The Keadby 3 Low Carbon Gas Power Station Project

PINS Ref: EN010114

The Keadby 3 Low-Carbon Gas Power Station Order

Land at and in the vicinity of the Keadby Power Station site, Trentside, Keadby, North Lincolnshire

Preliminary Environmental Information (PEI) Report Volume II - Appendix 8B: Air Quality – Operational Phase

The Planning Act 2008

The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017

Applicant: SSE Generation Limited

Date: November 2020

DOCUMENT HISTORY

Document Ref			
Revision	P1.0		
Author	Matthew Hill / Helen Watson		
Signed		**Date**	November 2020
Approved By	Richard Lowe		
Signed		**Date**	November 2020
Document Owner	AECOM		

GLOSSARY

Abbreviation	Description
ADMS	Atmospheric Dispersion Modelling System - a proprietary model for the assessment of effect of emissions to air from point sources and road sources.
AOD	Above Ordnance Datum - a spot height (an exact point on a map) with an elevation recorded beside it that represents its height above a given datum.
AQAL	Air Quality Assessment Levels - the baseline level of each pollutant species used during air quality assessments. The results of modelling undertaken to predict concentrations of pollutants are compared against these AQALs.
AQMA	Air Quality Management Area - an area designated by the local authority to be managed, through the implementation of a Local Air Quality Management Area, to ensure that it meets national air quality objectives.
AQMAU	Environment Agency's Air Quality Modelling Assessment Unit – routinely audits air quality modelling assessments.
BAT	Best Available Techniques - the available techniques which are the best for preventing or minimising emissions and impacts on the environment. BAT is required
BAT-AELS	Best Available Techniques – Associated Emission Levels - Achievable emissions values following the implementation of the best available techniques for preventing or minimising emissions and impacts on the environment.
CCGT	Combined Cycle Gas Turbine - a highly efficient form of energy generation technology. An assembly of heat engines work in tandem using the same source of heat to convert it into mechanical energy which drives electrical generators and consequently generates electricity.

Abbreviation	Description
DC	Doncaster Council
DMRB	Design Manual for Roads and Bridges - a series of 15 volumes that provide standards, advice notes and other documents relating to the design, assessment and operation of trunk roads in the United Kingdom.
ERYC	East Riding of Yorkshire Council
HRA	Habitats Regulations Assessment - the assessment of the impacts of implementing a plan or policy on a Natura 2000 site required under the Habitats Directive.
IED	Industrial Emissions Directive – European Union Directive committing member states to control and reduce the impact of industrial emissions on the environment.
LCP	Large Combustion Plant - a combustion plant with a thermal capacity of 50MW or greater.
LWS	Local Wildlife Site - - defined areas, identified and selected for their nature conservation value, based on important, distinctive and threatened habitats and species with a national, region.
NLC	North Lincolnshire Council
SAC	Special Area of Conservation - High quality conservation sites that are protected under the European Union Habitats Directive, due to their contribution to conserving those habitat types that are considered to be most in need of conservation.
SPA	Special Protection Area - strictly protected sites classified in accordance with article 4 of the EC birds directive. Special Protection Areas are Natura sites which are internationally important sites for the protection of threatened habitats and species.
SSSI	Site of Special Scientific Interest - nationally designated Sites of Special Scientific Interest, an area designated for protection under the Wildlife and Countryside Act 1981 (as amended), due to its value as a wildlife and/or geological site.

CONTENTS

TABLES

1.0 INTRODUCTION

1.1 Overview

1.1.1 This Technical Appendix supports **Chapter 8**: Air Quality (PEI Report Volume I) and describes the additional details for the dispersion modelling of point source emissions from the Proposed Development once operational. For more details about the Proposed Development, refer to **Chapter 4**: The Proposed Development (PEI Report, Volume I).

1.1.2 Emissions associated with the operational Proposed Development have the potential to affect human health and sensitive ecosystems, if not appropriately managed. This technical appendix identifies and proposes measures to address the potential impacts and effects of the Proposed Development on air quality during its operational phase.

1.1.3 The magnitude of air quality impacts at sensitive human and ecological receptors has been quantified for pollutants emitted from the main stacks associated with the Proposed Development. The impact of emissions on sensitive ecological receptors has been considered in the context of relevant critical levels and critical loads for designated and non-designated ecological sites.

1.1.4 The assessment has considered emissions from the Proposed Development during normal operational conditions. Non routine emissions, such as those which may occur during the commissioning process or other abnormal short-term events would typically only occur on an infrequent basis, are detected by the process control system and rectified within a short time period and are tightly regulated by the Environment Agency through the Environmental Permit required for the operation of the Proposed Development. For this reason, no detailed consideration of impacts associated with abnormal or emergency events has been included in this assessment.

2.0 SCOPE

2.1 Operational traffic emissions

2.1.1 No assessment of operational traffic emissions has been made, as the numbers of additional vehicles associated with the operational phase of the Proposed Development are below the DMRB and IAQM screening criteria for requiring such assessment. In addition, the predicted impacts for the construction phase traffic emissions show that the effect of additional construction traffic will be not significant at all identified receptors (**Appendix 8A**: Air Quality – Construction Phase PEI Volume II). The number of additional vehicles for the operational phase is well below the numbers assessed for the construction phase and therefore it is considered that the effect of operational traffic is also not significant.

2.2 Combustion plant and carbon capture emissions

2.2.1 The assessment has considered the impact of the operational process emissions on local air quality under normal operating conditions, with the CCGT operational and the flue gas being abated by the carbon capture plant, operating for 8,760 hours per year. The assessment considers impacts in the year in which the Proposed Development is due to commence operation, considered to be 2025 at the earliest.

2.2.2 The dispersion of emissions has been predicted using the latest version of the atmospheric dispersion model ADMS (currently version 5.2.2). The results are presented in both tabular format and as contours plots of predicted ground level process contributions overlaid on mapping of the surrounding area.

2.2.3 The dispersion modelling assessment has considered the effects of combustion emissions associated with the operation of the CCGT plant of oxides of nitrogen (NO_x) and carbon monoxide (CO) with consideration also of the impacts from ammonia (NH_3) slip (from the Selective Catalytic Reduction NO_x abatement system). In addition, emissions of amines and their potential degradation products from the carbon capture plant have also been assessed.

2.2.4 Emissions from Large Combustion Plant (LCP) are currently governed by Directive 2010/75/EU the Industrial Emissions Directive (IED) which contains measures relating to the control of emissions, including setting limits on emissions to air from LCP and requires operators to monitor and report emissions.

2.2.5 The Proposed Development would be regulated under the IED and in accordance with the current version of the LCP Best Available Technique (BAT) Reference document (LCP BRef) (E.C., 2017). The recommendations of the LCP BRef are enforceable through Environmental Permits and the Environment Agency sets specific emission limits in the Environmental Permit issued to the Proposed Development, based on the BAT-associated emission levels (BAT-AELs).

2.2.6 A comparison has been made between predicted model output concentrations, and short-term and long-term Air Quality Assessment Levels (AQALs) as detailed in **Chapter 8**: Air Quality (PEI Report Volume I).

2.3 Cumulative impacts

2.3.1 Cumulative impacts from existing sources of pollution in the area are accounted for in the adoption of site-specific background pollutant concentrations from archive sources and air quality monitoring in close proximity to the Proposed Development site. It is recognised, however, that there is a potential impact on local air quality from emission sources which have received planning permission but have yet to come into operation. Specifically, the cumulative impacts with the Keadby 2 Power Station (currently under construction) have been considered in this Appendix.

2.3.2 The full long list of other cumulative schemes will be available for the final ES. Cumulative air quality effects with all identified cumulative schemes will be assessed for the final ES.

2.4 Sources of information

2.4.1 The information that has been used within this assessment includes:

- data on emissions to atmosphere from the process, taken from IED limits, BAT-AEL values and data provided by Licensors of the carbon capture technology;
- details on the site layout provided through a pre-FEED design of the Proposed Development;
- Ordnance Survey mapping;
- baseline air quality data from published sources and Local Authorities; and
- meteorological data supplied by ADM Ltd.

3.0 METHODOLOGY

3.1 Dispersion model selection

3.1.1 The assessment of emissions from the Proposed Development has been undertaken using the advanced dispersion model ADMS (version V5.2.2), supplied by Cambridge Environmental Research Consultants Limited (CERC). ADMS is a modern dispersion model that has an extensive published validation history for use in the UK. This model is well validated and has been extensively used throughout the UK for regulatory purposes (CERC, 2020).

3.2 Modelled scenarios

3.2.1 The dispersion modelling undertaken for the assessment of emissions from the operational Proposed Development main stacks includes:

- modelling of maximum ground-level impacts at a range of release heights (between 100m and 110m AOD), for the main carbon capture plant absorber stack, in order to evaluate the effect of increasing the release height on dispersion;
- reporting of impacts at selected human health and sensitive ecological receptors, based on an absorber stack height of 105m, as the main reported assessment; and
- modelling of impacts on a receptor grid and at discrete sensitive human and ecological receptors for all pollutants emitted from the stack.

3.3 Model inputs

3.3.1 The general model conditions used in the assessment are summarised in Table 1. Other data used to model the dispersion of emissions is considered below.

Table 1: General ADMS 5 model inputs

Variable	**Input**
Surface roughness at source	0.2m
Surface roughness at meteorological site	0.2m
Receptors	Selected discrete receptors (as **Tables 4** and **Table 5**)
	Regular spaced grid
Receptor location	X, Y co-ordinates determined by GIS
	z (ground level) = 1.5m for residential receptors
	z = 0m for ecological receptors
Source location	X, Y co-ordinates determined by GIS
Emissions	IED emission limits, BAT-AEL values and data provided by Licensors

Variable	Input
Sources	1 x Carbon Capture Plant Absorber Stack for the Proposed Development 1 x CCGT Stack for Keadby 2
Meteorological data	5 years of meteorological data, Doncaster Robinhood Airport Meteorological Station (2015 - 2019)
Terrain data	Not applicable
Buildings that may cause building downwash effects	2 x Gas turbine halls, 2 x HRSG buildings, 1 x Steam turbine hall, 1 x Absorber, 1 x DCC building

3.4 Emissions data

3.4.1 During normal operation, the carbon capture plant stack would be the primary source of emissions from both the combustion and carbon capture processes associated with the Proposed Development. Emissions from the adjacent Keadby 2 CCGT stack have also been considered in the assessment.

3.4.2 There would be an additional stack associated with Proposed Development's CCGT plant, which would only be operational when the Proposed Development is operating in an unabated mode (i.e. combustion emissions only, with no carbon capture taking place).

3.4.3 The combustion emissions (NO_x and CO) associated with these two modes of operation would be subject to the same emission limits for NO_x and CO and therefore the associated release rates would be comparable. The unabated emissions from the CCGT plant only would be released at a higher temperature (approximately 75ºC compared with circa 60ºC for the carbon capture process) and therefore would have improved thermal buoyancy, and consequentially dispersion, resulting in a level of impact that is no worse than for the carbon capture mode of operation. The CCGT stack would be sized appropriate to ensure that this is the case.

