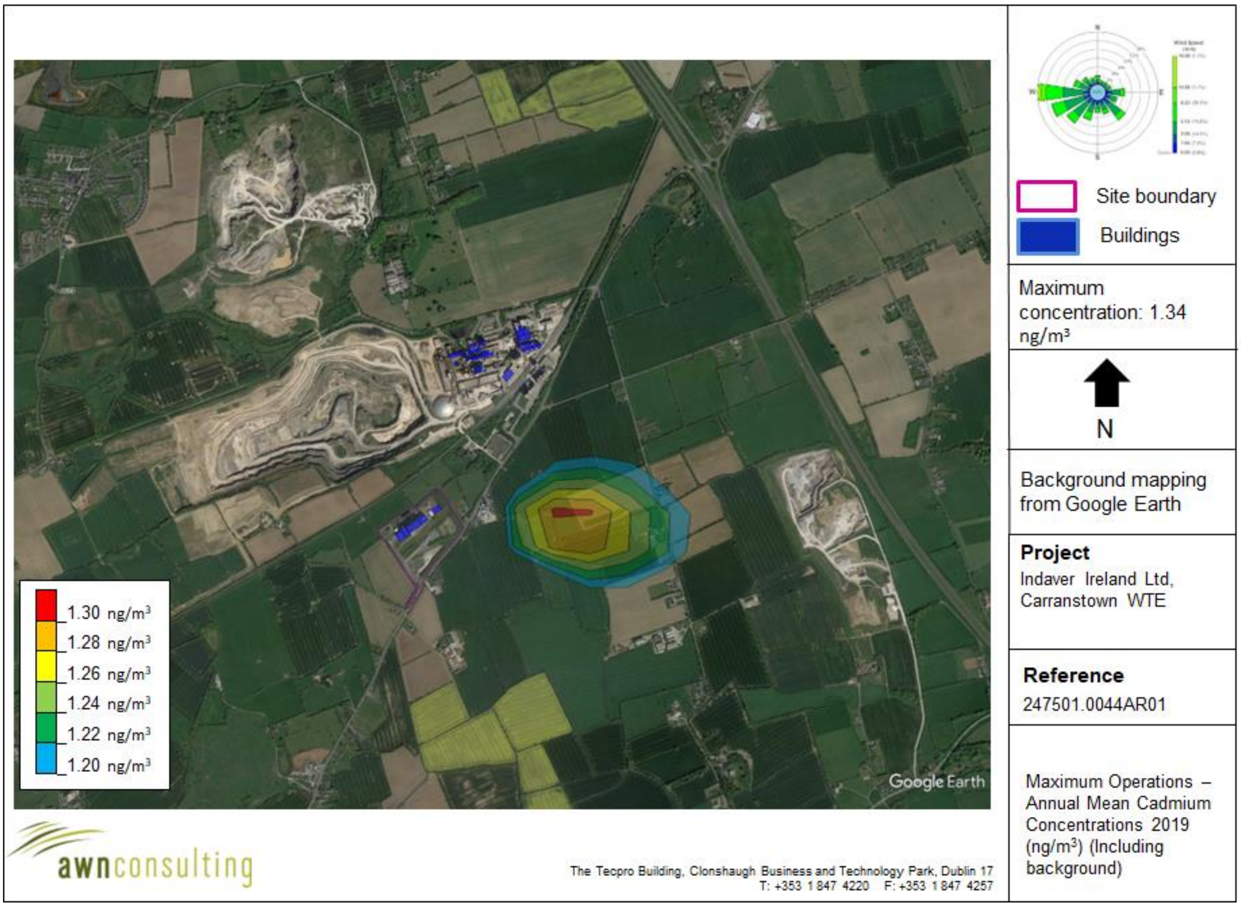

Figure 13 Maximum Operation: Predicted Cd Annual Average Concentration (Year 2019)

