Cloughton Appraisal Well

Cloughton Appraisal Wellsite, Burniston Mill, Burniston, YO13 0DB

Air quality assessment of hydrocarbon appraisal operations

Carried out for:

Europa Oil and Gas Limited

30 Newman Street
London
W1T PT1

Carried out by:

SOCOTEC UK Limited

Unit D
Bankside Trade Park
Cirencester
Gloucestershire
GL7 1YT

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Air quality assessment of hydrocarbon appraisal operations
Europa Oil and Gas Limited, Cloughton Appraisal Well, Burniston

SUMMARY

Europa Oil and Gas Limited proposes to undertake hydrocarbon appraisal operations on land off the A165 to the south east of Burniston. The proposal is to construct a wellsite, drill a single well and undertake production appraisal operations before reinstating the land. It is expected that operations will take around a year, although taking into account equipment availability and lead times, it is likely that the development will be staggered over a period of up to three years.

As part of the planning and permitting process it is necessary to assess the dispersion of releases to atmosphere associated with the proposed development to determine their impact on ambient concentrations of important pollutants around the local area. In particular, impact at locations of permanent human habitation and designated and local ecological sites, in the context of attainment of applicable environmental standards, requires assessment.

The predominant source of pollutant releases during site operations will be from the use of diesel fuel in mobile plant and stationary engines and from the incineration of produced natural gas. Releases of nitrogen oxides, carbon monoxide, volatile organic compounds, particulate matter and sulphur dioxide were therefore considered. The assessment was undertaken using the UK ADMS 6 modelling system, with an operating regime considered to provide unlikely worst case conditions for pollutant releases and air quality impact.

Maximum pollutant process contributions from site operations occur within the proposed wellsite boundary. Beyond this location, process contributions reduce significantly with distance. It is not considered that statutory air quality standards would be applicable around the area of maximum impact, or around and just beyond the site boundary, due to the infrequency of human exposure and limited access.

Along the nearby public footpaths, where short term environmental standards might be expected to apply, it is considered that process pollutant contributions in practice will be insignificant and unlikely to compromise attainment of these standards.

At neighbouring locations of residential occupation, where long term human exposure might be expected, it is considered that, in practice pollutant process contributions from the site operations will be insignificant, with predicted environmental concentrations of all pollutants around, and in most cases substantially less than, a third of the applicable standard.

Bearing in mind the precautionary assumptions made in the assessment, it is considered unlikely that pollutant process contributions from the development will pose any risk to, or have any meaningful influence on, the continued attainment of air quality standards at the nearest locations of human exposure.

At the nearest designated and local ecological sites requiring assessment, which are sensitive to nitrogen oxides, sulphur dioxide and nitrogen and acid deposition, process contributions are considered unlikely to pose any threat to, or have any substantial influence on, the attainment of critical levels and critical loads.

Necessary assumptions made to undertake the modelling are considered to have the effect of substantially overestimating the process contribution to ambient concentrations. It is considered that the predicted process impact reported herein is a conservative assessment and the conclusions reached therefore incorporate a reasonable margin of comfort in spite of the inevitable uncertainty of such modelling studies.

It is likely that the construction activities associated with the development of the wellsite and the reinstatement of the site will give rise to dust emissions. It is expected, based on Institute of Air Quality Management methodology, that with adequate mitigation measures in place the risk of dust impact from all proposed development operations will be 'negligible'.

Increases in road traffic, brought about by the construction activities and subsequent site operation, are assessed to have a neutral impact on air quality based on the guidance within Highways England's (now National Highways) Design Manual for Roads and Bridges.

Operations on site will give rise to releases of greenhouse gases. Based on an assessment of worst case operation, it is considered that proposed development lifetime greenhouse gas releases are largely insignificant in relation to the UK's current inventory and future budgets at around 9900 tonnes CO_2 equivalent. A separate assessment of the estimated downstream greenhouse gas emissions arising from the development accompanies the planning application.

There is a risk, albeit considered negligible, of fugitive releases of natural has during well drilling development and testing. The sulphur compounds within this release are potentially odorous. An odour impact assessment concluded that fugitive releases pose a negligible risk to loss of amenity due to odour at the nearest residential neighbours.

1   INTRODUCTION

Europa Oil and Gas Limited (Europa) placed a contract with SOCOTEC UK Limited (SOCOTEC) to undertake an assessment of the impact on local air quality of proposed hydrocarbon appraisal operations at their Cloughton wellsite near Burniston.

1.1   Scope of study

Europa proposes to undertake hydrocarbon appraisal operations on land off the A165 to the south east of Burniston. The proposal is to construct a wellsite, drill a single well and undertake production appraisal operations before reinstating the land. It is expected that operations will take around a year, although taking into account equipment availability and lead times, it is likely that the development will be staggered over a period of up to three years. In the event that appraisal test proves satisfactory, any future production operations would be the subject of a separate planning application.

As part of the planning and permitting process, the dispersion of releases to atmosphere associated with the wellsite development and production testing has been assessed to determine their impact on ambient concentrations of important pollutants around the local area.

The main sources of pollutant releases during site development, testing and reinstatement will be from the use of diesel fuel in on-site stationary engines and construction and transport vehicles and from the short term disposal of produced natural gas by incineration.

Releases of nitrogen oxides, carbon monoxide, volatile organic compounds, sulphur dioxide and particulate matter were considered. The assessment was undertaken using the UK ADMS 6 modelling system with an operating scenario considered to provide worst case conditions for pollutant releases and air quality impact for the proposed development.

The purpose of this study is to determine whether, under what is considered a worst case operating regime, releases to atmosphere are likely to be dispersed adequately in the context of applicable environmental standard attainment.

1.2   General approach

The approach taken comprised the following main stages:

- Determine a suitable modelling tool for the assessment.
- Collect appropriate representative operational data for the plant and vehicles intended for use for input to the model.
- Establish the proposed timeline for operations and their duration and frequency to determine the amount of discharges from each source and the likely timeline for discharge.
- Establish the location of the points of discharge for each source relative to proposed temporary structures on the wellsite.
- Establish the locations of any sensitive areas that might be impacted by releases from the wellsite including residential properties, public footpaths and designated and local ecological sites.
- Obtain information on local background concentrations of important pollutants.
- Obtain 5 years' recent meteorological data from a measurement station representative of the wellsite location.
- Model the dispersion of releases from the site operations to determine the process contribution to ambient concentrations of selected pollutants over the local area with particular attention to locations of human exposure and designated and local ecological sites.

- Assess the predicted process contributions and established background concentrations with reference to applicable environmental standards to determine compliance.
- Undertake a sensitivity analysis on the results for other important variable parameters and assess compliance with applicable environmental standards.

Further details of the approach taken and model input information are provided in the following sections.

1.3   Structure of the report

This report provides an assessment of the impact of releases from proposed wellsite development and hydrocarbon production test operations on local air quality around the Cloughton Appraisal wellsite, near Burniston. The approach to the assessment has been described above. The following sections provide a detailed commentary on the assessment and conclusions:

Section 2   Policy context and assessment criteria
Section 3   Modelling methodology
Section 4   Modelling results
Section 5   Conclusions

2   POLICY CONTEXT AND ASSESSMENT CRITERIA

Europa proposes to undertake hydrocarbon appraisal operations on land off the A165 to the south east of Burniston. The proposal is to construct a wellsite, drill a single well and undertake production appraisal operations before reinstating the land. It is expected that operations will take around a year, although taking into account equipment availability and lead times, it is likely that the development will be staggered over a period of up to three years. In the event that appraisal test proves satisfactory, any future production operations would be the subject of a separate Application.

The proposed wellsite is currently farmland adjacent to an existing ground-mounted solar photovoltaic array and near a small industrial area accessed by an existing track off the A165 (Coastal Road) to the south east of Burniston. The site lies within a rural area. An animal feed mill is around 200m to the south west of the wellsite and the nearest residential property (Wayside Farm) is around 320m to the south west. Further residential properties are located to the south west beyond the A165 in Burniston at a distance of around 350m. The wellsite is partly screened by existing woodland to the south and north. The nearest ecological conservation site is around 440m to the east (Scarborough to Whitby disused railway site of importance for nature conservation).

2.1   Context of assessment

As part of the planning and permitting application, it is necessary to demonstrate the likely impact of the proposed development on local ambient concentrations of important pollutants. It is in this context that the operations are being examined to determine their additional contribution to the existing concentrations of pollutants and therefore determine compliance with applicable air quality standards and environmental benchmarks.

Local Authorities are required to assess compliance with applicable air quality objectives. Where the objectives are unlikely to be met, the Local Authority is required to declare an Air Quality Management Area (AQMA) and prepare proposals for remedial action to achieve the required objective. The nearest AQMA is the Scarborough AQMA, around 35km to the north west, designated for 24 hour mean PM_{10}. The Hull AQMA designated for annual mean nitrogen dioxide is around 62km to the south. It is considered highly unlikely that ambient pollutant concentrations at either AQMA would be influenced by releases from the proposed Cloughton Appraisal wellsite. In this case the impact of wellsite releases at AQMAs is not considered.

A survey of planning and permitting applications did not indicated any recently approved, or proposed future developments, with the potential to influence background concentrations of pollutants of interest in the area near the wellsite. In this case in-combination effects are not considered.

The Environment Agency play an important role in relation to local air quality management by ensuring that processes under their regulatory control do not contribute any significant threat to the attainment of air quality standards. As part of the planning and permitting process, it is necessary to demonstrate the impact of site operations on local air quality in the context of the published guidance provided by the Environment Agency[1].

2.2   Local policies

The following policies are most relevant to the preparation of an Air Quality Assessment in North Yorkshire. These have been taken into account in preparing this Assessment.

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Minerals and Waster Joint Plan (2022)

D14 Air quality

Proposals for mineral and waste development will be permitted provided that:

(a) there are no unacceptable impacts on the intrinsic quality of air;
and
(b) there are no unacceptable impacts on the management and protection of air quality, including any unacceptable impacts on Air Quality Management Areas.

M17 Other spatial and locational criteria applying to hydrocarbon development

Cumulative impact

2(i) Hydrocarbon development will be permitted in locations where it would not give rise to unacceptable cumulative impact, as a result of a combination of individual impacts from the same development and/or through combinations of impacts in conjunction with other existing, planned or unrestored hydrocarbons development.

Specific local amenity considerations relevant to hydrocarbon development

4(i) Hydrocarbon development will be permitted in locations where it would not give rise to unacceptable impact on local communities or public health. Adequate separation distances should be maintained between hydrocarbon development and residential buildings and other sensitive receptors in order to protect against unacceptable adverse individual and cumulative impacts on amenity and public health….

4(II) Proposals should refer to any relevant data from baseline monitoring and other available information to ensure that a robust assessment of potential impacts is undertaken…

4(iii) Proposals involving hydraulic fracturing should be accompanied by an air quality monitoring plan and Health Impact Assessment.

The assessment herein considers the above policies. It may be noted that in the pre-application advice, no requirement for an air quality monitoring plan was identified and as such at this stage this is not included within the Application.

2.3   Pollutants from wellsite operations

The principal source of pollutant releases to atmosphere will be the operation of stationary and mobile plant and vehicles:

- Stationary diesel engines and generators providing power for site drilling operations
- The disposal by incineration of produced natural gas during well testing
- Non-road mobile plant brought to site for construction and site restoration operations
- The movement of heavy duty vehicles (HDV) for transport operations throughout the proposed development.

All plant will be diesel fuelled and as such pollutant releases will be characteristic of the combustion of diesel fuel. The main pollutants from the combustion of diesel fuel are oxides of nitrogen, carbon monoxide and fine particulate matter. In addition to the combustion of diesel fuel, the natural gas produced during production test operations will be disposed of by incineration. Combustion of natural gas will give rise to the same pollutants as combustion of diesel fuel, although it is not expected that there will be any significant releases of particulate matter.

Oxides of nitrogen are generally considered to comprise primarily of nitrogen monoxide and nitrogen dioxide. While nitrogen oxides from road transport is a major contributor to ground level concentrations, emissions from combustion processes are also significant. Oxides of nitrogen are associated with lung damage and enhanced sensitivity to allergens. Emissions from combustion primarily consist of nitrogen monoxide, although reaction in the atmosphere results in conversion to nitrogen dioxide, which is the primary nitrogen oxide of interest with respect to ambient pollution. The emission of nitrogen oxides and their transformation products can cause a wide range of environmental effects including acidification and eutrophication

Combustion of diesel fuel will generally release some form of particulate matter. Particle size will determine the potential impact. Generally, the finer the particulate, the further it can travel into the human respiratory system. Particle size is defined by effective aerodynamic diameter. Material termed PM_{10} (i.e. all particles with an effective aerodynamic diameter up to 10µm) is seen as significant in this regard. Lower particle sizes (e.g. $PM_{2.5}$) are also considered in some air quality legislation and are the subject of monitoring.

Carbon monoxide is a product of incomplete combustion of the fuel and is therefore related to combustion efficiency. It reacts with other pollutants to form ground level ozone and has implications for neurological health. With incomplete combustion there is also the risk of elevated levels of volatile organic compounds which can give rise to odours and influence ground level ozone formation.

There will also be a release of sulphur dioxide which will be dependent on the sulphur content of the diesel fuel and the produced natural gas.

Fugitive releases of natural gas, principally methane, are considered unlikely to be significant based on information provided by Europa[2]. Leakages from the well and associated transport pipework on the wellsite are likely to be minimal and will be subject to best practices for loss prevention. Nevertheless, the assessment does consider fugitive releases during the well development and testing phases, at rates considered typical of worldwide oil and gas industry operations, and the implications for odour nuisance due to the potential release of sulphurous compounds (e.g. hydrogen sulphide and mercaptans). For the purposes of the assessment fugitive releases are considered to be the sole contributor to odour releases from site operations.

This assessment considers the air quality impact of the following substances resulting from the proposed wellsite operations:

Nitrogen oxides (NO_x, consisting of nitrogen monoxide (NO) and nitrogen dioxide (NO_2))
Sulphur dioxide (SO_2)
Carbon monoxide (CO)
Particulate matter (considered as both $PM_{2.5}$ and PM_{10})
Volatile organic compounds (VOCs – assessed as benzene)
Odour (due to fugitive releases of hydrogen sulphide (H2S) and mercaptans (as methyl mercaptan (CH_4S)))

2.4   Environmental Standards

The UK's air quality strategy is based on the European Union (EU) Ambient Air Quality Directive (2008/50/EC, 21 May 2008)[3] and the Fourth Daughter Directive (2004/107/EC, relating to metals and hydrocarbons[4]. These directives specify limit values and target values. Limit values are set for individual pollutants and are made up of a concentration value, an averaging time over which it is to be measured, the number of exceedances allowed per year, if any, and a date by which it must be achieved. Some pollutants have more than one limit value covering different endpoints or averaging times. Target values are set out in the same way as limit values and are to be attained where possible by taking all necessary measures not entailing disproportionate costs.

The Air Quality (Standards) Regulations 2010[5] transpose into English law the requirements of Directives 2008/50/EC and 2004/107/EC on ambient air quality. Equivalent regulations have been made by the devolved

administrations in Scotland, Wales and Northern Ireland. Schedules 2 and 3 of the Regulations specify limit and target values respectively.

Table 2.1 summarises the applicable limit values for the substances considered in this assessment as at 2024.

The limit values below are expressed as concentrations recorded over a specified time period which are considered acceptable in terms of current knowledge of the impact on health and the environment. Limit values are legally binding time averaged limits which must not be exceeded. In the case of target values these are values which are expected to be met by a specified date.

Table 2.1   Air Quality Standard Limit Values and Target Values

Substance	Basis	Concentration
Carbon monoxide	running 8 hour mean across a 24 hour period[c]	10 mg/m^3
Nitrogen dioxide	1 hour mean (99.79 percentile – 18 exceedances per year)	200 µg/m^3
	annual mean	40 µg/m^3
Sulphur dioxide	*15 minute mean (99.90 percentile – 35 exceedances per year[a]*	*266 µg/m^3*
	1 hour mean (99.72 percentile – 24 exceedances per year)	350 µg/m^3
	24 hour mean (99.18 percentile – 3 exceedances per year)	125 µg/m^3
PM$_{10}$	24 hour mean (90.41 percentile – 35 exceedances per year)	50 µg/m^3
	annual mean	40 µg/m^3
PM$_{2.5}$	annual mean	20 µg/m^3
Benzene	annual mean	5 µg/m^3

a. Target value included in Environment Agency guidance[1].
b. Annual means refer to a calendar year.
c. Running 8 hour mean for each daily period commences at 1700 on the previous day and is updated every hour for the following 24 hours.

Critical levels are specified for sulphur dioxide and nitrogen oxides in relation to the protection of ecological conservation areas as shown in Table 2.2.

Table 2.2   Critical levels for the protection of ecological conservation areas

Substance	Basis	Concentration
Nitrogen oxides (as NO$_2$)	annual mean	30 µg/m^3
	daily mean[b]	200 µg/m^3
Sulphur dioxide	annual mean[a]	10 µg/m^3

a. refers to the lower limit for sensitive lichen communities & bryophytes and ecosystems where lichens & bryophytes are an important part of the ecosystem's integrity. The upper limit where lichens are not present is 20 µg/m^3.
b. The daily critical level for nitrogen oxides is 75 µg/m^3, although this may be increased[1] to 200 µg/m^3 in the case of detailed assessments where the ozone concentration is below the AOT40 critical level (6000 µg/m^3) and the sulphur dioxide concentration is below the lower critical level of 10 µg/m^3. In this case the AOT 40 for ozone is 3483µg/m^3 (see Annex C) and the sulphur dioxide concentration is less than 10 µg/m^3 (see Table F.2) across all sites considered. As such a daily critical level of 200 µg/m^3 is adopted.

In addition, for the purposes of assessing the significance of pollutants in the ambient atmosphere, the Environment Agency also publish Environmental Assessment Levels (EALs) for the protection of human health[1].

The EALs relevant to this study are summarised in Table 2.3.

Table 2.3   Environmental Assessment Levels

Substance	Basis	Concentration
Carbon monoxide	hourly mean	30000 µg/m^3
Benzene	24 hour mean	30 µg/m^3
Nitrogen monoxide	hourly mean	4400 µg/m^3
	annual mean	310 µg/m^3

Standards for odour are discussed in Annex J.

2.4.1   Application of environmental standards

The Air Quality Standards Regulations 2010[5] specify legally binding concentrations of pollutants in the atmosphere which can broadly be taken to achieve a certain level of environmental quality. The Regulations define ambient air as;

"…outdoor air in the troposphere, excluding workplaces where members of the public do not have regular access."

Compliance with limit values for the protection of human health does not need to be assessed (Schedule 1, Part 1) at the following locations:

a) any location situated within areas where members of the public do not have access and there is no fixed habitation;
b) on factory premises or at industrial locations to which all relevant provisions concerning health and safety at work apply;
c) on the carriageway of roads and on the central reservation of roads except where there is normally pedestrian access to the central reservation.

It is therefore considered that compliance with environmental benchmarks should concentrate on areas where members of the general public are present over the entire duration of the concentration averaging period specific to the relevant standard. For the longer averaging periods the standards are considered to apply around the frontage of premises such as residential properties, schools and hospitals. The shorter term limit values (1 hour or 1 day means) apply at these locations and other areas where exposure is likely to be of one hour or more on a regular basis.

In this context, this assessment of compliance with environmental benchmarks in respect of protection of human health is considered at the residential locations near the Cloughton wellsite and on nearby public footpaths. The assessment of compliance with critical loads and critical levels with respect to ecological impact is assessed at the designated and local ecological sites required for assessment within Environment Agency guidance[1] (see section 2.6.3).

2.5   Background air quality in Burniston

In considering the overall impact of a proposed development, such as this herein, on local air quality and compliance with environmental benchmarks, it is necessary not only to consider the contribution from the proposed source but also the existing levels of pollutants of interest. Background air quality data for the area around the proposed wellsite are available from the Department for Environment Food and Rural Affairs (DEFRA) air quality archive[6]. The archive provides modelled background concentrations of important pollutants for 1km^2 areas for the UK. The latest available background levels for the area within an approximate 1 km radius of the Cloughton wellsite (502090 492810) were used for this assessment. Table 2.4 summarises the background pollutant concentrations obtained from the air quality archive for the assessment area. The values reported are the mean and maximum at the points for which data were available.

Table 2.4   Modelled background pollutant concentrations from the DEFRA archive

Substance	Averaging basis	Concentration ($\mu g/m^3$)	
		Maximum	Mean
Nitrogen dioxide (2022)	annual mean	4.84	4.59
Total nitrogen oxides (2022)	annual mean (as NO_2)	6.22	5.89
Nitrogen monoxide (2022)[a]	annual mean	0.90	0.85
PM_{10} (2022)	annual mean	11.89	11.03
$PM_{2.5}$ (2022)	annual mean	5.22	5.15
Carbon monoxide (2010)	maximum 8 hour rolling mean	1440	1430
Sulphur dioxide (2022)	annual mean	0.98	0.92
Benzene (2022)	annual mean	0.24	0.24

a. calculated based on the difference between total nitrogen oxides and nitrogen dioxide assuming total nitrogen oxides is the sum of nitrogen monoxide and nitrogen dioxide.

North Yorkshire Council[7] does not undertake automatic air quality monitoring in the Burniston area. The nearest automatic monitoring stations covering the pollutants of interest in this case are in excess of 50km from the proposed wellsite in Redcar and York. Non-automatic monitoring for nitrogen dioxide is undertaken, although the nearest monitoring station is around 4km to the south east (Peasholm Drive, Scarborough). There are no monitoring stations within the area considered to be influenced by releases from operations at the proposed wellsite.

For the purposes of this assessment background concentrations are assumed to be the maximum values from the DEFRA archive across the assessment area. This is considered a precautionary approach which will most likely overestimate the existing background concentrations in the important areas of human exposure.

When considering the combination of estimated process contributions and background concentrations it should be noted that background concentrations are generally available as annual mean values and as such simple addition when considering short term air quality standards may not be appropriate. Guidance from the Environment Agency[1] suggests a simplified method for combining estimated process contributions and background concentrations. For comparison with long term standards the overall concentration is the sum of the process contribution (annual mean) and background concentration (annual mean). For comparison with short term standards the Environment Agency suggest the sum of the process contribution (hourly or daily mean) and twice the background concentration (annual mean). This methodology has been employed in this assessment.
Table 2.5 summarises the pollutant background concentrations adopted for this assessment.

Table 2.5   Background concentrations adopted in the assessment

Substance	Averaging basis	Background concentration	
		$\mu g/m^3$	% of standard
Air Quality Standard Limit Values and Target Values			
Carbon monoxide	8 hour mean	1440	14.4
Nitrogen dioxide	1 hour mean	9.68[a]	4.8
	annual mean	4.84	12.1
Sulphur dioxide	15 minute mean	2.62[b]	1.0
	1 hour mean	1.96[a]	0.6
	24 hour mean	1.16[c]	0.9
PM_{10}	24 hour mean	14.03[d]	28.1
	annual mean	11.89	29.7
$PM_{2.5}$	annual mean	5.22	26.1
Benzene[e]	annual mean	0.24	4.8

Table 2.5   continued

Substance	Averaging basis	Background concentration	
		µg/m³	% of standard
Environmental assessment levels			
Carbon monoxide	hourly mean	2059[f]	6.9
Benzene[e]	24 hour mean	0.28[d]	0.9
Nitrogen monoxide	hourly mean	1.8[a]	<0.1
	annual mean	0.9	0.3

a. One hour mean is determined from annual mean value using a conversion factor of 2.0[1].
b. 15 minute mean is determined from the hourly mean using a conversion factor of 1.34[1].
c. 24 hour mean is determined from the hourly mean using a conversion factor of 0.59[1].
d. 24 hour mean is determined from annual mean value using a conversion factor of 1.18 (a and c above).
e. Volatile organic compounds are assessed against the limit value for benzene in accordance with Environment Agency guidance[1] for situations where the composition of the organic compound release is unknown.
f. One hour mean is determined from 8 hour mean using a conversion factor of 1.43[1].

