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AIR DISPERSION MODELLING ASSESSMENT FOR WEST OFFALY POWER STATION, COUNTY OFFALY

Technical Report Prepared For

ESBI

Technical Report Prepared By

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Our Reference

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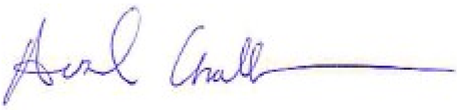
Signature		
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EXECUTIVE SUMMARY

AWN Consulting was instructed by ESB International (ESBI) to conduct an air modelling study to assess the impact to ambient air quality from the emission point PS-A1 at the West Offaly Power station (WOP) in Shannonbridge, County Offaly. The contribution of both current licenced and proposed BAT emissions from the facility to off-site levels of release substances was assessed and the location and maximum of the worst-case ground level concentrations for each compound identified. The proposed BAT emissions facilitate the phased transition of WOP to exclusive firing with biomass.

Air dispersion modelling was carried out using the United States Environmental Protection Agency's regulatory model AERMOD (Version 16216r) and the methodology outlined in the policy and technical guidance notes, LAQM.PG(16) and LAQM.TG(16), issued by UK Department for Environment, Food and Rural Affairs[1-5]. The assessment of air quality is carried out using a phased approach as recommended by the UK Department for Environment, Food and Rural Affairs[2]. The dispersion modelling study consisted of the following components:

- Review of emissions data and other relevant information needed for the modelling study;
- Summary of background NO_2, SO_2, $PM_{10}/PM_{2.5}$, hydrogen chloride, hydrogen fluoride and mercury concentrations;
- Dispersion modelling of released substances under the following scenarios:
  - Permitted emission concentrations of pollutants as per existing IED Licence P0611-02 (hereafter *Maximum Existing Scenario*).
  - Expected Maximum permitted emission concentrations of pollutants as per the EU Commission Implementing Decision (EU) 2017/1442 of 31 July 2017. The Best Available Technique (BAT) limit values will likely be implemented as part of the plants transition to exclusive firing with biomass (hereafter *Maximum Proposed Scenario*).
  - Sensitivity Scenario assessment of cumulative impact in event of simultaneous emissions from PS-A1 (Main Stack) and PS-A2 (Auxiliary Boiler).
- Presentation of predicted ground level concentrations of released substances;
- Review of traffic related impacts on sensitive receptors with respect to ambient air quality limit values ; and
- Evaluation of the significance of these predicted concentrations, including consideration of whether these ground level concentrations are likely to exceed the relevant ambient air quality limit values.

Assessment Summary

The modelling results demonstrate that ambient pollutant concentrations (including background) are well below the applicable air quality limit values at all off-site receptors.

Maximum Existing Scenario

Maximum Existing Scenario is the permitted emission concentrations of pollutants as per existing IED Licence P0611-02. All predicted ambient pollutant concentrations (including background) are in compliance with the relevant air quality standards limit values. The results indicate that the ambient ground level NO_2 concentrations (including background) reach 16% of the maximum 1-hour limit value (measured as a 99.8th%ile) and 29% of the annual limit value at the worst-case off-site receptor. Ambient ground level SO_2 concentrations (including background) reach 14% of the maximum 1-hour limit value (measured as a 99.7th%ile) and 16% of the maximum 24-hour limit value (measured as a 99.2nd%ile) at the worst-case off-site receptor. Ambient ground level PM_{10} concentrations (including background) reach 30% of the maximum 24-hour limit value (measured as a 90.4th%ile) and 30% of the annual limit value at the worst-case off-site receptor. Ambient ground level $PM_{2.5}$ concentrations (including background) reach 29% of the annual EU limit value at the worst-case off-site receptor. When compared against the more stringent WHO limit values, ground level $PM_{2.5}$ concentrations (including background) reach 73% of the annual WHO limit value and 35% of the maximum 24-hour WHO limit value (measured as a 99th%ile) at the worst-case off-site receptor.

Maximum Proposed Scenario

Maximum Proposed Scenario is the permitted emission concentrations of pollutants as per proposed BAT limit values which will be implemented as part of the plants transition to exclusive firing with biomass. All predicted ambient pollutant concentrations (including background) are in compliance with the relevant air quality standards limit values. The results indicate that the ambient ground level NO_2 concentrations (including background) reach 16% of the maximum 1-hour limit value (measured as a 99.8th%ile) and 29% of the annual limit value at the worst-case off-site receptor. Ambient ground level SO_2 concentrations (including background) reach 14% of the maximum 1-hour limit value (measured as a 99.7th%ile) and 16% of the maximum 24-hour limit value (measured as a 99.2nd%ile) at the worst-case off-site receptor. Ambient ground level PM_{10} concentrations (including background) reach 30% of the maximum 24-hour limit value (measured as a 90.4th%ile) and 30% of the annual limit value at the worst-case off-site receptor. Ambient ground level $PM_{2.5}$ concentrations (including background) reach 29% of the EU annual limit value at the worst-case off-site receptor. When compared against the more stringent WHO limit values, ground level $PM_{2.5}$ concentrations (including background) reach 73% of the annual WHO limit value and 34% of the maximum 24-hour WHO limit value (measured as a 99th%ile) at the worst-case off-site receptor.

The modelling results for mercury indicate that emissions from the facility lead to an ambient concentration including background which is 13% of the annual limit value at the worst-case off-site receptor. Modelling results for hydrogen chloride and hydrogen fluoride lead to an ambient concentration including background for the worst-case which are less than 1% of the annual limit value at the worst-case off-site receptor.

Impact on Ecology

The NO_x modelling results indicate that the ambient ground level concentrations are below the relevant air quality standard for NO_x for the protection of ecosystems. Emissions from the facility lead to an ambient NO_x concentration including background for *Maximum Existing Scenario* which is 29.6% of the annual limit value at the worst-case location within the SAC / SPA. Emissions for *Maximum Proposed Scenario* lead to slightly lower annual NO_x concentrations within the SAC reaching 29.2% of the annual limit value for the protection of ecosystems.

The SO_2 modelling results indicate that the ambient ground level concentrations including background are below the relevant air quality standard for SO_2 for the protection of ecosystems for *Maximum Existing Scenario* and *Maximum Proposed Scenario* reaching 16.6% of the annual limit value. The results for are well below the applicable limit value for the protection of vegetation.

Sensitivity Study – Cumulative Study with Auxiliary Boiler

The main stack PS-A1 and auxiliary boiler stack PS-A2 are in operation for short periods simultaneously. The scenarios where both stacks are operational simultaneously are:

- on start up - returning the main stack to service after a period of maintenance; and
- after a cold start -where the main stack has been off for greater than 60 hours.

Otherwise the auxiliary boiler is used for house heating when the main stack is off load. When both stacks are running together a cumulative impact due to emissions from both stacks may occur on local sensitive receptors. While this is not predicted to occur frequently, a worst case sensitivity study has been conducted in order to ensure that no breach of ambient limit values occurs should the stacks run together continuously.

The cumulative scenario shows that even if both boilers were running simultaneously on a continuous basis the ambient concentrations of NO_2, particulates and SO_2 are significantly below the respective limit values.

Traffic Modelling Assessment

The results of the air dispersion modelling study with respect to traffic emissions indicate that the impacts of the WOP facility on air quality are predicted to be imperceptible with respect to the operational phase local air quality assessment for the long and short term.

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1.0 INTRODUCTION

AWN Consulting was instructed by ESB International (ESBI) to conduct an air modelling study to assess the impact to ambient air quality from the emission point PS-A1 at the West Offaly Power station (WOP) in Shannonbridge, County Offaly. The contribution of both current licenced and proposed BAT emissions from the facility to off-site levels of release substances was assessed and the location and maximum of the worst-case ground level concentrations for each compound identified. The proposed BAT emissions facilitate the phased transition of WOP to exclusive firing with biomass.

This report describes the outcome of this study. The study consists of the following components:

- Review of emissions data and other relevant information needed for the modelling study;
- Summary of background NO_2, SO_2, PM_{10}/$PM_{2.5}$, mercury, hydrogen chloride and hydrogen fluoride concentrations;
- Dispersion modelling of released substances under the following scenarios:
  - Maximum permitted emission concentrations of pollutants as per existing IED Licence P0611-02 (hereafter *Maximum Existing Scenario*).
  - Expected Maximum permitted emission concentrations of pollutants as per the EU Commission Implementing Decision (EU) 2017/1442 of 31 July 2017. The Best Available Technique (BAT) limit values will likely be implemented as part of the plants transition to exclusive firing with biomass (hereafter *Maximum Proposed Scenario*).
- Presentation of predicted ground level concentrations of released substances;
- Evaluation of the significance of these predicted concentrations, including consideration of whether these ground level concentrations are likely to exceed the relevant ambient air quality limit values.

Process emission information as well as stack heights and locations for the various scenarios modelled are provided in Table 7 of Section 2.7. Two emission scenarios plus a sensitivity study were modelled in total:

- ***Maximum Existing Scenario*** - Maximum permitted emission concentrations of pollutants as per existing IED Licence P0611-02;
- ***Maximum Proposed Scenario*** - Reduced maximum permitted emission concentrations of pollutants applicable as outlined in the new BAT Conclusions for Large Combustion Plant BREF; and
- ***Sensitivity Scenario*** – Assessment of cumulative impact in event of simultaneous emissions from PS-A1 (Main Stack) and PS-A2 (Auxiliary Boiler).

Information supporting the conclusions has been detailed in the following sections. The assessment methodology and study inputs are presented in Section 2. The dispersion modelling results and assessment summaries are presented in Section 3. The model formulation is detailed in Appendix I and a review of the meteorological data used is detailed in Appendix II.

2.0 MODELLING METHODOLOGY

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

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

- Maximum predicted concentrations are reported in this study, even if no residential receptors are near the location of this maximum;
- Conservative background concentrations were added to the modelled concentrations released from the site before comparing the total predicted concentrations with the applicable limit values;
- The effect of building downwash, due to nearby buildings, has been included in the model.

2.1 Air Dispersion Modelling Software

AERMOD

Emissions from the facility have been modelled the AERMOD dispersion model (Version 16216r) which has been developed by the U.S. Environmental Protection Agency (USEPA)[6,7]. AERMOD is a steady-state Gaussian plume model used to assess pollutant concentrations associated with industrial sources and has replaced ISCST3[8] as the regulatory model by the USEPA for modelling emissions from industrial sources in both flat and rolling terrain[9-11]. The model has more advanced algorithms and gives better agreement with monitoring data in extensive validation studies[12-15]. An overview of the AERMOD dispersion model is outlined in Appendix I.

DMRB Traffic Model

The assessment methodology involved air dispersion modelling using the UK Design Manual for Roads and Bridges Screening Model (UK Highways Agency 2007) (Version 1.03c, July 2007)[5], the NO_x to NO_2 Conversion(Version 5.1)[16], and following guidance issued by Transport Infrastructure Ireland[17], UK Highways Agency[1], UK Department for Environment, Food and Rural Affairs[2] and the EPA[18-19]. Concentrations of key pollutants are calculated at sensitive receptors which have the potential to be affected by the proposed development. For road links which are deemed to be affected by the proposed development and within 200 m of the chosen sensitive receptors inputs to the air dispersion model consist of; road layouts, receptor locations, annual average daily traffic movements (AADT), percentage heavy goods vehicles, annual average traffic speeds and background concentrations. The UK Design Manual for Roads and Bridges guidance states that road links at a distance of greater than 200 m from a sensitive receptor will not influence pollutant concentrations at the receptor. Using this input data the model predicts the road traffic contribution to ambient ground level concentrations at the worst-case sensitive receptors using generic meteorological data. The Design Manual for Roads and Bridges model uses conservative emission factors, the formulae for which are outlined in the Design Manual for Roads and Bridges Volume 11 Section 3 Part 1 – HA 207/07 Annexes B3 and B4.

2.2 Background Concentrations

Air quality monitoring programs have been undertaken in recent years by the EPA and Local Authorities[20,21]. The most recent annual report on air quality "Air Quality Monitoring Annual Report 2016"[21], 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[21]. Dublin is defined as Zone A and Cork as Zone B. Zone C is composed of 23 towns with a population of greater than 15,000. The remainder of the country, which represents rural Ireland but also includes all towns with a population of less than 15,000 is defined as Zone D. In terms of air monitoring, the area surrounding WOF Station is categorised as Zone D[14].

NO_2 and O_3

NO_2 monitoring was carried out at two rural Zone D locations in 2016, Emo and Kilkitt and in two urban areas, Enniscorthy and Castlebar[21]. The NO_2 annual average in 2016 for both rural sites was 3.5 µg/m^3 with the results for urban stations averaging 8.5 µg/m^3. Hence long-term average concentrations measured at all locations were significantly lower than the annual average limit value of 40 µg/m^3. The average results over the last five years at a range of urban Zone D locations suggest an upper average of no more than 11 µg/m^3 as a background concentration as shown in Table 1. Based on the above information a conservative estimate of the background NO_2 concentration in the region of the facility is 11 µg/m^3.

Year	Enniscorthy (µg/m^3)	Kilkitt (µg/m^3)	Emo (µg/m^3)	Castlebar (µg/m^3)
2012	-	4	-	8
2013	-	4	4	11
2014	13	3	3	8
2015	9	2	3	8
2016	10	3	4	9
Average	**10.7**	**3.2**	**3.5**	**8.8**

Table 1 Annual Mean NO_2 Background Concentrations in Zone D Locations 2012 – 2016 (µg/m^3)

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 (O_3) concentration[22,23]. 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 10% of the NO_X in the stack gas is already in the form of NO_2 before the gas leaves the stack[22,23]. The equation used in the algorithm to derive the ratio of NO_2/NO_X is:

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

The ozone data used in the PVMRM model runs assumes a conservative value of 70 μg/m^3.