3.4.4 When the plant is operating with carbon capture, there are additional emissions of amines and their potential degradation products (including nitrosamines and nitramines, collectively referred to as N-amines). The carbon capture mode of operation therefore has been assessed as representing the worst-case mode of operation in terms of the resulting predicted impacts, due to the additional species emitted and the lower release temperature resulting in reduced thermal buoyancy of the release.

3.4.5 The main reported emissions for the Proposed Development have therefore been modelled based on the carbon capture absorber stack. This stack has been evaluated for a range of stack heights but based on the predicted results a stack height of 105m AOD has been selected as the most appropriate, with an internal stack diameter of 6.8m. The physical properties of the modelled emission sources are shown in Table 2. These are based on the worst-case emission data provided by CCGT equipment suppliers and carbon capture plant licensors.

3.4.6 The position of the stacks and the buildings included within the model are illustrated in **Figure 8.4** (PEI Report Volume III).

Table 2: Emissions inventory

Parameter	Unit	Keadby 2	Proposed Development With CCS
Stack position	(NGR) m	482670, 411606	481916, 411918[1]
Stack release height (AOD)	m	75	105
Effective internal stack diameter	m	8	6.8
Flue temperature	°C	74.1	60.0
Flue H_2O content	%	10.2	7.4
Flue O_2 content (dry)	%	11.4	11.1
Stack gas exit velocity	m/s	20.5	24.3
Stack flow (actual)	Am^3/s	1,030	856.4
Stack flow at reference conditions (STP, dry, 15% O_2)	Nm^3/s	1,162	1,080

[1] Approximate location of the stack for the proposed layout, however in line with the Rochdale Envelope approach, the layout is subject to change and therefore the modelling carried out has considered a range of stack locations within the Main Site (Proposed PCC Site), with the worst-case results being reported.

3.4.7 The modelled pollutant emission rates (in grams per second (g/s)) have been calculated by multiplying the emission concentration by the volumetric flow rate at normalised reference conditions. The emission limits assumed to apply to the Proposed Development are shown in Table 3.

3.4.8 In order to achieve the required rate of carbon capture, emission concentrations of NO_x coming from the CCGT plant are required to be within the BAT-AEL range provided in the Large Combustion Plant BRef (10 - 30 mg/Nm^3 as a yearly average). That said, the proposed CCGT plant can achieve efficiencies in excess of 55%, and the BRef allows for a correction factor to be applied to the upper end of the BAT-AELs to allow for a higher NO_x emission where high efficiencies can be achieved.

3.4.9 NO_x emissions have therefore been modelled at a corrected rate of 34 mg/Nm^3, which is considered to be the maximum NO_x concentrations that could be released. Whilst it is recognised that some additional NO_x may be formed in the carbon capture plant itself, there would also be control of NO_x through the proposed SCR unit and removal of further NO_x from the CCP through reaction with amine. The use of the corrected LCP BAT-AEL on exit from the absorber stack therefore is considered to represent a worst-case NO_x emission; in practice the emission is likely to be lower than this concentration.

3.4.10 A NO_x abatement system such as Selective Catalytic Reduction (SCR) may be required to achieve the required NO_x emission on inlet to the CCP. SCR reduces NO_x concentrations by spraying urea (or other forms of NH_3) into the flue gas and therefore have the potential to result in 'ammonia slip' with a resulting emission of NH_3. In addition, depending on the amine solution used, ammonia can result as a degradation product during the carbon capture process itself. As there is uncertainty in the level of potential ammonia emission, the current design basis for the CCP includes provision for an acid wash to remove ammonia from the absorber stack gas. Emissions of NH_3 have therefore been assessed at a level considered to be achievable through the use of acid wash abatement or via primary means.

3.4.11 Depending on the final CCGT and solvent selection, acid wash may not be required to control ammonia emissions from the CCP. Alternatively, other design parameters may be applied to ensure that the impacts associated with any ammonia emission is acceptable at ecological receptors.

3.4.12 The carbon capture process utilises a proprietary amine solution to remove the carbon dioxide from the combustion emission. Emissions of 'amine slip' can therefore also result, and this has also been modelled at the maximum emission concentrations provided by any of the Licensors being considered for the design of the Proposed Development.

3.4.13 There are a number of Licensors with proprietary amine solutions available for use in carbon capture systems, however at this stage of the development the final Licensor has not been selected. Each Licensor's proprietary amine solution is likely to contain a different amine or mix of amines and therefore in order to consider this in the assessment, the potential amine release has been assessed at the maximum concentration provided by all the potential Licensors and has been assessed as monoethanolamine (MEA).

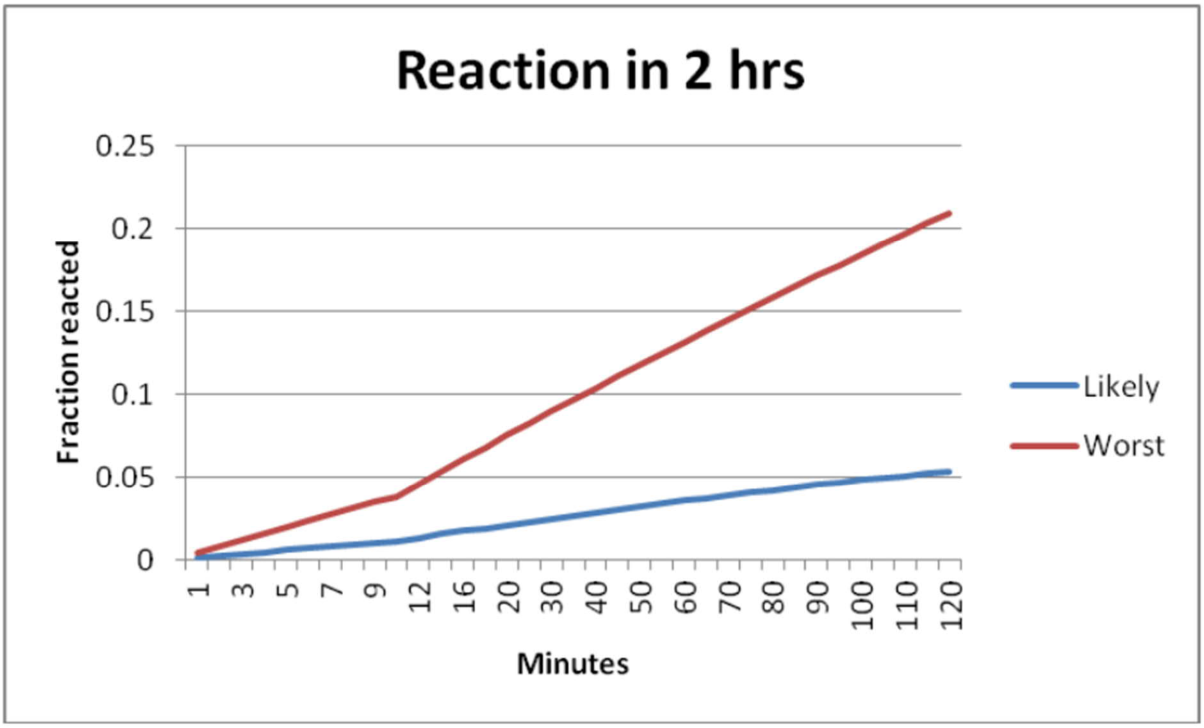
3.4.14 It is also known that amines degrade into nitrosamines and nitramines (collectively referred to as N-amines) both within the carbon capture process itself and also in the environment following release, and therefore this has also been considered in the assessment. Depending on the amine solvent, other degradation products, such as acetaldehyde, formaldehyde and acetic acid may be formed, and therefore these have also been included at the maximum value obtained from all the Licensors under consideration.

3.4.15 The ADMS model includes a specific amine chemistry module, for the assessment of emissions of amines and formation of N-amine degradation products. The model calculates the rate of amine degradation, taking into account the reaction of amines with other species present in the exhaust gas (e.g. NO_2) and also with hydroxyl radicals in the atmosphere. In order to generate meaningful results using the amine module, information on the ambient air concentrations of various species together with details on the type of amines present in the amine solution used in the carbon capture process are required to determine the relevant amine reaction rate constants for inclusion in the model set-up. As the specific amine solution has yet to be determined, it is therefore not possible to generate the specific model input data required at this stage of the project.

3.4.16 In addition, there are concerns over the validity of the amine chemistry module, in that there are only reaction rate constants for a limited number of amine species and as there are important aspects of the degradation process that are not built into the model (such as the time delay described in Section 3.4.16 below). Its relevance for use in the assessment will therefore continue to be assessed as more information becomes available from the Licensors. The Environment Agency's Air Quality Modelling Assessment Unit (AQMAU) are currently being consulted on the applicability of the use of the amines chemistry module for such assessments. Should it be considered appropriate, the assessment presented in the final ES will use the ADMS amines chemistry module to assess the formation of N-amine degradation products, however at PEI stage a preliminary screening approach has been taken to assess N-amine impacts.

3.4.17 The preliminary screening approach is based on the principle that not all amines present in the emission from the carbon capture plant would convert to N-amine in the environment near to the plant, and the conversion of those amines that would degrade in the atmosphere to N-amine can take many hours to occur. This is described by the work carried out by Tonnesen in 2011 (Norwegian Institute for Air Research (NILU), 2011), which demonstrated that less than 5% of the amines that would convert to N-amines would have do so in the first 10 minutes after release, in a worst-case scenario. After 2 hours, 20% of the amines that can convert to N-amine would have done so, and the work goes on to estimate that it would take in the order of 10 hours for 100% conversion to occur. The likely rate of conversion (shown as the blue line in **Plate 1**) is estimated to be significantly less than the worst-case scenario (shown as the red line in **Plate 1**) predicts. These rates of conversion are shown in **Plate 1**.

Plate 1: Conversion of amines to N-amine in the atmosphere over time (Reproduced from NILU, 2011)



3.4.18 Based on this information, two aspects for the preliminary screening assessment have been considered:

- The proportion of amine that can convert to N-amines in the atmosphere. This depends on the actual amine species released, with reported conversions of different amines being between 0.6 – 10% (Nielson et al, 2011). Higher conversions were found in areas with high background NO_x concentrations; however, this is not the case within the Proposed Development's study area, and therefore this data has been discounted. An average conversion rate of 5% has therefore been assumed for this screening assessment.
- The fraction of reacted amine that can convert to N-amines based on the time taken to reach the identified receptors. This has been based on the average wind speed in the area and the distance to the identified receptors.

3.4.19 It is considered that this screening assessment would lead to an overestimation of the potential N-amine concentrations in the atmosphere, as it assumes that 5% of all amines within the amine solvent used would have the potential to convert to N-amines, which may not be the case. It also does not take into account the destruction of N-amines within the atmosphere, which is known to occur relatively rapidly following the initial conversion process by photolysis (Neilson et al., 2012).

3.4.20 The assessment has assumed that the Proposed Development would operate at continuous design load (8,760 hours per year). No time-based variation in emissions have therefore been accounted for within the model.