Background levels specific to the designated and local ecological sites considered are obtained from the Air Pollution Information System (APIS)[8] and are discussed later.

2.6   Assessment criteria

The Environment Agency[1] provides a methodology for assessing the impact and determining the acceptability of emissions to atmosphere on ambient air quality for human health and ecology and for deposition to ground. Two stages of assessment are recommended.

Screening assessment – based on standard dispersion factors the ambient impact of releases to atmosphere may be estimated. The estimates tend to be very conservative since no account is taken of plume rise, meteorological conditions or the locations of the sensitive receptors where impact is to be assessed. The estimates are compared with the assessment criteria discussed in sections 2.6.1 to 2.6.3. Where a release can be demonstrated to be 'insignificant' it may be screened out. Where this is not possible a further detailed assessment is required.

Detailed assessment – based on atmospheric dispersion modelling taking into account the factors which influence dispersion and ambient impact (e.g. meteorology, release conditions, locations of sensitive receptors, etc.). Process contributions and predicted environmental concentrations are compared with the same assessment criteria. Where conditions for excluding the release from further consideration cannot be made, a detailed cost benefit assessment will be necessary.

In this assessment all releases have been assessed using detailed modelling approach only.

The criteria considered in this assessment are described below.

2.6.1 Criteria relevant to human health

The contribution of the process (PC) to the ambient concentration of a given pollutant is considered insignificant and requiring no further assessment, if both of the following conditions are met:

- the long term PC is less than 1% of the long term environmental standard
- the short term PC is less than 10% of the short term environmental standard

If these conditions are not met then the corresponding predicted environmental concentration (PEC, PC + background concentration) should be assessed. The process contribution is considered insignificant and requiring no further assessment, if both of the following conditions are met:

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

If these conditions are not met then the compliance of the process with Best Available Technique (BAT) will need to be assessed. No further action is necessary if it can be demonstrated that both of the following apply:

- proposed emissions comply with BAT associated emission levels (AELs) or the equivalent requirements where there is no BAT AEL
- the resulting PECs won't exceed environmental standards

Failure to meet these criteria requires that a cost-benefit analysis be undertaken for consideration by the Environment Agency.

2.6.2   Criteria for deposition to ground

Where any of the substances in Table 2.6 are released it is required that the impact they have when absorbed by soil and leaves (termed 'deposition') is assessed.

If the PC to ground for any of these substances is below 1% of the limit it is insignificant and requires no further assessment. Where the PC to ground is 1% of the limit or greater a further assessment will be necessary. In this case none of the substances in Table 2.6 are considered to be released in a quantity sufficient to merit an assessment for deposition to ground.

Table 2.6   Limits for deposition to ground

Substance	Deposition limit (PC to ground) $\mu g/m^2/day$
Arsenic	0.02
Cadmium	0.009
Chromium	1.5
Copper	0.25
Fluoride	2.1
Lead	1.1
Mercury	0.004
Molybdenum	0.016
Nickel	0.11
Selenium	0.012
Zinc	0.48

2.6.3   Criteria relevant to protected conservation areas

Where there are protected conservation areas near the release it is necessary to consider the impact of following pollutants:

- nitrogen oxides (long and short term bases)
- sulphur dioxide (long term basis)
- ammonia (long term basis)
- hydrogen fluoride (long and short term bases)
- nutrient nitrogen and acid deposition

In this case releases of nitrogen oxides and sulphur dioxide are considered, together with their impact in relation to the deposition of nutrient nitrogen and acid.

An assessment is required where the release is within 10 km (15 km if the site is a large electric power station or refinery) of any of the following designated sites:

- special protection area (SPA)
- special area of conservation (SAC)
- Ramsar site (protected wetland of international importance)

or within 2 km of a:

- site of special scientific interest (SSSI)
- local nature site (ancient wood, local wildlife site (LWS) and national or local nature reserve (NNR, LNR))

For some larger (greater than 50 MW) emitters there may be a requirement to extend the assessment to:

- 15km for European sites
- 10km or 15km for SSSIs

The impact of air emissions on protected conservation areas at a distance of 15km should be considered for both:

- natural gas (or fuels with a similarly low sulphur content) fired combustion plants, with more than 500 MW thermal input
- some larger combustion plants using more sulphurous fuels with more than 50 MW thermal input

If the PC at a SPA, SAC, Ramsar or SSSI meets both of the following criteria, it is insignificant and no further assessment is required:

- the short term PC is less than 10% of the short-term environmental standard for protected conservation areas
- the long term PC is less than 1% of the long-term environmental standard for protected conservation areas

If these criteria are not met then the corresponding PEC should be assessed. The emission is considered insignificant if:

- the long term PC is greater than 1% and the corresponding PEC is less than 70% of the long term environmental standard,

If either of the following criteria are met, a more detailed consideration of ecological impact is required:

- the long term PC is greater than 1% and the long term PEC is greater than 70% of the long term environmental standard
- the short term PC is greater than 10% of the short term environmental standard

For local conservation areas releases are considered insignificant where both of the following criteria are met:

- the short term PC is less than 100% of the short term environmental standard
- the long term PC is less than 100% of the long term environmental standard

A failure to meet the above criteria requires a more detailed consideration of ecological impact.

Environmental standards for conservation areas such as critical levels for ambient air and critical loads for nitrogen and acid deposition are considered specific to the habitat types associated with each conservation site. APIS provides acidity and nitrogen deposition critical loads for designated features within every SAC, SPA or A/SSSI in the UK.

2.6.4 Significance of impact

Environmental Protection UK (EP UK) and the Institute of Air Quality Management (IAQM) have published guidance on the impact of pollutant releases in the context of existing air quality assessment levels[9] (i.e. AAD limit and target values etc.). Their categorisation is shown in Table 2.7.

Table 2.7   Impact descriptor for individual receptors

Long term average concentration at receptor in assessment year	% change in concentration relative to Air Quality Assessment Level (AQAL)			
	1	2-5	6-10	>10
75% or less of AQAL	Negligible	Negligible	Slight	Moderate
76-94% of AQAL	Negligible	Slight	Moderate	Moderate
95-102% of AQAL	Slight	Moderate	Moderate	Substantial
103-109% of AQAL	Moderate	Moderate	Substantial	Substantial
110% or more of AQAL	Moderate	Substantial	Substantial	Substantial

In this case impact is considered as the change in the concentration of an air pollutant, as experienced by a receptor. This may have an effect on the health of a human receptor, depending on the severity of the impact and a range of other contributing factors. The descriptor in itself is not considered a measure of effect.

IAQM guidance indicates that for any point source some consideration must also be given to the impacts resulting from short term, peak concentrations of those pollutants that can affect health through inhalation. Background concentrations are considered less important in determining the severity of impact for short term concentrations. Short term concentrations in this context are those averaged over periods of an hour or less. These exposures would be regarded as acute and will occur when a plume from an elevated source affects airborne concentrations experienced by a receptor over an hour or less.

Where such peak short term concentrations from an elevated source are in the range 10-20% of the relevant AQA_L, then their magnitude can be described as small, those in the range 20-50% medium and those above 50% as large. These are the maximum concentrations experienced in any year and the severity of this impact can be described as slight, moderate and substantial respectively, without the need to reference background or baseline concentrations. Table 2.8 summarises these descriptors.

Table 2.8   Impact descriptors for short term process contributions

Short term process contribution (% AQA_L)	Magnitude	Severity
11-20	Small	Slight
21-50	Medium	Moderate
>51	Large	Substantial

Background concentrations are not unimportant, but they will, on an annual average basis, be a much smaller quantity than the peak concentration caused by a substantial plume and it is the contribution that is used as a measure of the impact, not the overall concentration at a receptor.

In most cases, the assessment of impact severity for a proposed development will be governed by the long term exposure experienced by receptors and it will not be a necessity to define the significance of effects by reference to short-term impacts. The severity of the impact will be substantial when there is a risk that the relevant AQAL for short-term concentrations is approached through the presence of the new source, taking into account the contribution of other prominent local sources.

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3   MODELLING METHODOLOGY

The contributions to ambient concentrations of the selected pollutant releases from wellsite development and production test operations have been modelled using the Atmospheric Dispersion Modelling System (ADMS) version 6. The use of this modelling tool is accepted by the Environment Agency and UK Local Authorities for regulatory purposes.

ADMS and the United States Environmental Protection Agency's (US EPA) AERMOD modelling systems are the two most widely used air dispersion models for regulatory purposes worldwide. Both are based on broadly similar principles. In this case ADMS 6 has been employed for the assessment, although the results have been compared with those obtained from the same modelling using the AERMOD system in order to provide confidence in the assessment findings.

ADMS 6 requires a range of information in order to perform the modelling.   The primary information required is discussed below and is summarised in Annex B.

All modelling files containing relevant input information (see Annex B) are provided to the Regulatory Authorities, on request, to assist in any required confirmatory assessment of the modelling undertaken herein.

3.1 Assessment area

The area over which the assessment was undertaken is a 1km x 1km area with the proposed wellsite (502090 492810) located around the centre as shown in Figures A.1 to A.4. A general grid, with receptors spaced at 10 m intervals (i.e. 10201 points for a 101 x 101 grid), was used to assess the process contribution to ground level concentrations over the assessment area. The grid was considered at an elevation of 1.5 m. This is intended to represent the typical height of human exposure.

Figure 3.1 illustrates the location of the site, the surrounding area and nearest residential locations and public footpaths.

In addition to the receptor grid, 59 receptors (1 to 59 in Figure 3.1) were positioned at residential locations near the proposed wellsite. These receptors were placed at an elevation of 1.5 m, as described in Table E.1, and are intended to correspond to locations of long term human exposure near the wellsite.

It is also expected that there will be frequent, although of short duration, human exposure along the nearby public footpaths. 26 receptors (87 to 112 in Figure 3.1) were located along the footpaths closest to the wellsite boundary, in order to assess the likely impact of wellsite releases on air quality along the length of each route. These receptors are described in Table E.1.

27 receptors (60 to 86) were located around the wellsite boundary to give an indication of the maximum off site process contributions. These receptors are also described in Table E.1.
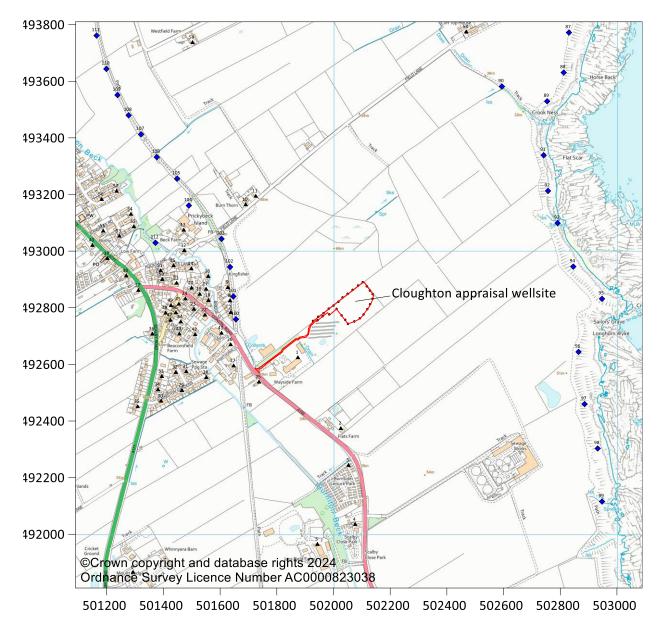
There are a number of tracks in the area which are generally used for farm access and which are not considered to be locations of frequent human exposure where air quality standards for human health would be expected to apply, (as defined in section 2.4.1). These locations are not considered in this assessment.

Figure 3.1   Location of the proposed Cloughton Appraisal wellsite

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For the purposes of the assessment, the receptors were considered in groups as described below:
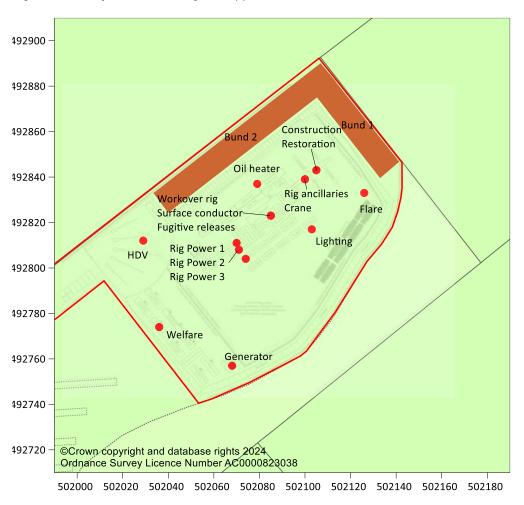
1 to 59	Residential locations (see Table E.1 and Figure 3.1)
60 to 86	Site boundary (see Table E.1 and Figure 3.1)
87 to 112	Footpaths (see Table E.1 and Figure 3.1)
113 to 117	Designated and local ecological sites (see Tables 3.1 and E.1)

Annex E describes the location of these discrete receptors.

Figure 3.2 illustrates the assumed general arrangement of the wellsite during the period of the development and the immediate surrounding area.

Figure 3.2   Layout of the Cloughton appraisal well site as assumed for the assessment

It is also necessary to consider the impact of releases on any nearby designated and local ecological sites. Following a review of all sites in the local area, five designated and local ecological sites, met the criteria for assessment (see 2.5.3). These were represented by a single receptor at the edge of the site closest to the proposed wellsite boundary. The locations of these receptors are described in Table 3.1.

Table 3.1   Location of receptors at the designated and local ecological sites

Receptor		Location[a]	Easting (m)	Northing (m)
113	Iron Scar and Hundale Point to Scalby Ness SSSI	0.7km E	502792	492949
114	Scarborough to Whitby Disused Railway Site Site of importance for nature conservation (SINC)[b]	0.4km W	501653	492823
115	Beast Cliff-Whitby SAC	6.1km N	500505	498749
116	North York Moors SAC, SPA	7.7km NW	497463	498908
117	Flamborough to Filey Coast SPA	9.3km SE	508932	486446

a. Location of the edge of the habitat closest to the centre of the proposed Cloughton Appraisal wellsite boundary. Details for all receptors are presented in Table E.1.
b. The SINC is also close to Burniston Beck (which is no longer a designated site, but is known for otter use and was mentioned in the screening opinion provided by North Yorkshire Council). This receptor is also used to provide a measure of impact at Burniston Beck.

3.2   Buildings

The presence of buildings close to a discharge flue can have a significant impact on the dispersion of releases. The most significant impact can be the downwash of a plume around a building causing increased concentrations in the immediate area around the building. Buildings can also disturb the wind flow causing a turbulent wake downwind which can also affect dispersion. It is normally considered that buildings up to 5 times the height of release or within 5 times the height of the building should be considered in any modelling.

The main structures present on the proposed wellsite for the majority of the development programme will be the soil bunds along the boundary of the wellsite (see Figure 3.2). While there will be other structures on the site from time to time, only the bunds are present throughout most of the proposed development and are considered likely to have an influence upon dispersion.

ADMS 6 models buildings as either rectangular or circular structures. In this case the two soil bunds are modelled as two rectangular blocks. Based on the drawings provided by Europa[2], the main parameters describing the bunds were estimated as summarised in Table 3.2.

Table 3.2   Parameters describing the Soil Bunds

Structure (see Figure 3.2)	Structure centre grid reference		Height (m)	Angle (° from north)	Length (m)	Width (m)
	Easting	Northing				
Bund 1	502121	492865	3	50	55	10
Bund 2	502074	492857	3	50	10	93

It is assumed, for the purposes of the assessment, that these are the only structures with the potential to influence dispersion of site releases. A sensitivity analysis was undertaken to determine whether the bunds have any significant impact on dispersion as summarised in Table 3.3.

Table 3.3   Sensitivity analysis - Buildings

Main structure (see Table 3.2 and Figure 3.2)	Change (%) in predicted PC of nitrogen dioxide over the residential receptors (1 to 59) compared with base case of the no consideration of building effects			
	Long term average		Short term average	
	Maximum	Mean	Maximum	Mean
Bund 1	-6.9	-3.2	4.2	-6.9
Bund 2	5.5	-3.1	0.1	5.5

The differences associated with the consideration of building effects are not significant in terms of the overall conclusions of this assessment which are based on maximum impact. It is apparent from the sensitivity analysis that consideration of the effects of bund 2 provides marginally greater maximum long term predicted process contributions. As such, for the purposes of the assessment, Bund 2 is considered as the main structure affecting dispersion. This is considered a precautionary approach.

Europa[2] provided details of a potential wellsite arrangement for the main drilling phase of the proposed development, and in particular, the locations of the main items of plant proposed for use, as illustrated in Figure 3.2. Table 3.4 describes the release point locations for the discharges considered in this assessment. This is indicative which, while considered representative and unlikely to have any significant effect on assessment outcomes, may not fully reflect the positioning in practice.

Table 3.4   Location of release points

Plant		Easting (m)	Northing (m)	Height of release (m)[a]	Diameter (m)[a]
A	Construction plant	502100	492839	3.0	0.30
B	Lighting towers	502103	492817	3.0	0.15
C	Welfare unit	502036	492774	3.0	0.10
D	Surface conductor	502085	492823	4.0	0.20
E	Generator	502068	492757	4.0	0.30
F1	Rig engine 1	502070	492811	4.0	0.40
F2	Rig engine 2	502071	492808	4.0	0.40
F3	Rig engine 3	502074	492804	4.0	0.40
F4	Rig ancillaries	502105	492843	3.0	0.20
G	Workover rig	502085	492823	4.0	0.30
H	Flare	502126	492833	12.2	2.0
I	Oil heater	502100	492839	3.5	0.35
J	Restoration plant	502100	492839	3.0	0.20
K	Crane	502105	492843	3.0	0.20
HDV		502029	492812	3.0	0.10
Fugitive releases		502085	492823	1.0	0.07

a. The release height and exhaust flue diameter is either assumed, based on experience, or taken from the equipment specification (see Table G.1). In the case of the lighting towers, rig ancillary equipment, HDVs, construction and restoration plant and fugitive releases, where there are multiple small sources, the release is combined into an assumed single point which represents the average location of operation (see section 3.5).

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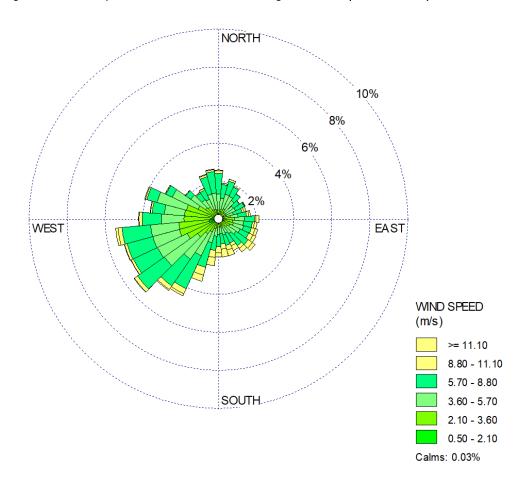
3.3   Meteorology

For this modelling assessment hourly sequential meteorological data from the nearest suitable meteorological station to the area was obtained. The data, provided by the UK Met Office, was from the Bridlington Maritime Rescue Sub Centre (Mrsc) station, and covered the 5 year period 2019 to 2023. The Bridlington station is around 30km south east of the proposed wellsite at an elevation of 15m, compared with the site elevation of around 50m and is at a similar distance of around 1km from the coast. Two other measurement stations were also considered as possible sources of meteorological data:

Station	Position	Elevation	Data coverage	Distance to coast
High Mowthorpe	27km SW	175m	Complete	26km
Fylingdales	12km NW	262m	Missing cloud data	6km

Based on advice provided by the Met Office, the proximity of the station, elevation, coastal location and data coverage, it was considered that data from the Bridlington station provided the most representative measurements of the conditions at the proposed wellsite.

Figure 3.3   Composite windrose for the Bridlington station (2019 to 2023)

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The data included, among other parameters, hourly measurements of wind speed and direction. Figure 3.3 illustrates a composite wind rose for the Bridlington station. It may be seen that the wind has significant westerly and south westerly components. Annex D provides a more detailed analysis of the meteorological data used.

3.4   Surface characteristics

The characteristics of the surrounding surfaces and the land use within the assessment area have an important influence in determining turbulent fluxes and hence the stability of the boundary layer and atmospheric dispersion. In ADMS it is necessary to consider the following parameters which describe land use and surface properties:

Surface roughness
Surface albedo
Minimum Monin Obukhov length
Priestley Taylor parameter

3.4.1   Surface roughness

The roughness length represents the aerodynamic effects of surface friction and is physically defined as the height at which the extrapolated surface layer wind profile tends to zero. This value is an important parameter used by meteorological pre-processors to interpret the vertical profile of wind speed and estimate friction velocities which are, in turn, used to define heat and momentum fluxes and, consequently, the degree of turbulent mixing.

The surface roughness length is related to the height of surface elements. Typically, the surface roughness length is around 10% of the height of the main surface features. Surface roughness is higher in built up areas than in rural locations.

A range of typical roughness values for common land use types are provided within ADMS:

Land use	Surface roughness (m)
Ice	0.00001
Snow	0.00005
Sea	0.0001
Short grass	0.005
Open grassland	0.02
Root crops	0.1
Agricultural areas	0.2-0.3
Parkland, open suburbia	0.5
Cities, woodland	1.0
Large urban areas	1.5

The proposed Cloughton appraisal wellsite is located in a rural area on relatively flat agricultural land, with scattered areas of woodland nearby. An animal feed mill is approximately 200m to the south west and the nearest residential property is approximately 320m to the south west, with further residential properties at approximately 350m. A surface roughness of 0.3m has been selected based on a sensitivity analysis, which considered variations in surface roughness between 0.1 and 1.0m. This resulted in variations in predicted hourly and annual process contributions of nitrogen dioxide over the residential receptors (1 to 59, see Figure 3.1) as summarised in Table 3.5.

Table 3.5   Sensitivity analysis – Surface roughness

| Surface roughness (m) | Change (%) in predicted PC of nitrogen dioxide over the residential receptors (1 to 59) compared with base case of a surface roughness of 0.3m | | | |
| | Long term average | | Short term average | |
	Maximum	Mean	Maximum	Mean
0.1	-12.0	2.6	15.6	13.7
0.2	-4.1	1.7	5.1	5.1
0.4	2.6	-1.9	-3.2	-5.4
0.5	3.4	-4.0	-7.4	-8.9
0.7	5.0	-7.1	-12.9	-16.2
1.0	5.9	-10.7	-22.0	-21.4

It is considered that a surface roughness of 0.3m is reasonably representative of the area of influence and tends towards a more conservative estimate of long term process contributions over the range likely to be most descriptive of the general assessment area (i.e. relatively flat agricultural land in the general direction of the prevailing wind). This selection does not introduce uncertainties which are significant in the context of the conclusions reached in section 4.

3.4.2 Surface albedo

The surface albedo is the ratio of reflected to incident shortwave solar radiation at the surface of the earth and lies in the range 0 to 1. This parameter is dependent upon surface characteristics and varies throughout the year. Surface albedo is higher (higher proportion of reflected radiation) when the ground is snow covered. Based on the recommendations of Oke (1987), ADMS provides default values of 0.6 for snow-covered ground and 0.23 for non snow covered ground, respectively. In this case a value for surface albedo of 0.23 has been employed.