In relation to the annual averages, the ambient background concentration was added directly to the process concentration with the short-term peaks calculated using the twice the annual mean concentration as an hourly background in line with guidance from the UK DEFRA(2).

SO_2

Long-term SO_2 monitoring was carried out at the Zone D locations of Enniscorthy, Kilkitt and the Shannon Estuary in 2016. The SO_2 annual average measured 2 μg/m^3 at all three locations in 2016(21). Previous monitoring from 2012 – 2016 at the three locations indicated annual averages ranging from 1.8 – 2.5 μg/m^3 (see Table 2). Based on the above information a conservative estimate of the background SO_2 concentration in the region of the facility is 2.5 μg/m^3.

Year	Enniscorthy (μg/m^3)	Kilkitt (μg/m^3)	Shannon Estuary (μg/m^3)
2012	-	3	2
2013	-	3	2
2014	4	2	3
2015	2	2	2
2016	3	2	2
Average	**2.8**	**2.4**	**2.2**

Table 2 Annual Mean SO_2 Background Concentrations in Zone D Locations 2011 – 2015 (μg/m^3)

When calculating the short-term peak results, concentrations due to emissions from stacks cannot be combined by directly adding the annual background level to the modelling results. Guidance from the UK DEFRA(2) and EPA(7) advises that for SO_2 an estimate of the maximum combined pollutant concentrations can be obtained as shown below:

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)

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)

The background data used to calculate the results in line with the equations above were taken from the EPA hourly SO_2 monitoring data for the Shannon Estuary for the year 2016.

PM_{10}

Long-term PM_{10} monitoring was carried out at the Zone D locations of Castlebar, Claremorris, Enniscorthy and Kilkitt in 2016. The PM_{10} annual averages for these four locations in 2015 ranged from 8.0 to 17.3 µg/m^3(21). The PM_{10} annual average in 2016 for the rural Zone D location of Kilkitt was 9.2 µg/m^3(21). Data from 2012 – 2016 for the four Zone D locations showed annual averages ranging from 9 to 19 µg/m^3 (see Table 3). Based on the above information, a conservative estimate of the background PM_{10} concentration of 12 µg/m^3 has been used and the maximum 24-hour averaging period was assessed using real monitoring data for Kilkitt for the year 2016 and using the methodology outlined below.

Year	Castlebar (µg/m^3)	Claremorris (µg/m^3)	Enniscorthy (µg/m^3)	Kilkitt (µg/m^3)
2012	12	10	-	9
2013	15	13	-	11
2014	12	10	22	9
2015	13	10	18	9
2016	10	8	17	12
Average	**11**	**9**	**19**	**13**

Table 3 Annual Mean PM_{10} Background Concentrations in Zone D Locations 2012 – 2016 (µg/m^3)

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, guidance from the UK DEFRA(2) and EPA(7) 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}

$PM_{2.5}$

The results of $PM_{2.5}$ monitoring at the Zone D location of Claremorris from 2012 - 2016(15) indicated that $PM_{2.5}/PM_{10}$ ratios ranged from 0.5 – 0.6 over that period. Based on this information, a conservative ratio of 0.6 was used to generate a background $PM_{2.5}$ concentration of 7.2 µg/m^3.

Mercury (Hg)

The annual average mercury concentrations from 2012 to 2016 for the Zone D location of Macehead ranged from 1.25 to 1.5 ng/m^3 with an average over the 5 year period of 1.41 ng/m^3 (21) (see Table 4). Based on this information, an estimate of the background mercury concentration in the region of the facility is 1.4 ng/m^3.

Year	Macehead (ng/m^3)
2012	1.48
2013	1.50
2014	1.44
2015	1.37
2016	1.25
Average	**1.41**

Table 4 Annual Mean Mercury Background Concentrations in Zone D Locations 2012 – 2016 (ng/m^3)

Hydrogen Chloride (HCl)

Background concentrations of HCL are predicted to be negligible. There is no background monitoring for HCL conducted by the EPA.

Hydrogen Fluoride (HF)

Background concentrations of HF are predicted to be negligible. For this reason there is no background monitoring for HF conducted by the EPA.

2.3 Air Quality Standards

Ambient Air Quality Standards

In order to reduce the risk to health from poor air quality, national and European statutory bodies have set limit values in ambient air for a range of air pollutants. These limit values or "Air Quality Standards" are health- or environmental-based levels for which additional factors may be considered. The applicable standards in Ireland include the Air Quality Standards Regulations 2011, which incorporate EU Directive 2008/50/EC (see Table 5). As there is currently no EU limit value set for mercury, the predicted concentrations are compared with the applicable WHO ambient air quality guideline value for inorganic mercury as set out in Table 5. In addition to applying the EU limit value for $PM_{2.5}$, the results will also be compared with the WHO limit values for $PM_{2.5}$ which are more stringent. The WHO have recommended an air quality guideline concentration of 10 µg/m^3 for annual average $PM_{2.5}$ and a 24-hour average air quality guideline concentration of 25 µg/m^3 expressed as the 99^{th}%ile[(26)]. HCl and HF limits have been derived from levels outlined in the UK publication "*UK DEFRA Expert Panel on Air Quality Standards (2008)*"[(27)].

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

Pollutant	Averaging Period	Limit / Target Value		
		SI No. 180 of 2011 (μg/m^3)	WHO 2000 / 2005 (μg/m^3)	UK DEFRA guidelines
NO_2	99.8th percentile of 1- Hourly Averages	200	-	-
NO_2	Annual Average (for the protection of human health)	40	-	-
NO_x	Annual Average (for the protection of vegetation)	30		-
SO_2	99.7th percentile of 1- Hourly Averages	350	-	-
SO_2	99.2th percentile of 24- Hourly Averages	125	-	-
SO_2	Annual Average (for the protection of ecosystems)	20		-
PM_{10}	90.4th percentile of 24- Hourly Averages	50	-	-
PM_{10}	Annual Average	40	-	-
$PM_{2.5}$	Annual Average	25	10	-
Mercury	Annual Average	-	1	-
Hydrogen Fluoride	Annual Average		-	20
Hydrogen Fluoride	Maximum 1-hour	-	-	800
Hydrogen Chloride	Annual Average		-	60
Hydrogen Chloride	Maximum 1-hour	-	-	160

Table 5 EU and WHO Ambient Air Quality Standards (Based on Directives 2008/50/EC and 2004/107/E, WHO Air Quality Guidelines and UK DEFRA guidelines)

2.4 Air Dispersion Modelling Methodology

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

- Three receptor grids were created at which concentrations would be modelled. Receptors were mapped with sufficient resolution to ensure all localised "hot-spots" were identified without adding unduly to processing time. The receptor grids were based on Cartesian grids with the site at the centre. An outer grid measuring 40 x 40 km, extended to 20km from the site with concentrations calculated at 1 km intervals. A second grid measuring 20 x 20 km extended to 10km from the site with concentrations calculated at 200m intervals. An inner grid measuring 5 x 5 km, extended to 2.5 km from the site with concentrations calculated at 50m intervals. Boundary receptor locations were also placed along the boundary of the site, at 50m intervals, giving a total of 22,185 calculation points for the models.

- All on-site buildings and significant process structures were mapped into the models 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.

- Hourly-sequenced meteorological information has been used in the model. Meteorological data over a five year period (Ballyhaise, 2012 – 2016) was used in the models.

- AERMOD incorporates a meteorological pre-processor AERMET[28]. The AERMET meteorological preprocessor requires the input of surface characteristics, including surface roughness (z_0), Bowen Ratio and albedo by sector and season, as well as hourly observations of wind speed, wind direction, cloud cover, and temperature. The values of albedo, Bowen Ratio and surface roughness depend on land-use type (e.g., urban, cultivated land etc) and vary with seasons and wind direction. The assessment of appropriate land-use type was carried out to a distance of 10km from the meteorological station for Bowen Ratio and albedo and to a distance of 1km for surface roughness in line with USEPA recommendations.

- The source and emission data, including stack dimensions, gas velocities, emission temperatures and pollutant emission rates have been incorporated into the models for the two emission scenarios (*Maximum Existing Scenario* and *Maximum Proposed Scenario*).

- Detailed terrain has been mapped into the model using SRTM (Shuttle Radar Topography Mission) data with 30m resolution. The site is located in rolling terrain. For AERMOD, all terrain features have been mapped in detail into the model using the terrain pre-processor AERMAP

Site Boundary

Emission Point

N

Project

West Offaly Power Station – Air Dispersion Model

Reference

18/10101AR01

Figure 1

Approximate Locations of Emission Point and Site Boundary

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2.5 Terrain

The terrain across the 40 x 40 km domain modelled has been illustrated as contours in Figure 2.

AERMOD

The AERMOD air dispersion model has a terrain pre-processor AERMAP which was used to map the physical environment in detail over the receptor grid. The digital terrain input data used in the AERMAP pre-processor was SRTM data. This data was run to obtain for each receptor point the terrain height and the terrain height scale. The terrain height scale is used in AERMOD to calculate the critical dividing streamline height, H_{crit}, for each receptor. The terrain height scale is derived from the Digitial Elevation Model (DEM) files in AERMAP by computing the relief height of the DEM point relative to the height of the receptor and determining the slope. If the slope is less than 10%, the program goes to the next DEM point. If the slope is 10% or greater, the controlling hill height is updated if it is higher than the stored hill height. In areas of complex terrain, such as the current region, AERMOD models the impact of terrain using the concept of the dividing streamline (H_c). As outlined in the AERMOD model formulation(6) a plume embedded in the flow below H_c tends to remain horizontal; it might go around the hill or impact on it. A plume above H_c will ride over the hill. Associated with this is a tendency for the plume to be depressed toward the terrain surface, for the flow to speed up, and for vertical turbulent intensities to increase.

AERMOD model formulation states that the model "captures the effect of flow above and below the dividing streamline by weighting the plume concentration associated with two possible extreme states of the boundary layer (horizontal plume and terrain-following). The relative weighting of the two states depends on: 1) the degree of atmospheric stability; 2) the wind speed; and 3) the plume height relative to terrain. In stable conditions, the horizontal plume "dominates" and is given greater weight while in neutral and unstable conditions, the plume traveling over the terrain is more heavily weighted"(6). 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.

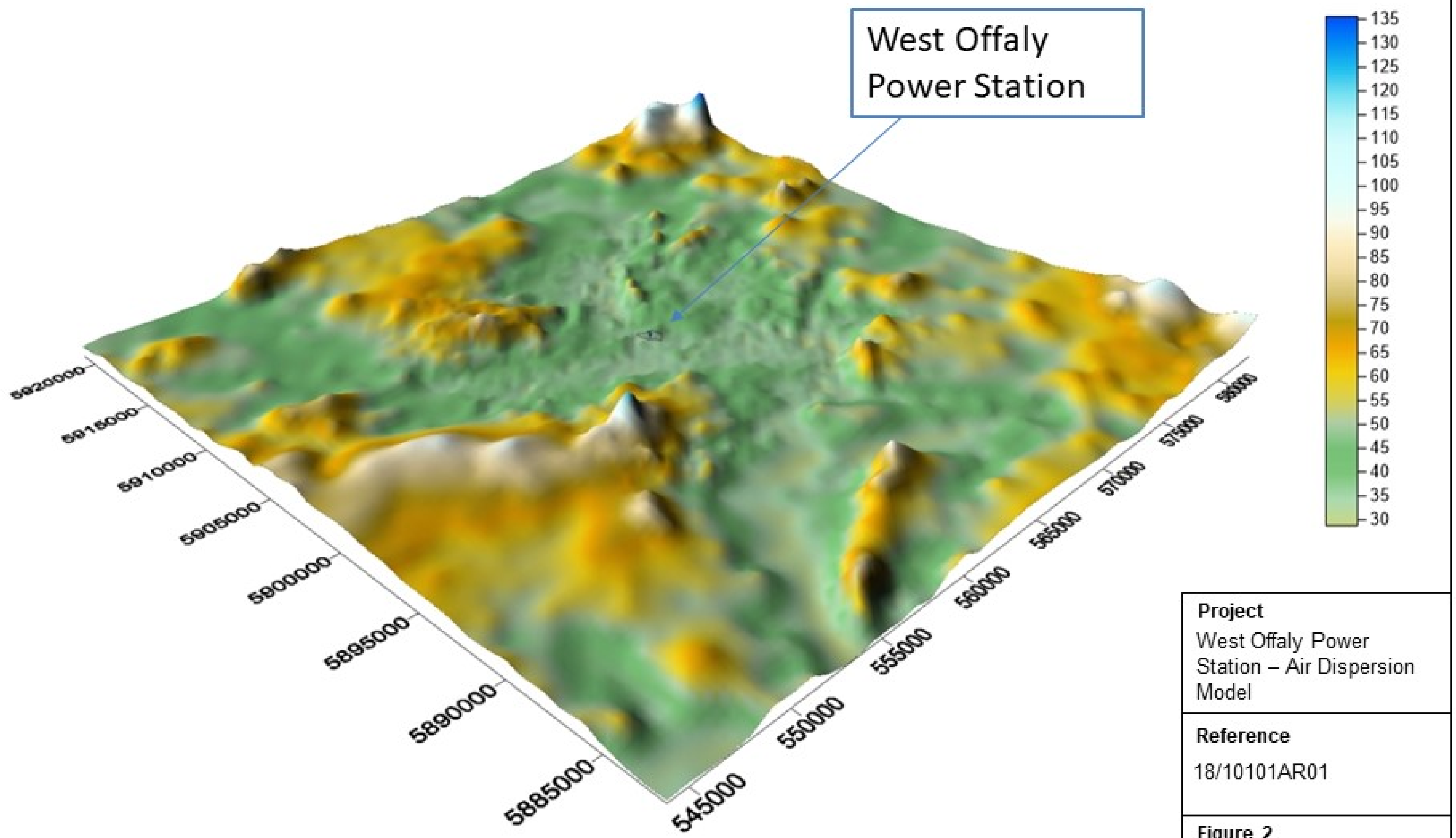
2.6 Meteorological Data

The selection of the appropriate meteorological data has followed the guidance issued by the USEPA(9). A primary requirement is that the data used should have a data capture of greater than 90% for all parameters. Ballyhaise meteorological station, which is located approximately 60 km north-east of the site, collects data in the correct format and has a data collection rate of greater than 90%. Meteorological data over a five year period (Ballyhaise, 2012 – 2016) was used in the model (see Figure 1).