Table 3: Emission concentrations and the assessed emission rates

Pollutant	Keadby 2 Power Station		Proposed Development	
	Emission concentration (mg/Nm^3)	Emission rate (g/s)	Emission concentration (mg/Nm^3)	Emission rate (g/s)
Oxides of Nitrogen (NO_x (as NO_2))	34	39.5	34	36.7
Carbon Monoxide (CO)	100	116.2	100	108.0
Ammonia (NH_3)	3.8	4.4	1.0	1.1
Amines	-		5.0	5.4
N-amines[1]	-		0.003	0.003
Acetaldehyde	-	-	5.3	5.7
Formaldehyde	-	-	0.5	0.5
Acetic acid	-	-	1.1	1.2

[1] At PEI Report stage the screening assessment of N-amines (nitrosamine and nitramine) has assumed that an arbitrary 5% of the amine emission is capable of degrading to N-amines in the atmosphere. An additional factor to account for the time and distance the emission takes to travel from the source to the receptor has also to be applied to the results presented and this is discussed further in Section 5.2 of this appendix.

3.5 Modelled domain – discrete receptors

Sensitive human receptors

3.5.1 Concentrations of the modelled pollutants relevant to human health have been predicted at discrete air quality sensitive receptors, as listed in Table 4. The locations of these receptors are also shown in **Figure 8.1** (PEI Report Volume III). The receptors are selected to be representative of residential dwellings in the area around the Proposed Development. (OR = Operational Receptor). For human health receptors, concentrations have been predicted at a height of 1.5m.

Table 4: Human health receptor locations

Receptor I.D.	Receptor description	Grid reference		Distance and direction from the operational Proposed Development
		X	Y	
OR1	Holly House	483036	411882	300m north-east
OR2	1 Trent Side	483368	411284	720m south-east
OR3	North Pilfrey Farm	480853	411403	1km south-west
OR4	Keadby Grange	481565	410909	880m south

Receptor I.D.	Receptor description	Grid reference		Distance and direction from the operational Proposed Development
		X	Y	
OR5	Pharon-Ville	484057	411661	1.2km east
OR6	Boskeydyke Farm	483860	413348	2.2km north-east
OR7	Grange Cottage	484708	412315	1.9km north-east
OR8	Pilfrey Farm	480769	409994	2.1km south-west

Sensitive ecological receptors

3.5.2 In line with the Environmental Agency's air emissions risk assessment guidance (Defra and Environment Agency, 2016), the impacts associated with emissions from the combustion process on statutory sensitive ecological sites has been quantified. The assessment considers European designated sites (Special Areas of Conservation (SACs), Special Protection Areas (SPAs) and Ramsar sites) and Sites of Special Scientific Interest (SSSIs) within 15km of the operational Proposed Development, as recommended by the Environment Agency's risk assessment guidance for "large emitters". The most notable of these sites is the Humber Estuary Ramsar, SPA and SSSI, which is adjacent to the water corridors of the Proposed Development Site.

3.5.3 In additional, Local Wildlife Sites (LWSs) within 2km of the Proposed Development have also been included in the assessment.

3.5.4 Ground-level concentrations of the modelled pollutants relevant to sensitive ecological receptors have been predicted at locations listed in Table 5. The locations of these receptors are also shown in **Figure 8.2** (PEI Report Volume III). The location reported for each ecology site is the point closest to the Proposed Development.

Table 5: Ecological receptor locations

Receptor I.D.	Receptor description	Designation	Grid reference		Distance and direction from the operational Proposed Development
			X	Y	
OE1	Humber Estuary	SSSI	483573	411823	1.3km east
OE2	Humber Estuary	SSSI	483612	412068	1.4km east
OE3	Humber Estuary	SSSI	483723	412323	1.5km east
OE4	Humber Estuary	SSSI	483817	412556	1.6km east
OE5	Humber Estuary	SSSI	483951	412817	1.8km east
OE6	Crowle Borrow Pits	SSSI	479102	410825	2.9km west
OE7	Hatfield Chase Ditch	SSSI	478769	410293	3.4km south-west
OE8	Eastoft Meadow	SSSI	478772	414311	3.7km north-west

Receptor I.D.	Receptor description	Designation	Grid reference		Distance and direction from the operational Proposed Development
			X	Y	
OE9	Belshaw	SSSI	476961	406079	7.5km south-west
OE10	Thorne Moor	SAC, SPA and SSSI	475934	414720	6.4km north-west
OE11	Epworth Turbary	SSSI	475690	404195	9.7km south-west
OE12	Risby Warren	SSSI	491180	413564	9.1km east
OE13	Hatfield Moor	SAC, SPA and SSSI	471828	408178	10.6km west
OE14	Messingham Heath	SSSI	487748	403574	9.8km south-east
OE15	Tuetoes Hills	SSSI	484361	401698	10.2km south
OE16	Haxey Turbary	SSSI	475107	401866	11.9km south-west
OE17	Rush Furlong	SSSI	478141	400564	11.7km south
OE18	Hewson's Field	SSSI	478493	399614	12.5km south
OE19	Messingham Sand Quarry	SSSI	491394	404065	11.9km south-east
OE20	Manton and Twigmoor	SSSI	492895	405918	12.2km south-east
OE21	Scotton and Laughton Forest Ponds	SSSI	485863	399966	12.2km south
OE22	Broughton Far Wood	SSSI	495776	410821	13.6km east
OE23	Broughton Alder Wood	SSSI	495914	409994	13.8km east
OE24	Scotton Beck Field	SSSI	487885	399177	13.7km south-east
OE25	Scotton Common	SSSI	486951	398641	13.8km south
OE26	Laughton Common	SSSI	483534	397224	14.5km south
OE27	Stainforth and Keadby Canal Corridor	LWS	482055	411529	100m south
OE28	Hatfield Waste Drain	LWS	480864	409988	2.0km south-west

Receptor I.D.	Receptor description	Designation	Grid reference		Distance and direction from the operational Proposed Development
			X	Y	
OE29	North Engine Drain, Belton	LWS	480884	409952	2.0km south-west
OE30	Keadby Wetland	LWS	482773	411433	640m east
OE31	River Torne	LWS	480904	409901	2.0km south-west
OE32	Keadby Wet Grassland	LWS	482785	411409	650m east
OE33	Three Rivers	LWS	482956	411068	970m south-east
OE34	South Engine Drain Belton	LWS	480964	409897	2.0km south-west
OE35	Gunness Common	LWS	484845	411588	2.6km east
OE36	Ash Tip	N/A	481797	412068	Adjacent to west

Modelled domain – receptor grid

3.5.5 Emissions from the stacks have also been modelled on a receptor grid that is 4km by 4km centred on the Proposed Development, to enable the generation of pollutant isopleth plots. The grid spacing is 44m, which is considered appropriate for the 105m stack.

3.5.6 In addition, the receptors detailed in Tables 4 and 5 have been included as specified points within the model and therefore this are unaffected by grid spacing.

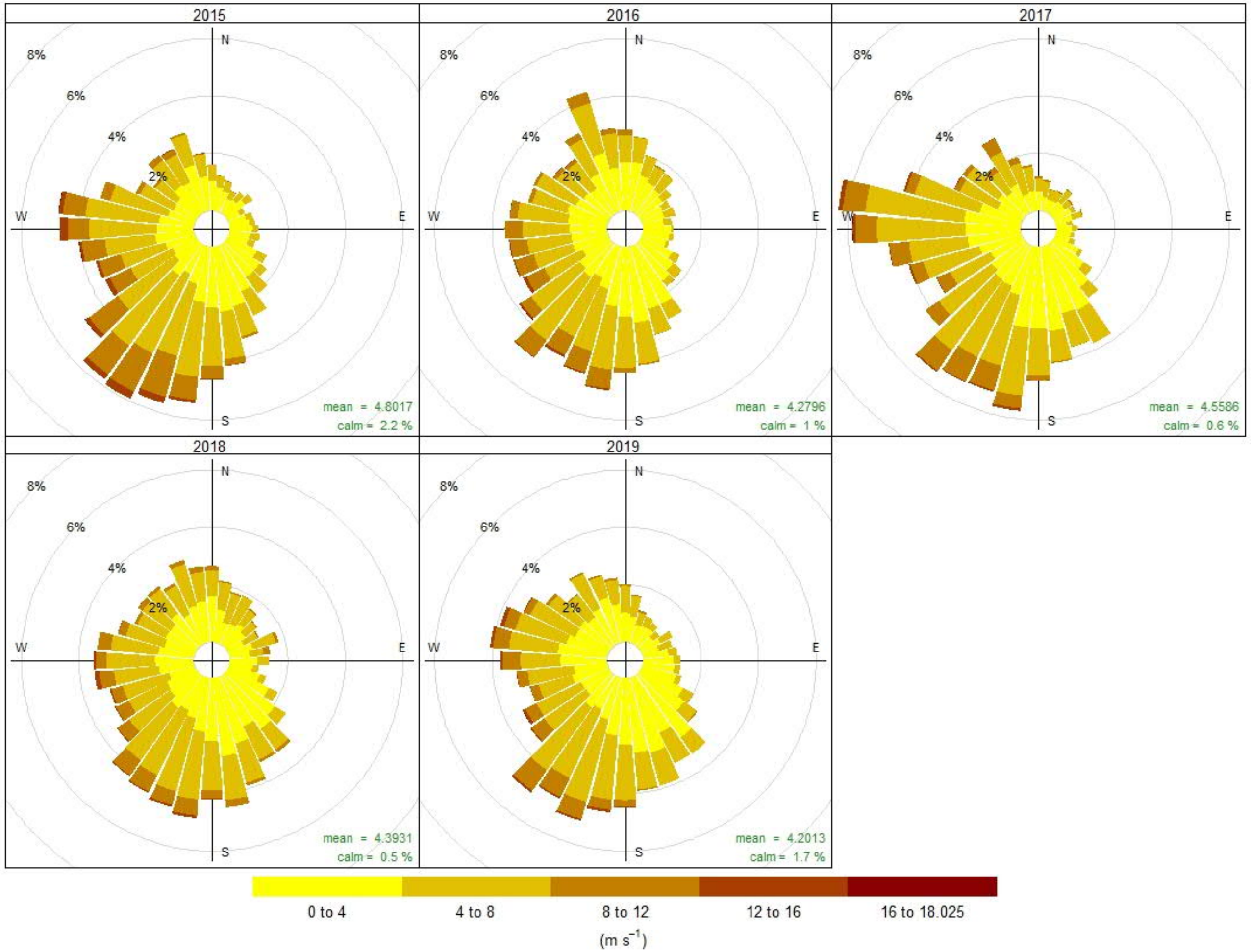
3.6 Meteorological data

3.6.1 Actual measured hourly-sequential meteorological data is available for input into dispersion models, and it is important to select data as representative as possible for the site that will be modelled. This is usually achieved by selecting a meteorological station as close to the site as possible, although other stations may be used if the local terrain and conditions vary considerably, or if the station does not provide sufficient data.