3.4.3 Monin Obukhov length

The Monin Obukhov length provides a measure of the stability of the atmosphere and allows for the effect of heat production in cities which may not be represented by the meteorological data. In urban areas heat generated from buildings and traffic warms the air above which has the effect of preventing the atmosphere from becoming very stable. Generally the larger the area the greater the effect. In stable conditions the Monin Obukhov length will not fall below a minimum value with the value becoming larger depending on the size of the city. The minimum value of the Monin Obukhov length generally lies between 1 and 200 m, with 1m corresponding to a rural area. ADMS provides the following guidance on minimum Obukhov length:

Population size	Minimum Obukhov length (m)
Large conurbations (>1 million)	100
Cities and large towns	30
Mixed urban/industrial	30
Small towns	10
Rural area	1

In this case the assessment area is considered typical of a small town. A minimum Monin Obukhov length of 10m has been employed. A sensitivity analysis has been undertaken considering minimum Monin Obukhov lengths in the range 1 to 30m. This resulted in variations in predicted hourly and annual process contributions of nitrogen dioxide over the residential receptors (1 to 59, see Figure 3.1) as shown in Table 3.6.

Table 3.6   Sensitivity analysis – Minimum Monin Obukhov length

| Minimum Monin Obukhov length (m) | Change (%) in predicted PC of nitrogen dioxide over the residential receptors (1 to 59) compared with base case of a minimum Monin Obukhov length of 10m | | | |
| | Long term average | | Short term average | |
	Maximum	Mean	Maximum	Mean
1	0.8	2.2	0.0	3.6
5	0.1	1.4	0.0	2.7
15	0.0	-0.4	0.0	-0.5
20	0.1	-0.1	0.0	-0.2
25	0.1	-0.1	0.0	-0.2
30	0.5	3.0	0.0	7.4

The variations are largely insignificant over the length range considered descriptive of the assessment area and are unlikely to influence the conclusions reached in section 4. The selected length tends towards a marginally more conservative assessment than might be expected with the use of a greater length. AERMOD does require that the minimum Monin Obukhov length be specified.

3.4.4 Priestley Taylor parameter

The Priestley Taylor parameter represents the surface 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. The Priestley Taylor parameter lies between 0 and 3. Based on suggestions by Holstag and van Ulden, ADMS provides default values of:

Land type	Priestley Taylor parameter
Dry bare earth	0
Dry grassland	0.45
Moist grassland	1

In this case the area is considered representative of moist grassland and a value of 1.0 for the Priestley Taylor parameter has been employed. A sensitivity analysis has been undertaken considering Priestley Taylor parameters in the range 0 to 1.5. This resulted in variations in predicted hourly and annual process contributions of nitrogen dioxide averaged over the residential receptors (1 to 59, see Figure 3.1) as summarised in Table 3.7.

Table 3.7   Sensitivity analysis – Priestley Taylor parameter

| Priestley Taylor parameter | Change (%) in predicted PC of nitrogen dioxide over the residential receptors (1 to 59) compared with base case of a Priestley Taylor parameter of 1 | | | |
| | Long term average | | Short term average | |
	Maximum	Mean	Maximum	Mean
1.5	-6.9	-3.2	4.2	16.4
0.5	5.5	-3.1	0.1	-3.2
0	7.7	-6.4	0.1	-4.8

The variations are not significant over the range considered most likely to be descriptive of the area and not likely to influence the conclusions reached in section 4. It is considered that the use of the model default value (for moist grassland) is likely to be most representative of the area.

It may be noted that AERMOD uses the Bowen ratio to describe available surface moisture rather than the Priestley Taylor parameter. The following default values are provided from Paine (1987).
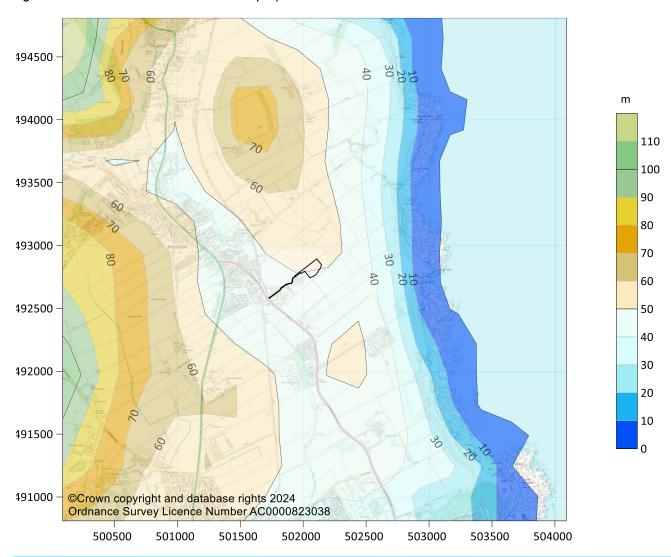
Land use	Bowen ratio (-variation with season)
Water	0.1
Deciduous forest	0.6-2.0
Coniferous forest	0.6-2.0
Swamp	0.2-2.0
Cultivated land	1.0-2.0
Grassland	1.0-2.0
Urban	2.0-4.0
Desert shrubland	5.0-10.0

For the modelling herein, a value of 1.0 was employed for the Bowen ratio.

3.4.5 Terrain

Terrain data was obtained for the assessment area from the Ordnance Survey Land-form Panorama DTM database. There are slight variations in elevation across the general area surrounding the proposed wellsite, with the ground rising from the coast to the north east towards the west at gradient of around 3 to 4% as shown in Figure 3.4.

Figure 3.4 Ground elevation around the proposed wellsite

A sensitivity analysis was undertaken to determine the impact of consideration of terrain in the assessment, in contrast to the assumption of a flat assessment area. The sensitivity of the predicted annual and hourly process contributions of nitrogen dioxide across the residential receptors (1 to 59, see Figure 3.1) to consideration of terrain was examined as summarised in Table 3.8.

Table 3.8   Sensitivity analysis – Terrain

Terrain	Change (%) in predicted PC of nitrogen dioxide over the residential receptors (1 to 59) compared with base case of an elevated assessment area			
	Long term average		Short term average	
	Maximum	Mean	Maximum	Mean
Flat	-3.5	-8.2	-1.9	-11.0

General guidance suggests that consideration of terrain is not necessary at gradients of less than 5%. In this case, the higher process contributions generally occur when an elevated assessment area is considered, although the differences are unlikely to significantly influence the main conclusions of this assessment. For avoidance of doubt, the assessment is based on an elevated assessment area. This is considered a precautionary approach.

3.5   Pollutant releases and conditions

Five sources of pollutant releases are considered in this assessment:

Flare for the incineration of produced natural gas
Diesel fired stationary engines and boilers associated with temporary plant.
Diesel fuelled construction vehicles used on site
Diesel fuelled HDV vehicle movements on site
Fugitive releases of natural gas from well development and testing

Europa[2] provided details of the incinerator, stationary engines, generators, construction vehicles and HDV movements intended over the various phases of the proposed development. A full listing of the equipment employed and references for the specifications used are provided in Annex G.

3.5.1   Flare

Disposal of produced natural gas by incineration will employ a PW Well Services[11] shrouded ground flare will be used with a maximum disposal capacity of 6.5 MMscfd (2.01 Nm^3/s). Europa[35] have provided an indicative test program which anticipates initially producing the well at 2 MMscf/d for 24 hours, followed by a 24 hour shut in. Multi stage flow for 36 hours at an average of 3 MMscf/d, followed by another 24 hour shut in. Finally, a sampling period with an average flow rate of 3 MMscf/d for 48 hours, followed by a 24 hour shut in. There is also a discretionary flow period of 4 MMscf/d for up to two weeks, which may be required to prove well commerciality if not already established from earlier stages of the test. This equates to a test disposal volume of 12.5 MMscf and a potential additional disposal requirement of 56.0 MMscf. The maximum daily natural gas disposal volume is 4 MMscf (1.24 Nm^3/s).

For the purposes of the air quality impact element of this assessment, it is assumed that the flare will operate at the anticipated maximum daily disposal capacity (4 MMscfd), continuously, for the entire 17 week production test operation, equating to a total disposal volume of 476 MMscf. This clearly represents a worst case in terms of air quality impact, particularly on a long term averaging basis.

For the purposes of determining photochemical ozone creation potential and greenhouse gas releases (sections 4.6 and 4.7 respectively), it is assumed that the anticipated test program will be undertaken. This provides a more representative assessment of these elements, albeit still adopting a precautionary approach by including the full disposal requirement from the discretionary flow period.

The release conditions for the flare have been assessed in Table 3.10, based on the natural gas composition provided by Europa[12] in Table 3.9.

Table 3.9   Natural gas composition

Parameter		Value
Methane	% v/v	96.98
C_2	% v/v	2.87
C_3	% v/v	0.13
C_4	% v/v	0.13
Sulphur[a]	mg/m^3	50

a. The sulphur content of the natural gas was not measured. A conservative estimate of 50ppm is assumed for the purposes of the assessment.

Table 3.10   Exhaust gas conditions

Property		Value
Disposal rate	MMscfd	4.0
	Nm^3/s	1.24
Exhaust gas temperature[a]	^oC	1000[a]
Exhaust gas flow rate (actual)[b]	m^3/s	109.1
Flue diameter[a]	m	2.0
Velocity	m/s	34.7
Carbon dioxide release[b]	g/s	2519

a. Based on flare specification[11].
b. Calculated based on the natural gas composition in Table 3.9.

Pollutant releases are estimated in Table 3.11. Releases are based on the emission factors for industrial flares published by the US EPA in their AP42 document[14] and emission factors from the EMEP-EEA for flaring in oil and gas extraction operations[13].

Table 3.11   Pollutant releases from flare operations

Emission factor source	US EPA AP42[a]	EMEP/EEA 2019[b]
Emission factors		
Total hydrocarbons	0.14 lb/MMBtu	-
Nitrogen oxides (as NO_2)	0.068 lb/MMBtu	1.4 g/kg gas
Carbon monoxide	0.31 lb/MMBtu	6.3 g/kg gas
Non methane volatile organic compounds	-	1.8 g/kg gas
Release rates (g/s per Nm^3/s of gas consumed)		
Non methane volatile organic compounds (as carbon)		1.65
Nitrogen oxides	1.48	1.28
Carbon monoxide	6.76	5.77
Sulphur dioxide[c]	0.18	
Total hydrocarbons (as carbon)	1.48	-

a. AP-42 factors are based on thermal input at the higher heating value.
b. EMEP/EEA factors are based on kg of natural gas burned and a gas density of 0.891 kg/Nm^3.
c. Sulphur dioxide release is based on total oxidation of the sulphur in a gas containing 50mgS/Nm^3.

It is expected that the majority of the release of VOCs will be in the form of methane and lower hydrocarbons, although there will be some releases of higher hydrocarbons. Experience suggests that a significant proportion of the volatile organic compounds emission will be methane and lower hydrocarbons and that that the concentration of

higher hydrocarbons (C_6 and above) present in the flue gas will generally be representative of the proportion of higher hydrocarbons in the natural gas[15]. For this assessment the volatile organic compound release, assessed as benzene, is assumed to be equivalent to the non-methane volatile organic compound release. This is considered a significant over estimate of higher hydrocarbons in practice based on the above experience. The higher hydrocarbon presence in the produced natural gas is less than 0.1% by mass (see Table 3.9).

Where there are corresponding emission factors from the USEPA and EMEP/EEA, the factor providing the greatest release rate is employed. Table 3.12 summarises the pollutant release rates assumed for this assessment.

Table 3.12   Flare stack pollutant release rates assumed for assessment

Pollutant		Value
Nitrogen oxides	gNO_2/s	1.48
Carbon monoxide	gCO/s	6.76
Sulphur dioxide	gSO_2/s	0.18
Benzene (total volatile organic compounds)	gbenzene/s	1.65

It may be noted that the flare manufacturer[11] indicates significantly lower releases of nitrogen oxides, carbon monoxide and hydrocarbons than determined from the standard emission factors in Table 3.12.

3.5.2   Stationary engines

Table 3.13 summarises the diesel fuelled stationary engines specified for use by Europa[2] during the proposed development.

The engine specifications generally indicate compliance with either European Union or United States emission standards. The engines are assumed to operate at the emission standards. In addition, it is assumed that the engines will use ultra-low sulphur diesel with a sulphur content of 10 mg/kg (10 ppm).

Based on the claimed emission standards and full load operation, fuel usage and pollutant release rates for each stationary engine have been determined as summarised in Table 3.14.

Table 3.13   Stationary engine and boiler performance

Equipment		Diesel fuel consumption		Power output full load	Emission standard
		l/h	kg/h[a]	kWh	
B	Lighting (4)	6.8	6.0	28.0	EU Stage 3A
C	Welfare unit	2.9	2.5	12	EU Stage 3A
D	Surface conductor rig	43.0	37.6	179	EU Stage 3A
E	Generator	84.1	73.5	350	EU Stage 3A
F1-3	Rig engine[d]	312.0	272.7	1420	US Tier 2[c]
F4	Rig ancillaries	43.2	37.8	180	EU Stage 3A
G	Workover rig	85.1	74.3	354	US Tier 2
I	Oil heater	69.0	60.3	410kW input	AP42 1.3
K	Crane	96.1	84.0	400	EU Stage 4

a. Based on a fuel density of 0.874 kg/l (at 0°C).
b. Assumes a brake specific fuel consumption of 0.21 kg/kWh, where fuel consumption is not specified.
c. The engine is assumed to comply with US EPA Tier 2 standards when operating in low emission mode.
d. The main drilling rig has three identical engines.
e. The oil heater can be fired on either diesel or natural gas. Natural gas is the normal fuel, although diesel firing generates the greater pollutant releases and is assumed as a worst case in this assessment.

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Table 3.14   Pollutant release rates for stationary engines and boilers

Equipment	Pollutant release rate per unit (g/s)					
	CO	THC[a,b]	NO_x[a,b]	PM	SO_2	CO_2
Lighting (4)	0.029	0.0029	0.036	0.031	0.000022	1.3
Welfare unit	0.018	0.002	0.023	0.002	0.000014	2.2
Surface conductor rig	0.174	0.015	0.184	0.010	0.00021	33.4
Generator	0.340	0.029	0.360	0.019	0.00041	65.4
Rig engine	1.380	0.187	2.337	0.079	0.0015	242.5
Rig ancillaries	0.250	0.015	0.185	0.015	0.00021	33.6
Workover rig	0.344	0.047	0.583	0.020	0.00041	66.1
Oil heater	0.011	0.001	0.046	0.005	0.00034	53.6
Crane	0.389	0.021	0.044	0.003	0.00047	74.7

a. Total hydrocarbons (THC) are expressed as benzene and nitrogen oxides are expressed as nitrogen dioxide.
b. Where the emission standard quotes a combined value for hydrocarbons and nitrogen oxides, it is assumed that nitrogen oxides comprise 92.6% of the total with the remainder being hydrocarbons[14].
c. A load of 100% is assumed for all engines and the oil heater.

The exhaust gas conditions in Table 3.15 have been estimated and used in the assessment.

Table 3.15   Exhaust gas conditions for stationary engines

Equipment	Height of release (m)	Internal flue diameter (m)	Velocity[b] (m/s)	Temperature[a] (°C)
Lighting[c]	3.0	0.15	0.7	150
Welfare unit	3.0	0.10	3.0	150
Surface conductor rig	4.0	0.20	21.4	550
Generator	4.0	0.30	18.6	550
Rig engine (3 units)	4.0	0.40	31.8	430
Rig ancillaries	3.0	0.20	11.1	150
Workover rig	4.0	0.30	18.8	550
Oil heater	3.5	0.35	5.2	150
Crane	3.0	0.20	22.0	150

a. Based on engine specification with allowance for heat loss.
b. Based on combustion calculations assuming diesel lower heating value of 42.78 MJ/kg.
c. Assumes a single combined release point for all four lighting towers.

It is assumed that all stationary engines and boilers operate at full load continuously when operational (see Table G.2).

3.5.3   Construction vehicles

Europa[2] specified the principal mobile plant that are intended to be employed for the construction and restoration phases of the proposed development as shown in Table 3.16.

It is assumed that all vehicles will operate at the specified emission standard at full load when operational. On this basis the pollutant emission rates for the construction vehicle fleet are estimated in Table 3.17.

Table 3.16   Specification of main construction vehicles

Type		Gross power output (kW)	Fuel consumption (kg/h)[a]	Emission standard
A1 J1	14 t excavator (Hitachi)	78.5	16.5	EU Stage 4
A2 J2	14 t excavator (Cat)	122	25.6	EU Stage 4
A3 J3	Dozer	120	25.2	EU Stage 4
A4	9t dumper (2)	55.4	11.6	EU Stage 3B
A5	13t sheeps roller (2)	115	24.2	EU Stage 5
A6	Roller (2)	24.6	5.2	EU Stage 5
A7	Concrete pump truck	240	50.4	EURO 6

a. Assumes a brake specific fuel consumption of 0.21 kg/kWh.

Table 3.17   Pollutant release rates for construction vehicles

Type	Pollutant release rate per unit (g/s)					
	CO	THC[a]	NO$_x$[a]	PM	SO$_2$[c]	CO$_2$
14 t excavator (Hitachi)	0.109	0.004	0.009	0.001	0.00009	14.7
14 t excavator (Cat)	0.169	0.006	0.014	0.001	0.00014	22.8
Dozer	0.167	0.006	0.013	0.001	0.00014	22.4
9t dumper[d]	0.154	0.011	0.134	0.001	0.00013	20.7
13t sheeps roller[d]	0.319	0.012	0.026	0.001	0.00027	42.9
Roller[d]	0.068	0.003	0.005	0.000	0.00006	9.2
Concrete pump truck	0.100	0.009	0.027	0.001	0.00028	44.8
Total construction phase	1.087	0.051	0.227	0.005	0.00111	177.5
Total restoration phase	0.445	0.017	0.036	0.002	0.00037	59.8

a. Total hydrocarbons are expressed as benzene and nitrogen oxides are expressed as nitrogen dioxide. Where the emission standard quotes a combined value for hydrocarbons and nitrogen oxides it is assumed that nitrogen oxides comprise 92.6% of the total with the remainder being hydrocarbons (based on US EPA AP42 emission factors for uncontrolled emissions from diesel engines -Table 3.3-1)[14].
b. A load of 100% is assumed for all plant.
c. Assumes a diesel sulphur content of 10 mg/kg.
d. The fleet contains two 6t dumpers, two 13t sheeps foot rollers and two rollers.

It is assumed that releases from the construction vehicles used in the construction phase can be considered as a single point release (diameter 0.3m) for the purposes of the assessment at a height of 3.0m with a velocity of 23.3 m/s and exhaust temperature of 150ºC. For the smaller fleet of vehicles used in the restoration phase, a single point release (diameter 0.2m) is considered at a height of 3.0m with a velocity of 17.6 m/s and exhaust temperature of 150ºC. Table G.2 details the construction vehicles used in the construction and restoration phases.

3.5.4   Heavy duty vehicles

Heavy duty vehicles will enter the site and then generally off load, load and leave site. For the purposes of the assessment of releases from these vehicles while on site it is assumed that the vehicle enters the wellsite and then idles for a period of one hour before leaving. This is considered a conservative estimate of releases and it is noted that in practice vehicles will be switched off when not in use.

The emission factors for idling in Table 3.18 have been assumed based on an evaluation of four studies of heavy duty vehicle idling emissions[16,17,18,19]. These are considered conservative estimates. A factor of 45 gNO_2/h for nitrogen oxides during HDV idling has been used as a guideline by the Greater London Authority[20].

Table 3.18   Emission factors for HDV idling

Parameter		Rahman[16]	DIESELNET[17]	Christopher Frey[18]	Khan[19]	Selected
Nitrogen oxides	g/h	56.9	70.9	89.5		70.9
Nitrous oxide	g/h	0.9				1.1[a]
Carbon monoxide	g/h	95.0	27.8	17.8		27.8
Carbon dioxide	g/h	9108		5931	4660	5296[b]
Particulate matter	g/h	2.6	2.5	1.3		2.6
Total hydrocarbons	g/h		13.6			13.6
Higher hydrocarbons	g/h	13.0		3.5		13.0
Sulphur dioxide	g/h	5.8		0.037	0.029	0.033[b]
Fuel consumption	l/h			2.12	1.67	1.90[b]

a. based on ratio of N_2O to NO_x from Rahman.
b. Mean of values from Christopher Frey and Khan.

Europa[10] has provided details of maximum daily HDV movements for the various phases of the proposed development (see Table G.3) as shown in Table 3.19.

Table 3.19   Frequency of HDV idling

Phase	HDV 2 way movements	Mean HDVs idling/working hour	Fuel consumption l/working hour
1	334	0.9	1.7
2A	80	1.3	2.5
2B	170	0.6	1.1
2C	80	1.3	2.5
3A	65	1.0	1.9
3B	75	0.9	1.7
4A	40	0.5	0.9
4B	310	1.4	2.7

a. In the determination of idling rate HDVs are assumed to operate for the stated operating periods in the development schedule (see Table G.2).

Based on the proposed development HDV movement schedule for the development, there will be a total of 1154 arrivals on site, equivalent to 2308 movements for the entire development. Assuming that the entire development program is completed within a single calendar year, the annual average traffic count (AADT) is 6.3.

Based on the average frequency of HDV idling (Table 3.19) and the selected pollutant emission rates (Table 3.18), the average pollutant release rates for HDV idling in each phase of the development were estimated as in Table 3.20 .

Table 3.20   Pollutant releases from HDV idling

Phase	Pollutant release rate in each working hour (g/s)					
	NO$_x$	CO	PM	VOC	SO$_2$	CO$_2$
1	0.017	0.007	0.0006	0.0033	0.000008	1.3
2A	0.026	0.010	0.0010	0.0050	0.000012	2.0
2B	0.011	0.004	0.0004	0.0021	0.000005	0.8
2C	0.026	0.010	0.0010	0.0050	0.000012	2.0
3A	0.020	0.008	0.0007	0.0038	0.000009	1.5
3B	0.018	0.007	0.0006	0.0034	0.000008	1.3
4A	0.009	0.004	0.0003	0.0018	0.000004	0.7
4B	0.028	0.011	0.0010	0.0054	0.000013	2.1
Maximum in phase	0.028	0.011	0.0010	0.0054	0.000013	2.1
Assumed for assessment	0.055	0.022	0.002	0.011	0.000026	5.3

It is assumed that releases from the HDVs during idling can be considered as a single point release (diameter 0.1m) for the purposes of the assessment at a height of 3.0m with a velocity of 4.9m/s and exhaust temperature of 150°C.

For the purposes of this air quality impact assessment the maximum hourly HDV pollutant rates in Table 3.20 (based on the scheduled operational day and the maximum average HDV movements per any individual phase) have been doubled (equivalent to a 3 vehicles idling per hour) and applied as a continuous release over 24 hours per day, 7 days per week for each phase of the development. This is a significant overestimate in all phases and will allow sufficient margin should minor changes to the above schedule become necessary.

3.5.5 Fugitive releases and odours

Site operations during wellsite development and testing operations have the potential to result in leakages of produced natural gas. This largely results from leakages in pipework and connections and from the well itself, but can also include releases from incineration and tank venting. It is expected that industry standard loss prevention and maintenance procedures will minimise any leakages. The drilling phase of the project is expected to result in negligible fugitive releases. The overbalanced drilling technique employed ensures that gas is retained within the reservoir during drilling. It would therefore be expected that unintentional releases of produced gas to atmosphere will be insignificant.

