



Wylfa Newydd Project

6.4.22 ES Volume D - WNDA Development App
D5-3 - Main Site Operational Dispersion - EIA
- Dispersion Modelling Report of the Emissions
to Air Arising from Operational Combustion
Plant (Scenarios to Support DCO Application)

PINS Reference Number: EN010007

Application Reference Number: 6.4.22

June 2018

Revision 1.0

Regulation Number: 5(2)(a)

Planning Act 2008

Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

[This page is intentionally blank]

Horizon Nuclear Power

Wylfa Newydd

Dispersion Modelling Report on the Emissions to Air arising from Operational Combustion Plant (Scenarios to Support DCO Application) - 207017-0000-AA40-RPT-0010

NOT PROTECTIVELY MARKED



February 2018

Amec Foster Wheeler Environment
& Infrastructure UK Limited



Report for

Horizon Nuclear Power
Sunrise House
1420 Charlton Court
Gloucester Business Park
Gloucester
GL3 4AE

Main contributors

Emma Dunabin
Martin Peirce
Adam Clegg
Alun McIntyre

Issued by


Adam Clegg

Approved by


Alun McIntyre

Amec Foster Wheeler

Block 2, Level 3
Booths Park
Chelford Road
Knutsford WA16 8QZ
United Kingdom
Tel +44 (0)1565 652100

Doc Ref. 35989 Final Report 18051i2

s:\e&i\projects\project sub files\35989 london horizon\d -
design\task 30 air quality\issued reports\lco combustion\feb 18
- 2\207017-0000-aa40-rpt-0010 final report 18051i2.docx

Copyright and non-disclosure notice

The contents and layout of this report are subject to copyright owned by Amec Foster Wheeler (© Amec Foster Wheeler Environment & Infrastructure UK Limited 2018) save to the extent that copyright has been legally assigned by us to another party or is used by Amec Foster Wheeler under licence. To the extent that we own the copyright in this report, it may not be copied or used without our prior written agreement for any purpose other than the purpose indicated in this report. The methodology (if any) contained in this report is provided to you in confidence and must not be disclosed or copied to third parties without the prior written agreement of Amec Foster Wheeler. Disclosure of that information may constitute an actionable breach of confidence or may otherwise prejudice our commercial interests. Any third party who obtains access to this report by any means will, in any event, be subject to the Third Party Disclaimer set out below.

Third-party disclaimer

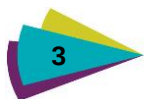
Any disclosure of this report to a third party is subject to this disclaimer. The report was prepared by Amec Foster Wheeler at the instruction of, and for use by, our client named on the front of the report. It does not in any way constitute advice to any third party who is able to access it by any means. Amec Foster Wheeler excludes to the fullest extent lawfully permitted all liability whatsoever for any loss or damage howsoever arising from reliance on the contents of this report. We do not however exclude our liability (if any) for personal injury or death resulting from our negligence, for fraud or any other matter in relation to which we cannot legally exclude liability.

Management systems

This document has been produced by Amec Foster Wheeler Environment & Infrastructure UK Limited in full compliance with the management systems, which have been certified to ISO 9001, ISO 14001 and OHSAS 18001 by LRQA.

Document revisions

No.	Details	Date
1	Draft Report 172571i for Client Review	July 2017
2	Final Report 18051i1	February 2018
3	Final Report 18051i2	February 2018



Contents

1.	Introduction	5
1.1	Purpose of this report	5
1.2	Terms and definitions	5
2.	Methodology	7
2.1	Air pollutants considered	7
2.2	Selection of dispersion model	7
2.3	Summary of sources	8
2.4	Operation and emission scenarios	9
2.5	Addressing short release durations	12
	Adjustment for annual means	12
	Probability of exceedance of short-term objectives	12
2.6	Meteorology	15
2.7	Model domain and receptors	17
	Modelled grid	17
	Human and ecological receptors	17
2.8	Buildings	18
2.9	Terrain	21
2.10	Surface characteristics	22
	Surface roughness	22
	Surface energy budget	23
	Parameters appropriate for the installation	23
2.11	NO to NO ₂ conversion	24
2.12	Background contributions	26
2.13	Predicting the combined impacts of point source and vehicle emissions	26
2.14	Deposition	27
2.15	Sensitivity analysis and uncertainty	29
	Buildings	29
	Terrain	30
	Coastal effects	30
	Meteorological data	31
3.	Results	32
3.1	Concentrations and deposition rates	32
3.2	Probabilistic assessment for short-term impacts on human health	32
3.3	Effects of climate change on air quality	34



Table 1.1	Terms and definitions	5
Table 2.1	Assumed combustion plant to be operational in various emission scenarios	10
Table 2.2	Physical stack parameters	11
Table 2.3	Meteorological data capture	16
Table 2.4	Modelled buildings	19
Table 2.5	Typical surface roughness lengths for different terrain types	22
Table 2.6	Pollutant specific deposition velocities	28
Table 2.7	Deposition rate conversion factors	28
Table 2.8	Building sensitivity analysis	30
Table 2.9	Terrain sensitivity analysis	30
Table 2.10	Coastal effects sensitivity analysis	31
Table 2.11	Meteorological data sensitivity analysis	31

Figure 2.1	Locations of modelled receptor locations	18
Figure 2.2	Modelled buildings and emission sources	20
Figure 2.3	Terrain within 2 km of the power station	21
Figure 2.4	Terrain across the wider area	22
Figure 2.5	Surface roughness file visualisation	24
Figure 3.1	Probability of exceeding the NO ₂ AQO for the commissioning scenario	33
Figure 3.2	Probability of exceeding the NO ₂ AQO for the LOOP/LOCA scenario	34

Appendix A	Model Parameters and Scenarios to be used in the Assessment of Emissions from Operational Combustion Plant (Report)	
Appendix B	Wind roses	
Appendix C	Receptor list (embedded Excel file)	
Appendix D	Model results (embedded Excel files)	
Appendix E	Concentration isopleths	

1. Introduction

1.1 Purpose of this report

This Report for Horizon Nuclear Power Wylfa Ltd has been produced for the purposes of providing the methodology and results associated with the detailed dispersion modelling study to quantify the potential impacts on local air quality associated with emissions to air from stationary combustion plant and road traffic during the operational phase of the Wylfa Newydd Project. **The report presents a factual account of the modelling methodology and results without interpretation or assessment of significance.**

1.2 Terms and definitions

Table 1.1 Terms and definitions

Term	Definition
AADT	Annual Average Daily Traffic
ADMS	Atmospheric Dispersion Modelling System
AERMIC	American Meteorological Society/Environmental Protection Agency Regulatory Model Improvement Committee
AERMOD	The dispersion model code developed by AERMIC (see above)
AMS	American Meteorological Society
AQMAU	Air Quality Modelling and Assessment Unit
AQO	Air Quality Objective
ASG	Auxiliary Standby Generator
B/B	Back-up Building
BBG	Back-up Building Generator
CBL	Convective Boundary Layer
CERC	Cambridge Environmental Research Consultants
CO	Carbon Monoxide
CURED	Calculator Using Realistic Emissions for Diesels
Defra	Department for Environment, Food and Rural Affairs
EDG	Emergency Diesel Generator
EFT	Emissions Factor Toolkit
HCW	High Chemical Impurity Waste
HDV	Heavy Duty Vehicle
LAQM	Local Air Quality Management
LDV	Light Duty Vehicle
LOCA	Loss of Coolant Accident

Term	Definition
LOOP	Loss of Off-site Power
MCPD	Medium Combustion Plant Directive
MCR	Maximum Continuous Rating
MEEG	Mobile Emergency Equipment Garage
NO_x	Oxides of Nitrogen
NO₂	Nitrogen Dioxide
NRW	Natural Resources Wales
NWP	Numerical Weather Prediction
O₃	Ozone
OS	Ordnance Survey
PBL	Planetary Boundary Layer
PC	Process Contribution
PEC	Predicted Environmental Concentration
PM_{2.5}	Particulate matter less than 2.5 micrometres in diameter
PM₁₀	Particulate matter less than 10 micrometres in diameter
RMSE	Root Mean Square Error
SO₂	Sulphur Dioxide
tph	Tonnes per hour
USEPA	United States Environmental Protection Agency

2. Methodology

2.1 Air pollutants considered

The combustion plant will emit a number of pollutants of concern, including oxides of nitrogen (NO_x , consisting of nitrogen monoxide (NO) and nitrogen dioxide (NO_2)), particulates (PM_{10} and $\text{PM}_{2.5}$), sulphur dioxide (SO_2) and carbon monoxide (CO) and these pollutants are the focus of this assessment. NO_x and SO_2 , in turn, contribute to nitrogen and acid deposition with the assessment aiming to quantify the additional contribution to background deposition levels as a result of additional emissions of these specific pollutants. Further information on operational point source emissions from the Wylfa Newydd Project is provided in Appendix A.

2.2 Selection of dispersion model

There are two primary dispersion models which have been used extensively throughout the UK for assessing the air quality impacts arising from developments of this nature and accepted as appropriate air quality modelling tools by Regulators and local planning authorities alike:

- ▶ The ADMS model, developed in the UK by Cambridge Environmental Research Consultants (CERC) in collaboration with the Meteorological Office, National Power and the University of Surrey; and
- ▶ The AERMOD model, developed in the United States by the American Meteorological Society (AMS)/United States Environmental Protection Agency (USEPA) Regulatory Model Improvement Committee (AERMIC).

Both models are termed 'new generation' models, parameterising stability and turbulence in the planetary boundary layer (PBL) by the Monin-Obukhov length¹ and the boundary layer depth². This approach allows the vertical structure of the PBL to be more accurately defined than by the stability classification methods of earlier dispersion models such as R91³ or ISC⁴. Like R91 and ISC, ADMS and AERMOD adopt a symmetrical Gaussian profile of the concentration distribution in the vertical and crosswind directions in neutral and stable conditions. However, unlike R91 or ISC, the ADMS and AERMOD vertical concentration profile in convective conditions adopts a skewed Gaussian distribution to take account of the heterogeneous nature of the vertical velocity distribution in the Convective Boundary Layer (CBL).

Numerous model inter-comparison studies have demonstrated little difference between the output of ADMS and AERMOD, except in certain complex terrain scenarios⁵. For the purposes of this particular study, ADMS (Version 5.2) has been selected as the most appropriate model to use. The justification for this selection is provided below.

ADMS is capable of calculating sub-hourly averaged concentrations based on site-specific meteorological and surface conditions, whereas AERMOD can only produce output down to hourly-averaged values. Therefore, to enable an assessment of impact against the 15-minute mean SO_2 air quality objective (AQO), a standard conversion factor (1.34) must be applied to the hourly output from AERMOD to estimate 15-minute mean concentrations. This factor is taken from Turner (1994)⁶ who published estimated ratios of calculated peak and mean concentrations at 3 minutes, 15 minutes, 1 hour, 3 hours and 24 hours from published data

¹ A measure of the effects of buoyancy on turbulent flows, particularly in the lower tenth of the atmospheric boundary layer.

² The lowest layer of the atmosphere in which turbulent motion, influenced by the earth's surface processes, affects the dispersion and dilution of emitted material.

³ <https://admlc.files.wordpress.com/2014/05/r91.pdf>

⁴ <https://www3.epa.gov/scram001/userg/regmod/isc3v1.pdf>

⁵ Carruthers et al., 2011. 'Comparison of the complex terrain algorithms incorporated into two commonly used local-scale air pollution dispersion models (ADMS and AERMOD) using a hybrid model.' J. Air Waste Manag. Assoc., 61, 1227-35

⁶ Turner, B., 1994. 'Workbook of Atmospheric Dispersion Estimates.'

on lateral and vertical diffusion coefficients in steady winds as reported by Nonhebel (1960)⁷. What is important to note here is that these estimates were based upon calculated dispersion coefficients, rather than monitoring results. Furthermore, Turner (1994) cautions that:

“...ratios of peak to mean data depend also on the stability of the atmosphere and the type of terrain that the plume is passing over.”

Therefore, application of a standard, non-site-specific conversion factor that does not have its basis in monitored data would significantly increase the uncertainty in modelled 15-minute mean values obtained from AERMOD. This limitation is not present in ADMS, which uses site-specific meteorological and surface conditions to directly calculate sub-hourly averaged concentrations⁸.

AERMOD also adopts a basic treatment of topographical effects on pollutant dispersion, using a dividing streamline approach, with the receptor concentration being a weighted average of the contribution from a horizontal plume and terrain following-plume. ADMS, however, through its FLOWSTAR sub-routine, explicitly calculates the 3-dimensional flow field over terrain, allowing more advanced treatment of dispersion in areas of complex terrain. The overly-pessimistic approach of AERMOD in areas of complex terrain has been discussed by Carruthers et al (2011) who concluded:

“...where there is plume impaction AERMOD has a tendency to overestimate concentrations and, therefore, may act as a screening model in this case, whereas ADMS may predict more realistic concentrations.”

Although Carruthers et al (2011) acknowledge both models appeared to perform reasonably when compared to measurements at the six specific monitoring sites in one of the case studies reviewed (the Clifty Creek case), they also state that:

“...although both models appear to perform reasonably, the comparisons provide relatively little insight into how well the two models are taking account of the impacts of the complex terrain because other factors such as differences in input meteorology arising from the two meteorological pre-processors may cause the model differences between the data and model predictions.”

Furthermore, as stated in Carruthers et al (2011), only ADMS was able to replicate the higher predicted concentrations as a result of the reduction in speed and streamline divergence across the valley, with associated increase in speed and streamline convergence towards the downwind edge of the valley, demonstrated in field studies of air flow by Wiggs et al (2002)⁹ and Mason (1987)¹⁰.

In the Clifty Creek case, the discharge occurs some 60 m above the valley. The specific concern with the AERMOD terrain module demonstrated in Carruthers et al (2011) is the direct impaction of the plume on windward sides of the terrain when the release height is lower than the terrain height particularly since, as discussed in Carruthers et al (2011), the AERMOD treatment effectively assumes 50% of the plume, as a minimum, impacts the surface without any consideration of the specific nature of boundary layer stability or the terrain features. Terrain to the south-west of the Wylfa Newydd Development Area and within the model domain exceeds 100 m above mean sea level, higher than the release elevation of the main emission points. In this set up, the treatment of terrain within AERMOD is considered to provide a less realistic simulation of the impacts associated with plume impaction.

2.3 Summary of sources

The combustion plant on the Power Station site will consist of the following:

- Emergency Diesel Generators (EDGs). Each of the two reactor Units will have three EDGs, designated A, B and C. Each EDG will be rated at 10.4 MWe, 23.6 MWth input, each in a

⁷ Nonhebel, G., 1960. 'Recommendations on Heights for Industrial Chimneys.' J. Inst. Fuel 33, 479-513

⁸ Despite the ability to predict 15-minute mean concentrations as a direct model output, additional sensitivity analysis to 15-minute mean SO₂ predictions has been undertaken by applying the 1.34 factor to the modelled 99.9th percentile 1-hour mean output at the request of NRW. The assessment presents results using both methods (ADMS 15-minute output and the factored 1-hour approach)

⁹ Wiggs, G.F.S.; Bullard, J.E.; Garvey, B. and Castro, I., 2002. 'Interactions between Airflow and Valley Topography with Implications for Aeolian Sediment Transport' Phys. Geogr. 23, 366-380.

¹⁰ Mason, P.J., 1987. 'Diurnal Variations in Flow over a Succession of Ridges and Valleys' Q. J. R. Meteorol. Soc. 113, 1117-1140.

separate EDG building, each with an individual stack. For each Unit, the A and B stacks will be routed up the side of the Unit's reactor building, while the C stack will project from the EDG C building;

- ▶ **Backup Building Generators (BBGs).** Each of the two reactor Units will have two BBGs, rated at 4.8 MWe, 11 MWth input, two in each Back-up Building, with each BBG having a separate stack;
- ▶ **Auxiliary Standby Generators (ASGs).** There will be two ASGs, each rated at 3.6 MWe, 8.2 MWth input. The ASGs will be housed in a single building and share a multi-flue stack;
- ▶ **House boilers.** There will be six house boilers, serving both Units between them. There will be four 25 tonnes (of steam) per hour (tph) boilers, rated at 15.8 MW thermal input and two 3 tph boilers, rated at 1.95 MW thermal input which will provide steam to the site during start-up, normal operation and shut-down. The boilers will be housed in a single building. There will be two multi-flue stacks, one for the 25 tph boilers and a second for the 3 tph boilers; and
- ▶ **Mobile generators stored in the on- and off-site Mobile Emergency Equipment Garage (MEEG).**

There are also a number of other minor combustion plant items (e.g. diesel engine fire pumps). Current proposals are that the net thermal input capacity of this other plant will aggregate to less than 3 MWth input. Following pre-application discussions with Natural Resources Wales (NRW), due to the small scale of these plant items, their emissions are unlikely to have any significant impact on receptors and have been excluded from the assessment.

2.4 Operation and emission scenarios

The operating scenarios that are considered in the assessment are described below. In brief, they are:

- ▶ **Standby generator commissioning scenario A** short-term scenario: Three EDGs operating at full load and two BBGs operating at low load (30% maximum continuous rating (MCR)) for four hours with three 25 tph boilers operating at 80% load (60 tph steam production). No ASGs operating. Used for assessing 15-minute and hourly mean impacts during standby generator commissioning only;
- ▶ **Standby generator commissioning scenario B** short-term scenario: Two EDGs operating at full load for 24 hours with three 25 tph boilers operating at 80% load (60 tph steam production). No ASGs operating. Used for assessing 8-hour and daily mean impacts during standby generator commissioning only;
- ▶ **Standby generator routine testing** short-term scenario: One EDG or one BBG or one ASG operating at 100% MCR for 10 hours, and all boilers operating at full load during their commissioning programme (106 tph steam production);
- ▶ **LOOP/LOCA** short-term scenario: All six EDGs, four BBGs and two ASGs operating at full load, with two 25 tph boilers and one 3 tph boiler operating at 95% load (50.3 tph steam production) for 24 hours;
- ▶ **Boilers maximum impact** short-term scenario: This is the worst-case possible scenario involving operation of the boilers in isolation. All boilers are assumed to be operating at maximum duty (total steam production of 106 tph). No other combustion plant is operational in this scenario;
- ▶ **MEEG maintenance testing** short-term scenario: Current estimates are that maintenance testing of the mobile generators in the MEEG will take place once a month where each item of emergency response equipment would be started up and run for no longer than five minutes. Equipment stored in the off-site MEEG will be brought on-site for testing. The emergency response equipment testing will be carried out separately (i.e. each plant item will be operated separately) and will not coincide with any other testing of installed standby plant (EDGs, BBGs or ASGs). It is assumed that the boilers will be operating at routine winter duty demand for both Units during the MEEG maintenance testing;

- ▶ **MEEG emergency exercise** short-term scenario: Current estimates are that the equipment will need to be tested as part of an emergency exercise once per year and would involve moving the vehicles to their deployment locations on site and returning them after a period of around 6 hours. For testing purposes, the emergency response equipment will not be run constantly as they would for a real response but would only be used for a maximum of 1 hour within the 6 hour period. Not all emergency generating units will be deployed during the emergency exercise and the current estimate is that 31 of the 45 generating units will be tested simultaneously, equating to an aggregated total thermal input of 76.5 MWth. The emergency exercise will not coincide with any other testing of installed standby plant (EDGs, BBGs or ASGs) but it is assumed that the boilers will be operating at routine winter duty demand for both Units; and
- ▶ **Long-term (annual mean)** scenario: Unit 1 combustion plant in routine testing phase, Unit 2 combustion plant initially in commissioning phase followed by 11 months of routine testing, the house boilers operating continuously throughout the year at normal summer and winter demand including 26 days of winter High Chemical Impurity Waste (HCW) operation. The Unit 2 commissioning run in the long-term scenario assumes each item of standby plant associated with Unit 2 is tested for up to for 72 hours. This is a worst-case assumption. The scenario also includes routine testing of the MEEG generators and a single emergency exercise involving the MEEG generators.

Table 2.1 summarises the type of plant included in each scenario. The scenario descriptions and emission parameters for each scenario, including references to the use of relevant emission limit values, are defined within 206230-0000-AA40-RPT-0002 'Model Parameters and Scenarios to be used in the Assessment of Emissions from Operational Combustion Plant' which is included as Appendix A to this report. Rationale for the selection of emission limit values is provided in the permit application supplementary technical information report. Table 2.2 provides the physical stack parameters. The relative positions of emission stacks and buildings are shown in Figure 2.2.

Table 2.1 Assumed combustion plant to be operational in various emission scenarios

Scenario	EDGs	BBGs	ASGs	House Boilers	MEEG Generators
Commissioning A	✓	✓	✗	✓	✗
Commissioning B	✓	✗	✗	✓	✗
Routine testing ^A	✓	✓	✓	✓	✗
LOOP/LOCA	✓	✓	✓	✓	✗
Maximum boiler impact	✗	✗	✗	✓	✗
MEEG maintenance testing	✗	✗	✗	✓	✓
MEEG exercise	✗	✗	✗	✓	✓
Long-term	✓	✓	✓	✓	✓

^A Only a single standby generator is tested at any one time

Table 2.2 Physical stack parameters

Source	Emission Point Reference	Location (X,Y)	Stack height above local ground level (m)	Stack internal diameter (m)
House Boiler 1 (25tph) [North stack]	CA001	234746, 393166	20	0.70
House Boiler 2 (25tph) [North stack]	CA002	234746, 393166	20	0.70
House Boiler 3 (25tph) [North stack]	CA003	234746, 393166	20	0.70
House Boiler 4 (25tph) [North stack]	CA004	234746, 393166	20	0.70
House Boiler 5 (3tph) [South stack]	CA005	234728, 393136	20	0.25
House Boiler 6 (3tph) [South stack]	CA006	234728, 393136	20	0.25
ASG A	CA007	234724, 392863	21	0.75
ASG B	CA008	234724, 392863	21	0.75
ABWR Unit 1 EDG A	CA101	234938, 393104 ^A	37	1.25
ABWR Unit 1 EDG B	CA102	234879, 393165 ^A	37	1.25
ABWR Unit 1 EDG C	CA103	234902, 393075	20	1.25
ABWR Unit 1 BBG A	CA104	234823, 392973	30	0.85
ABWR Unit 1 BBG B	CA105	234842, 392964	30	0.85
ABWR Unit 2 EDG A	CA201	235084, 393049 ^A	37	1.25
ABWR Unit 2 EDG B	CA202	235002, 393067 ^A	37	1.25
ABWR Unit 2 EDG C	CA203	235038, 392998	20	1.25
ABWR Unit 2 BBG A	CA204	234847, 392961	30	0.85
ABWR Unit 2 BBG B	CA205	234865, 392948	30	0.85
MEEG Testing	---	234942, 392760	3	0.40
MEEG Exercise (U1)	---	234880, 393070	3	1.60
MEEG Exercise (U2)	---	235010, 393000	3	1.60

^A These stacks run up the side of the reactor building and discharge 3 m above the parapet level but below the apex of the domed roof. As the height of the apex has been selected as the building height for the reactor building, these particular stacks have been artificially moved within the model by a few metres from their actual physical location to prevent the stacks effectively discharging within the modelled building, which would cause the model not to produce output. Moving the stacks in this way is unlikely to have any material effect on the modelled result. The alternative solution would be to artificially increase the discharge height of the stacks to just above the height of the dome, which would likely have a much larger effect on the modelled result.

The following sources have been combined into separate multi-flue stacks using the COMBINEFLUES sub-routine within ADMS:

- ▶ ASGs 1 and 2;

- ▶ House boilers 1, 2, 3 and 4; and
- ▶ House boilers 5 and 6.

2.5 Addressing short release durations

With the exception of the house boilers, the combustion sources will only, under normal conditions, operate for short periods of time. To ensure that the worst-case meteorological conditions (i.e. those that produce the highest concentrations at a relevant receptor) are captured by the model, the dispersion model runs are carried out on the assumption that the sources emit continuously for the whole year. The outputs from the dispersion model are, therefore, over-estimates and the degree of over-estimation needs to be addressed.

When assessing against long-term assessment levels (i.e., annual means), a temporal adjustment to the concentrations can be applied to obtain a more realistic estimate. When assessing against short-term assessment levels (e.g. 1 hour mean), an adjustment to the concentrations is not possible but the probability of exceedance can be calculated. These procedures are detailed in the following sub-sections.

Adjustment for annual means

NRW's 'Air emissions risk assessment for your environmental permit' guidance¹¹ provides the following guidance for emission sources that are not continuous throughout the year:

"Adjust your figures down, based on the percentage of the year that your site isn't operating. For example, a site that only operates January to June should reduce its PC figures by 50%. This only applies to annual average calculations and not short term assessments."

Based on this guidance, the following algorithm is used to calculate the installation-wide annual mean process contribution (PC) from individual source group contributions, taking into account the respective annual operational hours of each source group:

$$PC_{Ann} = \frac{1}{T} \sum_{i=1}^N PC_i \cdot t_i$$

Where:

PC_{Ann} = annual mean installation wide process contribution;

PC_i = raw modelled long-term process contribution for the i th source group;

t_i = annual operational hours for the i th source group;

T = total number of hours in the year;

N = number of source groups.

Probability of exceedance of short-term objectives

The short-term NO₂ air quality objective (AQO) is set at 200 µg m⁻³ as an hourly mean, not to be exceeded on more than 18 occasions in a calendar year. Expressed in percentile terms, this is equivalent to a 99.79 percentile hourly mean concentration of 200 µg m⁻³¹².

With the exception of the house boilers, the combustion sources will only operate for short periods of time. Compared to a continuous release, this reduces the probability of exceeding 200 µg m⁻³ as an hourly mean more than 18 times a year, as operation of the combustion plant would have to coincide exactly with those meteorological conditions which produce the highest impact at ground level for this outcome to be realised.

¹¹ <https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit>

¹² The Air Quality Standards (Wales) Regulations 2010. Welsh Statutory Instrument 2010 No. 1433 (W.126)

It is theoretically possible that the hours when the emission sources are operating could coincide with those hours of the year when the meteorological conditions are such as to give the highest concentrations at receptors. Therefore, as a first estimate, the model is run assuming continuous operation of the combustion plant with no correction made to the calculated short-term process contributions. This produces the maximum potential 99.79 percentile hourly mean PEC (C_{max}).

However, while an outcome corresponding to C_{max} is theoretically possible, it is statistically unlikely and becomes exponentially more unlikely as the number of operating hours reduces. This holds true as long as there is no causal relationship between operations and weather patterns. This assumption is valid in the present case, since operation (testing and commissioning) of the generators will be programmed in advance throughout the year and the programme will be unaffected by weather conditions.

The 'actual' 99.79 percentile hourly mean PEC could be any value in the range 0 - C_{max} . For a non-continuous, largely random release (as is the case here), there are a near infinite number of outcomes between 0 - C_{max} dependent upon which hours of the year the combustion sources are assumed to be operating. Therefore, it is not possible, with any degree of confidence, to calculate a 'typical' 99.79 percentile hourly mean PEC without running a significant number of possible operational profiles.

Running the model in a deterministic manner, i.e., predicting a 99.79 percentile hourly mean concentration, is not the most effective means of assessing compliance with an AQO which specifies a certain number of exceedances of a particular concentration, particularly for a non-continuous release. This is especially true when one considers that short-term percentile concentrations from different installations/sources are not additive, because the maximum impacts from different sources do not occur over the same temporal scales, i.e., the hour which produces the 19th highest concentration for one source at a particular receptor would not be the same hour which produces the 19th highest concentration for another source due to the different variables affecting dispersion (e.g. release height, temperature, wind direction, source and receptor location etc.) influencing the prediction in different ways. As a result, the 99.79 percentile hourly mean PEC from one source would not become the short-term background concentration for another source and available 'headroom' between a modelled prediction and the AQO is largely a redundant metric as a result.

Where the first estimate of assumed continuous operation indicates potential exceedances of the 1-hour mean AQO, further probabilistic assessment has been undertaken. The cumulative probability (P) of exceeding $200 \mu\text{g m}^{-3}$ on more than 18 occasions in a single year at the worst-case receptor location can be calculated assuming the exceedances (E) follow a hypergeometric distribution. This approach was recently adopted by the Environment Agency's Air Quality Modelling and Assessment Unit (AQMAU) in its assessment of impacts associated with increased use of diesel generators in short-term operating reserve and Capacity Mechanism plant¹³ to support Defra's consultation on transposition of the Medium Combustion Plant Directive (MCPD) into regulations for England and Wales.

