REPORT

Petrojarl Rosebank FPSO - Air Quality Assessment

Prepared for: **Altera Infrastructure**

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Contents

Figures & Tables

Figures

Tables

ABBREVIATIONS

Abbreviation	Definition
°C	Degrees Celsius
Am^3/h	Actual metres cubed per hour
g/s	Grams per second
m	Metres
m/s	Metres per second
mg/m^3	Milligrams per cubic metre
µg/m^3	Micrograms per meter cubed
ADMS	Atmospheric Dispersion Modelling System
AQS	Air Quality Standards
BC	Background Concentration
CERC	Cambridge Environmental Research Consultants
CO	Carbon Monoxide
EA	Environment Agency
FPSO	Floating Production Storage and Offloading
GT	Gas Turbines
HP	High Pressure
IED	Industrial Emissions Directive
IAQM	Institute of Air Quality Management
LCI	Large Combustion Installations
MCP	Medium Combustion Plant
NO_2	Nitrogen Dioxide
NO_X	Oxides of Nitrogen
PC	Process Contribution
PEC	Predicted Environmental Concentration
PPC	Pollution Prevention and Control
PPMV	Parts Per Million by Volume
SO_2	Sulphur dioxide
UK	United Kingdom

1.0 INTRODUCTION

1.1 Background

Altera Infrastructure has commissioned Genesis Energies to undertake an air quality assessment as part of the application for a permit under The Offshore Combustion Installations (Pollution Prevention and Control) (Amendment) Regulations 2018 (PPC) for the Petrojarl Rosebank Floating, Production, Storage and Offloading (FPSO) installation.

This report has been prepared to assess air quality impacts associated with the provision of main power requirements as part of the operation of the FPSO. The Rosebank Field is located approximately 130 km north-west of Shetland, in the Faroe-Shetland Channel on the north-west edge of the UK Continental Shelf (UKCS). It spans blocks 213/26b & 213/27a (license P1026), block 205/1a (license P1191) and block 205/2a (license P1272).

Pollutant concentrations of NO_2, SO_2, and CO caused by emissions from the combustion facilities during the production phase have been modelled to assess their significance. Modelling has been undertaken for the production phase as this will relate to the highest power generation requirements on the FPSO and the results can therefore be considered conservative.

The proprietary Atmospheric Dispersion Modelling System package (ADMS 6) was used to carry out the modelling. The assessment in this report followed guidance for air dispersion modelling for environmental permitting issued by the Department for Energy Security & Net Zero (Ref 6) and the Environment Agency (Ref 9).

NO_2, SO_2 and CO were chosen because these compounds are generally implicated in local and regional impacts caused by combustion processes and are target pollutants under the Industrial Emissions Directive.

The purpose of the air quality assessment at this stage is to assess the sea level concentrations resulting from the operation of the Rosebank FPSO main combustion plant against health-based limits set out in the UK Air Quality Strategy. Any assumptions are based on data for similar installations and are considered acceptable for the purposes of this assessment.

2.0 POLICY, LEGISLATION AND GUIDANCE

2.1 Pollution Prevention and Control

The Offshore Combustion Installations (Pollution Prevention and Control) (Amendment) Regulations 2018 transpose the relevant provisions of the Industrial Emissions Directive (IED) 2010/75/EU (Ref 1) with respect to specific atmospheric pollutants from offshore combustion installations with aggregated thermal input capacities greater than 50 megawatts (MW). Installations with combustion equipment exceeding 50 MW_{th} must apply for a PPC permit. As part of the application process, atmospheric dispersion modelling of pollutants should be carried out, and updates completed if significant combustion plant operational changes have occurred. The atmospheric dispersion modelling assessment presented in this report follows OPRED guidance for offshore facilities (Ref 6).

2.2 Air Quality Standards

The significance of the concentrations of pollutants in the environment is generally compared against published environmental Air Quality Standards (AQSs) (Ref 2). However, there are no prescribed air quality standards for the offshore environment. Therefore, for comparison purposes and in order to assess the impacts of emissions to air in this assessment, the terrestrial UK AQSs will be used. The AQSs are based on standards from expert recommendations representing levels at which no significant health effects would be expected in the population as a whole. The standards are based on assessment of the effects of each pollutant on human health including the effects on sensitive subgroups.

Considering the emissions from the Rosebank FPSO combustion equipment, the key pollutants of concern under the AQSs are NO_2, SO_2 and CO. The air quality objectives for these pollutants are presented in Table 2-1.

Table 2-1: Relevant UK Air Quality Limit Values

Pollutant	Air Quality Limit Value	Period
NO_2	200 µg/m^3	1-hour mean not to be exceeded more than 18 times/year (99.79th percentile)
	40 µg/m^3	Annual Mean
SO_2	350 µg/m^3	1-hour mean not to be exceeded more than 24 times/year (99.73rd percentile)
	125 µg/m^3	24-hour mean not to be exceeded more than 3 times/year (99.18th percentile)
	266 µg/m^3	15-minute mean not to be exceeded more than 35 times/year (99.9th percentile)
CO	10 mg/m^3	Maximum Daily Running 8-hour mean

For the purposes of this assessment, long-term and short-term averaging periods will be used. The short-term averaging periods, hourly and 15-minute mean thresholds will be assessed because shorter averaging periods are generally more stringent for air quality as they are at a resolution to show short-term peaks in ground/sea level concentrations.

Model results will be considered in terms of the relevant percentile. For example, where the benchmark allows for 24 exceedances of the hourly mean per year, this equates to the 99.73rd percentile; in this case the maximum value occurring anywhere in the model domain at the 99.73rd percentile is reported.

Environment Agency's air quality risk assessment guidance (Ref 3) sets out criteria for determining the significance of emissions from industrial sources. Emissions from a source such as the Rosebank FPSO are termed "insignificant" if the Process Contribution (PC) comprises:

- Less than 1% of the long-term environmental standard;
- Less than 10% of the short-term environmental standard.

However, if the PC does not meet these criteria, the emission may still be judged as having an acceptable level of environmental risk if the total concentration of the pollutant (i.e. the Predicted Environmental Concentration (PEC) including the existing background concentrations) falls below the benchmark below:

- The long-term PEC is less than 70% of the long-term environmental standard;
- The short-term PC is less than 20% of the short-term environmental standard minus twice the long-term background concentration.

3.0 METHODOLOGY

3.1 Dispersion Modelling

Cambridge Environmental Research Consultants' (CERC) ADMS 6 (version 6.0.2) (Ref 4) was used to calculate the potential air quality impact for this assessment. ADMS is a computer-based Gaussian plume dispersion model that simulates a wide range of buoyant and passive releases from single or multiple sources.

ADMS 6 models the air quality impact of emissions from industrial installations to the atmosphere. The model calculates long-term and short-term concentrations from pollutant sources. It uses hourly data for the relevant location, allowing realistic outputs to be generated. ADMS 6 can take many factors into account, providing a complex, realistic prediction. ADMS is one of the modelling software packages that are suitable for this type of study and is accepted by UK regulators.

3.2 Combustion Equipment

The main combustion equipment on the Rosebank FPSO included in the modelling is listed below:

- 4No x Solar Titan 130 dual fuel (fuel gas and diesel) turbine generators; and
- HP Flare.

Each dual fuel turbine generator has a maximum thermal Input of 42.106 MW_{th}. As the combined thermal input of the main combustion equipment, total thermal capacity of 168.424 MW_{th}, exceeds 50MW_{th}, the Rosebank FPSO is classed as a LCI (Ref 6).

There are a variety of smaller combustion items which have not been modelled as emissions from these items are not considered material based on their size and mode of operation in the context of the main combustion equipment set out above.

3.3 Mode of Operation

The power demand of the Rosebank FPSO during normal production operations (30.9 MW) with a peak demand during offloading operations (33.7 MW) will require three out of four Solar Titan 130 turbines running on fuel gas with a power demand ranging between 60% and 70% load. The fourth turbine will be on cold standby and there may be rare events when all four machines run together for a short duration, for example turbine switch-over operations. Each turbine will discharge gas emissions via individual exhaust/discharge stack to enable maintenance of individual turbines without a full facility shutdown (Ref 5).

Solar Titan 130 turbines emissions associated with abnormal operating conditions, including use of diesel for limited operating hours or emergency situations, typically result in process gas being routed to the flare system.

During normal operation, Dry Low Emissions (DLE) technology (SoLoNOx™ nozzles) will be in place for the 4No x Solar Titan 130 turbines to reduce NOx emissions (as low as 25 ppmv) (Ref 5).

3.4 Modelling Scenarios

Air dispersion modelling was carried out such that conservative cases, with respect to planned "normal" operations, were modelled to determine the worst emissions cases for the main combustion equipment, which might occur during a typical year.

Altera have forecasted the power demand for the Rosebank FPSO and have determined the future loads that the gas turbines must operate at to meet this power demand are between 60% and 70%. To ensure the air quality assessment is conservative with respect to planned operation, the Rosebank FPSO gas turbine emissions have been modelled at 84% load. The following scenarios including different operating conditions were considered for this assessment:

- Scenario 1: Normal Operations:
  - 3x Solar Titan 130 running on fuel gas at 84% load;
- Scenario 1b: Sensitivity Test:
  - 2x Solar Titan 130 running on fuel gas at 84% load plus 2x Solar Titan 130 running on fuel gas at <50% load (No DLE NO_X Technology in operation);
- Scenario 2: Non-Routine Operations:
  - 3x Solar Titan 130 operation running on diesel at 89% load;
- Scenario 3: Non-Routine Operations with flaring:
  - 2x Solar Titan 130 Operation on diesel running on diesel at 89% load with flaring. As demand is reduced, fewer turbines are required to be running.

Scenarios 1b, 2 and 3 will not occur over a long-term duration and are considered temporary (i.e. temporary operation of the GTs on fuel gas (<50% load), diesel fuel use and flaring, blowdown events). However, in order to capture the worst-case emissions these scenarios are modelled over a full year. This will provide results for these scenarios to show what the worst-case pollutant concentrations could be under the least favourable meteorological conditions across the entire modelling period.

Blowdown flaring is anticipated to be a low frequency event and would also be of very short duration. This event was modelled using ADMS 6. Whilst a blowdown would lead to a short-term peak in pollutant concentrations as the event duration is only 15 minutes there would be little bearing on performance against the AQS on an annual basis.

3.5 Modelling Inputs

The following sections present details on the modelling inputs which were used in the modelling, which are specific to the Rosebank FPSO.

3.5.1.1 Emission Calculations

The emissions rates are input into ADMS in grams per second (g/s). These rates are derived from annual emissions loads in tonnes per year (Ref 7) calculated using an emission factor for key pollutants. These factors are primarily taken from the Environmental and Emissions Monitoring System (EEMS). For the Solar Titan 130 turbines using fuel gas, specific NO_X emission rates have been calculated based on the emission factor derived for the Rosebank PPC permit application (Ref 5).