Long-term hourly observations at Ballyhaise meteorological station provide an indication of the prevailing wind conditions for the region (see Figure 3). Results indicate that the prevailing wind direction is from southerly to westerly in direction with a mean wind speed of approximately 3.3 m/s over this period.

2.7 Process Emissions

The information used in the dispersion model for the emission points is shown in Table 10.



Project
West Offaly Power Station – Air Dispersion Model

Reference
18/10101AR01

Figure 2
Terrain in the Vicinity of the Facility (UTM Zone 29 Co-ordinates)

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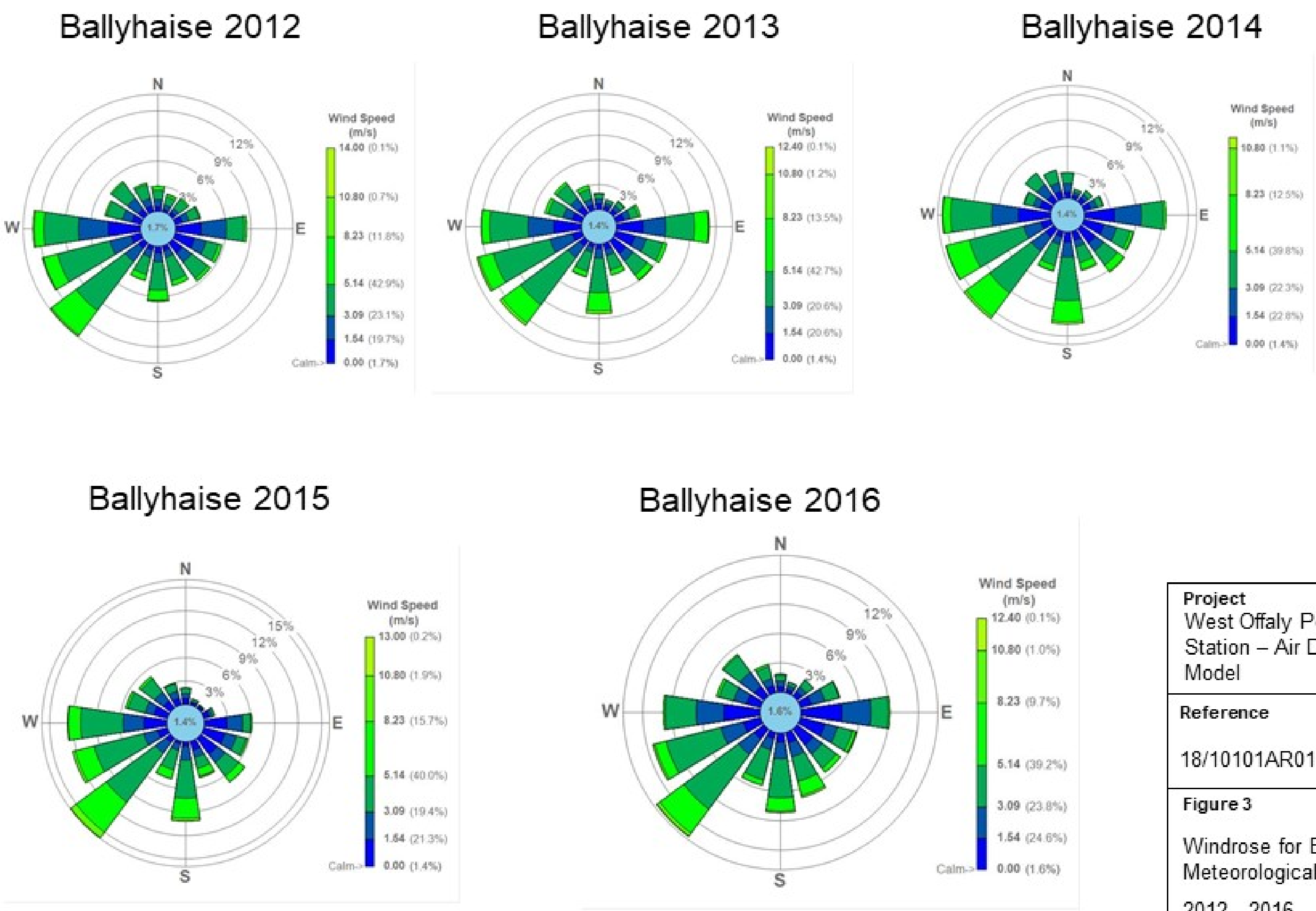

Project
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Reference
18/10101AR01

Figure 3
Windrose for Ballyhaise Meteorological Station
2012 - 2016

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Parameter	Maximum Existing Scenario				Maximum Proposed Scenario			
Stack Name	PS-A1-		PS-A2-		PS-A1-		PS-A2-	
Stack Location Note 1	563998, 593133		563941, 5903105		563998, 593133		563941, 5903105	
Height above Ground (m)	80		67		80		67	
Exit Diameter (m)	4		0.875		4		0.875	
Cross-sectional Area (m^2)	12.57		0.60		12.57		0.60	
Temperature (K)	345.15		407		345.15		407	
Max Volume Flow (Nm^3/hr)	594,709 (Note: Licenced 567,000)		15,500		594,709 (Note: Licenced 567,000)		15,500	
Exit Velocity (m/sec actual)	25.12		10.67		25.12		10.67	
Process Emissions	**Conc. (mg/Nm^3)**	**Mass Emission (g/s)**	**Conc. (mg/Nm^3)**	**Mass Emission (g/s)**	**Conc. (mg/Nm^3)**	**Mass Emission (g/s)**	**Conc. (mg/Nm^3)**	**Mass Emission (g/s)**
NO_2	200	30.15	300	129	165	24.87	300	129
SO_2	200	30.15	1,700	7.32	200	30.15	1,700	7.32
PM_{10} (& $PM_{2.5}$) Note 2	20	3.01	20	0.1	16	2.41	20	0.1
Mercury	N/A	N/A	N/A	N/A	12	1.80	N/A	N/A
Hydrogen Fluoride	N/A	N/A	N/A	N/A	1	0.15	N/A	N/A
Hydrogen Chloride	N/A	N/A	N/A	N/A	5	0.75	N/A	N/A

Note 1 Stack location is in UTM Zone 29
Note2 All PM_{10} assumed to be $PM_{2.5}$ as a worst-case

Table 7 Stack Emission Details for the Two Scenarios Modelled

2.8 Traffic Emissions Methodology

The air quality assessment was carried out following procedures described in the publications by the EPA(18,19) and using the methodology outlined in the policy and technical guidance notes, LAQM.PG(16) and LAQM.TG(16), issued by UK Department for Environment, Food and Rural Affairs(1-5). The assessment of air quality is carried out using a phased approach as recommended by the UK Department for Environment, Food and Rural Affairs(2). The phased approach recommends that the complexity of an air quality assessment be consistent with the risk of failing to achieve the air quality standards. In the current assessment, an initial scoping of key pollutants will be carried out at sensitive receptors. These sensitive receptors have the potential to have an impact on the concentration of key pollutants due to the proposed development. An examination of recent EPA and Local Authority data in Ireland(20,21), has indicated that SO_2 and smoke and CO are unlikely to be exceeded at locations such as the current one and thus these pollutants do not require detailed monitoring or assessment to be carried out. However, the analysis did indicate potential problems in regards to nitrogen dioxide (NO_2) and PM_{10} at busy junctions in urban centres(20,21). Benzene, although previously reported at quite high levels in urban centres, has recently been measured at several city centre locations to be well below the EU limit value(20,21). Historically, CO levels in urban areas were a cause for concern. However, CO concentrations have decreased significantly over the past number of years and are now measured to be well below the limits even in urban centres(20,21). The key pollutants reviewed in the assessments are NO_2, PM_{10}, $PM_{2.5}$, benzene and CO, with particular focus on NO_2 and PM_{10}.

The assessment methodology involved air dispersion modelling using the UK DMRB Screening Model(5), the NO_x to NO_2 Conversion Spreadsheet(16), and following guidance issued by the TII(17), UK Highways Agency(5), UK DEFRA(2) and the EPA(18,19).

TII guidance states that the assessment must progress to detailed modelling if:

- Concentrations exceed 90% of the air quality limit values when assessed by the screening method; or
- sensitive receptors exist within 50m of a complex road layout (e.g. grade separated junctions, hills etc).

The UK DMRB guidance(5), on which the TII guidance was based, states that road links meeting one or more of the following criteria can be defined as being ‘affected’ by a proposed development and should be included in the local air quality assessment:

- Road alignment change of 5 metres or more;
- Daily traffic flow changes by 1,000 AADT or more;
- HDV flows change by 200 vehicles per day or more;
- Daily average speed changes by 10 km/h or more; or
- Peak hour speed changes by 20 km/h or more.

Concentrations of key pollutants are calculated at sensitive receptors which have the potential to be affected by the proposed development. For road links which are deemed to be affected by the proposed development and within 200 m of the chosen sensitive receptors inputs to the air dispersion model consist of; road layouts, receptor locations, annual average daily traffic movements (AADT), percentage heavy goods vehicles, annual average traffic speeds and background concentrations. The degree of impact is determined based on both the absolute and relative impact of the Proposed Development. The TII significance criteria have been adopted for the Proposed Development and are detailed in Table 8-10. The significance criteria are based on PM_{10} and NO_2 as these pollutants are most likely to exceed the annual mean limit values (40 μg/m^3).

Magnitude of Change	Annual Mean NO_2 / PM_{10}	No. days with PM_{10} concentration > 50 μg/m^3	Annual Mean $PM_{2.5}$
Large	Increase / decrease ≥4 μg/m^3	Increase / decrease >4 days	Increase / decrease ≥2.5 μg/m^3
Medium	Increase / decrease 2 - <4 μg/m^3	Increase / decrease 3 or 4 days	Increase / decrease 1.25 - <2.5 μg/m^3
Small	Increase / decrease 0.4 - <2 μg/m^3	Increase / decrease 1 or 2 days	Increase / decrease 0.25 - <1.25 μg/m^3
Imperceptible	Increase / decrease <0.4 μg/m^3	Increase / decrease <1 day	Increase / decrease <0.25 μg/m^3

Table 8 Definition of Impact Magnitude for Changes in Ambient Pollutant Concentrations
Source: Guidelines for the Treatment of Air Quality During the Planning and Construction of National Road Schemes – Transport Infrastructure Ireland (2011)

Absolute Concentration in Relation to Objective / Limit Value	Change in Concentration		
	Small	**Moderate**	**Large**
Increase with Scheme			
Above Objective/Limit Value With Scheme (≥40 μg/m^3 of NO_2 or PM_{10}) (≥25 μg/m^3 of $PM_{2.5}$)	Slight adverse	Moderate adverse	Substantial adverse
Just Below Objective/Limit Value With Scheme (36 - <40 μg/m^3 of NO_2 or PM_{10}) (22.5 - <25 μg/m^3 of $PM_{2.5}$)	Slight adverse	Moderate adverse	Moderate adverse
Below Objective/Limit Value With Scheme (30 - <36 μg/m^3 of NO_2 or PM_{10}) (18.75 - <22.5 μg/m^3 of $PM_{2.5}$)	Negligible	Slight adverse	Slight adverse
Well Below Objective/Limit Value With Scheme (<30 μg/m^3 of NO_2 or PM_{10}) (<18.75 μg/m^3 of $PM_{2.5}$)	Negligible	Negligible	Slight adverse
Decrease with Scheme			
Above Objective/Limit Value With Scheme (≥40 μg/m^3 of NO_2 or PM_{10}) (≥25 μg/m^3 of $PM_{2.5}$)	Slight beneficial	Moderate beneficial	Substantial beneficial
Just Below Objective/Limit Value With Scheme (36 - <40 μg/m^3 of NO_2 or PM_{10}) (22.5 - <25 μg/m^3 of $PM_{2.5}$)	Slight beneficial	Moderate beneficial	Moderate beneficial
Below Objective/Limit Value With Scheme (30 - <36 μg/m^3 of NO_2 or PM_{10}) (18.75 - <22.5 μg/m^3 of $PM_{2.5}$)	Negligible	Slight beneficial	Slight beneficial
Well Below Objective/Limit Value With Scheme (<30 μg/m^3 of NO_2 or PM_{10}) (<18.75 μg/m^3 of $PM_{2.5}$)	Negligible	Negligible	Slight beneficial