Emissions factors for releases from gas exploration operations, based on surveys of operations throughout the world, have been derived, primarily to provide an indication of the impact with respect to greenhouse gases. The Intergovernmental Panel on Climate Change (IPCC)[28] provide emission factors for fugitive releases for, among other gases, methane, from activities associated with conventional on shore natural gas exploration which considers exploratory well drilling, well development and testing and includes provision for venting, flaring and leakage.

While it is expected that fugitive releases in practice will be negligible, a conservative approach is taken and the fugitive emission factors in Table 3.21 are adopted for this assessment. This is considered a precautionary approach which will most likely over estimate the quantity and subsequent impact of any fugitive release in practice.

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Table 3.21   Emissions factors for fugitive releases from on-shore natural gas exploration

Activity	Natural gas exploration On shore conventional gas exploration t/well drilled per year
Methane	5.78
Carbon dioxide	4.72
Non-methane VOCs	0.87
Nitrous oxide	0.000034

It is assumed that the fugitive releases will occur uniformly across the entire development program. This, together with the factors assumed, is seen as a worse case precautionary approach and will in some cases include releases which might also be included elsewhere (e.g. gas disposal). Table 3.22 summarises the fugitive releases from the well based on the gas composition in Table 3.9 and an even distribution of the annual fugitive release over the 273 days of the proposed program.

Table 3.22   Fugitive natural gas releases from gas exploration

Activity		Gas exploration
Total annual methane release per well	t	5.78
Methane content of produced gas per well	% mass	94.0
Produced natural gas release per well	m^{3a}	8321
	kg	6148
Duration	days	273
Number of wells		1
Methane release rate	gCH_4/s	0.2450
Non methane VOC release rate	gC/s	0.0369
Carbon dioxide release rate	gCO_2/s	0.20
Nitrous oxide release rate	gN_2O/s	0.00000144
Methyl mercaptan release rate[b]	gCH_4S/s	0.000026
Hydrogen sulphide release rate[b]	gH_2S/s	0.000019

a. Assumes a determined natural gas density of 0.739 kg/Nm^3.
b. In the assessment of mercaptans and hydrogen sulphide it is assumed that the total sulphur content of the natural gas is either in the form of methyl mercaptan or hydrogen sulphide as appropriate (see Table 3.9).
c. Pollutant release rates assume a continuous uniform release averaged over the 273 days.

Fugitive releases are represented as a point source release with a velocity of 0.1 m/s and temperature of 50°C.

In this assessment it is assumed that odour release from site operations arise solely from the presence of sulphurous compounds contained in the fugitive releases of produced natural gas. The most important sulphurous compound in terms of odour is hydrogen sulphide which has an odour threshold of 0.0005 ppm (0.76 $\mu g/m^3$)[29]. Other sulphur bearing compounds such as mercaptans have odour thresholds greater than hydrogen sulphide. For instance, methyl mercaptan has an odour threshold reported to be around 0.002 ppm (4.6 $\mu g/m^3$)[30]. In the absence of understanding the synergistic odour effects of a mixture of sulphurous compounds, the assumption in the assessment of odour is that all sulphur in the produced natural gas is present as either hydrogen sulphide or methyl mercaptan, depending on which substance is being assessed. This is considered a precautionary approach.

The above release rates and gas conditions have been used to assess the likely amenity impact of fugitive releases.

3.5.6 Other releases

The combustion of diesel fuel and natural gas will also give rise to other releases which are greenhouse gases. It is important that these be considered. In addition to the pollutants above, the inventory of nitrous oxide has also been considered.

For nitrous oxide emission factors of 0.5 gN_2O/GJ and 2.1gN_2O/GJ(heat input) for natural gas and diesel combustion[15] respectively, have been employed.

3.6 Modelling scenarios

ADMS 6 has been employed to estimate process contributions to ambient pollutant concentrations based on the general conditions specified above. For the assessment the model has been run using meteorological data for each of five years (2019 to 2023) and has considered five separate years of operation.

The expected programme of work is listed in Table G.2.

Table 3.23 summarises the equipment usage for the individual phases of the development. The specification for each item of equipment is presented in Table G.1.

Table 3.23 Equipment usage

Equipment	Phase (Days operational)							
	1	2A	2B	2C	3A	3B	4A	4B
A Construction plant	1-49				99-112			
B Lighting towers	1-49	50-56	57-91	92-98	99-112	113-231	232-245	246-273
C Welfare unit	1-49	50-56	57-91	92-98	99-112	113-231	232-245	246-273
D Surface conductor rig	1-49						232-245	
E Generator	1-49	50-56	57-91	92-98	99-112	113-231	232-245	246-273
F Main drilling rig and ancillaries			57-91					
G Workover rig						113-231		
H Flare						113-231		
I Oil heater						113-231		
J Restoration plant								246-273
K Mobile crane		50-56	57-91	92-98	99-112			
HDV	1-49	50-56	57-91	92-98	99-112	113-231	232-245	246-273

a. See Tables G.1 and G.2 for equipment description and daily operational hours respectively.

The development programme, consisting of four phases, has a total operational duration of approximately 39 weeks. Europa expects that this programme will be undertaken over a period of up to three years, which allows for breaks between and within phases based on expectations of equipment availability. Long term air quality standards are largely based on an average over a period of a calendar year. While it is considered highly unlikely in practice, accommodating the entire development programme within a single calendar year would provide the greatest long term air quality impact, For the purposes of this assessment, it is assumed that the development programme commences on the 1 January and runs continuously throughout the year as shown in Table G.2. This represents a highly unlikely worst case in terms of the development's long term air quality impact.

As shown in Table 3.23, some simplifying assumptions are made regarding periods of operation. It is assumed that the engines associated with the lighting (B), welfare unit (C) and site generator (D) will operate continuously throughout the entire duration of the development. Mobile plant (A and J) and HDVs are limited in their operating hours (see Table G.2), however for the purposes of this assessment it is assumed that they will operate 24 hours per

day and 7 days per week when required within the programme. All other plant is assumed to operate continuously over their scheduled periods of operation. This is a substantial over estimate of their activity.

Any departures in practice, from the proposed development schedule should not result in changes to air quality impacts which would be any worse than those determined in this assessment. There is, therefore, a reasonable margin of headroom inherent in the conclusions of this assessment.

Sensitivity analyses have been undertaken to look at the influence on air quality impact of model selection. The US EPA's AERMOD modelling system is a widely used model for determining the dispersion of releases to air and their subsequent ambient impact and is accepted by the Environment Agency and UK Local Authorities for regulatory purposes. To determine the influence of the model selection, part of the assessment was repeated using the AERMOD model.

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4 MODELLING RESULTS

ADMS 6 has been run for the operating scenario described in Section 3.6. The results of the modelling are discussed below. In this section results are presented in tabular form, while in Annex A contour plots are provided which illustrate the estimated process contribution to selected ambient pollutant concentrations over the entire assessment area.

The initial part of this assessment is used to determine the air quality impact at the location of maximum concentration in order to identify those pollutants which are clearly insignificant in terms of air quality impact and those which may require further assessment. The second part of the assessment then considers in detail the impact of process contributions of selected pollutants at sensitive locations to determine their significance in the context of applicable air quality standards and critical levels and loads.

4.1 Impact of process releases

Figures A.1 and A.2 illustrate the dispersion of nitrogen dioxide on short term and long term bases respectively. Figures A.3 and A.4 provide the corresponding illustrations for total volatile organic compounds (assessed as benzene). The dispersion patterns are reasonably typical of all pollutants considered. On both the long and short term averaging bases, the location of maximum process contribution is within the proposed wellsite boundary. This pattern is typical of low level releases. The maximum off site process contribution occurs at the wellsite's north eastern boundary in the general direction of the prevailing wind for standards with a long term averaging basis and on the northern boundary for short term standards. Table 4.1 summarises the maximum process contributions and predicted environmental concentrations at the proposed wellsite boundary.

Table 4.1   Maximum process contributions and predicted environmental concentrations – Site boundary

Substance	Averaging basis	Process contribution		Background	Predicted environmental concentration	
		$\mu g/m^3$	% standard	$\mu g/m^3$	$\mu g/m^3$	% standard
Carbon monoxide	8 hours	1957	19.6	1440	3397	34.0
	1 hour	2351	7.8	2059	4410	14.7
Nitrogen dioxide	1 hour	1234	617	9.68	1244	622
	annual	47.5	119	4.84	52.3	131
Sulphur dioxide	15 min	2.5	0.9	2.62	5.1	1.9
	1 hour	2.2	0.6	1.96	4.2	1.2
	24 hours	0.98	0.8	1.16	2.1	1.7
PM_{10}	24 hours	8.1	16.2	14.03	22	44
	annual	2.9	7.3	11.89	14.8	37
$PM_{2.5}$	annual	2.9	14.6	5.22	8.1	40.7
Benzene	24 hours	649	2162	0.28	649	2163
	annual	30	609	0.24	30.7	614
Nitrogen monoxide	1 hour	2590	58.9	1.80	2592	58.9
	annual	44.3	14.3	0.90	45.2	14.6

For all substances, with the exception of sulphur dioxide and $PM_{2.5}$, maximum process contributions are in excess of the Environment Agency screening criteria (short term process contributions are less than 20% of the short term environmental standard less the corresponding background and/or the maximum long term predicted

environmental concentration is less than 70% of the long term environmental standard). Process contributions of sulphur dioxide and $PM_{2.5}$ are considered insignificant and requiring no further investigation.

Maximum process contributions of nitrogen dioxide and volatile organic compounds exceed Environment Agency screening criteria and their corresponding predicted environmental concentrations exceed the respective air quality benchmarks. Maximum predicted environmental concentrations of all other substances considered are comfortably within their environmental benchmarks.

Air quality standards with respect to human health are not considered to be applicable within the proposed wellsite or around its boundary and beyond in the areas most affected by site process contributions. Frequent human exposure, over the periods of the standards, is unlikely in these areas (see section 2.4.1) due to the absence of any residential locations or designated footpaths. Figures A.1 to A.4 include identification of the area within which screening criteria are exceeded. Process contributions beyond this area are not considered significant.

The air quality impacts of these substances are considered in more detail in the following sections at sensitive locations where air quality standards would be expected to apply. These locations include the nearest residential properties and the neighbouring footpaths. Nitrogen dioxide, nitrogen oxides and sulphur dioxide are also considered at designated and local ecological sites where critical levels and critical loads are applicable.

4.2 Impact of process releases at locations of human exposure

In order to determine the impact of wellsite releases at locations of frequent human exposure, discrete receptors were located at the residential locations in the vicinity of the proposed wellsite and along the footpaths to the west and east of the wellsite (see Figure 3.1 and Table E.1). These are considered to be the only locations in the vicinity of the proposed wellsite to which the public normally have access and where human exposure for some or all of the air quality standard averaging periods is likely.

Table 4.2 summarises the maximum process contributions and predicted environmental concentrations at the nearest footpaths. In view of the short term presence of members of the public along the footpath, it is considered that only short term environmental standards would be applicable in this area.

Table 4.2   Maximum process contributions and predicted environmental concentrations at footpaths (short term impact)

Substance	Averaging basis	Process contribution		Background	Predicted environmental concentration	
		µg/m^3	% standard	µg/m^3	µg/m^3	% standard
Carbon monoxide	8 hours	104.1	1.04	1440	1544	15.4
	1 hour	229.0	0.76	2059	2288	7.6
Nitrogen dioxide	1 hour	36.1	18.1	9.68	45.8	22.9
Sulphur dioxide	15 min	0.70	0.26	2.62	3.3	1.2
	1 hour	0.61	0.17	1.96	2.6	0.7
	24 hours	0.282	0.23	1.16	1.4	1.2
PM_{10}	24 hours	0.29	0.6	14.03	14.3	28.6
Benzene	24 hours	9.8	32.8	0.28	10.1	33.7
Nitrogen monoxide	1 hour	218.5	5.0	1.80	220.3	5.0

The maximum process contributions of all substances, with the exception of nitrogen dioxide and volatile organic compounds are equivalent to less than 20% of their short term environmental standard less the corresponding background, and are therefore considered insignificant.

While maximum process contributions of nitrogen dioxide and volatile organic compounds exceed screening criteria, the corresponding predicted environmental concentrations are around a third of their respective standards. The area of exceedance is confined to a small section of the footpath following the disused railway line to the south west. Bearing in mind the very conservative approach to the assessment, particularly for these substances, it is expected that process contributions for these and all other pollutants in practice will be well within screening criteria.

All maximum short term predicted environmental concentrations are comfortably within the applicable short term environmental standards. It is concluded that process contributions from the proposed wellsite operations in practice, are likely to be insignificant and to pose no meaningful threat to environmental standard compliance at the nearby public footpaths.

Table 4.3 summarises the maximum process contributions and predicted environmental concentrations at residential locations near the proposed wellsite. These are considered to be the only locations near the wellsite to which the public normally have access and where human exposure for both the long and short term air quality standard averaging periods is likely.

The maximum short term process contributions of the all substances, with the exception of nitrogen dioxide and volatile organic compounds, are less than 20% of their short term environmental standard less the corresponding background and/or the maximum long term predicted environmental concentration is less than 70% of the long term environmental standard. Process contributions of these substances are therefore considered insignificant.

While maximum process contributions of nitrogen dioxide and volatile organic compounds exceed screening criteria, the corresponding predicted environmental concentrations are around a third of their respective standards. The exceedance is related to short term process contributions and is confined to the nearest properties (Wayside Farm and Flatts Farm) to the south west and south east of the proposed wellsite. Bearing in mind the very conservative approach to the assessment, particularly for these substances, it is expected that process contributions for these and all other pollutants in practice will be well within screening criteria.

Table E.2 provides the maximum process contributions of nitrogen dioxide and volatile organic compounds at all of the discrete receptors considered.

Table 4.3   Maximum process contributions and predicted environmental concentrations – Residential locations

Substance	Averaging basis	Process contribution		Background	Predicted environmental concentration	
		µg/m³	% standard	µg/m³	µg/m³	% standard
Carbon monoxide	8 hours	140.4	1.4	1440	1580	15.8
	1 hour	226.8	0.8	2059	2286	7.6
Nitrogen dioxide	1 hour	63.9	32.0	9.68	73.6	36.8
	annual	2.3	5.9	4.84	7.2	18.0
Sulphur dioxide	15 min	0.9	0.3	2.62	3.5	1.3
	1 hour	0.6	0.2	1.96	2.6	0.7
	24 hours	0.3	0.3	1.16	1.5	1.2
PM$_{10}$	24 hours	0.5	1.0	14.03	14.5	29.0
	annual	0.15	0.4	11.89	12.0	30.1
PM$_{2.5}$	annual	0.15	0.7	5.22	5.4	26.8

Table 4.3   continued

Substance	Averaging basis	Process contribution		Background	Predicted environmental concentration	
		µg/m³	% standard	µg/m³	µg/m³	% standard
Benzene	24 hours	11.8	39.3	0.28	12.1	40.3
	annual	0.5	10.5	0.24	0.8	15.3
Nitrogen monoxide	1 hour	216.4	4.9	1.80	218.2	5.0
	annual	2.2	0.7	0.90	3.1	1.0

In all cases the predicted environmental concentration of all pollutants is less than, and in some cases substantially less than, a 40% of the applicable standard. Bearing in mind the precautionary assumptions made in the assessment, it is considered unlikely that pollutant process contributions from proposed wellsite operations will pose any risk to, or have any meaningful influence on, continued attainment of air quality standards at the nearest locations of human exposure.

Based on Environmental Protection UK and the Institute of Air Quality Management classification (section 2.6.4) the maximum impact significance of releases of nitrogen dioxide and volatile organic compounds at the most affected sensitive location (Wayside Farm) is considered to be 'slight' and 'moderate' respectively, falling to 'negligible' for all other substances. Table 4.4 summarises the assessment of significance.

Table 4.4   Assessment of impact significance based on IAQM classification

Substance	Maximum process contribution[a]	Predicted environmental concentration[a]	IAQM classification (see Table 2.7)
	% environmental standard		
Nitrogen dioxide	5.9	18	Slight
PM$_{10}$	0.4	30	Negligible
PM$_{2.5}$	0.7	27	Negligible
Volatile organic compounds	10.5	12	Moderate
Nitrogen monoxide	0.7	1	Negligible

a. Process contributions and predicted environmental concentrations are expressed as a percentage of the applicable long term environmental standard (see Table 4.3) for the most affected residential location.

4.3   Impact of process releases at designated and local ecological sites

Five designated and local ecological sites, requiring assessment based on Environment Agency criteria (see section 2.5.3), were identified near the proposed wellsite as discussed in section 3.1.

The main substances of interest at these sites are nitrogen oxides, nitrogen dioxide and sulphur dioxide. For the purposes of the assessment of process contributions at these sites, discrete receptors were placed at the boundary of each site closest to the wellsite as described in Table 3.1.

The critical loads and levels adopted for use in this assessment have been obtained from the APIS and are summarised in Table F.1 In the selection of critical loads, the minimum for the most sensitive habitat within each site has been selected. The nitrogen critical load is provided as a range and the minimum in that range has been adopted for the assessment. This represents a worst case precautionary approach to the assessment and will most likely result in an overestimate of impact. It may be noted that the Iron Scar and Hundale Point to Scalby Ness SSSI has a largely geological designation and critical loads for nitrogen and acid deposition are not provided within APIS. The Flamborough and Filey Coast SPA is not sensitive to nitrogen deposition and APIS does not provide a critical load for acid deposition. For both sites an assessment of nitrogen and acid deposition is undertaken, although there is no determination of compliance with critical loads.

The site background concentrations, as obtained from APIS, are summarised in Table F.2. These represent the maximum background concentration across the entire site in each case and as such there will be parts of the site which experience somewhat lower background concentrations. This represents precautionary approach.

The maximum process contributions to concentrations of nitrogen oxides and sulphur dioxide at the designated and local ecological sites are summarised in Table 4.5. Table F.3 presents the detailed determination of these process contributions at each site.

Table 4.5   Maximum process contributions of nitrogen oxides and sulphur dioxide at designated and local ecological sites

Site	Nitrogen oxides[a]				Sulphur dioxide	
	Annual mean		Daily mean		Annual mean	
	PC	PEC	PC	PEC	PC	PEC
	% of critical level					
Iron Scar and Hundale Point to Scalby Ness SSSI	5.5	20	0.83	6	0.093	6
Scarborough to Whitby Disused Railway Site SINC	5.8	23	0.90	7	0.111	8
Beast Cliff-Whitby SAC	0.1	16	0.01	5	0.003	6
North York Moors SAC, SPA	0.1	26	0.01	8	0.005	13
Flamborough to Filey Coast SPA	0.1	20	0.01	6	0.001	13

a. Total nitrogen oxides are expressed as NO_2.

The maximum long term and short term process contributions of nitrogen oxides and sulphur dioxide are equivalent to less than 1% and 10% respectively, of the applicable critical levels for all sites with a European designation. Maximum long term and short term process contributions of nitrogen oxides and sulphur dioxide are less than 100% of the critical levels for the SINC. As such, for all sites, process contributions are considered insignificant.

The determination of nitrogen and acid deposition at the designated and local ecological sites is summarised in Table 4.6. Tables F.4 and F.5 present the detailed determination of nitrogen and acid deposition respectively at these sites. The determination was undertaken in accordance with the guidance in AQTAG 06[21] and considered dry deposition only. Guidance indicates that wet deposition over relatively short distances is unlikely to be significant.

Table 4.7   Nitrogen and acid deposition at designated and local ecological sites

Site	Nitrogen deposition		Acid deposition	
	PC	PEC	PC	PEC
	% of critical load			
Iron Scar and Hundale Point to Scalby Ness SSSI	no determination		no determination	
Scarborough to Whitby Disused Railway Site SINC	3.5	244	1.5	101
Beast Cliff-Whitby SAC	0.05	220	0.01	55
North York Moors SAC, SPA	0.08	692	0.05	326
Flamborough to Filey Coast SPA	not sensitive		no determination	

a. Determination of deposition is based on the deposition velocity for forest terrain[21].
b. The critical load selected is the minimum of the range specified for the most sensitive habitat over the entire site.

The maximum process contributions to nitrogen and acid deposition are equivalent to less than 1% of the applicable critical loads for all sensitive sites with a European designation and below 100% of the applicable critical load at the SINC and as such are not considered significant. While there is exceedance of the critical load at some sensitive sites,

this is due to existing large background depositions. It is not considered that the process contributions have any significant influence on critical load compliance at these sites.

For all designated and local ecological sites requiring assessment, process contributions are insignificant and pose no threat to and have no meaningful influence on, the attainment of applicable critical levels and critical loads.

4.4 Sensitivity analyses

In the assessment of the impact of process contributions the worst case results have been reported. For the assessment, process contributions were modelled for each of 5 years' meteorological data using the ADMS 6 modelling system. A sensitivity analysis was undertaken to determine the influence of meteorological conditions and model selection on the findings of the assessment and hence provide some measure of their robustness.

4.4.1 Meteorological conditions

Table 4.7 summarises the influence of meteorological conditions on maximum process contributions for the discrete receptor groups describing the neighbouring residential locations, the local footpaths and wellsite boundary (see Annex E).

Annual variations in meteorological conditions, on average, show up to a twofold difference between maximum and minimum process contributions. This assessment is based on the maximum process contribution for all the years considered at each location, and as such will be an over estimation for most years.

Table 4.7   Influence of meteorological conditions on maximum process contribution

Substance	Averaging basis	Residential	Footpath	Site boundary
		Maximum process contribution (ratio of maximum to minimum year)		
Carbon monoxide	8 hours	2.3	1.7	1.6
	1 hour	1.6	1.4	1.3
Nitrogen dioxide	1 hour	2.0	1.8	3.0
	annual	1.8	1.8	1.6
Sulphur dioxide	15 min	1.1	1.1	1.6
	1 hour	1.2	1.3	1.6
	24 hours	1.8	1.8	1.9
PM_{10}	24 hours	1.7	1.6	1.4
	annual	1.7	1.7	1.5
$PM_{2.5}$	annual	1.7	1.7	1.5
Benzene	24 hours	1.4	1.6	1.5
	annual	2.1	1.8	2.7
Nitrogen monoxide	1 hour	2.3	1.6	1.3
	annual	1.8	1.8	1.6

4.4.2 Model selection

The main assessment has been undertaken using the ADMS modelling system. The US EPA's AERMOD model is also commonly used for regulatory purposes worldwide. To determine how the model used may have influenced the findings of the assessment, the AERMOD model was employed to predict process contributions over the important averaging bases at 2023 meteorological conditions. Table 4.8 presents the comparison between the ADMS and

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AERMOD model predictions averaged over receptor groups describing the neighbouring residential locations, the local footpaths and site boundary (see Annex E).

Table 4.8 Maximum process contributions (variation with model)

Averaging basis	Maximum process contribution (ratio of ADMS to AERMOD - 2023)		
	Residential	Footpaths	Site boundary
annual	1.4	1.3	1.8
1 hour	1.1	1.2	1.0
24 hour	1.7	1.4	2.8

In general, the AERMOD and ADMS models provide predicted ambient process contributions which are in reasonable agreement for all averaging bases at the receptors considered. There are slight differences between the receptor groups, although on average ADMS provides a marginally higher predicted process contribution across all sensitive receptors groups for all averaging bases. Bearing in mind the margin available in the assessment of air quality standard compliance and the maximum impact relative to critical loads and levels at the ecological receptors, it is not considered that the differences exhibited due to model selection will have any substantial impact on the overall conclusions of this assessment.