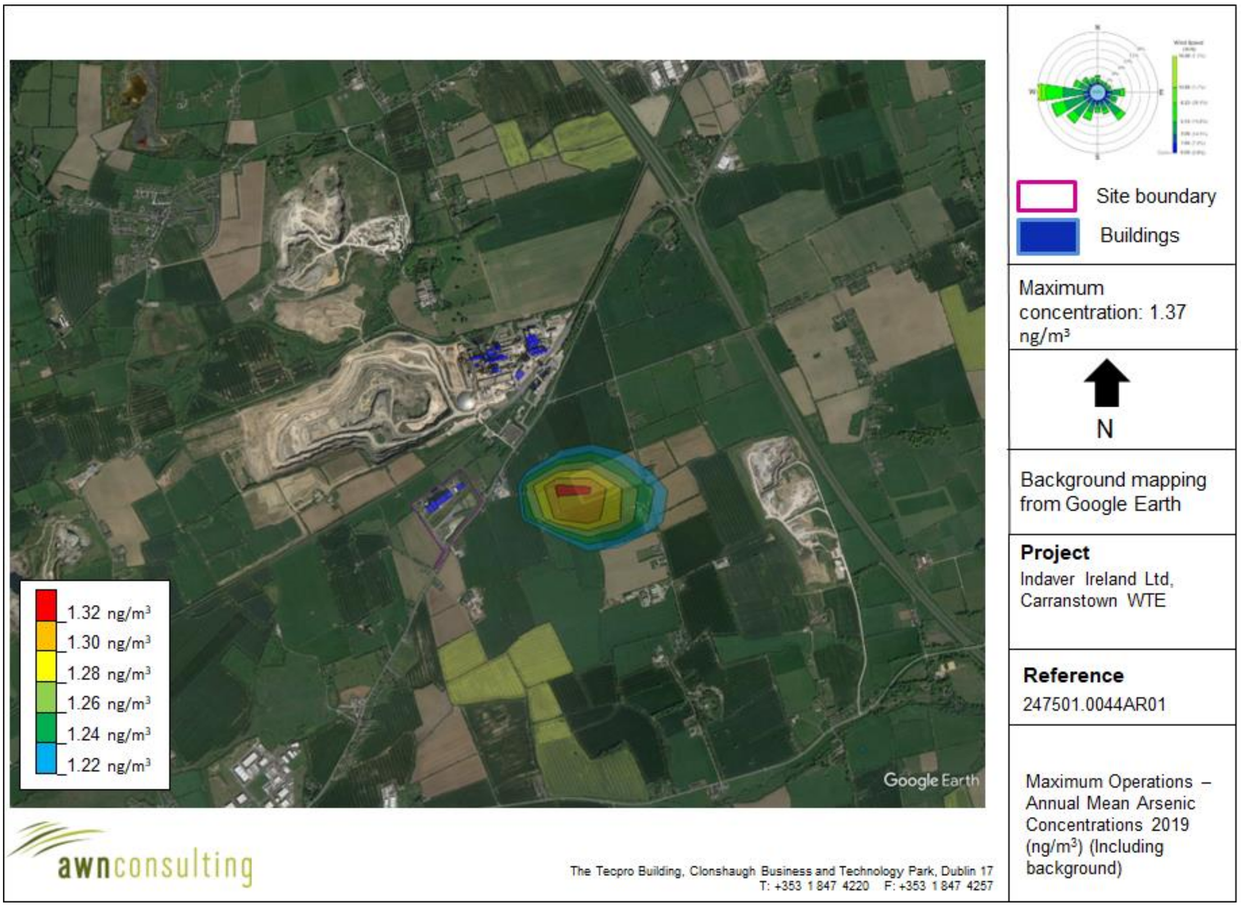

Figure 14 Maximum Operation: Predicted As Annual Average Concentration (Year 2019)

Result Findings

Cd and Tl

Modelling results indicate that the ambient ground level concentrations will be below the relevant air quality standards for the protection of human health for cadmium under maximum and abnormal operations of the site. Emissions at maximum operations equate to an ambient Cd and Tl concentration (excluding background concentration) which is 7% of the annual target value for Cd close to the site boundary (the comparison is made with the Cd limit value as this is more stringent than that for Tl).

Hg

Modelling results indicate that the ambient ground level concentrations will be below the relevant air quality standards for the protection of human health for mercury under maximum and abnormal operations of the site. Emissions at maximum operations equate to an ambient Hg concentration (excluding background concentration) which is 0.03% of the annual target value for Cd close to the site boundary.

Sum of As, Ni, Sb, Pb, Cr, Co, Cu, Mn and V

Modelling results indicate that the ambient ground level concentrations are below the relevant air quality standards for the protection of human health for arsenic and antimony (the metals with the most stringent limit values) under maximum and abnormal emissions from the site. Thus, no adverse impact on public health or the environment is envisaged to occur under these conditions at or beyond the site boundary. Emissions at maximum operations equate to ambient As concentrations (excluding background concentrations) which are only 6% of the annual limit value at the worst-case receptor whilst emissions at maximum operations equate to ambient Sb concentrations (excluding background concentrations) which are only 0.4% of the maximum 1-hour limit value at the worst-case receptor. Emissions under abnormal operations equate to ambient As concentrations (excluding background concentrations) which are only 34% of the annual limit value at the worst-case receptor whilst emissions at maximum operations equate to ambient Sb concentrations (excluding background concentrations) which are only 6% of the maximum 1-hour limit value at the worst-case receptor.