It should be noted that, for combustion of diesel, low sulphur diesel (LSD) has been used (<0.1 wt %), as part of the emission calculations of this assessment.

Hydrogen sulphide (H_2S) is the only source of sulphur in the fuel gas used in GTs in the Rosebank FPSO. Based on the expected H_2S content (0.00 Mole%) in the fuel gas composition (Ref 13), sulphur content is expected to be negligible. Therefore, SO_2 emissions from fuel gas are scoped out of the detailed modelling assessment and are not assessed further in this report.

3.5.1.2 Modelling Domain

Figure 3-1 illustrates the proximity of receptors to the proposed Rosebank FPSO location. The modelled closest receptors to the proposed FPSO location are listed in Table 3-1. In addition to these receptors, predicted concentrations over 2No 10x10km grids, 50m space resolution, centred on the Rosebank FPSO and the closest UKCS Median location were also calculated.

Figure 3-1: Rosebank FPSO- Study Area

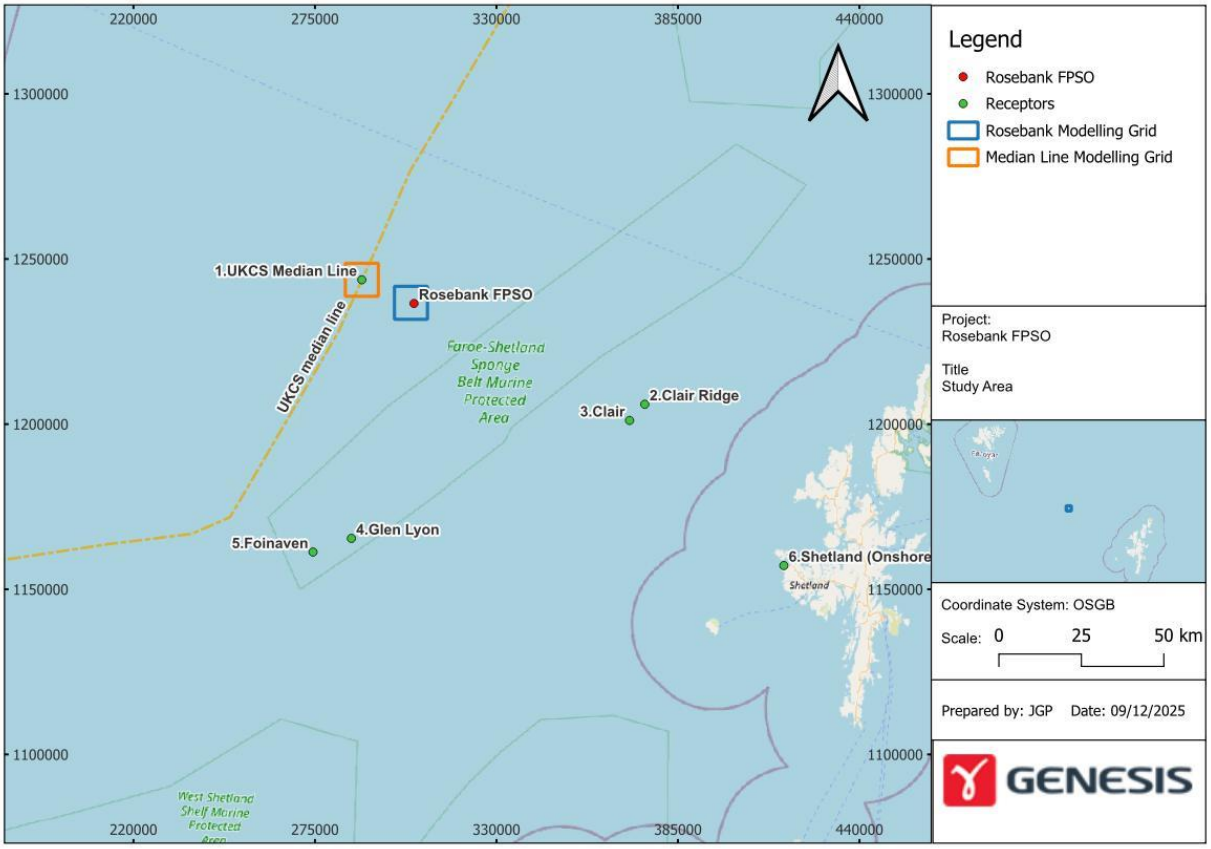


Table 3-1: Receptors of Interest

Receptor	Coordinates (OSGB 1936 British National Grid)		Height above sea level (m)	Distance from Site (km)
	Eastings (m)	Northings (m)		
1.UKCS Median Line	289260	1243674	30	17
2.Clair Ridge	375055	1205961	30	76
3.Clair	370445	1201067	30	74
4.Glen Lyon	286099	1165331	30	74
5.Foinaven	274462	1161198	30	81
6.Shetland (Onshore) Nearest Landfall (Shetland West Coast)	417213	1157103	0	137

3.5.1.3 Meteorological Data

Three years of hourly sequential meteorology data (2022 to 2024) has been used for this modelling study in ADMS 6 format and provided by ADM Ltd (Ref 11). The meteorological data has been obtained from Numerical Weather Prediction (NWP) model data for the proposed Rosebank FPSO location. The meteorological data include wind speed, wind direction, temperature, relative humidity, cloud cover and precipitation. This data source is considered suitable for the purposes of this assessment. The wind roses for this study are presented in Appendix A.

3.5.1.4 Background Pollutant Concentrations

Ambient levels of pollution are incorporated into model outputs for analysis in context of the AQS. Ambient air quality data is not gathered offshore. Therefore, available information for rural coastal areas (Ref 8) located at the west cost of the Shetland (OSGB coordinates, X=416500, Y=1161500) has been used to represent offshore Background Concentrations (BC) for this air quality assessment. Table 3-2 presents the background concentrations used for this assessment.

Table 3-2: Background Concentrations

AVERAGING TIME	NO_2 (µg/m^3)	SO_2 (µg/m^3)	CO (mg/m^3)
Long-Term	1.0	0.2	0.2
Short-Term	2.0	0.4	0.4

As per EA guidelines (Ref 4), the long-term ambient concentrations have been doubled to approximate a short-term background concentration in Table 3-2.

3.5.1.5 NO_X to NO_2 Conversion Rates

The AQS objectives for the protection of human health relate to the concentrations of the NO_2 component of NO_X. Once released, NO can be converted to NO_2 by reaction with low level ozone in the atmosphere. The process is also reversible in sunlight and the net rate of conversion of NO to NO_2 in the plume is therefore a function of the rate of dilution of the plume by ambient air, trace gas concentrations in the air and meteorology.

As per EA guidance (Ref 9), the conversion ratio from NO_X to NO_2 used in this assessment was 35% of the modelled short-term NO_x values and 70% of the modelled long-term NO_x values.

3.5.1.6 Surface Roughness

ADMS 6 includes a 'surface roughness' parameter. This is an index of surface height derived from land-use. Each point in the grid is assigned a roughness value related to land-use. The surface roughness has been modelled within ADMS for this assessment using the 'Marine Module'. This module uses the specific meteorological data input to the modelling to calculate the factor for the area being modelled.

3.5.1.7 ADMS Inputs

Specific model inputs as entered into the ADMS 6 model are tabulated in Table 3-3 below.

Physical stack flare parameters used in this assessment are based on the Ontario guidance (Ref 10). Modelling open flares adds a layer of technical complexity to the modelling with certain pseudo-parameters being used within the model to better emulate the conditions of the open flare emissions.

Table 3-3: Summary of Model Inputs

INPUT	SOLAR TITAN 130 (80-DE-001A)		SOLAR TITAN 130 (80-DE-001B)		SOLAR TITAN 130 (80-DE-001C)		SOLAR TITAN 130 (80-DE-001D)	HP FLARE
FUEL TYPE	Fuel Gas	Diesel	Fuel Gas	Diesel	Fuel Gas	Diesel	Fuel Gas	Gas
Operational Load (%)	84/84	89	84/84	89	84/50	89	50	100
Scenario	1/1b	2,3	1/1b	2,3	1/1b	2	1b	3
Stack Location OSGB (X&Y) coordinates	X=304155, Y=1236693		X=304152, Y=1236698		X=304149, Y=1236704		X=304146, Y=1236709	X=304185 Y=1236712
Stack Height (m)	31.2		31.2		31.2		31.2	130.57*
Exit Diameter (m)	2.0		2.0		2.0		2.0	39.19*
Exit Temperature (°C)	527	510	527	510	527/579	510	579	1,000*
Exit Velocity (m/s)	29.98	32.28	29.98	32.28	29.98/23.11	32.28	23.11	4.9*
Volume Flow Rate (Am^3/s)	94.18	101.43	94.18	101.43	94.18/72.61	101.43	72.61	-
NO_X (g/s)	1.65	12.46	1.65	12.46	1.65/3.63	12.46	3.63	12.87
SO_2 (g/s)	-	1.85	-	1.85	-	1.85	-	0.14
CO (g/s)	4.74	0.85	4.74	0.85	4.74/3.73	0.85	3.73	71.84

Note:
*Input values are derived from the Ontario Technical Bulletin- Modelling Open Flares (Ref 10). Physical parameters for the flare stack were used from the Rosebank flare study report (Ref 12).

4.0 RESULTS

The key results from the assessment of pollutant concentrations are presented in the context of the relevant AQS. These results represent the maximum mean concentrations (annual or percentile based) modelled within the designated calculation grid for the worst-case meteorological year.

The AQS were derived for the purposes of onshore air quality management and the protection of human health and the environment. The AQS apply at the site boundary rather than within the boundaries, where occupational health standards apply.

The results presented in this section are the maximum PCs and PEC identified within all modelled grid and assessment receptor locations for each pollutant and scenario. The full results are presented in Appendix B.

4.1 Scenario 1 – Normal Operations

The maximum NO_2, and CO concentrations for Scenario 1 are presented in Table 4-1. These results show that the AQS are not likely to be breached during normal operations. The concentrations modelled represent a conservative worst case operational mode and do not predict any AQS breaches.

The maximum long-term PC for NO_2 was 0.6% of the AQS, which is below the 1% AQS and therefore using the criteria set out in Section 2, the change in the long-term PC is considered to be insignificant.

The maximum short-term PC was identified for NO_2 and is less than 1.7% of the relevant AQS.The short-term PCs is classed as insignificant (<10% of the relevant AQS).

Scenario 1 NO_2 and CO contour plots are shown in Figure 4-1 to Figure 4-3. These figures illustrate that the highest concentrations occur approximately 600 – 750m to the south of the proposed location of the Rosebank FPSO.

Table 4-1: Scenario 1 – Normal Operations- Maximum Concentrations.