3.6.2 The meteorological site that was selected for the assessment is Doncaster Robinhood Airport, located approximately 21km southwest of the Proposed Development site, at a flat airfield in a principally agricultural area, and therefore a surface roughness of 0.2m (representative of an agricultural area) has been selected for the meteorological site.

3.6.3 The modelling for this assessment has utilised 5 years of meteorological data for the period 2015 – 2019. Wind roses for each of the years within this period are shown in **Plate 2.**.

Plate 2: Wind roses for Doncaster Robinhood Airport, 2015 to 2019



3.7 Building downwash effects

3.7.1 The buildings that make up the Proposed Development have the potential to affect the dispersion of emissions from the operational process stacks. The ADMS buildings effect module has therefore been used to incorporate building downwash effects as part of the modelling procedure. Buildings greater than one third of the range of stack heights modelled have been included within the modelling assessment.

3.7.2 Buildings associated with the Proposed Development that have been considered to be of sufficient height and volume to potentially impact on the dispersion of emission stacks are shown in Table 6. A plan showing the buildings layout used in the ADMS simulation is illustrated in **Figure 8.4** (PEI Report Volume III).

3.7.3 The dimensions of the Keadby 3 buildings are understood to be the maximum measurements that could potentially be required (as defined in the Rochdale Envelope) and have been provided by the Design Engineers. Keadby 2 buildings have been included within the model with the parameters that were assessed at Planning/ Permitting stage for that Development.

Table 6: Buildings incorporated into the modelling assessment

Building	Building centre grid reference (x, y)		Height (m)	Length (m)	Width (m)	Angle (°)
Keadby 2 Power Station HRSG	482676	411630	40	26.15	46.17	104
Keadby 2 Power Station GT	482699	411676	30	47.3	19.9	104
Keadby 2 Power Station Building	482630	411659	30	45.8	45.7	104
Proposed Development Absorber	481915	411919	90[1]	13	40	0
Proposed Development GT	482148	411925	32	22	50	90
Proposed Development HRSG	482112	411925	56	28	50	0
Proposed Development Steam Turbine	482111	411987	35	40	50	0

[1] The full height of the absorber tower is 98m, however the top 16m of the tower is formed from a sloping transition piece that tapers the footprint of the absorber building to the stack bottom, and as such the absorber height in the model has been reduced by half of the height of the transition piece to take account of the fact that this will reduce the downwash effects of the absorber building on the emission.

3.8 Terrain

3.8.1 The immediate local area of the Proposed Development is flat agricultural land, with the urban area of Scunthorpe (including the industrial area on the east side) approximately 5.5km to the east. The Proposed Development is situated near to the River Trent and River Humber. A surface roughness of 0.2m, corresponding to the minimum value associated with the terrain type, has therefore been selected to represent the local terrain.

3.8.2 Site-specific terrain data has not been used in the model, as there are no potentially significant changes in gradient within the study area.

3.9 NO_x to NO_2 conversion

3.9.1 Emissions of nitrogen oxides from industrial point sources are typically dominated by nitric oxide (NO), with emissions from combustion sources typically in the ratio of nitric oxide to nitrogen dioxide of 9:1. However, it is nitrogen dioxide that has specified environmental standards due to its potential impact on human health. In the ambient air, nitric oxide is oxidised to nitrogen dioxide by the ozone present, and the rate of oxidation is dependent on the relative concentrations of nitric oxide and ozone in the ambient air.

3.9.2 For the purposes of detailed modelling, and in accordance with Environment Agency technical guidance it is assumed that 70% of nitric oxide emitted from the stack is oxidised to nitrogen dioxide in the long term and 35% of the emitted nitric oxide is oxidised to nitrogen dioxide in the local vicinity of the site in the short-term.

3.10 Calculation of deposition at sensitive ecological receptors

3.10.1 Nutrient nitrogen and acid deposition at sensitive ecological receptors has been calculated using the predicted process contributions at the receptor points. The deposition rates are determined using conversion rates and factors contained within published guidance (Highways England, 2019) (IAQM, 2020), which takes into account variations in the deposition mechanisms for different types of habitat.

3.10.2 The conversion rates and factors used in the assessment are shown in Table 7.

Table 7: Conversion factors

Pollutant	Deposition velocity grassland (m/s)	Deposition velocity woodland (m/s)	Deposition Conversion factors	
			Nutrient Nitrogen ($\mu g/m^3/s$ to kg/ha/yr)	Acid ($\mu g/m^3/s$ to keq/ha/yr)
NO_x as NO_2	0.0015	0.003	96	6.84
NH_3	0.02	0.03	259.7	18.5

3.11 Specialised model treatments

3.11.1 Emissions have been modelled such that they are not subject to dry and wet deposition or depleted through chemical reactions. The assumption of continuity of mass is likely to result in an over-estimation of impacts at receptors, and therefore is considered to be conservative.

4.0 BASELINE AIR QUALITY

4.1 Overview

4.1.1 This section presents the information used to evaluate the background and baseline ambient air quality in the area surrounding the Proposed Development. The following steps have been taken in the determination of background values:

- identification of Air Quality Management Areas;
- review of North Lincolnshire Council (NLC) ambient monitoring data;
- review of data from Defra's background mapping database; and
- review of background data and site relevant critical loads from the APIS website.

4.2 Air Quality Management Areas

4.2.1 NLC has declared a single AQMA within their administrative area (7km east of the Proposed Development Site), for the exceedance of the 24-hour mean PM_{10} AQAL (50µg/m^3 not to be exceeded more than 35 times within a year). As the AQMA has not been declared for the pollutant species emitted from the Proposed Development, it would not be impacted by the emissions from it.

4.2.2 The study area includes small parts of the administrative areas of Doncaster Council (DC) and East Riding of Yorkshire Council (ERYC). DC has declared AQMA within their administrative area, but none are within the study area, the closest being over 10km from the Proposed Development Site.

4.3 Local authority monitoring data

4.3.1 NLC undertook automatic monitoring for NO_2 at 3 sites within their administrative area in 2018 and undertook diffusion tube monitoring at 22 locations.

4.3.2 The nearest automatic monitors are located approximately 7.5km from the Proposed Development Site; CM1 (Scunthorpe Town AURN) and CM3 (Low Santon). The annual mean for NO_2 for 2018 at CM1 monitor was 18µg/m^3 and at CM3 it was 20µg/m^3.

4.3.3 The nearest NO_2 diffusion tube monitoring locations to the Proposed Development are approximately 4.5km to the east, located on Doncaster Road (DT3 and DT4) and Scotter Road (DT2, near junction with Doncaster Road). Doncaster Road is a major road from the A18 and M181 into the centre of Scunthorpe. Annual mean concentrations of NO_2 at these locations range between 19 - 24µg/m^3, well below the annual AQAL of 40µg/m^3.

4.3.4 Monitoring undertaken by NLC therefore confirms that concentrations of NO_2 are all well below the annual mean AQAL.

4.4 Defra background data

4.4.1 Defra's 2018-based background maps are available at a 1x1 km resolution for the UK for 2018 and are projected forward to the year 2030. These projections of pollution concentrations across England are available for NO_2 and NO_x.

4.4.2 Data for 2018 has been presented for the assessment, as the typical trend shown in the Defra background mapping is that over the projected time period, concentrations of NO_2 and NO_x will decrease. This corresponds to a reduction overtime of vehicle emissions as newer, cleaner vehicles replace older ones. Therefore, assuming no reduction occurs until the opening year of the Proposed Development (2025), is considered to represent a conservative approach, and is in line with advice from the Environment Agency on similar projects.

4.4.3 Background concentrations from the Defra 2018-based background maps are presented for the year 2018 in Table 8 taken for the grid square in which the operational Proposed Development is located (482500,411500) for NO_x and NO_2.

4.4.4 Background concentrations for CO are not available for the most recent Defra maps, but data for 2001-based background concentrations are available and this has been adjusted for 2018 using the Defra published year adjustment factors.

4.4.5 There is no background monitoring data for the other trace species emitted from the Proposed Development (amines, N-amines). Ammonia concentrations are discussed below.

4.4.6 A review of the background map concentrations over the study area for human health receptors shows that the concentrations presented in Table 8 for the Site location are also representative of the background concentrations at the receptor locations (the average NO_2 concentration in the grid squares with identified receptors was 9.1µg/m^3).

Table 8: Defra background concentrations (NGR 482500,411500)

Pollutant	Background concentration (µg/m^3)
NO_x	12.5
NO_2	9.5
CO	111.8

4.4.7 There is no information on background concentrations of N-amines in the atmosphere, as levels are likely to be below the limit of detection of any monitoring technique currently available for these species.

Ecological site background data

4.4.8 The NO_x and NH_3 background concentrations for designated SAC, SPA and SSSI sites are available from the APIS website. The average concentrations present at the relevant habitat receptor sites are presented in Table 9.

Table 9: APIS background data NO_x and NH_3

Receptor I.D.	Ecology site	NO_x ($\mu g/m^3$)	NH_3 ($\mu g/m^3$)
OE1-5	Humber Estuary SSSI, SAC, SPA	14.3	1.9
OE6	Crowle Borrow Pits	14.6	2.2
OE7	Hatfield Chase Ditch	14.6	2.2
OE8	Eastoft Meadow SSSI	12.0	2.2
OE9	Belshaw	11.7	2.5
OE10	Thorne Moor	12.2	1.5
OE11	Epworth Turbary	11.6	1.8
OE12	Risby Warren	15.6	2.5
OE13	Hatfield Moor	12.1	2.5
OE14	Messingham Heath	11.9	2.3
OE15	Tuetoes Hills	11.2	1.9
OE16	Haxey Turbary	11.4	1.8
OE17	Rush Furlong	11.3	1.8
OE18	Hewsons Field	11.5	1.7
OE19	Messingham Sand Quarry	12.5	1.9
OE20	Manton and Twigmoor	12.9	1.9
OE21	Scotton and Laughton forest Ponds	11.4	1.9
OE22	Broughton Far Wood	13.9	2.5
OE23	Broughton Alder Wood	14.2	2.9
OE24	Scotton Beck Field	11.7	2
OE25	Scotton Common	11.8	2
OE26	Laughton Common	11.2	1.5
OE27	Stainforth and Keadby Canal Corridor	14.3	1.9
OE28	Hatfield Waste Drain	14.6	2.2
OE29	North Engine Drain, Belton	14.6	2.2
OE30	Keadby Wetland	14.3	1.9
OE31	River Torne	14.6	2.2
OE32	Keadby Wet Grassland	14.8	1.9
OE33	Three Rivers	13.3	1.9
OE34	South Engine Drain Belton	13.5	2.1
OE35	Gunness Common	15.4	1.9
OE36	Ash Tip	12.7	1.9

4.4.9 In addition, the APIS website provides information on the relevant critical loads for the assessment of depositional impacts, as well as background nitrogen deposition and acid deposition loads. This data has been presented in Table 10.