3.7 75% Of Volume Flow Emissions and Results

As shown in Table 30, the modelling results based on a volume flow of 150,000 Nm^3/hr (75% of maximum volume flow) indicate that the maximum ambient GLC are in compliance with all ambient air quality standards. In addition, in all cases, results are less than the maximum volume flow. Thus, the results indicate that the impact from the proposed facility is minor and limited to the immediate environs of the site.

Table 30 Dispersion Model Results – 75% Of Maximum Volume Flow

Pollutant / Scenario	Background ($\mu g/m^3$)	Averaging Period	Process Contribution ($\mu g/m^3$)	Predicted Emission Concentration ($\mu g/Nm^3$)	Standard ($\mu g/Nm^3$)
NO_2 / Maximum Operation	14	Annual Mean	0.70	14.7	40
	28	99.8th%ile of 1-hr means	21.4	49.4	200
SO_2 / Maximum Operation	67	99.7th%ile of 1-hr means	27.5	66.1	350
	33	99.2th%ile of 24-hr means	2.5	33.5	125
	6	Annual Mean	0.34	6.3	20
PM_{10} / Maximum	35	90.4th%ile of 24-hr means	0.21	35.1	50
	19	Annual mean	0.07	19.1	40
$PM_{2.5}$ / Maximum	15	Annual mean	0.07	15.1	25
TOC / Maximum	1.0	Annual Average	0.07	1.1	5
NH3 / Maximum	1.8	Maximum 1-hr	4.5	9.1	2500
		Annual Average	0.10	1.9	180
HCl / Maximum	0.5	Maximum 1-hr	18.1	19.1	750
		Annual Average	0.07	0.57	20
HF / Maximum	0.1	Maximum 1-hr	1.21	1.41	160
		Annual Average	0.007	0.11	16
PCCD/PCDFs / Maximum Operation	0.028 0.046	Annual Average	0.00067	0.0287 0.0467	n/a
Cd / Maximum	1.0	Annual mean	0.34	1.34	5.0
Hg / Maximum	1.0	Annual mean	0.34	1.34	1000
Arsenic / Maximum	1.0	Annual mean	0.34	1.34	6.0
Antimony / Maximum	1.0	Maximum One-Hour	16.0	18.0	5000

3.8 Cumulative Emissions and Results

As shown in Table 31, the cumulative modelling results indicate that the maximum ambient GLC are in compliance with all ambient air quality standards.

Table 31 Dispersion Model Results – Cumulative Assessment

Pollutant / Scenario	Annual Mean Background (μg/m^3)$^{(1)}$	Averaging Period	Process Contribution (μg/m^3)	Predicted Emission Concentration (μg/Nm^3)	Standard$^{(2)}$ (μg/Nm^3)
NO_2 / Maximum Operation	14	Annual Mean	5.9	19.9	40
	28	99.8th%ile of 1-hr means	91.8	104.8	200
SO_2 / Maximum Operation	67	99.7th%ile of 1-hr means	55.9	74.0	350
	33	99.2th%ile of 24-hr means	21.6	40.0	125
	6	Annual Mean	3.5	9.5	20
PM_{10} / Maximum	35	90.4th%ile of 24-hr means	18.4	37.4	50
	19	Annual mean	7.3	26.3	40
$PM_{2.5}$ / Maximum	15	Annual mean	7.3	22.3	25
TOC / Maximum	1.0	Annual Average	0.66	1.7	5
NH_3 / Maximum	1.8	Maximum 1-hr	12.6	16.2	2500
		Annual Average	0.41	2.2	180
HCl / Maximum	0.5	Maximum 1-hr	29.4	30.4	750
		Annual Average	0.80	1.3	20
HF / Maximum	0.1	Maximum 1-hr	2.81	3.0	160
		Annual Average	0.07	0.17	16
PCCD/PCDFs / Maximum Operation	0.028 pg/m^3 0.046 pg/m^3	Annual Average	0.0062 pg/m^3	0.0342 pg/m^3 0.0522 pg/m^3	n/a
Hg / Maximum	1.0 ng/m^3	Annual mean	0.42 ng/m^3	1.83 ng/m^3	5.0 ng/m^3
Cd / Maximum	1.0 ng/m^3	Annual mean	0.83 ng/m^3	1.83 ng/m^3	5.0 ng/m^3
Arsenic / Maximum	1.0 ng/m^3	Annual mean	0.43 ng/m^3	1.43 ng/m^3	6.0 ng/m^3
Antimony / Maximum	1.0 ng/m^3	Maximum One-Hour	18.0 ng/m^3	20.0 ng/m^3	5000 ng/m^3

Concentration Contours

The geographical variations in the cumulative ground level concentrations beyond the site boundary for the short-term NO_2 and SO_2 scenarios are illustrated as concentration contours in Figures 15 to 16.