POLLUTANT	AVERAGING PERIOD	PC	AQS	PC (%AQS)	BC	PEC	PEC (%AQS)
NO_2	Annual mean	0.24	40	0.6	1.0	1.2	3.1
	1-Hour Mean (99.79th)	3.45	200	1.7	2.0	5.4	2.7
CO	Max Daily Running 8 - Hour Mean	0.03	10	0.3	0.4	0.4	4.3

Note: Units NO_2 µg/m^3, CO mg/m^3

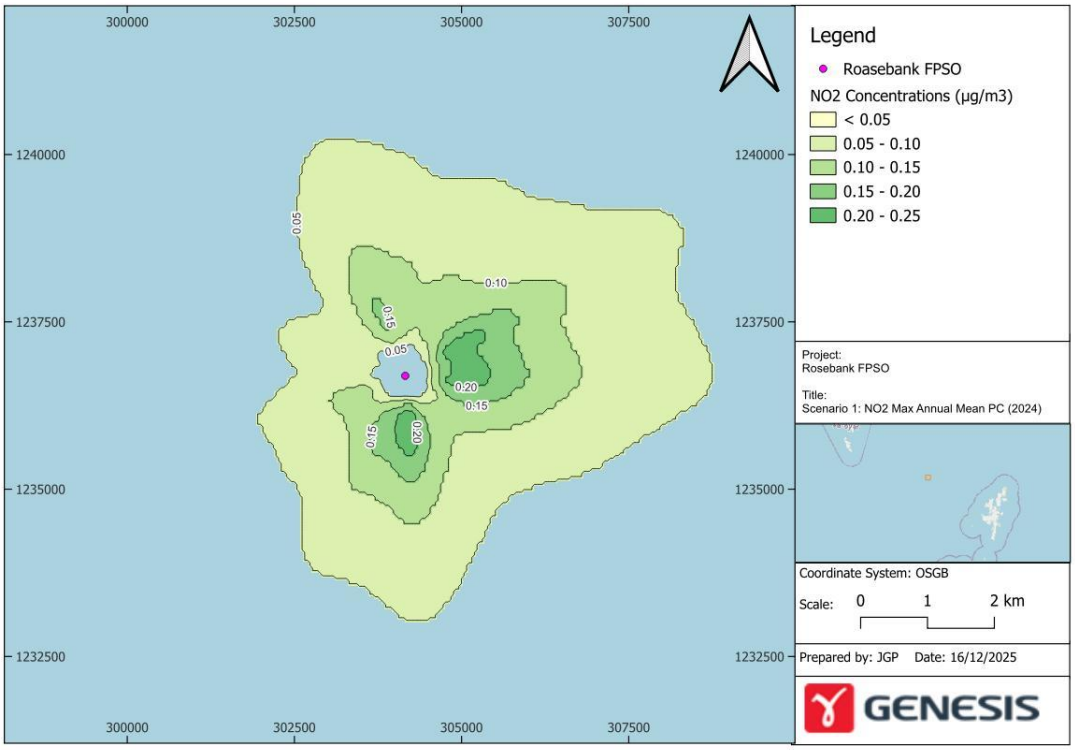


Figure 4-1: Scenario 1: NO_2 Annual Mean Max PC (µg/m^3)

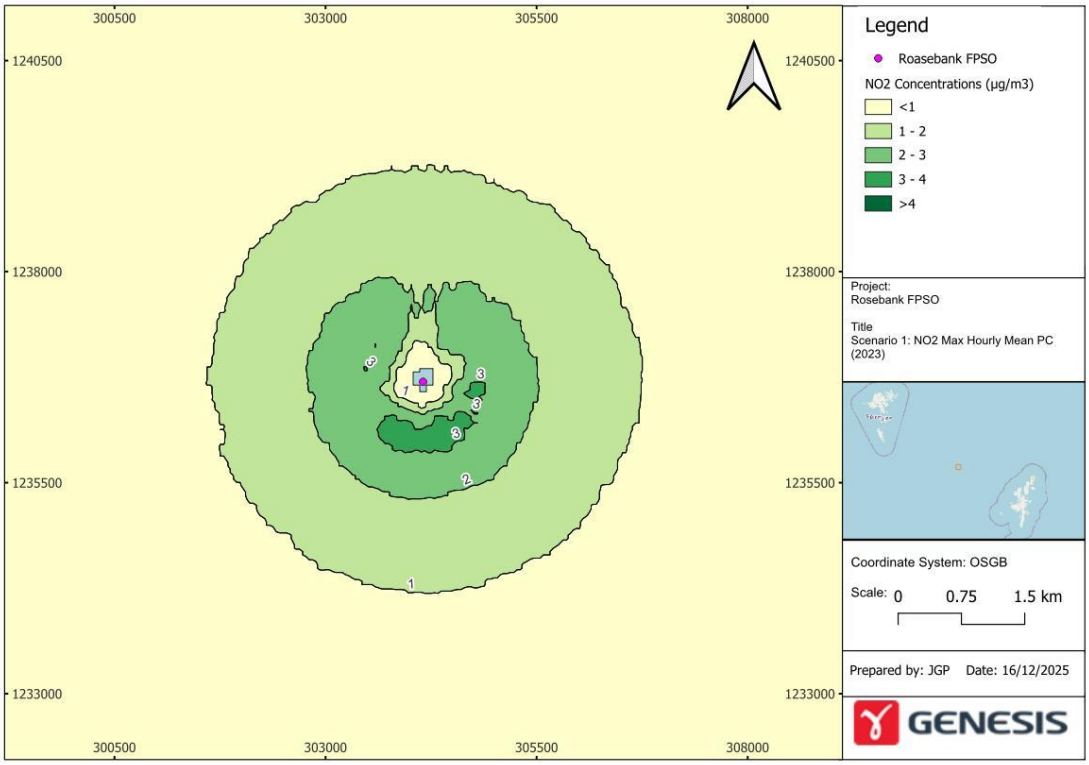


Figure 4-2: Scenario 1: NO_2 1-Hour Mean (99.79th percentile) Max PC (µg/m^3)

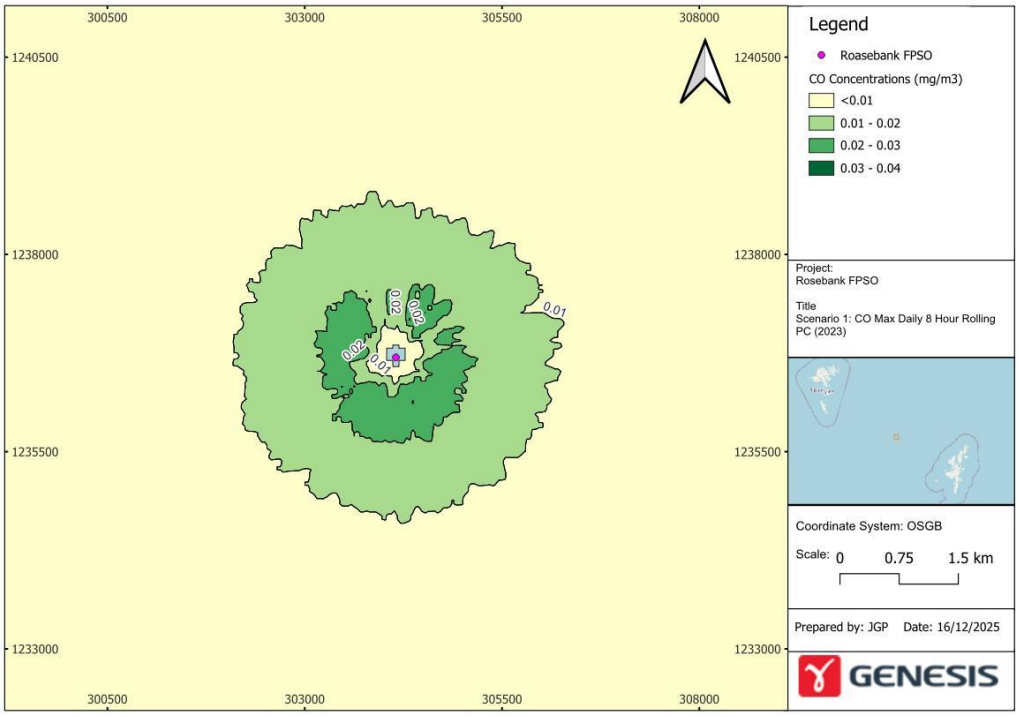


Figure 4-3: Scenario 1: CO Max Daily Running 8 - hour Mean Max PC (mg/m^3)

4.2 Scenario 1b - Sensitivity Test

The maximum NO_2, and CO concentrations for Scenario 1b are presented in Table 4 2. These results show that the relevant pollutants AQS are not likely to be breached at sea level during this event. The concentrations modelled represent a conservative worst case operational mode and do not predict any AQS breaches.

The short-term PCs were screened out as insignificant (<10% of the relevant AQS) using the criteria set out in Section 2.0. The maximum short-term PC occurs for NO_2 and comprises less than 4.1% of the relevant AQS.

Scenario 1b contour plots are shown in Figure 4-4 to Figure 4-5. These figures illustrate that the highest concentrations occur approximately 550m – 650m to the south of the proposed location of the Rosebank FPSO.

Table 4-2: Scenario 1b – Sensitivity Test- Maximum Concentrations.