Inherent assumptions in this approach are that the operational hours are randomly distributed over the year and that, for an individual receptor, the probability of exceedance during any one hour is independent of the hour(s) immediately before or after. The assumption of randomness was considered by AQMAU, who concluded:

"... the assumption that operational hours are random at any time of the year must be made. This is not likely to be strictly correct because times of higher energy demand when these plants operate are likely to coincide with specific times of the year and times of the day. However, a standard environmental permit would not normally restrict when the 500 operational hours happen and theoretically they can be any 500 hours within a year. The hypergeometric distribution allows discrete hours to be trialled independently and has therefore been selected as a reasonable representation of these unplanned operations."

In the Wylfa Newydd Project case, the testing programme is distributed throughout the entire year and the environmental permit will not restrict when the testing actually takes place. The testing schedule will also need to contain flexibility in order to respond to changing monthly operational demands, so the assumption of a random distribution is reasonable.

With regard to the second assumption, whilst there may be an increased probability of exceedance at any location in the model domain following an exceedance in the previous hour due to factors such as the wider

¹³ AQMAU, 2016. 'Diesel generator short term NO₂ impact assessment.' Report reference AQMAU-C1457-RP01

synoptic set up, the assumption of independence holds true for a specific receptor since, over short intervals, it is wind direction, which can exhibit significant fluctuation over both intra and inter-hour temporal scales, that is the main variable driving the probability of exceedance at a specific location.

The probability of exceeding $200 \mu\text{g m}^{-3}$ as an hourly mean on more than 18 occasions during a calendar year can therefore be calculated as:

$$P(E > 18) = 1 - P(E \leq 18)$$

Where:

$$P(E \leq 18) = \sum_{E=0}^{E=18} \frac{\binom{E_{tot}}{E} \binom{N-E_{tot}}{n-E}}{\binom{n}{N}}$$

And where:

E_{tot} = total number of hours where the hourly mean NO_2 PEC exceeds $200 \mu\text{g m}^{-3}$ assuming continuous operation across all modelled hours of meteorological data

N = total number of modelled hours of meteorological data

n = number of actual operational hours per annum for the source(s) contributing to the exceedances

In order to calculate E_{tot} , the model is run with an exceedance threshold equating to a PEC of $200 \mu\text{g m}^{-3}$ entered into the model output setup. However, as the model outputs NO_x concentrations (as opposed to NO_2) and does not consider other non-modelled background contributions (these are added-in during the results post-processing), an equivalent exceedance threshold needs to be calculated such that the exceedance relates directly to NO_2 PECs as opposed to NO_x PCs. This is obtained as follows:

$$\text{Exceedance threshold} = \frac{200 - \text{Background}_{ST}}{f\text{NO}_x}$$

Here, 200 is the AQO concentration, Background_{ST} the short-term background concentration of NO_2 and $f\text{NO}_x$ the short-term $\text{NO}_x:\text{NO}_2$ conversion factor. For each hour of met data that the model predicts a concentration above this threshold for a specific receptor, an increment of 1 is added to a running counter. For each year of met data, E_{tot} is therefore calculated for each receptor as:

$$E_{tot} = \sum_{i=1}^N \chi_i$$

Where $\chi = 1$ if the modelled hourly mean concentration is above the exceedance threshold during the i th hour of meteorological data, else $\chi = 0$.

Following the guidance from the Environment Agency's Air Quality Modelling and Assessment Unit (AQMAU)¹⁴, it is typical to use a value of 0.35 for $f\text{NO}_x$ for hourly mean predictions. However, there is a special case to be made for diesel generator emissions. As the initial NO_x and NO concentration in the plumes from diesel generators can be very high, considerably higher than gas-fired combustion plant (an order of magnitude difference between gas-fired plant), the availability of O_3 to promote further oxidation to NO_2 at short ranges is limited. This factor was also considered by AQMAU in their modelling assessment of diesel engine emissions to support the MCPD consultation. They concluded:

"Due to the very high NO_x emissions of the diesel generator engines and the very high resulting process contributions (PCs) the amount of conversion is likely to be limited by the amount of available O_3 in the background... Our checks indicate that a short term conversion ratio of 15% is likely to be reasonably representative within the first few hundred meters from the source. At greater distances the conversion ratio is likely to increase as the PCs become lower and therefore larger proportions are converted. A 15%

¹⁴ AQMAU, undated. 'Conversion ratios for NO_x and NO_2 '
http://webarchive.nationalarchives.gov.uk/20140328084622/http://www.environment-agency.gov.uk/static/documents/Conversion_ratios_for_NOx_and_NO2_.pdf

conversion is more likely to underestimate the impacts greater than 500 m from the source; however it is within 500 m that potential exceedances are more likely to occur.”

In this assessment, 0.35 has been used for fNO_x for hourly mean concentrations for all receptors. However, as the receptors which experience the highest level of impact are within 500 m of the emission sources, it must be acknowledged that the predicted probability of exceedance is likely to be overstated for these receptors as a result.

In terms of defining an acceptable/tolerable probability of exceedance, consideration is once more given to AQMAU's modelling assessment to support Defra's MCPD consultation. In this assessment, AQMAU states:

“If the operational lifetime of these plants is approximately 20 years then values less than 1/20th can be considered an acceptable probability threshold.”

Applied to the Wylfa Newydd Project which has a projected operational lifetime of 60 years, an acceptable probability threshold would be 1 in 60 years, or 1.7×10^{-2} expressed as a fractional probability. An example calculation is provided below.

Inputs				
Modelled number of operational hours	8760	h y ⁻¹		
Modelled number of hourly exceedances	729	h		
Number of exceedances allowed by AQO	18	h y ⁻¹		
Actual number of operational hours	58	h y ⁻¹		
Probability of not breaching AQO	100.00%			
Probability of breaching AQO	1.0E-07	OR 1 in	9,780,883	year event

It should be noted that this procedure can only be used for short-term impacts. It cannot be applied to long-term impacts and, as such, cannot be used in the deposition assessment. Here, the only probabilistic assessment that could be made would be to identify which one of the 10 individual years of meteorological data produces deposition rate PCs greater than 1%. However, at best, this would only produce a minimum probability of 1 in 10, which is likely to be too high not to be considered a credible event.

In order to address the potential limitation of the hypergeometric distribution in relation to the randomness of operation assumption and coincidence with worst-case meteorological conditions, particularly as the number of consecutive hours of operation increases, further statistical analysis similar to a Monte Carlo approach has been used to validate the prediction from the hypergeometric method. Further details of this approach are presented in Section 3.2.

2.6 Meteorology

For meteorological data to be suitable for dispersion modelling purposes a number of meteorological parameters need to be measured on an hourly basis. These parameters include wind speed, wind direction, cloud cover and temperature. There are only a limited number of sites where the required meteorological measurements are made and the data quality assured. The nearest synoptic station to the Wylfa Newydd Development Area that records these parameters in a format suitable for the model is RAF Valley, located approximately 20 km to the south-west on the southern coast of Anglesey.

However, due to the distance and potential localised influences of topographical/coastal effects, it may not necessarily be the case that data from RAF Valley is completely representative of those conditions more local to the development site. Therefore, the assessment has used interpolated meteorological data from the Met Office Numerical Weather Prediction (NWP) models for the latitude and longitude of the Wylfa Newydd Development Area during the period 2007-2016.

NWP models, such as the Unified Model (UM), are now used operationally by the Met Office for weather forecasting and to model climate change. These models are run on large supercomputers and input observations from ground stations, buoys at sea, radiosondes, aircraft, and satellites. The models integrate the governing equations forward in time to move from a current view of the weather to some future state (the

“Forecast”). The starting point of NWP forecasts is a set of data (the “Analysis”) that combines the currently available observations measured all over the globe with an initial state taken from the previous NWP model run.

Versions of the Unified Model include the global and mesoscale models. These cover various domains and grid resolutions. The mesoscale model covers a limited area focused on the UK. In 2006, the North-Atlantic & European (NAE) model replaced the mesoscale model. It covers a larger area but has the same resolution as the immediately preceding version of the mesoscale model.

When generating data suitable for the ADMS model, the NWP Analysis data for the chosen year from the UM mesoscale model is retrieved from storage and then processed using multi-linear interpolation in all 4 dimensions to resolve the effective values of each variable at the station position (latitude & longitude). The raw NWP data are, strictly speaking, analysis data at each assimilation step in the mesoscale model run, mixed with forecast data for the intervening hours. Data before 2004 is interpolated from older versions of the UM mesoscale model with a 60 km resolution, whilst data from 2004 to 2006 is interpolated from a finer 12 km resolution version of the UM NAE model. From 2007 to 2012, model resolution increased to a 4 km level whilst, from 2013 onwards, model resolution is at 1.5 km.

Gaussian plume models, such as ADMS, cannot, as standard, model calm weather conditions, since this results in a discontinuity produced by a ‘divide by zero’ calculation. Most Gaussian plume models simply skip lines of meteorological data where calm conditions occur. Data lines will also be skipped where any of the required meteorological input parameters are missing. If there are a significant number of calm conditions or missing data, this can result in an equally significant number of data lines being discounted and an unrepresentative prediction of modelled impact, particularly for annual mean or percentile-based concentrations. Table 2.3 shows the percentage of missing meteorological data for each year of the NWP datasets used in this analysis.

Table 2.3 Meteorological data capture

Year	Number of data lines used	Percentage of lines not used
2007	8727	0.4%
2008	8747	0.4%
2009	8725	0.4%
2010	8717	0.5%
2011	8716	0.5%
2012	8744	0.5%
2013	8700	0.7%
2014	8712	0.5%
2015	8705	0.6%
2016	8731	0.6%

The generally accepted rule-of-thumb best practice requirement is to ensure no more than 10% of meteorological data is omitted from the run. Table 2.3 demonstrates this requirement is easily satisfied for all modelled years of data.

ADMS does possess an additional sub-routine, allowing estimates of modelled contributions during calm conditions to be made. However, validation of this particular method of calculating concentrations has never been carried out and, consequently, this sub-routine was not used as part of the model runs.

Wind roses are provided in Appendix B.

2.7 Model domain and receptors

Modelled grid

The model incorporates a 6 km x 6 km Cartesian grid, centred on the Power Station Site with a receptor resolution of 60 m, to assess the impact of atmospheric emissions from the proposed development on local air quality. This is the key area within which there will be a potential effect upon air quality. The Cartesian grid was used for the purposes of generating concentration isopleths/contour plots.

Human and ecological receptors

Guidance from the UK Government and Devolved Administrations¹⁵ makes it clear that exceedances of the human health based objectives should only be assessed at outdoor locations where members of the general public are regularly present over the averaging time of the objective. The receptors considered were chosen based on places where people may be located, judged in terms of the likely duration of their exposure to pollutants, and proximity to the site. The human receptors chosen were those within 2 km of the Wylfa Newydd Development Area boundary.

With regard to ecological receptors, NRW's 'Air emissions risk assessment for your environmental permit' guidance states:

"Check if there are any of the following within 10km of your site (or within 15km for coal or oil fired power stations):

- ▶ *Special protection areas (SPAs);*
- ▶ *Special areas of conservation (SACs); and*
- ▶ *Ramsar sites (protected wetlands).*

Check if there are any of the following within 2km of your site:

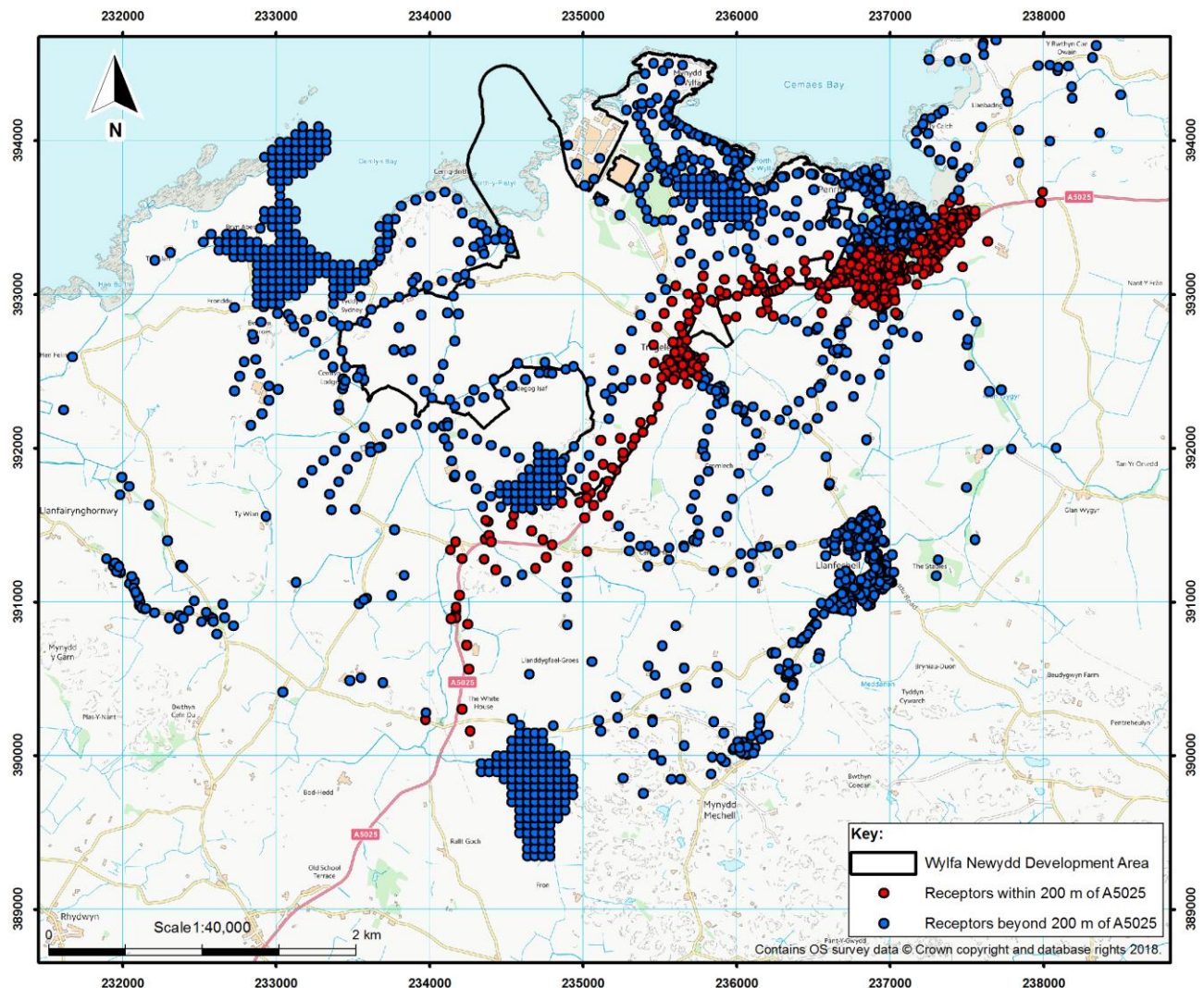
- ▶ *Sites of special scientific interest (SSSIs); and*
- ▶ *Local nature sites (ancient woods, local wildlife sites and national and local nature reserves).*

Some larger (greater than 50 megawatt) emitters may be required to screen to 15km for European sites and to 10km or 15km for SSSIs."

As the standby combustion plant constitutes a listed Part A(1) combustion activity under the Environmental Permitting Regulations 2016 and exceeds 50 MW in aggregate, the standby combustion plant may be considered a significant emitter and, consequently, ecological receptors within the specified assessment distances of the Wylfa Newydd Development Area referred to by the NRW guidance have been considered. For clarity, European designated sites have been considered within 15 km of the Wylfa Newydd Development Area, whilst all other designations within 2 km of the Wylfa Newydd Development Area have been included in the model. Locations of human and ecological receptors within 2 km of the Wylfa Newydd Development Area are provided in Figure 2.1 below whilst a full list of all receptors considered is provided in Appendix C.

¹⁵ Defra, 2016. Local Air Quality Technical Guidance LAQM.TG(16)

Figure 2.1 Locations of modelled receptor locations



Notes: Please refer to Section 2.12 for an explanation of the distinction between receptors within/outside 200 m of the A5025.

2.8 Buildings

Any large object has an impact on atmospheric flow and air turbulence within the locality of the object, which affects the dispersion of material emitted from nearby stacks. This can result in maximum ground level concentrations that are significantly different (generally higher) from those encountered in the absence of buildings. The building 'zone of influence' is generally regarded as extending a distance of $5L$ (where L is the lesser of the building height or width) from the foot of the building in the horizontal plane and three times the height of the building in the vertical plane.

Using these criteria, relevant buildings have been included in the assessment as necessary (Table 2.4 and Figure 2.2). As ADMS agglomerates individual buildings into a single, effective building, on large, complex sites, including a large number of buildings in the model can result in an artificially large effective building with resultant consequential effects on plume dispersion. This phenomenon is discussed in Defra's Local Air Quality Management Technical Guidance LAQM.TG(16)¹⁶ and the guidance at paragraph 7.467 is followed with respect to treatment of buildings on large industrial sites:

¹⁶ Defra (2016) Local Air Quality Management Technical Guidance LAQM.TG(16)

“Where there are a large number of buildings in the vicinity of stack source, those closest (and often tallest) should be included and the surface roughness assumed in the model may be increased.”

Based on this guidance, for the main Power Station Site, a higher surface roughness length of 1.5 m has been specified, which is the upper range for an industrialised area.

A “Parameter Plan” approach for the main Power Station site has been adopted for the DCO Application, where the dimensions of the various buildings have been assigned nominal (average), minimum and maximum values. In order to approximate a worst-case assessment, the following approach has been adopted in relation to the relative heights above ground level of the combustion plant stacks (see Table 2.2 above) and their relationship with the buildings identified in Table 2.4 and Figure 2.2:

- ▶ For those buildings which are associated directly with a combustion plant emission stack, the building heights have been set at their minimum “Parameter Plan” building height and the stack heights are set at 3 m above this minimum building height; and
- ▶ For buildings not associated with a combustion plant emission stack, these were set at their maximum “Parameter Plan” dimensions.

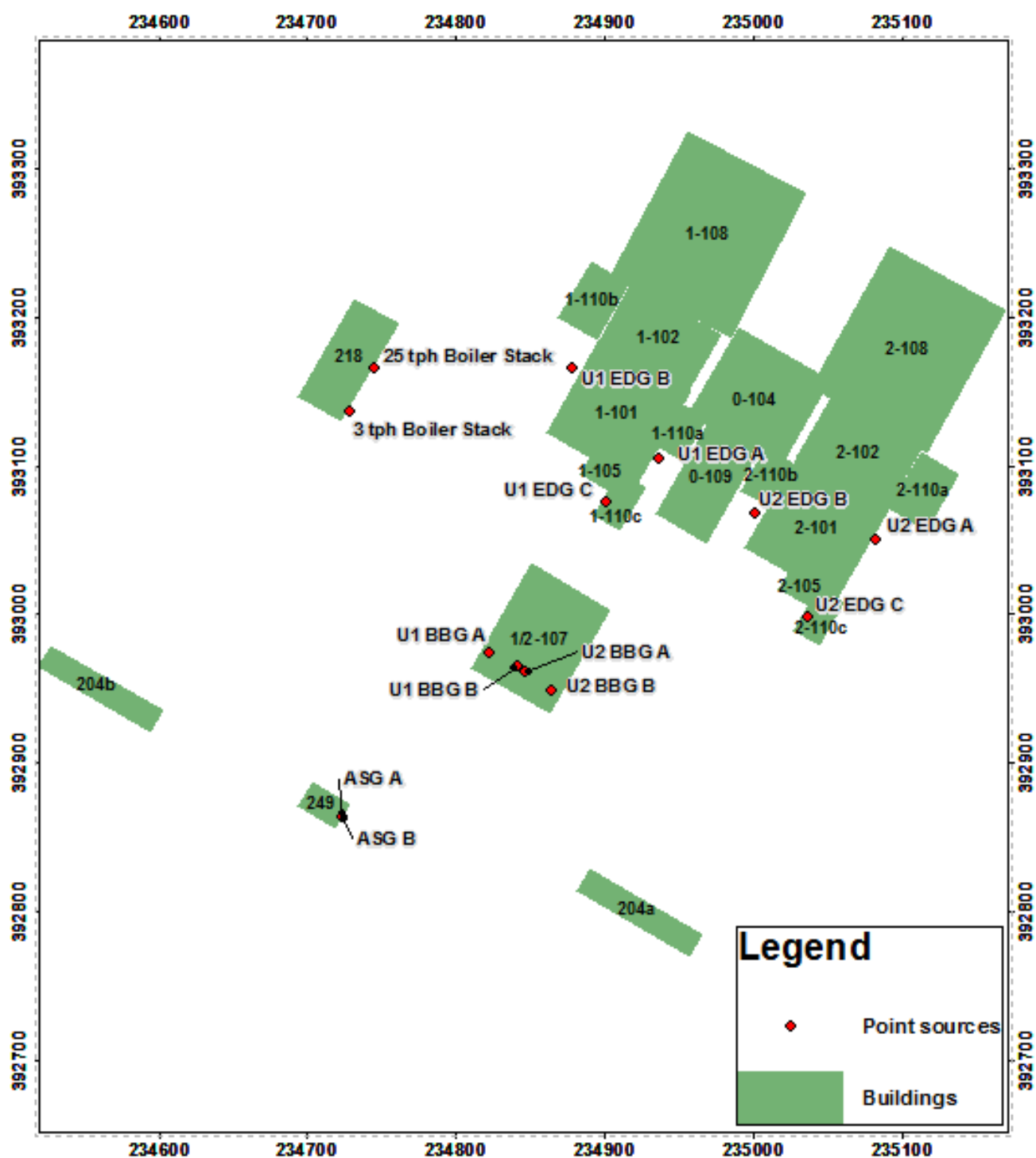
The rationale for this approach was to maximise the potential for ground level air pollutant concentrations by minimising the combustion plant stack heights above ground level and to maximise the potential turbulence and interference with effective dispersion of emissions by maximising the dimensions of other buildings on the Power Station site.

Table 2.4 Modelled buildings

Name	X (m)	Y (m)	Height (m)	Length (m)	Width (m)	Angle from north (deg)
1-101	234910	393136	41	73	71	210
1-102	234938	393186	49	45	70	210
0-104	235005	393146	49	68	72	210
1-105	234898	393097	49	18	23	210
1/2-107	234857	392983	27	81	62	210
1-108	234971	393256	49	110	91	208
0-109	234972	393093	49	82	40	210
1-110a	234952	393123	49	34	21	210
1-110b	234893	393211	49	44	30	210
1-110c	234910	393076	17	34	21	210
2-101	235044	393058	41	73	71	210
2-102	235072	393109	49	45	70	210
2-108	235105	393178	49	110	91	209
2-105	235032	393019	49	18	23	210
2-110a	235115	393083	49	44	30	210
2-110b	235010	393093	49	34	21	209
2-110c	235045	392998	17	34	21	210
218	234728	393171	17	77	34	210

Name	X (m)	Y (m)	Height (m)	Length (m)	Width (m)	Angle from north (deg)
249	234711	392871	18	20	30	210
204a	234924	392799	14	17	88	210
204b	234561	392950	14	17	88	210

Figure 2.2 Modelled buildings and emission sources



2.9 Terrain

The ground level concentrations of pollutants arising from emissions in areas of complex terrain differ from those found in simple, level terrain due to a number of topographical-induced effects on the three-dimensional flow and turbulent fields over the terrain. These effects are most pronounced when terrain gradients exceed 1 in 10. The terrain in the model domain approaches or exceeds this criterion and, consequently, digitally mapped terrain data has been included in the model set up.

OS Landform Panorama DTM NTF data has been used to create a base terrain file for the wider model domain. Superimposed on this base file is a finer resolution terrain file which reflects the development's Phase 5 final landscaping contours. Figure 2.3 provides a shaded relief map of terrain within 2 km of the Power Station Site and Figure 2.4 includes a snapshot of terrain across the wider area.

Figure 2.3 Terrain within 2 km of the power station

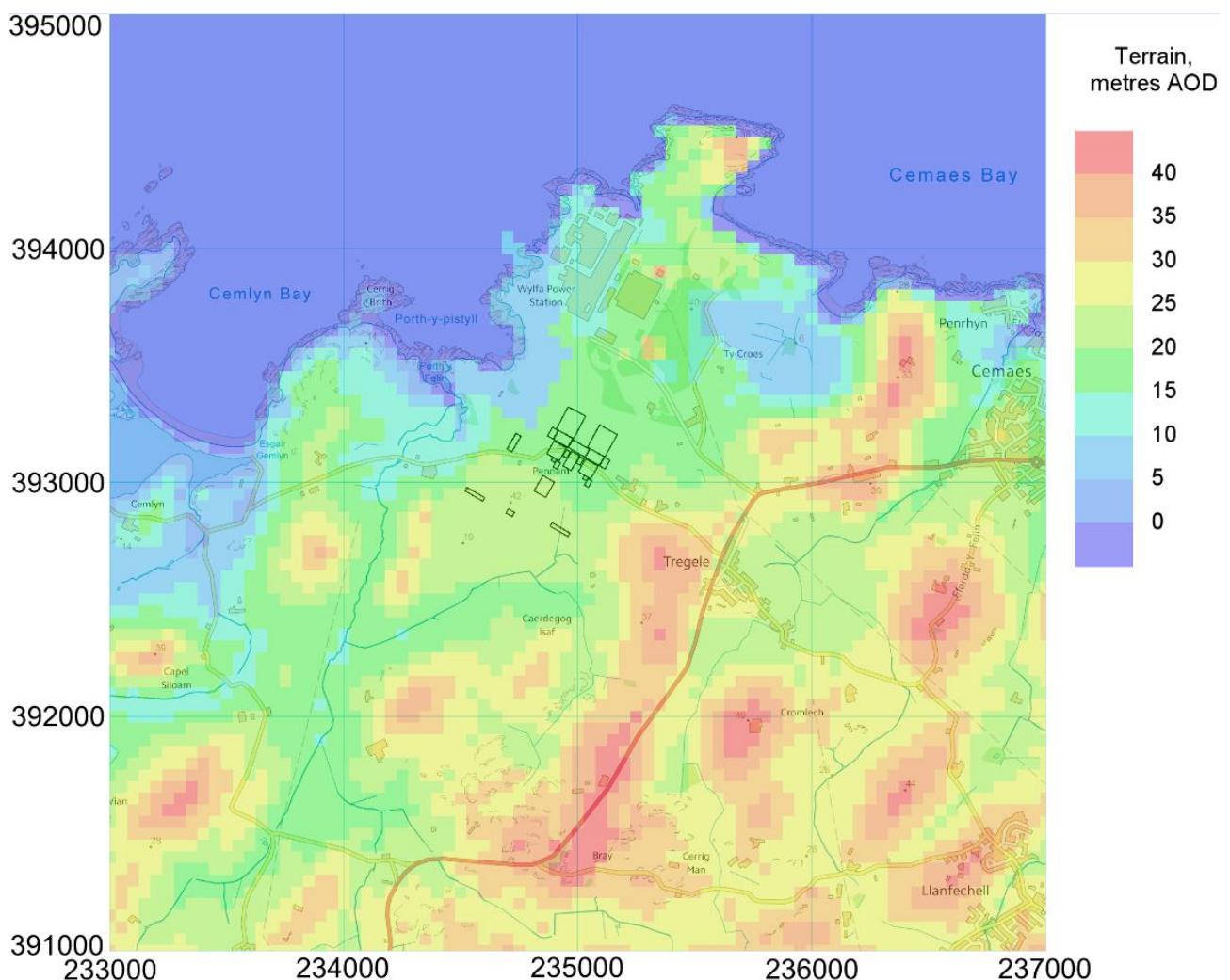
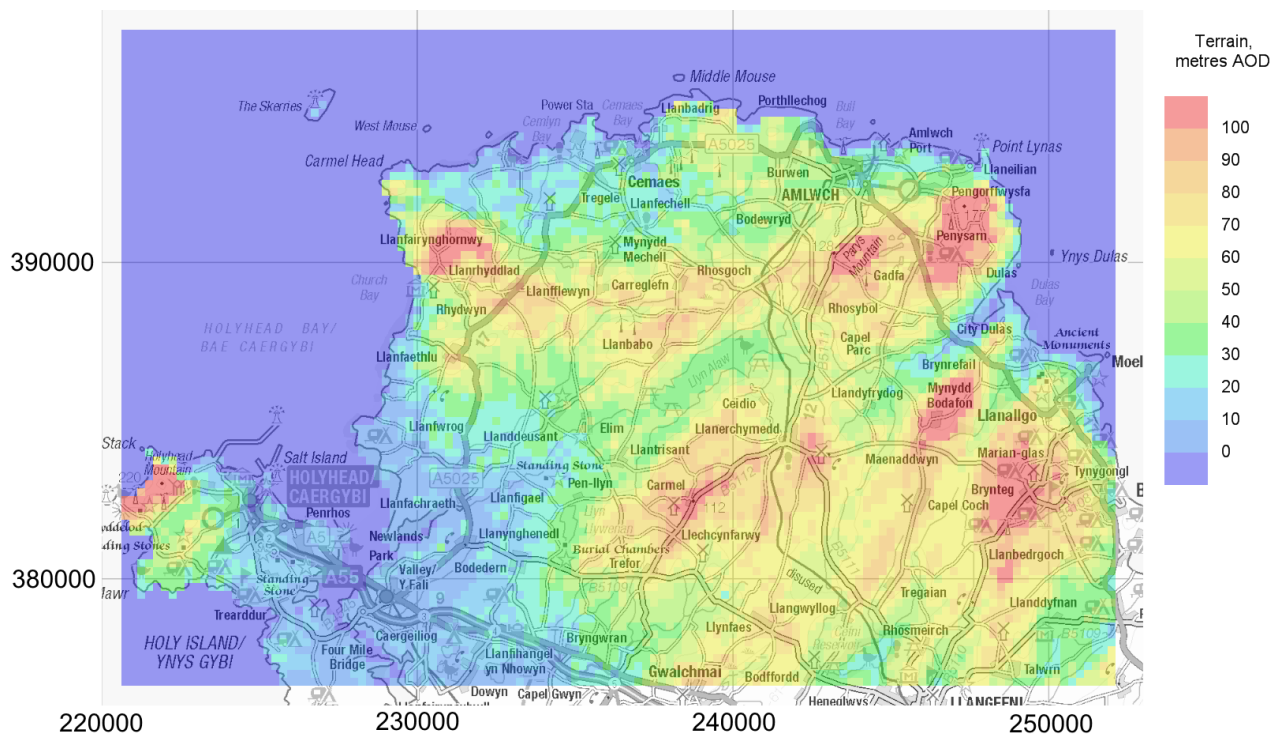


Figure 2.4 Terrain across the wider area



Units are metres above ordnance datum (m AOD)

2.10 Surface characteristics

The predominant surface characteristics and land use in a model domain have an important influence in determining turbulent fluxes and, hence, the stability of the boundary layer and subsequent dispersion. The principal parameters of interest are the surface roughness length, albedo and the modified Priestly-Taylor parameter/Bowen ratio.

