Environmental Monitoring Solutions

Chemviron Carbon Ltd

Air Dispersion Modelling Report

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Executive Summary

Purpose of Report

Bureau Veritas has been commissioned by Environmental Monitoring Solutions (EMS) to undertake an air quality assessment for three natural gas furnaces at the Chemviron Carbon site in Houghton-le-Spring, Sunderland. This document provides supporting technical information for the application of an Environmental Permit variation on the existing permit (EPR/BT2831IA), which has been issued to Chemviron Carbon Limited. The variation to the existing permit covers the installation of a new carbonisation furnace and activator. The new furnace will be serviced by a relocated emission point. This report should be read in conjunction with Durham – EA Permit V006.

The assessment has used detailed dispersion modelling to undertake a study of emissions to air during the operation of the three generators on site.

Each of the generators are operated using natural gas as the fuel, hence, the following pollutants were included in the assessment: nitrogen oxides (NO_x) and benzene (C_6H_6).

Release rates for NO_x and benzene have been provided by EMS. Due to the operational hours of the generator plant, the emissions results have been post-processed, to account for the generators running 90% (7884 hrs) of a calendar year.

Summary of Conclusions

The assessment has resulted in the following conclusions:

- Considering annual mean results, all results at both human and ecological receptors were below the relevant assessment metrics.
- The results for nitrogen deposition show exceedances at some of the considered ecological receptors. The results for nitrogen deposition show no exceedances at Hetton Bogs SSSI and LNR and Joe's Pond SSSI.
- The maximum total predicted environmental nitrogen deposition rate is 263.4% of the CL. This is due to the background deposition rate at all receptors being relatively high when compared to the minimum CL. When taking the PC, this makes up less than 1% of the overall result at all modelled ecological receptors, so the contribution from the plant can be considered not significant. In the same manner, all results at all considered ecological receptor, for acid deposition can be described as not significant.
- Considering short-term results, all results at both human and ecological receptors were below the relevant assessment metrics.
- Due to worst-case conditions being employed through the assessment, the modelled predictions are expected to represent the upper limit of concentrations.
- As such, the plant is not expected to have a significant impact on annual mean pollutant concentrations in the surrounding area.

1 Introduction

Bureau Veritas has been commissioned by Environmental Monitoring Solutions (EMS) to undertake an air quality assessment for three natural gas furnaces at the Chemviron Carbon site in Houghton-le-Spring, Sunderland. This document provides supporting technical information for the application of an Environmental Permit variation on the existing permit (EPR/BT2831IA), which has been issued to Chemviron Carbon Limited. The variation to the existing permit covers the installation of a new carbonisation furnace and activator. The new furnace will be serviced by a relocated emission point. This report should be read in conjunction with Durham – EA Permit V006.

An initial H1 screening assessment was previously submitted as part of the permit variation application. Following submission, the Environment Agency (EA) highlighted the need for detailed modelling of NOx and Benzene. The EA outlined the following requirements for this assessment:

> *"Regarding the air emissions though, the H1 submitted does mean that detailed modelling would be required for benzene and NOx parameters, and therefore acid and nutrient nitrogen deposition too, based on the fact that these parameters do not screen out using H1.*
>
> *Please note that of the receptors you have discussed only Joe's Pond SSSI and Hetton Bogs SSSI are relevant as the SSSI screening distance is 2km. However, the screening distance for European sites (SACs, SPAs) and Ramsar sites is 10km, so these should be included in the detailed modelling if present."*

This report presents the methodology and the subsequent results of the required dispersion modelling of emissions to air in line with the EAs requirements.

1.1 Site location

The site is located on Commerce Way, approximately 1.4 km southeast of Houghton-le-Spring town centre. The area around the site is primarily commercial in nature, with residential areas at a greater distance. The site location is shown in Figure 1.1.

The closest receptors to the site are residential properties on Dunelm Drive, located approximately 460 m from the site boundary to the north. The closest ecological receptor, designated as a Site of Special Scientific Interest (SSSI) (Joe's Pond), is located approximately 390 m southwest of the site.

In terms of existing air quality conditions in the area, there are no Air Quality Management Areas (AQMAs) declared within the jurisdiction of Sunderland City Council. The closest AQMA to the site is the Durham County Council AQMA, approximately 7.8km southwest of the site, located along the main roads in Durham city centre. This AQMA is declared for exceedances of the annual mean nitrogen dioxide (NO_2) objective.

Figure 1.1 - Site Location

2 Dispersion Modelling Methodology

ADMS 5 version 5.2 modelling software was used for this study. ADMS 5 is an advanced atmospheric dispersion model that has been developed and validated by Cambridge Environmental Research Consultants (CERC). The model was used to predict ground level concentrations of combustion products emitted to atmosphere from the combustion plant at the Chemviron Carbon site. The model is used extensively throughout the UK for regulatory compliance purposes. It is accepted as an appropriate air quality modelling tool by the Environment Agency (EA) and local authorities.

ADMS 5 parameterises stability and turbulence in the Atmospheric Boundary Layer (ABL) by the Monin-Obukhov length and the boundary layer depth. This approach allows the vertical structure of the ABL to be more accurately defined than by the stability classification methods of earlier dispersion models such as R91 or ISCST3. In ADMS, the concentration distribution follows a symmetrical Gaussian profile in the vertical and crosswind directions in neutral and stable conditions. However, the vertical profile in convective conditions follows a skewed Gaussian distribution to take account of the inhomogeneous nature of the vertical velocity distribution in the Convective Boundary Layer (CBL).