Table 9 Definition of Impact Magnitude for Changes in Ambient Pollutant Concentrations
Note 1 Where the Impact Magnitude is Imperceptible, then the Impact Description is Negligible
Source: Guidelines for the Treatment of Air Quality During the Planning and Construction of National Road Schemes - Transport Infrastructure Ireland (2011)

Absolute Concentration in Relation to Objective / Limit Value	Change in Concentration		
	Small	**Medium**	**Large**
Increase with Scheme			
Above Objective/Limit Value With Scheme (≥35 days)	Slight Adverse	Moderate Adverse	Substantial Adverse
Just Below Objective/Limit Value With Scheme (32 - <35 days)	Slight Adverse	Moderate Adverse	Moderate Adverse
Below Objective/Limit Value With Scheme (26 - <32 days)	Negligible	Slight Adverse	Slight Adverse
Well Below Objective/Limit Value With Scheme (<26 days)	Negligible	Negligible	Slight Adverse
Decrease with Scheme			
Above Objective/Limit Value With Scheme (≥35 days)	Slight Beneficial	Moderate Beneficial	Substantial Beneficial
Just Below Objective/Limit Value With Scheme (32 - <35 days)	Slight Beneficial	Moderate Beneficial	Moderate Beneficial
Below Objective/Limit Value With Scheme (26 - <32 days)	Negligible	Slight Beneficial	Slight Beneficial
Well Below Objective/Limit Value With Scheme (<26 days)	Negligible	Negligible	Slight Beneficial

Table 10 Definition of Impact Magnitude for Changes in Ambient Pollutant Concentrations

Note 1 Where the Impact Magnitude is Imperceptible, then the Impact Description is Negligible

Source: Guidelines for the Treatment of Air Quality During the Planning and Construction of National Road Schemes - Transport Infrastructure Ireland (2011)

3.0 RESULTS & DISCUSSION

3.1 NO_2

Maximum Existing Scenario

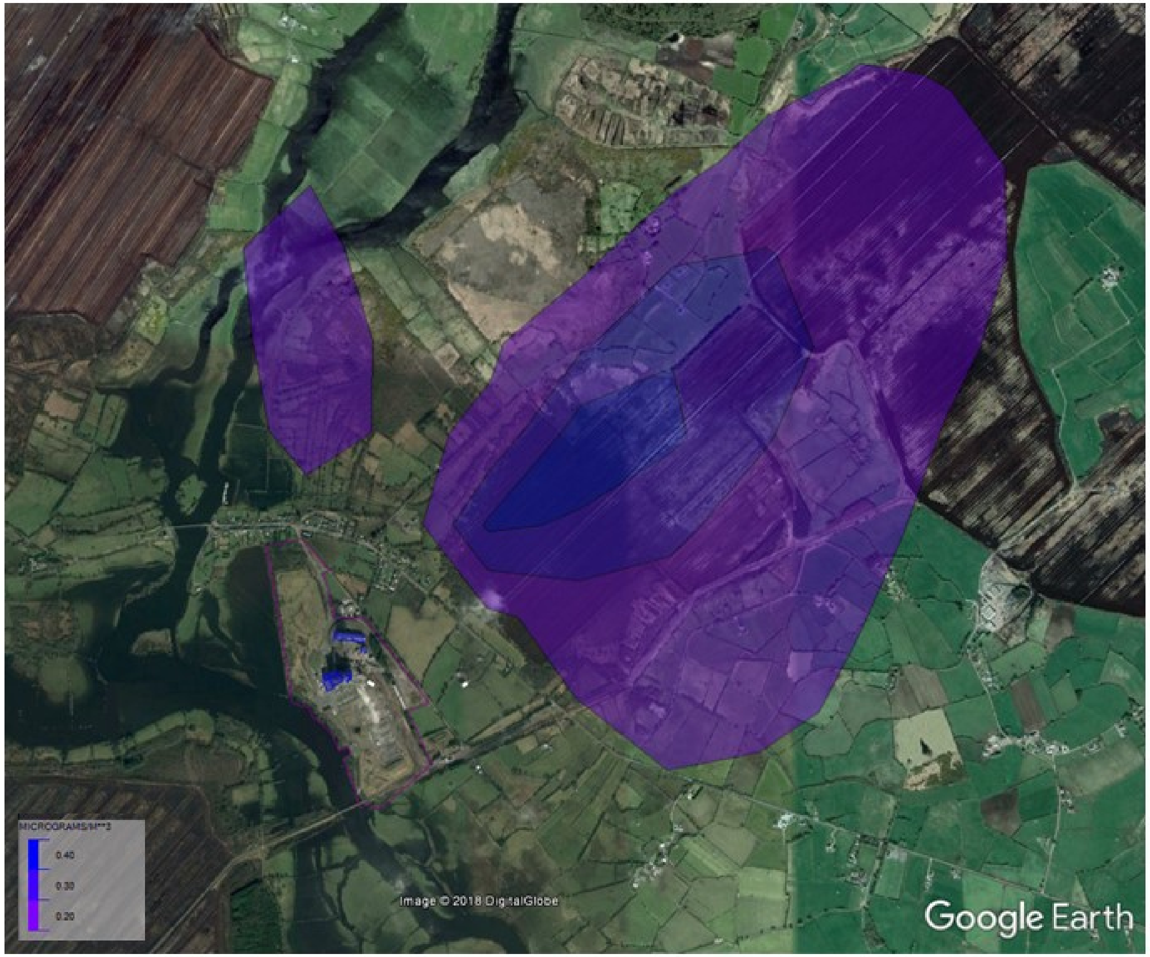
The NO_2 modelling results for the Maximum Existing Scenario are detailed in Table 11. The results indicate that the ambient ground level concentrations are below the relevant air quality standards for NO_2. Emissions from the facility lead to an ambient NO_2 concentration which is 4.7% of the maximum 1-hour limit value (measured as a 99.8^{th}%ile) and 1.1% of the annual limit value at the worst-case off-site receptor for the worst-case years modelled (2015). When background concentrations are included this rises to 29% of the maximum 1-hour limit value (measured as a 99.8^{th}%ile) and 16% of the annual limit value at the worst-case off-site receptor.

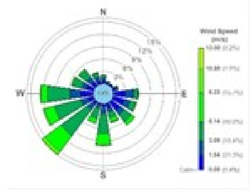
The geographical variations in ground level NO_2 concentrations (without background) beyond the facility boundary for the worst-case years modelled are illustrated as concentration contours in Figure 4 which shows maximum existing scenario predicted annual mean NO_2 concentrations (2015).

Pollutant/ Scenario / Year	Averaging Period	Process Contribution ($\mu g/m^3$)	Annual Mean Background ($\mu g/m^3$	Predicted Emission Concentration - PEC ($\mu g/Nm^3$)	Standard ($\mu g/Nm^3$)Note 1	PEC as a % of Standard
NO_2 / Maximum Existing Scenario / 2012	Annual Mean	0.36	11	11.36	40	28%
	99.8^{th}%ile of 1-hr means	9.32	22	31.3	200	16%
NO_2 / Maximum Existing Scenario / 2013	Annual Mean	0.35	11	11.35	40	28%
	99.8^{th}%ile of 1-hr means	9.18	22	31.2	200	16%
NO_2 / Maximum Existing Scenario / 2014	Annual Mean	0.32	11	11.32	40	28%
	99.8^{th}%ile of 1-hr means	9.13	22	31.1	200	16%
NO_2 / Maximum Existing Scenario / 2015	Annual Mean	0.46	11	11.46	40	29%
	99.8^{th}%ile of 1-hr means	9.41	22	31.4	200	16%
NO_2 / Maximum Existing Scenario / 2016	Annual Mean	0.39	11	11.39	40	28%
	99.8^{th}%ile of 1-hr means	8.80	22	30.8	200	15%

Note 1 Air Quality Standards 2011 (from EU Directive 2008/50/EC)

Table 11 Modelled NO_2 Concentrations for Maximum Existing Scenario ($\mu g/m^3$)





Background Mapping from Google Earth

Maximum Exisiting Scenario Annual Mean NO_2 Concentrations (excluding background) Maximum Concentration = 0.45 µg/m^3

Boundary Of Facility

N

Project
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Figure 4

Maximum Existing Scenario: Predicted NO_2 Annual Mean Concentrations (2015) (µg/m^3)

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Maximum Proposed Scenario

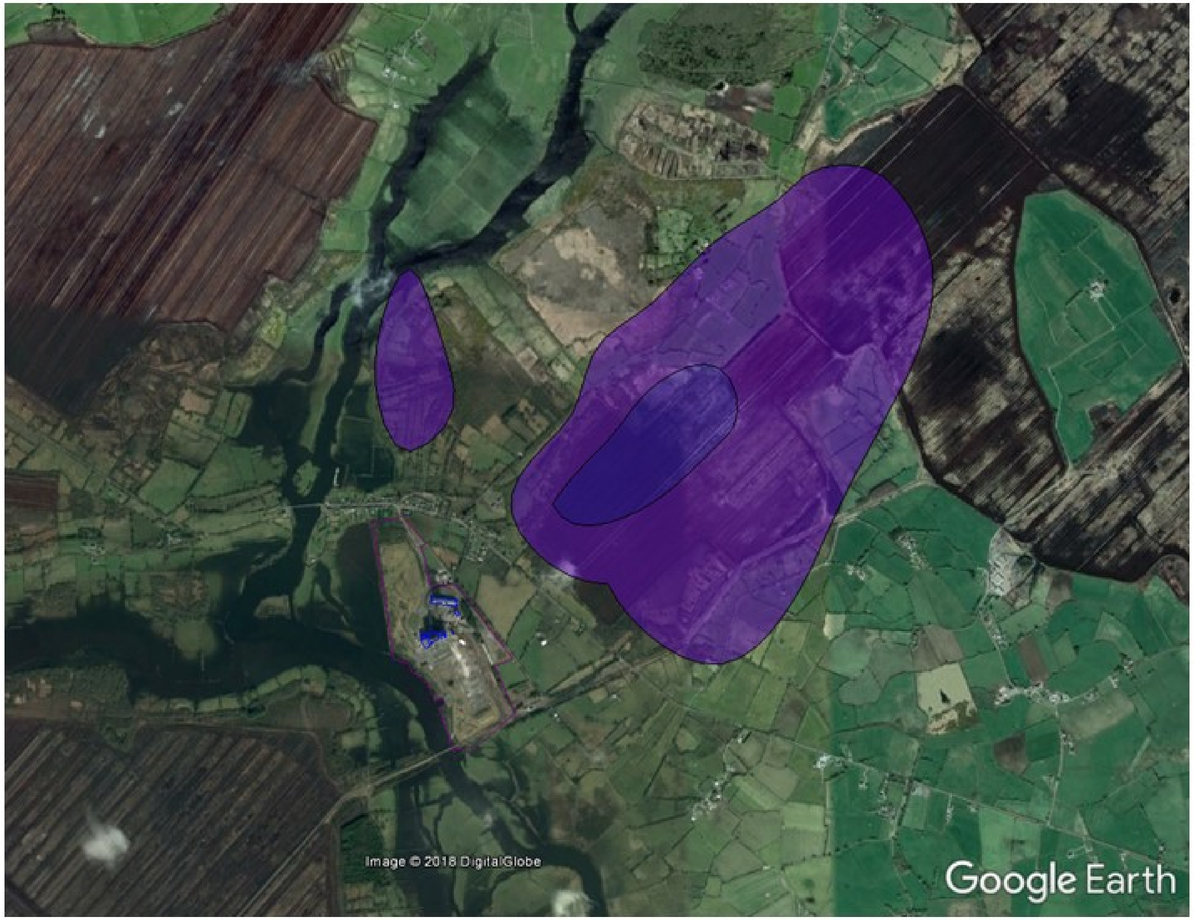
The NO_2 modelling results for the Maximum Proposed Scenario are detailed in Table 12. The results indicate that the ambient ground level concentrations are below the relevant air quality standards for NO_2. Emissions from the facility lead to an ambient NO_2 concentration which is 1.0% of the maximum 1-hour limit value (measured as a 99.8th%ile) and 4.6% of the annual limit value at the worst-case off-site receptor for the worst-case years modelled (2015 and 2011). When background concentrations are included this rises to 16% of the maximum 1-hour limit value (measured as a 99.8th%ile) and 29% of the annual limit value at the worst-case off-site receptor.

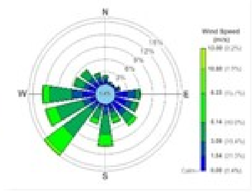
The geographical variations in ground level NO_2 concentrations (without background) beyond the facility boundary for the worst-case year modelled are illustrated as concentration contours in Figures 5 which shows the maximum proposed scenario predicted annual mean NO_2 concentrations (2015).