Table 10: APIS Critical Load and background deposition information

Receptor I.D.	Ecology site	N-Deposition	Acid Deposition	
		(kg N/ha/yr)	(keq N/ha/yr)	(keq S/ha/yr)
OE1-5	Humber Estuary SSSI, SAC, SPA	17.1	1.2	0.2
OE6	Crowle Borrow Pits	31.2	2.2	0.2
OE7	Hatfield Chase Ditch	18.1	1.3	0.2
OE8	Eastoft Meadow SSSI	18.1	1.3	0.2
OE9	Belshaw	9.8	0.7	0.2
OE10	Thorne Moor	14.6	1	0.2
OE11	Epworth Turbary	16.3	1.2	0.2
OE12	Risby Warren	21.8	1.6	0.4
OE13	Hatfield Moor	19.6	1.4	0.2
OE14	Messingham Heath	19.4	1.4	0.2
OE15	Tuetoes Hills	16.6	1.2	0.2
OE16	Haxey Turbary	16.0	1.1	0.2
OE17	Rush Furlong	16.3	1.2	0.2
OE18	Hewsons Field	15.5	1.1	0.2
OE19	Messingham Sand Quarry	30.6	2.2	0.3
OE20	Manton and Twigmoor	18.2	1.3	0.2
OE21	Scotton and Laughton Forest Ponds	17.2	1.2	0.2
OE22	Broughton Far Wood	35.9	2.6	0.3
OE23	Broughton Alder Wood	40.0	2.9	0.3
OE24	Scotton Beck Field	17.8	1.3	0.2
OE25	Scotton Common	17.8	1.3	0.2
OE26	Laughton Common	14.8	1.1	0.2
OE27	Stainforth and Keadby Canal Corridor	17.1	1.22	0.22
OE28	Hatfield Waste Drain	18.1	1.29	0.2
OE29	North Engine Drain, Belton	18.1	1.29	0.2
OE30	Keadby Wetland	17.1	1.22	0.22
OE31	River Torne	18.1	1.29	0.2

Receptor I.D.	Ecology site	N-Deposition	Acid Deposition	
		(kg N/ha/yr)	(keq N/ha/yr)	(keq S/ha/yr)
OE32	Keadby Wet Grassland	17.1	1.22	0.22
OE33	Three Rivers	17.1	1.22	0.22
OE34	South Engine Drain Belton	17.9	1.28	0.21
OE35	Gunness Common	17.1	1.22	0.22
OE36	Ash Tip	17.1	1.22	0.22

4.5 Summary of background air quality

4.5.1 For human health receptors, the background concentration for NO_2, and CO has been taken from the Defra background mapping, as presented in Table 8Table 8: Defra background concentrations (NGR 482500,411500).

4.5.2 The background NO_x and NH_3 concentrations for ecological receptors were sourced from APIS using the specific location for the relevant ecological receptor, as detailed in Tables 9 and 10**.**

4.5.3 Short-term background concentrations have been calculated by multiplying the selected annual mean background concentration by a factor of two, in accordance with the Environment Agency Risk Assessment methodology.

4.5.4 In order to represent a conservative approach, it has been assumed that background concentrations of NO_2 would not decrease in future years. Therefore, the current background concentrations have been assumed to apply to the projected opening year of 2025.

5.0 OPERATIONAL EMISSIONS MODELLING RESULTS

5.1 Evaluation of stack height

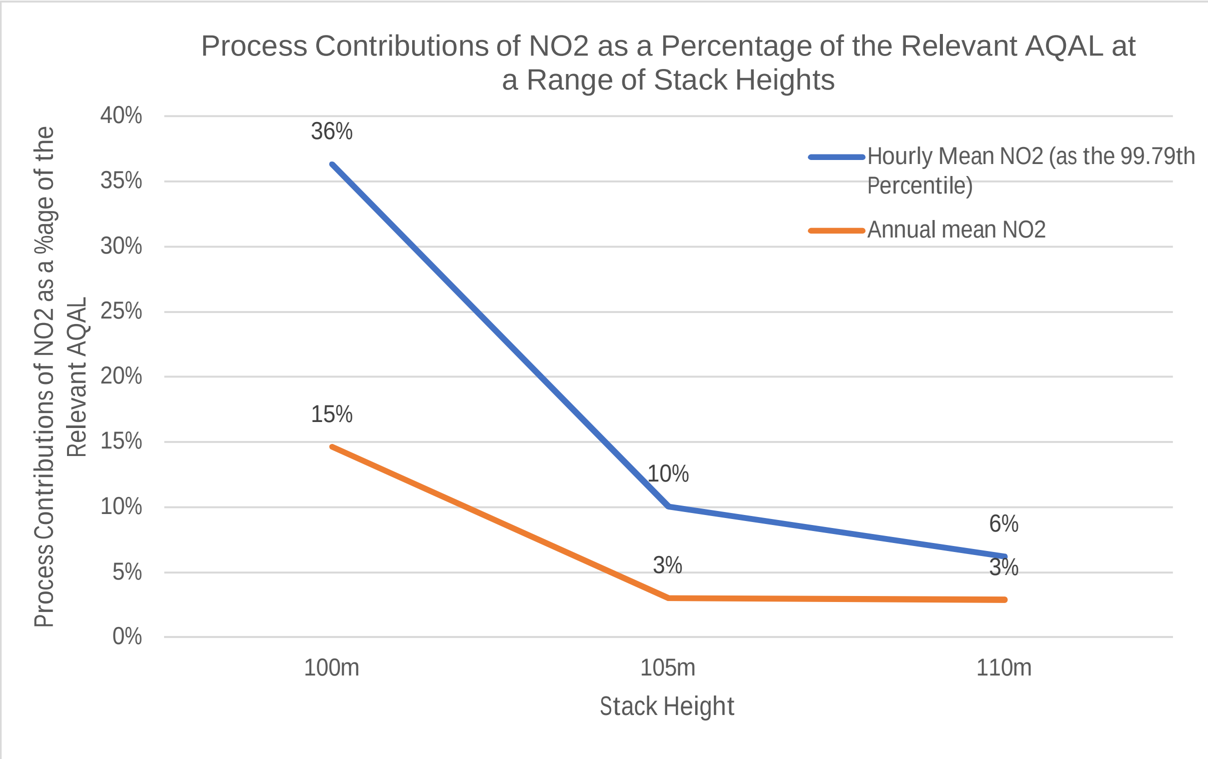
5.1.1 The selection of an appropriate stack release height requires a number of factors to be taken into account, the most important of which is the need to balance a release height sufficient to achieve adequate dispersion of pollutants against other constraints such as the visual impact of tall stacks.

5.1.2 The emissions from the carbon capture plant primarily occur from a stack on top of the absorber building. The absorber building itself has been included in the model at a height of 90m. The top 16m of the absorber building consists of a sloped transition piece that tapers the footprint of the absorber building to the stack bottom, and as such the absorber height in the model has been reduced by half of the height of the transition piece to take account of the fact that this tapering will reduce the downwash effects of the absorber building on the emission.

5.1.3 Given the tall height of the absorber building, the stack has been modelled at heights between 100m and 110m, at 5m increments. A graph, showing the percentage process contribution to the relevant AQALs for the annual mean and maximum 1-hour NO_2 concentrations are presented in **Plate 3**. The purpose of the graph is to evaluate the optimum release height in terms of the dispersion of pollutants which would occur, against the visual constraints of further increases in release height, with the 'elbow' of the resulting curve showing where the reductions in ground level concentrations become disproportionate to the increasing height, regarded as the stack height that represents BAT for the emission source.

5.1.4 Analysis of the curves shows that the benefit of the incremental increase in release heights between 100m and 105m are relatively pronounced. At heights above 105m, the air quality benefit of increasing release height further is reduced, especially for annual average impacts. The reported results are therefore based on a 105m stack

Plate 3: Stack Height Determination



5.2 Human Health Receptor Results

<u>Nitrogen dioxide emissions</u>

5.2.1 The predicted change in annual mean NO_2 concentrations that would occur during the operation of the Proposed Development, at the identified human health receptors, are presented in Table 11. The results presented represent the highest (worst-case) result from all five years of the meteorological data used in the model and include contributions from Keadby 2 as well as the Proposed Development.

5.2.2 The maximum predicted annual mean NO_2 concentration that occurs anywhere within the study area as a result of the Proposed Development is 1.2µg/m^3, which represents 3% of the annual mean AQAL. This occurs just to the north of the operational Proposed Development. The annual mean NO_2 predicted environmental concentration (i.e. the process contribution and the existing background concentration) is 10.6µg/m^3 and therefore is well below the annual mean NO_2 AQAL of 40µg/m^3. NO_2 emissions from the Proposed Development are therefore not predicted to lead to a risk of the annual mean AQALs being exceeded anywhere within the study area.

5.2.3 The discrete receptor most affected by emissions from the Proposed Development is receptor OR6 Boskeydyke Farm, with a predicted annual mean NO_2 concentration as a result of the Proposed Development of 0.9µg/m^3, representing 2% of the AQAL.

5.2.4 The significance of the predicted change in annual mean NO_2 concentrations in EIA terms is discussed in Chapter 8: Air Quality (PEI Report, Volume I).

Table 11: Predicted change in annual mean NO_2 concentrations

Receptor	AQAL ($\mu g/m^3$)	(PC) ($\mu g/m^3$)	PC/AQAL %	BC ($\mu g/m^3$)	PEC ($\mu g/m^3$)	PEC/ AQAL %
Max anywhere	40	1.2	3.0%	9.5	10.7	27%
OR1		0.6	1.5%	9.3	9.9	25%
OR2		0.5	1.3%	9.3	9.8	24%
OR3		0.2	0.5%	9.2	9.4	24%
OR4		0.3	0.7%	8.6	8.9	22%
OR5		0.8	2.1%	9.4	10.3	26%
OR6		0.9	2.1%	8.4	9.3	23%
OR7		0.5	1.3%	9.3	9.9	25%
OR8		0.2	0.5%	8.9	9.1	23%

PC = Process Contribution, AQAL = Air Quality Assessment Level, BC = Background Concentration, PEC = Predicted Environmental Concentration

5.2.5 The maximum predicted hourly mean NO_2 concentration (as the 99.79th percentile of hourly averages) that occurs anywhere within the study area as a result of the Proposed Development is 20.1µg/m^3, and this occurs again just to the north of the operational Proposed Development. The predicted environmental concentration (i.e. the process contribution and the existing background concentration) is 39.1µg/m^3 and therefore is well below the hourly mean NO_2 AQAL of 200µg/m^3. NO_2 emissions from the Proposed Development are therefore not predicted to lead to a risk of the hourly mean air quality standard being exceeded anywhere within the study area.

5.2.6 The discrete receptor most affected by emissions from the Proposed Development is receptor OR2 Trent Side, with a predicted hourly mean NO_2 concentration as a result of the Proposed Development of 12.7µg/m^3, representing 6% of the AQALs.