4.5   Modelling uncertainty

The use of models to predict the dispersion of releases has associated uncertainties. The main uncertainties in this assessment result from:

- The proposed development is modelled on the basis of each phase of the development being undertaken consecutively with no breaks, such that the entire 39 week programme is accommodated in one calendar year. In practice, given the issues associated with equipment availability, Europa expect significant breaks between and possibly within phases which will most likely see the programme completed over a period of three years. Long term air quality standards are based on annual means over a calendar year. The assumption of completion within one calendar year represents an unlikely worst case which will lead to a substantial over estimate in long term air quality impacts. Air quality standards based on shorter term averages will be less affected. Departures from the modelled development schedule will, in practice, most likely result in a lower air quality impact than that determined herein

- The operational load in practice is likely to be lower on most occasions than that modelled in this assessment. The proposed development is modelled based on full load operation of all plant on a continuous 24 hour per day basis for the entire duration of the proposed development phases, except where specifically limited by working hours or Europa's schedule. This provides what is considered to be a significant over estimate of process releases in practice, particularly for the high energy intensive well drilling phase and for the incineration of produced natural gas during the testing phase, where gas volumes are expected to be considerably less overall than assumed for this assessment. It is expected that the duration, frequency and intensity of equipment operation will be substantially lower than that considered in this assessment. As such, the process contributions and subsequent ambient impact for all pollutants are likely to be a significant overestimate of those in practice.

- The release rates upon which the assessment is based are consistent with the operation of engines, incinerators and construction vehicles at the regulation or benchmark limits. In addition, heavy duty vehicle idling emissions are considered conservative estimates. In practice, it is likely that pollutant release rates will be somewhat lower, and in some cases substantially lower, than the levels assumed in this assessment. This will result in an overestimate of ambient impact.

- Conversion rates for nitrogen monoxide to nitrogen dioxide of 35% and 70% have been employed as recommended by the Environment Agency[1] for short and long term air quality impacts respectively. These are generally considered quite conservative estimates. Conversion rates over the relatively short distances considered in this assessment are likely to be substantially lower than those assumed. Estimates based on the Janssen relationship[22] indicate a likely overestimate of the significance of process releases (see Annex C and Table E.1) of nitrogen dioxide and associated nitrogen and acid deposition at the designated and local ecological sites.

- In the assessment of particulate matter releases the environmental standards used are those for $PM_{2.5}$ and PM_{10}. A precautionary approach is adopted and it is assumed that when comparing the release with the corresponding standards, all particulate matter is present as either PM_{10} or $PM_{2.5}$ as appropriate.

- Volatile organic compounds are assessed as benzene as required within guidance[1] for situations where the composition of the release is not known. In practice, it is expected that a large proportion of the volatile organic compounds release will be methane or other lower hydrocarbons. This is particularly relevant to volatile organic releases from site equipment such as stationary engines and incinerators. Methane and lower hydrocarbons have significantly higher environmental benchmarks compared with benzene and as such significance of the air quality impact on human health in practice will be substantially less than reported in this assessment.

- The meteorological conditions upon which the assessment was based vary from year to year and influence ambient impact. A sensitivity analysis has shown the differences expected due to changes in meteorological conditions for a five year period. This assessment is based on the year providing the maximum impact for each location and pollutant and as such is likely to be an overestimate for most meteorological years.

- The model used can influence predictions of ambient impact. In this case a sensitivity analysis of the two most widely used models for regulatory purposes indicated that the conclusions of the assessment were not dependent on the selection of model. ADMS and AERMOD show generally good agreement and it is not considered that model selection has any significant impact on assessment conclusions, although the ADMS model does tend to provide higher predicted process contributions at sensitive locations compared with AERMOD.

- The necessary assumptions made regarding surface characteristics (section 3.4) can have either a negative or positive impact on modelling outcomes. A sensitivity analysis indicates that variations due to the assumed surface characteristics are unlikely to be significant in terms of the conclusions of the assessment as the potential for any impact is mitigated by the selection of descriptive parameters considered representative of the assessment area.

There are inherent uncertainties associated with the use of air dispersion models to predict the ambient impact of releases. With this in mind the assessment herein has been undertaken using conservative assumptions which tend towards an over estimation of the ambient impact. It is considered that the assessment has taken a precautionary approach and the conclusions reached therefore incorporate a reasonable margin of comfort to allow for the inevitable uncertainty of such modelling studies.

4.6   Photochemical ozone creation potential

Some of the pollutants released have the potential to react to form ozone. Ground level ozone is a highly reactive pollutant with a potential to damage human health and vegetation. It is produced by the action of sunlight on volatile organic compounds and oxides of nitrogen. Environment Agency guidance[23], provides a standardised methodology for determination of the photochemical ozone creation potential (POCP) of a release. In the case of the proposed operations it is considered that releases of volatile organic compounds, nitrogen dioxide, sulphur dioxide and carbon monoxide have implications for ozone formation. The total release of each of these over the duration of the proposed development is assessed in Table 4.9 based on operating conditions in section 3.5.

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The assumptions made in relation to releases are considered to represent the worst case for the proposed operations. The determination indicates a POCP for the entire proposed development of 372 tonnes.

Table 4.9   Calculation of POCP related releases

| Substance | Release over proposed development (t) | | | | POCP | |
	NO_2	CO	SO_2	Benzene	tonnes	% of total project releases
POCP factor	2.8	2.7	4.8	21.8	tonnes	% of total project releases
Phase						
1	3.2	4.0	<0.1	0.5	29.8	8.0
2	24.6	16.9	<0.1	2.2	162.9	43.8
3	11.6	16.5	0.3	3.6	157.6	42.4
4	2.5	2.5	<0.1	0.4	21.8	5.8
Total	42	40	<1	7	372	100

4.7   Greenhouse gas releases and climate change

Some of the pollutants released are greenhouse gases and it is required that the impact on global warming be determined. In this case the assessment confines itself to the consideration of direct emissions to air from the proposed plant exhausts. There is no assessment of any indirect emission (i.e. heat or power imported to site for use in operations). It is understood that there is no intention to export natural gas from site during the development. As such there is no consideration within this assessment of the subsequent usage of any produced materials which may be exported from site.

Environment Agency guidance[24], provides a standardised methodology for determination of the impact on global warming of a release based on the equivalent annual mass release of carbon dioxide. The global warming potential factors for methane and nitrous oxide use the values specified in the Intergovernmental Panel on Climate Change's 5th Assessment Report[25]. For the purposes of this assessment methane is assumed to comprise both methane and non-methane volatile organic compounds.

In the case of the proposed development, releases of carbon dioxide, methane and nitrous oxide are considered in respect of climate change. The annual release of each of these is assessed in Table 4.10 based on operating conditions in section 3.5 and represents the total release for the proposed development.

Table 4.10   Calculation of greenhouse gas releases

| Substance | Release over proposed development (t) | | | Impact | |
	CO_2	CH_4	N_2O	t CO_2 equivalent	% of total project releases
Global warming potential (relative to CO_2, 100 years)	1	28	265	t CO_2 equivalent	% of total project releases
Phase					
1	668	1	0.02	711	7.2
2	2949	3	0.08	3058	30.9
3	5442	8	0.08	5687	57.4
4	417	1	0.01	451	4.6
Total	9477	14	0.2	9907	100.0

The assumptions made in relation to releases are considered to represent the worst case for the proposed operations. The determination indicates an equivalent carbon dioxide release for the proposed development of 9907 tonnes. This is taken into account in the separate assessment of likely downstream greenhouse gas emissions arising from the development.

The disposal of produced natural gas is the predominant contributor to on-site development greenhouse gas releases. Its contribution to the overall total release in Table 4.10 is based on a disposal volume of 68.5 MMscf (see section 3.5.1). Should the discretionary flow period not be required, the overall greenhouse gas release for the development falls to 6749 tonnes.

4.8 Construction dust

It is likely that the construction activities associated with the wellsite development will give rise to dust emissions, albeit temporary in nature and largely restricted the areas close to the construction site.

The potential for fugitive dust is most likely to arise from the movement of vehicles over the earth, the stripping of soil, excavations and the subsequent storage of excavated materials and transfer of materials to and from lorries. This may be exacerbated by spillages during transportation and handling and also by periods of dry weather and high wind speeds. This is considered in Annex H in accordance with the methodology described in the IAQM's guidance[26]on the assessment of dust from demolition and construction.

It is expected that, with adequate mitigation measures in place, the risk of dust impact from all operations will be 'negligible'.

4.9 Operations traffic

The development of the wellsite and the subsequent operation will have the effect of increasing traffic flow, albeit temporarily, in the area, which in turn will result in additional releases of certain pollutants to air. It is necessary to understand the likely ambient impact of this increase in traffic flow. This is assessed in Annex I using methodology provided by the Highways England[27] and the IAQM[9].

Increases in road traffic brought about by the construction activities and subsequent wellsite operations are assessed to have a neutral impact on air quality based the guidance within Highways England's Design Manual for Roads and Bridges, the additional contributions to ambient pollutant concentrations from associated road traffic have no influence on the findings of the main air quality assessment for plant releases to air.

4.10 Odour impact assessment

Operations at the wellsite, during drilling, well development and testing have the potential for fugitive releases of natural gas. The techniques proposed for use and adoption of industry standard best practice in loss prevention are considered to mitigate this risk, and in practice it is expected that there will be negligible fugitive releases. Nevertheless, as a precautionary approach, a fugitive release of natural gas typical of on-shore conventional gas exploration operations has been adopted.

The release of organic compounds associated with this release is taken into account within the main air quality assessment. There is also a need to look at the potential for odour nuisance arising from the sulphur content of the fugitive release. This has been addressed in Annex J.

The maximum process contribution to odour at residential locations, from releases of hydrogen sulphide and mercaptans, are estimated to be equivalent to 0.04% and 0.01% respectively, of the Environment Agency's benchmark for moderately offensive odours. It is therefore considered that fugitive releases from operations at the Cloughton wellsite pose a negligible risk of loss of amenity due to odour.

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5 CONCLUSIONS

Europa Oil and Gas Limited proposes to undertake hydrocarbon appraisal operations on land off the A165 to the south east of Burniston. The proposal is to construct a wellsite, drill a single well and undertake production appraisal operations before reinstating the land. It is expected that operations will take around a year, although taking into account equipment availability and lead times, it is likely that the development will be staggered over a period of up to three years.

As part of the planning and permitting process it is necessary to assess the dispersion of releases to atmosphere associated with the proposed development to determine their impact on ambient concentrations of important pollutants around the local area. In particular, impact at locations of permanent human habitation and designated and local ecological sites, in the context of attainment of applicable environmental standards, requires assessment.

The predominant source of pollutant releases during site operations will be from the use of diesel fuel in mobile plant and stationary engines and from the incineration of produced natural gas. Releases of nitrogen oxides, carbon monoxide, volatile organic compounds, particulate matter and sulphur dioxide were therefore considered. The assessment was undertaken using the UK ADMS 6 modelling system, with an operating regime considered to provide unlikely worst case conditions for pollutant releases and air quality impact.

Maximum pollutant process contributions from site operations occur within the proposed wellsite boundary. Beyond this location, process contributions reduce significantly with distance. It is not considered that statutory air quality standards would be applicable around the area of maximum impact, or around and just beyond the site boundary, due to the infrequency of human exposure and limited access.

Along the nearby public footpaths, where short term environmental standards might be expected to apply, it is considered that process pollutant contributions in practice will be insignificant and unlikely to compromise attainment of these standards.

At neighbouring locations of residential occupation, where long term human exposure might be expected, it is considered that, in practice pollutant process contributions from the site operations will be insignificant, with predicted environmental concentrations of all pollutants around, and in most cases substantially less than, a third of the applicable standard.

Bearing in mind the precautionary assumptions made in the assessment, it is considered unlikely that pollutant process contributions from the development will pose any risk to, or have any meaningful influence on, the continued attainment of air quality standards at the nearest locations of human exposure.

At the nearest designated and local ecological sites requiring assessment, which are sensitive to nitrogen oxides, sulphur dioxide and nitrogen and acid deposition, process contributions are considered unlikely to pose any threat to, or have any substantial influence on, the attainment of critical levels and critical loads.

Necessary assumptions made to undertake the modelling are considered to have the effect of substantially overestimating the process contribution to ambient concentrations. It is considered that the predicted process impact reported herein is a conservative assessment and the conclusions reached therefore incorporate a reasonable margin of comfort in spite of the inevitable uncertainty of such modelling studies.

It is likely that the construction activities associated with the development of the wellsite and the reinstatement of the site will give rise to dust emissions. It is expected, based on Institute of Air Quality Management methodology, that with adequate mitigation measures in place the risk of dust impact from all proposed development operations will be 'negligible'.

Increases in road traffic, brought about by the construction activities and subsequent site operation, are assessed to have a neutral impact on air quality based on the guidance within Highways England's (now National Highways) Design Manual for Roads and Bridges.

Operations on site will give rise to releases of greenhouse gases. Based on an assessment of worst case operation, it is considered that proposed development lifetime greenhouse gas releases are largely insignificant in relation to the UK's current inventory and future budgets at around 9900 tonnes CO_2 equivalent. A separate assessment of the estimated downstream greenhouse gas emissions arising from the development accompanies the planning application.

There is a risk, albeit considered negligible, of fugitive releases of natural has during well drilling development and testing. The sulphur compounds within this release are potentially odorous. An odour impact assessment concluded that fugitive releases pose a negligible risk to loss of amenity due to odour at the nearest residential neighbours.
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Annex A   Dispersion modelling contour plots

The results of the modelling of the impact of pollutant releases from wellsite development and production test operations on local ambient ground level concentrations are presented in tabular form in Section 4. In Annex A typical examples of the long term and short term dispersion patterns for nitrogen dioxide and volatile organic compounds (assessed as benzene), the most significant pollutants, are presented. Contour plots illustrating the process contribution to ground level concentrations of each are provided. The results relate to what is considered a highly unlikely worst case where all operations are accommodated in a single calendar year and at meteorological conditions which are considered to provide the maximum process contributions over the entire proposed development. All results are presented as the maximum contribution of the process (excluding existing background concentrations), expressed as a percentage of the applicable air quality benchmark.

The plots are considered over an area of 1km x 1km, which comprises the assessment area including the immediate area around the proposed wellsite and the nearest residential neighbours.

For presentational purposes contour plots are limited to minimum values of 1% and 10% of the long and short term environmental standards respectively. Process contribution of less than 1% and 10% of the long term and short term standards respectively, are generally considered insignificant in terms of air quality impact.

The plots also identify the area within which Environment Agency screening criteria are exceeded. Any process contribution beyond this area does not require further consideration with regard to human health effects.

The following figures are presented:

Figure 1   Predicted maximum process contributions of nitrogen dioxide
                         (AQS limit 99.8 percentile of 1 hour means – 2022)

Figure 2   Predicted maximum process contributions of nitrogen dioxide
                         (AQS limit annual mean - 2019)

Figure 3   Predicted maximum process contributions of volatile organic compounds
                         (EAL for benzene 24 hour means – 2020)

Figure 4   Predicted maximum process contributions of volatile organic compounds
                         (AQS limit for benzene annual mean - 2023)

Figure A.1   Predicted maximum process contributions of nitrogen dioxide
(AQS limit 99.8 percentile of 1 hour means – 2022)

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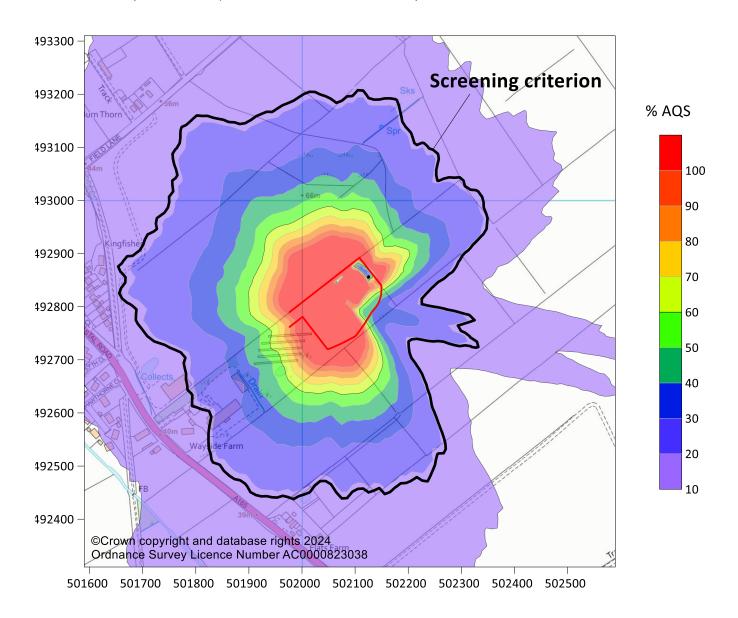
Figure A.2 Predicted maximum process contributions of nitrogen dioxide
(AQS limit annual mean - 2019)
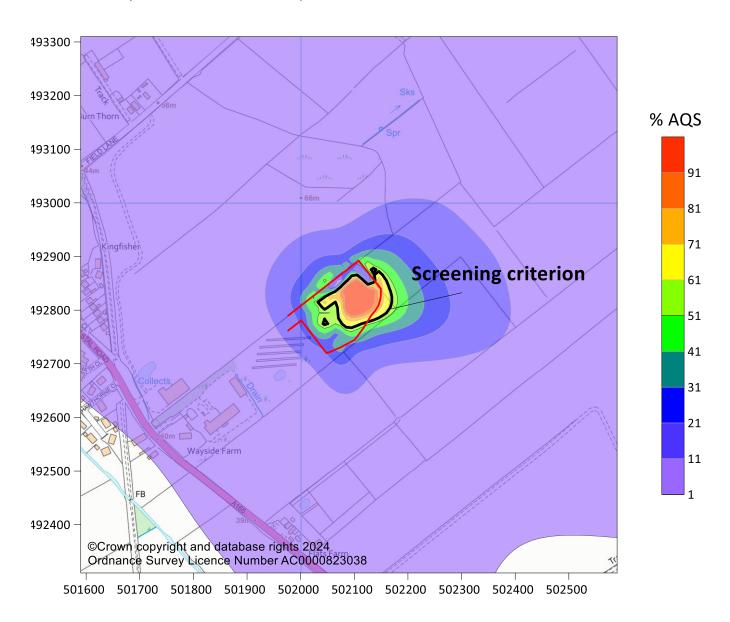
Figure A.3   Predicted maximum process contributions of volatile organic compounds
(EAL for benzene 24 hour means – 2020)

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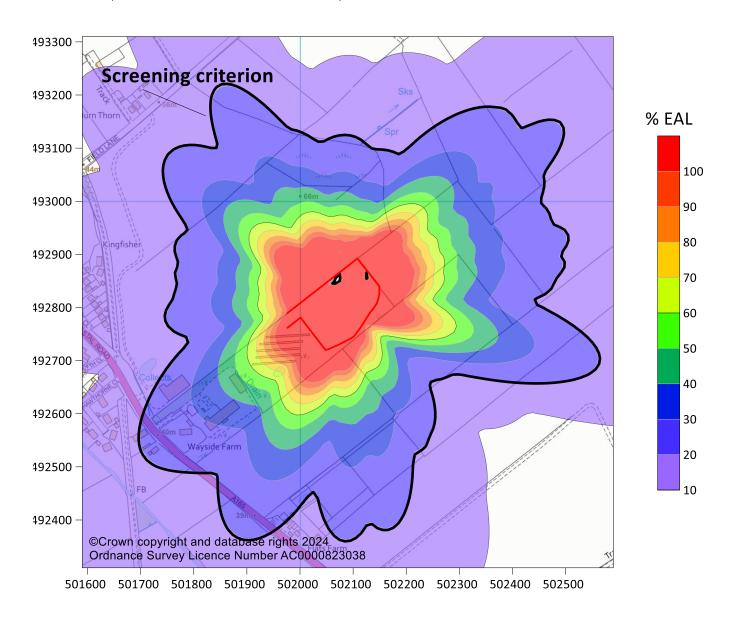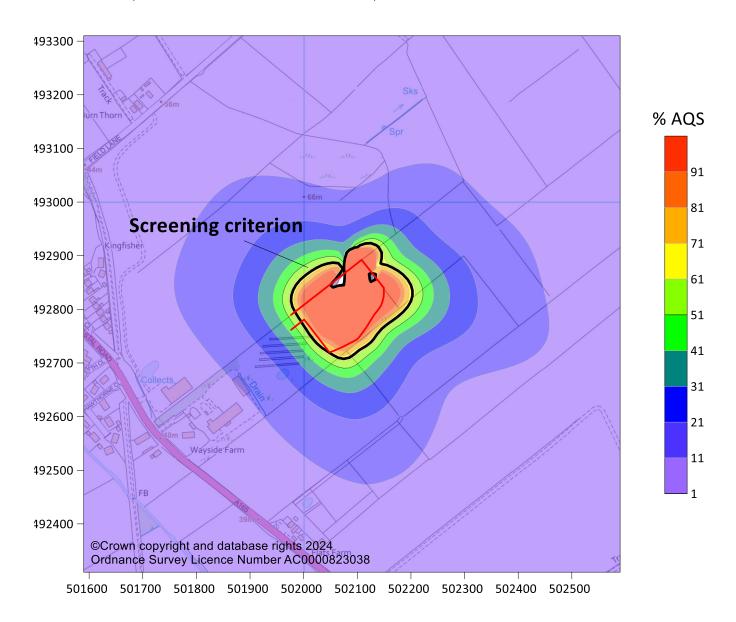
Figure A.4 Predicted maximum process contributions of volatile organic compounds (AQS limit for benzene annual mean - 2023)

ANNEX B Model input data

B.1   Assessment area and surface characteristics

Table B.1 summarises the assessment area considered in the modelling and the values of the parameters describing its surface characteristics. These are described in more detail in sections 3.1 to 3.4.

Table B.1   Assessment area and surface characteristics

Parameter	Value
Assessment area	1000 m x 1000m area with centre 502090 492810
Cartesian receptor grid	101 x 101 receptor grid (total 10201) with receptors spaced at 10m intervals
Discrete receptors	117 receptors - see Table E.1 for description
Meteorological data	Hourly sequential data supplied by the UK Meteorological Office from the Bridlington Mrsc station for the 5 year period 2019 to 2023
Topography	Elevated terrain -Ordnance Survey Land-form Panorama DTM for area considered, (NZ80, SE88 & TA08)
Surface roughness	0.3m
Minimum Monin Obukhov length	1m
Surface albedo	0.23
Priestley Taylor parameter	1.0

The release characteristics of the wellsite sources considered in this assessment are detailed in full in Tables 3.10 to 3.20. Tables B.1 and B.2 summarise the main input data to the model.