POLLUTANT	AVERAGING PERIOD (PERCENTILE)	PC	AQS	PC (%AQS)	BC	PEC	PEC (%AQS)
NO_2	1 Hour Mean (99.79th)	8.18	200	4.1	2.0	10.1	5.1
CO	Max Daily Running 8 - hour Mean	0.04	10	0.4	0.4	0.4	4.4

Note: Units NO_2 µg/m^3, CO mg/m^3

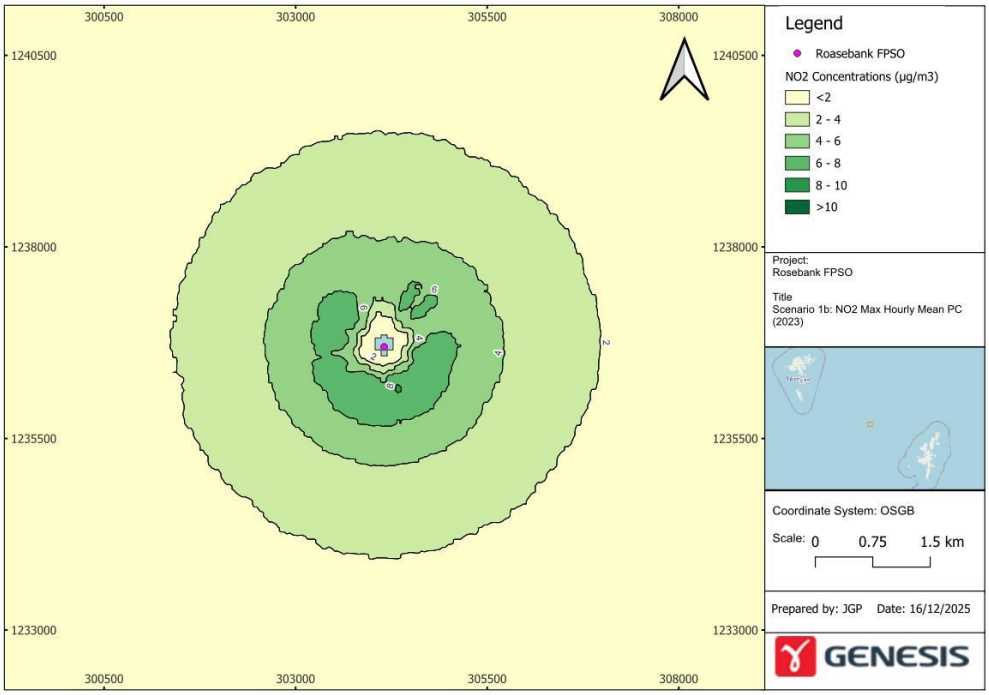


Figure 4-4: Scenario 1b: NO_2 1-Hour Mean (99.79th percentile) Max PC (µg/m^3)

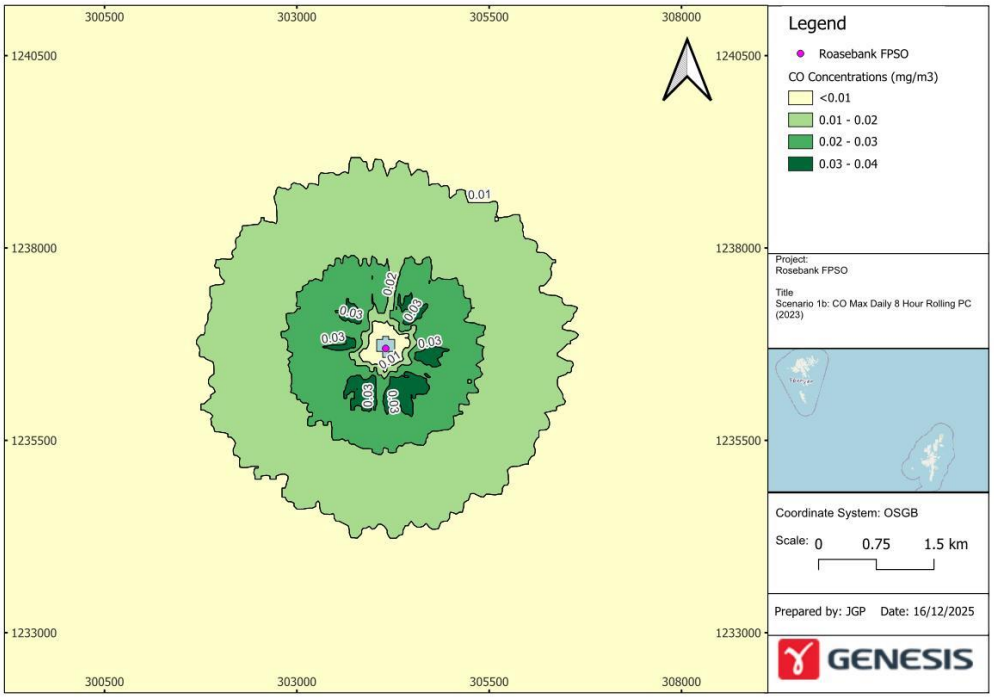


Figure 4-5: Scenario 1b: CO Max Daily Running 8 - hour Mean Max PC (mg/m^3)

4.3 Scenario 2 – Non-Routine Operations

Scenario 2 results presented in Table 4-3 show that the relevant pollutants AQS are not likely to be breached at sea level during temporary non-routine operations (diesel use). As noted previously, only the short-term concentrations are considered to be relevant for non-routine operations. The concentrations modelled for this scenario represent a conservative worst case non-routine operational mode.

Overall, all the short-term PCs have been screened out as insignificant using the criteria set out in Section 2.0, except for NO_2. The maximum modelled hourly mean NO_2 PC with non-routine operations of the Rosebank FPSO is 25 µg/m^3 and the PEC is 27.1µg/m^3 which is well below the AQS (200µg/m^3). The maximum PEC is 13.6% of the AQS, and therefore, based on the criteria set out in Section 2.0, the maximum hourly NO_2 PEC is considered to be insignificant.

NO_2, SO_2 and CO contour plots for Scenario 2 are illustrated in Figure 4-6 to Figure 4-10. These figures show that max PC occur to the south approximately 600m-750m of the proposed Rosebank FPSO location.

Table 4-3: Scenario 2 – Non-Routine Operations - Maximum Concentrations.

POLLUTANT	AVERAGING PERIOD (PERCENTILE)	PC	AQS	PC (%AQS)	BC	PEC	PEC (%AQS)
NO_2	1 Hour Mean (99.79th)	25.14	200	12.6	2.0	27.1	13.6
SO_2	15 - minute (99.9th)	12.03	266	4.5	0.4	12.4	4.7
	1 - Hour Mean (99.73th)	10.44	350	3.0	0.4	10.8	3.1
	24 - Hour (99.18th)	6.53	125	5.2	0.4	6.9	5.5
CO	Max Daily Running 8 - hour Mean	0.01	10	0.1	0.4	0.4	4.1

Note: Units NO_2 and SO_2 µg/m^3, CO mg/m^3.

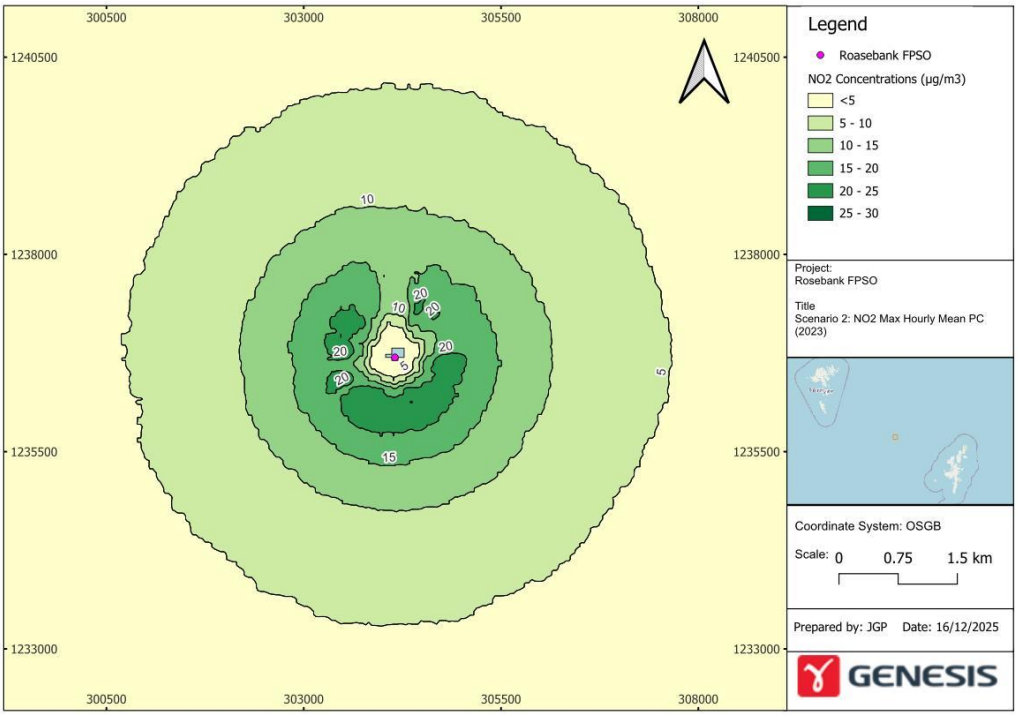


Figure 4-6: Scenario 2: NO_2 1-Hour Mean (99.79th percentile) Max PC (µg/m^3)

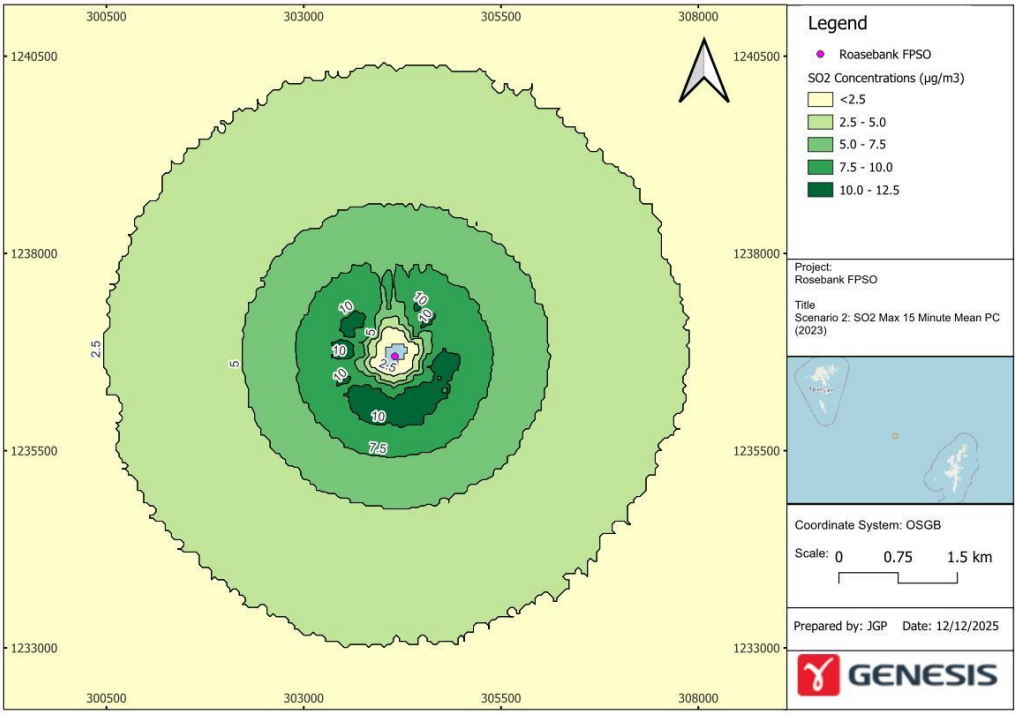


Figure 4-7: Scenario 2: SO_2 15 - Minute Mean (99.9th Percentile) Max PC (µg/m^3)