Surface roughness

The surface roughness length is related to the height of surface elements; typically, the surface roughness length is approximately 10% of the height of the main surface features. Thus, it follows that surface roughness is greater in urban and congested areas than in rural and open areas. Oke (1987)¹⁷ and CERC (2016)¹⁸ suggest typical roughness lengths for various land use categories (Table 2.5).

Table 2.5 Typical surface roughness lengths for different terrain types

Type of surface	Typical surface roughness length (m)
Ice	0.00001
Smooth snow	0.00005
Smooth sea	0.0002
Lawn grass	0.01
Pasture	0.2

¹⁷ Oke (1987). 'Boundary Layer Climates'.

¹⁸ CERC (2014). 'The Met Input Module'

Type of surface	Typical surface roughness length (m)
Isolated settlement (farms, trees, hedges)	0.4
Parkland, woodlands, villages, open suburbia	0.5-1.0
Forests/cities/industrialised areas	1.0-1.5
Heavily industrialised areas	1.5-2.0

Increasing surface roughness increases turbulent mixing in the lower boundary layer. With respect to elevated sources under neutral and stable conditions, conflicting impacts in terms of ground level concentrations often occur:

- ▶ On the one hand, the increased mixing can bring portions of an elevated plume down towards ground level, resulting in increased ground level concentrations closer to the emission source; and
- ▶ On the other hand, the increased mixing increases entrainment of ambient air into the plume and dilutes plume concentrations, resulting in reduced ground level concentrations further downwind from an emission source.

The overall impact on ground level concentration is, therefore, strongly correlated with the distance of a receptor from the emission source.

Surface energy budget

One of the key factors governing the generation of convective turbulence is the magnitude of the surface sensible heat flux. This, in turn, is a factor of the incoming solar radiation. However, not all solar radiation arriving at the Earth's surface is available to be emitted back to atmosphere in the form of sensible heat. By adopting a surface energy budget approach, it can be identified that, for fixed values of incoming short and long wave solar radiation, the surface sensible heat flux is inversely proportional to the surface albedo and latent heat flux.

The surface albedo is a measure of the fraction of incoming short-wave solar radiation reflected back into the atmosphere by the Earth's surface. This parameter is dependent upon surface characteristics and varies throughout the year. Oke (1987) recommends average surface albedo values of 0.6 for snow covered ground and 0.23 for non-snow covered ground, respectively.

The latent heat flux is dependent upon the amount of moisture present at the surface. The modified Priestly-Taylor parameter can be used to represent the amount of moisture available for evaporation. Areas where moisture availability is greater will experience a greater proportion of incoming solar radiation released back to atmosphere in the form of latent heat, leaving less available in the form of sensible heat and, thus, decreasing convective turbulence. Holstag and van Ulden (1983)¹⁹ suggest modified Priestly-Taylor values of 0.45 and 1.0 for dry grassland and moist grassland respectively.

Parameters appropriate for the installation

A detailed analysis of the effects of surface characteristics on ground level concentrations by Auld et al. (2002)²⁰ led them to conclude that, with respect to uncertainty in model predictions:

"...the energy budget calculations had relatively little impact on the overall uncertainty"

In this regard, it is not considered necessary to vary the surface energy budget parameters spatially or temporally and annual averaged values have been adopted throughout the model domain for this

¹⁹ van Ulden and Holstag (1983). 'The Stability of the Atmospheric Surface Layer during Nighttime'. American Met. Soc., 6th Symposium on Turbulence and Diffusion.

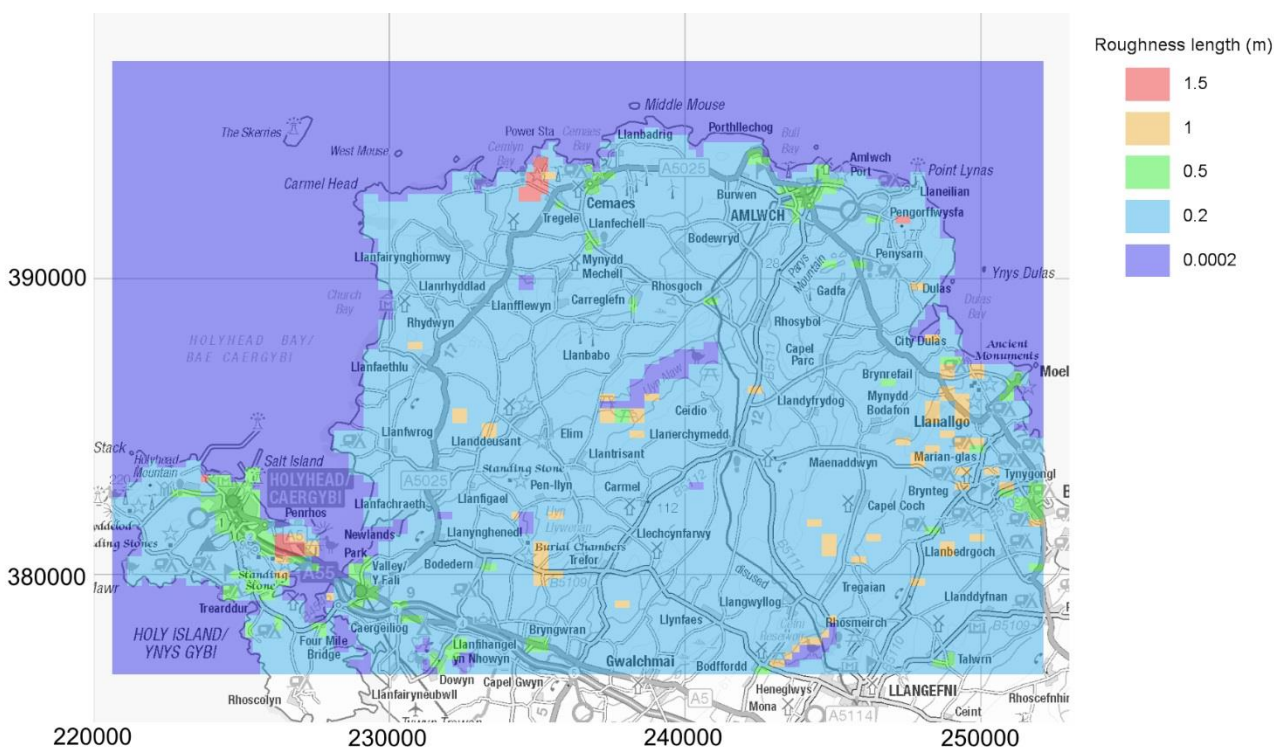
²⁰ Auld et al (2002). 'Uncertainty in Deriving Dispersion Parameters from Meteorological Data'. Atmospheric Dispersion Modelling Liaison Committee (ADMLC). Annual Report 2002-2003.

assessment. As snow covered ground is only likely to be present for a small fraction of the year, the surface albedo of 0.23 for non-snow covered ground advocated by Oke (1987) has been used, whilst the model default modified Priestly-Taylor parameter value of 1.0 has also been retained.

However, due to the variability and contrasting nature of land use within the model domain, a spatially varying surface roughness file has been used instead of adopting a uniform surface roughness length throughout the model domain. The surface roughness file, whose varying nature is visualised in Figure 2.5, is composed of the following values and land use categories:

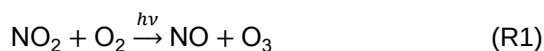
- ▶ 0.0002 m - representative of the sea/water;
- ▶ 0.2 m - representative of open grass and scrubland;
- ▶ 0.5 m - representative of suburbia and isolated settlement;
- ▶ 1.0 m - representative of built up areas and woodland; and
- ▶ 1.5 m - representative of large industrialised areas.

Figure 2.5 Surface roughness file visualisation



2.11 NO to NO₂ conversion

Emissions of NO_x from combustion processes are predominantly in the form of NO. Excess oxygen in the combustion gases and further atmospheric reactions cause the oxidation of NO to NO₂. NO_x chemistry in the lower troposphere is strongly interlinked in a complex chain of reactions involving volatile organic compounds (VOCs) and ozone (O₃). Two of the key reactions interlinking NO and NO₂ are detailed below:



Where $h\nu$ is used to represent a photon of light energy (i.e., sunlight).

Taken together, reactions R1 and R2 produce no net change in O₃ concentrations and NO and NO₂ adjust to establish a near steady state reaction (photo-equilibrium). However, the presence of VOCs and CO in the

atmosphere offer an alternative production route of NO₂ for photolysis, allowing O₃ concentrations to increase during the day with a subsequent decrease in the NO₂:NO_x ratio.

However, at night, the photolysis of NO₂ ceases, allowing reaction R2 to promote the production of NO₂, at the expense of O₃, with a corresponding increase in the NO₂:NO_x ratio.

Near to an emission source of NO, the result is a net increase in the rate of reaction R2, suppressing O₃ concentrations immediately downwind of the source, and increasing further downwind as the concentrations of NO begin to stabilise to typical background levels.

Given the complex nature of NO_x chemistry, the Environment Agency's Air Quality Modelling and Assessment Unit (AQMAU) has adopted a pragmatic, risk-based approach in determining the conversion rate of NO to NO₂ which dispersion model practitioners can use in detailed assessments. AQMAU guidance advises that the source term should be modelled as NO_x (expressed as NO₂) and then suggests a tiered approach when considering ambient NO₂:NO_x ratios:

- ▶ Screening Scenario: 50% and 100% of the modelled NO_x process contributions should be used for short-term and long-term average NO₂ concentrations, respectively;
- ▶ Worst Case Scenario: 35% and 70% of the modelled NO_x process contributions should be used for short-term and long-term average NO₂ concentrations, respectively; and
- ▶ Case Specific Scenario: Operators are asked to justify their use of percentages lower than 35% for short-term and 70% for long-term assessments in their application reports.

In line with the AQMAU guidance, this assessment has adopted the 'Worst Case Scenario' approach in determining the conversion rate of NO to NO₂ as a robust assumption. The 'Screening Scenario' factors are only applicable for screening assessments using the H1 software tool, not once a decision has been made to progress to detailed modelling. Use of the screening scenario approach in detailed assessments, particularly the assumption of 100% conversion to NO₂ would, effectively, require perpetual darkness and a non-limiting ozone concentration, to ensure that photolysis of NO₂ does not take place (i.e. reaction R1 ceases) and that the equilibrium shifts reaction R2 to completion. These conditions, quite obviously, could not occur in reality and their use in anything other than a basic, screening assessment, is unrealistic and overly pessimistic.

AQMAU undertook an assessment of the potential short-term impacts of diesel generator emissions on local air quality²¹ to support Defra's consultation on the transposition of the Medium Combustion Plant Directive (MCPD)²². Within this assessment, they concluded:

"Due to the very high NO_x emissions of the diesel generator engines and the very high resulting process contributions (PCs) the amount of conversion is likely to be limited by the amount of available O₃ in the background...Our checks indicate that a short term conversion ratio of 15% is likely to be reasonably representative within the first few hundred meters from the source. At greater distances the conversion ratio is likely to increase as the PCs become lower and therefore larger proportions are converted. A 15% conversion is more likely to underestimate the impacts greater than 500 m from the source; however, it is within 500 m that potential exceedances are more likely to occur."

Use of a 35% short-term conversion factor at all distances in this assessment is, therefore, likely to over-predict the actual impact for receptors within 500m of the EDGs, BBGs, ASGs and MEEG, which are all diesel generators, and the degree of over-prediction must be appreciated before concluding the significance of any impact on local air quality.

²¹ AQMAU, 2016. 'Diesel generator short term NO₂ impact assessment.' Report reference AQMAU-C1457-RP01

²² Directive (EU) 2015/2193 of the European Parliament and of the Council of 25 November 2015 on the limitation of emissions of certain pollutants into the air from medium combustion plants

2.12 Background contributions

Background concentrations are summarised in the baseline air quality report²³. In summary, the following data sources have been used to quantify baseline concentrations:

- ▶ **NO_x and NO₂:** For receptors more than 200 m from the A5025, 2013 data from Defra background maps is used assuming no reduction in future years with a varying background concentration dependent upon which grid square individual receptors are located in. For receptors within 200 m of the A5025, the contribution from the A5025 has been explicitly modelled for each receptor and added to the 2013 background mapped value;
- ▶ **SO₂ and CO:** Concentrations have been determined from the 2001 reference year Defra background mapping data representative of the locations of each modelled receptor. The 2001 map value has been used, with no reduction assumed in future year concentrations. For receptors in 1 km x 1 km grid square centred on E 235500 N 393500 a value of 2.1 µg m⁻³ is used since concentrations within this square are influenced by contributions from Wylfa A which is no longer operational; and
- ▶ **PM₁₀ and PM_{2.5}:** Uniform concentrations across the entire model domain based on maximum values obtained from monitored data collected by IACC in the vicinity of the Wylfa Newydd Development Area in 2013/14 and 2016 (PM₁₀ = 14.9 µg m⁻³; PM_{2.5} = 7.8 µg m⁻³) assuming no reduction in future years. For receptors within 200 m of the A5025 the contribution from the A5025 has been explicitly modelled for each receptor and added to the monitored data.

Short-term baseline concentrations have been derived from annual mean baseline concentrations by applying a factor of 2 to the annual mean data, in accordance with guidance contained within NRW's '*Air emissions risk assessment for your environmental permit*' guidance. Section 2.13 provides further information on how the combined impact of background, road traffic and point source contributions has been estimated.

2.13 Predicting the combined impacts of point source and vehicle emissions

This study uses the ADMS Roads version 4.1.1 model, with version 7.0 of the Emission Factors Toolkit (EFT)²⁴ supported by the Calculator Using Realistic Emissions for Diesels (CURED)²⁵ version 2A to quantify the contribution from on-road vehicles on the A5025. Emissions from on-road vehicles have been explicitly modelled for those receptors within 200 m of the A5025 and in close proximity to the Wylfa Newydd Development Area in order to more accurately predict the combined impacts of point source and vehicle emissions at these receptors during operation of the Wylfa Newydd Project.

Further information on the methodology for modelling vehicle emissions from traffic on the A5025 can be found in Appendix C4-01 of the Environmental Statement.

In order to estimate the combined impact of point source and road traffic emissions, the long-term baseline concentration used in the assessment of point source emissions takes a value of the total modelled NO₂ concentration from the roads model, i.e. local roads contribution plus background after verification, before the long-term process contribution from the point source emissions is added. Analogous to NRW's '*Air emissions risk assessment for your environmental permit*' guidance²⁶, the short-term baseline concentration used in the assessment of point source emissions takes a value of twice the total modelled NO₂ concentration from the roads model before the 99.79th percentile 1-hour mean process contribution from the point source emissions is added.

²³ Jacobs, 2017. 'Baseline Data Synopsis Report – Air Quality' WN03.03.01-S5-PAC-REP-00017

²⁴ <https://laqm.defra.gov.uk/review-and-assessment/tools/emissions-factors-toolkit.html>

²⁵ <http://www.aqconsultants.co.uk/News/August-2016/Updated-CURED-to-V2A.aspx>

²⁶ <https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit#calculate-pec>

Due to the non-linearity in the $\text{NO}_x:\text{NO}_2$ relationship (Section 2.11 provides further explanation), a more appropriate method would perhaps be to consider the combined modelled NO_x road source and point source contribution for each hour before calculating the combined long-term and short-term NO_2 impacts using Defra's NO_x to NO_2 calculator²⁷. However, use of the proposed method is considered appropriate in this instance due to the following factors:

- ▶ The fraction of primary NO_2 in point source and road traffic emissions is likely to be different which increases the uncertainty in the fraction of primary NO_2 estimate in methods such as Defra's NO_x to NO_2 calculator;
- ▶ Accurate predictions of the road contribution for each hour would require a diurnal profile of traffic flows which are not always readily available;
- ▶ Maximum short-term impacts from point source and road traffic emissions rarely occur under the same meteorological conditions (the maximum impact from road emissions generally occurring during stable conditions, whereas these conditions generally result in the lowest impact for an elevated point source); and
- ▶ Experience suggests use of the $\text{NO}_x:\text{NO}_2$ conversion factors from the Environment Agency's Air Quality Modelling and Assessment Unit (AQMAU) guidance²⁸ generally results in a more conservative prediction of impact for point sources and therefore provides a precautionary approach.

2.14 Deposition

Deposition processes in the form of dry and wet deposition remove material from a plume and alter the plume concentration. Dry deposition occurs when gases and particles are brought to the surface by gravitational settling and/or turbulence. They are then removed from the atmosphere by deposition or uptake on the land surface or on vegetation. Wet deposition occurs due to rainout (within cloud) scavenging and washout (below cloud) scavenging of the material in the plume.

These processes lead to a variation with downwind distance of the plume strength and may alter the shape of the vertical concentration profile, as dry deposition only occurs at the surface.

Near to sources of pollutants (< 2 km), dry deposition is generally the predominant removal mechanism for pollutants such as NO_x , SO_2 and NH_3 (Fangmeier et al. 1994)²⁹. Dry deposition may be quantified from the near-surface plume concentration and the deposition velocity (Chamberlin and Chadwick, 1953)³⁰:

$$F_d = v_d C(x, y, 0)$$

Where:

F_d = dry deposition flux ($\mu\text{g m}^{-2} \text{s}^{-1}$)

v_d = deposition velocity (m s^{-1})

$C(x, y, 0)$ = ground level concentration ($\mu\text{g m}^{-3}$)

AQTAG06 guidance (AQTAG, 2014)³¹ recommends deposition velocities for various pollutants dependent upon the habitat type (Table 2.6).

²⁷ https://laqm.defra.gov.uk/documents/no2tonox9_ja-forweb_june2016.xls

²⁸ AQMAU, undated. 'Conversion ratios for NO_x and NO_2 ' http://webarchive.nationalarchives.gov.uk/20140328084622/http://www.environment-agency.gov.uk/static/documents/Conversion_ratios_for_NOx_and_NO2_.pdf

²⁹ Fangmeier, A. et al., (1994). 'Effects of atmospheric ammonia on vegetation – a review', *Environmental Pollution*, 86, 43–82.

³⁰ Chamberlin and Chadwick (1953). 'Deposition of Airborne Radioiodine Vapour.' *Nucleonics*, 2, 22-25

³¹ AQTAG06 (2014). 'Technical Guidance on Detailed Modelling Approach for an Appropriate Assessment for Emissions to Air'

Table 2.6 Pollutant specific deposition velocities

Pollutant	Deposition velocity (ms ⁻¹)	
	Short vegetation	Long vegetation
NO ₂	0.0015	0.003
SO ₂	0.012	0.024

In order to assess the impacts of deposition, habitat-specific critical loads and critical levels have been created. These are generally defined as (e.g. Nilsson and Grennfelt, 1988)³²:

"...a quantitative estimate of exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge."

It is important to distinguish between a critical load and a critical level. The critical load relates to the quantity of a material deposited from air to the ground, whilst critical levels refer to the concentration of a material in air. The UK Air Pollution Information System (APIS) provides critical load data for ecological sites in the UK.

The critical loads used to assess the impact of compounds deposited to land which result in eutrophication and acidification are expressed in terms of kilograms of nitrogen deposited per hectare per year (kg N ha⁻¹ y⁻¹) and kilo-equivalents deposited per hectare per year (keq ha⁻¹ y⁻¹). The unit of 'equivalents' (eq) is used for the purposes of assessing acidification, rather than a unit of mass. The unit eq (1 keq ≡ 1,000 eq) refers to molar equivalent of potential acidity resulting from e.g. sulphur, oxidised and reduced nitrogen, as well as base cations. Essentially, it means 'moles of charge' and is a measure of how acidifying a particular chemical species can be.

To convert the predicted concentration in air of NO₂ and SO₂ the following algorithm is used.

$$DR_i = C_i v_{d_i} f_i$$

Where:

DR_i = annual deposition (kg ha⁻¹ y⁻¹)

C_i = annual mean concentration of the i th chemical species (µg m⁻³)

v_{d_i} = deposition velocity of i th species (Table 2.6)

f_i = factor to convert from µg m⁻² s⁻¹ to kg ha⁻¹ y⁻¹ for the i th species

Table 2.7 provides the relevant conversion factors as extracted from AQTAG06.

Table 2.7 Deposition rate conversion factors

Pollutant	Conversion factor (µg m ⁻² s ⁻¹ to kg ha ⁻¹ y ⁻¹ for the i th species)	
	Of	f_i
NO ₂	N	96
SO ₂	S	157.7

In order to convert deposition of N or S to acid equivalents, the following relationships can be used:

³² Nilsson J. and Grennfelt P. (Eds) 1988. 'Critical Loads for Sulphur and Nitrogen'. Miljørapport 1988:15. Nordic Council of Ministers, Copenhagen.

- ▶ $1 \text{ keq ha}^{-1} \text{ y}^{-1} = 14 \text{ kg N ha}^{-1} \text{ y}^{-1}$; and
- ▶ $1 \text{ keq ha}^{-1} \text{ y}^{-1} = 16 \text{ kg S ha}^{-1} \text{ y}^{-1}$.

With respect to wet deposition, AQTAG06 states:

"It is considered that wet deposition of SO_2 , NO_2 and NH_3 is not significant within a short range."

Therefore, the assessment only considers dry deposition of nitrifying and acidifying N and S compounds. The assessment assumes there is no depletion of material within the plume to allow a more conservative estimate of concentrations and resultant deposition rates.

2.15 Sensitivity analysis and uncertainty

Process emissions have been modelled using the standard steady state algorithms in ADMS to determine the impact on local human and ecological receptors. In order to model atmospheric dispersion using standard Gaussian methods, the following assumptions and limitations have to be made:

- ▶ Conservation of mass – the entire mass of emitted pollutant remains in the atmosphere and no allowance is made for loss due to chemical reactions or deposition processes (although the standard Gaussian model can be modified to include such processes). Portions of the plume reaching the ground are assumed to be dispersed back away from the ground by turbulent eddies (eddy reflection);
- ▶ Steady state emissions – emission rates are assumed to be constant and continuous over the time averaging period of interest; and
- ▶ Steady state meteorology – no variations in wind speed, direction or turbulent profiles occur during transport from the source to the receptor. This assumption is reasonable within a few kilometres of a source but may not be valid for receptor distances in the order of tens of kilometres. For example, for a receptor 50 km from a source and with a wind speed of 5 m s^{-1} it will take nearly three hours for the plume to travel this distance during which time many different processes may change (e.g., the sun may rise or set and clouds may form or dissipate affecting the turbulent profiles). For this reason, Gaussian models are practically limited to predicting concentrations within ~20 km of a source.

As a result of the above, and in combination with other factors, not least attempting to replicate stochastic processes (e.g., turbulence) by deterministic methods, dispersion modelling is inherently uncertain, but is nonetheless a useful tool in plume footprint visualisation and prediction of ground level concentrations. The use of dispersion models has been widespread in the UK for both regulatory and compliance purposes for a number of years and is an accepted approach for this type of assessment.

The assessment has incorporated a number of worst-case assumptions with regard to input parameters, which will likely result in overestimation of the predicted ground level concentrations. As a result of these worst-case assumptions, the predicted results should be considered to be at the upper limit of model uncertainty for a scenario where the actual site impact is determined.

However, sensitivity analysis is an important component of any model assessment, since it helps to identify the magnitude of potential uncertainty in model predictions. The results of the model sensitivity analysis with respect to changes in key input areas are explored below.

Buildings

Sensitivity analysis has been undertaken to identify whether including buildings within the model produces worst-case results. Models have been run with and without the inclusion of buildings for each year of meteorological data for the long-term and commissioning scenarios with maximum long-term and short-term NO_2 process contributions at modelled receptor locations compared. The results of the sensitivity analysis are provided in Table 2.8. Results have been normalised by the value obtained from the model run resulting in the highest ground level concentration (i.e. a value of 0.9 would indicate concentrations during that run are 10% less than the year producing the highest concentration).

Table 2.8 Building sensitivity analysis

Run	Normalised Annual Mean NO ₂	Normalised 99.79 Percentile 1-hour Mean NO ₂
With buildings	<u>1.00</u>	<u>1.00</u>
Without buildings	0.97	0.90

Terrain

Sensitivity analysis has been undertaken to identify whether including terrain data within the model produces worst-case results. Models have been run with and without the inclusion of terrain for each year of meteorological data for the long-term and commissioning scenarios with maximum long-term and short-term NO₂ process contributions at modelled receptor locations compared. The results of the sensitivity analysis are provided in Table 2.9. Results have been normalised by the value obtained from the model run resulting in the highest ground level concentration.

Table 2.9 Terrain sensitivity analysis

Run	Normalised Annual Mean NO ₂	Normalised 99.79 Percentile 1-hour Mean NO ₂
With terrain	<u>1.00</u>	<u>1.00</u>
Without terrain	0.97	0.96

Coastal effects

Localised flow patterns can result near to coastal areas due to the atmospheric pressure differential established between land and sea areas as a consequence of their different heat capacities (the heat capacity of the sea being much greater than that of the land). The land surface can exhibit a significant diurnal temperature variation whilst the variation in sea temperature remains fairly constant throughout the day, changing only on a monthly/seasonal basis.