Pollutant/ Scenario / Year	Averaging Period	Process Contribution ($\mu g/m^3$)	Annual Mean Background ($\mu g/m^3$	Predicted Emission Concentration - PEC ($\mu g/Nm^3$)	Standard ($\mu g/Nm^3$)Note 1	PEC as a % of Standard
NO_2 / Maximum Proposed Scenario / 2012	Annual Mean	0.31	11	11.31	40	28%
	99.8th%ile of 1-hr means	9.05	22	31.1	200	16%
NO_2 / Maximum Proposed Scenario / 2013	Annual Mean	0.30	11	11.30	40	28%
	99.8th%ile of 1-hr means	9.32	22	31.3	200	16%
NO_2 / Maximum Proposed Scenario / 2014	Annual Mean	0.29	11	11.29	40	28%
	99.8th%ile of 1-hr means	8.60	22	30.6	200	15%
NO_2 / Maximum Proposed Scenario / 2015	Annual Mean	0.42	11	11.42	40	29%
	99.8th%ile of 1-hr means	8.65	22	30.6	200	15%
NO_2 / Maximum Proposed Scenario / 2016	Annual Mean	0.35	11	11.35	40	28%
	99.8th%ile of 1-hr means	8.52	22	30.5	200	15%

Note 1 Air Quality Standards 2011 (from EU Directive 2008/50/EC)

Table 12 Modelled NO_2 Concentrations for Maximum Proposed Scenario ($\mu g/m^3$)





Background Mapping from Google Earth

Maximum Proposed Scenario Annual Mean NO_2 Concentrations (excluding background)

Maximum Concentration = 0.42 µg/m^3

Boundary Of Facility

N

Project

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Reference

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Figure 5

Maximum Proposed Scenario: Predicted NO_2 Annual Mean Concentrations (2015) (µg/m^3)

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3.2 SO_2

Maximum Existing Scenario

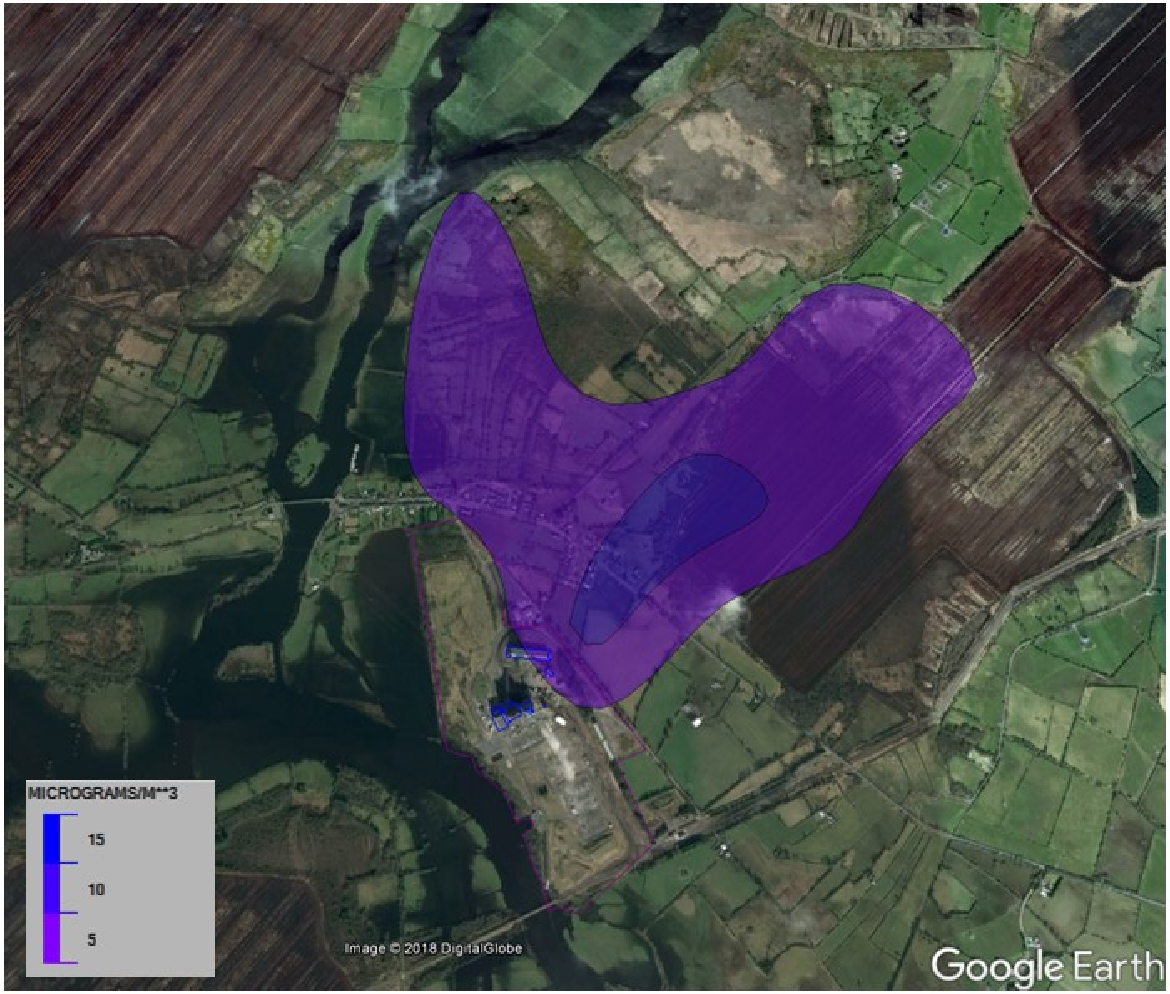
The SO_2 modelling results for the Maximum Existing Scenario are detailed in Table 13. The results indicate that the ambient ground level concentrations are below the relevant air quality standards for SO_2. Emissions from the facility lead to an ambient SO_2 concentration which is 13% of the maximum 1-hour limit value (measured as a 99.7^{th}%ile) and 12% of the maximum 24-hour limit value (measured as a 99.2^{nd}%ile) at the worst-case off-site receptor for the worst-case year modelled (2015). When background concentrations are included this rises to 14% of the 1-hour limit value (measured as a 99.7^{th}%ile) and 16% of the 24-hour limit value (measured as a 99.2^{nd}%ile) at the worst-case off-site receptor.

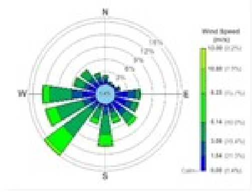
The geographical variations in ground level SO_2 concentrations (without background) beyond the facility boundary for the worst-case year modelled are illustrated as concentration contour in Figure 6 as shown in the maximum existing scenario predicted SO_2 99.2^{nd} percentile of 24-Hour mean concentrations (2015).

Pollutant/ Scenario / Year	Averaging Period	Process Contribution (μg/m^3)	Annual Mean Background (μg/m^3) Note 1	Predicted Emission Concentration - PEC (μg/Nm^3)	Standard (μg/Nm^3)Note 2	PEC as a % of Standard
SO_2 / Maximum Existing Scenario / 2012	99.2nd%ile of 24-hr means	8.34	2.50	13.3	125	11%
	99.7th%ile of 1-hr means	27.62	2.50	32.6	350	9%
SO_2 / Maximum Existing Scenario / 2013	99.2nd%ile of 24-hr means	8.05	2.50	13.0	125	10%
	99.7th%ile of 1-hr means	27.21	2.50	32.2	350	9%
SO_2 / Maximum Existing Scenario / 2014	99.2nd%ile of 24-hr means	9.12	2.50	14.1	125	11%
	99.7th%ile of 1-hr means	27.10	2.50	32.1	350	9%
SO_2 / Maximum Existing Scenario / 2015	99.2nd%ile of 24-hr means	15.41	2.50	20.4	125	16%
	99.7th%ile of 1-hr means	44.89	2.50	49.9	350	14%
SO_2 / Maximum Existing Scenario / 2016	99.2nd%ile of 24-hr means	9.73	2.50	14.7	125	12%
	99.7th%ile of 1-hr means	32.80	2.50	37.8	350	11%

Note 1 Short-term Immission Concentrations calculated according to UK DEFRA guidance[20]
Note 2 Air Quality Standards 2011 (from EU Directive 2008/50/EC)

Table 13 Modelled SO_2 Concentrations for Maximum Existing Scenario (μg/m^3)





Background Mapping from Google Earth

Maximum Existing Scenario 99.2nd%ile of 24-Hour Mean SO_2 Concentrations (excluding background)
Maximum Concentration = 15.4 µg/m^3

Boundary Of Facility

N

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Figure 6

Maximum Existing Scenario: Predicted SO_2 99.2nd Percentile of 24-Hourly Concentrations (2015) (µg/m^3)

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Maximum Proposed Scenario

The SO_2 modelling results for the Maximum Proposed Scenario are detailed in Table 14. The results indicate that the ambient ground level concentrations are below the relevant air quality standards for SO_2. Emissions from the facility lead to an ambient SO_2 concentration which is 13% of the maximum 1-hour limit value (measured as a 99.7th%ile) and 12% of the maximum 24-hour limit value (measured as a 99.2nd%ile) at the worst-case off-site receptor for the worst-case year modelled (2015). When background concentrations are included this rises to 14% of the 1-hour limit value (measured as a 99.7th%ile) and 16% of the 24-hour limit value (measured as a 99.2nd%ile) at the worst-case off-site receptor.

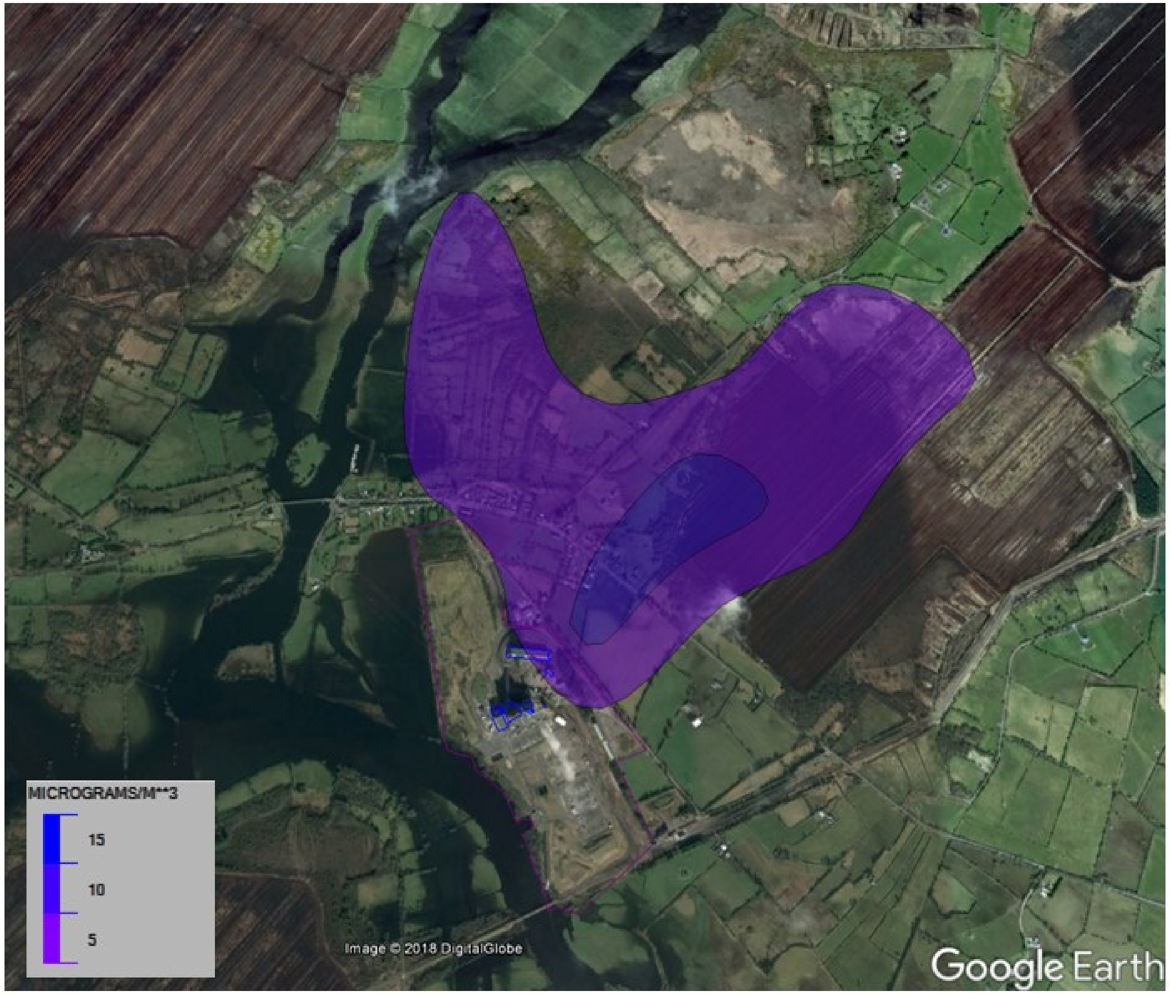
The geographical variations in ground level SO_2 concentrations (without background) beyond the facility boundary for the worst-case SO_2 99.2nd Percentile of 24-Hour Mean Concentrations (2015) modelled is illustrated as concentration contours in Figure 7.