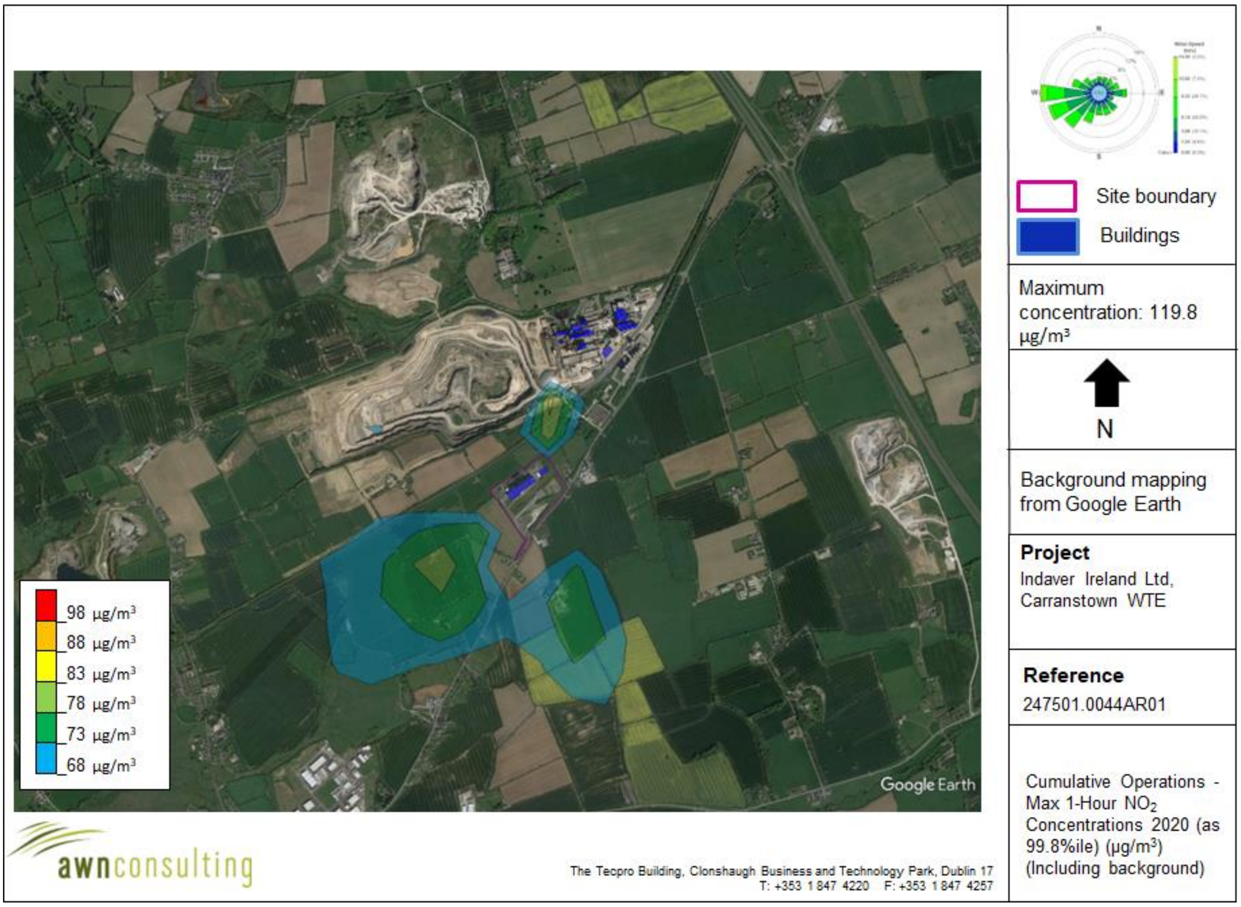

Figure 15 Cumulative Operations: Predicted NO_2 99.8th Percentile Concentration (Year 2020)