Table 12: Predicted change in hourly mean NO_2 concentrations (as the 99.79th Percentile of Hourly Averages)

Receptor	AQAL ($\mu g/m^3$)	PC ($\mu g/m^3$)	PC/AQAL %	Background Concentration (BC) ($\mu g/m^3$)	Predicted Environmental Concentration (PEC) ($\mu g/m^3$)	PEC/ AQAL %
Max anywhere	200	20.1	10%	19.0	39.1	20%
OR1		8.8	4%	18.6	27.3	14%
OR2		12.7	6%	18.6	31.2	16%
OR3		5.7	3%	18.5	24.2	12%
OR4		6.0	3%	17.2	23.2	12%
OR5		8.7	4%	18.8	27.6	14%
OR6		4.8	2%	16.8	21.6	11%

Receptor	AQAL (µg/m³)	PC (µg/m³)	PC/AQAL %	Background Concentration (BC) (µg/m³)	Predicted Environmental Concentration (PEC) (µg/m³)	PEC/ AQAL %
OR7		5.5	3%	18.7	24.2	12%
OR8		4.2	2%	17.8	22.0	11%

PC = Process Contribution, AQAL = Air Quality Assessment Level, BC = Background Concentration, PEC = Predicted Environmental Concentration

Carbon monoxide emissions

5.2.7 The maximum hourly and 8 hour running mean predicted concentrations that occur anywhere as a result of the Proposed Development represent less than 2% of the relevant AQAL and therefore can be considered to be insignificant/ negligible at all receptor locations. In addition, when added to the background concentrations in the study area, the predicted environmental concentration remains less than 4% of the relevant AQALs for both averaging periods. The results at individual receptors have therefore not been presented.

Ammonia emissions

5.2.8 The annual and hourly average predicted concentrations of ammonia that occur anywhere as a result of the Proposed Development represent less than 1% of the relevant AQAL and therefore can be considered to be insignificant/ negligible at all receptor locations. In addition, when added to the background concentrations in the study area, the predicted environmental concentration remains less than 1% of the relevant AQAL for both averaging periods. The results at individual receptors have therefore not been presented.

Amine emissions

5.2.9 The annual average predicted concentration of amines that occurs anywhere as a result of the Proposed Development represent less than 1% of the relevant AQAL at all locations and therefore can be considered to be insignificant/ negligible. The results at individual receptors have therefore not been presented.

5.2.10 The hourly average concentration at the maximum impacted location represents 6% of the AQAL, and therefore can also be considered to be insignificant/ negligible. The results at individual receptors have therefore not been presented.

Other potential degradation products emissions

5.2.11 The annual average predicted concentration of other degradation products (formaldehyde, acetaldehyde and acetic acid) that occurs anywhere as a result of the Proposed Development represent less than 1% of the relevant AQAL at all locations and therefore can be considered to be insignificant/ negligible. The results at individual receptors have therefore not been presented.

5.2.12 The hourly average concentrations of these species at the maximum impacted location represent less than 10% of the relevant AQAL, and therefore can also be considered to be insignificant/ negligible. The results at individual receptors have therefore not been presented.

Additional consideration of N-amine degradation products

5.2.13 As stated previously, it has been assumed that 5% of the amine release could degrade into N-amines following release from the emission stacks.

5.2.14 Additional consideration needs to be taken into account of the time (and therefore distance from the emission source) that this conversion takes place over. The specified receptors included in the model are between 300m and 2km from the emission sources, and therefore considering that the average wind speed in the study area is approximately 4.5m/s, the pollutants released from the stacks would take approximately 1 – 7.5 minutes to reach these receptors. Due to the slow rate of the degradation of amine to N-amine in the atmosphere (especially in an area with low background NO_2 concentrations) it is considered that less than 1% of the amine that could degrade to N-amine would have done so by the time it reaches the identified receptors (based on the work carried out by Tonnesen).

5.2.15 Obviously over a greater distance, further degradation would occur, and therefore this could result in N-amine concentrations increasing with distance from the stacks, although this would be countered by the additional dispersion of the plume over the greater distance.

5.2.16 Taking the outlined assumptions into account, the predicted N-amine concentrations at the identified receptors are shown in Table 13. There is no information on background concentrations of N-amines in the atmosphere, as levels are likely to be below the limit of detection of any monitoring technique currently available for these species.

5.2.17 The results show that based on the screening approach, although the impacts of N-amines cannot be considered insignificant, they are well within the proposed AQAL for N-amines at the worst-case location, and consequently at all receptor locations.

Table 13: Predicted change in annual mean N-amine concentrations

Receptor	AQAL (ng/m^3)	PC (µg/m^3)	PC/AQAL %
Max anywhere	0.2	0.10	48%
OR1		0.04	19%
OR2		0.03	14%
OR3		0.01	6%

Receptor	AQAL (ng/m^3)	PC ($\mu g/m^3$)	PC/AQAL %
OR4		0.02	8%
OR5		0.04	18%
OR6		0.03	17%
OR7		0.02	12%
OR8		0.01	6%

PC = Process Contribution, AQAL = Air Quality Assessment Level

5.3 Ecological Receptor Results

5.3.1 The results of the dispersion modelling of predicted impacts on sensitive ecological receptors are presented in Table 14 to Table 17. The tables set out the predicted PC to atmospheric concentrations of NO_x and NH_3 and also nutrient nitrogen and acid deposition.

5.3.2 The effect of atmospheric NO_x concentrations, nitrogen deposition rates and acid deposition rates on the modelled receptor locations will be considered in detail in the report to inform the Habitats Regulations Assessment (HRA) within the final ES. Further discussion on the significance of the impact on sensitive ecological receptors is provided in **Chapter 11**: Biodiversity and Nature Conservation (PEI Report, Volume I).

Oxides of nitrogen emissions – Critical Levels

5.3.3 The assessment results show that the predicted annual average and daily average NO_x impacts are below the criteria for insignificance at the majority of the ecological receptors.

5.3.4 PCs of more than 1% of the long-term critical level for NO_x occur at the adjacent Humber Estuary SPA, SSSI and Ramsar, Keadby Wetland LWS, Three Rivers LWS and Gunness Common LWS, however in combination with the background concentrations, all sites are less than 70% of the CL threshold for insignificance, therefore no exceedances of the annual critical level is predicted.

5.3.5 The daily critical level is below the 10% screening for insignificance at all the designated sites except for the Humber Estuary. In combination with the background concentration at the Humber Estuary, the impacts are 48% of the daily critical level and therefore indicate that no exceedance of the daily critical level is predicted.

5.3.6 Five of the LWS have impacts over the 10% daily critical level, however again with the background concentrations taken into account the impacts are well below the daily critical level at all sites, and therefore no exceedance of the daily critical level is predicted at any site.

Ammonia – Critical Levels

5.3.7 The assessment results show that the predicted annual average NH_3 impacts at the majority of the ecological receptors are below the criteria for insignificance (<1% of the critical level). Only the Humber Estuary, Risby Warren, Broughton Alder and Broughton

Far Wood designated sites have impacts that are over this level. In combination with background concentrations at the Humber Estuary, the PEC is below the 70% threshold and therefore can be considered insignificant.

5.3.8 The background concentrations at the Risby Warren, Broughton Alder and Broughton Far Wood sites are already exceeding the critical level at these sites, due to the lower of the critical level being applied. Further interpretation of the significance of these results is therefore provided in **Chapter 11**: Biodiversity and Nature Conservation (PEI Report, Volume I).

Nitrogen deposition – Critical Loads

5.3.9 The Environment Agency and Natural England have agreed that depositional impacts that are below 1% of the relevant critical load for a site can be regarded as insignificant.

5.3.10 The majority of sites have impacts that can be screened as being insignificant as they are less than 1% of the critical load, or where this is not the case, the process contribution together with the background concentration do not exceed the critical load.

5.3.11 There are a number of sites where the background deposition is already exceeding the critical load, however the process contributions in all these cases are less than 1.5% of the critical load, and therefore can be considered to be only slightly over the level of insignificance.

5.3.12 Further interpretation of the significance of these results is therefore provided in **Chapter 11**: Biodiversity and Nature Conservation (PEI Report, Volume I).

Table 14: NO_x Dispersion modelling results for ecological receptors

Receptor ID	Site Name	Annual average (µg/m^3)						24-hour average (µg/m^3)					
		CL	PC	PC % of CL	BC	PEC	PEC % of CL	CL	PC	PC % of CL	BC	PEC	PEC % of CL
OE1-5	Humber Estuary SSSI, SAC, SPA	30	1.26	4.4%	14.27	15.53	52%	75	14.8	20%	21.4	36.2	48%
OE6	Crowle Borrow Pits		0.20	0.7%	14.62	14.82	49%		7.1	9%	21.9	29.0	39%
OE7	Hatfield Chase Ditch		0.18	0.6%	14.61	14.79	49%		6.9	9%	21.9	28.8	38%
OE8	Eastoft Meadow SSSI		0.16	0.5%	11.99	12.15	41%		4.1	5%	18.0	22.1	29%
OE9	Belshaw		0.11	0.4%	11.73	11.84	39%		2.2	3%	17.6	19.8	26%
OE10	Thorne Moor		0.10	0.3%	12.15	12.25	41%		2.8	4%	18.2	21.0	28%
OE11	Epworth Turbary		0.09	0.3%	11.62	11.71	39%		1.7	2%	17.4	19.2	26%
OE12	Risby Warren		0.23	0.8%	15.56	15.79	53%		2.0	3%	23.3	25.3	34%
OE13	Hatfield Moor		0.07	0.2%	12.14	12.21	41%		2.5	3%	18.2	20.8	28%
OE14	Messingham Heath		0.15	0.5%	11.92	12.07	40%		3.0	4%	17.9	20.9	28%
OE15	Tuetoes Hills		0.17	0.6%	11.20	11.37	38%		2.6	3%	16.8	19.4	26%
OE16	Haxey Turbary		0.08	0.3%	11.42	11.50	38%		1.5	2%	17.1	18.6	25%
OE17	Rush Furlong		0.10	0.3%	11.33	11.43	38%		2.1	3%	17.0	19.1	25%
OE18	Hewsons Field		0.09	0.3%	11.47	11.56	39%		1.8	2%	17.2	19.0	25%

Receptor ID	Site Name	Annual average (µg/m³)						24-hour average (µg/m³)					
		CL	PC	PC % of CL	BC	PEC	PEC % of CL	CL	PC	PC % of CL	BC	PEC	PEC % of CL
OE19	Messingham Sand Quarry		0.12	0.4%	12.49	12.61	42%		1.8	2%	18.7	20.5	27%
OE20	Manton and Twigmoor		0.15	0.5%	12.86	13.01	43%		3.2	4%	19.3	22.5	30%
OE21	Scotton and Laughton forest Ponds		0.17	0.6%	11.41	11.58	39%		4.6	6%	17.1	21.7	29%
OE22	Broughton Far Wood		0.22	0.7%	13.93	14.15	47%		1.8	2%	20.9	22.7	30%
OE23	Broughton Alder Wood		0.22	0.8%	14.17	14.39	48%		1.5	2%	21.3	22.8	30%
OE24	Scotton Beck Field		0.15	0.5%	11.66	11.81	39%		2.3	3%	17.5	19.8	26%
OE25	Scotton Common		0.16	0.5%	11.80	11.96	40%		4.1	5%	17.7	21.8	29%
OE26	Laughton Common		0.11	0.4%	11.19	11.30	38%		1.8	2%	16.8	18.5	25%
OE27	Stainforth and Keadby Canal Corridor		0.22	1.0%	14.27	14.49	48%		10.4	14%	21.4	31.8	42%
OE28	Hatfield Waste Drain		0.22	0.8%	14.63	14.85	50%		5.1	7%	21.9	27.1	36%
OE29	North Engine Drain, Belton		0.27	1.0%	14.63	14.90	50%		4.7	6%	21.9	26.6	36%