Table B.1   Exhaust gas conditions

Plant		Easting (m)	Northing (m)	Height of release (m)	Diameter (m)	Temperature (ºC)	Velocity (m/s)
A	Construction plant	502100	492839	3.0	0.30	150	29.5
B	Lighting towers	502103	492817	3.0	0.15	150	0.8
C	Welfare unit	502036	492774	3.0	0.10	150	3.0
D	Surface conductor	502085	492823	4.0	0.20	550	21.4
E	Generator	502068	492757	4.0	0.30	550	18.6
F1	Rig engine 1	502070	492811	4.0	0.40	430	31.8
F2	Rig engine 2	502071	492808	4.0	0.40	430	31.8
F3	Rig engine 3	502074	492804	4.0	0.40	430	31.8
F4	Rig ancillaries	502105	492843	3.0	0.20	150	11.1
G	Workover rig	502085	492823	4.0	0.30	550	18.8
H	Flare	502126	492833	12.2	2.0	1000	34.7
I	Oil heater	502100	492839	3.5	0.35	150	5.2
J	Restoration plant	502100	492839	3.0	0.20	150	17.6
K	Crane	502105	492843	3.0	0.20	150	22.0
HDV		502029	492812	3.0	0.10	150	4.9
Fugitive		502085	492823	1.0	0.07	50	0.1

Table B.2   Modelled pollutant releases

		Pollutant release rate (g/s)				
Plant		CO	Benzene	NO_2	PM_{10}	SO_2
A	Construction plant	1.087	0.051	0.270	0.005	0.0011
B	Lighting towers	0.029	0.0029	0.036	0.031	0.000022
C	Welfare unit	0.018	0.002	0.023	0.002	0.000014
D	Surface conductor	0.174	0.015	0.184	0.010	0.00021
E	Generator	0.340	0.029	0.360	0.019	0.00041
F1	Rig engine 1	1.380	0.187	2.337	0.079	0.0015
F2	Rig engine 2	1.380	0.187	2.337	0.079	0.0015
F3	Rig engine 3	1.380	0.187	2.337	0.079	0.0015
F4	Rig ancillaries	0.250	0.015	0.185	0.015	0.00021
G	Workover rig	0.344	0.047	0.583	0.020	0.00041
H	Flare	6.761	1.649	1.483	0	0.177
I	Oil heater	0.011	0.001	0.046	0.005	0.00034
J	Restoration plant	0.445	0.017	0.036	0.002	0.00037
K	Crane	0.389	0.021	0.044	0.003	0.00047
HDV		0.022	0.011	0.055	0.002	0.000026
Fugitive		0	0.0369	0	0	0

B.2   Model input files

The input data used in the current assessment have been provided under separate cover. Electronic files containing the input data used in the modelling of the maximum process contributions over the entire assessment area of all pollutants considered have been provided as detailed below:

Carbon monoxide	8 hour mean	BUR WC 2020.APL
	hourly mean	BUR WC 2020APL
Nitrogen dioxide	1 hour mean	BUR WC 2022.APL
	annual mean	BUR WC 2019.APL
Sulphur dioxide	15 minute mean	BUR WC 2022.APL
	1 hour mean	BUR WC 2022.APL
	24 hour mean	BUR WC 2022.APL
PM_{10}	24 hour mean	BUR WC 2019.APL
	annual mean	BUR WC 2021.APL
$PM_{2.5}$	annual mean	BUR WC 2021.APL
Benzene	24 hour mean	BUR WC 2020.APL
	annual mean	BUR WC 2023.APL
Nitrogen monoxide	hourly mean	BUR WC 2022.APL
	annual mean	BUR WC 2019.APL
Odour	hourly mean	BUR Odour 2022.APL

B.3   Models used

ADMS	Cambridge Environmental Research Consultants Limited ADMS 6.0: version 6.0.0.1 License: A01-1347-C-AD520-UK (10.10.24)
AERMOD	Lakes Environmental Software AERMOD View: version 12.0.0 (AERMOD version 23132) License: AER0005882 (21.11.24)

ANNEX C Conversion of nitrogen monoxide to nitrogen dioxide

The majority of oxides of nitrogen released will be in the form of nitrogen monoxide. While conversion to nitrogen dioxide will occur in the atmosphere it is unlikely that all of the nitrogen oxides in the flue emission will be in the form of nitrogen dioxide at ground level. It may be noted that for this type of assessment the Environment Agency[1] recommend that conversion rates of 35% and 70% be considered for short and long term air quality impacts respectively. These are considered quite conservative estimates. These conversion rates have been used in this assessment and represent a precautionary approach which will, it is considered, significantly over estimate the process contribution to ground level concentrations of nitrogen dioxide at most locations and as such provide a reasonable margin of headroom which should go some way to offsetting the inevitable uncertainties associated with this type of assessment and the necessary modelling assumptions.

There are methodologies available which enable a more representative estimation of conversion rates at specific locations, largely based on distance from the point of release. Based on a study of Dutch power station plumes, Janssen et al[22] determined an approximate relationship between the conversion of NO to NO_2 and the distance from the point of release as below:

$$\frac{NO_2}{NO_x} = A\left(1 - e^{(-\alpha x)}\right)$$

where   A is the ozone parameter describing the oxidation of NO to NO_2 in the presence of ozone and the photolysis of NO_2 by sunlight to reform NO.
α is the wind parameter which expresses conversion rates in respect of downwind distance based on wind speed at plume height and ozone concentration.
x is the downwind distance (km)

The values of A and α depend on ozone concentration, incoming solar radiation and wind speed. Janssen developed empirical values for these based on seasonal measurements of conditions in the Netherlands. It is assumed that a similar relationship is applicable in the UK.

Janssen proposed the following seasonal values for A and α:

Winter (December to February)

Background ozone concentration (ppb)	Wind speed at plume height (m/s)					
	0-5		5-15		>15	
	A	α	A	α	A	α
0-10	0.49	0.05	0.49	0.05	0.49	0.05
10-20	0.74	0.07	0.74	0.07	0.74	0.07
20-30	0.83	0.07	0.83	0.07	0.83	0.10
30-40	0.87	0.07	0.87	0.07	0.87	0.15

Spring/Autumn (March to May and September to November)

| Background ozone concentration (ppb) | Wind speed at plume height (m/s) | | | | | |
| | 0-5 | | 5-15 | | >15 | |
	A	α	A	α	A	α
10-20	0.635	0.10	0.635	0.10	0.635	0.10
20-30	0.74	0.10	0.74	0.10	0.74	0.15
30-40	0.80	0.10	0.80	0.10	0.80	0.25
40-60	0.85	0.10	0.85	0.15	0.85	0.30

Summer (June to August)
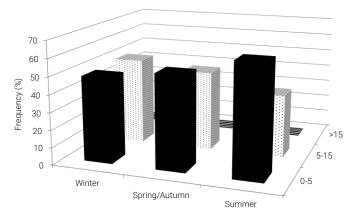
| Background ozone concentration (ppb) | Wind speed at plume height (m/s) | | | | | |
| | 0-5 | | 5-15 | | >15 | |
	A	α	A	α	A	α
20-30	0.67	0.10	0.67	0.10	0.67	0.10
30-40	0.74	0.10	0.74	0.15	0.74	0.25
40-60	0.81	0.15	0.81	0.25	0.81	0.35
60-120	0.88	0.20	0.88	0.35	0.88	0.45
120-200	0.93	0.40	0.93	0.65	0.93	0.80

Janssen indicates that '*the method presented therefore proved to be highly suitable to predict NO_2/NO_x ratios in power plant plumes under widely varying atmospheric conditions*'.

An assessment of the meteorological data for the Bridlington Mrsc station over the period employed in this assessment (2019 to 2023) indicated the following seasonal distribution of wind speed.

| Season | Frequency in wind speed category (%) | | | Mean wind speed (m/s) |
	0-5 m/s	5-15 m/s	>15 m/s	
Winter	48.8	50.1	1.1	5.7
Spring/Autumn	53.8	45.9	0.4	5.1
Summer	63.8	36.2	0.1	4.3

Seasonal wind speed
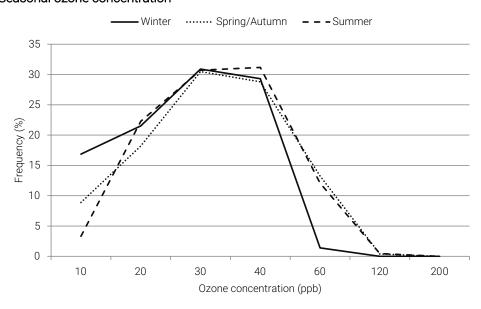
The wind speed is almost exclusively below the 15 m/s category for all seasons, with an overall average of 5.1 m/s. The nearest automatic station monitoring station which provides measurement of a full year of ozone monitoring data for 2023 is Hull Freetown (UKA00450) which is located around 64km south of the Cloughton wellsite (509482 429322). An analysis of hourly average data for 2023 indicated the following seasonal concentrations:

Season	Frequency in ozone concentration category (%)							Mean
	0-10	10-20	20-30	30-40	40-60	60-120	120-200	
	ppb							
Winter	16.9	21.5	30.9	29.3	1.4	<0.1	<0.1	22.9
Spring/Autumn	8.9	18.2	30.5	28.8	13.3	0.4	<0.1	27.1
Summer	3.3	22.3	30.7	31.2	12.1	0.5	<0.1	28.2

Seasonal ozone concentration
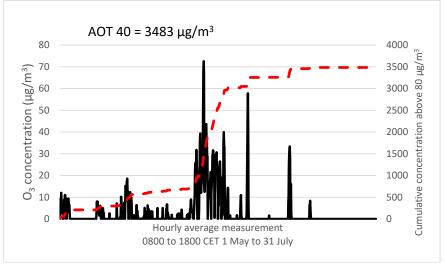
Based the values of wind speed and ozone concentration and Janssen's empirical relationship, it is considered that the following seasonal values for the parameters A and α are appropriate:

Season	Wind speed (m/s)	Ozone concentration (ppb)	A	α
Winter	5-15	20-30	0.83	0.07
Spring/Autumn	5-15	20-30	0.74	0.10
Summer	0-5	30-40	0.74	0.10

The measured ozone concentrations were also examined to determine the AOT 40. This is the sum of the differences of the measured ozone concentrations which are greater than $80\mu g/m^3$ (40 ppb) for the period 0800 to 2000 (Central European Time) over the 1 May to 31 July. The assessment indicated an AOT40 for the data set of $3483\mu g/m^3$ as summarised below.

Ozone AOT 40 assessment (1 May to 31 July 2023)

AOT 40 = 3483 μg/m^3
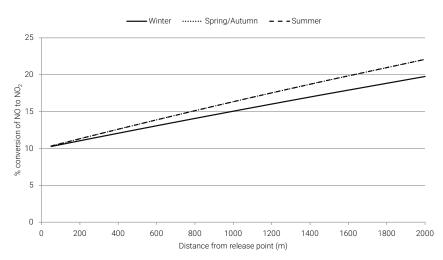
It is likely that a small amount of the nitrogen oxides emitted will be in the form of nitrogen dioxide. For the purposes of this assessment it is assumed that 10% of nitrogen oxides comprise nitrogen dioxide and as such Janssen's relationship for this situation is described by:

$$\frac{NO_2}{NO_x} = y + (1-y)A\left(1-e^{(-\alpha x)}\right)$$

where y is the fraction of nitrogen oxides present as nitrogen dioxide at the point of release.

Based on Janssen's relationship the following seasonal conversion rates are estimated with distance from the source.

Estimated seasonal NO to NO$_2$ conversion rates

The conversion rates expected for locations within 1 km of the source are less, and in some cases significantly less, than those assumed within the assessment.

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ANNEX D Meteorological data

For this modelling assessment hourly sequential meteorological data provided by the UK Met Office from the Bridlington Mrsc station were employed and covered the 5 year period 2019 to 2023. Further details of the data employed are provided in this section.

D.1   Windroses

In section 3.3 a cumulative wind rose for the period 2019 to 2023 is presented. The windroses for each individual year of data used are illustrated below.

Figure D.1   Bridlington Mrsc 2019
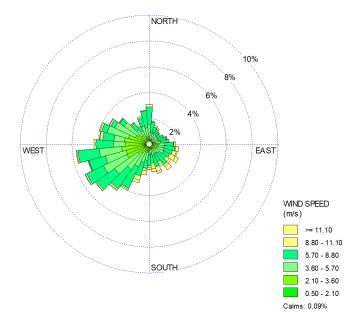
Figure D.2   Bridlington Mrsc 2020
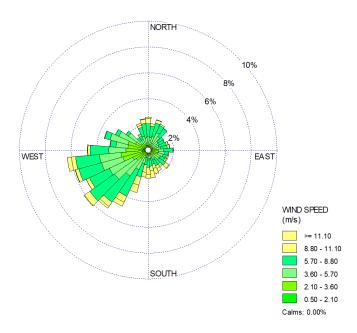
Figure D.3   Bridlington Mrsc 2021
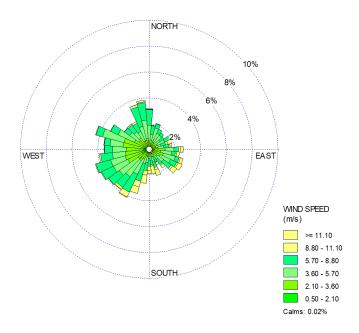
Figure D.4   Bridlington Mrsc 2022
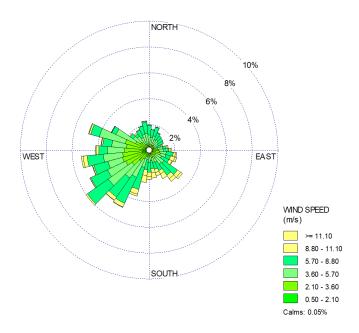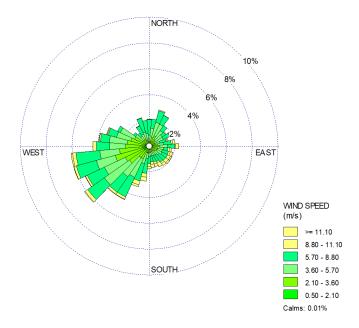
Figure D.5   Bridlington Mrsc 2023

D.2   Data analysis and characteristics

Analyses of the wind direction, wind speed and precipitation are summarised in Tables D.1 and D.2 for the period 2019 to 2023.

Table D.1   Wind speed and direction (2019 to 2023) for Bridlington Mrsc

Wind direction blowing from	Wind speed (m/s)						
	0.3-2.1	2.1-3.6	3.6-5.7	5.7- 8.8	8.8-11.1	> 11.1	Total
	Frequency (% of time)						
N	0.6	1.9	4.1	4.6	0.5	0.1	11.8
NE	0.6	1.5	2.5	1.9	0.1	<0.1	6.6
E	1.2	2.4	2.4	2.4	0.6	0.6	9.7
SE	0.8	1.5	2.0	2.7	0.8	0.9	8.6
SE	0.9	1.6	2.3	3.9	1.7	1.7	12.1
SW	1.2	3.8	6.9	6.7	0.9	0.2	19.7
W	2.1	7.6	6.8	5.1	0.7	0.2	22.6
NW	0.8	2.6	3.5	1.7	0.2	<0.1	8.9
Calm							<0.1

a. Missing data is ignored from the determination of percentage frequency.

Table D.2   Rainfall and wind direction (2019 to 2023) for Bridlington Mrsc

Wind direction Blowing from	Rain fall (mm/h)						
	Dry	0.1-0.3	0.3-0.6	0.6-0.9	0.9-1.2	1.2-1.5	>1.5
	Frequency (% of time)						
N	10.2	0.7	0.4	0.1	0.2	<0.1	0.2
NE	5.8	0.3	0.2	0.1	<0.1	<0.1	0.1
E	8.6	0.4	0.3	0.1	0.1	<0.1	0.2
SE	7.7	0.3	0.2	0.1	0.1	<0.1	0.2
SE	10.2	0.6	0.6	0.1	0.2	0.1	0.2
SW	18.1	0.7	0.4	0.1	0.1	<0.1	0.2
W	21.4	0.5	0.3	0.1	0.1	<0.1	0.1
NW	7.7	0.4	0.4	0.1	0.1	<0.1	0.1
Calm	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total	90.0	3.9	2.8	0.7	1.0	0.3	1.3

a. Missing data is ignored from the determination of percentage frequency.

The main data characteristics are summarised in Table D.3.

Table D.3   Dataset characteristics (2019 to 2023) for Bridlington Mrsc

No. days data	1826		
No. hours data	43824		
No. calm hours (<0.3 m/s)	15	0.03	%
No. dry hours (<0.1 mm/h)	39458	90.32	%
Mean wind speed (m/s)	5.1		
No. missing records	138	0.32	%
Available records	43686	99.69	%

ANNEX E Discrete receptors

Discrete receptors were used to monitor the process contribution to ambient pollutant concentrations at a range of locations including nearby residential locations and local footpaths as illustrated in Figure 3.1. Details of their location are provided in Table E.1, together with the predicted nitrogen monoxide to nitrogen dioxide conversion rate (see Annex C). All receptors were at an elevation of 1.5m, with the exception of the designated and local ecological sites, which had an elevation of 0m.

The receptors fall into the following groups:

1 to 59	Residential locations (see Figure 3.1)
60 to 86	Site boundary (see Figure 3.1)
87 to 112	Footpaths (see Figure 3.1)
113 to 117	Designated and local ecological sites (see Table 3.1)

Table E.1   Receptor locations

Receptor		Position[a]	Easting (m)	Northing (m)	NO to NO$_2$ conversion rate (%)
1	WaysideFarm	284 m SW	501874	492625	11.9
2	Flats Farm	440 m S	502026	492375	12.9
3	Burnside Leisure Park	567 m S	502053	492245	13.7
4	Scalby Close Park	775 m S	502077	492035	15.0
5	Ians Field Farm	857 m S	501943	491966	15.5
6	Mount Lodge	1235 m SW	501293	491867	17.7
7	Bridge Close 1	453 m W	501638	492785	12.9
8	Bridge Close 2	455 m W	501635	492826	13.0
9	Bridge Close 3	467 m W	501628	492873	13.0
10	Field Lane 1	535 m NW	501690	493165	13.5
11	Field Lane 2	530 m NW	501726	493195	13.4
12	Field Lane 3	646 m W	501473	493003	14.2
13	Beck Farm	673 m NW	501472	493076	14.3
14	Rocks Lane Close 1	605 m W	501499	492939	13.9
15	Rocks Lane Close 2	669 m W	501436	492950	14.3
16	Bridge Close 4	542 m W	501558	492912	13.5
17	Bridge Close 5	542 m W	501551	492867	13.5
18	Coastal Road 1	531 m W	501559	492827	13.4
19	Coastal Road 2	563 m W	501528	492849	13.6
20	Coastal Road 3	594 m W	501499	492871	13.8
21	Coastal Road 4	648 m W	501447	492888	14.2
22	Coastal Road 5	545 m W	501546	492776	13.5
23	Coastal Road 6	583 m W	501507	492796	13.8
24	Coastal Road 7	613 m W	501478	492833	14.0
25	Coastal Road 8	445 m SW	501737	492539	12.9

Table E.1   continued

Receptor		Position[a]	Easting (m)	Northing (m)	NO to NO$_2$ conversion rate (%)
26	Hawthorne Close 1	474 m W	501637	492671	13.1
27	Hawthorne Close 2	491 m SW	501648	492596	13.2
28	Burniston Gardens 1	596 m SW	501551	492555	13.9
29	Burniston Gardens 2	693 m SW	501465	492509	14.5
30	Burniston Gardens 3	776 m SW	501392	492472	15.0
31	Burniston Gardens 4	653 m W	501481	492576	14.2
32	Burniston Gardens 5	688 m W	501444	492573	14.4
33	Scalby Road 1	740 m W	501394	492559	14.7
34	Scalby Road 2	769 m SW	501381	492512	14.9
35	Scalby Road 3	859 m SW	501309	492452	15.5
36	Scalby Road 4	736 m W	501361	492709	14.7
37	Scalby Road 5	780 m W	501312	492863	15.0
38	Scalby Road 6	828 m W	501269	492914	15.3
39	Scalby Road 7	903 m W	501202	492975	15.7
40	Scalby Road 8	964 m W	501149	493022	16.1
41	Willymath Close	495 m W	501605	492712	13.2
42	Kendall Close 1	587 m W	501512	492707	13.8
43	Kendall Close 2	642 m W	501456	492709	14.1
44	Southend Close	631 m W	501461	492752	14.1
45	Southend 1	636 m W	501454	492814	14.1
46	Southend 2	647 m W	501444	492784	14.2
47	Southend 3	667 m W	501425	492757	14.3
48	Southend 4	683 m W	501408	492783	14.4
49	Southend 5	663 m W	501427	492809	14.3
50	Cross Lane 1	700 m W	501396	492901	14.5
51	Cross Lane 2	710 m W	501390	492932	14.6
52	Wandalls Road 1	841 m W	501296	493088	15.4
53	Wandalls Road 2	880 m W	501244	493054	15.6
54	Wandalls Road 3	867 m W	501285	493132	15.5
55	Wandalls Road 4	940 m W	501188	493073	16.0
56	Overgreen View 1	982 m W	501182	493184	16.2
57	Overgreen View 2	946 m NW	501235	493213	16.0
58	Cliff Top House	1037 m N	502468	493776	16.6
59	Westfield Farm	1098 m NW	501503	493738	16.9
60	Site boundary	172 m W	501928	492753	11.1
61		150 m W	501946	492768	11.0
62		128 m W	501965	492781	10.9
63		108 m W	501983	492797	10.7
64		90 m W	502000	492808	10.6
65		74 m W	502017	492821	10.5
66		64 m NW	502032	492836	10.4
67		56 m NW	502050	492849	10.4

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Table E.1   continued

Receptor	Position[a]	Easting (m)	Northing (m)	NO to NO_2 conversion rate (%)
68	58 m NW	502067	492863	10.4
69	68 m N	502087	492878	10.5
70	81 m N	502103	492890	10.5
71	71 m NE	502118	492875	10.5
72	63 m NE	502128	492860	10.4
73	61 m NE	502138	492848	10.4
74	52 m NE	502138	492831	10.3
75	39 m E	502129	492812	10.3
76	33 m SE	502119	492795	10.2
77 Site boundary	37 m SE	502106	492776	10.2
78	48 m S	502093	492762	10.3
79	61 m S	502073	492751	10.4
80	78 m SW	502051	492743	10.5
81	72 m SW	502041	492757	10.5
82	72 m SW	502029	492773	10.5
83	80 m W	502011	492796	10.5
84	110 m W	501985	492776	10.7
85	135 m W	501961	492770	10.9
86	155 m W	501944	492756	11.0
87	1214 m NE	502831	493772	17.6
88	1093 m NE	502812	493631	16.9
89	979 m NE	502754	493529	16.2
90	922 m NE	502594	493581	15.9
91	839 m NE	502742	493339	15.4
92	779 m NE	502757	493213	15.0
93 Footpath coastal	758 m E	502791	493099	14.9
94	768 m E	502846	492945	14.9
95	858 m E	502947	492832	15.5
96	792 m E	502865	492644	15.1
97	870 m SE	502886	492460	15.5
98	983 m SE	502932	492303	16.2
99	1104 m SE	502947	492115	17.0
100	437 m W	501656	492759	12.8
101	444 m W	501647	492840	12.9
102	474 m W	501635	492944	13.1
103	538 m NW	501605	493043	13.5
104 Footpath railway	695 m NW	501490	493161	14.5
105	781 m NW	501448	493256	15.0
106	884 m NW	501376	493332	15.6
107	977 m NW	501321	493413	16.2
108	1053 m NW	501277	493480	16.7

Table E.1   continued

Receptor		Position[a]	Easting (m)	Northing (m)	NO to NO_2 conversion rate (%)
109		1129 m NW	501238	493551	17.1
110	Footpath railway	1220 m NW	501199	493644	17.7
111		1328 m NW	501164	493761	18.3
112		751 m W	501372	493029	14.8
113	Iron Scar and Hundale Point to Scalby Ness SSSI	716 m E	502792	492949	14.6
114	Scarborough to Whitby Disused Railway Site SINC	437 m W	501653	492823	12.8
115	Beast Cliff-Whitby SAC	6147 m N	500505	498749	40.6
116	North York Moors SAC, SPA	7655 m NW	497463	498908	45.6
117	Flamborough to Filey Coast SPA	9344 m SE	508932	486446	50.4

a. Position of receptor relative to the centre of the Cloughton appraisal wellsite.