When the land is warmer than the sea, an onshore breeze is established as the warm air above the land surface is heated and rises, forming a localised low pressure area above the land towards which the cooler, denser air over the sea flows. Due to the high heat capacity of liquid water, the boundary layer over the sea is most frequently neutral. However, as the air over the sea begins to flow inland, an internal convective boundary layer begins to grow as a function of distance inland. When this internal boundary layer reaches the height of a discharged plume, a coastal fumigation event can occur, whereby portions of the plume are rapidly mixed towards ground level due to the strong vertical motion in the internal boundary layer. This can cause transient, elevated ground level concentrations which may persist for 10-15 minutes.

ADMS does have the capability of modelling coastal effects. However, the coastal module cannot be applied at the same time as the buildings and/or terrain modules. Sensitivity analysis has, therefore, been undertaken to identify whether coastal effects or buildings and terrain effects in the model produces worst-case results. Models have been run for both scenarios and maximum short-term NO₂ process contributions at modelled receptor locations compared. The results of the sensitivity analysis are provided in Table 2.10. Results have been normalised by the value obtained from the model run resulting in the highest ground level concentration.

The sensitivity analysis indicates that the combined effects of buildings and terrain have a greater influence on maximum predicted impact than coastal effects. Cooling water discharges from the Wylfa Newydd Generating Station may cause localised increases in sea temperature. Such an effect would further reduce the influence of coastal influences as it will reduce the sea/land temperature differential and/or the number of instances when the land is warmer than the sea (coastal effects and the generation of an internal convective boundary layer only being a factor when the land is warmer than the sea).

Table 2.10 Coastal effects sensitivity analysis

Run	Normalised 99.79 Percentile 1-hour Mean NO ₂
With coastal effects, without buildings and terrain	0.75
Without coastal effects, with buildings and terrain	<u>1.00</u>

Meteorological data

Sensitivity analysis on the choice of meteorological data to use in the assessment has been undertaken by substituting NWP data for that recorded at RAF Valley during the same period. Maximum long-term and short-term NO₂ process contributions at any receptor location have been compared for each year of meteorological data for the long-term and commissioning A scenarios. The results of the sensitivity analysis are provided in Table 2.11. Results have been normalised by the value obtained from dataset resulting in the highest ground level concentration.

Table 2.11 Meteorological data sensitivity analysis

Dataset	Normalised Annual Mean NO ₂	Normalised 99.79 Percentile 1-hour Mean NO ₂
NWP (2007-2016)	<u>1.00</u>	0.74
Valley (2007-2016)	0.93	<u>1.00</u>

Table 2.11 demonstrates that the NWP dataset produces higher estimates of long-term impacts but lower estimates of short-term impacts. However, the aim of the sensitivity analysis is not to determine which dataset produces the highest result; it is merely to inform the understanding of the potential sensitivity in the meteorological data on the outputs. The principal decision on which meteorological dataset should be used in an air quality assessment should be made following an appraisal on which recording station is likely to provide the most representative data for the conditions local to the development site. Justification for the use of NWP data above Valley data is provided in Section 2.5.

3. Results

3.1 Concentrations and deposition rates

Results tables providing the combustion plant process contribution (PC), predicted environmental concentration with combustion plant contribution only (PEC(C))³³ and PEC with total Wylfa Newydd Project contribution (PEC(T))³⁴ for each receptor and each scenario, including a numerical comparison against the relevant AQO, are presented in Appendix D. These results are the highest concentrations predicted for individual receptors obtained from any year of meteorological data. As discussed in Section 1.1, this report presents a factual account of the modelling methodology and results without interpretation or assessment of significance.

It should be noted that the results for the MEEG emergency exercise scenario do not permit a direct comparison with the AQOs³⁵, particularly those which are expressed on a percentile basis or with an averaging period greater than 1 hour. The results for the emergency exercise have been obtained by assuming the scenario operates continuously throughout the year to allow for consideration of 'worst-case' meteorological conditions. However, the actual duration of this scenario is only 1 hour per annum. Any results presented with an averaging period greater than 1 hour, or presented with a percentile less than 100, are not directly comparable with the AQO. These results have been included only to provide an indication of the potential magnitude of off-site concentrations during the exercise.

Similarly, estimates of the impact during routine testing of the MEEG generators have been obtained by assuming, as a worst-case assumption, that the largest single item of plant to be tested (a 14.5 MWth Large Electric Power Source Vehicle Power Supply for Class 1 Safety System) operates continuously throughout the year. On this basis, there are predicted to be exceedances of the hourly mean NO₂ AQO at a limited number of receptors. However, in actual operation, each individual item of plant is only operated for 5-minutes during each monthly test. There are three Large Electric Power Vehicles and, consequently, the actual aggregated operation of this size of generator will only amount to 15 minutes per month, or 3 hours per annum. As the AQO permits 18 hours of exceedance during a calendar year, it would be impossible in actual operation for routine tests on this particular generator to cause an exceedance of the AQO. The second largest generator, at 3.4 MWth, does not result in a predicted exceedance of the hourly mean NO₂ AQO when assumed to be continuously operational throughout the year.

3.2 Probabilistic assessment for short-term impacts on human health

Modelling of the routine testing and maximum boiler impact scenarios demonstrates that, even under the worst-case possible assumption of continuous operation of the combustion plant for the full year, there are no predicted exceedances of any of the human health based AQOs. However, under this same assumption, potential exceedances of the hourly mean NO₂ AQO have been predicted for the commissioning and LOOP/LOCA scenarios. In order to estimate the likelihood of the AQOs being exceeded based on the actual operational hours of the combustion plant, additional probability analysis has been undertaken as described in Section 2.5.

Figure 3.1 provides the output from the probability of exceedance assessment for the commissioning scenario using the hypergeometric distribution approach for the receptor which is predicted to experience the highest number of exceedances of the AQO concentration (i.e. it represents the worst-case probability of exceedance). The probability of exceedance during commissioning is the probability of the 24 hour partial in-combination run (2x EDGs operational for 24 hours) causing more than 18 exceedances, or the 24 hour endurance run (1x EDG operational for 24 hours) causing more than 18 exceedances. Although it is

³³ PEC(C) = PC + baseline concentration without additional Wylfa Newydd Project operational traffic contribution

³⁴ PEC(T) = PC + baseline concentration with additional Wylfa Newydd Project operational traffic contribution

³⁵ This is equally true for Commissioning Scenario A where the duration of the full in-combination commissioning run is not sufficient to cause the number of exceedances permitted by the AQOs. However, as the initial modelling assumption is that emissions occur continuously throughout the year so that worst-case meteorological conditions are captured, results have been presented for this scenario.

impossible for the full in-combination test (i.e. 3x EDGs at 100% MCR and 2x BBGs at low load operational for 4 hours) to directly cause more than 18 exceedances of the AQO, this operation needs to be taken into account, since it may affect the number of permitted exceedances the other commissioning scenarios have available before more than 18 exceedances occur in aggregate. This has been taken into account in the probability calculation by subtracting the likely number of exceedances contributed by the full in-combination site acceptance test (SAT) (defined by np , where n is the duration of the full in-combination test (=4 hrs) and $p = E_{tot}/N$) from the number of exceedances permitted by the AQO.

Figure 3.1 Probability of exceeding the NO₂ AQO for the commissioning scenario

Inputs (2xEDG for 24hrs)	
Modelled number of operational hours	8760 h y ⁻¹
Modelled number of hourly exceedances	182 h
Number of exceedances allowed by AQO ¹	17 h y ⁻¹
Actual number of operational hours ¹	24 h y ⁻¹
¹ Takes into account likely number of exceedances from 3x EDG and 2x EDG operation for 4 hours	
Probability of not breaching AQO	100.00%
Probability of breaching AQO (B)	< 1.0E-15

The probability of exceeding the NO₂ AQO during the in-combination run is < 1x10⁻¹⁵. This is the lower cut-off point for the Excel function (any value below this returns a zero probability of exceedance). As 2x EDGs operational for 24 hours carries a < 1x10⁻¹⁵ probability of exceedance, simple logic would dictate that 1x EDG operational for 24 hours would also carry a < 1x10⁻¹⁵ probability of exceedance. Therefore, at most, the probability of the commissioning scenario causing more than 18 exceedances of the AQO is 1x10⁻¹⁵.

The hypergeometric distribution method effectively assumes the operation of the combustion plant is randomly distributed throughout the year. This assumption might not hold as true for commissioning where the operation is confined to a specific continuous set of hours. Therefore, additional analysis has been undertaken to validate the conclusion obtained by the hypergeometric distribution method.

Commissioning scenario B has been re-run with the model operating in 'short-term (ST)' mode. In this mode, the model produces concentration output for each hour of meteorological data, rather than producing an average or percentile based concentration output. This output has been interrogated to identify how many rolling 24 consecutive hourly periods have more than 18 individual hours exceeding 200 µg m⁻³ as a PEC.

Across the full 10 years of meteorological data considered in the assessment, there were no occasions where greater than 18 individual hours exceeding 200 µg m⁻³ as a PEC occurred in a rolling 24 hour period for any receptor. The highest number of exceedances in any 24 hour period was 12. Additional analysis was undertaken to identify the highest number of exceedances in any 24 hour period for a single EDG in operation to reflect the additional SAT commissioning outside of the in-combination run. This analysis indicated that, with a single EDG in operation, the highest number of exceedances in any 24 hour period is 2. Therefore, assuming in the worst-case scenario that the full in-combination run contributes 4 exceedances during its 4 hours of operation, the highest number of exceedances which could potentially occur during commissioning based on this analysis is 18 (4 exceedances during the full in-combination run, 12 exceedances from 2x EDGs operating simultaneously and continuously for 24 hours, and 2 exceedances from a single EDG operating continuously for 24 hours)

The above analysis would indicate there is zero probability of breaching the AQO, since the highest combined number of exceedances of the various commissioning operational configurations is not greater than 18. However, the probability as reported using this method is influenced by the number of met years/data points available to the analysis (if more data was considered this value would change). It would be more correct to state that the probability of exceedance using this secondary method would be < 1 in 87,672 or < 1.1x10⁻⁵ in this case, since there are 87,672 data points/rolling 24 hour periods in the 10 years of met data that have been considered.

Readers should not be confused by the apparent factor of difference in the order of 10^{10} between the hypergeometric method and this secondary method, since both results are quoted as a less than figure which is influenced solely by the data coverage/limit imposed by the respective method. In the hypergeometric case, the cut-off point in the Excel function limits the value that can be returned, whilst in the second method, the number of data points in the met data limits the value that can be returned. Importantly, both methods suggest the probability of exceedance is less than the acceptable probability level of 1.7×10^{-2} .

Figure 3.2 presents the outcome of the probability assessment for the LOOP/LOCA scenario using the hypergeometric distribution method which indicates a probability of exceedance of 2.5×10^{-10} .

Figure 3.2 Probability of exceeding the NO₂ AQO for the LOOP/LOCA scenario

Inputs		
Modelled number of operational hours	8760	h y ⁻¹
Modelled number of hourly exceedences	1651	h
Number of exceedences allowed by AQO	18	h y ⁻¹
Actual number of operational hours	24	h y ⁻¹
Probability of not breaching AQO	100.00%	
Probability of breaching AQO	2.50E-10	

Using the same 'ST' probability method as that described for commissioning, in the 10 year period of meteorological data coverage there were a total of 1,584 rolling 24 hour periods where more than 18 exceedences of $200 \mu\text{g m}^{-3}$ were predicted. This equates to a probability of exceedance of 1.8×10^{-2} . However, this does not take in to account the actual probability of the emission scenario itself occurring. Unlike commissioning, where the operational scenario will definitely occur, there is no certainty that a LOOP/LOCA event will actually occur. In any year, the ONR estimates the probability of a 24 hour LOOP event to be 5×10^{-3} . The overall probability of exceedance is the probability of contributing to more than 18 exceedences **IF** the operational scenario occurred **AND** the probability of the operational event itself occurring. Combined, this produces an overall probability of exceedance of 9.0×10^{-5} .

The increased divergence between the two methods of calculating probability for the LOOP/LOCA scenario is likely to be due to the fact that an intrinsic assumption behind certain probabilistic distributions is that the probability of a single event occurring is relatively small and/or that the distribution of occurrence is entirely random. Where the probability of a single event occurring is relatively high and/or where the probability of occurrence is not entirely random, increased uncertainty will be introduced to the estimate from these distributions. In the case of the LOOP/LOCA scenario, the probability of a single event occurring is relatively high at 0.19 (1,651 modelled hours of exceedance out of a total number of 8,760 modelled hours) whilst the distribution of the operational hours may not necessarily completely satisfy the requirements for a random distribution with the operational hours being concentrated in to a single, consecutive 24 hour period. The 'ST' approach to calculating the probability of exceedance does not have the same limitations or requirements and it is the specific nature of this scenario which drives the divergence between the two methods.

3.3 Effects of climate change on air quality

The 2007 report produced by the Air Quality Expert Group³⁶ indicated that the winter season may become windier with fewer stable weather conditions by the end of the century, whilst summer seasons are anticipated to become hotter and sunnier, with an increase in unstable weather conditions by the 2040s. The net effect of these anticipated changes on the baseline air quality is difficult to establish, but is unlikely to significantly alter the baseline air quality to an extent that it would affect the outcome of this assessment. Other factors such as changes in technology and the move away from combusting fossil fuels driven by

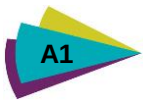
³⁶ AQEG, 2007. 'Air Quality and Climate Change: A UK Perspective'

climate change mitigation are likely to lead to decreases in emissions of the key pollutants considered in this assessment and also a decrease in background concentrations of air pollutants into the future.

With regard to the effects of a greater number of extreme weather events upon dispersion of air pollutants, an increased frequency of windier and fewer stable conditions during winter months is likely to improve the dispersion of emissions in the atmosphere and reduce the ground level concentrations of air pollutants arising from those emissions at those times. If there is, in the future, an increased frequency of higher temperature, sunny summer days, then, depending upon wind speeds, this could bring about an increase in the ground level concentrations of air pollutants, as a result of an increased frequency of highly convective atmospheric conditions.

The effects upon overall long-term (annual) ground level air pollutant concentrations will most likely be small, as the two effects will have, more or less, a cancelling-out effect. However, the effect under future summer conditions could enhance short-term (hourly average) ground level concentrations during, for example, routine testing and commissioning of the standby combustion plant. Whilst concentrations above the AQO of $200 \mu\text{g m}^{-3}$ may occur during commissioning, if the plant is running for the whole year, as forecast using past meteorological records, the probability of exceedances actually occurring is very low at less than 1×10^{-15} because the actual plant operation represents only a small proportion of the year. If the number of hourly average concentrations above the AQO during a year were to increase in the future, as a result of hotter, sunnier summer conditions, then the probability of an exceedance occurring would also increase. However, as an illustration, considering the standby combustion plant commissioning scenario, if the potential number of exceedances were to double as a result of climate change effects during summer months, then the probability of an exceedance of the AQO would still be less than 1×10^{-15} . Sensitivity analysis demonstrates that the number of hourly exceedances (and, therefore, the frequency of hotter, sunnier summer conditions) would have to increase by more than a factor of 10, for the probability to even increase above 1×10^{-15} .

It is considered, therefore, that any future effects of climate change upon the ground level air pollutant concentrations generated by the Wylfa Newydd Project would be small and, most likely, indiscernible, as far as the current best scientific knowledge of climate change effects is concerned.



Appendix A

Model Parameters and Scenarios to be used in the Assessment of Emissions from Operational Combustion Plant (Report)

Model Parameters and Scenarios to be used in the Assessment of Emissions from Operational Combustion Plant

DCRM Ref Number: 206230-0000-AA40-RPT-0002

Additional Requirements or Controls			
LISTED READERS ONLY		LEGALLY PRIVILEGED	

Comments:

THIS DOCUMENT CONTAINS PROPRIETARY INFORMATION OF HORIZON NUCLEAR POWER LIMITED'S GROUP. ANY INFORMATION CONTAINED HEREIN, IN WHOLE OR IN PART, SHALL NOT BE USED FOR ANY PURPOSE OTHER THAN THE PERFORMANCE OF WORK UNDER CONTRACT, OR BE DISCLOSED IN ANY MANNER OR BY ANY MEANS TO ANY THIRD PERSON OR PERSONS WITHOUT SPECIFIC CONSENT IN WRITING FROM THE APPROPRIATE MEMBER OF HORIZON NUCLEAR POWER LIMITED'S GROUP

This document may contain EXPORT CONTROLLED Information. The release of this information to any other party other than its intended recipient may result in a violation of U.S., Japanese or UK export controls. If you have received this document in error, please notify Horizon immediately by returning the document to the sender. You must take reasonable measures to prevent unauthorised persons from having access to or using any EXPORT CONTROLLED Information contained herein.

Distribution		
<i>Required for Listed Readers Only and Legally Privileged but can be used with other markings</i>		

Approvals Table				
	Role	Printed Name	Signed Name	Date
Originated by	Document Author	Martin Peirce		
Reviewed by	Document Reviewer	Adam Clegg		
Checked by	Head of Section			
Approved by	EMT Representative			

NOT PROTECTIVELY MARKED

Model Parameters and Scenarios to be used in the Assessment of Emissions from Operational Combustion Plant	DCRM Reference No	
	206230-0000-AA40-RPT-0002	Issue date: 05/06/2017

Revision History				
Date	Rev No.	Summary of Changes	Ref Section	Purpose of Issue
15/08/15	1.0			For Horizon Review
23/09/16	2.0			For Horizon Review
21/03/17	3.0			For Horizon Review
27/04/17	4.0			For Horizon Review
05/06/17	5.0			For Horizon Review
06/12/17	6.0			For Horizon Review

NOT PROTECTIVELY MARKED

NOT PROTECTIVELY MARKED

Model Parameters and Scenarios to be used in the Assessment of Emissions from Operational Combustion Plant	DCRM Reference No	
	206230-0000-AA40-RPT-0002	Issue date: 05/06/2017

Contents

1	Introduction.....	5
1.1	Purpose of this Report	5
1.2	Terms and Definitions	5
2	Combustion Plant Details	6
3	Operation and Emission Scenarios	7
3.1	Short-term Impact Scenarios.....	7
3.1.1	Commissioning of Standby Generators (DCO and EP)	8
3.1.2	Routine Testing of Standby Generators (DCO and EP).....	9
3.1.3	Maximum Boiler Impact (DCO and EP).....	10
3.1.4	On-site MEEG Maintenance Testing (DCO only).....	10
3.1.5	MEEG Emergency Exercise (DCO only).....	11
3.1.6	LOOP/LOCA (DCO and EP)	13
3.1.7	Long-term Impact Scenario (DCO and EP).....	14
4	Process Emissions	16
5	References	18
	Appendix A	20
	MODEL PROCESS AND EMISSIONS DATA	20

List of Tables

Table 1: Terms and Definitions	6
Table 2: Worst-case short-term impact model scenario during commissioning.....	9
Table 3: Proposed standby power generation plant maintenance regime.....	9
Table 4: Worst-case short-term impact model scenario during routine testing.....	10
Table 5: Worst-case short-term impact model scenario during MEEG maintenance testing.....	11
Table 6: Worst-case short-term impact model scenario during MEEG emergency exercise	12
Table 7: Worst-case short-term impact model scenario during LOOP/LOCA.....	14
Table 8: Worst-case long-term impact model scenario	16
Table 9: Assumed Emission Concentrations for EDGs, BBGs and MEEG Generators.....	17
Table 10: Assumed Emission Concentrations for ASGs	17
Table 11: Assumed Emission Concentrations for 30tph House Boilers.....	18
Table 12: Assumed Emission Concentrations for 2tph House Boilers.....	18
Table 13: References	19

NOT PROTECTIVELY MARKED

NOT PROTECTIVELY MARKED

Model Parameters and Scenarios to be used in the Assessment of Emissions from Operational Combustion Plant	DCRM Reference No	
	206230-0000-AA40-RPT-0002	Issue date: 05/06/2017

NOT PROTECTIVELY MARKED

Model Parameters and Scenarios to be used in the Assessment of Emissions from Operational Combustion Plant	DCRM Reference No	
	206230-0000-AA40-RPT-0002	Issue date: 05/06/2017

1 Introduction

1.1 Purpose of this Report

This Report has been produced for the purposes of summarising the emission scenarios and associated emission parameters to support the detailed dispersion modelling study. The modelling study will quantify the potential impacts on local air quality associated with emissions to air from combustion plant during the operational phase of the Wylfa Newydd Project.

1.2 Terms and Definitions

TERM	DEFINITION
AQO	Air Quality Objective
ASG	Auxiliary Standby Generator
B/B	Backup Building
BBG	Backup Building Generator
CO	Carbon Monoxide
DG	Diesel Generator
Defra	Department for Environment, Food and Rural Affairs
EAL	Environmental Assessment Level
EDG	Emergency Diesel Generator
ELV	Emission Limit Value
FAT	Factory Acceptance Testing
HCW	High Chemical Impurity Waste
LOCA	Loss of Coolant Accident
LOOP	Loss of Off-site Power
LV	Limit Value
MEEG	Mobile Emergency Equipment Garage

Model Parameters and Scenarios to be used in the Assessment of Emissions from Operational Combustion Plant	DCRM Reference No	
	206230-0000-AA40-RPT-0002	Issue date: 05/06/2017

TERM	DEFINITION
NO _x	Oxides of Nitrogen
NO ₂	Nitrogen Dioxide
PC	Process Contribution
PEC	Predicted Environmental Concentration
PM _{2.5}	Particulate matter less than 2.5 micrometers in diameter
PM ₁₀	Particulate matter less than 10 micrometers in diameter
SAT	Site Acceptance Testing
SO ₂	Sulphur Dioxide
ULSD	Ultra Low Sulphur Diesel

Table 1: Terms and Definitions

2 Combustion Plant Details

The Wylfa Newydd Generation Station standby combustion plant is required to provide power generation so that the reactor can be shut down safely and adequate cooling provided in the event of loss of off-site power (LOOP) or a loss of coolant accident (LOCA) occurring simultaneously with a LOOP event.

The main standby combustion plant consists of:

- Emergency Diesel Generators (EDGs). Each of the two reactor Units will have three EDGs, rated at 10.4 MW_e, 23.6 MW_{th} input, each in a separate EDG building, each with an individual stack;
- Backup Building Generators (BBGs). Each of the two reactor Units will have two BBGs, rated at 4.8 MW_e, 11 MW_{th} input, two in each Back-up Building (B/B), with each BBG having a separate stack;
- Auxiliary Standby Generators (ASGs). There will be two ASGs, each rated at 3.6 MW_e, 8.2 MW_{th} input. The ASGs will be housed in a single building and share a multi-flue stack;
- House boilers. There will be six house boilers, serving both Units between them. There will be four 25 tonnes per hour (of steam) (tph) boilers, rated at 15.8 MW thermal input and two 3 tph boilers, rated at 1.95 MW thermal input. These will provide steam to

Model Parameters and Scenarios to be used in the Assessment of Emissions from Operational Combustion Plant	DCRM Reference No	
	206230-0000-AA40-RPT-0002	Issue date: 05/06/2017

the site during start-up, normal operation and shut-down. The boilers will be housed in a single building. There will be two multi-flue stacks, one for the 25 tph boilers and a second for the 3 tph boilers; and

- Various emergency mobile generators, with a total net thermal input rating of 104 MWth, stored in the on-site and off-site Mobile Emergency Equipment Garage (MEEG).

There are also a number of other minor combustion plant items (e.g. diesel engine fire pumps). Current proposals are that the net thermal input capacity of this other plant will aggregate to less than 3 MWth input. Following pre-application discussions with Natural Resources Wales (NRW), due to the small scale of these plant items, their emissions are unlikely to have any significant impact on receptors and have been excluded from the assessment.

It is expected that all combustion plant will operate on Ultra Low Sulphur Diesel (ULSD) which has a sulphur content of 10 ppm or less.

3 Operation and Emission Scenarios

There are three potential operating scenarios for the EDGs, BBGs and ASGs:

- Commissioning;
- Routine testing; and
- LOOP/LOCA.

There are a number of potential operational scenarios for the house boilers:

- Commissioning
- Start-up and shut-down (shut-down loads mirror start-up)
- Outage/ inspection (rather than shut-down)
- Outage with intermittent High Chemical Impurity Waste (HCW) evaporator
- Routine operation.

With regard to the mobile generators in the on-site MEEG, there are two potential operating scenarios which are relevant to the DCO Application only:

- Maintenance testing; and
- Emergency exercises.

The intended operation profile of the standby combustion plant and associated parameters has been defined by Horizon. However, this operational profile needs to be converted into equivalent model scenarios to allow appropriate consideration of maximum potential long-term and short-term impacts.

3.1 Short-term Impact Scenarios

Due to the duration of the following operational scenarios, only short-term impacts (i.e. those with an air quality objective (AQO) averaging period of 24 hours or less) are considered.

Model Parameters and Scenarios to be used in the Assessment of Emissions from Operational Combustion Plant	DCRM Reference No	
	206230-0000-AA40-RPT-0002	Issue date: 05/06/2017

3.1.1 Commissioning of Standby Generators (DCO and EP)

Commissioning will be conducted at both the manufacturer's factory (Factory Acceptance Testing (FAT)) and on site following installation (Site Acceptance Testing (SAT)). Each unit will be both FAT and SAT tested separately to confirm successful individual operation. SAT testing to confirm functional operation of the entire system, as per the design specification, will also be conducted.

It is planned that commissioning of EDGs and BBGs will take place over a 72 hour period with a variety of combinations of generators tested. Each standby generator will be tested for 24 hours during this period, either in combination with similar plant or individually. Limited in-combination testing of the EDGs and BBGs could also occur, as a worst case for up to 4 hours.

Although each generator will only be tested for up to 24 hours over the 72 hour SAT period, for the purposes of modelling long-term impacts, it has been assumed conservatively that up to 72 hours of SAT testing will be required for each standby power generator. This is to allow additional flexibility should a generator fail its initial SAT and require additional testing beyond the planned 24 hours. It is assumed that commissioning of the standby generators will not occur during an outage of the other Unit or during outage with HCW operation.

The worst-case short-term impacts during commissioning will occur during the combination test, for which there are two separate operational configurations:

- Three EDGs operating with full system load and two BBGs operating with low load for a period of 4 hours, and no further EDG operation during the 24 hour period; and
- Two EDGs operating with full system load for a period of 24 hours.

Based on relative mass emissions, it is expected that the first scenario would represent 'worst-case' emission parameters for hourly and 15-minute mean predictions whilst the second would represent 'worst-case' emission parameters for 8-hourly and daily means. In order to allow consideration of those meteorological conditions producing maximum ground level concentrations, it is assumed that the combustion plant is operating continuously throughout the year.

Remaining commissioning hours will involve individual combustion plant runs. It is possible that there could be a 24 hour run for a standby generator individually. However, in any case, the combination test of two EDGs operating with full system load for a period of 24 hours will bound this scenario.

Commissioning of the ASGs will occur separately to the EDGs and BBGs, so will not contribute to the worst-case short-term scenarios. Given that the ASG emission rates are considerably lower than the EDGs/BBGs, any impacts during commissioning of the ASGs will be bounded by the EDG/BBG commissioning.

The source groups and annual meteorological hours considered by this scenario are detailed in table 2.

NOT PROTECTIVELY MARKED

Model Parameters and Scenarios to be used in the Assessment of Emissions from Operational Combustion Plant	DCRM Reference No	
	206230-0000-AA40-RPT-0002	Issue date: 05/06/2017

SOURCE GROUP	NUMBER OF PLANT AND LOAD	ANNUAL OPERATIONAL HOURS
Unit 1 DGs	Not operational	N/A
Unit 2 DGs	3x EDGs at 100% MCR and 2x BBGs at 'low load' (assumed to be 30% MCR) for 4 hours (15-minute and hourly mean predictions only) and 2x EDGs at 100% MCR for 24 hours (8-hour and daily mean predictions)	Continuous throughout the year to allow consideration of worst-case meteorological conditions
House boilers	3x 25 tph boiler at 80% MCR	Continuous throughout the year to allow consideration of worst-case meteorological conditions
ASGs	Not operational	N/A
MEEG generators	Not operational	N/A

Table 2: Worst-case short-term impact model scenario during commissioning

3.1.2 Routine Testing of Standby Generators (DCO and EP)

Routine maintenance will be conducted in accordance with a defined maintenance programme at various set intervals. This will consist of preventative maintenance as well as testing to confirm the equipment can perform its safety-related duty.