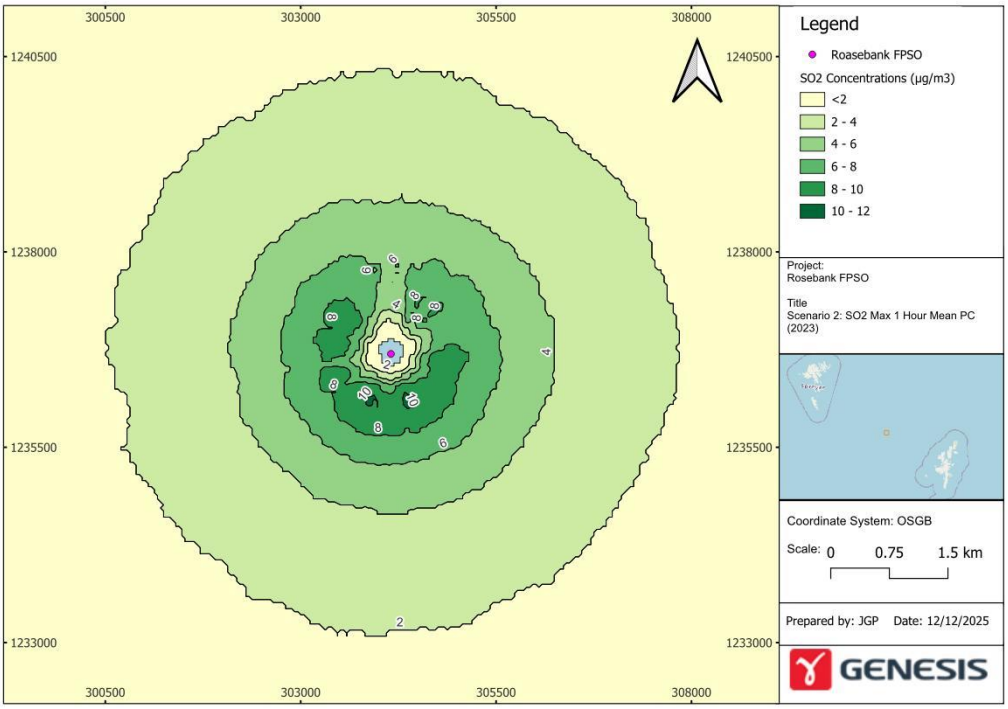


Figure 4-8: Scenario 2: SO_2 1 - Hour Mean (99.73th Percentile) Max PC (µg/m^3)

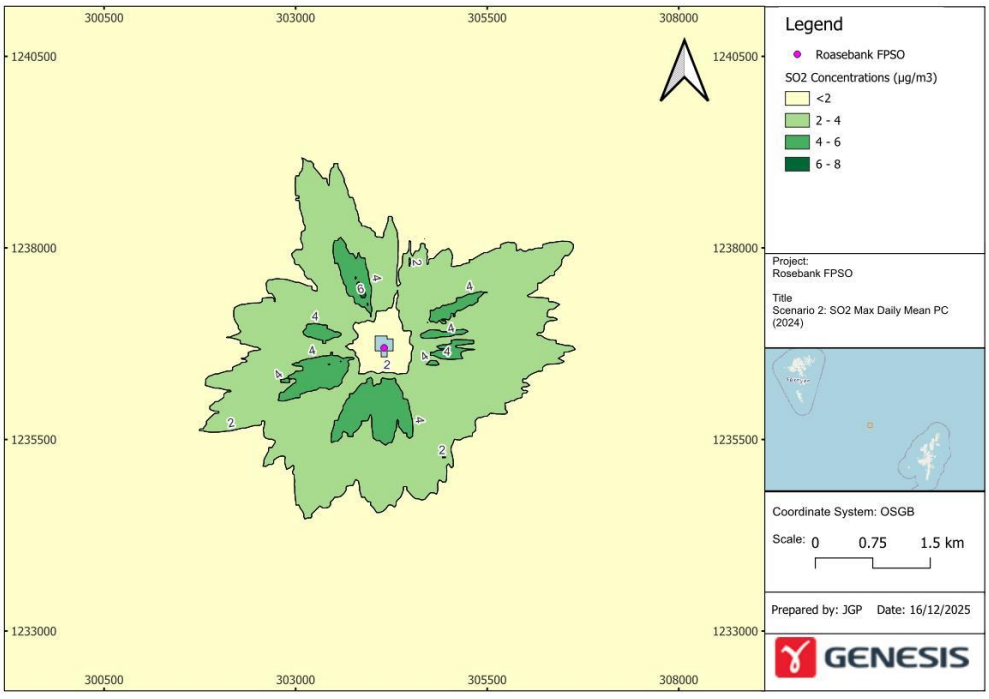


Figure 4-9: Scenario 2: SO_2 24 Hour (99.18th Percentile) Max PC (µg/m^3)

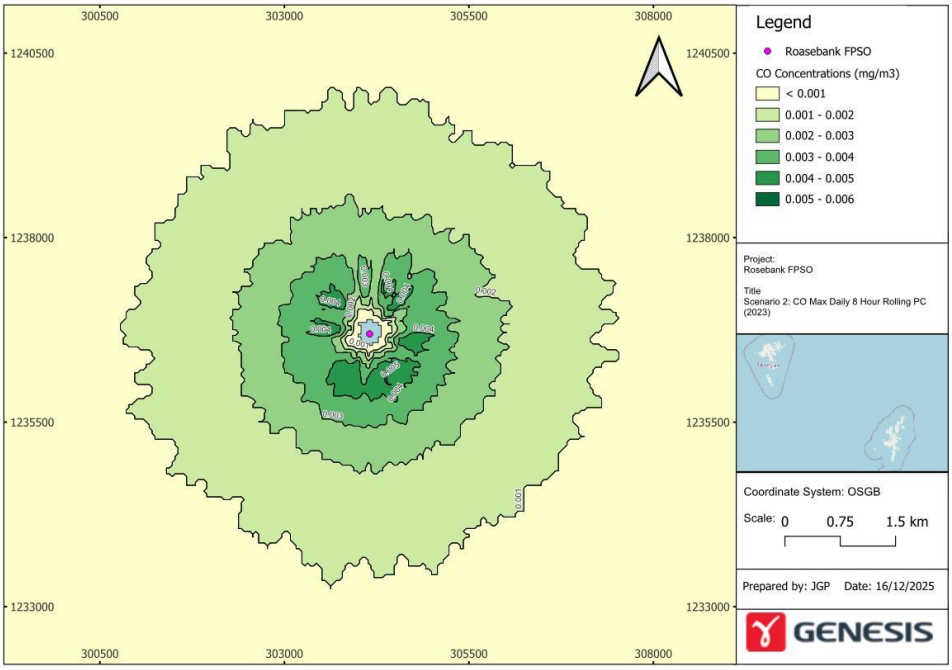


Figure 4-10: Scenario 2: CO Max Daily Running 8 - hour Mean Max PC (µg/m^3)

4.4 Scenario 3 – Non-Routine Operations With Flaring

The key results for Scenario 3 are summarised in Table 4-4. The combination of non-routine operations, including diesel use and flaring, associated with the Rosebank FPSO are expected to be temporary. The concentrations modelled for this scenario represent a conservative worst case and do not predict any AQS breaches.

Overall, all the short-term PCs were screened out as insignificant using the criteria set out in Section 2.0, except for NO_2. The maximum modelled hourly mean NO_2 PC for Scenario 3 is 47.9 µg/m^3. The max NO_2 PEC concentration is 49.9 µg/m^3 which is within the air quality standard (200µg/m^3). The NO_2 PEC is 24.9% of the relevant standard and therefore, the NO_2 PEC is insignificant.

NO_2, SO_2 and CO contour plots for Scenario 3 are presented in Figure 4-11 to Figure 4-15. These figures illustrate that the highest concentrations typically occur to the south and east approximately 790 m of the Rosebank FPSO location.

Table 4-4: Scenario 3 – Non-Routine Operations + Flaring - Maximum Concentrations.

POLLUTANT	AVERAGING PERIOD (PERCENTILE)	PC	AQS	PC (%AQS)	BC	PEC	PEC (%AQS)
NO_2	1 Hour Mean (99.79th)	47.90	200	23.9	2.0	49.9	24.9
SO_2	15 - minute (99.9th)	8.03	266	3.0	0.4	8.4	3.2
	1 - Hour Mean (99.73th)	6.98	350	2.0	0.4	7.4	2.1
	24 - Hour (99.18th)	4.36	125	3.5	0.4	4.8	3.8
CO	Max Daily Running 8 - hour Mean	0.79	10	7.9	0.4	1.2	11.9

Note: Units NO_2 and SO_2 µg/m^3, CO mg/m^3.

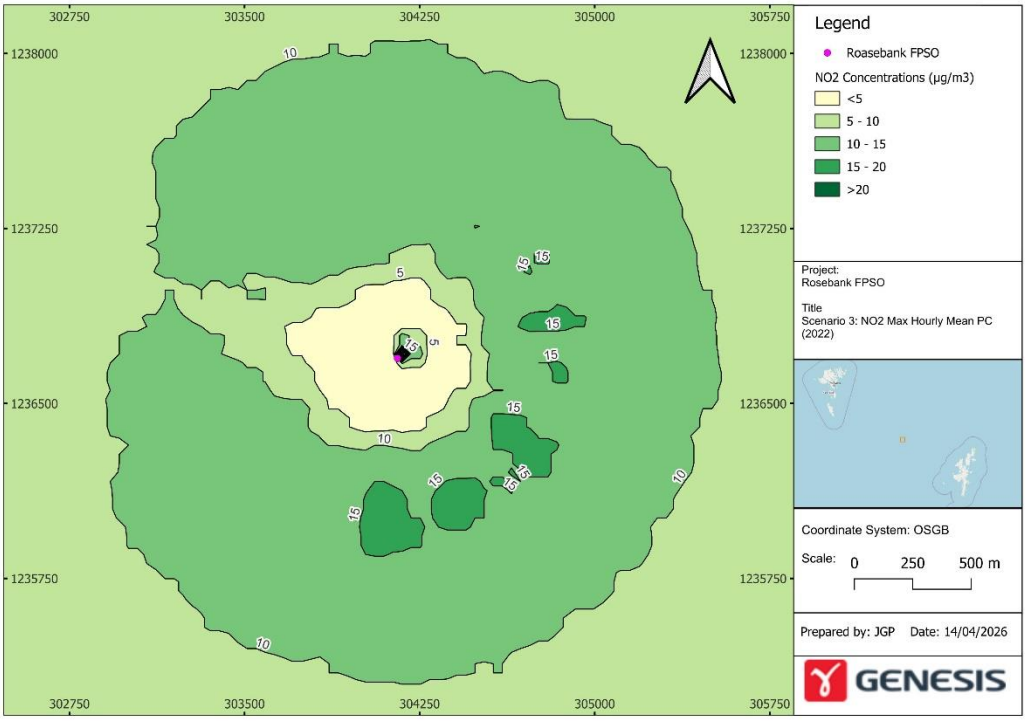


Figure 4-11: Scenario 3: NO_2 1-Hour Mean (99.79th percentile) Max PC (µg/m^3)