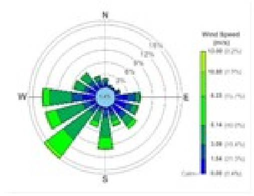
Pollutant/ Scenario / Year	Averaging Period	Process Contribution ($\mu g/m^3$)	Annual Mean Background ($\mu g/m^3$) Note 1	Predicted Emission Concentration - PEC ($\mu g/Nm^3$)	Standard ($\mu g/Nm^3$) Note 2	PEC as a % of Standard
SO_2 / Maximum Proposed Scenario / 2012	99.2nd%ile of 24-hr means	8.34	5.00	13.3	125	11%
	99.7th%ile of 1-hr means	27.62	5.00	32.6	350	9%
SO_2 / Maximum Proposed Scenario / 2013	99.2nd%ile of 24-hr means	8.05	5.00	13.0	125	10%
	99.7th%ile of 1-hr means	27.21	5.00	32.2	350	9%
SO_2 / Maximum Proposed Scenario / 2014	99.2nd%ile of 24-hr means	9.12	5.00	14.1	125	11%
	99.7th%ile of 1-hr means	27.10	5.00	32.1	350	9%
SO_2 / Maximum Proposed Scenario / 2015	99.2nd%ile of 24-hr means	15.41	5.00	20.4	125	16%
	99.7th%ile of 1-hr means	44.89	5.00	49.9	350	14%
SO_2 / Maximum Proposed Scenario / 2016	99.2nd%ile of 24-hr means	9.73	5.00	14.7	125	12%
	99.7th%ile of 1-hr means	32.80	5.00	37.8	350	11%

Note 1 Short-term Immission Concentrations calculated according to UK DEFRA guidance[20]

Note 2 Air Quality Standards 2011 (from EU Directive 2008/50/EC)

Table 14 Modelled SO_2 Concentrations for Maximum Proposed Scenario ($\mu g/m^3$)





Background Mapping from Google Earth

Maximum Proposed Scenario 99.2nd%ile of 24-Hour Mean SO_2 Concentrations (excluding background)

Maximum Concentration = 15.4 µg/m^3

Boundary Of Facility

N

Project

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Reference

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Figure 7

Maximum Proposed Scenario: Predicted SO_2 99.2nd Percentile of 24-Hourly Concentrations (2015) (µg/m^3)

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3.3 PM_{10}

Maximum Existing Scenario

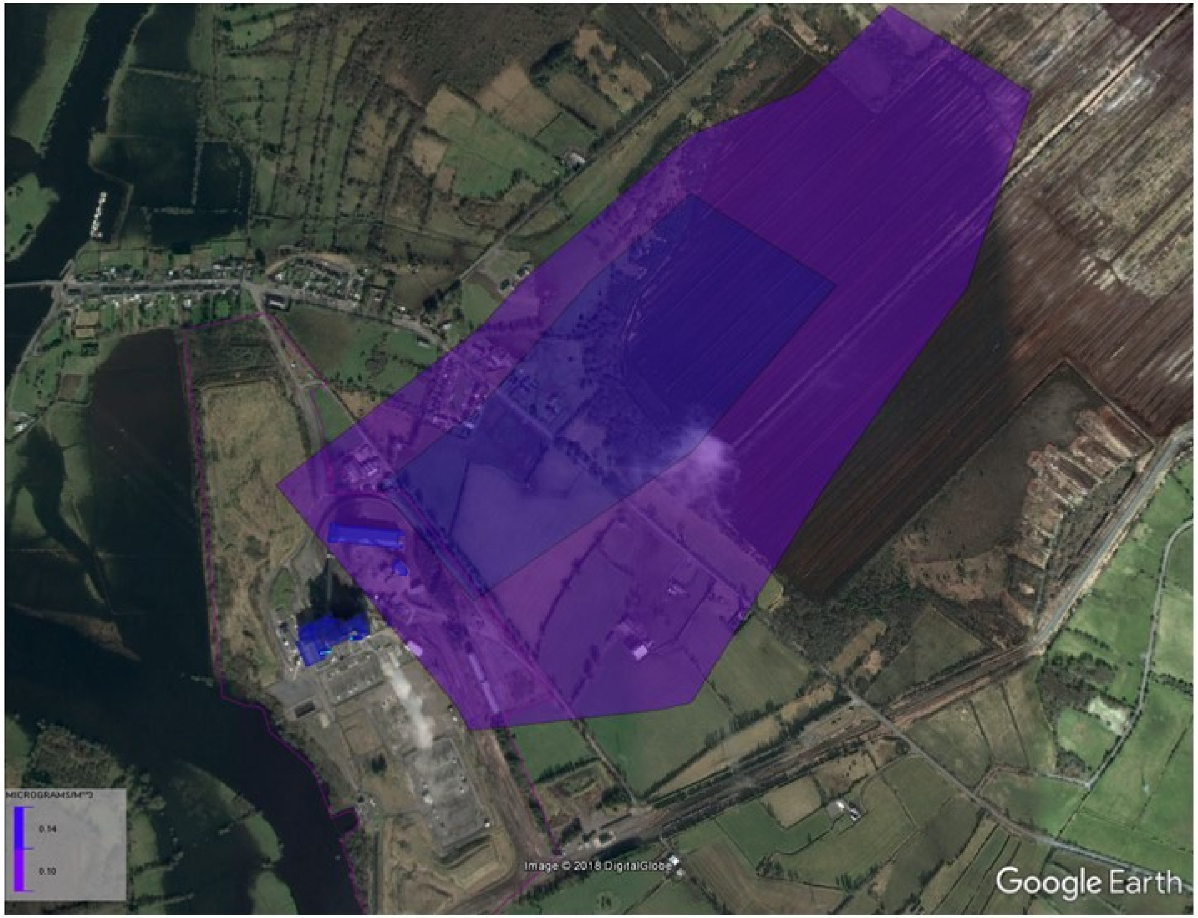
The PM_{10} modelling results for the Maximum Existing Scenario are detailed in Table 15. The results indicate that the ambient ground level concentrations are below the relevant air quality standards for PM_{10}. Emissions from the facility lead to an ambient PM_{10} concentration which is 1% of the maximum 24-hour limit value (measured as a 90.4^{th}%ile) and less than 1% of the annual limit value at the worst-case off-site receptor for the worst-case years modelled (2015). When background concentrations are included this rises to 30% of the maximum 24-hour limit value (measured as a 90.4^{th}%ile) and 30% of the annual limit value at the worst-case off-site receptor.

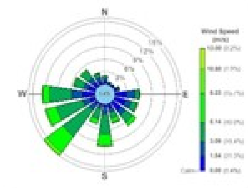
The geographical variations in ground level PM_{10} concentrations (without background) beyond the facility boundary for the worst-case year (2015) modelled is illustrated as concentration contours in Figure 8.

Pollutant/ Scenario / Year	Averaging Period	Process Contribution ($\mu g/m^3$)	Annual Mean Background ($\mu g/m^3$) Note 1	Predicted Emission Concentration - PEC ($\mu g/Nm^3$)	Standard ($\mu g/Nm^3$) Note 2	PEC as a % of Standard
PM_{10} / Maximum Existing Scenario / 2012	Annual Mean	0.101	12	12.1	40	30%
	90.4^{th}%ile of 24-hr means	0.369	12	15.1	50	30%
PM_{10} / Maximum Existing Scenario / 2013	Annual Mean	0.098	12	12.1	40	30%
	90.4^{th}%ile of 24-hr means	0.336	12	15.1	50	30%
PM_{10} / Maximum Existing Scenario / 2014	Annual Mean	0.089	12	12.1	40	30%
	90.4^{th}%ile of 24-hr means	0.263	12	15.1	50	30%
PM_{10} / Maximum Existing Scenario / 2015	Annual Mean	0.143	12	12.1	40	30%
	90.4^{th}%ile of 24-hr means	0.395	12	15.1	50	30%
PM_{10} / Maximum Existing Scenario / 2016	Annual Mean	0.103	12	12.1	40	30%
	90.4^{th}%ile of 24-hr means	0.321	12	15.1	50	30%

Note 1 Short-term Immission Concentrations calculated according to UK DEFRA guidance[20]
Note 2 Air Quality Standards 2011 (from EU Directive 2008/50/EC)

Table 15 Modelled PM_{10} Concentrations for Maximum Existing Scenario ($\mu g/m^3$)





Background Mapping from Google Earth

Maximum Existing Scenario Annual Mean PM_{10} Concentrations (excluding background)

Maximum Concentration = 0.142 µg/m^3

Boundary Of Facility

N

Project

West Offaly Power Station – Air Dispersion Model

Reference

18/10101AR01

Figure 8

Maximum Existing Scenario: Predicted PM_{10} Annual Mean Concentrations (2015) (µg/m^3)

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Maximum Proposed Scenario

The PM_{10} modelling results for the Maximum Proposed Scenario are detailed in Table 16. The results indicate that the ambient ground level concentrations are below the relevant air quality standards for PM_{10}. Emissions from the facility lead to an ambient PM_{10} concentration which is 1% of the maximum 24-hour limit value (measured as a 90.4^{th}%ile) and 1% of the annual limit value at the worst-case off-site receptor for the worst-case years modelled (2015). When background concentrations are included this rises to 30% of the maximum 24-hour limit value (measured as a 90.4^{th}%ile) and 30% of the annual limit value at the worst-case off-site receptor.

The geographical variations in ground level PM_{10} concentrations (without background) beyond the facility boundary for the worst-case year (2015) modelled is illustrated as concentration contours in Figure 9.

Pollutant/ Scenario / Year	Averaging Period	Process Contribution ($\mu g/m^3$)	Annual Mean Background ($\mu g/m^3$) Note 2	Predicted Emission Concentration - PEC ($\mu g/Nm^3$)	Standard ($\mu g/Nm^3$) Note 2	PEC as a % of Standard
PM_{10} / Maximum Proposed Scenario / 2012	Annual Mean	0.081	12	12.1	40	30%
	90.4^{th}%ile of 24-hr means	0.295	12	15.1	50	30%
PM_{10} / Maximum Proposed Scenario / 2013	Annual Mean	0.078	12	12.1	40	30%
	90.4^{th}%ile of 24-hr means	0.269	12	15.1	50	30%
PM_{10} / Maximum Proposed Scenario / 2014	Annual Mean	0.071	12	12.1	40	30%
	90.4^{th}%ile of 24-hr means	0.211	12	15.1	50	30%
PM_{10} / Maximum Proposed Scenario / 2015	Annual Mean	0.114	12	12.1	40	30%
	90.4^{th}%ile of 24-hr means	0.316	12	15.1	50	30%
PM_{10} / Maximum Proposed Scenario / 2016	Annual Mean	0.082	12	12.1	40	30%
	90.4^{th}%ile of 24-hr means	0.257	12	15.1	50	30%

Note 1 Short-term Immission Concentrations calculated according to UK DEFRA guidance[20]
Note 2 Air Quality Standards 2011 (from EU Directive 2008/50/EC)

Table 16 Modelled PM_{10} Concentrations for Maximum Proposed Scenario ($\mu g/m^3$)

3.4 $PM_{2.5}$

Maximum Existing Scenario

The $PM_{2.5}$ modelling results for Maximum Existing Scenario are detailed in Table 17. The results indicate that the ambient ground level concentrations are below the relevant air quality standard for $PM_{2.5}$. Emissions from the facility lead to an ambient $PM_{2.5}$ concentration which is 1% of the EU annual limit value at the worst-case off-site receptor for the worst-case years modelled (2015). When background concentrations are included this rises to 29% of the annual EU limit value and 73% of the WHO annual average guideline value at the worst-case off-site receptor. In relation to the 24-hour guideline value for $PM_{2.5}$ stipulated by the WHO, emissions from the facility lead to an ambient concentration which is 6% of the maximum 24-hour limit value (expressed as a 99^{th}%ile) and 35% of the guideline value including the background concentration.

The geographical variations in ground level $PM_{2.5}$ annual average concentrations (without background) beyond the facility boundary for the worst-case year modelled are illustrated as concentration contours in Figure 8 (all PM_{10} is assumed to be $PM_{2.5}$).

Pollutant/ Scenario / Year	Averaging Period	Process Contribution (µg/m³)	Annual Mean Background (µg/m³)	Predicted Emission Concentration - PEC (µg/Nm³)	EU Standard (µg/Nm³)Note 1	PEC as a % of EU Standard	WHO Standard (µg/Nm³)Note 2	PEC as a % of WHO Standard
$PM_{2.5}$ / Maximum Existing Scenario / 2012	Annual Mean	0.10	7.20	7.30	25	29%	10	73%
	99^{th}%ile of 24-hr means	0.83	7.20	8.03	-	29%	25	29%
$PM_{2.5}$ / Maximum Existing Scenario / 2013	Annual Mean	0.10	7.20	7.30	25	29%	10	73%
	99^{th}%ile of 24-hr means	0.80	7.20	8.00	-	-	25	29%
$PM_{2.5}$ / Maximum Existing Scenario / 2014	Annual Mean	0.09	7.20	7.29	25	29%	10	73%
	99^{th}%ile of 24-hr means	0.91	7.20	8.11	-	-	25	29%
$PM_{2.5}$ / Maximum Existing Scenario / 2015	Annual Mean	0.14	7.20	7.34	25	29%	10	73%
	99^{th}%ile of 24-hr means	1.54	7.20	8.74	-	-	25	29%
$PM_{2.5}$ / Maximum Existing Scenario / 2016	Annual Mean	0.10	7.20	7.30	25	29%	10	73%
	99^{th}%ile of 24-hr means	0.97	7.20	8.17	-	-	25	29%

Note1 Air Quality Standards 2011 (from EU Directive 2008/50/EC)
Note 2 Air Quality Guideline Value from *WHO Air Quality Guidelines* (2005)
Table 17 Modelled $PM_{2.5}$ Concentrations for Maximum Existing Scenario (µg/m³)

Maximum Proposed Scenario

The $PM_{2.5}$ modelling results for Maximum Proposed Scenario are detailed in Table 18. The results indicate that the ambient ground level concentrations are below the relevant air quality standard for $PM_{2.5}$. Emissions from the facility lead to an ambient $PM_{2.5}$ concentration which is less than 1% of the EU annual limit value at the worst-case off-site receptor for the worst-case years modelled (2015). When background concentrations are included this rises to 29% of the annual EU limit value and 73% of the WHO annual average guideline value at the worst-case off-site receptor. In relation to the 24-hour guideline value for $PM_{2.5}$ stipulated by the WHO, emissions from the facility lead to an ambient concentration which is 5% of the maximum 24-hour limit value (expressed as a 99th%ile) and 34% of the guideline value including the background concentration.