All tests and maintenance will be conducted on each EDG, BBG and ASG individually. The figures stated are applicable for each standby generator. It is assumed that the tests outlined in table 3 will not be conducted simultaneously or during a single 24 hour period.

TEST	FREQUENCY
4 hour run at maximum continuous rating	Monthly
Preventative maintenance: 4 hours of short-duration runs at maximum continuous rating and a 6 hour continuous test run at maximum continuous rating (total of 10 hours of test runs at MCR)	Every outage (18 months)

Table 3: Proposed standby power generation plant maintenance regime

NOT PROTECTIVELY MARKED

NOT PROTECTIVELY MARKED

Model Parameters and Scenarios to be used in the Assessment of Emissions from Operational Combustion Plant	DCRM Reference No	
	206230-0000-AA40-RPT-0002	Issue date: 05/06/2017

The expectation is that each standby generator will be tested individually and, as a result, there will only ever be a single standby generator operating at any moment in time across both Units in this scenario. It is assumed that the house boilers will be operating at full duty to take in to account any generator testing during boiler commissioning. Testing of the mobile generators in the MEEG are considered separately (section 3.1.4; this is relevant for the DCO application only).

Each EDG, BBG and ASG is modelled as an individual source group (which also includes boiler emissions) with the highest concentration from any source group reported for individual receptors. The combustion plant and annual meteorological hours considered by this scenario are detailed in table 4.

SOURCE GROUP	NUMBER OF PLANT AND LOAD	ANNUAL OPERATIONAL HOURS
Unit 1 and 2 EDGs and BBGs and ASGs	1x EDG, BBG or ASG at 100% MCR	Continuous throughout the year to allow consideration of worst-case meteorological conditions
House boilers	4x 25 tph boilers at 100% MCR and 2x 3 tph boilers at 100% MCR (106,000 kg/h steam demand)	Continuous throughout the year to allow consideration of worst-case meteorological conditions

Table 4: Worst-case short-term impact model scenario during routine testing

3.1.3 Maximum Boiler Impact (DCO and EP)

This is the worst-case possible scenario involving operation of the boilers in isolation. It is assumed that all boilers are operating simultaneously at full load. Whilst this scenario may not necessarily occur in practice, it does allow consideration of potential impacts of the various other short-term boiler operating scenarios where the loads are less than that assumed here. No other combustion plant, other than the boilers, are operational in this scenario.

3.1.4 On-site MEEG Maintenance Testing (DCO only)

Current estimates are that maintenance testing of the mobile generators in the MEEG will take place once a month where each item of emergency response equipment would be started up and run for no longer than 5 mins. Equipment stored in the off-site MEEG will be brought on-site for testing. The emergency response equipment testing will be carried out separately (i.e. each plant item will be operated separately) and will not coincide with any other testing of installed standby plant (EDGs, BBGs or DAGs).

There are 45 individual items of plant in the on-site and off-site MEEG with thermal input ratings ranging from 0.5-14.5 MW_{th}. Assuming a 10-minute gap between tests, it is estimated that all

NOT PROTECTIVELY MARKED

NOT PROTECTIVELY MARKED

Model Parameters and Scenarios to be used in the Assessment of Emissions from Operational Combustion Plant	DCRM Reference No	
	206230-0000-AA40-RPT-0002	Issue date: 05/06/2017

MEEG generators could be tested in approximately 11 hours (or approximately 7.5 hours if a 5-minute gap between tests was attainable). Due to the number of different plant items and wide range of thermal input ratings, it has been assumed, as a worst-case assumption, that the largest plant item will be operational continuously throughout the year in the consideration of short-term impacts during this scenario.

It is assumed that the boilers will be operating at winter duty demand for both Units during the MEEG maintenance testing. The combustion plant and annual meteorological hours considered by this scenario are detailed in table 5.

SOURCE GROUP	NUMBER OF PLANT AND LOAD	ANNUAL OPERATIONAL HOURS
MEEG Generators	Single generator at 14.5 MW _{th} input	Continuous throughout the year to allow consideration of worst-case meteorological conditions
Unit 1 and 2 DGs	Not operational	N/A
ASGs	Not operational	N/A
House boilers	2x 25 tph boilers at 95% MCR and 1 x 3tph boiler at 95% MCR (50,352 kg/h winter steam demand during routine operation of two Units)	Continuous throughout the year to allow consideration of worst-case meteorological conditions

Table 5: Worst-case short-term impact model scenario during MEEG maintenance testing

3.1.5 MEEG Emergency Exercise (DCO only)

Current estimates are that the equipment will need to be tested as part of an emergency exercise once per year and would involve moving the vehicles to their deployment locations on site and returning them after a period of around 6 hours. For testing purposes, the emergency response equipment will not be run constantly as they would for a real response but would only be used for a maximum of 1 hour within the 6 hour period. Not all emergency generating units will be deployed during the emergency exercise and the current estimate is that 31 of the 45 generating units will be tested simultaneously, equating to an aggregated total thermal input of 76.5 MW_{th}.

The generating units will be deployed in laydown areas adjacent to the Nuclear Islands of Unit 1 and 2. Due to the complexity of this scenario, including the number of plant and varying release characteristics, the modelled scenario assumes a single point source release occurs in each

NOT PROTECTIVELY MARKED

NOT PROTECTIVELY MARKED

Model Parameters and Scenarios to be used in the Assessment of Emissions from Operational Combustion Plant	DCRM Reference No	
	206230-0000-AA40-RPT-0002	Issue date: 05/06/2017

laydown area with release characteristics derived on the basis of 50% of the total aggregated thermal input of all plant involved in the exercise (i.e. 50% assigned to Unit 1 laydown area and 50% to Unit 2 laydown area).

As the exercise will only take place for 1-hour per year, it is not technically correct to compare impacts from this scenario against those short-term AQOs/EALs that are percentile based (e.g. the 1-hour mean NO₂ and SO₂ AQOs, PM₁₀ AQO etc) since these assessment metrics permit a certain number of exceedences of the AQO concentration before a breach of the AQO is considered to have occurred. By definition, it is impossible for this scenario to breach these AQOs due to the number of hours of operation being less than the number of hours of permitted exceedence.

However, as a worst-case basis, the 100th percentile prediction will be compared against the AQOs/EALs. It should be noted that this will represent a gross over-estimation of the potential impact.

The combustion plant and annual meteorological hours considered by this scenario are detailed in table 6.

SOURCE GROUP	NUMBER OF PLANT AND LOAD	ANNUAL OPERATIONAL HOURS
Unit 1 MEEG Generators	Single effective generator with a combined thermal input of 38.25 MW _{th}	Continuous throughout the year to allow consideration of worst-case meteorological conditions
Unit 2 MEEG Generators	Single effective generator with a combined thermal input of 38.25 MW _{th}	Continuous throughout the year to allow consideration of worst-case meteorological conditions
Unit 1 and 2 DGs	Not operational	N/A
ASGs	Not operational	N/A
House boilers	2x 25 tph boilers at 95% MCR and 1 x 3tph boiler at 95% MCR (50,352 kg/h winter steam demand during routine operation of two Units)	Continuous throughout the year to allow consideration of worst-case meteorological conditions

Table 6: Worst-case short-term impact model scenario during MEEG emergency exercise

NOT PROTECTIVELY MARKED

NOT PROTECTIVELY MARKED

Model Parameters and Scenarios to be used in the Assessment of Emissions from Operational Combustion Plant	DCRM Reference No	
	206230-0000-AA40-RPT-0002	Issue date: 05/06/2017

3.1.6 LOOP/LOCA (DCO and EP)

In the event of a LOOP or LOCA, all EDGs and BBGs will start and connect to the system. When only a LOOP occurs, the EDGs and BBGs will not operate at MCR as full output from all units is greater than the load required to operate the essential safety equipment, however, for the purposes of the modelling to support this permit application it was assumed that they operate at MCR.

In the event of a LOOP or LOCA, both the ASGs will be started and it is assumed for modelling that the ASGs will run for the duration of the LOOP at MCR. In practice one ASG may be shut off once it is operating in a stable manner and all required loads have been connected..

To enable assessment of maximum potential 1-hour mean impacts, the assumption will be that all EDGs, BBGs and ASGs are operational throughout the year so that worst-case meteorological conditions can be considered.

The combustion plant and annual meteorological hours considered by this scenario are detailed in table 7.

SOURCE GROUP	NUMBER OF PLANT AND LOAD	ANNUAL OPERATIONAL HOURS
Unit 1 DGs	3x EDGs at 100% MCR and 2x BBGs at 100% MCR	Continuous throughout the year to allow consideration of worst-case meteorological conditions
Unit 2 DGs	3x EDGs at 100% MCR and 2x BBGs at 100% MCR	Continuous throughout the year to allow consideration of worst-case meteorological conditions
House boilers	2x 25 tph boilers at 95% MCR and 1 x 3tph boiler at 95% MCR (50,352 kg/h winter steam demand during routine operation of two Units)	Continuous throughout the year to allow consideration of worst-case meteorological conditions
ASGs	2x ASGs at 100% MCR	Continuous throughout the year to allow consideration of worst-case meteorological conditions
MEEG generators	Not operational	N/A

NOT PROTECTIVELY MARKED

Model Parameters and Scenarios to be used in the Assessment of Emissions from Operational Combustion Plant	DCRM Reference No	
	206230-0000-AA40-RPT-0002	Issue date: 05/06/2017

Table 7: Worst-case short-term impact model scenario during LOOP/LOCA

3.1.7 Long-term Impact Scenario (DCO and EP)

For the purposes of assessing long-term (i.e. annual mean) air quality impacts, a single scenario has been developed which considers the maximum potential combined annual mean impact of emissions from the house boilers and standby combustion plant associated with both reactors. This scenario considers:

- Unit 1 EDGs, BBGs and DAG undergoing routine testing throughout the year;
- Unit 2 EDGs, BBGs and DAG in commissioning phase for one month of the year with 11 months of routine testing;
- ASGs undergoing routine testing throughout the year;
- MEEG generators undergoing routine testing throughout the year with a single emergency exercise (DCO only); and
- House boilers operating at routine summer demand for ~7 months of the year and routine winter demand for ~4 months of the year (demand based on two UK ABWR Units in operation).
- House boilers operating at winter outage with HCW operation for 26 days of the year (effectively accounts for two outages in one calendar year).

In order to estimate the long-term contribution from routine testing of the MEEG generators (DCO only), the modelled scenario assumes a single point source release with a thermal input based on the thermal input weighted average of all mobile plant stored in the MEEG (~2.6 MW_{th}). This is derived by:

$$\bar{T} = \frac{1}{N} \sum_{i=1}^N T_i \cdot n_i$$

Where:

$\bar{T}$ = thermal input weighted average of all mobile plant

N = total number of all plant in the on-site and off-site MEEG

T_i = thermal input for the i th plant type

n_i = number plants in the i th plant type

As per Section 3.1.4, assuming a 10-minute gap between tests, it is estimated that all MEEG generators could be tested in approximately 11 hours each month. This has been used as the basis for calculating the annual operational hours for this source group.

NOT PROTECTIVELY MARKED

Model Parameters and Scenarios to be used in the Assessment of Emissions from Operational Combustion Plant	DCRM Reference No	
	206230-0000-AA40-RPT-0002	Issue date: 05/06/2017

With regard to the emergency exercise involving the MEEG mobile generators (DCO only), this is modelled as per Section 3.1.5 with the inclusion of NO_x, SO₂ and PM₁₀/PM_{2.5} emissions and with 1-hour of operation per year only¹.

The source groups and annual operational hours considered by this scenario are detailed in table 8.

SOURCE GROUP	NUMBER OF PLANT AND LOAD	ANNUAL OPERATIONAL HOURS
Unit 1 DGs	3x EDGs and 2x BBGs (100% MCR)	58 hours per engine (12x4 hour monthly tests, 1x10 hour 18 monthly test)
Unit 2 DGs	3x EDGs and 2x BBGs (100% MCR)	126 hours per engine (72 hours for SAT commissioning followed by 11x 4 hour monthly tests and 1x 10 hour 18 monthly test)
House boilers (routine summer demand)	1x 3 tph boiler at 33% MCR (982 kg/h steam demand)	5,112 hours
House boilers (winter demand)	2x 25 tph boilers at 95% MCR and 1 x 3tph boiler at 95% MCR (50,352 kg/h steam demand)	3,024 hours
House boilers (winter outage with HCW operation)	3x 25 tph boilers at 93% MCR (69,566 kg/h steam demand)	624 hours
ASGs	2x ASGs (at 100% MCR)	58 hours per engine (12x4 hour monthly tests, 1x10 hour 18 monthly test)
MEEG generators (testing) (DCO only)	1x generator with an effective thermal input of 2.6 MW _{th}	135 hours (12 months of testing with 11.25 hours of testing per month)

¹ Arguably, such a short release duration would not normally need to be assessed for long-term impacts. However, due to the large emission rate from a relatively short stack, there is the potential that this scenario may account a disproportionately large (compared to duration alone) contribution to annual mean impacts

NOT PROTECTIVELY MARKED

Model Parameters and Scenarios to be used in the Assessment of Emissions from Operational Combustion Plant	DCRM Reference No	
	206230-0000-AA40-RPT-0002	Issue date: 05/06/2017

SOURCE GROUP	NUMBER OF PLANT AND LOAD	ANNUAL OPERATIONAL HOURS
MEEG generators (emergency exercise) (DCO only)	2x generators with an effective thermal input of 38.25 MW _{th} each	1 hour (single emergency exercise per year with mobile generators operational for 1 hour of this exercise only)

Table 8: Worst-case long-term impact model scenario

The long-term model is run with all sources emitting continuously throughout the year with individual contributions from those source groups defined above modelled. NRW's *Air emissions risk assessment for your environmental permit* [RD6] provides the following guidance for emission sources that are not continuous throughout the year:

“Adjust your figures down, based on the percentage of the year that your site isn’t operating. For example, a site that only operates January to June should reduce its PC figures by 50%. This only applies to annual average calculations and not short term assessments.”

Based on this guidance, the following algorithm is then used to calculate the installation-wide annual mean process contribution (PC) from individual source group contributions, taking into account the respective annual operational hours of each source group:

$$PC_{Ann} = \frac{1}{T} \sum_{i=1}^N PC_i \cdot t_i$$

Where:

PC_{Ann} = annual mean installation wide process contribution

PC_i = raw modelled long-term process contribution for the i th source group

t_i = annual operational hours for the i th source group

T = total number of hours in the year

N = number of source groups

4 Process Emissions

Process and emission parameters for each scenario, including their derivation, are provided in appendix A. Emission concentrations have been obtained from data supplied by vendors or the relevant emission benchmarks within Combustion Sector Guidance Note EPR 1.01 [RD1], Directive 2010/75/EU [RD2], the Large Combustion Plant BAT Reference (BREF) document [RD3] or Directive (EU) 2015/2193 [RD4].

NOT PROTECTIVELY MARKED

Model Parameters and Scenarios to be used in the Assessment of Emissions from Operational Combustion Plant	DCRM Reference No	
	206230-0000-AA40-RPT-0002	Issue date: 05/06/2017

Although EPR 1.01 does specify HCl benchmarks for liquid fuelled boilers, this only applies to large boilers which are individually greater than 50 MWth. Such boilers are more likely to be involved in combustion of heavier distillates (such as at refineries) which are likely to have higher fuel bound chlorine content.

The benchmark does not apply to compression ignition (CI) engines or turbines which typically combust lighter diesels where the fuel bound chlorine content is negligible (<5 ppm). As a result, HCl emissions are not considered in this assessment.

In the absence of size distribution data of the particulate matter emissions, it is assumed that all particulate matter is emitted in both the PM₁₀ and PM_{2.5} fractions.

The assumed emission concentrations for the different combustion plant are provided in tables 9 through 12.

POLLUTANT	EMISSION CONCENTRATION (mg Nm ⁻³)	REFERENCE CONDITIONS
NO _x (as NO ₂)	1,900	273K, 101.3kPa, 15% O ₂ , dry gas
SO ₂	0.5	273K, 101.3kPa, 15% O ₂ , dry gas
CO	150	273K, 101.3kPa, 15% O ₂ , dry gas
PM	65	273K, 101.3kPa, 15% O ₂ , dry gas

Table 9: Assumed Emission Concentrations for EDGs, BBGs and MEEG Generators

POLLUTANT	EMISSION CONCENTRATION (mg Nm ⁻³)	REFERENCE CONDITIONS
NO _x (as NO ₂)	1,600	273K, 101.3kPa, 15% O ₂ , dry gas
SO ₂	0.5	273K, 101.3kPa, 15% O ₂ , dry gas
CO	150	273K, 101.3kPa, 15% O ₂ , dry gas
PM	55	273K, 101.3kPa, 15% O ₂ , dry gas

Table 10: Assumed Emission Concentrations for ASGs

NOT PROTECTIVELY MARKED

NOT PROTECTIVELY MARKED

Model Parameters and Scenarios to be used in the Assessment of Emissions from Operational Combustion Plant	DCRM Reference No	
	206230-0000-AA40-RPT-0002	Issue date: 05/06/2017

POLLUTANT	EMISSION CONCENTRATION (mg Nm ⁻³)	REFERENCE CONDITIONS
NO _x (as NO ₂)	200	273K, 101.3kPa, 3% O ₂ , dry gas
SO ₂	1.6	273K, 101.3kPa, 3% O ₂ , dry gas
CO	30	273K, 101.3kPa, 3% O ₂ , dry gas
PM	10	273K, 101.3kPa, 3% O ₂ , dry gas

Table 11: Assumed Emission Concentrations for 25 tph House Boilers

POLLUTANT	EMISSION CONCENTRATION (mg Nm ⁻³)	REFERENCE CONDITIONS
NO _x (as NO ₂)	200	273K, 101.3kPa, 3% O ₂ , dry gas
SO ₂	1.6	273K, 101.3kPa, 3% O ₂ , dry gas
CO	150	273K, 101.3kPa, 3% O ₂ , dry gas
PM	15	273K, 101.3kPa, 3% O ₂ , dry gas

Table 12: Assumed Emission Concentrations for 3 tph House Boilers

5 References

REF. NO.	DOCUMENT NUMBER	TITLE
[RD1]		Natural Resources Wales (2014). 'Additional Guidance for Combustion Activities'. EPR 1.01
[RD2]		Directive 2010/75/EU of the European Parliament and of The Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) (Recast)
[RD3]		European IPPC Bureau (2017) 'Best Available Techniques (BAT) Reference Document for Large Combustion Plants'

NOT PROTECTIVELY MARKED

NOT PROTECTIVELY MARKED

Model Parameters and Scenarios to be used in the Assessment of Emissions from Operational Combustion Plant	DCRM Reference No	
	206230-0000-AA40-RPT-0002	Issue date: 05/06/2017

REF. NO.	DOCUMENT NUMBER	TITLE
[RD4]		Directive (EU) 2015/2193 of the European Parliament and the Council of 25 November 2015 on the limitation of emissions of certain pollutants into the air from medium combustion plants
[RD5]		Air emissions risk assessment for your environmental permit (https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit)

Table 13: References

NOT PROTECTIVELY MARKED

NOT PROTECTIVELY MARKED

Model Parameters and Scenarios to be used in the Assessment of Emissions from Operational Combustion Plant	DCRM Reference No	
	206230-0000-AA40-RPT-0002	Issue date: 05/06/2017

APPENDIX A

MODEL PROCESS AND EMISSIONS DATA

NOT PROTECTIVELY MARKED

Wylfa Newydd - Combustion Plant Summary Input Data for EP Assessment

Scenario: Long-term impacts (short-term impacts not reported in this scenario)

Input Parameters	
Unit 1 EDGs (Routine Testing)	
Number in operation	3
%MCR	100 %
Operational hours per engine	58 hr/yr
Stack diameter	1.25 m
Discharge temperature	375 °C
Exhaust gas volumetric flow at actual conditions	41.36 Am ³ /s
Exhaust gas volumetric flow at reference conditions	20.31 Nm ³ /s
Discharge velocity	33.7 m/s
Emission concentration at reference conditions (273K, 101.3kPa, 15% O₂, dry gas)	
NO _x	1,900 mg/Nm ³
SO ₂	0.5 mg/Nm ³
CO	150 mg/Nm ³
PM	65 mg/Nm ³
Emission rates (per engine)	
NO _x	38.60 g/s
SO ₂	0.01 g/s
CO	3.05 g/s
PM	1.32 g/s
Unit 2 EDGs (Commissioning)	
Number in operation	3
%MCR	100 %
Operational hours per engine	126 hr/yr
Stack diameter	1.25 m
Discharge temperature	375 °C
Exhaust gas volumetric flow at actual conditions	41.36 Am ³ /s
Exhaust gas volumetric flow at reference conditions	20.31 Nm ³ /s
Discharge velocity	33.7 m/s
Emission concentration at reference conditions (273K, 101.3kPa, 15% O₂, dry gas)	
NO _x	1,900 mg/Nm ³
SO ₂	0.5 mg/Nm ³
CO	150 mg/Nm ³
PM	65 mg/Nm ³
Emission rates (per engine)	
NO _x	38.60 g/s
SO ₂	0.01 g/s
CO	3.05 g/s
PM	1.32 g/s
Unit 1 BBGs (Routine Testing)	
Number in operation	2
%MCR	100 %
Operational hours per engine	58 hr/yr
Stack diameter	0.85 m
Discharge temperature	375 °C
Exhaust gas volumetric flow at actual conditions	19.28 Am ³ /s
Exhaust gas volumetric flow at reference conditions	9.47 Nm ³ /s
Discharge velocity	34.0 m/s
Emission concentration at reference conditions (273K, 101.3kPa, 15% O₂, dry gas)	
NO _x	1,900 mg/Nm ³
SO ₂	0.5 mg/Nm ³
CO	150 mg/Nm ³
PM	65 mg/Nm ³
Emission rates (per engine)	
NO _x	17.99 g/s
SO ₂	0.005 g/s
CO	1.42 g/s
PM	0.62 g/s
Unit 2 BBGs (Commissioning)	
Number in operation	2
%MCR	100 %
Operational hours per engine	126 hr/yr
Stack diameter	0.85 m
Discharge temperature	375 °C
Exhaust gas volumetric flow at actual conditions	19.28 Am ³ /s
Exhaust gas volumetric flow at reference conditions	9.47 Nm ³ /s
Discharge velocity	33.97 m/s
Emission concentration at reference conditions (273K, 101.3kPa, 15% O₂, dry gas)	
NO _x	1,900 mg/Nm ³
SO ₂	0.5 mg/Nm ³
CO	150 mg/Nm ³
PM	65 mg/Nm ³
Emission rates (per engine)	
NO _x	17.99 g/s

SO ₂	0.01 g/s
CO	1.42 g/s
PM	0.62 g/s
25 tph House Boilers (Summer Demand)	
Number in operation	0
%MCR	%
Operational hours per boiler	hr/yr
Stack diameter (N.B. per flue not per stack)	m
Discharge temperature	°C
Exhaust gas volumetric flow at actual conditions	Am ³ /s
Exhaust gas volumetric flow at reference conditions	Nm ³ /s
Discharge velocity	m/s
Emission concentration at reference conditions (273K, 101.3kPa, 3% O₂, dry gas)	
NO _x	mg/Nm ³
SO ₂	mg/Nm ³
CO	mg/Nm ³
PM	mg/Nm ³
Emission Rate (per boiler)	
NO _x	g/s
SO ₂	g/s
CO	g/s
PM	g/s
25 tph House Boilers (Winter Demand)	
Number in operation	2
%MCR	95 %
Operational hours per boiler	3024 hr/yr
Stack diameter (N.B. per flue not per stack)	0.70 m
Discharge temperature	170 °C
Exhaust gas volumetric flow at actual conditions	7.82 Am ³ /s
Exhaust gas volumetric flow at reference conditions	4.27 Nm ³ /s
Discharge velocity	20.3 m/s
Emission concentration at reference conditions (273K, 101.3kPa, 3% O₂, dry gas)	
NO _x	200 mg/Nm ³
SO ₂	1.6 mg/Nm ³
CO	30 mg/Nm ³
PM	10 mg/Nm ³
Emission Rate (per boiler)	
NO _x	0.85 g/s
SO ₂	0.007 g/s
CO	0.13 g/s
PM	0.04 g/s
25 tph House Boilers (Winter HCW Operation)	
Number in operation	3
%MCR	92.8 %
Operational hours per boiler	624 hr/yr
Stack diameter (N.B. per flue not per stack)	0.70 m
Discharge temperature	170 °C
Exhaust gas volumetric flow at actual conditions	7.64 Am ³ /s
Exhaust gas volumetric flow at reference conditions	4.17 Nm ³ /s
Discharge velocity	19.8 m/s
Emission concentration at reference conditions (273K, 101.3kPa, 3% O₂, dry gas)	
NO _x	200 mg/Nm ³
SO ₂	1.6 mg/Nm ³
CO	30 mg/Nm ³
PM	10 mg/Nm ³
Emission Rate (per boiler)	
NO _x	0.83 g/s
SO ₂	0.01 g/s
CO	0.12 g/s
PM	0.04 g/s
3 tph House Boilers (Summer Demand)	
Number in operation	1
%MCR	32.7 %
Operational hours per boiler	5112 hr/yr
Stack diameter (N.B. per flue not per stack)	0.25 m
Discharge temperature	170 °C
Exhaust gas volumetric flow at actual conditions	0.33 Am ³ /s
Exhaust gas volumetric flow at reference conditions	0.18 Nm ³ /s
Discharge velocity	6.8 m/s
Emission concentration at reference conditions (273K, 101.3kPa, 3% O₂, dry gas)	
NO _x	200 mg/Nm ³
SO ₂	1.6 mg/Nm ³
CO	150 mg/Nm ³
PM	15 mg/Nm ³
Emission Rate (per boiler)	
NO _x	0.04 g/s
SO ₂	0.0003 g/s
CO	0.03 g/s
PM	0.003 g/s
3 tph House Boilers (Winter Demand)	
Number in operation	1
%MCR	95 %
Operational hours per boiler	3024 hr/yr
Stack diameter (N.B. per flue not per stack)	0.25 m
Discharge temperature	170 °C

Exhaust gas volumetric flow at actual conditions	0.96 Am ³ /s
Exhaust gas volumetric flow at reference conditions	0.53 Nm ³ /s
Discharge velocity	20 m/s
Emission concentration at reference conditions (273K, 101.3kPa, 3% O₂, dry gas)	
NO _x	200 mg/Nm ³
SO ₂	1.6 mg/Nm ³
CO	150 mg/Nm ³
PM	15 mg/Nm ³
Emission Rate (per boiler)	
NO _x	0.11 g/s
SO ₂	0.001 g/s
CO	0.08 g/s
PM	0.01 g/s
ASGs Testing	
Number in operation	2
%MCR	100 %
Operational hours	58 hr/yr
Stack diameter	0.75 m
Discharge temperature	375 °C
Exhaust gas volumetric flow at actual conditions	14.37 Am ³ /s
Exhaust gas volumetric flow at reference conditions	7.06 Nm ³ /s
Discharge velocity	32.5 m/s
Emission concentration at reference conditions (273K, 101.3kPa, 15% O₂, dry gas)	
NO _x	1,600 mg/Nm ³
SO ₂	0.5 mg/Nm ³
CO	150 mg/Nm ³
PM	55 mg/Nm ³
Emission rates (per engine)	
NO _x	11.29 g/s
SO ₂	0.004 g/s
CO	1.06 g/s
PM	0.39 g/s

Wylfa Newydd - Combustion Plant Summary Input Data for EP Assessment

Scenario: Commissioning A (15-minute and hourly mean impacts only)