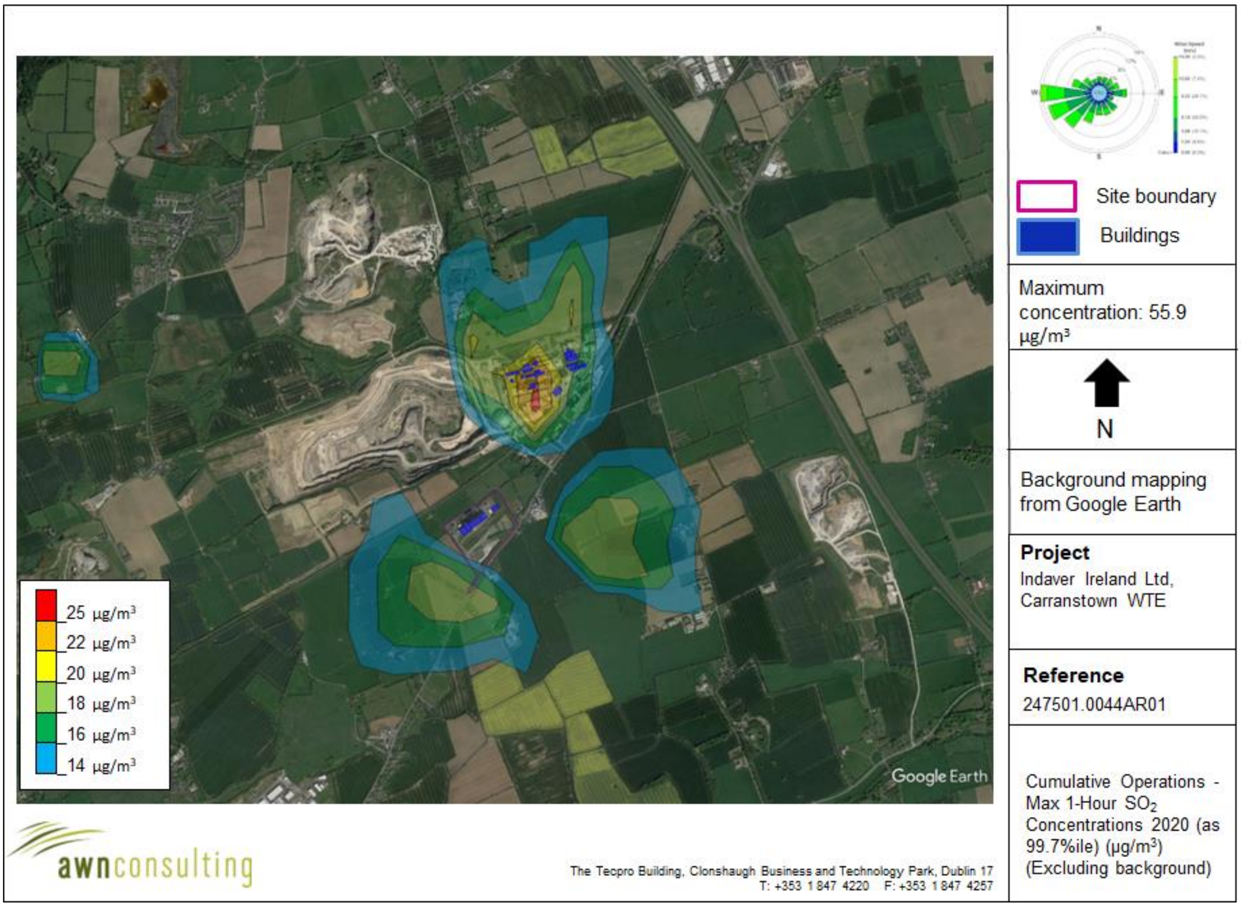

Figure 16 Cumulative Operations: Predicted SO_2 99.7th Percentile Concentration (Year 2020)

4.0 SUMMARY OF AIR QUALITY IMPACTS

Modelling results indicate that the ambient ground level concentrations are below the relevant air quality standards or guidelines for the protection of human health for all compounds under maximum and abnormal operation of the site. The modelling results indicate that this maximum occurs near the site's boundary. Maximum operations are based on the emission concentrations outlined in EU Directive 2010/75/EU.

Concentrations fall off rapidly away from this maximum and the short-term limit values at the nearest residential receptor (not including background concentrations) are less than 11% of the short-term limit values. The annual average concentration has an even more dramatic decrease in maximum concentration away from the site with concentrations from emissions at the facility accounting for less than 5% of the limit value (not including background concentrations) at worst case sensitive receptors near the site. Thus, the results indicate that the impact from the facility is minor and limited to the immediate environs of the site.

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(3) USEPA (2017) Guidelines on Air Quality Models, Appendix W to Part 51, 40 CFR Ch.1

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(5) USEPA (2022) AERMOD - Description of Model Formulation

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(8) Hanrahan, P (1999a) The Plume Volume Molar Ratio Method for Determining NO_2/NO_X Ratios in Modelling – Part 1: Methodology J. Air & Waste Management Assoc. 49 1324-1331.

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(10) EPA and UCD (2017) Ambient Atmospheric Ammonia in Ireland, 2013-2014

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(12) UNECE (2010) Empirical Critical Loads & Dose-Response Relationships

(13) European Commission (2000) Assessment of Dietary Intake of Dioxins & Related PCBs by the Population of EU Member States

(14) USEPA (2004) Estimating Exposure to Dioxin-Like Compounds Volume IV, Chapter 5 Demonstration of Methodology

(15) USEPA (2022) AERMET – User Guide

APPENDIX I

Description of the AERMOD Model

The AERMOD dispersion model has been developed in part by the U.S. Environmental Protection Agency (USEPA)[3,5].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[3,5].