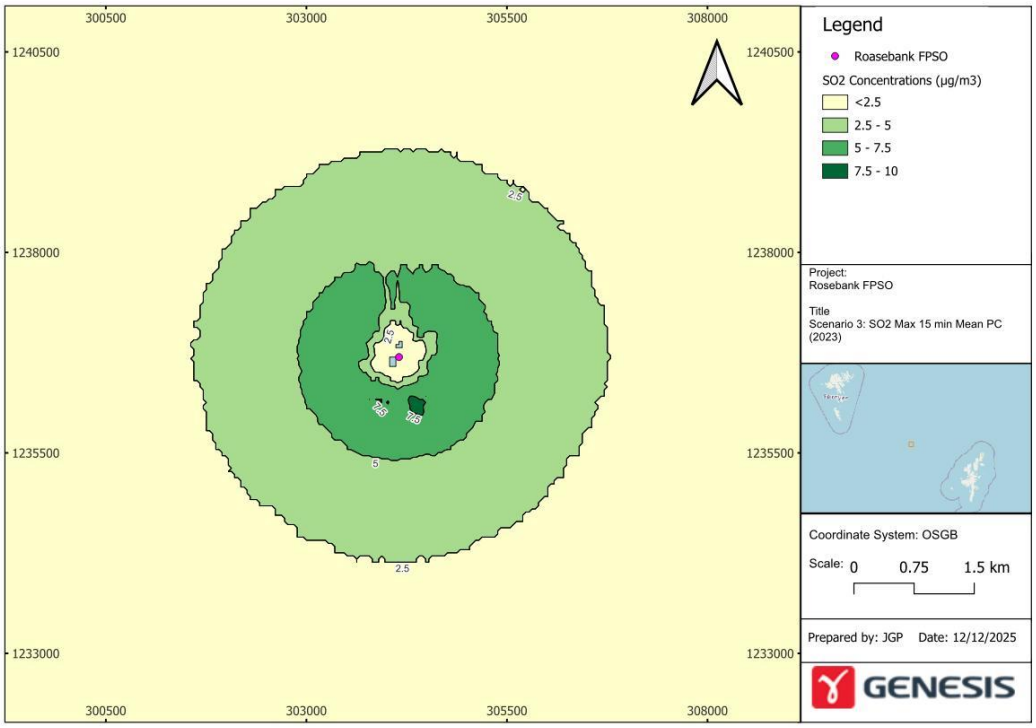


Figure 4-12: Scenario 3: SO_2 15 - Minute Mean (99.9th Percentile) Max PC (µg/m^3)

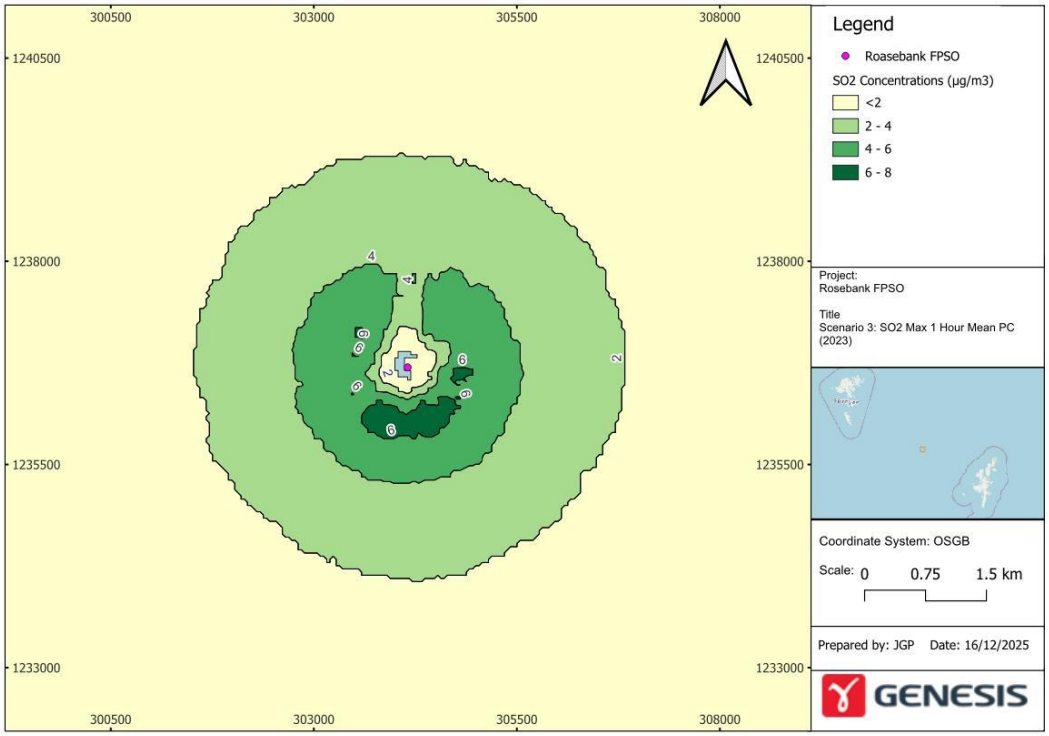


Figure 4-13: Scenario 3: SO_2 1 - Hour Mean (99.73th Percentile) Max PC (µg/m^3)

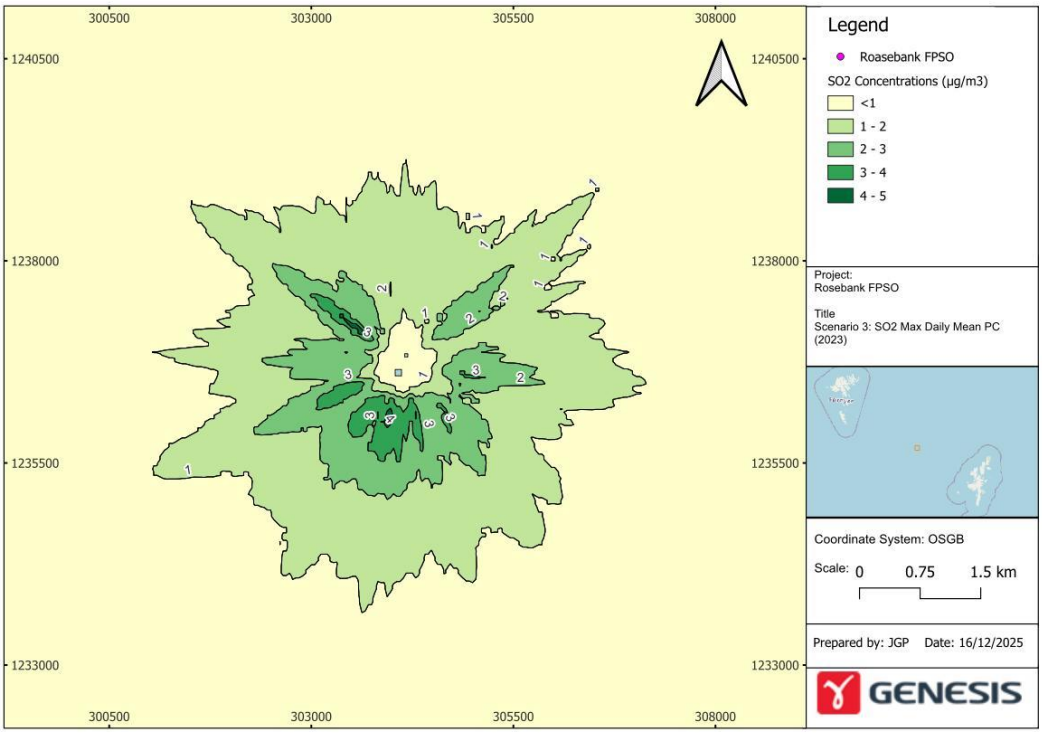


Figure 4-14: Scenario 3: SO_2 24 Hour (99.18th Percentile) Max PC (µg/m^3)

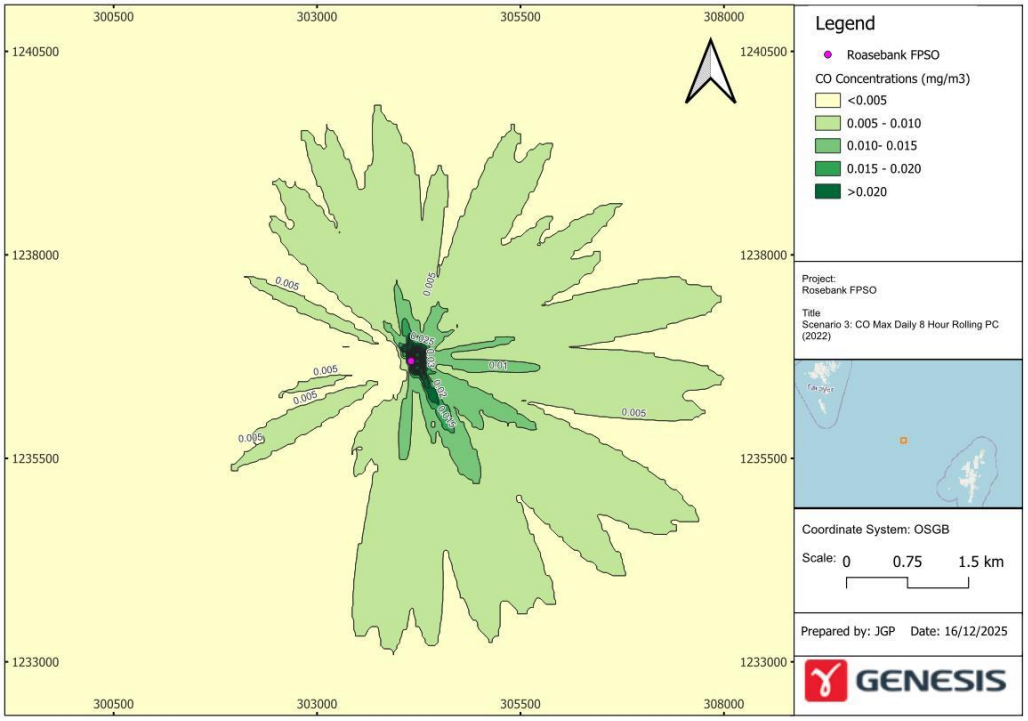


Figure 4-15: Scenario 3: CO Max Daily Running 8 - Hour Mean Max PC (µg/m^3)

5.0 CONCLUSIONS

An air quality assessment was undertaken for the Rosebank FPSO as part of the PPC Permit Application.

The production emissions from the Rosebank FPSO on sensitive receptors, offshore and onshore, has been assessed using dispersion modelling. The results have been compared to the UK short-term and long-term ambient air quality objectives.