Receptor ID	Site Name	Annual average (µg/m³)						24-hour average (µg/m³)					
		CL	PC	PC % of CL	BC	PEC	PEC % of CL	CL	PC	PC % of CL	BC	PEC	PEC % of CL
OE30	Keadby Wetland		0.40	1.6%	14.27	14.67	49%		11.8	16%	21.4	33.2	44%
OE31	River Torne		0.23	0.8%	14.63	14.86	50%		4.8	6%	21.9	26.7	36%
OE32	Keadby Wet Grassland		0.31	1.3%	14.75	15.06	50%		11.1	15%	22.1	33.2	44%
OE33	Three Rivers		0.50	1.8%	13.32	13.82	46%		17.9	24%	20.0	37.9	51%
OE34	South Engine Drain Belton		0.27	1.0%	13.50	13.77	46%		4.5	6%	20.3	24.8	33%
OE35	Gunness Common		0.94	3.2%	15.43	16.37	55%		9.6	13%	23.1	32.7	44%
OE36	Ash tip		0.10	0.3%	12.65	12.75	42%		3.4	5%	19.0	22.4	30%
CL = Critical Level, PC = Process Contribution, BC = Background Concentration, PEC = Predicted Environmental Concentration													

Table 15: Dispersion modelling results for ecological receptors – NH_3

Receptor ID	Site Name	Annual Average (µg/m3)					
		CL	PC	PC % of CL	BC	PEC	PEC % of CL
OE1-5	Humber Estuary SSSI, SAC, SPA	3	0.10	3.5%	1.90	2.00	67%
OE6	Crowle Borrow Pits	1	0.013	1.3%	2.20	2.21	221%
OE7	Hatfield Chase Ditch	N/A	0.012	0.4%	2.20	2.21	74%
OE8	Eastoft Meadow SSSI	3	0.011	0.4%	2.20	2.21	74%
OE9	Belshaw	N/A	0.007	0.2%	2.47	2.48	83%
OE10	Thorne Moor	1	0.007	0.7%	1.52	1.53	153%
OE11	Epworth Turbary	1	0.006	0.6%	1.79	1.80	180%
OE12	Risby Warren	1	0.017	1.7%	2.53	2.55	255%
OE13	Hatfield Moor	1	0.005	0.5%	2.52	2.53	253%
OE14	Messingham Heath	1	0.011	1.1%	2.27	2.28	228%
OE15	Tuetoes Hills	1	0.012	1.2%	1.87	1.88	188%
OE16	Haxey Turbary	1	0.006	0.6%	1.79	1.80	180%
OE17	Rush Furlong	3	0.007	0.2%	1.79	1.80	60%
OE18	Hewsons Field	3	0.007	0.2%	1.72	1.73	58%
OE19	Messingham Sand Quarry	1	0.009	0.9%	1.93	1.94	194%
OE20	Manton and Twigmoor	1	0.011	1.1%	1.89	1.90	190%
OE21	Scotton and Laughton forest Ponds	1	0.012	1.2%	1.91	1.92	192%
OE22	Broughton Far Wood	1	0.016	1.6%	2.48	2.50	250%

Receptor ID	Site Name	Annual Average (µg/m3)					
		CL	PC	PC % of CL	BC	PEC	PEC % of CL
OE23	Broughton Alder Wood	1	0.017	1.7%	2.86	2.88	288%
OE24	Scotton Beck Field	1	0.011	1.1%	2.00	2.01	201%
OE25	Scotton Common	1	0.012	1.2%	2.00	2.01	201%
OE26	Laughton Common	1	0.008	0.8%	1.51	1.52	152%
OE27	Stainforth and Keadby Canal Corridor	3	0.007	0.2%	1.90	1.91	63%
OE28	Hatfield Waste Drain	3	0.015	0.5%	2.20	2.21	74%
OE29	North Engine Drain, Belton	3	0.017	0.6%	2.20	2.22	74%
OE30	Keadby Wetland	3	0.015	0.5%	1.90	1.91	64%
OE31	River Torne	3	0.015	0.5%	2.20	2.22	74%
OE32	Keadby Wet Grassland	3	0.010	0.3%	1.90	1.91	64%
OE33	Three Rivers	3	0.035	1.2%	1.90	1.93	64%
OE34	South Engine Drain Belton	3	0.017	0.6%	2.08	2.10	70%
OE35	Gunness Common	3	0.073	2.4%	1.90	1.97	66%
OE36	Ash tip	1	0.011	1.1%	1.90	1.91	191%

CL = Critical Level, PC = Process Contribution, BC = Background Concentration, PEC = Predicted Environmental Concentration

Table 16: Dispersion modelling results for ecological receptors – Nutrient nitrogen deposition (Kg/Ha/Yr)

Receptor ID	Site name	Background nitrogen deposition (kg N/ha/yr)	Most stringent Critical Load class applicable for the site	Lower value of applicable Critical Load range	PC (kg N/ha/yr)	PC % Critical Load	PEC (kg N/ha/yr)	PEC % Critical Load
OE1-5	Humber Estuary SSSI, SAC, SPA	17.1	Pioneer, Low-mid, mid-upper saltmarshes	20	0.67	3.3%	17.8	89%
OE6	Crowle Borrow Pits	31.2	Broad-leaved, mixed and yew woodland	10	0.14	1.4%	31.3	313%
OE7	Hatfield Chase Ditch	No features listed in APIS						
OE8	Eastoft Meadow	18.1	Neutral grassland	20	0.07	0.4%	18.2	91%
OE9	Belshaw	No critical loads assigned for the features present						
OE10	Thorne Moor	14.6	Degraded Raised Bogs	5	0.05	0.9%	14.6	293%
OE11	Epworth Turbary	16.3	Raised and blanket bogs	5	0.04	0.8%	16.3	327%
OE12	Risby Warren	21.8	Acid Grassland	8	0.11	1.4%	21.9	274%
OE13	Hatfield Moor	19.6	Raised and blanket bogs	5	0.03	0.7%	19.6	393%
OE14	Messingham Heath	19.4	Acid Grassland	8	0.07	0.9%	19.5	243%
OE15	Tuetoes Hills	16.6	Acid Grassland	8	0.08	1.0%	16.7	208%

Receptor ID	Site name	Background nitrogen deposition (kg N/ha/yr)	Most stringent Critical Load class applicable for the site	Lower value of applicable Critical Load range	PC (kg N/ha/yr)	PC % Critical Load	PEC (kg N/ha/yr)	PEC % Critical Load
OE16	Haxey Turbary	16.0	Raised and blanket bogs	5	0.04	0.7%	16.0	321%
OE17	Rush Furlong	16.3	Neutral Grassland	20	0.05	0.2%	16.3	82%
OE18	Hewsons Field	15.5	Neutral Grassland	20	0.04	0.2%	15.5	78%
OE19	Messingham Sand Quarry	30.6	Broadleaved deciduous woodland	10	0.10	1.0%	30.7	307%
OE20	Manton and Twigmoor	18.2	Acid Grassland	8	0.07	0.9%	18.3	228%
OE21	Scotton and Laughton forest Ponds	17.2	Fen, Marsh and Swamp (assumed)	10	0.08	0.8%	17.3	173%
OE22	Broughton Far Wood	35.9	Broad-leaved, mixed and yew woodland	15	0.17	1.1%	36.1	240%
OE23	Broughton Alder Wood	Broad-leafed, mixed and yew woodland - Not sensitive to nitrogen deposition						
OE24	Scotton Beck Field	17.8	Acid Grassland	10	0.07	0.7%	17.9	179%
OE25	Scotton Common	17.8	Dwarf Shrub Heath	10	0.08	0.8%	17.9	179%
OE26	Laughton Common	14.8	Acid grasslands	8	0.05	0.6%	14.9	186%
OE27	Stainforth and Keadby	17.1	Neutral grassland	20	0.06	0.3%	17.1	86%

Receptor ID	Site name	Background nitrogen deposition (kg N/ha/yr)	Most stringent Critical Load class applicable for the site	Lower value of applicable Critical Load range	PC (kg N/ha/yr)	PC % Critical Load	PEC (kg N/ha/yr)	PEC % Critical Load
	Canal Corridor							
OE28	Hatfield Waste Drain	18.1	Neutral grassland	20	0.10	0.5%	18.2	91%
OE29	North Engine Drain, Belton	18.1	Neutral grassland	20	0.12	0.6%	18.2	91%
OE30	Keadby Wetland	17.1	Broadleaved deciduous woodland	10	0.12	1.2%	17.2	172%
OE31	River Torne	18.1	Neutral grassland	20	0.10	0.5%	18.2	91%
OE32	Keadby Wet Grassland	17.1	Coastal and floodplain grazing marsh	20	0.08	0.4%	17.2	86%
OE33	Three Rivers	17.1	Coastal and floodplain grazing marsh	20	0.23	1.1%	17.3	87%
OE34	South Engine Drain Belton	17.9	Neutral grassland	20	0.12	0.6%	18.0	90%
OE35	Gunness Common	17.1	Acid grassland	10	0.47	4.7%	17.6	176%
OE36	Ash tip	17.1	Acid grassland	10	0.07	0.7%	17.1	171%

Table 17: Dispersion modelling results for ecological receptors – Acid deposition N (Keq/Ha/Yr)

Receptor ID	Site name	Acid deposition				PC acid deposition (keq/ha/yr)		
		Critical Load (keq/ha/yr)	Baseline (keq/ha/yr)	Lowest Critical Load class applicable	Baseline % of Critical Load	PC	PC % of Critical Load	PEC% of Critical Load
OE1-5	Humber Estuary SSSI, SAC, SPA	Fen, marsh and swamp – not sensitive to acidity						
OE6	Crowle Borrow Pits	Min CL Min N: 0.142 Min CL Max N: 2.694 Min CL Max S: 2.337	N: 2.2 S: 0.2	Unmanaged Broadleaved/ Coniferous Woodland	89%	0.010	0.4%	89%
OE7	Hatfield Chase Ditch	No features listed in APIS						
OE8	Eastoft Meadow	Min CL Min N: 0.438 Min CL Max N: 2.008 Min CL Max S: 1.57	N: 1.3 S: 0.2	Acid grassland	75%	0.005	0.3%	75%
OE9	Belshaw	No critical loads assigned for the features present						
OE10	Thorne Moor	Min CL Min N: 0.321 Min CL Max N: 0.462 Min CL Max S: 0.141	N: 1.0 S: 0.2	Bogs	260%	0.003	0.0%	260%
OE11	Epworth Turbary	Min CL Min N: 0.321 Min CL Max N: 0.478 Min CL Max S: 0.157	N: 1.2 S: 0.2	Bogs	293%	0.003	0.6%	293%
OE12	Risby Warren	Min CL Min N: 0.223 Min CL Max N: 0.858 Min CL Max S: 0.42	N: 1.6 S: 0.4	Acid grassland	233%	0.008	0.9%	234%
OE13	Hatfield Moor	Min CL Min N: 0.321	N: 1.4	Bogs	337%	0.002	0.5%	337%