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

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

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

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

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

Improvements have also been made in relation to mixing height[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[3,5]. 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[3] and using the detailed methodology outlined by the Alaska Department of Environmental Conservation. 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.

<u>Surface roughness</u>

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 facility.

Albedo

Noon-time Albedo is the fraction of the incoming solar radiation that is reflected from the ground when the sun is directly overhead. Albedo is used in calculating the hourly net heat balance at the surface for calculating hourly values of Monin-Obuklov length. The area-weighted arithmetic mean albedo derived from the land use classification over a 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	WinterNote 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 facility.

Bowen Ratio

The Bowen ratio is a measure of the amount of moisture at the surface of the earth. The presence of moisture affects the heat balance resulting from evaporative cooling which, in turn, affects the Monin-Obukhov length which is used in the formulation of the boundary layer. The area-weighted geometric mean Bowen ratio derived from the land use classification over a 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 facility.

APPENDIX III

Results Under Maximum Operations At 100% For All Five Years (2018 – 2022)

Table A4 Nitrogen Dioxide Normal Operation Results At 100% Volume Flow: 2018 - 2022

Pollutant / Year	Averaging Period	Process Contribution NO_2 (µg/m³)	Background (µg/m³)	PEC NO_2 (µg/m³)	Standard (µg/m³)	Percentage of Standard (%)
NO_2 / 2018	99.8th%ile of 1-hr means	23.6	28	51.6	200	26%
	Annual Mean	0.78	14	14.78	40	37%
NO_2 / 2019	99.8th%ile of 1-hr means	26.6	28	54.6	200	27%
	Annual Mean	0.52	14	14.52	40	36%
NO_2 / 2020	99.8th%ile of 1-hr means	27.2	28	55.2	200	28%
	Annual Mean	0.60	14	14.60	40	37%
NO_2 / 2021	99.8th%ile of 1-hr means	27.0	28	55.0	200	28%
	Annual Mean	0.63	14	14.63	40	37%
NO_2 / 2022	99.8th%ile of 1-hr means	27.0	28	55.0	200	28%
	Annual Mean	0.52	14	14.52	40	36%

Table A5 Sulphur Dioxide Normal Operation Results At 100% Volume Flow: 2018 - 2022

Pollutant / Year	Averaging Period	Process Contribution SO_2 (µg/m³)	Background Concentration (µg/m³)	PEC SO_2 (µg/m³)	Standard (µg/m³)	PEC as a % of Limit Value
SO_2 / 2018	Annual Mean	0.28	6	6.28	20	31%
	99.7th%ile of 1-hr means	27.42	67	94.42	350	27%
	99.2th%ile of 24-hr means	2.47	33	35.47	125	28%
SO_2 / 2019	Annual Mean	0.34	6	6.34	20	32%
	99.7th%ile of 1-hr means	28.53	67	95.53	350	27%
	99.2th%ile of 24-hr means	2.30	33	35.30	125	28%
SO_2 / 2020	Annual Mean	0.32	6	6.32	20	32%
	99.7th%ile of 1-hr means	27.31	67	94.31	350	27%
	99.2th%ile of 24-hr means	2.45	33	35.45	125	28%
SO_2 / 2021	Annual Mean	0.33	6	6.33	20	32%
	99.7th%ile of 1-hr means	29.19	67	96.19	350	27%
	99.2th%ile of 24-hr means	2.65	33	35.65	125	29%
SO_2 / 2022	Annual Mean	0.32	6	6.32	20	32%
	99.7th%ile of 1-hr means	28.64	67	95.64	350	27%
	99.2th%ile of 24-hr means	2.67	33	35.67	125	29%

Table A6 PM_{10} Normal Operation Results At 100% Volume Flow: 2018 - 2022

Pollutant / Year	**Averaging Period**	**Process Contribution PM_{10} (µg/m³)**	**Background (µg/m³)**	**PEC PM_{10} (µg/m³)**	**Standard (µg/m³)**	**PEC as % of Standard**
PM_{10} / 2018	Annual Mean	0.057	19	19.1	40	48%
	90.4th%ile of 24-hr means	0.205	35	35.1	50	70%
PM_{10} / 2019	Annual Mean	0.069	19	19.1	40	48%
	90.4th%ile of 24-hr means	0.217	35	35.1	50	70%
PM_{10} / 2020	Annual Mean	0.064	19	19.1	40	48%
	90.4th%ile of 24-hr means	0.211	35	35.1	50	70%
PM_{10} / 2021	Annual Mean	0.066	19	19.1	40	48%
	90.4th%ile of 24-hr means	0.230	35	35.1	50	70%
PM_{10} / 2022	Annual Mean	0.065	19	19.1	40	48%
	90.4th%ile of 24-hr means	0.224	35	35.1	50	70%