The power demand of the main combustion equipment for the Rosebank FPSO is anticipated to be up to 70% load of the gas turbines. To ensure the air quality assessment is conservative with respect to planned operation, the Rosebank FPSO gas turbine emissions were modelled at higher power demand loads. Details of the modelled scenarios are listed below:

- Scenario 1: Normal Operations. 3 x Solar Titan 130 running on fuel gas at 84% load;
- Scenario 1b: Sensitivity Test. 2 x Solar Titan 130 running on fuel gas at 84% load plus 2x Solar Titan 130 running on fuel gas at <50% load (No DLE NOx Technology in operation);
- Scenario 2: Non-Routine Operations. 3 x Solar Titan 130 operation running on diesel at 89% load;
- Scenario 3: Non-Routine Operations with flaring. 2 x Solar Titan 130 Operation on diesel running on diesel at 89% load with flaring. As demand is reduced, fewer turbines are required to be running.

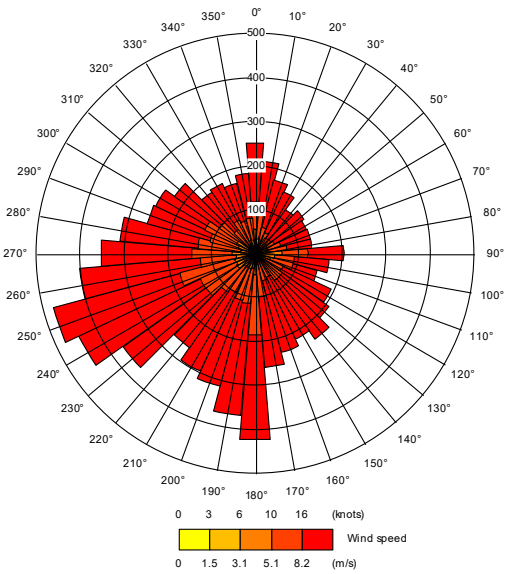
The results of the air quality assessment showed that overall, the short-term and long-term NO_2, SO_2 and CO Process Contributions (PCs) have been screened out as insignificant (1% of the Air Quality Standards), except for the short-term NO_2 PCs during non-routine operations, Scenarios 2 and 3, (>10% of the Air Quality Standard). The NO_2 Predicted Environmental Concentrations (PECs) for these two scenarios ranged between 13.6% and 24.9% of the short-term air quality standard (200 µg/m^3) and therefore considered to be insignificant.

It is observed for all scenarios, that the NO_2, SO_2, and CO AQS limits were not exceeded at any receptor modelled. Key pollutant concentrations for all scenarios have been identified as insignificant.

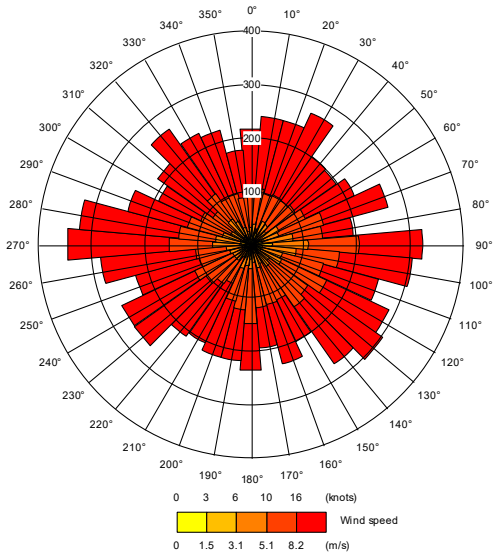
6.0 REFERENCES

REFERENCE	DESCRIPTION
1	Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control)
2	Defra (2010). National Air Quality Objectives. Available at: https://uk-air.defra.gov.uk/assets/documents/National_air_quality_objectives.pdf.
3	Gov UK (2025). Guidance: Air emissions risk assessment for your environmental permit. Available at: https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit
4	Cambridge Environmental Research Consultants (CERC) (2023). ADMS 6. Available at: http://www.cerc.co.uk
5	Genesis (2025). Petrojarl Rosebank FPSO BAT Assessment (PPC/352). PPC Permit Application Support
6	Department for Energy, Security & Net Zero (2023) Offshore Pollution Prevention and Control (PPC) Guidance
7	UK Department of Energy & Climate Change (2025). EEMS-Atmospheric Emissions Calculations
8	Department for Environment, Food and Rural Affairs (2021). Background Mapping data for local authorities. Available at: https://uk-air.defra.gov.uk/data/laqm-background-home
9	Gov UK (2024). Environmental permitting: air dispersion modelling reports. Available at: https://www.gov.uk/guidance/environmental-permitting-air-dispersion-modelling-report
10	Technical Bulletin – Modelling Open Flares (Ontario Regulation 419/05 Air Pollution – Local Air Quality (O. Reg. 419/05))
11	ADM Ltd. ADM Ltd has been a trusted provider of model-ready meteorological data for more than 25 years. https://www.aboutair.com/
12	ALTERA (2021). Flare, Vent, Relief and Blow Down Study Report.
13	ALTERA (2026) PPC Permit Application Support. Petrojarl Rosebank FPSO BAT Assessment (PPC/123). Report No. 217505C-003-RT-6200-0001/2

APPENDIX A: WINDROSE ROSEBANK



2022



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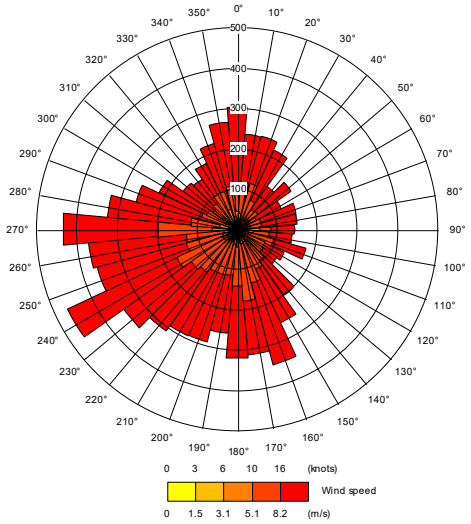

2024

APPENDIX B: FULL RESULTS

This appendix has the modelling results for each pollutant for all scenarios modelled.

NO_2

Table B-1: Scenario 1: NO_2 Annual Mean Concentrations (µg/m^3).

RECEPTOR	PC			PC (MAX)	PC (%AQS)	BC	PEC	PEC (%AQS)
	2022	2023	2024					
Max on Rosebank Grid	0.21	0.20	0.24	0.24	0.6	1.0	1.2	3.1
Max on UKCS Median Grid	<0.1	<0.1	<0.1	<0.1	<0.1	1.0	1.0	2.5
1.UKCS Median Line	<0.1	<0.1	<0.1	<0.1	<0.1	1.0	1.0	2.5
2.Clair Ridge	<0.1	<0.1	<0.1	<0.1	<0.1	1.0	1.0	2.5
3.Clair	<0.1	<0.1	<0.1	<0.1	<0.1	1.0	1.0	2.5
4.Glen Lyon	<0.1	<0.1	<0.1	<0.1	<0.1	1.0	1.0	2.5
5.Foinaven	<0.1	<0.1	<0.1	<0.1	<0.1	1.0	1.0	2.5
6.Shetland (Onshore)	<0.1	<0.1	<0.1	<0.1	<0.1	1.0	1.0	2.5

Table B-2: All Scenarios: NO_2 1-Hour Mean concentrations (µg/m^3)

ID	RECEPTOR	PC			PC (MAX)	PC (%AQS)	BC	PEC	PEC (%AQS)
		2022	2023	2024					
Scenario 1	Max on Rosebank Grid	3.26	3.45	3.37	3.45	1.7	2.0	5.4	2.7
	Max on UKCS Median Grid	0.28	0.34	0.26	0.34	0.2	2.0	2.3	1.2
	1.UKCS Median Line	0.17	0.22	0.19	0.22	0.1	2.0	2.2	1.1
	2.Clair Ridge	0.04	0.06	0.04	0.06	<0.1	2.0	2.0	1.0
	3.Clair	0.04	0.05	0.04	0.05	<0.1	2.0	2.0	1.0
	4.Glen Lyon	0.04	0.05	0.04	0.05	<0.1	2.0	2.0	1.0
	5.Foinaven	0.04	0.05	0.04	0.05	<0.1	2.0	2.0	1.0
	6.Shetland (Onshore)	0.02	0.03	0.02	0.03	<0.1	2.0	2.0	1.0
Scenario 1b	Max on Rosebank Grid	7.80	8.19	8.00	8.19	4.1	2.0	10.1	5.1
	Max on UKCS Median Grid	0.68	0.78	0.61	0.78	0.4	2.0	2.7	1.4
	1.UKCS Median Line	0.38	0.49	0.41	0.49	0.2	2.0	2.4	1.2
	2.Clair Ridge	0.09	0.13	0.08	0.13	0.1	2.0	2.1	1.0
	3.Clair	0.09	0.11	0.08	0.11	0.1	2.0	2.1	1.0
	4.Glen Lyon	0.08	0.11	0.12	0.12	0.1	2.0	2.1	1.0
	5.Foinaven	0.08	0.11	0.09	0.11	0.1	2.0	2.1	1.0
	6.Shetland (Onshore)	0.04	0.06	0.04	0.06	<0.1	2.0	2.0	1.0
Scenario 2	Max on Rosebank Grid	23.69	25.14	24.55	25.14	12.6	2.0	27.1	13.6
	Max on UKCS Median Grid	2.04	2.52	1.93	2.52	1.3	2.0	4.5	2.2
	1.UKCS Median Line	1.31	1.64	1.31	1.64	0.8	2.0	3.6	1.8
	2.Clair Ridge	0.31	0.42	0.29	0.42	0.2	2.0	2.4	1.2
	3.Clair	0.33	0.37	0.28	0.37	0.2	2.0	2.3	1.2
	4.Glen Lyon	0.28	0.37	0.31	0.37	0.2	2.0	2.3	1.2

Table B-2: All Scenarios: NO_2 1-Hour Mean concentrations (µg/m^3)

ID	RECEPTOR	PC			PC (MAX)	PC (%AQS)	BC	PEC	PEC (%AQS)
		2022	2023	2024					
	5.Foinaven	0.28	0.38	0.32	0.38	0.2	2.0	2.3	1.2
	6.Shetland (Onshore)	0.14	0.20	0.14	0.20	0.1	2.0	2.2	1.1
Scenario 3	Max on Rosebank Grid	47.90	37.50	43.80	47.90	23.9	2.0	49.9	24.9
	Max on UKCS Median Grid	1.36	1.68	1.28	1.68	0.8	2.0	3.6	1.8
	1.UKCS Median Line	0.88	1.10	0.88	1.10	0.5	2.0	3.1	1.5
	2.Clair Ridge	0.21	0.28	0.20	0.28	0.1	2.0	2.2	1.1
	3.Clair	0.22	0.25	0.19	0.25	0.1	2.0	2.2	1.1
	4.Glen Lyon	0.20	0.25	0.21	0.25	0.1	2.0	2.2	1.1
	5.Foinaven	0.19	0.25	0.22	0.25	0.1	2.0	2.2	1.1
	6.Shetland (Onshore)	0.09	0.14	0.10	0.14	0.1	2.0	2.1	1.0