The geographical variations in ground level $PM_{2.5}$ annual average concentrations (without background) beyond the facility boundary for the worst-case year modelled are illustrated as concentration contours in Figure 9 (all PM_{10} is assumed to be $PM_{2.5}$).

Pollutant/ Scenario / Year	Averaging Period	Process Contribution (µg/m^3)	Annual Mean Background (µg/m^3)	Predicted Emission Concentration - PEC (µg/Nm^3)	EU Standard (µg/Nm^3)Note 1	PEC as a % of EU Standard	WHO Standard (µg/Nm^3)Note 2	PEC as a % of WHO Standard
$PM_{2.5}$ / Maximum Proposed Scenario / 2012	Annual Mean	0.08	7.20	7.28	25	29%	10	73%
	99th%ile of 24-hr means	0.67	7.20	7.87	-	29%	25	29%
$PM_{2.5}$ / Maximum Proposed Scenario / 2013	Annual Mean	0.08	7.20	7.28	25	29%	10	73%
	99th%ile of 24-hr means	0.64	7.20	7.84	-	-	25	29%
$PM_{2.5}$ / Maximum Proposed Scenario / 2014	Annual Mean	0.07	7.20	7.27	25	29%	10	73%
	99th%ile of 24-hr means	0.73	7.20	7.93	-	-	25	29%
$PM_{2.5}$ / Maximum Proposed Scenario / 2015	Annual Mean	0.11	7.20	7.31	25	29%	10	73%
	99th%ile of 24-hr means	1.23	7.20	8.43	-	-	25	29%
$PM_{2.5}$ / Maximum Proposed Scenario / 2016	Annual Mean	0.08	7.20	7.28	25	29%	10	73%
	99th%ile of 24-hr means	0.78	7.20	7.98	-	-	25	29%

Note1 Air Quality Standards 2011 (from EU Directive 2008/50/EC)
Note 2 Air Quality Guideline Value from *WHO Air Quality Guidelines* (2005)

Table 18 Modelled $PM_{2.5}$ Concentrations for Maximum Proposed Scenario (µg/m^3)

3.5 Mercury

Maximum Existing Scenario

Concentrations of mercury have only been assessed for Maximum Proposed Scenario.

Maximum Proposed Scenario

The modelling results for mercury for the Maximum Existing Scenario for the worst-case year (2015) are detailed in Table 19. The results indicate that the ambient ground level concentrations are below the relevant air quality standards for mercury. Emissions from the facility lead to an ambient concentration for the worst-case year which is 0.004% of the annual limit value at the worst-case off-site receptor. When a background concentration for mercury is included, the result rises to 0.15% of the annual limit value at the worst-case off-site receptor.

Pollutant/ Scenario / Year	Averaging Period	Process Contribution (ng/m^3)	Annual Mean Background (ng/m^3)	Predicted Emission Concentration - PEC (ng/m^3)	Standard (ng/m^3)	PEC as a % of Standard
Mercury / Maximum Proposed Scenario / 2012	Annual Mean	0.025	1.5	1.53	1000	0.15%
Mercury / Maximum Proposed Scenario / 2013	Annual Mean	0.025	1.5	1.52	1000	0.15%
Mercury / Maximum Proposed Scenario / 2014	Annual Mean	0.022	1.5	1.52	1000	0.15%
Mercury / Maximum Proposed Scenario / 2015	Annual Mean	0.036	1.5	1.54	1000	0.15%
Mercury / Maximum Proposed Scenario / 2016	Annual Mean	0.026	1.5	1.53	1000	0.15%

Table 19 Modelled Mercury Concentrations for Maximum Proposed Scenario (ng/m^3)

3.6 Hydrogen Chloride (HCL)

Maximum Existing Scenario

Concentrations of HCL have only been assessed for Maximum Proposed Scenario.

Maximum Proposed Scenario

The modelling results for HCL for the Maximum Existing Scenario are detailed in Table 20. The results indicate that the ambient ground level concentrations are below the relevant air quality standards for HCL. Emissions from the facility lead to an ambient concentration for the worst-case year which is less than 0.43% of the annual limit and maximum 1-hour value at the worst-case off-site receptor. There is no background value for HCL to be added to the emission contribution.

Pollutant/ Scenario / Year	Averaging Period	Process Contribution (µg/m³)	Predicted Emission Concentration - PEC (µg/Nm³)	Standard (µg/Nm³) Note 1	PEC as a % of Standard
HCl / Maximum Proposed Scenario / 2012	Annual mean	0.06	0.06	20	0.3%
	Maximum 1-Hour	3.97	3.97	800	0.5%
HCl / Maximum Proposed Scenario / 2013	Annual mean	0.06	0.06	20	0.3%
	Maximum 1-Hour	4.23	4.23	800	0.5%
HCl / Maximum Proposed Scenario / 2014	Annual mean	0.05	0.05	20	0.3%
	Maximum 1-Hour	3.79	3.79	800	0.5%
HCl / Maximum Proposed Scenario / 2015	Annual mean	0.09	0.09	20	0.4%
	Maximum 1-Hour	3.65	3.65	800	0.5%
HCl / Maximum Proposed Scenario / 2016	Annual mean	0.06	0.06	20	0.3%
	Maximum 1-Hour	3.72	3.72	800	0.5%

Note 1 UK DEFRA guidelines

Table 20 Modelled Hydrogen Chloride Concentrations for Maximum Proposed Scenario (µg/m³)

3.7 Hydrogen Fluoride (HF)

Maximum Existing Scenario

Concentrations of HCL have only been assessed for Maximum Proposed Scenario.

Maximum Proposed Scenario

The modelling results for HF for the Maximum Proposed Scenario for the worst-case year (2013) are detailed in Table 21. The results indicate that the ambient ground level concentrations are below the relevant air quality standards for mercury. Emissions from the facility lead to an ambient concentration for the worst-case year which is less than 0.22% of the maximum 1-hour and annual limit value at the worst-case off-site receptor. There is no background value for HF to be added to the emission contribution.

Pollutant/ Scenario / Year	Averaging Period	Process Contribution ($\mu g/m^3$)	Predicted Emission Concentration - PEC ($\mu g/Nm^3$)	Standard ($\mu g/Nm^3$)[Note 1]	PEC as a % of Standard
HF / Maximum Proposed Scenario / 2012	Annual mean	0.005	0.005	16	0.01%
	Maximum 1-Hour	0.332	0.332	160	0.21%
HF / Maximum Proposed Scenario / 2013	Annual mean	0.005	0.005	16	0.01%
	Maximum 1-Hour	0.353	0.353	160	0.22%
HF / Maximum Proposed Scenario / 2014	Annual mean	0.004	0.004	16	0.01%
	Maximum 1-Hour	0.317	0.317	160	0.20%
HF / Maximum Proposed Scenario / 2015	Annual mean	0.007	0.007	16	0.01%
	Maximum 1-Hour	0.304	0.304	160	0.19%
HF / Maximum Proposed Scenario / 2016	Annual mean	0.005	0.005	16	0.01%
	Maximum 1-Hour	0.310	0.310	160	0.19%

Note 1 UK DEFRA guidelines

Table 21 Modelled Hydrogen Fluoride Concentrations for Maximum Proposed Scenario ($\mu g/m^3$)

3.8 Impact of NO_x and SO_2 Emissions on Sensitive Ecosystems

The impact of the emissions of NO_x and SO_2 from West Offaly Power on ambient ground level concentrations within the River Shannon Callows SAC, River Suck Callows SPA, Middle Shannon Callows SPA and Moyclare Bog SAC and Fin Lough (Offaly) SAC was assessed using AERMOD. Annual limit values for both pollutants are specified within EU Directive 2008/50/EC for the protection of ecosystems and vegetation. Annual average concentrations for both pollutants were predicted at receptors located within the SAC / SPA boundary up to a distance of 20km from the emission points for the worst-case year for annual average concentrations (2015).

The NO_x modelling results for the two scenarios are detailed in Table 22. The results indicate that the ambient ground level concentrations are below the relevant air quality standard for NO_x for the protection of ecosystems. Emissions from the facility for Maximum Existing Scenario lead to an ambient NO_x concentration which is 2.8% of the annual limit value at the worst-case location within the SAC / SPA's. When background concentrations are included this rises to 29.6% of the annual limit value at the worst-case location. Emissions for Maximum Proposed Scenario lead to lower annual NO_x concentrations within the SAC, which is 2.3% of the annual limit value at the worst-case location within the SAC / SPA's. Ambient NO_x concentrations including background reach 29.2% the annual limit value at the worst-case location within the SAC / SP's for Maximum Proposed Scenario.

Pollutant/ Scenario / Year	Averaging Period	Process Contribution ($\mu g/m^3$)	Annual Mean Background ($\mu g/m^3$)	Predicted Emission Concentration - PEC ($\mu g/Nm^3$)	Standard ($\mu g/Nm^3$) Note 1	PEC as a % of Standard
NO_x/ Maximum Existing Scenario / 2015	Annual Mean	0.83	11	11.83	30	29%
NO_x/ Maximum Proposed Scenario / 2015	Annual Mean	0.68	11	11.68	30	29%

Note 1 Air Quality Standards 2011 (from EU Directive 2008/50/EC)

Table 22 Modelled NO_x Concentrations within the SAC / SPA's

The SO_2 modelling results for the two scenarios are detailed in Table 23. The results indicate that the ambient ground level concentrations are below the relevant air quality standard for SO_2 for the protection of vegetation for Maximum Proposed Scenario. Emissions from the facility for Maximum Existing Scenario and Maximum Proposed Scenario lead to an ambient SO_2 concentration which are 4% of the annual limit value at the worst-case location within the SAC / SPA. When background concentrations are included this rises to 17% of the annual limit value at the worst-case location. The annual mean SO_2 results for Maximum Existing Scenario indicate that the ambient ground level concentrations including background do not exceed the relevant air quality standard for SO_2 at the worst-case location within the SAC / SPA.

Pollutant/ Scenario / Year	Averaging Period	Process Contribution ($\mu g/m^3$)	Annual Mean Background ($\mu g/m^3$)	Predicted Emission Concentration - PEC ($\mu g/Nm^3$)	Standard ($\mu g/Nm^3$) Note 1	PEC as a % of Standard
SO_2/ Scenario 1 / 2011	Annual Mean	0.83	2.5	3.33	20	17%
SO_2/ Scenario 2 / 2011	Annual Mean	0.83	2.5	3.33	20	17%

Note 1 Air Quality Standards 2011 (from EU Directive 2008/50/EC)

Table 23 Modelled SO_2 Concentrations within the SAC / SPA's

3.9 Sensitivity Study for Auxiliary Boiler (PS-A2)

The main stack PS-A1 and auxiliary boiler stack PS-A2 are in operation for short periods simultaneously. The scenarios where both stacks are operational simultaneously are:

- On start up - returning the main stack to service after a period of maintenance; and
- After a cold start - where the main stack has been off for greater than 60 hours.

Otherwise the auxiliary boiler is used for house heating when the main stack is off load. When both stacks are running together a cumulative impact due to emissions from both stacks may occur on local sensitive receptors. While this is not predicted to occur frequently, a worst case sensitivity study has been conducted in order to ensure that no breach of ambient limit values occurs should the stacks run together continuously throughout the year. The modelling results for *Cumulative Scenario* are detailed in Table 24. The results indicate that the ambient ground level concentrations are below the relevant air quality standards for NO_2, particulates (PM_{10} and PM_2.) and SO_2.

Emissions from the two stacks running simultaneously at the facility lead to an ambient NO_2 concentrations including background to 18% of the maximum 1-hour limit value (measured as a 99.8th%ile) and 30% of the annual limit value at the worst-case off-site receptor.

Emissions from the two stacks running simultaneously at the facility lead to an ambient SO_2 concentrations including background of 50% of the maximum 1-hour limit value (measured as a 99.7th%ile) and 55% of the 24-hour limit value (measured as a 99.2nd%ile) at the worst-case off-site receptor.

Emissions from the two stacks running simultaneously at the facility lead to an ambient PM_{10} concentrations including background of 31% of the annual mean limit value and 31% of the 24-hour limit value (measured as a 90.4th%ile) at the worst-case off-site receptor. The worst-case off-site receptor concentration including background of $PM_{2.5}$ are 31% of the annual mean limit value for the cumulative scenario.

The cumulative scenario shows that even if both boilers were running simultaneously on a continuous basis the ambient concentrations of NO_2, particulates and SO_2 are significantly below the respective limit values.