Table E.2 details the results of the assessment for the discrete receptors. The maximum process contributions for nitrogen dioxide and volatile organic compounds (assessed as benzene), identified as the two largest contributors to air quality impact of the pollutants considered, are provided for each discrete receptor expressed as a proportion of the applicable air quality standard.

Table E2   Maximum process contributions at discrete receptors

Receptor		Maximum process contribution (% air quality standard)			
		Nitrogen dioxide		Volatile organic compounds	
		1 hour	annual	24 hours	annual
1	WaysideFarm	32.0	5.9	39.3	10.5
2	Flats Farm	18.9	4.1	20.7	7.1
3	Burnside Leisure Park	13.3	2.6	14.9	5.0
4	Scalby Close Park	7.9	1.6	10.6	3.3
5	Ians Field Farm	7.8	1.5	9.3	2.9
6	Mount Lodge	3.7	0.6	4.7	1.1
7	Bridge Close 1	16.9	2.7	32.0	6.3
8	Bridge Close 2	17.9	2.9	29.0	6.6
9	Bridge Close 3	17.6	3.0	21.5	6.6
10	Field Lane 1	14.0	3.2	19.4	6.2
11	Field Lane 2	15.2	3.4	18.8	6.5
12	Field Lane 3	11.1	1.9	11.3	4.1
13	Beck Farm	9.3	1.8	11.4	3.9
14	Rocks Lane Close 1	11.8	2.0	12.8	4.4
15	Rocks Lane Close 2	10.5	1.7	10.8	3.8
16	Bridge Close 4	14.7	2.4	15.2	5.2
17	Bridge Close 5	15.1	2.3	18.9	5.2

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Air quality assessment of hydrocarbon appraisal operations
Europa Oil and Gas Limited, Cloughton Appraisal Well, Burniston

Table E2   continued

Receptor		Maximum process contribution (% air quality standard)			
		Nitrogen dioxide		Volatile organic compounds	
		1 hour	annual	24 hours	annual
18	Coastal Road 1	14.1	2.3	23.6	5.2
19	Coastal Road 2	12.8	2.1	19.9	4.8
20	Coastal Road 3	13.0	2.0	16.6	4.5
21	Coastal Road 4	11.5	1.8	13.6	3.9
22	Coastal Road 5	14.0	2.0	25.3	4.6
23	Coastal Road 6	12.5	1.9	22.6	4.3
24	Coastal Road 7	11.3	1.8	19.1	4.1
25	Coastal Road 8	17.3	2.5	22.0	4.8
26	Hawthorne Close 1	11.4	1.9	19.6	4.7
27	Hawthorne Close 2	11.4	1.8	15.0	4.0
28	Burniston Gardens 1	8.5	1.3	11.2	3.0
29	Burniston Gardens 2	7.3	1.0	9.2	2.3
30	Burniston Gardens 3	6.4	0.8	8.0	2.0
31	Burniston Gardens 4	8.9	1.1	10.9	2.6
32	Burniston Gardens 5	7.7	1.0	10.3	2.4
33	Scalby Road 1	7.7	0.9	9.3	2.2
34	Scalby Road 2	6.4	0.8	8.7	2.0
35	Scalby Road 3	5.7	0.7	7.3	1.7
36	Scalby Road 4	8.3	1.1	15.6	2.6
37	Scalby Road 5	8.0	1.3	12.3	2.9
38	Scalby Road 6	7.6	1.2	9.1	2.7
39	Scalby Road 7	6.9	1.1	6.2	2.4
40	Scalby Road 8	6.6	1.0	5.7	2.2
41	Willymath Close	13.1	1.9	24.2	4.7
42	Kendall Close 1	10.3	1.5	20.1	3.6
43	Kendall Close 2	9.4	1.3	18.4	3.2
44	Southend Close	11.0	1.5	20.5	3.5
45	Southend 1	11.0	1.7	19.3	3.8
46	Southend 2	10.8	1.6	19.8	3.6
47	Southend 3	10.2	1.4	19.1	3.3
48	Southend 4	10.0	1.4	18.4	3.3
49	Southend 5	10.7	1.6	18.4	3.6
50	Cross Lane 1	10.0	1.6	11.6	3.5
51	Cross Lane 2	9.9	1.6	9.5	3.4
52	Wandalls Road 1	7.3	1.2	7.3	2.7
53	Wandalls Road 2	6.5	1.1	6.8	2.5
54	Wandalls Road 3	6.6	1.2	7.5	2.7
55	Wandalls Road 4	5.8	1.0	6.1	2.3
56	Overgreen View 1	5.7	1.0	6.4	2.2
57	Overgreen View 2	6.1	1.1	7.2	2.4

Table E2   continued

Receptor		Maximum process contribution (% air quality standard)			
		Nitrogen dioxide		Volatile organic compounds	
		1 hour	annual	24 hours	annual
58	Cliff Top House	4.8	1.0	5.5	1.9
59	Westfield Farm	4.9	1.0	6.7	2.0
60		53.2	11.2	78.2	26.3
61		68.6	14.6	104.3	34.0
62		90.9	19.7	135.7	45.0
63		129.0	28.5	194.3	65.3
64		178.8	43.0	267.3	99.9
65		234.1	75.6	375.1	167.4
66		383.2	88.1	563.2	161.8
67		617.1	118.7	547.3	205.7
68		492.5	80.0	427.6	148.9
69		236.5	46.0	1344.6	290.6
70		278.5	51.2	2161.7	609.4
71		234.1	47.9	0.00	0.00
72		209.4	63.4	0.00	0.00
73	Site boundary	198.7	56.1	0.00	0.00
74		182.7	88.6	320.4	282.3
75		223.3	102.5	348.6	275.6
76		251.3	90.0	262.1	194.9
77		219.6	62.6	252.4	149.3
78		254.1	66.3	326.9	137.8
79		230.7	54.1	322.5	106.8
80		215.3	64.0	308.5	98.3
81		238.8	72.0	371.4	113.8
82		216.8	71.0	271.2	124.8
83		160.5	46.1	210.7	106.9
84		100.5	25.5	143.1	55.6
85		78.8	17.7	110.6	40.0
86		61.1	13.6	88.4	30.8
87		5.7	1.2	6.0	2.2
88		6.1	1.5	6.6	2.8
89		7.1	1.7	7.3	3.3
90		7.2	1.7	7.8	3.1
91		8.6	2.0	10.6	4.1
92		9.4	2.3	9.3	4.8
93	Footpath coastal	10.4	2.6	9.7	5.5
94		8.9	2.6	10.2	5.5
95		8.3	2.4	7.6	4.4
96		12.7	2.8	12.1	4.6
97		8.2	1.7	7.3	2.8
98		5.1	0.9	3.6	1.7

Table E2   continued

Receptor		Maximum process contribution (% air quality standard)			
		Nitrogen dioxide		Volatile organic compounds	
		1 hour	annual	24 hours	annual
99	Footpath coastal	3.9	0.5	2.8	1.2
100		16.3	2.6	32.8	6.3
101		18.1	3.1	28.1	7.0
102		15.3	3.0	19.2	6.5
103		12.6	2.6	16.2	5.4
104		8.4	1.8	11.9	3.8
105		8.0	1.6	9.8	3.2
106	Footpath railway	6.2	1.3	8.1	2.7
107		5.5	1.2	6.7	2.4
108		4.9	1.1	6.2	2.2
109		4.4	1.0	5.7	2.0
110		4.2	0.9	5.1	1.9
111		4.0	0.8	4.5	1.7
112		8.6	1.5	8.9	3.2
113	Iron Scar and Hundale Point to Scalby Ness SSSI	9.6	2.9	11.4	6.2
114	Scarborough to Whitby Disused Railway Site SINC	18.7	3.1	31.0	7.0
115	Beast Cliff-Whitby SAC	0.3	0.04	0.3	0.1
116	North York Moors SAC, SPA	0.2	0.04	0.5	0.1
117	Flamborough to Filey Coast SPA	0.3	0.03	0.3	0.1

ANNEX F   Detailed results for designated and local ecological sites

The impact of wellsite process contributions with regard to critical levels for nitrogen oxides and sulphur dioxide and critical loads for nitrogen and acid deposition at designated and local ecological sites is summarised in Section 4.3. Annex F provides the corresponding detailed results.

The critical loads and levels adopted for use in this assessment have been obtained from the APIS and are summarised in Table F.1.

Table F.1   Site relevant critical loads and levels

Site	113 Iron Scar & Hundale Point to Scalby Ness SSSI	114 Scarborough to Whitby disused railway site SINC	115 Beast Cliff-Whitby SAC	116 North York Moors SAC, SPA	117 Flamborough & Filey Coast SPA
Critical levels for nitrogen oxides and sulphur dioxide (see Table 2.2)					
Annual mean NO_x $\mu gNO_2/m^3$			30		
Daily mean NO_x $\mu gNO_2/m^3$			200		
Annual mean SO_2 $\mu gSO_2/m^3$			10		
Critical load for nitrogen deposition					
Most sensitive habitat	Geological designation[c]	Broadleaved, mixed and yew woodland	Vegetated sea cliffs	Dwarf shrub	Kittiwakes & other species[d]
N deposition CL kgN/ha/y	not specified	10-15	10-15[b]	5-15	not sensitive
Critical loads for acid deposition					
Most sensitive habitat	Geological designation[c]	Broadleaved, mixed and yew woodland	Vegetated sea cliffs	Dwarf shrub	Kittiwakes & other species
Minimum CLminN keq	No critical loads available	0.357	0.357	0.499	No critical loads available
Minimum CLmaxS keq		1.466	2.637	0.150	
Minimum CLmaxN keq		1.823	2.994	0.792	

a. The critical levels and critical loads are the minimum specified for most sensitive habitat within the site.
b. No critical load is available for nitrogen deposition for this habitat. For the purposes of this study a broadleaved, mixed and yew woodland habitat is assumed.
c. The site is largely designated for geological features and no critical loads are available.
d. The site is not sensitive to nitrogen deposition and no critical loads are available for acid deposition.

The site background concentrations, as obtained from APIS, are summarised in Table F.2. These represent the maximum background concentration across the entire site in each case.

Table F.2 — Site relevant background concentrations

Site		113 Iron Scar & Hundale Point to Scalby Ness SSSI	114 Scarborough to Whitby disused railway site SINC	115 Beast Cliff-Whitby SAC	116 North York Moors SAC, SPA	117 Flamborough & Filey Coast SPA
Nitrogen oxides annual mean	$\mu gNO_2/m^3$	4.88	5.74	4.79	7.83	5.92
Sulphur dioxide annual mean	$\mu gSO_2/m^3$	0.61	0.82	0.57	1.31	1.28
Nitrogen deposition	kgN/ha/y	23.97	24.05	21.98	34.58	26.81
Acid deposition	keq/ha y	1.81	1.81	1.64	2.58	1.97

a. Background concentrations are the maximum across the entire site.

The maximum process contributions to concentrations of nitrogen oxides and sulphur dioxide at the designated and local ecological sites are detailed in Table F.3 and are correspond to the summary in Table 4.5.

Table F.3 — Maximum process contributions of nitrogen oxides and sulphur dioxide at designated and local ecological sites

Site		113 Iron Scar & Hundale Point to Scalby Ness SSSI	114 Scarborough to Whitby disused railway site SINC	115 Beast Cliff-Whitby SAC	116 North York Moors SAC, SPA	117 Flamborough & Filey Coast SPA
Nitrogen oxides[a]						
Maximum annual mean PC	$\mu gNO_2/m^3$	1.664	1.751	0.026	0.021	0.018
	% CL	5.55	5.84	0.09	0.07	0.06
Background concentration	$\mu gNO_2/m^3$	4.88	5.74	4.79	7.83	5.92
Maximum annual mean PEC	$\mu gNO_2/m^3$	6.04	6.97	4.81	7.84	5.93
	% CL	20	23	16	26	20
Maximum daily mean PC	$\mu gNO_2/m^3$	1.663	1.801	0.026	0.021	0.018
	% CL	0.83	0.90	0.01	0.01	0.01
Back ground concentration	$\mu gNO_2/m^3$	9.76	11.48	9.58	15.66	11.84
Maximum daily mean PEC	$\mu gNO_2/m^3$	11.42	13.28	9.61	15.68	11.86
	% CL	6	7	5	8	6
Sulphur dioxide						
Maximum annual mean PC	$\mu gSO_2/m^3$	0.0093	0.0111	0.0003	0.0005	0.0001
	% CL	0.093	0.111	0.003	0.005	0.001
Background concentration	$\mu gSO_2/m^3$	0.61	0.82	0.57	1.31	1.28
Maximum annual mean PEC	$\mu gSO2/m^3$	0.62	0.83	0.57	1.31	1.28
	% CL	6	8	6	13	13

a. Total nitrogen oxides are expressed as NO_2.

The determination of nitrogen deposition at the designated and local ecological sites is summarised in Table 4.7. Table F.4 provides the corresponding detailed determination.

Table F.4   Nitrogen deposition at designated and local ecological sites

		113	114	115	116	117
Site		Iron Scar & Hundale Point to Scalby Ness SSSI[c]	Scarborough to Whitby disused railway site SINC	Beast Cliff-Whitby SAC	North York Moors SAC, SPA	Flamborough & Filey Coast SPA[d]
Maximum process N deposition	$\mu gNO_2/m^2/s$[a]	0.00349	0.00368	0.00005	0.00004	0.00004
	kgN/ha/y	0.335	0.353	0.005	0.004	0.004
	% CL[b]	n.a.	3.53	0.05	0.08	n.a.
Background concentration	kN/ha y	23.97	24.05	21.98	34.58	26.81
Maximum annual mean PEC	kN/ha y	24.31	24.40	21.99	34.58	26.81
	% CL[b]	n.a.	244	220	692	n.a.

a. Determination of deposition is based on the deposition velocity for forest terrain[21].
b. The critical load selected is the minimum of the range specified for the most sensitive habitat over the entire site.
c. The site has a largely geological designation and no critical load is available.
d. The site is not sensitive to nitrogen deposition.

The determination of the process contribution to acid deposition at these sites is summarised in Table 4.6. The detailed determination of acid deposition is presented in Table F.5.

Table F.5   Acid deposition at designated and local ecological sites

		113	114	115	116	117
Site		Iron Scar & Hundale Point to Scalby Ness SSSI[d]	Scarborough to Whitby disused railway site SINC	Beast Cliff-Whitby SAC	North York Moors SAC, SPA	Flamborough & Filey Coast SPA[e]
Nitrogen acid deposition	$\mu gNO_2/m^2/s$[a]	0.00349	0.00368	0.00005	0.00004	0.00004
	kgN/ha/y	0.335	0.353	0.005	0.004	0.004
	keq/ha y	0.0239	0.0252	0.0004	0.0003	0.0003
Sulphur acid deposition	$\mu gSO_2/m^2/s$[a]	0.000224	0.000267	0.000007	0.000012	0.000004
	keq/ha y	0.00221	0.00262	0.00007	0.00012	0.00003
Total process acid deposition	keq/ha/y	0.0261	0.0278	0.0004	0.0004	0.0003
	% CL[b,c]	n.a.	1.52	0.01	0.05	n.a.
Total background acid deposition	keq/ha/y	1.84	1.84	1.64	2.58	1.97
Maximum annual mean PEC	keq/ha y	1.84	1.84	1.64	2.58	1.97
	% CL[b,c]	n.a.	101	55	326	n.a.

a. Determination of deposition is based on the deposition velocity for forest terrain[21].
b. Calculations of process contribution and predicted environmental concentrations were used the APIS critical load tool.
c. The critical loads selected are the minimum specified for all habitats over the entire site, where applicable.
d. The site is largely designated for geological features and no critical loads are available.
e. No critical loads are available for acid deposition for this site.

ANNEX G Site equipment specification

Details of the equipment specified for use and its operation during the proposed development are provided in Tables G.1 and G2. Table G.3 provides details of the expected HDV movements during the proposed development.

Table G.1   Site equipment specification

Equipment		Type	Description	Reference
A1	Construction plant	14 t excavator	Hitachi ZX130-6 14t excavator, 78.5 kW Isuzu AR-4JJX DOC and SCR, EU Stage 4	Hitachi, ZAXIS utility class excavators (17/08), 2019.
A2		14 t excavator	Caterpillar 323 14t excavator, Caterpillar 7.1 engine, 122 kW, EU Stage 4	Caterpillar 323 product specification, Cat.com
A3		Dozer	Liebherr PR726 dozer, Liebherr 934 A7, 120 kW, EU Stage 4	Liebherr, PR 726 Litronic, LWT/VM 12227193-0, 5.05.19.
A4		9t dumper (2)	Thwaites MACH 2098 9t dumper, Deutz TD 3.6 L4 engine, 55.4 kW, EU Stage 3B	Thwaites Limited, MACH 2098 9t power swivel, 08/2017
A5		13t sheeps foot roller (2)	Hamm 13i 13t sheeps foot roller, Deutz TCD 4.1 L4, 115 kW, EU Stage 5	Hamm AG, Hamm3i, 12.19, 2737730
A6		Roller (2)	Bomag BW120 roller, Kubota D1803, engine, 24.6 kW, EU Stage 5	Bomag, Technical data, tandem rollers, BW 120 AD-5, 130220 sa04.
A7		Concrete pump	Schwing Stetter concrete pump, engine OM470, R6, 240 kW, EU Stage 6	http://www.schwing-stetter.co.uk/Downloads/S20.pdf?t=637436076063436607
B		Lighting Towers (4)	Site light 908, Perkins 403D-11G engine, 8.8 kVA, EU stage 3A	Bruno Generators, Site light 908P specification.
C		Welfare Unit	Librerty Guard Welfare Unit, 15 kVA generator, assumed to be EU Stage 3A compliant	MHM UK, MG15000 SSK-MV specification
D		Surface Conductor Rig	Junttan PM 20LC surface conductor rig, Cummins QSB6.7 engine, 179 kW, EU stage 3A	Junttan, PM20LC Pile Driving Rig Data sheet, M120LC003, 2 March 2009
E		Generator	Perkins 2206A- E143TAG3 generator, 350 kW, EU Stage 3A	Perkins, PM1880A/12/14.2206A-E13TAG3 engine specification
F1-F3		Main drilling rig engines (3)	MTU 12V4000G23 3B diesel engine 1420kW, US Tier 2 assumed for low emission mode operation	MTU Technical Engine Data, 12V4000G23, October 2007.
F4		Accommodation	Cummins 6BTA5.9 G5 80 kW (100kVA) diesel generator, assumed EU Stage 3A	Cummins Inc, Generator data sheet C110 D5 (6B), DS381-CPGK, October 2017
		Telescopic Handler	10 ton Merlo P40.13CSTOP, Perkins 904J 100kW diesel engine, EU Stage V	Merlo Spa, MKT MERLO RANGE EU A503, March 2024.

Table G.1 continued

Equipment		Type	Description	Reference
G		Workover rig	Moor 475 workover rig, Detroit Series 60 engine, 354 kW, US Tier 2 compliant.	Detroit Diesel Corp, Detroit engine series 50 and 60 for petroleum applications, 6SA587 304, 2003.
H		Flare	PW Well Test Shrouded Ground Flare (6.5 MMscfd disposal capacity)	P W Well Test Limited, Technical document, shrouded flare, April 2016
I		Oil heater	RBC 600 oil burner, fuel consumption 69 l/h assumed at AP42, 1.3 emission rates	Fulton, Technical information, Sheet 109, Issue 6.
J1	Restoration plant	14 t excavator	Hitachi ZX130-6 14t excavator, 78.5 kW Isuzu AR-4JJX DOC and SCR, EU Stage 4	Hitachi, ZAXIS utility class excavators (17/08), 2019.
J2		14 t excavator	Caterpillar 323 14t excavator, Caterpillar 7.1 engine, 122 kW, EU Stage 4	Caterpillar 323 product specification, Cat.com
J34		Dozer	Liebherr PR726 dozer, Liebherr 934 A7, 120 kW, EU Stage 4	Liebherr, PR 726 Litronic, LWT/VM 12227193-0, 5.05.19.
K		100 tonne crane	Liebherr 400kW diesel engine assume EU Stage 4	Liebherr-Werk Ehingen GmbH, Mobile and crawler cranes, LTM1100-5.3, 10/2022.

Table G.2 Equipment usage during proposed development phases

Phase	Activity	Duration (days)	Start	End	Days/week	Hours/day	Working days	Equipment in use
1	Site construction works	49	1	49	6	10[a]	42	A,B,C,D,E
2A	Mobilisation	7	50	56	6	10	6	B,C,E,K
2B	Drilling of Well	35	57	91	7	24	35	B,C,E.F.K
2C	Demobilisation	7	92	98	6	10	6	B,C,E,K
3A	Test preparation	14	99	112	6	12[a]	12	A,B,C,E,K
3B	Proppant squeeze and Production test	119	113	231	7	24	119	B,C,E,G,H,I
4A	Well Abandonment	14	232	245	7	24	14	B,C,D,E
4B	Site Restoration	28	246	273	6	10[a]	24	B,C,E,J

a. Four hours operation on Saturdays.
b. HDVs are operational in all phases of the development.

Table G.3   HDV movements during proposed development phases

Phase		Duration (days)	HDVs arriving at site	Total HDV movements (in and out)
1	Site construction works	49	334	668
2A	Mobilisation	7	80	160
2B	Drilling of Well	35	170	340
2C	Demobilisation	7	80	160
3A	Test preparation	14	65	130
3B	Proppant squeeze and Production test	119	75	150
4A	Well Abandonment	14	40	80
4B	Site Restoration	28	310	620
Total		273	1154	2308

a. AADT - annual average daily traffic count - based on 365 days per year and the maximum number of two way movements (in and out of site).
b. HDV – a heavy duty vehicle of gross weight greater than 3.5 t.

The highest number of two-way HDV movements over a period of 365 consecutive days is 2308 equivalent to an annual average daily traffic (AADT) count of 6.

ANNEX H Construction dust risk assessment

H.1 Introduction

It is likely that the construction activities associated with the proposed development of the wellsite will give rise to dust emissions, albeit temporary in nature and largely restricted the areas close to the wellsite.

The potential for fugitive dust is most likely to arise from the movement of vehicles over the earth, the stripping of soil, excavations and the subsequent storage of excavated materials and transfer of materials to and from lorries. This may be exacerbated by spillages during transportation and handling and also by periods of dry weather and high wind speeds.

The potential for dust impact has been assessed based on the guidance provided by the Institute of Air Quality Management[26]. Four activities considered to have the most significant potential for fugitive release of dust are identified; demolition, earthworks, construction, and track-out. In this case there are no demolition activities associated with the proposed development.

The construction of the Cloughton appraisal wellsite (phase 1) will last for an estimated 7 weeks. During the subsequent well drilling and testing (phases 2 and 3) there will be no appreciable construction work likely to give rise to significant dust emissions. While there will be some movement of waste materials and aggregates, this is not expected to result in dust emissions any greater than those in phase 1. The restoration phase of the proposed development (phase 4) is of 6 weeks duration and utilises substantially fewer construction and heavy duty vehicles compared with the construction phase. It is therefore considered that the construction phase is likely to provide the greatest air quality impact with respect to dust and is representative of the worst case.

H.2 Screening assessment

IAQM guidance indicates that an assessment will normally be required where there is:

• a 'human receptor' within 250 m of the boundary of the site or within 50 m of the route(s) used by construction vehicles on the public highway, up to 250 m from the site entrance(s).

• an 'ecological receptor' within 50 m of the boundary of the site or 50 m of the route(s) used by construction vehicles on the public highway, up to 250 m from the site entrance(s).