Input Parameters	
Unit 1 or 2 EDGs (Commissioning)	
Number in operation	3
%MCR	100 %
Operational hours per engine	Continuous
Stack diameter	1.25 m
Discharge temperature	375 °C
Exhaust gas volumetric flow at actual conditions	41.36 Am ³ /s
Exhaust gas volumetric flow at reference conditions	20.31 Nm ³ /s
Discharge velocity	33.7 m/s
Emission concentration at reference conditions (273K, 101.3kPa, 15% O₂, dry gas)	
NO _x	1,900 mg/Nm ³
SO ₂	0.5 mg/Nm ³
CO	150 mg/Nm ³
PM	65 mg/Nm ³
Emission rates (per engine)	
NO _x	38.60 g/s
SO ₂	0.01 g/s
CO	3.05 g/s
PM	1.32 g/s
Unit 1 or 2 BBGs (Commissioning)	
Number in operation	2
%MCR	30 %
Operational hours per engine	Continuous
Stack diameter	0.85 m
Discharge temperature	375 °C
Exhaust gas volumetric flow at actual conditions	5.78 Am ³ /s
Exhaust gas volumetric flow at reference conditions	2.84 Nm ³ /s
Discharge velocity	10.2 m/s
Emission concentration at reference conditions (273K, 101.3kPa, 15% O₂, dry gas)	
NO _x	1,900 mg/Nm ³
SO ₂	0.5 mg/Nm ³
CO	150 mg/Nm ³
PM	65 mg/Nm ³
Emission rates (per engine)	
NO _x	5.40 g/s
SO ₂	0.002 g/s
CO	0.43 g/s
PM	0.18 g/s
25 tph House Boilers	
Number in operation	3
%MCR	80 %
Operational hours per boiler	Continuous
Stack diameter (N.B. per flue not per stack)	0.70 m
Discharge temperature	170 °C
Exhaust gas volumetric flow at actual conditions	6.59 Am ³ /s
Exhaust gas volumetric flow at reference conditions	3.59 Nm ³ /s
Discharge velocity	17.1 m/s
Emission concentration at reference conditions (273K, 101.3kPa, 3% O₂, dry gas)	
NO _x	200 mg/Nm ³
SO ₂	1.6 mg/Nm ³
CO	30 mg/Nm ³
PM	10 mg/Nm ³
Emission Rate (per boiler)	
NO _x	0.72 g/s
SO ₂	0.01 g/s
CO	0.11 g/s
PM	0.04 g/s

Wylfa Newydd - Combustion Plant Summary Input Data for EP Assessment

Scenario: Commissioning B (8-hourly and daily impacts only)

Input Parameters	
<i>Unit 1 or 2 EDGs (Commissioning)</i>	
Number in operation	2
%MCR	100 %
Operational hours per engine	Continuous
Stack diameter	1.25 m
Discharge temperature	375 °C
Exhaust gas volumetric flow at actual conditions	41.36 Am ³ /s
Exhaust gas volumetric flow at reference conditions	20.31 Nm ³ /s
Discharge velocity	33.7 m/s
<i>Emission concentration at reference conditions (273K, 101.3kPa, 15% O₂, dry gas)</i>	
NO _x	1,900 mg/Nm ³
SO ₂	0.5 mg/Nm ³
CO	150 mg/Nm ³
PM	65 mg/Nm ³
<i>Emission rates (per engine)</i>	
NO _x	38.60 g/s
SO ₂	0.01 g/s
CO	3.05 g/s
PM	1.32 g/s
<i>25 tph House Boilers</i>	
Number in operation	3
%MCR	80 %
Operational hours per boiler	Continuous
Stack diameter (N.B. per flue not per stack)	0.70 m
Discharge temperature	170 °C
Exhaust gas volumetric flow at actual conditions	6.59 Am ³ /s
Exhaust gas volumetric flow at reference conditions	3.59 Nm ³ /s
Discharge velocity	17.1 m/s
<i>Emission concentration at reference conditions (273K, 101.3kPa, 3% O₂, dry gas)</i>	
NO _x	200 mg/Nm ³
SO ₂	1.6 mg/Nm ³
CO	30 mg/Nm ³
PM	10 mg/Nm ³
<i>Emission Rate (per boiler)</i>	
NO _x	0.72 g/s
SO ₂	0.01 g/s
CO	0.11 g/s
PM	0.04 g/s

Wylfa Newydd - Combustion Plant Summary Input Data for EP Assessment

Scenario: Routine testing (short-term impacts only)

Input Parameters	
Unit 1 and 2 EDGs (Routine Testing)	
Number in operation	1
%MCR	100 %
Operational hours per engine	Continuous
Stack diameter	1.25 m
Discharge temperature	375 °C
Exhaust gas volumetric flow at actual conditions	41.36 Am ³ /s
Exhaust gas volumetric flow at reference conditions	20.31 Nm ³ /s
Discharge velocity	33.7 m/s
Emission concentration at reference conditions (273K, 101.3kPa, 15% O₂, dry gas)	
NOx	1,900 mg/Nm ³
SO ₂	0.5 mg/Nm ³
CO	150 mg/Nm ³
PM	65 mg/Nm ³
Emission rates (per engine)	
NOx	38.60 g/s
SO ₂	0.01 g/s
CO	3.05 g/s
PM	1.32 g/s
Unit 1 and 2 BBGs (Routine Testing)	
Number in operation	1
%MCR	100 %
Operational hours per engine	Continuous
Stack diameter	0.85 m
Discharge temperature	375 °C
Exhaust gas volumetric flow at actual conditions	19.28 Am ³ /s
Exhaust gas volumetric flow at reference conditions	9.47 Nm ³ /s
Discharge velocity	34.0 m/s
Emission concentration at reference conditions (273K, 101.3kPa, 15% O₂, dry gas)	
NOx	1,900 mg/Nm ³
SO ₂	0.5 mg/Nm ³
CO	150 mg/Nm ³
PM	65 mg/Nm ³
Emission rate (per engine)	
NOx	17.99 g/s
SO ₂	0.005 g/s
CO	1.42 g/s
PM	0.62 g/s
25 tph House Boilers	
Number in operation	4
%MCR	100 %
Operational hours per boiler	Continuous
Stack diameter (N.B. per flue not per stack)	0.70 m
Discharge temperature	170 °C
Exhaust gas volumetric flow at actual conditions	8.23 Am ³ /s
Exhaust gas volumetric flow at reference conditions	4.49 Nm ³ /s
Discharge velocity	21.4 m/s
Emission concentration at reference conditions (273K, 101.3kPa, 3% O₂, dry gas)	
NOx	200 mg/Nm ³
SO ₂	1.6 mg/Nm ³
CO	30 mg/Nm ³
PM	10 mg/Nm ³
Emission Rate (per boiler)	
NOx	0.90 g/s
SO ₂	0.01 g/s
CO	0.13 g/s
PM	0.04 g/s
3 tph House Boilers	
Number in operation	2
%MCR	100 %
Operational hours per boiler	Continuous
Stack diameter (N.B. per flue not per stack)	0.25 m
Discharge temperature	170 °C
Exhaust gas volumetric flow at actual conditions	1.01 Am ³ /s
Exhaust gas volumetric flow at reference conditions	0.55 Nm ³ /s
Discharge velocity	21 m/s
Emission concentration at reference conditions (273K, 101.3kPa, 3% O₂, dry gas)	
NOx	200 mg/Nm ³
SO ₂	1.6 mg/Nm ³
CO	150 mg/Nm ³
PM	15 mg/Nm ³
Emission Rate (per boiler)	
NOx	0.11 g/s
SO ₂	0.0009 g/s
CO	0.08 g/s

PM	0.008 g/s
ASGs Testing	
Number in operation	1
%MCR	100 %
Operational hours	Continuous
Stack diameter	0.75 m
Discharge temperature	375 °C
Exhaust gas volumetric flow at actual conditions	14.37 Am ³ /s
Exhaust gas volumetric flow at reference conditions	7.06 Nm ³ /s
Discharge velocity	32.5 m/s
Emission concentration at reference conditions (273K, 101.3kPa, 15% O₂, dry gas)	
NOx	1,600 mg/Nm ³
SO ₂	0.5 mg/Nm ³
CO	150 mg/Nm ³
PM	55 mg/Nm ³
Emission rates (per engine)	
NOx	11.29 g/s
SO ₂	0.004 g/s
CO	1.06 g/s
PM	0.39 g/s

Wylfa Newydd - Combustion Plant Summary Input Data for EP Assessment

Scenario: Boiler Maximum Impact (short-term impacts only)

Input Parameters	
25 tph Boilers	
Number in operation	4
%MCR	100 %
Operational hours per boiler	Continuous
Stack diameter (N.B. per flue not per stack)	0.70 m
Discharge temperature	170 °C
Exhaust gas volumetric flow at actual conditions	8.23 Am ³ /s
Exhaust gas volumetric flow at reference conditions	4.49 Nm ³ /s
Discharge velocity	21 m/s
Emission concentration at reference conditions (273K, 101.3kPa, 3% O₂, dry gas)	
NO _x	200 mg/Nm ³
SO ₂	1.6 mg/Nm ³
CO	30 mg/Nm ³
PM	10 mg/Nm ³
Emission Rate (per boiler)	
NO _x	0.90 g/s
SO ₂	0.01 g/s
CO	0.13 g/s
PM	0.04 g/s
3 tph Boilers	
Number in operation	2
%MCR	100 %
Operational hours per boiler	Continuous
Stack diameter (N.B. per flue not per stack)	0.25 m
Discharge temperature	170 °C
Exhaust gas volumetric flow at actual conditions	1.01 Am ³ /s
Exhaust gas volumetric flow at reference conditions	0.55 Nm ³ /s
Discharge velocity	21 m/s
Emission concentration at reference conditions (273K, 101.3kPa, 3% O₂, dry gas)	
NO _x	200 mg/Nm ³
SO ₂	1.6 mg/Nm ³
CO	150 mg/Nm ³
PM	15 mg/Nm ³
Emission Rate (per boiler)	
NO _x	0.11 g/s
SO ₂	0.001 g/s
CO	0.08 g/s
PM	0.01 g/s

Wylfa Newydd - Combustion Plant Summary Input Data for EP Assessment

Scenario: LOOP/LOCA (short-term impacts only)

Input Parameters	
Unit 1 EDGs	
Number in operation	3
%MCR	100
Operational hours per engine	Continuous
Stack diameter	1.25 m
Discharge temperature	375 °C
Exhaust gas volumetric flow at actual conditions	41.36 Am ³ /s
Exhaust gas volumetric flow at reference conditions	20.31 Nm ³ /s
Discharge velocity	33.7 m/s
Emission concentration at reference conditions (273K, 101.3kPa, 15% O₂, dry gas)	
NO _x	1,900 mg/Nm ³
SO ₂	0.5 mg/Nm ³
CO	150 mg/Nm ³
PM	65 mg/Nm ³
Emission rates (per engine)	
NO _x	38.60 g/s
SO ₂	0.01 g/s
CO	3.05 g/s
PM	1.32 g/s
Unit 2 EDGs	
Number in operation	3
%MCR	100
Operational hours per engine	Continuous
Stack diameter	1.25 m
Discharge temperature	375 °C
Exhaust gas volumetric flow at actual conditions	41.36 Am ³ /s
Exhaust gas volumetric flow at reference conditions	20.31 Nm ³ /s
Discharge velocity	33.7 m/s
Emission concentration at reference conditions (273K, 101.3kPa, 15% O₂, dry gas)	
NO _x	1,900 mg/Nm ³
SO ₂	0.5 mg/Nm ³
CO	150 mg/Nm ³
PM	65 mg/Nm ³
Emission rates (per engine)	
NO _x	38.60 g/s
SO ₂	0.01 g/s
CO	3.05 g/s
PM	1.32 g/s
Unit 1 BBGs	
Number in operation	2
%MCR	100
Operational hours per engine	Continuous
Stack diameter	0.85 m
Discharge temperature	375 °C
Exhaust gas volumetric flow at actual conditions	19.28 Am ³ /s
Exhaust gas volumetric flow at reference conditions	9.47 Nm ³ /s
Discharge velocity	34.0 m/s
Emission concentration at reference conditions (273K, 101.3kPa, 15% O₂, dry gas)	
NO _x	1,900 mg/Nm ³
SO ₂	0.5 mg/Nm ³
CO	150 mg/Nm ³
PM	65 mg/Nm ³
Emission rates (per engine)	
NO _x	17.99 g/s
SO ₂	0.01 g/s
CO	1.42 g/s
PM	0.62 g/s
Unit 2 BBGs	
Number in operation	2
%MCR	100
Operational hours per engine	Continuous
Stack diameter	0.85 m
Discharge temperature	375 °C
Exhaust gas volumetric flow at actual conditions	19.28 Am ³ /s
Exhaust gas volumetric flow at reference conditions	9.47 Nm ³ /s
Discharge velocity	33.97 m/s
Emission concentration at reference conditions (273K, 101.3kPa, 15% O₂, dry gas)	
NO _x	1,900 mg/Nm ³
SO ₂	0.5 mg/Nm ³
CO	150 mg/Nm ³
PM	65 mg/Nm ³
Emission rates (per engine)	
NO _x	17.99 g/s

SO ₂	0.01 g/s
CO	1.42 g/s
PM	0.62 g/s
25 tph House Boilers	
Number in operation	2
%MCR	95.0 %
Operational hours per boiler	Continuous
Stack diameter (N.B. per flue not per stack)	0.7 m
Discharge temperature	170 °C
Exhaust gas volumetric flow at actual conditions	7.82 Am ³ /s
Exhaust gas volumetric flow at reference conditions	4.27 Nm ³ /s
Discharge velocity	20.3 m/s
Emission concentration at reference conditions (273K, 101.3kPa, 3% O₂, dry gas)	
NO _x	200 mg/Nm ³
SO ₂	1.6 mg/Nm ³
CO	30 mg/Nm ³
PM	10 mg/Nm ³
Emission Rate (per boiler)	
NO _x	0.85 g/s
SO ₂	0.007 g/s
CO	0.13 g/s
PM	0.04 g/s
3 tph Boilers	
Number in operation	1
%MCR	95 %
Operational hours per boiler	Continuous
Stack diameter (N.B. per flue not per stack)	0.25 m
Discharge temperature	170 °C
Exhaust gas volumetric flow at actual conditions	0.96 Am ³ /s
Exhaust gas volumetric flow at reference conditions	0.53 Nm ³ /s
Discharge velocity	20 m/s
Emission concentration at reference conditions (273K, 101.3kPa, 3% O₂, dry gas)	
NO _x	200 mg/Nm ³
SO ₂	1.6 mg/Nm ³
CO	150 mg/Nm ³
PM	15 mg/Nm ³
Emission Rate (per boiler)	
NO _x	0.11 g/s
SO ₂	0.001 g/s
CO	0.08 g/s
PM	0.01 g/s
ASGs	
Number in operation	2
%MCR	100 %
Operational hours	Continuous
Stack diameter	0.75 m
Discharge temperature	375 °C
Exhaust gas volumetric flow at actual conditions	14.37 Am ³ /s
Exhaust gas volumetric flow at reference conditions	7.06 Nm ³ /s
Discharge velocity	32.5 m/s
Emission concentration at reference conditions (273K, 101.3kPa, 15% O₂, dry gas)	
NO _x	1,600 mg/Nm ³
SO ₂	0.5 mg/Nm ³
CO	150 mg/Nm ³
PM	55 mg/Nm ³
Emission rates (per engine)	
NO _x	11.29 g/s
SO ₂	0.004 g/s
CO	1.06 g/s
PM	0.39 g/s

Combustion Calculations for EDGs (Data at 100% MCR)*Input data in red cells***Engine Design Parameters**

Electrical Output	10,400 kW
Electrical Efficiency	44 %
Thermal Input	23,600 kW
Fuel Oil	100 %
Stack Discharge Diameter	1,250 mm
Net CV Fuel Oil (gas oil)	43.50 MJ/kg
Fuel Oil Required to Provide Energy Input	0.54 kg/s
Sulphur Content of Fuel	0.001% %

Source

WD03.03.02-S5-PDC-REP-00001
Calculated from thermal input and electrical output
WD03.03.02-S5-PDC-REP-00001
WD03.03.02-S5-PDC-REP-00001
Calculated to produce a typical efflux velocity of ~33 m/s
Typical CV for diesel
Calculated
WD03.03.02-S5-PDC-REP-00001

Exhaust Conditions

Actual O ₂	13 %	Typical value for CI engine
Actual Temperature	375 °C	WN008-S3-ELC-MEM-00002
Reference O ₂	15 %	As per EPR 1.01 for CI engines
Waste Gas from Fuel Oil (wet)	12.14 m ³ /kg	@273K, 101.3kPa, 0% O ₂ <i>Rose (1970) Combustion of Fuels</i>
Waste Gas from Fuel Oil (dry)	10.57 m ³ /kg	@273K, 101.3kPa, 0% O ₂ <i>Rose (1970) Combustion of Fuels</i>

Exhaust Gas Volumetric Flows

@ 0 C 0%O ₂ dry	5.73 m ³ /s
@ 0 C refO ₂ dry	20.31 m ³ /s
@ 0 C 0%O ₂ wet	6.59 m ³ /s
@ 0 C refO ₂ wet	23.33 m ³ /s
@ actual conditions	41.36 m ³ /s
Efflux Velocity	33.7 m/s

Emission Concentration at Reference Conditions (273K, 101.3kPa, 15% O₂, dry gas)

NOx	1,900 mg/Nm ³	WD03.03.02-S5-PDC-REP-00001
CO	150 mg/Nm ³	WD03.03.02-S5-PDC-REP-00001
SOx	0.5 mg/Nm ³	Calculated value based on sulphur content of fuel
Particulates	65 mg/Nm ³	WD03.03.02-S5-PDC-REP-00001

Mass Emission Rates

NOx	38.60 g/s
CO	3.05 g/s
SOx	0.01 g/s
Particulates	1.32 g/s

Combustion Calculations for BBGs (Data at 100% MCR)*Input data in red cells***Engine Design Parameters**

Electrical Output	4,800 kW
Electrical Efficiency	44 %
Thermal Input	11,000 kW
Fuel Oil	100 %
Stack Discharge Diameter	850 mm
Net CV Fuel Oil (gas oil)	43.50 MJ/kg
Fuel Oil Required to Provide Energy Input	0.25 kg/s
Sulphur Content of Fuel	0.001% %

Source

WD03.03.02-S5-PDC-REP-00001
Calculated from thermal input and electrical output
WD03.03.02-S5-PDC-REP-00001
WD03.03.02-S5-PDC-REP-00001
Calculated to produce a typical efflux velocity of ~33 m/s
Typical CV for diesel
Calculated
WD03.03.02-S5-PDC-REP-00001

Exhaust Conditions

Actual O ₂	13 %	Typical value for CI engine
Actual Temperature	375 °C	WN008-S3-ELC-MEM-00002
Reference O ₂	15 %	As per EPR 1.01 for CI engines
Waste Gas from Fuel Oil (wet)	12.14 m ³ /kg	@273K, 101.3kPa, 0% O ₂ <i>Rose (1970) Combustion of Fuels</i>
Waste Gas from Fuel Oil (dry)	10.57 m ³ /kg	@273K, 101.3kPa, 0% O ₂ <i>Rose (1970) Combustion of Fuels</i>

Exhaust Gas Volumetric Flows

@ 0 C 0%O ₂ dry	2.67 m ³ /s
@ 0 C refO ₂ dry	9.47 m ³ /s
@ 0 C 0%O ₂ wet	3.07 m ³ /s
@ 0 C refO ₂ wet	10.87 m ³ /s
@ actual conditions	19.28 m ³ /s
Efflux Velocity	34.0 m/s

Emission Concentration at Reference Conditions (273K, 101.3kPa, 15% O₂, dry gas)

NOx	1,900 mg/Nm ³	WD03.03.02-S5-PDC-REP-00001
CO	150 mg/Nm ³	WD03.03.02-S5-PDC-REP-00001
SOx	0.5 mg/Nm ³	Calculated value based on sulphur content of fuel
Particulates	65 mg/Nm ³	WD03.03.02-S5-PDC-REP-00001

Mass Emission Rates

NOx	17.99 g/s
CO	1.42 g/s
SOx	0.01 g/s
Particulates	0.62 g/s

Combustion Calculations for ASGs (Data at 100% MCR)*Input data in red cells***Engine Design Parameters**

Electrical Output	3,600 kW	Source
Electrical Efficiency	44 %	Horizon - TQ004
Thermal Input	8,200 kW	Calculated from thermal input and electrical output
Fuel Oil	100 %	Horizon - TQ004
Stack Discharge Diameter	750 mm	Assume same as EDGs, BBGs
Net CV Fuel Oil (gas oil)	43.50 MJ/kg	Calculated to produce a typical efflux velocity of ~33 m/s
Fuel Oil Required to Provide Energy Input	0.19 kg/s	Typical CV for diesel
Sulphur Content of Fuel	0.001% %	Calculated
		Assume same as EDGs, BBGs

Exhaust Conditions

Actual O ₂	13 %	Typical value for CI engine
Actual Temperature	375 °C	Assume same as EDGs, BBGs
Reference O ₂	15 %	As per EPR 1.01 for CI engines
Waste Gas from Fuel Oil (wet)	12.14 m ³ /kg	@273K, 101.3kPa, 0% O ₂ <i>Rose (1970) Combustion of Fuels</i>
Waste Gas from Fuel Oil (dry)	10.57 m ³ /kg	@273K, 101.3kPa, 0% O ₂ <i>Rose (1970) Combustion of Fuels</i>

Exhaust Gas Volumetric Flows

@ 0 C 0%O ₂ dry	1.99 m ³ /s
@ 0 C refO ₂ dry	7.06 m ³ /s
@ 0 C 0%O ₂ wet	2.29 m ³ /s
@ 0 C refO ₂ wet	8.11 m ³ /s
@ actual conditions	14.37 m ³ /s
Efflux Velocity	32.5 m/s

Emission Concentration at Reference Conditions (273K, 101.3kPa, 15% O₂, dry gas)

NOx	1,600 mg/Nm ³	Assume same as EDGs, BBGs
CO	150 mg/Nm ³	Assume same as EDGs, BBGs
SOx	0.5 mg/Nm ³	Calculated value based on sulphur content of fuel
Particulates	55 mg/Nm ³	Assume same as EDGs, BBGs

Mass Emission Rates

NOx	11.29 g/s
CO	1.06 g/s
SOx	0.004 g/s
Particulates	0.39 g/s

Combustion Calculations for MEEG Generators (LT Scenario Only)*Input data in red cells***Engine Design Parameters**

Electrical Output	---	kW	
Electrical Efficiency	---	%	
Thermal Input	2,577	kW	MPTQ_173_1 (thermal input weighted average)
Fuel Oil	100	%	Assume same as EDGs, BBGs
Stack Discharge Diameter	400	mm	Calculated to produce a typical efflux velocity of ~33 m/s
Net CV Fuel Oil (gas oil)	43.50	MJ/kg	Typical CV for diesel
Fuel Oil Required to Provide Energy Input	0.06	kg/s	Calculated
Sulphur Content of Fuel	0.001%	%	Assume same as EDGs, BBGs

Source**Exhaust Conditions**

Actual O ₂	13	%	Typical value for CI engine
Actual Temperature	375	°C	Assume same as EDGs, BBGs
Reference O ₂	15	%	As per EPR 1.01 for CI engines
Waste Gas from Fuel Oil (wet)	12.14	m ³ /kg	@273K, 101.3kPa, 0% O ₂ <i>Rose (1970) Combustion of Fuels</i>
Waste Gas from Fuel Oil (dry)	10.57	m ³ /kg	@273K, 101.3kPa, 0% O ₂ <i>Rose (1970) Combustion of Fuels</i>

Exhaust Gas Volumetric Flows

@ 0 C 0%O ₂ dry	0.63	m ³ /s
@ 0 C refO ₂ dry	2.22	m ³ /s
@ 0 C 0%O ₂ wet	0.72	m ³ /s
@ 0 C refO ₂ wet	2.55	m ³ /s
@ actual conditions	4.52	m ³ /s
Efflux Velocity	35.9	m/s

Emission Concentration at Reference Conditions (273K, 101.3kPa, 15% O₂, dry gas)

NOx	1,900	mg/Nm ³	Assume same as EDGs, BBGs
CO	150	mg/Nm ³	Assume same as EDGs, BBGs
SOx	0.5	mg/Nm ³	Calculated value based on sulphur content of fuel
Particulates	65	mg/Nm ³	Assume same as EDGs, BBGs

Mass Emission Rates

NOx	4.21	g/s
CO	0.33	g/s
SOx	0.001	g/s
Particulates	0.14	g/s

Combustion Calculations for House Boilers*Input data in red cells***Calculation of Boiler Thermal Input**

Max Steam Production Rate	25,000 kg/hr	Provided by MN
Efficiency	90 %	WN009-S3-ME-TEC-00002
Boiler Thermal Input	15,833 kW	Pro-rated from 30 tph boiler

Boiler Design Parameters

Thermal Input	15,833 kW	Pro-rated from 30 tph boiler
Fuel Oil	100 %	WN009-S3-ME-TEC-00002
Stack Discharge Diameter	700 mm	Calculated diameter required to achieve 21 m/s
Net CV Fuel Oil (gas oil)	43.5 MJ/kg	Typical value
Fuel Oil Required to Provide Energy Input	0.364 kg/s	
Sulphur Content of Fuel	0.001%	WN009-S3-ME-TEC-00002

Exhaust Conditions

Actual O ₂	2.7 %	Provided by MN
Actual Temperature	170 °C	Provided by Horizon
Reference O ₂	3 %	IED/LCP BREF
CO ₂ density	1.86 kg/m ³	
Fuel Oil Density	0.78 kg/m ³	
Exhaust Gas from Fuel Oil (wet)	12.14 m ³ /kg	@273K, 101.3kPa, 0% O ₂ <i>Rose (1970) Combustion of Fuels</i>
Exhaust Gas from Fuel Oil (dry)	10.57 m ³ /kg	@273K, 101.3kPa, 0% O ₂ <i>Rose (1970) Combustion of Fuels</i>

Exhaust Gas Volumetric Flows

@ 0 °C refO ₂ dry	4.49 Nm ³ /s
@ actual conditions	8.23 m ³ /s
Efflux Velocity	21 m/s

Emission Concentration at Reference Conditions (273K, 101.3kPa, 3% O₂, dry gas)

NO _x	200 mg/Nm ³	IED/LCP BREF
CO	30 mg/Nm ³	IED/LCP BREF
SO _x	1.6 mg/Nm ³	Calculated value based on sulphur content of fuel
Particulates	10 mg/Nm ³	IED/LCP BREF

Mass Emission Rates

NO _x	0.90 g/s
CO	0.13 g/s
SO _x	0.01 g/s
Particulates	0.04 g/s

Combustion Calculations for House Boilers*Input data in red cells***Calculation of Boiler Thermal Input**

Max Steam Production Rate	3,000 kg/hr	Data from MN
Efficiency	90 %	WN009-S3-ME-TEC-00002
Boiler Thermal Input	1,950 kW	Pro-rated from 2tph boiler

Boiler Design Parameters

Thermal Input	1,950 kW	Pro-rated from 2tph boiler
Fuel Oil	100 %	WN009-S3-ME-TEC-00002
Stack Discharge Diameter	250 mm	Calculated diameter required to achieve 21 m/s
Net CV Fuel Oil (gas oil)	43.5 MJ/kg	Typical value
Fuel Oil Required to Provide Energy Input	0.045 kg/s	
Sulphur Content of Fuel	0.001%	WN009-S3-ME-TEC-00002

Exhaust Conditions

Actual O ₂	2.7 %	Provided by Horizon
Actual Temperature	170 °C	Provided by Horizon
Reference O ₂	3 %	From MCPD
CO ₂ density	1.86 kg/m ³	
Fuel Oil Density	0.78 kg/m ³	
Exhaust Gas from Fuel Oil (wet)	12.14 m ³ /kg	@273K, 101.3kPa, 0% O ₂ <i>Rose (1970) Combustion of Fuels</i>
Exhaust Gas from Fuel Oil (dry)	10.57 m ³ /kg	@273K, 101.3kPa, 0% O ₂ <i>Rose (1970) Combustion of Fuels</i>

Exhaust Gas Volumetric Flows

@ 0 °C refO ₂ dry	0.55 Nm ³ /s
@ actual conditions	1.01 m ³ /s
Efflux Velocity	21 m/s