Pollutant/ Scenario / Year	Averaging Period	Process Contribution (mg/m^3)	Annual Mean Background (mg/m^3)	Predicted Emission Concentration - PEC (mg/Nm^3)	Standard (mg/Nm^3) Note 1	PEC as a % of Standard
NO_2/ Maximum Existing Scenario / 2015	Annual mean	1.15	11	12.15	40	30%
	99.8th%ile of 1-hr Means	13.39	11	35.39	200	18%
NO_2/ Maximum Proposed Scenario/ 2015	Annual mean	1.16	11	535.76	40	30%
	99.8th%ile of 1-hr Means	13.43	11	35.43	200	18%
SO_2/ Maximum Existing Scenario / 2015	99.2nd%ile of 24-hr Means	63.14	2.50	68.46	125	55%
	99.7th%ile of 1-hr Means	169.85	2.50	174.85	350	50%
SO_2/ Maximum Proposed Scenario / 2015	99.2nd%ile of 24-hr Means	63.14	2.50	68.46	125	55%
	99.7th%ile of 1-hr Means	169.85	2.50	174.85	350	50%
PM_{10} / Maximum Existing Scenario/ 2015	Annual mean	0.22	12	12.22	40	31%
	90.4th%ile of 24-hr Means	0.56	12	15.56	50	31%
PM_{10} / Maximum Proposed Scenario / 2015	Annual mean	0.51	12	12.51	40	31%
	90.4th%ile of 24-hr Means	0.51	12	15.51	50	31%

Table 24 Modelled NO_2,SO_2 and PM_{10} Concentrations for Sensitivity Study($\mu g/m^3$)

3.10 Traffic Impact Assessment

The WOP facility has 75 full time employees plus up to 16 seasonal employees, assuming that each of these drive to work the worst case number of cars on site 116 or 182 movements per day. The 95%thile of HGV's on site per day is 129 movements. An additional HGV per day has been allowed to include for additional movements which occur such as bin lorries, sand, lime, ammonia, bulk caustic and sulphuric etc deliveries. A HGV percentage of 48% is calculated for the facility. The distribution of these vehicles on the local road network is not known, however the impact of these vehicles is dependent on the distance from sensitive receptors. A worst case assumption that all traffic takes a single route and a sensitive receptor is located 2 m from the road.

The results of this impact assessment are shown in Table 25, indicating that in a worst case scenario the level of all traffic generated due to the WOP facility increases concentrations by no more than 1.2% of the annual mean limit value when a receptor is 2 m from the road. As receptors move further back from the road the impact will significantly drop-off with no impact on receptors 200 m or more from the roadside.

Taking account for background and worst case process contributions from the stacks, the impact magnitude is predicted to be negligible as per Tables 8 to 10.

Traffic Modelling Assessment	Pollutant Concentration (µg/m³)		
	NO_2	PM_{10}	$PM_{2.5}$
Impact	0.49	0.05	0.05
Impact as % of Annual Mean Limit	1.2%	0.1%	0.2%
Annual Mean Limit	40	40	25

Table 25 Definition of Impact Magnitude for Changes in Ambient Pollutant Concentrations

3.11 Summary of Modelling Results

Maximum Existing Scenario

Maximum Existing Scenario is the permitted emission concentrations of pollutants as per existing IED Licence P0611-02. All predicted ambient pollutant concentrations (including background) are in compliance with the relevant limit values. The results indicate that the ambient ground level NO_2 concentrations (including background) reach 16% of the maximum 1-hour limit value (measured as a 99.8th%ile) and 29% of the annual limit value at the worst-case off-site receptor. Ambient ground level SO_2 concentrations (including background) reach 14% of the maximum 1-hour limit value (measured as a 99.7th%ile) and 16% of the maximum 24-hour limit value (measured as a 99.2nd%ile) at the worst-case off-site receptor. Ambient ground level PM_{10} concentrations (including background) reach 30% of the maximum 24-hour limit value (measured as a 90.4th%ile) and 30% of the annual limit value at the worst-case off-site receptor. Ambient ground level $PM_{2.5}$ concentrations (including background) reach 29% of the annual EU limit value at the worst-case off-site receptor. When compared against the more stringent WHO limit values, ground level $PM_{2.5}$ concentrations (including background) reach 73% of the annual WHO limit value and 35% of the maximum 24-hour WHO limit value (measured as a 99th%ile) at the worst-case off-site receptor.

Maximum Proposed Scenario

Maximum Proposed Scenario is the permitted emission concentrations of pollutants as per proposed BAT limit values which will be implemented as part of the plants transition to exclusive firing with biomass. All predicted ambient pollutant concentrations (including background) are in compliance with the relevant limit values. The results indicate that the ambient ground level NO_2 concentrations (including background) reach 16% of the maximum 1-hour limit value (measured as a 99.8^{th}%ile) and 29% of the annual limit value at the worst-case off-site receptor. Ambient ground level SO_2 concentrations (including background) reach 14% of the maximum 1-hour limit value (measured as a 99.7^{th}%ile) and 16% of the maximum 24-hour limit value (measured as a 99.2^{nd}%ile) at the worst-case off-site receptor. Ambient ground level PM_{10} concentrations (including background) reach 30% of the maximum 24-hour limit value (measured as a 90.4^{th}%ile) and 30% of the annual limit value at the worst-case off-site receptor. Ambient ground level $PM_{2.5}$ concentrations (including background) reach 29% of the EU annual limit value at the worst-case off-site receptor. When compared against the more stringent WHO limit values, ground level $PM_{2.5}$ concentrations (including background) reach 73% of the annual WHO limit value and 34% of the maximum 24-hour WHO limit value (measured as a 99^{th}%ile) at the worst-case off-site receptor.

The modelling results for mercury indicate that emissions from the facility lead to an ambient concentration including background for the worst-case which is 13% of the annual limit value at the worst-case off-site receptor. Modelling results for hydrogen chloride and hydrogen fluoride lead to an ambient concentration including background for the worst-case which are less than 1% of the annual limit value at the worst-case off-site receptor.

Impact on Ecology

The NO_x modelling results indicate that the ambient ground level concentrations are below the relevant air quality standard for NO_x for the protection of ecosystems. Emissions from the facility lead to an ambient NO_x concentration including background for *Maximum Existing Scenario* which is 29.6% of the annual limit value at the worst-case location within the SAC / SPA. Emissions for *Maximum Proposed Scenario* lead to slightly lower annual NO_x concentrations within the SAC reaching 29.2% of the annual limit value for the protection of ecosystems.

The SO_2 modelling results indicate that the ambient ground level concentrations including background are below the relevant air quality standard for SO_2 for the protection of ecosystems for *Maximum Existing Scenario* and *2* reaching 17% of the annual limit value. The results for are well below the applicable limit value for the protection of vegetation.

Sensitivity Study – Cumulative Study with Auxiliary Boiler

The main stack PS-A1 and auxiliary boiler stack PS-A2 are in operation for short periods simultaneously. The scenarios where both stacks are operational simultaneously are:

- on start up - returning the main stack to service after a period of maintenance; and
- after a cold start -where the main stack has been off for greater than 60 hours.

Otherwise the auxiliary boiler is used for house heating when the main stack is off load. When both stacks are running together a cumulative impact due to emissions from both stacks may occur on local sensitive receptors. While this is not predicted to occur frequently, a worst case sensitivity study has been conducted in order to ensure that no breach of ambient limit values occurs should the stacks run together continuously.

The cumulative scenario shows that even if both boilers were running simultaneously on a continuous basis the ambient concentrations of NO_2, particulates and SO_2 are significantly below the respective limit values.

Traffic Modelling Assessment

The results of the air dispersion modelling study with respect to traffic emissions indicate that the impacts of the WOP facility on air quality are predicted to be imperceptible with respect to the operational phase local air quality assessment for the long and short term.

References

(1) UK DEFRA (2001) DMRB Model Validation for the Purposes of Review and Assessment
(2) UK DEFRA (2016a) Part IV of the Environment Act 1995: Local Air Quality Management, LAQM.TG(09)
(3) UK DEFRA (2016b) Part IV of the Environment Act 1995: Local Air Quality Management, LAQM. PG(09)
(4) UK Department of the Environment, Transport and Roads (UK DETR) (1998) Preparation of Environmental Statements for Planning Projects That Require Environmental Assessment - A Good Practice Guide, Appendix 8 - Air & Climate
(5) UK Highways Agency (2007) Design Manual for Roads and Bridges, Volume 11, Section 3, Part 1 - HA207/07 (Document & Calculation Spreadsheet)
(6) USEPA (2014) AERMOD Description of Model Formulation
(7) EPA (2010) Air Dispersion Modelling from Industrial Installations Guidance Note (AG4)
(8) USEPA (1995) User's Guide for the Industrial Source Complex (ISC3) Dispersion Model Vol I & II
(9) USEPA (2016) Guidelines on Air Quality Models, Appendix W to Part 51, 40 CFR Ch.1
(10) USEPA (2000) Seventh Conference on Air Quality Modelling (June 2000) Vol I & II
(11) USEPA (1998) Human Health Risk Assessment Protocol, Chapter 3: Air Dispersion and Deposition Modelling, Region 6 Centre for Combustion Science and Engineering
(12) USEPA (1999) Comparison of Regulatory Design Concentrations: AERMOD vs. ISCST3 vs. CTDM PLUS
(13) Schulman et al "Development and evaluation of the PRIME Plume Rise and Building Downwash Model" Air & Waste Management Association, 1998.
(14) Paine, R & Lew, F. "Consequence Analysis for Adoption of PRIME: an Advanced Building Downwash Model" Prepared for the EPRI, ENSR Document No. 2460-026-450 (1997).
(15) Paine, R & Lew, F. "Results of the Independent Evaluation of ISCST3 and ISC-PRIME" Prepared for the EPRI, ENSR Document No. 2460-026-3527-02 (1997).
(16) UK DEFRA (2014) NO_x to NO_2 Conversion Spreadsheet (Version 4.1)
(17) TII (formerly National Roads Authority (NRA)) (2011) Guidelines for the Treatment of Air Quality During the Planning and Construction of National Road Schemes
(18) EPA (2002, 2015 & 2017) Guidelines On Information To Be Contained in Environmental Impact Statements
(19) EPA (2003) Advice Notes On Current Practice (In The Preparation Of Environmental Impact Statements)
(20) EPA (2018) http://www.epa.ie/whatwedo/monitoring/air/data/
(21) Environmental Protection Agency (2017) Air Quality Monitoring Report 2016
(22) Hanrahan, P The Plume Volume Molar Ratio Method for Determining NO_2/NO_X Ratios in Modeling – Part 1: Methodology J. Air & Waste Management Assoc. 49 1324 (1999).
(23) Hanrahan, P The Plume Volume Molar Ratio Method for Determining NO_2/NO_X Ratios in Modeling – Part 21: Evaluation Studies J. Air & Waste Management Assoc. 49 1332 (1999).
(24) ACTEC (2004) Sensitivity Analysis of PVMRM and OLM in AERMOD, Alaska DEC Contract No. 18-8018-04
(25) ACTEC (2005) Evaluation Of Bias In AERMOD-PVMRM, Alaska DEC Contract No. 18-9010-12
(26) WHO (2005) WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide - Global update 2005 – Summary of Risk Assessment
(27) UK DEFRA (2008) *Expert Panel on Air Quality Standards*
(28) USEPA (1998) User's Guide to the AERMOD Meteorological Preprocessor (AERMET)

APPENDIX I

The AERMOD dispersion model has been recently developed in part by the U.S. Environmental Protection Agency (USEPA)[6]. The model is a steady-state Gaussian model used to assess pollutant concentrations associated with industrial sources. The model is an enhancement on the Industrial Source Complex-Short Term 3 (ISCST3) model which has been widely used for emissions from industrial sources.

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

In contrast to ISCST3, AERMOD is widely applicable in all types of terrain. Differentiation of the simple versus complex terrain is unnecessary with AERMOD. In complex terrain, AERMOD employs the dividing-streamline concept in a simplified simulation of the effects of plume-terrain interactions. In the dividing-streamline concept, flow below this height remains horizontal, and flow above this height tends to rise up and over terrain. Extensive validation studies have found that AERMOD (precursor to AERMOD with PRIME) performs better than ISCST3 for many applications and as well or better than CTDMPLUS for several complex terrain data sets[12].

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(6). 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(6). 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 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[28]. 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[9].

<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 an upwind area-weighted average of the land use within the sector, by using the eight land use categories outlined by the USEPA. The inverse-distance weighted surface roughness length derived from the land use classification within a radius of 1km from Ballyhaise Meteorological Station is shown in Table A1.

Sector	Inverse Distance Weighted Land Use Classification	Spring	Summer	Autumn	Winter[1]
0-360	100% Grassland	0.05	0.10	0.01	0.01

(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 in Ireland.

Table A1 Surface Roughness based on an inverse distance weighted average of the land use within a 1km radius of Ballyhaise Meteorological Station.

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. A 10km x 10km square area is drawn around the meteorological station to determine the albedo based on a simple average for the land use types within the area independent of both distance from the station and the near-field sector. The classification within 10km from Ballyhaise Airport Meteorological Station is shown in Table A2.

Simple Average Land Use Classification	Spring	Summer	Autumn	Winter[1]
25% Cultivated Land, 75% Grassland	0.170	0.185	0.195	0.195

(1) For the current location autumn more accurately defines "winter" conditions in Ireland.

Table A2 Albedo based on a simple average of the land use within a 10km × 10km grid centred on Ballyhaise Meteorological Station.

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. A 10km x 10km square area is drawn around the meteorological station to determine the Bowen Ratio based on geometric mean of the land use types within the area independent of both distance from the station and the near-field sector. The classification within 10km from Ballyhaise Meteorological Station is shown in Table A3.

Geometric Mean Land Use Classification	Spring	Summer	Autumn	Winter[1]
25% Cultivated Land, 75% Grassland	0.375	0.725	0.925	0.925

(1) For the current location autumn more accurately defines "winter" conditions in Ireland.

Table A3 Bowen Ratio based on a geometric mean of the land use within a 10km × 10km grid centred on Ballyhaise Meteorological Station.