In this case there are no ecological receptors within 50 m of the wellsite boundary (see Table 3.1). The nearest site is the Scarborough to Whitby Disused Railway SINC to the west at distance of 440m and in excess of 250m from the wellsite main entrance. It is not considered necessary to consider ecological receptors within this assessment.

The nearest human receptors are around 320m to the south west of the main wellsite boundary at Wayside Farm. The wellsite entrance is considered to be at the end of the access track which passes Wayside Farm at a distance of around 290m. The access track passes within 30m of Wayside Farm close to its junction with the A165 (Coastal Road). There are residential properties directly beyond this junction, although these are some 380m from the wellsite boundary. All other residential locations are beyond 500m of the wellsite boundary. On the basis of the screening criteria an assessment of human impact is not required.

It is considered that activities likely to give rise to the greatest release of construction related dust are distant from residential locations, such that significant impact is unlikely. It is noted, however that there will be some construction activities to link the existing access track, which terminates at the industrial area, beyond the solar array, to the wellsite. This work albeit of a substantially smaller scale than that intended at the wellsite will be within

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250m of Wayside Farm. For completeness, an assessment of the impact on human receptors has been undertaken.

H.3 Risk of dust impact

H3.1 Potential dust emission magnitude

The potential dust emission magnitude for the earthwork, construction and track-out activities, before any mitigation, are assessed in Tables H.1 to H.4. The assessment generally adopts a conservative approach.

Table H.1   Dust emission magnitude for earthworks activities

Criteria	Effect	Classification
Site area	The area of the wellsite and extended access track is around 12500 m^2.	Small
Soil type	Moderately dusty soil	Medium
Earth moving vehicles operating	There is likely to be between 5 and 10 earth moving vehicles active at any one time (see Tables G.2 and G.3)	Medium
Material moved	Expected that around 7000 tonnes of top soil will be removed and around 12000 tonnes of aggregate laid down during the construction of the wellsite and extended access track.	Medium
Presence of bunds	Bunds of a maximum of 3 m height are expected around two sides of the wellsite.	Medium
Operating times	The major construction phase of the proposed development will last for 7 weeks and restoration is expected to last for up to 6 weeks. The scheduling is as yet unknown.	Small
Overall rating	Conservative estimate of effects.	Medium

The dust emission magnitude for the earthworks associated with the proposed development is considered to be 'Medium'.

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Table H.2   Dust emission magnitude for construction activities

Criteria	Effect	Classification
Building volume	Total building volume is less than 12000 m^3.	Small
Dust potential of construction materials	Largely concrete for drilling pad and MOT type 1 aggregate for site surface and access track (c. 12,000 tonnes).	Small
Concrete batching	Small scale concrete batching is possible, but unlikely.	Medium
Sand blasting	No sand blasting is expected.	Small
Overall rating	Conservative estimate of effects.	Medium

Construction activities on the wellsite will involve the levelling of the wellsite area, excavation of topsoil and subsoil, creating bunds of up to 3m in height. The area will be covered with 2mm of fully welded HDPE membrane and protective geotextile matting covered in a 300mm layer of aggregate. A drainage ditch will be formed to capture run off from the area. These activities will be conducted over a relatively short duration, estimated at 7 weeks, and will be largely confined to the main wellsite, with some activity to extend the existing access track from the industrial area, beyond the solar array, to the wellsite entrance.

While the dust magnitude is classified as 'Medium' this is considered a precautionary assessment.

Table H.3   Dust emission magnitude for track out

Criteria	Effect	Classification
Number of HDV vehicle movements	Less than 20 HDV outward movements expected in any one day (see Table G.3) during the construction and restoration phases.	Small
Surface material	Moderately dusty.	Medium
Length of unpaved road	The site entrance is at the end of an extend stone covered track off the A165. The track is around 350m in length with minimal unpaved surface.	Small
Overall rating	Conservative estimate of effects.	Medium

Access to the wellsite is from the A165 via an existing access track which will be extended to the proposed wellsite entrance. The extended section will be built up with stone to make a serviceable track. There is minimal unpaved track between the wellsite entrance and the junction with the A165. While the dust magnitude is conservatively estimated as 'Medium', it is considered that significant impact at the nearest residential locations will be unlikely.

Table H.4   Summary of dust emission magnitude

Activity	Dust emission magnitude
Earthworks	Medium
Construction	Medium
Track-out	Medium

H3.2   Sensitivity of the area

IAQM guidance recommends the assessment of the sensitivity of the area take into account:

- the specific sensitivities of receptors in the area
- the proximity and number of those receptors
- in the case of PM_{10}, the local background concentration
- site specific factors, such as whether there are natural shelters, such as trees, to reduce the risk of wind-blown dust.

It is considered that in terms of both dust soiling and the human health effects of PM_{10} there are a number of 'high' sensitivity receptors present at up to 350m from the nearest location of substantial earthworks associated with the proposed development (i.e. Wayside Farm and properties adjacent to the A165 opposite the access track junction). All other high sensitivity receptors are beyond 350m from any substantial construction activity associated with the proposed development.

IAQM guidance for trackout sensitivity indicates that receptor distances should be measured from the side of the roads used by construction traffic. Without site specific mitigation, trackout may occur from roads up to 500 m from large sites, 200 m from medium sites and 50 m from small sites, as measured from the site exit. The impact declines with distance from the site, and it is only necessary to consider trackout impacts up to 50m from the edge of the road.

The site entrance is assumed to be the main wellsite entrance at the end of the extended access track off the A165. The nearest residential location to the main route for HDVs is Wayside Farm, which is some 290m from the wellsite entrance. All other residential locations are beyond 300m of the site entrance.

There are areas of woodland to the south and southwest between the wellsite and the nearest residential properties which might provide a natural barrier to wind blown dust emissions.

The sensitivity of the area for the site activities is estimated in Table H.5.

Table H.5   Assessment of sensitivity of area

Potential impact	Condition	Earthworks	Construction	Trackout
Dust soiling	Receptor sensitivity	High	High	High
	Number of receptors	1-10	1-10	1-10
	Distance from site (m)	350	350	290
	Sensitivity of area	Low	Low	Low
Human health	Receptor sensitivity	High	High	High
	Number of receptors	1-10	1-10	1-10
	Distance from site (m)	350	350	290
	PM_{10} background concentration ($\mu g/m^3$)	<24	<24	<24
	Sensitivity of area	Low	Low	Low

H3.3   Risk of impact

The risk of impact for human health and dust soiling is estimated by considering the magnitude of the effect (Table H.4) and the sensitivity of the receiving area (Table H.5), as summarised in Table H.6.

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Table H.6   Assessment of risk of impact

Potential impact	Earthworks	Construction	Trackout
Dust soiling	Low	Low	Low
Human health	Low	Low	Low
Ecology	Negligible		

H.4   Conclusions and mitigation measures

The impact on human health is considered 'low' based on the distance between the wellsite and access road and the nearest residential locations, the small number of receptors at that distance and the generally low background concentration of PM_{10}.

The risk of dust soiling is considered to be 'low' based on the location of residential properties relative to the site and the small number of receptors.

The assessment indicates that due to the distance between the wellsite and the nearest designated and local ecological sites (see Table 3.1), the risk of impact on ecological receptors is 'negligible'.

This assessment is made without any mitigation measures being considered.

Mitigation measures, adhering to industry best practice, specific to the control of dust during construction have been incorporated into the design of the development. The following measures will further reduce the dust impact risk determined in this assessment:

- A construction environmental management plan (CEMP), incorporating best practices, will be employed during the construction phase.

- Material deliveries and stock piles on site will be sheeted to prevent windblown dust releases.

- Loads entering and leaving the site will be sheeted, where appropriate, to prevent windblown dust releases.

- In dry periods, a bowser will be available to dampen any dry and dusty road surfaces to minimise entrainment of dust.

- Vehicle wheel washing facilities will be available to minimise the transfer of site dust on to the road network.

It is expected that, with these mitigation measures in place and bearing in mind the conservative approach to the assessment before mitigation, the risk of dust impact from all operations will reduce to 'negligible' for all activities and for all impacts.

ANNEX I Air quality impact of construction and operations traffic

I.1   Introduction

The development of the site and subsequent operation will have the effect of increasing traffic flow in the area, which in turn will result in additional releases of certain pollutants to air. It is necessary to assess the likely ambient impact of this increase in traffic flow.

Assessment methodology, based on the Design Manual for Roads and Bridges (DMRB) published by Highways England[27] (now National Highways) has been used to determine significance and impact of additional off-site traffic movements during the main phases of the proposed development. The impact of on-site vehicle movements is considered within the main air quality assessment.

I.2   Expected traffic flows

The wellsite is accessed by an access track from the A165 Coastal Road.

Table I.1 summarises the expected maximum heavy duty vehicle (HDV) movements for the duration of the proposed development.

Table I.1   HDV movements over the proposed development

Phase		Duration (days)	HDVs arriving at site	Total HDV movements (in and out)
1	Site construction works	49	334	668
2A	Mobilisation	7	80	160
2B	Drilling of Well	35	170	340
2C	Demobilisation	7	80	160
3A	Test preparation	14	65	130
3B	Proppant squeeze and Production test	119	75	150
4A	Well Abandonment	14	40	80
4B	Site Restoration	28	310	620
Total		273	1154	2308

Although unlikely in practice, the entire development programme could be accommodated within a single calendar year. The number of two-way HDV movements over the development is 2308 equivalent, on a worst case basis, to an annual average daily traffic (AADT) count of 6.3.

In addition to HDV movements it is expected that there will be no more than 50 movements of passenger cars and light goods vehicles (less than 3.5 t gross weight) during each day of the proposed development.

I.3 Assessment criteria

The DRMB provides guidance on the screening out of changes with the objective of determining whether a proposed development is likely to have a significant impact in terms of air quality. It is first necessary to identify any affected roads in the vicinity using the criteria in Table I.2.

Table I.2 Screening assessment for affected roads

Criterion	Assessment
Road alignment will change by 5 m or more	Not applicable
Daily traffic flows will change by 1,000 AADT or more	No – see Table I.1
Heavy duty vehicle flows will change by 200 AADT or more	No – see Table I.1
Daily average speed will change by 10 km/h or more	Unlikely
Peak hour speed will change by 20 km/h or more	Unlikely

In this case none of the proposed routes to and from the wellsite is classed as an affected road. The DMRB specifies that if none of the roads in the relevant network meet any of the traffic/alignment criteria, then the impact of the scheme can be considered to be neutral in terms of local air quality and no further work is needed.

The IAQM[9] also provide guidance on the need for an air quality assessment based on indicative criteria related to the change in traffic flow brought about by a development as summarised in Table I.3.

Table I.3 IAQM indicative criteria for traffic change significance

The development will	Indicative criteria to proceed to an air quality assessment
Cause a significant change in Light Duty Vehicle (LDV) traffic flows on local roads with relevant receptors. (LDV = cars and small vans of <3.5 t gross weight)	A change of LDV flows of: - more than 100 AADT within or adjacent to an AQMA - more than 500 AADT elsewhere
Cause a significant change in Heavy Duty Vehicle (HDV) flows on local roads with relevant receptors. (HDV = goods vehicles + buses >3.5t gross vehicle weight)	A change of HDV flows of - more than 25 AADT within or adjacent to an AQMA - more than 100 AADT elsewhere

There are no air quality management areas adjacent to any of the proposed routes into or out of the wellsite. Expected increases in average vehicle movements over the duration of the development fall well below the IAQM criteria for an air quality assessment, with AADT for HDVs of 6.3.

On this basis, it is determined that an air quality assessment for the change in traffic brought about by the proposed development is not required.

I.4 Conclusions

Increases in road traffic brought about by the construction activities and subsequent site operation are assessed to have a neutral impact on air quality based on Highways England guidance. The additional contributions to ambient pollutant concentrations from associated road traffic have no influence on the findings of the main air quality assessment for plant releases to air.

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ANNEX J Odour impact assessment

Fugitive releases of natural gas may have implications for both human health and amenity with respect to odours. Odour associated with fugitive releases of produced natural gas are assessed in this annex, separately to other releases from wellsite operations, although the main assessment does include consideration of volatile organic compounds component of the fugitive release.

Odour is, for the purposes of this assessment, considered to be confined to the release of sulphurous compounds present in fugitive releases of natural gas during well development and testing operations as discussed in section 3.5.5. In this assessment the sulphur content of the fugitive natural gas release is assumed to be present totally as either hydrogen sulphide or methyl mercaptan.

J.1   Odour assessment criteria

The assessment of whether an odour discharge can be considered a cause for annoyance and hence pollution depends on a range of factors including the regularity of exposure and the offensiveness of the odour.

Five factors are generally considered to determine the degree of odour pollution:

- Frequency of detection
- Intensity as perceived
- Duration of exposure
- Offensiveness
- Receptor sensitivity

Methods have been developed to measure the relative odour potential of a discharge. Odour detection threshold values for individual chemicals are based on the concentration at which half of a test group can just detect the odour. Recognition thresholds and annoyance/nuisance benchmarks are expressed as multiples of the odour threshold concentration. In most cases odours will be the result of the discharge of a mixture of compounds. In this case the concentration is expressed as an odour unit and is determined by olfactometry. BS EN 13725:2003 provides a standard method based on olfactometry for the assessment of odour concentration. 1 European Odour Unit (1 ou_E/m^3) is defined as the point of odour detection and is referenced to 40 ppb of n-butanol.

Since the impact of an odour is a function of both the strength of the odour and the duration and frequency of exposure, benchmark exposure criteria are usually based on a concentration limit for a defined time period.

The Environment Agency's Horizontal Guidance Note for Odour H4[31] defines three different levels of exposure at which odour impact or annoyance could be expected to occur. These are based on odours with high, moderate and low offensiveness. The benchmarks are based on the 98th percentile of hourly average concentrations of odour considered over a year and are summarised in Table J.1.

Table J.1   Indicative odour exposure criteria

Relative offensiveness of odour		Indicative criterion of significant pollution as 98th percentile of hourly mean
More offensive odours	Activities involving putrescible wastes Processes involving animal or fish remains Brickworks Creamery Fat & Grease Processing Waste water treatment Oil refining Livestock feed factory	1.5 ou_E/m^3
Odours which do not obviously fall within a high or low category	Intensive Livestock rearing Fat Frying (food processing) Sugar Beet Processing	3.0 ou_E/m^3
Less offensive odours	Chocolate Manufacture Brewery Confectionary Fragrance and Flavourings Coffee Roasting Bakery	6.0 ou_E/m^3

The above criteria can be used in conjunction with atmospheric modelling to determine the likely dispersion of odour discharges and their impact in terms of annoyance.

It should be recognised that when maximum concentrations are considered on the basis of the above criteria, the predicted maximum is the 98th percentile of hourly mean concentrations, which essentially means that the maximum quoted is the 176th highest value of 8760 values predicted for that location during the year of interest.

How an odour is perceived and its subsequent effects are not straightforward. The perception of the intensity of odour in relation to the odour concentration is not a linear, but a logarithmic relationship which means that if the concentration of an odour increases tenfold, the perceived increase in intensity will be by a much smaller amount. Interactions between mixtures of odorous compounds as in this case can also occur. These are known as synergistic effects. The odour intensity experienced by an observer is, in general, not equivalent to the sum of the intensities of the component odorous compounds. The perceived intensity may be greater or less than the components depending on the synergistic effects of the compounds present.

Exposure to an odour can result in people becoming desensitised so that they can no longer detect the odour even though the odorous chemical is constantly present in the air. Conversely, individuals may become sensitised to olfactory stimulants through acute exposure events or as a result of repeated exposure to nuisance levels of odours.

Guidance was produced in 2012 by the Chartered Institution of Water and Environmental Management (CIWEM) for application to waste water treatment sites[32]. CIWEM considered the following quantification of the likelihood of odour nuisance (based on a 98th percentile of hourly means):

$>10 ou_E/m^3$ complaints are highly likely and odour exposure at these levels represents an actionable nuisance

$>5 ou_E/m^3$ complaints may occur and depending on the sensitivity of the locality and nature of the odour this level may constitute a nuisance

$<3 ou_E/m^3$ complaints are unlikely to occur and exposure below this level is unlikely to constitute significant pollution or significant detriment to amenity unless the locality is highly sensitive or the odour highly unpleasant in nature

The Institute of Air Quality Management (IAQM)[33] propose that the descriptors in Tables J.2 and J.3 be used to determine the magnitude of odour effects for moderately offensive and most offensive odours respectively.

Table J.2   Proposed descriptors for magnitude of odour effects (Moderately offensive odour)

Odour exposure level, ou_E/m^3 (98th percentile of hourly means)	Receptor sensitivity		
	Low	Medium	High
≥10	Moderate	Substantial	Substantial
5->10	Slight	Moderate	Moderate
3->5	Negligible	Slight	Moderate
1.5->3	Negligible	Negligible	Slight
0.5-<1.5	Negligible	Negligible	Negligible
<0.5	Negligible	Negligible	Negligible

Table J.3   Proposed descriptors for magnitude of odour effects (Most offensive odour)

Odour exposure level, ou_E/m^3 (98th percentile of hourly means)	Receptor sensitivity		
	Low	Medium	High
≥10	Moderate	Substantial	Substantial
5->10	Moderate	Moderate	Substantial
3->5	Slight	Moderate	Moderate
1.5->3	Negligible	Slight	Moderate
0.5-<1.5	Negligible	Negligible	Slight
<0.5	Negligible	Negligible	Negligible

Receptor sensitivity is described as:

High sensitivity	Surrounding land where: • users can reasonably expect enjoyment of a high level of amenity; and • people would reasonably be expected to be present here continuously, or at least regularly for extended periods, as part of the normal pattern of use of the land. Examples may include residential dwellings, hospitals, schools/education and tourist/cultural locations.
Medium sensitivity	Surrounding land where: • users would expect to enjoy a reasonable level of amenity, but wouldn't reasonably expect to enjoy the same level of amenity as in their home; or • people wouldn't reasonably be expected to be present here continuously or regularly for extended periods as part of the normal pattern of use of the land. Examples may include places of work, commercial/retail premises and playing/recreation fields.
Low sensitivity	Surrounding land where: • the enjoyment of amenity would not reasonably be expected; or • there is transient exposure, where the people would reasonably be expected to be present only for limited periods of time as part of the normal pattern of use of the land. Examples may include industrial use, farms, footpaths and roads.

It is important to note that the environmental benchmarks discussed above are based on hourly means. During an hour meteorological conditions can vary widely from the mean and as such the hourly average odour concentration estimate is likely to be somewhat less than that experienced over much shorter periods within that hour. This is the subject of considerable research. It is suggested[34] that short term peak concentrations may be determined from the equation:

$$C_1 = C_o \left(\frac{t_o}{t_1} \right)^n$$

where C_1 and C_o are the short term and hourly odour concentrations respectively
t_o and t_1 are durations of the short term and hourly averaging periods respectively
n is based on the degree of atmospheric turbulence (generally assigned a value of 0.28)

On the basis of a ten minute averaging period, a peak value over the hour would be expected to be some 11 times the hourly average.

In this case it is considered that the odours arising for the hydrogen sulphide and methyl mercaptan content of fugitive release of natural gas would generally be classified as a moderate odour, and a benchmark for annoyance of 3.0 ou_E/m^3 (Table J.1) is employed. An ambient odour impact below this benchmark, even at a receptor with a high sensitivity (Table J.2), would be expected to have just a 'slight' odour effect.

J.2   Odour background concentration in Burniston

In considering the overall impact of a site operation, such as this herein, it is useful to have some measure of the existing background concentration. Odour is not routinely monitored around the Burniston area and no detailed quantitative odour impact study has been undertaken for the general area. There are no other significant industrial operations in the vicinity that are considered to have the potential to meaningfully contribute to odour impact in the areas neighbouring the wellsite. The actual significance of these sources and any synergistic effects is not known and is not considered further. This assessment addresses solely the odour releases arising from fugitive natural gas releases from the wellsite development and their subsequent ambient impact.

J.3   Odour impact assessment

In the assessment of odour the ADMS 6 model was used to assess the fugitive releases discussed in section 3.5.5. The assessment assumed a continuous uniform fugitive release over the entire 273 day development program. The assessment was undertaken using meteorological data covering the period 2019 to 2023 and covered the assessment area and all discrete receptors described in section 3.1.

Table J.4 summarises the risk to amenity from odour impact at local residential locations. Residential premises are considered to be the only locations were the general public might have an exposure consistent with the benchmark averaging period (i.e. one year).

Table J.4   Maximum process odour contributions at residential locations resulting from fugitive releases

Parameter		Value
Maximum process contribution of hydrogen sulphide (98 percentile of hourly means)[c]	$\mu g/m^3$	0.0010
	ou_E/m^{3a}	0.0013
	% benchmark[b]	0.04
Maximum process contribution of methyl mercaptan (98 percentile of hourly means)[c]	$\mu g/m^3$	0.0016
	ou_E/m^{3a}	0.0004
	% benchmark[b]	0.01
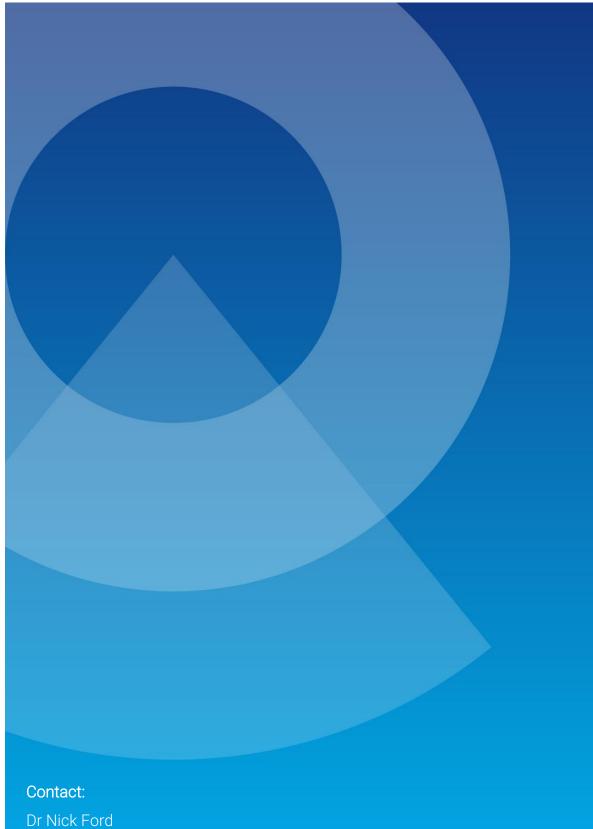
a. Odour thresholds of 0.76 and 4.3 $\mu g/m^3$ are assumed for hydrogen sulphide and methyl mercaptans respectively.
b. The Environment Agency odour benchmark adopted for the assessment is 3.0 ou_E/m^3 (98th percentile of hourly means) consistent with a 'moderately offensive odour'.
c. In the assessment of hydrogen sulphide and mercaptans it is assumed that the total sulphur content of the gas is present as either hydrogen sulphide or methyl mercaptan depending on the substance being assessed.

The maximum process contribution to odour at residential locations from releases of hydrogen sulphide and mercaptans are estimated to be equivalent to 0.04% and 0.01% respectively of the Environment Agency's benchmark for moderately offensive odours. It is therefore considered that fugitive releases from operations at the Cloughton wellsite pose a negligible risk to loss of amenity due to odour.

END OF REPORT

Contact:

Dr Nick Ford
SOCOTEC UK Ltd
Unit D
Bankside Trade Park
Cirencester
Gloucestershire
GL7 1YT
T: 07768 257628
E: nick.ford@socotec.com