SO_2

Table B-3: Scenarios 2 and 3: SO_2 15- Minute Mean Concentrations (µg/m^3)

ID	RECEPTOR	PC			PC (MAX)	PC (%AQS)	BC	PEC	PEC (%AQS)
		2022	2023	2024					
Scenario 2	Max on Rosebank Grid	11.26	12.03	11.39	12.03	4.5	0.4	12.4	4.7
	Max on UKCS Median Grid	1.68	2.07	1.73	2.07	0.8	0.4	2.5	0.9
	1.UKCS Median Line	1.13	1.30	1.03	1.30	0.5	0.4	1.7	0.6
	2.Clair Ridge	0.26	0.30	0.20	0.30	0.1	0.4	0.7	0.3
	3.Clair	0.27	0.30	0.23	0.30	0.1	0.4	0.7	0.3
	4.Glen Lyon	0.31	0.32	0.24	0.32	0.1	0.4	0.7	0.3
	5.Foinaven	0.25	0.30	0.25	0.30	0.1	0.4	0.7	0.3
	6.Shetland (Onshore)	0.12	0.24	0.12	0.24	0.1	0.4	0.6	0.2
Scenario 3	Max on Rosebank Grid	7.52	8.03	7.62	8.03	3.0	0.4	8.4	3.2
	Max on UKCS Median Grid	1.12	1.38	1.15	1.38	0.5	0.4	1.8	0.7
	1.UKCS Median Line	0.76	0.87	0.68	0.87	0.3	0.4	1.3	0.5
	2.Clair Ridge	0.18	0.20	0.13	0.20	0.1	0.4	0.6	0.2
	3.Clair	0.18	0.20	0.15	0.20	0.1	0.4	0.6	0.2
	4.Glen Lyon	0.21	0.22	0.16	0.22	0.1	0.4	0.6	0.2
	5.Foinaven	0.17	0.20	0.17	0.20	0.1	0.4	0.6	0.2
	6.Shetland (Onshore)	0.08	0.16	0.08	0.16	0.1	0.4	0.5	0.2

Table B-4: Scenarios 2 and 3: SO_2 1- Hour Mean Concentrations (µg/m³)

ID	RECEPTOR	PC			PC (MAX)	PC (%AQS)	BC	PEC	PEC (%AQS)
		2022	2023	2024					
Scenario 2	Max on Rosebank Grid	9.91	10.44	10.30	10.44	3.0	0.4	10.8	3.1
	Max on UKCS Median Grid	0.82	1.02	0.75	1.02	0.3	0.4	1.4	0.4
	1.UKCS Median Line	0.50	0.65	0.51	0.65	0.2	0.4	1.0	0.3
	2.Clair Ridge	0.13	0.16	0.11	0.16	<0.1	0.4	0.6	0.2
	3.Clair	0.13	0.14	0.11	0.14	<0.1	0.4	0.5	0.2
	4.Glen Lyon	0.11	0.14	0.12	0.14	<0.1	0.4	0.5	0.2
	5.Foinaven	0.09	0.14	0.11	0.14	<0.1	0.4	0.5	0.2
	6.Shetland (Onshore)	0.05	0.08	0.05	0.08	<0.1	0.4	0.5	0.1
Scenario 3	Max on Rosebank Grid	6.64	6.98	6.86	6.98	2.0	0.4	7.4	2.1
	Max on UKCS Median Grid	0.54	0.68	0.50	0.68	0.2	0.4	1.1	0.3
	1.UKCS Median Line	0.33	0.43	0.34	0.43	0.1	0.4	0.8	0.2
	2.Clair Ridge	0.09	0.11	0.08	0.11	<0.1	0.4	0.5	0.1
	3.Clair	0.08	0.10	0.07	0.10	<0.1	0.4	0.5	0.1
	4.Glen Lyon	0.07	0.10	0.08	0.10	<0.1	0.4	0.5	0.1
	5.Foinaven	0.06	0.09	0.07	0.09	<0.1	0.4	0.5	0.1
	6.Shetland (Onshore)	0.04	0.05	0.04	0.05	<0.1	0.4	0.4	0.1

Table B-5: Scenarios 2 and 3: SO_2 Daily Mean Concentrations (µg/m³)

ID	RECEPTOR	PC			PC (MAX)	PC (%AQS)	BC	PEC	PEC (%AQS)
		2022	2023	2024					
Scenario 2	Max on Rosebank Grid	6.20	6.50	6.53	6.53	5.2	0.4	6.9	5.5
	Max on UKCS Median Grid	0.34	0.33	0.27	0.34	0.3	0.4	0.7	0.6
	1.UKCS Median Line	0.18	0.19	0.14	0.19	0.2	0.4	0.6	0.5
	2.Clair Ridge	0.03	0.03	0.02	0.03	<0.1	0.4	0.4	0.3
	3.Clair	0.04	0.03	0.02	0.04	<0.1	0.4	0.4	0.3
	4.Glen Lyon	0.04	0.04	0.05	0.05	<0.1	0.4	0.4	0.4
	5.Foinaven	0.02	0.03	0.03	0.03	<0.1	0.4	0.4	0.3
	6.Shetland (Onshore)	0.02	0.02	0.01	0.02	<0.1	0.4	0.4	0.3
Scenario 3	Max on Rosebank Grid	4.13	4.36	4.35	4.36	3.5	0.4	4.8	3.8
	Max on UKCS Median Grid	0.23	0.22	0.18	0.23	0.2	0.4	0.6	0.5
	1.UKCS Median Line	0.12	0.13	0.09	0.13	0.1	0.4	0.5	0.4
	2.Clair Ridge	0.02	0.02	0.02	0.02	<0.1	0.4	0.4	0.3
	3.Clair	0.03	0.02	0.02	0.03	<0.1	0.4	0.4	0.3
	4.Glen Lyon	0.03	0.03	0.03	0.03	<0.1	0.4	0.4	0.3
	5.Foinaven	0.01	0.02	0.02	0.02	<0.1	0.4	0.4	0.3
	6.Shetland (Onshore)	0.01	0.01	0.01	0.01	<0.1	0.4	0.4	0.3

CO

Table B-6: All Scenarios: CO Max Daily Running 8 - Hour Mean Concentrations (mg/m^3)

ID	RECEPTOR	PC			PC (MAX)	PC (%AQS)	BC	PEC	PEC (%AQS)
		2022	2023	2024					
Scenario 1	Max on Rosebank Grid	0.028	0.030	0.029	0.030	0.3	0.4	0.4	4.3
	Max on UKCS Median Grid	0.002	0.003	0.002	0.003	<0.1	0.4	0.4	4.1
	1.UKCS Median Line	<0.001	<0.001	<0.001	<0.001	<0.1	0.4	0.4	4.0
	2.Clair Ridge	<0.001	<0.001	<0.001	<0.001	<0.1	0.4	0.4	4.0
	3.Clair	<0.001	<0.001	<0.001	<0.001	<0.1	0.4	0.4	4.0
	4.Glen Lyon	<0.001	<0.001	<0.001	<0.001	<0.1	0.4	0.4	4.0
	5.Foinaven	<0.001	<0.001	<0.001	<0.001	<0.1	0.4	0.4	4.0
	6.Shetland (Onshore)	<0.001	<0.001	<0.001	<0.001	<0.1	0.4	0.4	4.0
Scenario 1b	Max on Rosebank Grid	0.035	0.039	0.037	0.039	0.4	0.4	0.4	4.4
	Max on UKCS Median Grid	<0.001	<0.001	<0.001	<0.001	<0.1	0.4	0.4	4.1
	1.UKCS Median Line	<0.001	<0.001	<0.001	<0.001	<0.1	0.4	0.4	4.0
	2.Clair Ridge	<0.001	<0.001	<0.001	<0.001	<0.1	0.4	0.4	4.0
	3.Clair	<0.001	<0.001	<0.001	<0.001	<0.1	0.4	0.4	4.0
	4.Glen Lyon	<0.001	<0.001	<0.001	<0.001	<0.1	0.4	0.4	4.0
	5.Foinaven	<0.001	<0.001	<0.001	<0.001	<0.1	0.4	0.4	4.0
	6.Shetland (Onshore)	<0.001	<0.001	<0.001	<0.001	<0.1	0.4	0.4	4.0
Scenario 2	Max on Rosebank Grid	0.005	0.005	0.005	0.005	0.1	0.4	0.4	4.1
	Max on UKCS Median Grid	<0.001	<0.001	<0.001	<0.001	<0.1	0.4	0.4	4.0
	1.UKCS Median Line	<0.001	<0.001	<0.001	<0.001	<0.1	0.4	0.4	4.0
	2.Clair Ridge	<0.001	<0.001	<0.001	<0.001	<0.1	0.4	0.4	4.0
	3.Clair	<0.001	<0.001	<0.001	<0.001	<0.1	0.4	0.4	4.0
	4.Glen Lyon	<0.001	<0.001	<0.001	<0.001	<0.1	0.4	0.4	4.0

Table B-6: All Scenarios: CO Max Daily Running 8 - Hour Mean Concentrations (mg/m^3)

ID	RECEPTOR	PC			PC (MAX)	PC (%AQS)	BC	PEC	PEC (%AQS)
		2022	2023	2024					
	5.Foinaven	<0.001	<0.001	<0.001	<0.001	<0.1	0.4	0.4	4.0
	6.Shetland (Onshore)	<0.001	<0.001	<0.001	<0.001	<0.1	0.4	0.4	4.0
Scenario 3	Max on Rosebank Grid	0.788	0.623	0.732	0.788	7.9	0.4	1.2	11.9
	Max on UKCS Median Grid	<0.001	<0.001	<0.001	<0.001	<0.1	0.4	0.4	4.0
	1.UKCS Median Line	<0.001	<0.001	<0.001	<0.001	<0.1	0.4	0.4	4.0
	2.Clair Ridge	<0.001	<0.001	<0.001	<0.001	<0.1	0.4	0.4	4.0
	3.Clair	<0.001	<0.001	<0.001	<0.001	<0.1	0.4	0.4	4.0
	4.Glen Lyon	<0.001	<0.001	<0.001	<0.001	<0.1	0.4	0.4	4.0
	5.Foinaven	<0.001	<0.001	<0.001	<0.001	<0.1	0.4	0.4	4.0
	6.Shetland (Onshore)	<0.001	<0.001	<0.001	<0.001	<0.1	0.4	0.4	4.0