Table A7 $PM_{2.5}$ Normal Operation Results At 100% Volume Flow: 2018 - 2022

Pollutant / Year	**Averaging Period**	**Process Contribution $PM_{2.5}$ (µg/m³)**	**Background (µg/m³)**	**PEC $PM_{2.5}$ (µg/m³)**	**Standard (µg/m³)**	**PEC as % of Standard**
$PM_{2.5}$ / 2018	Annual Mean	0.06	15	15.06	20	75%
$PM_{2.5}$ / 2019	Annual Mean	0.07	15	15.07	20	75%
$PM_{2.5}$ / 2020	Annual Mean	0.06	15	15.06	20	75%
$PM_{2.5}$ / 2021	Annual Mean	0.07	15	15.07	20	75%
$PM_{2.5}$ / 2022	Annual Mean	0.06	15	15.06	20	75%

Table A8 TOC (Benzene) Normal Operation Results At 100% Volume Flow: 2018 - 2022

Pollutant / Year	**Averaging Period**	**Process Contribution Benzene (µg/m³)**	**Background (µg/m³)**	**PEC Benzene (µg/m³)**	**Standard (µg/m³)**	**PEC as % of Standard**
TOC / 2018	Annual Mean	0.06	1	1.06	5	21%
TOC / 2019	Annual Mean	0.07	1	1.07	5	21%
TOC / 2020	Annual Mean	0.06	1	1.06	5	21%
TOC / 2021	Annual Mean	0.07	1	1.07	5	21%
TOC / 2022	Annual Mean	0.06	1	1.06	5	21%

Table A9 Ammonia Normal Operation Results At 100% Volume Flow: 2018 - 2022

Pollutant / Year	**Averaging Period**	**Process Contribution NH_3 (µg/m^3)**	**Background (µg/m^3)**	**PEC NH_3 (µg/m^3)**	**Standard (µg/m^3)**	**PEC as % of Standard**
NH3 / 2018	Annual Mean	0.08	1.8	1.9	180	1.0%
	Maximum 1-Hour	3.49	3.6	3.7	2500	0.1%
NH3 / 2019	Annual Mean	0.10	1.8	1.9	180	1.1%
	Maximum 1-Hour	3.51	3.6	3.7	2500	0.1%
NH3 / 2020	Annual Mean	0.10	1.8	1.9	180	1.1%
	Maximum 1-Hour	3.50	3.6	3.7	2500	0.1%
NH3 / 2021	Annual Mean	0.10	1.8	1.9	180	1.1%
	Maximum 1-Hour	5.19	3.6	3.7	2500	0.1%
NH3 / 2022	Annual Mean	0.10	1.8	1.9	180	1.1%
	Maximum 1-Hour	3.50	3.6	3.7	2500	0.1%

Table A10 HCl Normal Operation Results At 100% Volume Flow: 2018 - 2022

Pollutant / Year	**Averaging Period**	**Process Contribution HCl (µg/m^3)**	**Background (µg/m^3)**	**PEC HCl (µg/m^3)**	**Standard (µg/m^3)**	**PEC as % of Standard**
HCl / 2018	Annual Mean	0.06	0.5	0.6	20	2.8%
	Maximum 1-Hour	13.95	1	1.1	750	0.1%
HCl / 2019	Annual Mean	0.07	0.5	0.6	20	2.8%
	Maximum 1-Hour	14.02	1	1.1	750	0.1%
HCl / 2020	Annual Mean	0.06	0.5	0.6	20	2.8%
	Maximum 1-Hour	13.99	1	1.1	750	0.1%
HCl / 2021	Annual Mean	0.07	0.5	0.6	20	2.8%
	Maximum 1-Hour	20.75	1	1.1	750	0.1%
HCl / 2022	Annual Mean	0.06	0.5	0.6	20	2.8%
	Maximum 1-Hour	13.99	1	1.1	750	0.1%