Emission Concentration at Reference Conditions (273K, 101.3kPa, 3% O₂, dry gas)

NO _x	200 mg/Nm ³	MCPD
CO	150 mg/Nm ³	EPR 1.01
SO _x	1.6 mg/Nm ³	Calculated value based on sulphur content of fuel
Particulates	15 mg/Nm ³	EPR 1.01

Mass Emission Rates

NO _x	0.11 g/s
CO	0.08 g/s
SO _x	0.001 g/s
Particulates	0.01 g/s



Appendix B

Wind roses

Figure B1 2007 wind rose

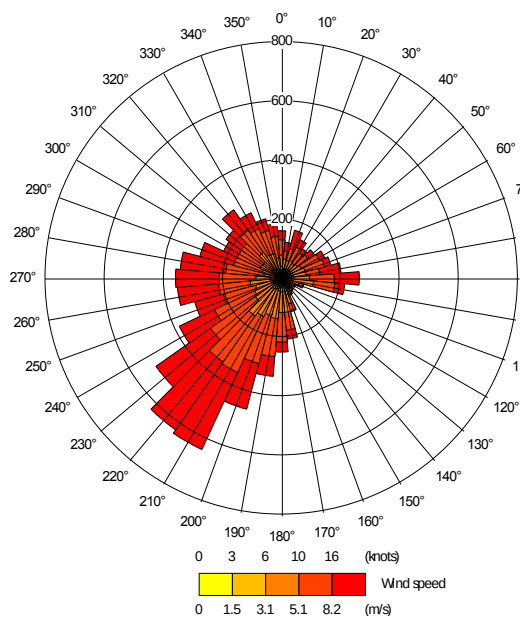


Figure B2 2008 wind rose

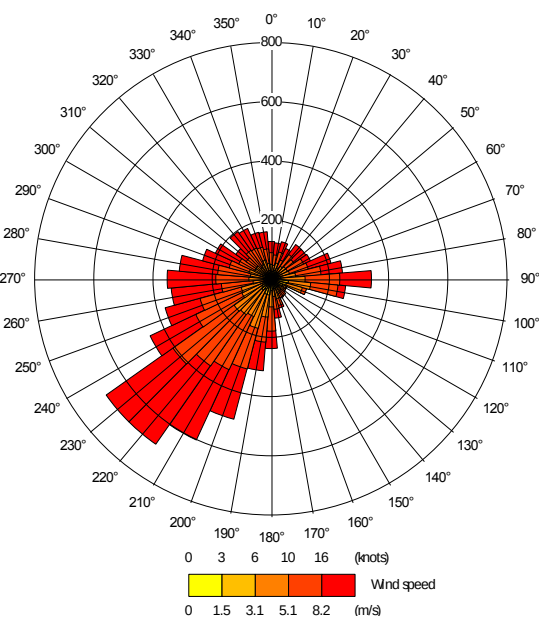


Figure B3 2009 wind rose

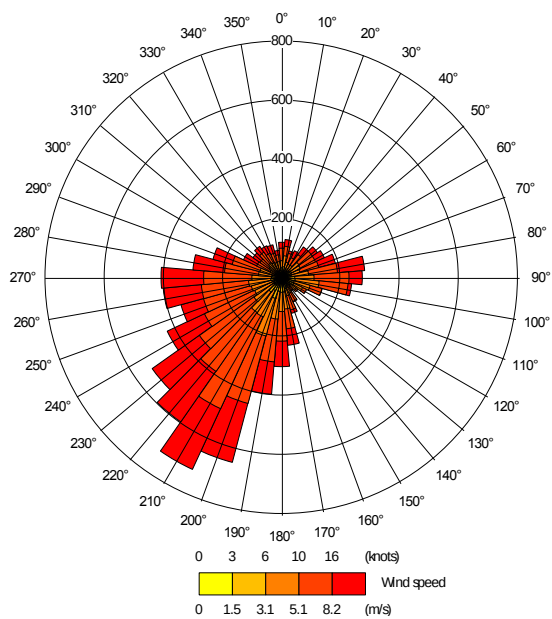


Figure B4 2010 wind rose

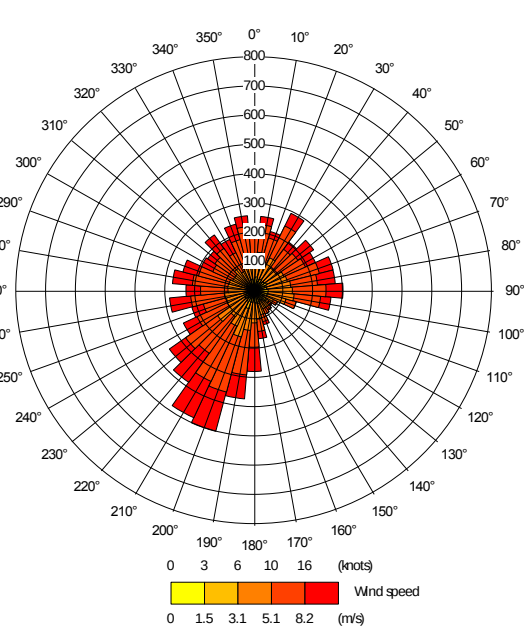


Figure B5 2011 wind rose

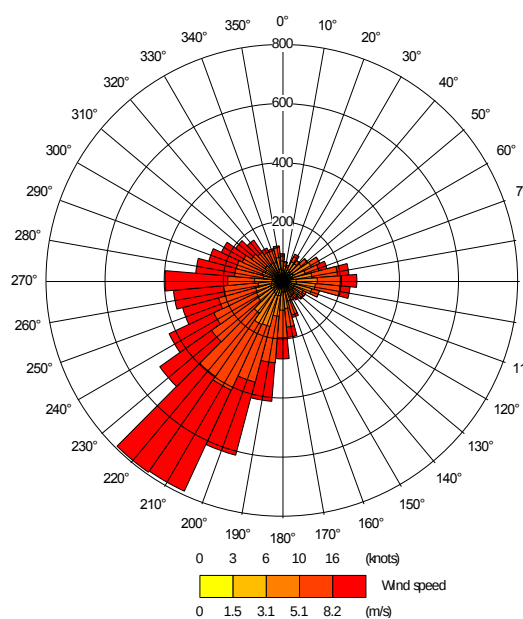


Figure B6 2012 wind rose

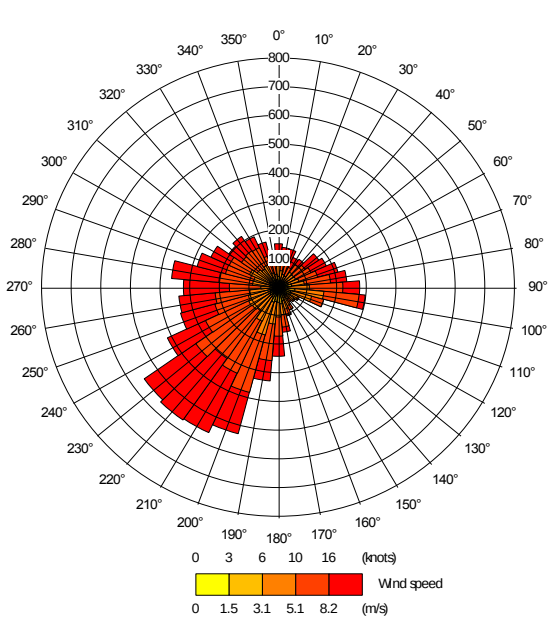


Figure B7 2013 wind rose

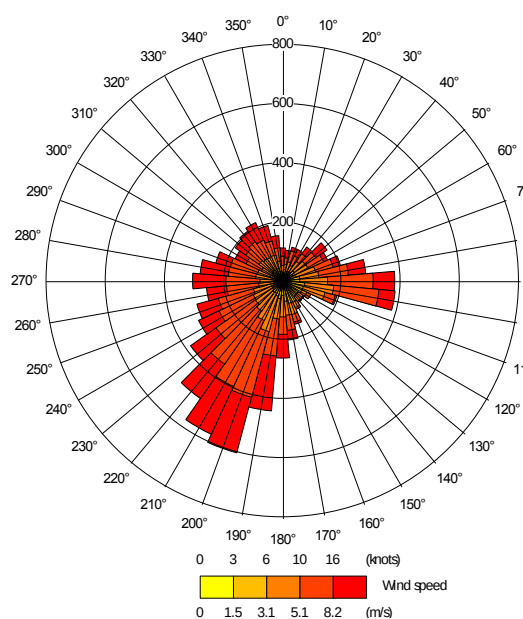


Figure B8 2014 wind rose

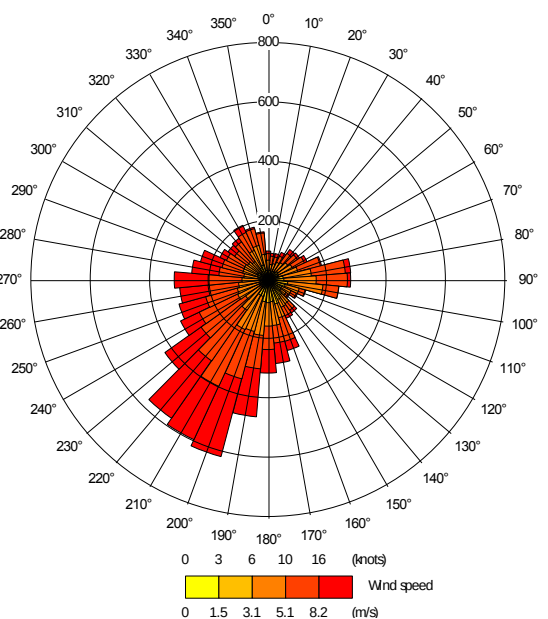


Figure B9 2015 wind rose

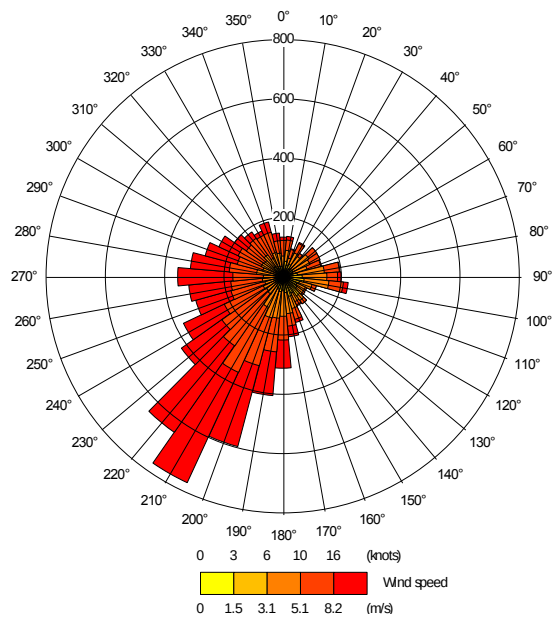
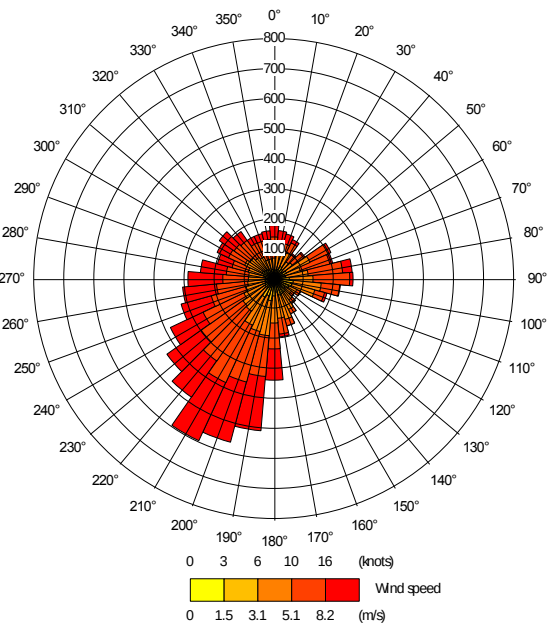
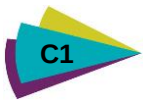


Figure B10 2016 wind rose





Appendix C

Receptor list (embedded Excel file)



[This appendix will not be shown in the hard copy and only available electronically due to the size of the appendix]



Appendix D

Model results (embedded Excel files)

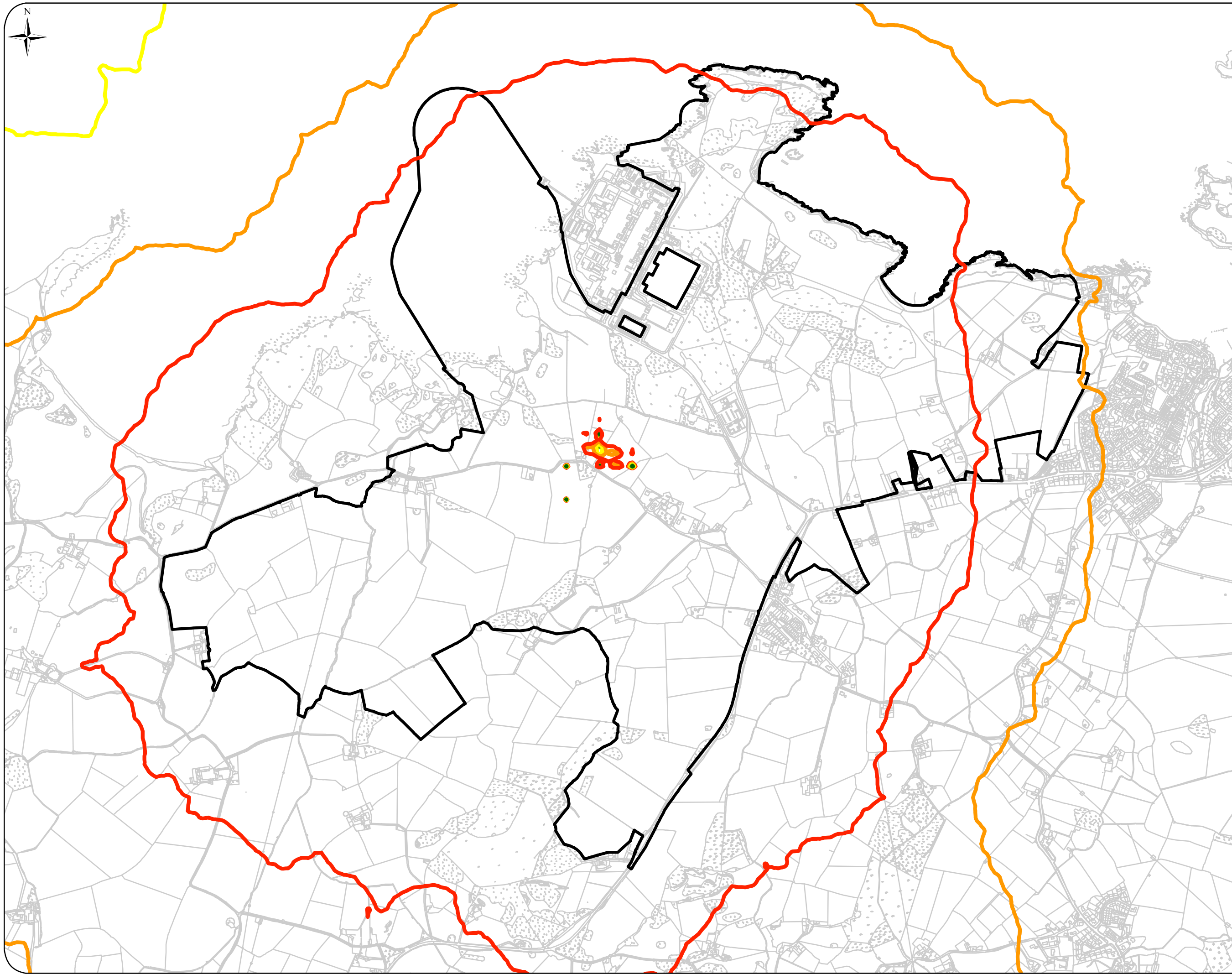


[This appendix will not be shown in the hard copy and only available electronically due to the size of the appendix]



Appendix E

Concentration isopleths



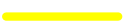
LEGEND

 Wylfa Newydd Development Area

One Hour Mean Process Contribution for NO₂ (µg/m³)

 20

 50

 100

 150

 200

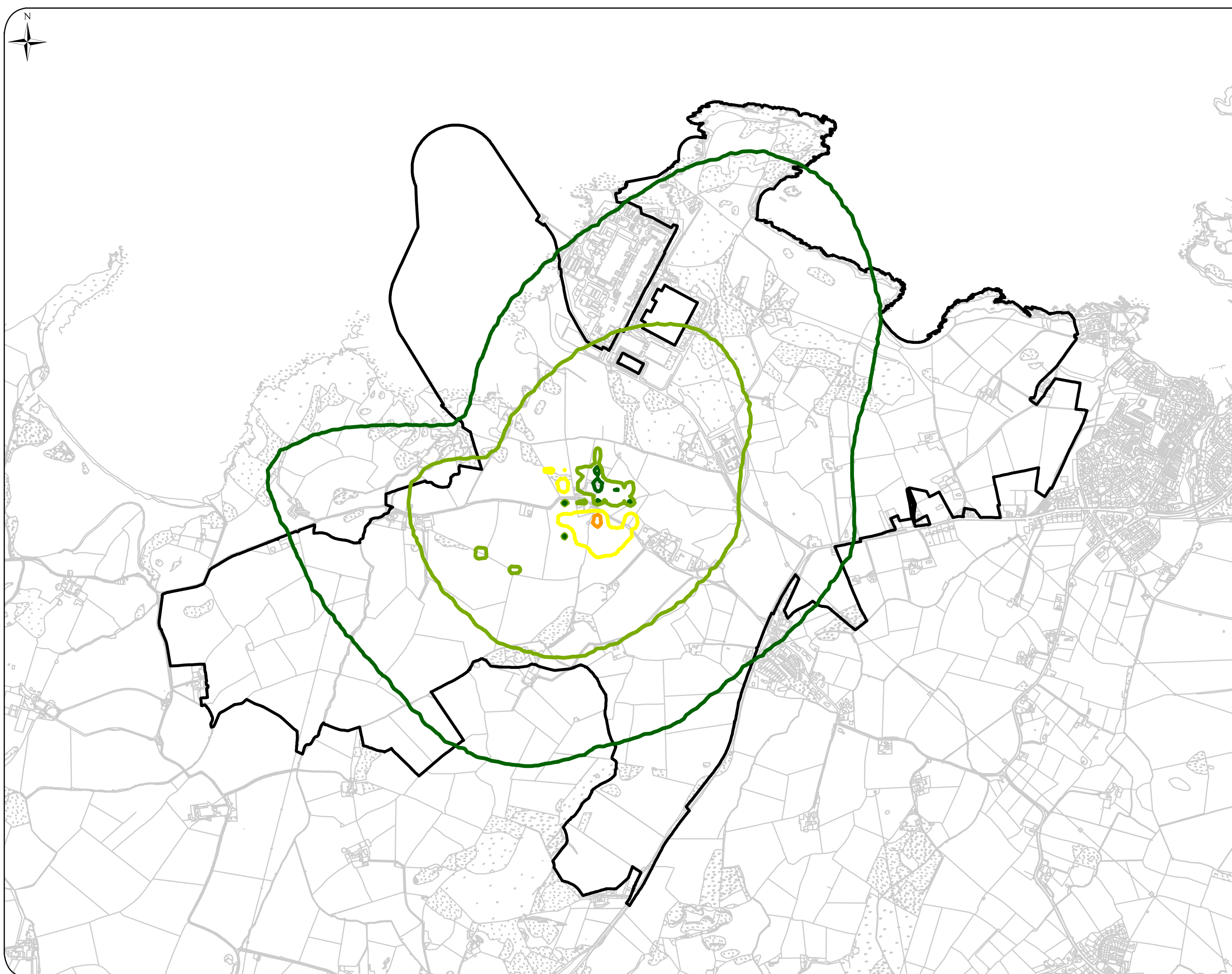
Loss of Off-Site Power (LOOP)
99.79 Percentile 1-hour Mean
NO₂ Process Contribution



Scale: 1:12,500
When printed at A3

0 150 300 450 M

HORIZON
NUCLEAR POWER



LEGEND

 Wylfa Newydd Development Area

Annual Mean Process Contribution for NO₂ (µg/m³)

Contour

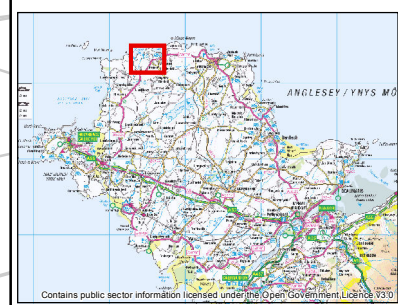
 0.4

 1

 5

 10

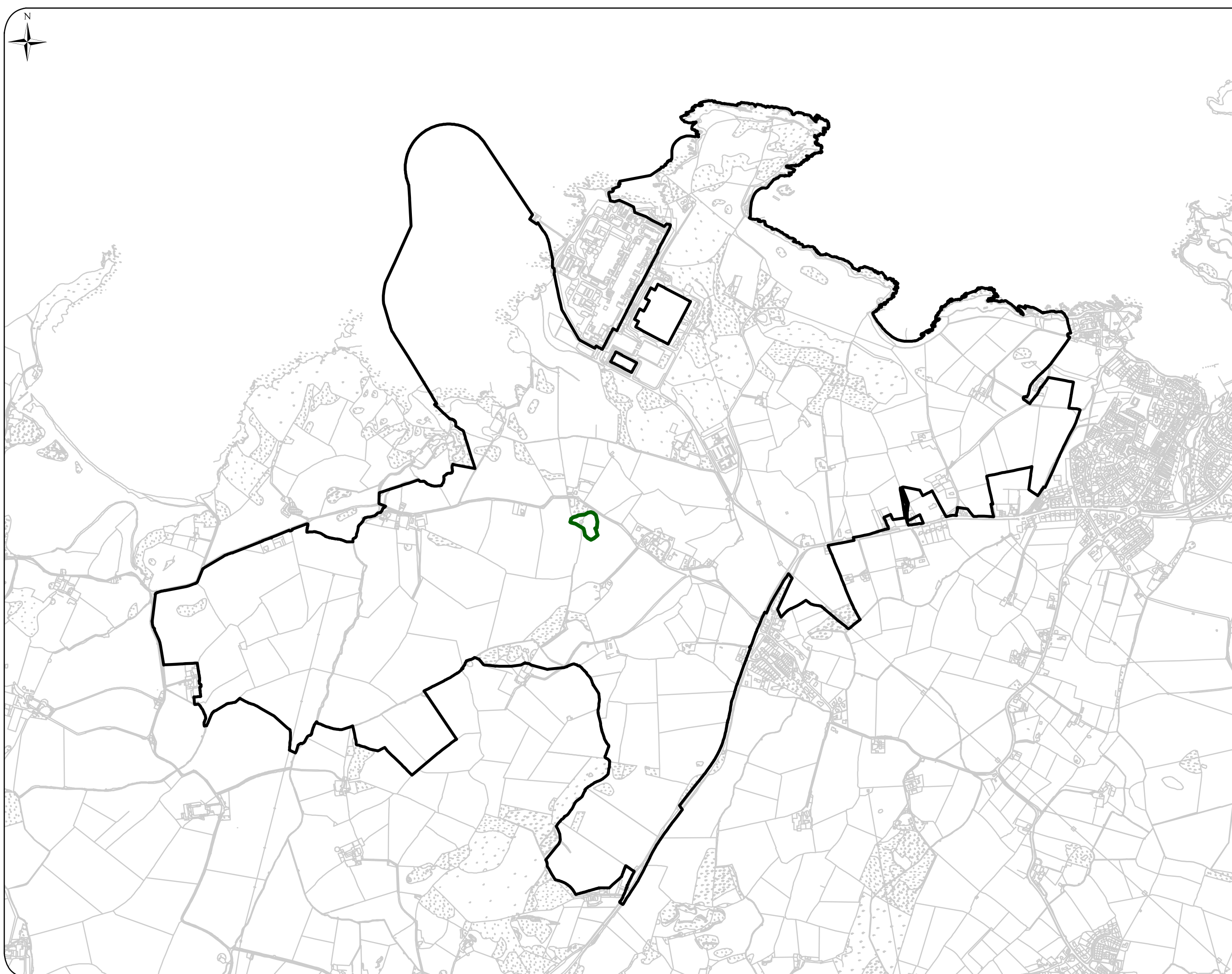
Operational Combustion Plant Annual Mean NO₂ Process Contribution



Scale: 1:12,500
When printed at A3

0 150 300 450 M





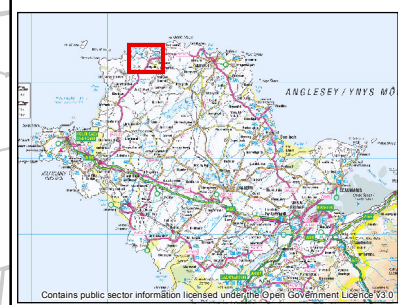
LEGEND

 Wylfa Newydd Development Area

Contour

 0.4

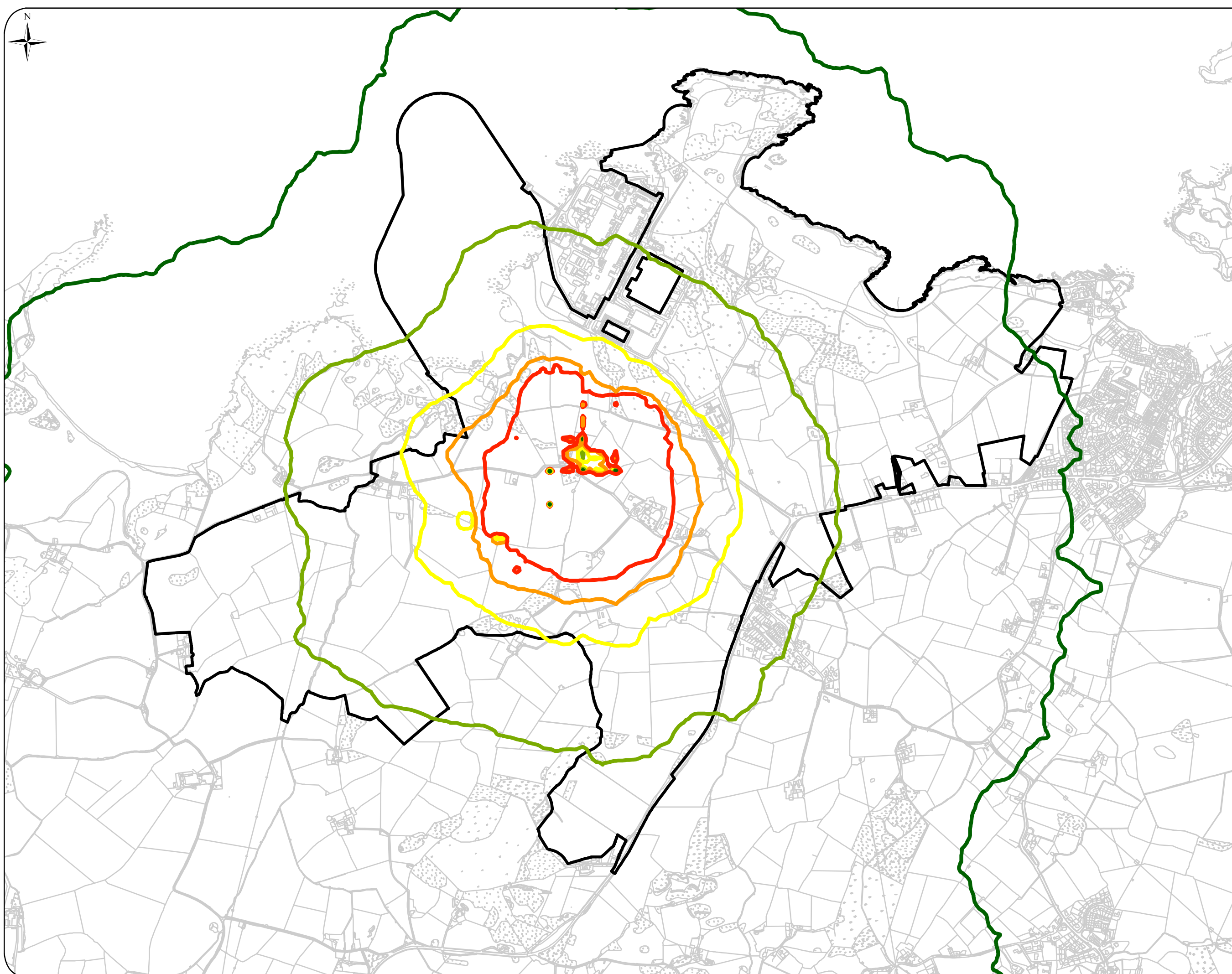
Operational Combustion Plant
Annual Mean PM₁₀ and PM_{2.5}
Process Contribution