Receptor ID	Site name	Acid deposition				PC acid deposition (keq/ha/yr)		
		Critical Load (keq/ha/yr)	Baseline (keq/ha/yr)	Lowest Critical Load class applicable	Baseline % of Critical Load	PC	PC % of Critical Load	PEC% of Critical Load
		Min CL Max N: 0.475 Min CL Max S: 0.154	S: 0.2					
OE14	Messingham Heath	Min CL Min N: 0.366 Min CL Max N: 0.556 Min CL Max S: 0.19	N: 1.4 S: 0.2	Acid grassland	288%	0.005	0.9%	289%
OE15	Tuetoes Hills	Min CL Min N: 0.366 Min CL Max N: 0.556 Min CL Max S: 0.20	N: 1.2 S: 0.2	Acid grassland	252%	0.006	1.0%	253%
OE16	Haxey Turbary	Min CL Min N: 0.321 Min CL Max N: 0.477 Min CL Max S: 0.156	N: 1.1 S: 0.2	Bogs	273%	0.003	0.6%	273%
OE17	Rush Furlong	Min CL Min N: 0.295 Min CL Max N: 2.028 Min CL Max S: 1.59	N: 1.2 S: 0.2	Acid grassland	69%	0.003	0.2%	69%
OE18	Hewsons Field	Min CL Min N: 0.438 Min CL Max N: 2.048 Min CL Max S: 1.61	N: 1.1 S: 0.2	Acid grassland	63%	0.003	0.2%	64%
OE19	Messingham Sand Quarry	Min CL Min N: 0.142 Min CL Max N: 1.214 Min CL Max S: 1.016	N: 2.2 S: 0.3	Unmanaged Broadleaved/ Coniferous Woodland	206%	0.007	0.6%	206%
OE20	Manton and Twigmoor	Min CL Min N: 0.223 Min CL Max N: 0.556 Min CL Max S: 0.19	N: 1.3 S: 0.2	Acid grassland	270%	0.005	0.9%	271%

Receptor ID	Site name	Acid deposition				PC acid deposition (keq/ha/yr)		
		Critical Load (keq/ha/yr)	Baseline (keq/ha/yr)	Lowest Critical Load class applicable	Baseline % of Critical Load	PC	PC % of Critical Load	PEC% of Critical Load
OE21	Scotton and Laughton forest Ponds	Min CL Min N: 0.321 Min CL Max N: 0.484 Min CL Max S: 0.163	N: 1.2 S: 0.2	Bogs	289%	0.006	1.2%	290%
OE22	Broughton Far Wood	Min CL Min N: 0.285 Min CL Max N: 0.989 Min CL Max S: 0.704	N: 2.6 S: 0.3	Unmanaged Broadleaved/ Coniferous Woodland	293%	0.012	1.2%	294%
OE23	Broughton Alder Wood	Broad-leafed, mixed and yew woodland - Not sensitive to acidity						
OE24	Scotton Beck Field	Min CL Min N: 0.366 Min CL Max N: 0.556 Min CL Max S: 0.19	N: 1.3 S: 0.2	Acid grassland	270%	0.005	0.9%	271%
OE25	Scotton Common	Min CL Min N: 1.035 Min CL Max N: 1.225 Min CL Max S: 0.19	N: 1.3 S: 0.2	Dwarf shrub heath	122%	0.005	0.4%	123%
OE26	Laughton Common	Min CL Min N: 0.223 Min CL Max N: 0.576 Min CL Max S: 0.21	N: 1.1 S: 0.2	Acid grassland	226%	0.004	0.6%	226%
OE27	Stainforth and Keadby Canal Corridor	No information available						
OE28	Hatfield Waste Drain	No information available						
OE29	North Engine Drain, Belton	No information available						
OE30	Keadby Wetland	No information available						
OE31	River Torne	No information available						

Receptor ID	Site name	Acid deposition				PC acid deposition (keq/ha/yr)		
		Critical Load (keq/ha/yr)	Baseline (keq/ha/yr)	Lowest Critical Load class applicable	Baseline % of Critical Load	PC	PC % of Critical Load	PEC% of Critical Load
OE32	Keadby Wet Grassland	No information available						
OE33	Three Rivers	No information available						
OE34	South Engine Drain Belton	No information available						
OE35	Gunness Common	No information available						
OE36	Ash tip	No information available						

6.0 ASSESSMENT LIMITATIONS AND ASSUMPTIONS

6.1.1 This section outlines the potential limitations associated with the dispersion modelling assessment. Where assumptions have been made, this is also detailed here.

6.1.2 The greatest uncertainty associated with any dispersion modelling assessment arises through the inherent uncertainty of the dispersion modelling process itself. Despite this, the use of dispersion modelling is a widely applied and accepted approach for the prediction of impacts from industrial sources.

6.1.3 In order to minimise the likelihood of under-estimating the PC to ground level concentrations from the main stack, the following conservative assumptions have been made within the assessment:

- the operational Proposed Development has been assumed to operate on a continuous basis i.e. for 8,760 hour per year, although in practice the plant would require routine maintenance periods;
- the modelling predictions are based on the use of five full years of meteorological data from Doncaster Robin Hood meteorological station for the years 2015 to 2019 inclusive, with the highest result being reported for all years assessed;
- the largest possible building sizes within the Rochdale Envelope have been included, in particular the carbon capture plant absorber. Should the height of the absorber tower be reduced, the stack height could also be lowered, as the down wash effects would also have reduced. Any changes to the absorber height and stack height will be made ensuring that the level of impacts presented in this assessment are not exceeded;
- emission concentrations for the process are calculated based on the use of IED limits, BAT-AEL concentrations, or Licensor maximum emission rates when annual average rates would be below this; and
- the use of a preliminary screening assessment for the impacts of N-amines, based conservative assumptions from literature research.

6.1.4 The following assumptions have been made in the preparation of the assessment:

- 70% NO_x to NO_2 conversion rate has been assumed in predicting the long-term process contribution, and 35% for the short-term process contribution respectively;
- Ammonia emissions have been assessed based on a concentration of 1mg/Nm^3, which may need an acid wash abatement step to enable this to be achieved;
- Heating has been assumed for the absorber stack gases to improve dispersion and reduce plume visibility (this will be assessed in the final ES); and,
- The screening assessment of N-amines is considered to be deliberately conservative at this stage, and further work for the final ES is planned to take into account specific amine species and utilising the amines specific module within ADMS.

7.0 CONCLUSIONS

7.1.1 This report has assessed the impact on local air quality of the operation of the Proposed Development. The assessment has used the dispersion model ADMS to predict the increases in pollutant species released from the operational Development to the local study area.

7.1.2 An evaluation of the release height for the main stack has shown that a release height of 105m is capable of mitigating the short-term and long-term impacts of emissions to an acceptable level, with regard to existing air quality and ambient air quality standards at human health receptors. This is based on the assumption that the absorber tower is at a height of up to 98m. Should the height of the tower be reduced, the stack height could also be lowered, as the down wash effects would have reduced.

7.1.3 Emissions from the main stack would result in small increases in ground-level concentrations of the modelled pollutants. Taking into account available information on background concentrations within the modelled domain, predicted operational concentrations of the modelled pollutants would be within current environmental standards for the protection of human health.

7.1.4 At this stage the screening assessment of N-amines concludes that a moderate adverse impact could occur, however this assessment will be refined for the final ES.

7.1.5 The modelling of impacts at designated ecological sites (SAC / Ramsar / SPA and SSSI) has predicted that emissions would give rise to no significant impacts with regard to increases in atmospheric concentrations of NO_x.

7.1.6 Impacts of NH_3 are insignificant at the majority of designated ecological sites, however 3 sites (Risby Warren, Broughton Alder and Broughton Far Wood) have predicted impacts of 1.7% of the critical level. This is largely due to the lower NH_3 critical level value being detailed in APIS for these sites. In addition, the background concentration of NH_3 at these sites is already exceeding the critical level the significance criteria used indicates that this represents a moderate to major adverse magnitude of impact.

7.1.7 Further discussion is required on the relevance of the use of the lower critical level at these sites, as there is minimal information to justify the use of this level on APIS. If the higher critical level was applied, the impacts at these sites would be the PC would only be 0.6% of the critical level, and therefore would be considered to be insignificant.

7.1.8 Depositional impacts of nutrient nitrogen and acid are considered to be insignificant. Further interpretation and discussion of these impacts is provided in **Chapter 11**: Biodiversity and Nature Conservation (PEI Report, Volume I).

8.0 REFERENCES

Cambridge Environmental Research Consultants (2020), *Model Validation* [Online] [Accessed 02/06/2020]. Available from: https://www.cerc.co.uk/environmental-software/model-validation.html

Department for Environment, Food & Rural Affairs and Environment Agency (2016) *Air emissions risk assessment for your environmental permit*. [Online]. [Accessed 04 September 2020]. Available from: https://www.gov.uk/government/collections/risk-assessments-for-specific-activities-environmental-permits

European Commission (2010), *Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control (Recast)).*

European Commission (2017) *Best available techniques Reference document for Large Combustion Plants*. [Online]. [Accessed 04 September 2020]. Available from: https://eippcb.jrc.ec.europa.eu/sites/default/files/2019-11/JRC_107769_LCPBref_2017.pdf

H.M. Government (2016) *The Environmental Permitting (England and Wales) Regulations 2016*. SI 1154, the Stationary Office.

Highways England (2019) *Design Manual for Roads and Bridges (DMRB), Volume 11 Environmental Assessment, Section 3 Environmental Assessment Techniques, Part 1, LA 105 Air Quality.*

Institute of Air Quality Management (2020) *A guide to the assessment of air quality impacts on designated nature conservation sites, v1.1,* May 2020

Nielsen et al. (2011). *Atmospheric degradation of amines summary report: Photo-oxidation of methylamine, dimethylamine and trimethylamine*

Nielsen C J, Herrmann H and Weller C. (2012). *Atmospheric chemistry and environmental impact of the use of amines in carbon capture and storage (CCS)*.

Norwegian Institute for Air Research (2011), *Update and Improvement of Dispersion Calculations for Emissions to Air from TCM's Amine Plant, Part II – Likely case Nitrosamines, Nitramines and Formaldehyde*

Planning Inspectorate (2017) *Planning Inspectorate Advice Note Seven (Environmental Impact Assessment: Preliminary Environmental Information, Screening and Scoping).* Version 6 December 2017.

Norwegian Institute for Air Research (NILU), Tønnesen (2011) *Update and improvement of dispersion calculations for emissions to air from TCMs amine plant Part II – Likely case nitrosamines, nitramines and formaldehyde.*