Table A11 HF Normal Operation Results At 100% Volume Flow: 2018 - 2022

Pollutant / Year	Averaging Period	Process Contribution HF (µg/m³)	Background (µg/m³)	PEC HF (µg/m³)	Standard (µg/m³)	PEC as % of Standard
HF/ 2018	Annual Mean	0.006	0.1	0.11	16	0.66%
	Maximum 1-Hour	0.930	0.2	1.13	160	0.71%
HF/ 2019	Annual Mean	0.007	0.1	0.11	16	0.67%
	Maximum 1-Hour	0.935	0.2	1.13	160	0.71%
HF/ 2020	Annual Mean	0.006	0.1	0.11	16	0.67%
	Maximum 1-Hour	0.932	0.2	1.13	160	0.71%
HF/ 2021	Annual Mean	0.007	0.1	0.11	16	0.67%
	Maximum 1-Hour	1.383	0.2	1.58	160	0.99%
HF/ 2022	Annual Mean	0.006	0.1	0.11	16	0.67%
	Maximum 1-Hour	0.932	0.2	1.13	160	0.71%

Table A12 Dioxins/Furans Normal Operation Results At 100% Volume Flow: 2018 - 2022

Pollutant / Scenario	Annual Mean Background (pg/m³)	Averaging Period	Process Contribution PCCD/PCDFs (pg/m³)	PEC PCCD/PCDFs (pg/Nm³)
PCCD/PCDFs / 2018	0.028 0.046	Annual Average	0.00056	0.0286 0.0466
PCCD/PCDFs / 2019	0.028 0.046	Annual Average	0.00068	0.0287 0.0467
PCCD/PCDFs / 2020	0.028 0.046	Annual Average	0.00064	0.0286 0.0466
PCCD/PCDFs / 2021	0.028 0.046	Annual Average	0.00065	0.0287 0.0467
PCCD/PCDFs / 2022	0.028 0.046	Annual Average	0.00064	0.0286 0.0466

Table A13 Mercury Normal Operation Results At 100% Volume Flow: 2018 - 2022

Pollutant / Year	Averaging Period	Process Contribution Hg (µg/m³)	Background (µg/m³)	PEC Hg (µg/m³)	Standard (µg/m³)	PEC as a % of Limit Value
Hg / 2018	Annual mean	0.00028	0.001	0.0013	1	0.13%
Hg / 2019	Annual mean	0.00034	0.001	0.0013	1	0.13%
Hg / 2020	Annual mean	0.00032	0.001	0.0013	1	0.13%
Hg / 2021	Annual mean	0.00033	0.001	0.0013	1	0.13%
Hg / 2022	Annual mean	0.00032	0.001	0.0013	1	0.13%

Table A14 Cadmium Normal Operation Results At 100% Volume Flow: 2018 - 2022

Pollutant / Year	**Averaging Period**	**Process Contribution Cd (µg/m^3)**	**Background (µg/m^3)**	**PEC Cd (µg/m^3)**	**Standard (µg/m^3)**	**PEC as a % of Limit Value**
Cd / 2018	Annual mean	0.00028	0.001	0.0013	0.005	25.6%
Cd / 2019	Annual mean	0.00034	0.001	0.0013	0.005	26.8%
Cd / 2020	Annual mean	0.00032	0.001	0.0013	0.005	26.4%
Cd / 2021	Annual mean	0.00033	0.001	0.0013	0.005	26.5%
Cd / 2022	Annual mean	0.00032	0.001	0.0013	0.005	26.4%

Table A15 Arsenic Normal Operation Results At 100% Volume Flow: 2018 - 2022

Pollutant / Year	**Averaging Period**	**Process Contribution As (µg/m^3)**	**Background (µg/m^3)**	**PEC As (µg/m^3)**	**Standard (µg/m^3)**	**PEC as a % of Limit Value**
As / 2018	Annual mean	0.00030	0.001	0.0013	0.006	21.7%
As / 2019	Annual mean	0.00037	0.001	0.0014	0.006	22.8%
As / 2020	Annual mean	0.00035	0.001	0.0013	0.006	22.4%
As / 2021	Annual mean	0.00035	0.001	0.0014	0.006	22.5%
As / 2022	Annual mean	0.00035	0.001	0.0013	0.006	22.5%

Table A16 Antimony Normal Operation Results At 100% Volume Flow: 2018 - 2022

Pollutant / Year	**Averaging Period**	**Process Contribution Sb (µg/m^3)**	**Background (µg/m^3)**	**PEC Sb (µg/m^3)**	**Standard (µg/m^3)**	**PEC as a % of Limit Value**
Sb/ 2018	Maximum 1-Hour	0.0123	0.002	0.0143	5	0.3%
Sb/ 2019	Maximum 1-Hour	0.0124	0.002	0.0144	5	0.3%
Sb/ 2020	Maximum 1-Hour	0.0124	0.002	0.0144	5	0.3%
Sb/ 2021	Maximum 1-Hour	0.0187	0.002	0.0207	5	0.4%
Sb/ 2022	Maximum 1-Hour	0.0124	0.002	0.0144	5	0.3%