Scale: 1:12,500
When printed at A3

0 150 300 450 M

HORIZON
NUCLEAR POWER



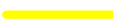
LEGEND

 Wylfa Newydd Development Area

One Hour Mean Process Contribution for NO₂ (µg/m³)

 20

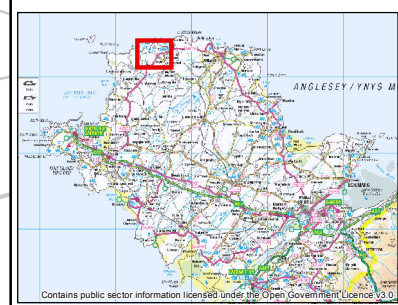
 50

 100

 150

 200

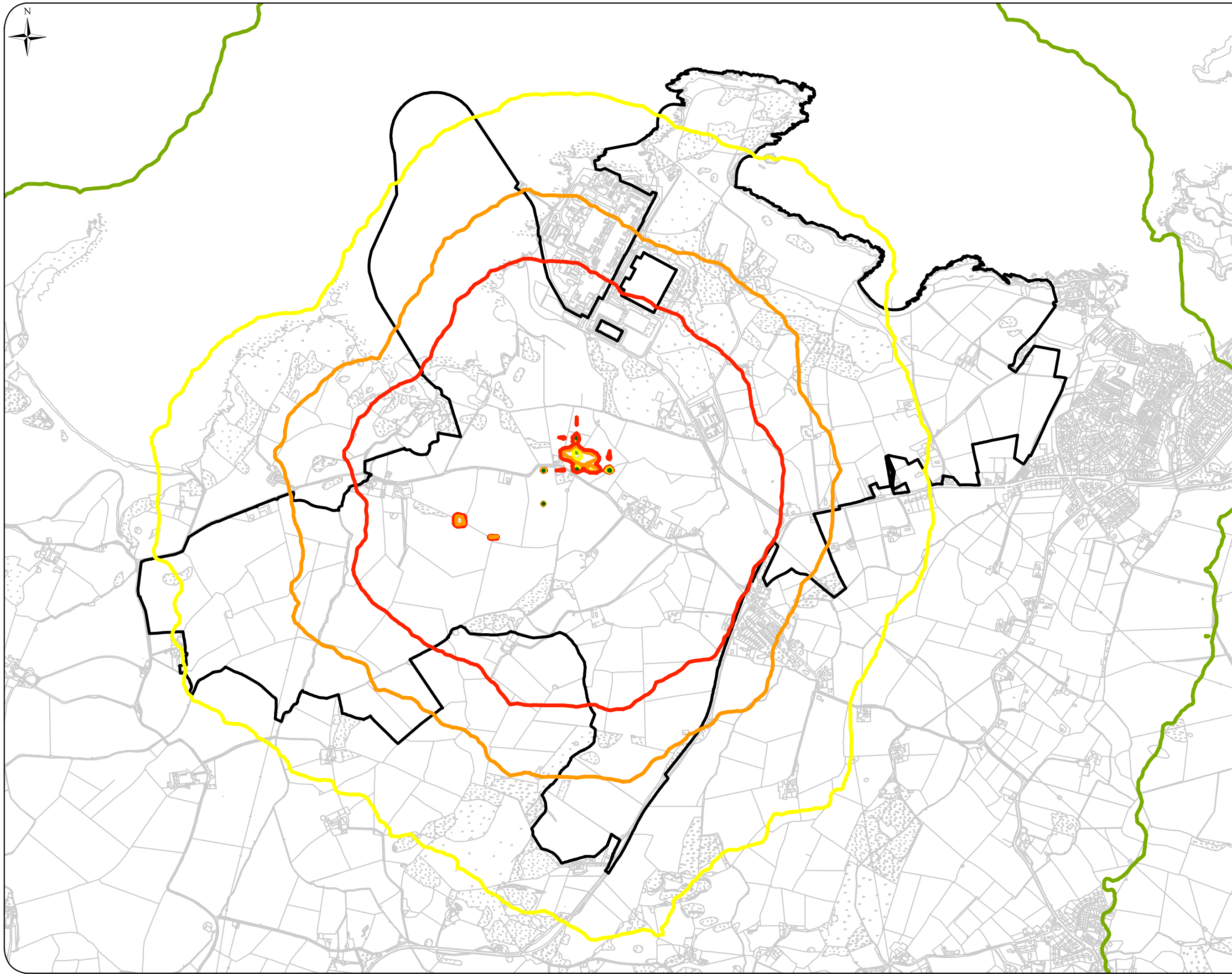
Operational Combustion Plant
Routine Testing 99.79 Percentile
1-hour Mean NO₂ Process
Contribution



Scale: 1:12,500
When printed at A3

0 150 300 450 M

HORIZON
NUCLEAR POWER

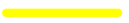


LEGEND

 Wylfa Newydd Development Area

 20

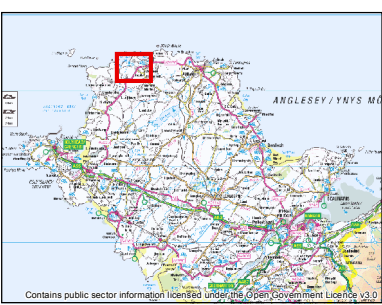
 50

 100

 150

 200

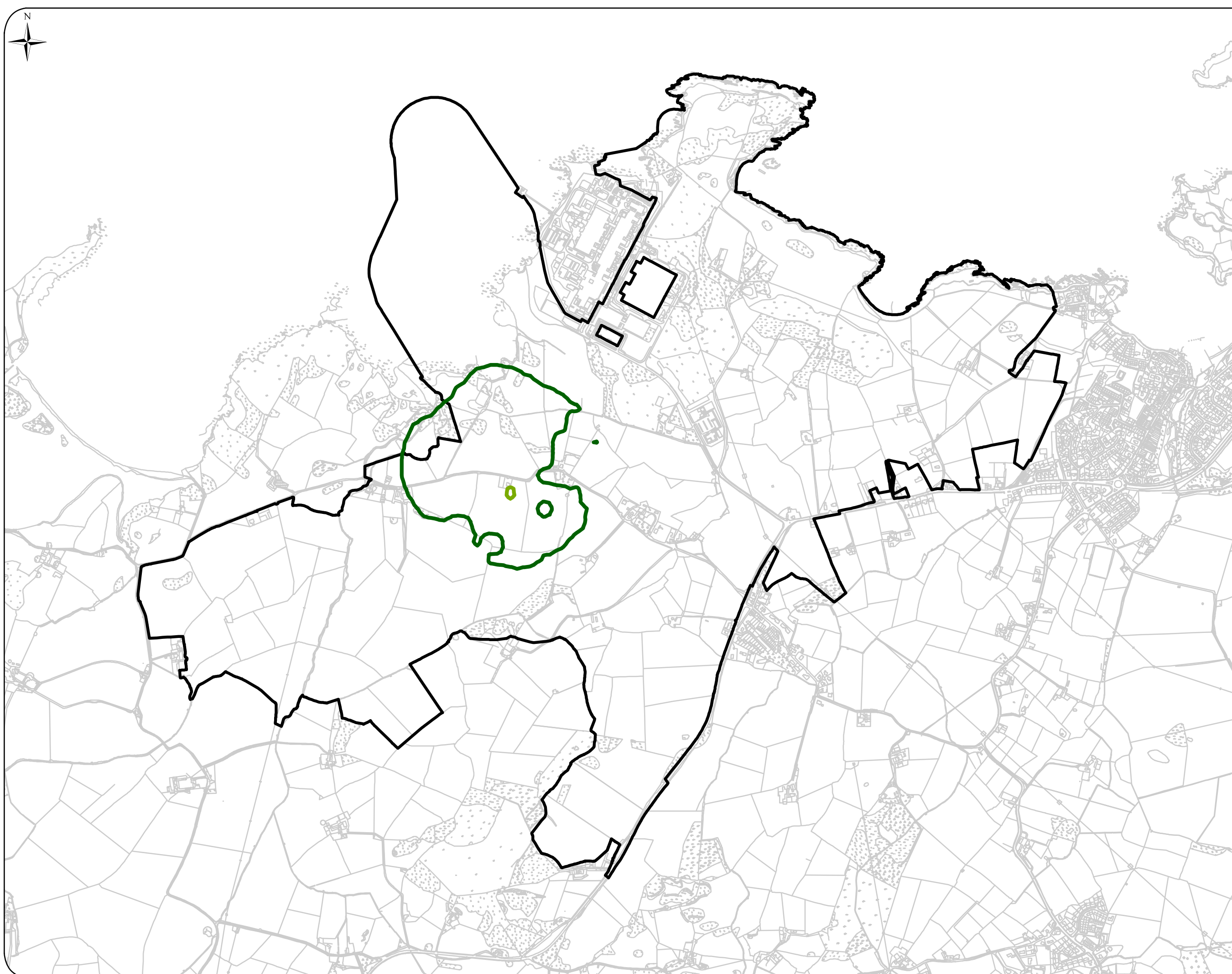
Operational Combustion Plant
Commissioning 99.79 Percentile
1-hour Mean NO₂ Process
Contribution



Scale: 1:12,500
When printed at A3

0 150 300 450 M

HORIZON
NUCLEAR POWER



LEGEND

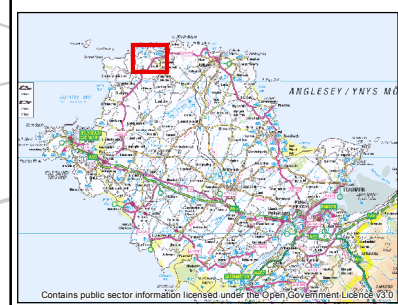
 Wylfa Newydd Development Area

One Hour Mean Process Contribution for NO₂ (µg/m³)

 20

 50

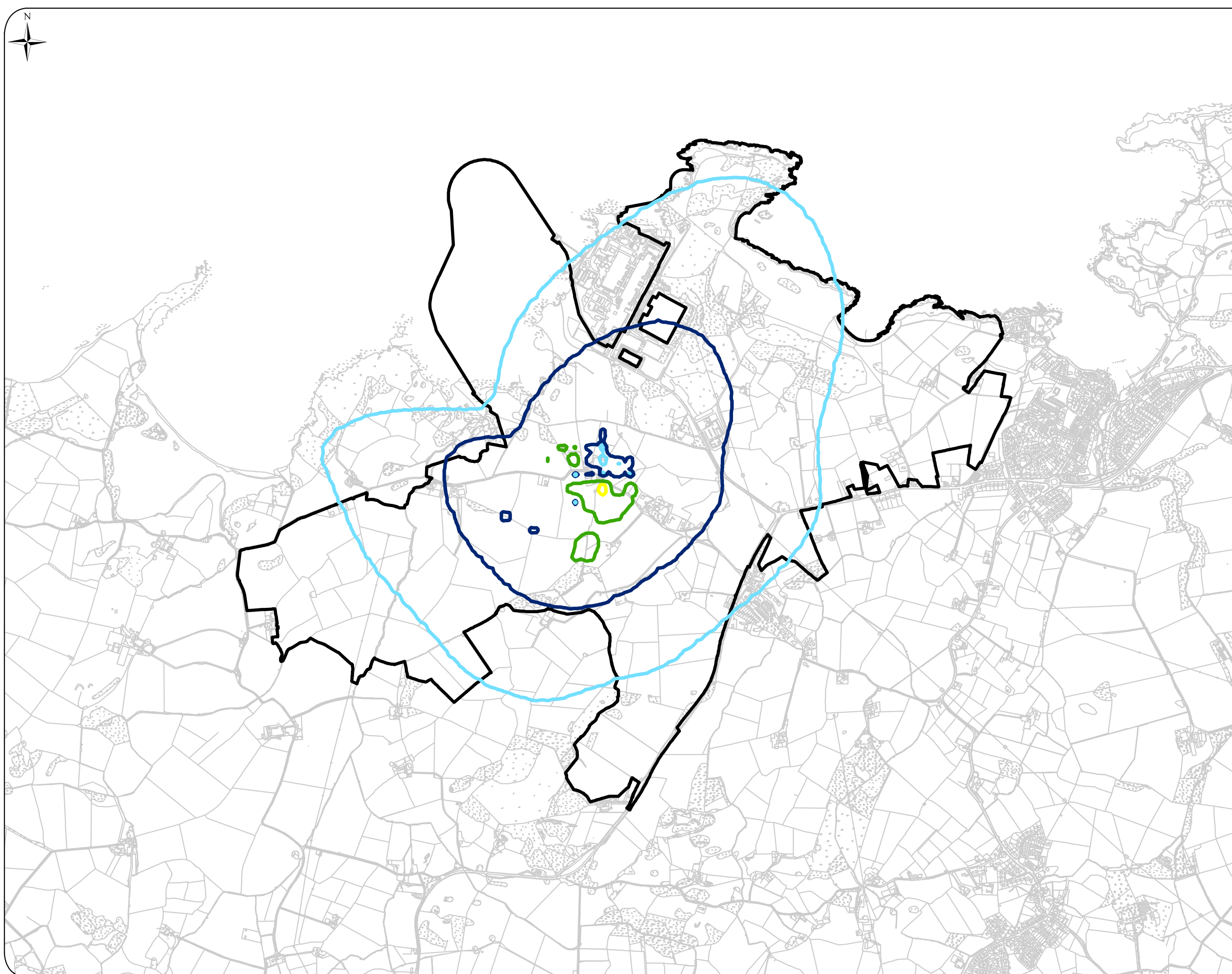
Boiler Start-up / Shutdown / Commissioning 99.79 Percentile 1-hour Mean NO₂ Process Contribution



Scale: 1:12,500
When printed at A3

0 150 300 450 M





LEGEND

 Wylfa Newydd Development Area

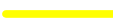
Annual Mean Process Contribution for NO₂ (µg/m³)

CONTOUR

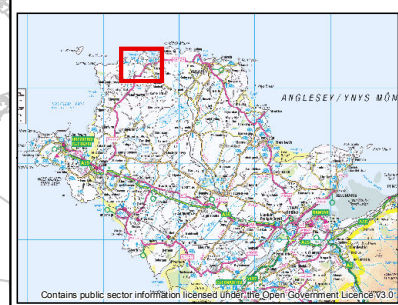
 0.4

 1

 5

 10

Operational Combustion Plant Annual Mean NO₂ Process Contribution



Scale: 1:15,000
When printed at A3

0 150 300 450 M





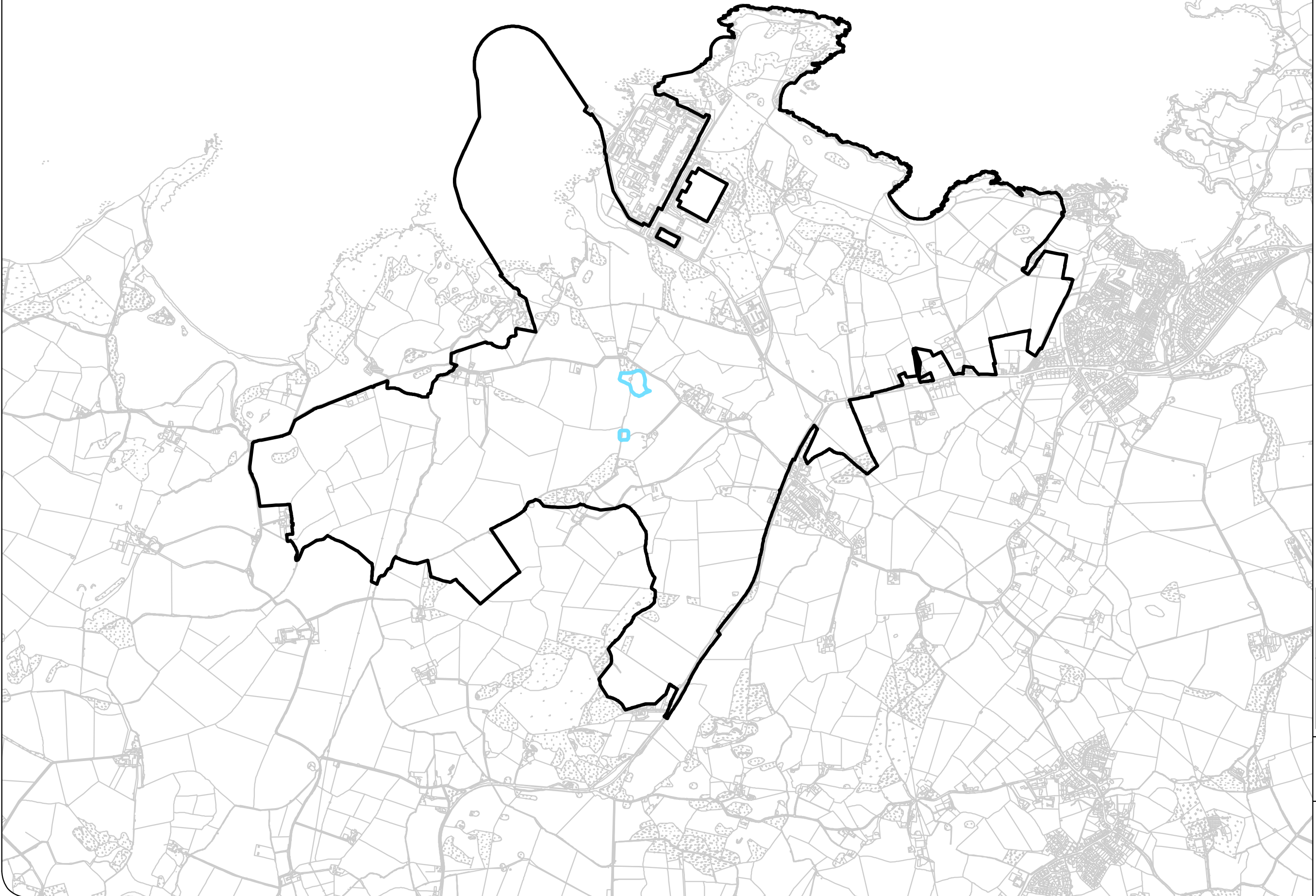
LEGEND

 Wylfa Newydd
Development Area

**Annual Mean Process
Contribution for PM₁₀
and PM_{2.5} (µg/m³)**

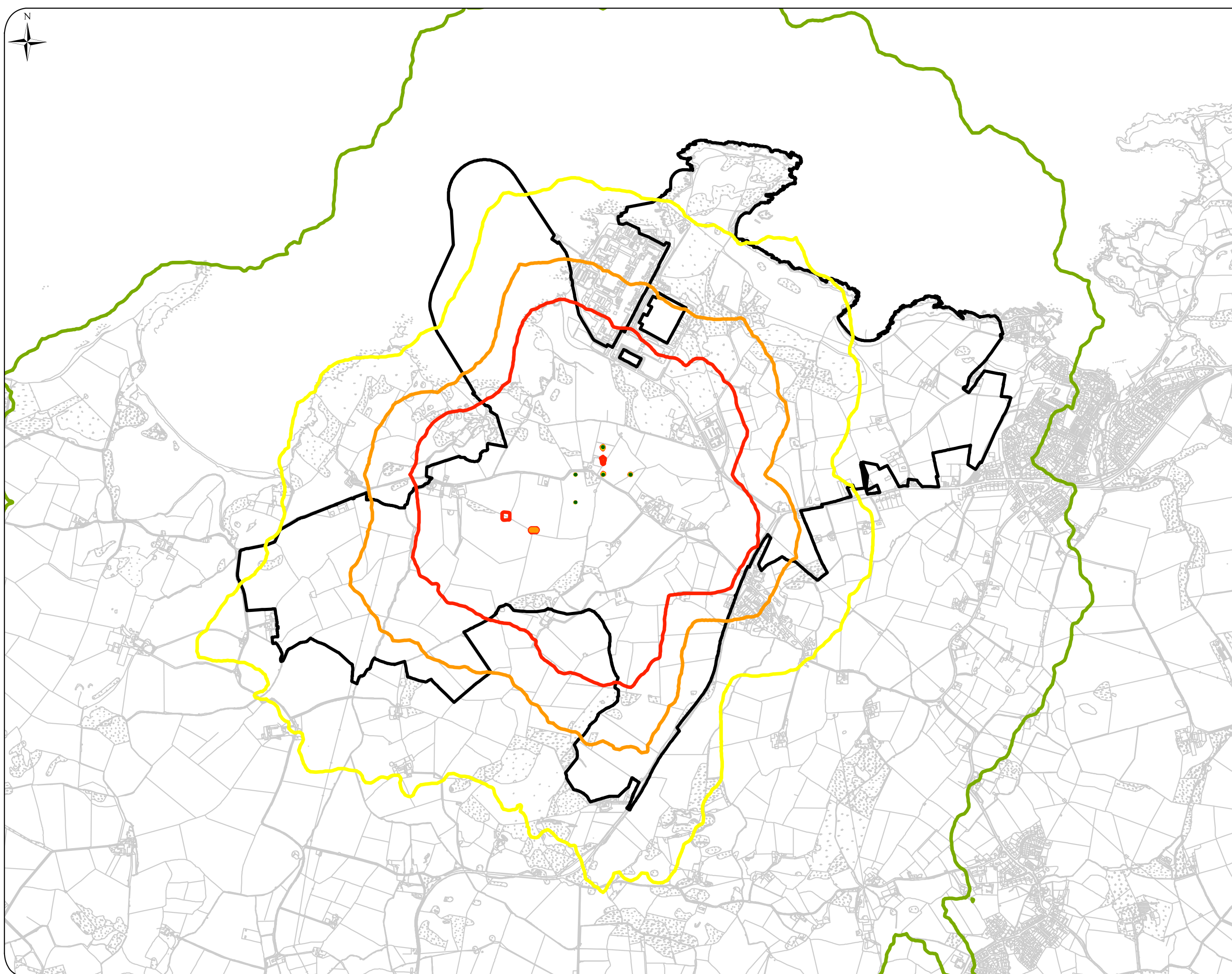
Contour
 0.4

Operational Combustion Plant
Annual Mean PM₁₀ and PM_{2.5}
Process Contribution



Scale: 1:15,000
When printed at A3
0 150 300 450
M

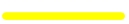
HORIZON
NUCLEAR POWER



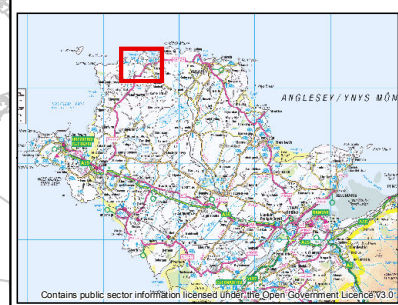
LEGEND

 Wylfa Newydd Development Area

One Hour Mean Process Contribution for NO₂ (µg/m³)

-  20
-  50
-  100
-  150
-  200

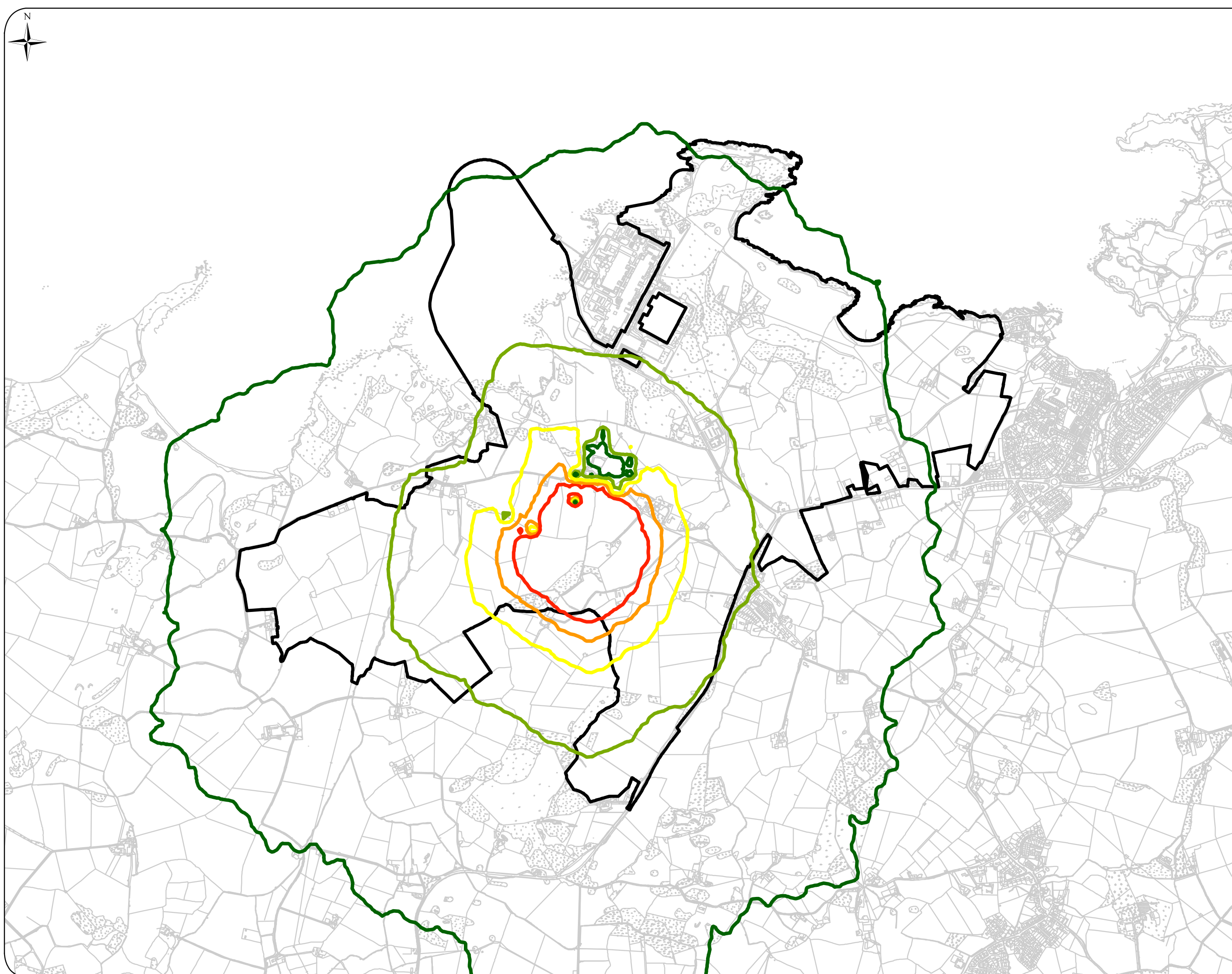
Operational Combustion Plant
MEEG Exercise 99.79th
Percentile 1-hour Mean NO₂
Process Contribution



Scale: 1:15,000
When printed at A3

0 150 300 450 M

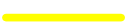
HORIZON
NUCLEAR POWER



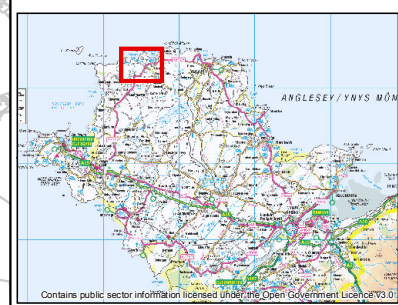
LEGEND

 Wylfa Newydd Development Area

One Hour Mean Process Contribution for NO₂ (µg/m³)

-  20
-  50
-  100
-  150
-  200

Operational Combustion Plant
MEEG Testing 99.79th Percentile
1-hour Mean NO₂ Process Contribution



Scale: 1:15,000
When printed at A3

0 150 300 450 M

HORIZON
NUCLEAR POWER