A number of complex modules, including the effects of plume rise, complex terrain, coastlines, concentration fluctuations, radioactive decay and buildings effects, are also included in the model, as well as the facility to calculate long-term averages of hourly mean concentration, dry and wet deposition fluxes, and percentile concentrations, from either statistical meteorological data or hourly average data.

A range of input parameters is required for the model. This includes, but is not limited to, data describing the local area, meteorological measurements, and emissions data. The data utilised within the modelling assessment is detailed in the following sections of this chapter.

2.1 Process Emissions

Details of the generators at the Chemviron Carbon site have been provided to Bureau Veritas by EMS. The assessment has assumed three generators (gens) across the building (unit) at the site. The model input parameters for each type of combustion plant are detailed in Table 2.1.

Release rates for NO_x and benzene have been derived from information provided by EMS. All generators have been modelled as vertical point sources.

Table 2.1 - Model Input Parameters

Parameter	Stack A0	Stack A3	Stack A4
Stack Location (x, y)	433253, 548979	433251, 548966	433247, 548956
Stack Height (m) [a]	9	12	12
Stack Diameter (m) [a]	0.35	0.43	0.33
Volume Flux ($m^3 s^{-1}$) [a]	1.0021	3.4689	2.1903
Efflux Velocity ($m s^{-1}$)	10.416	23.887	25.609
Efflux Temperature (°C) [a]	28	33	34
Emission Rates (per combustion unit)[d]			
NO_x (g/s) [b]	0.33398	0.00451	0.00107
Benzene (g/s) [b]	0.01193	0.15645	0.02760

[a] Data provided by EMS.
[b] Emission Rates for NO_x and Benzene have been derived from emission information provided by EMS.

The data input into the calculations which have been undertaken to derive pollutant emission rates from information provided by EMS are detailed in Table 2.2.

Table 2.2 – Generator Emission Rate Calculations

ID	Source Name	Calculation / Information Source	Furnace Reference		
			A0	A3	A4
a	Discharge Diameter (mm)	EMS provided data from H1 Risk Assessment	350	430	330
b	Discharge Height (m)		9	12	12
c	Actual O_2 (%)		20.5	20.5	20.5
d	Discharge Temperature (ºC)		28	33	34
e	Efflux Velocity (m/s)		1.0021	3.4689	2.1903

The following scenarios have been included in this assessment, based on operating information provided by EMS.

Table 2.3 – Modelled Scenarios

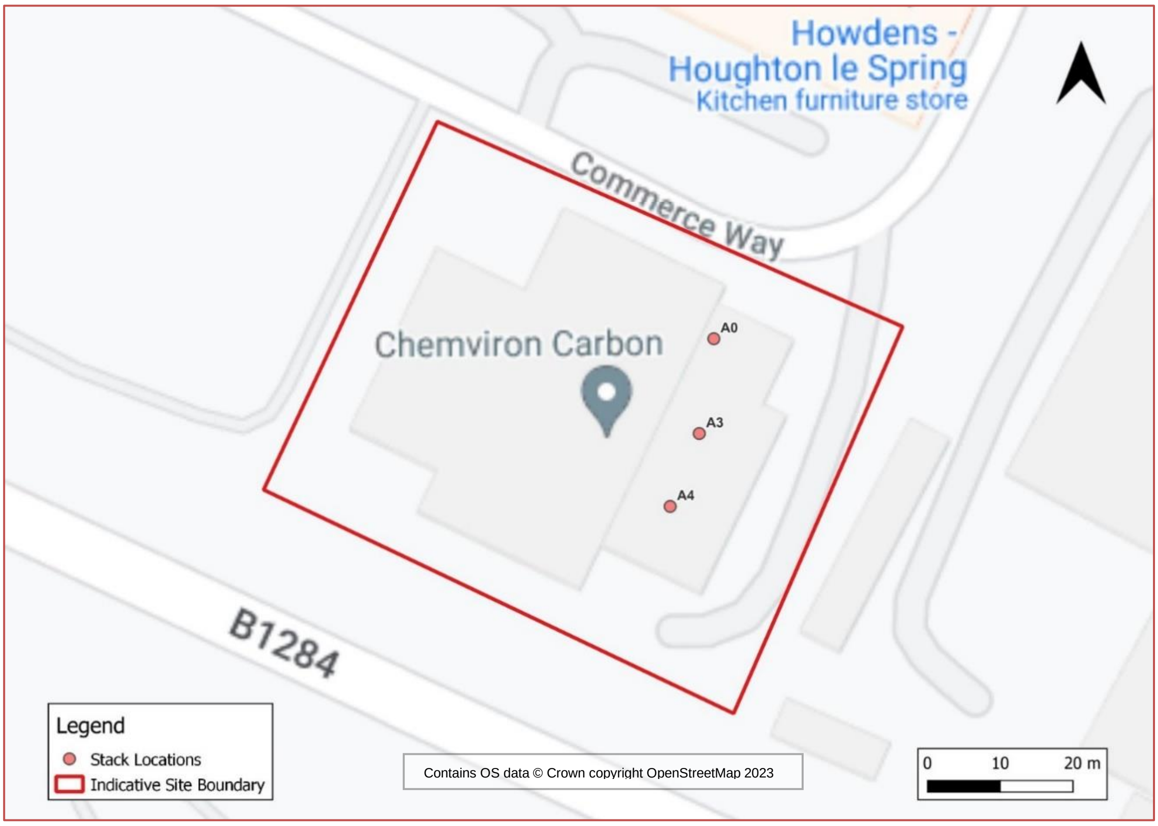
Scenario Name	Operations
Operational	Three generators, running 7884 hrs annually per generator (90% of the year).

Since the exact time during the year when the gensets will operate is currently unknown, the model has assumed that they may operate at any hour of the year. However, due to the plant operating for only 90% of the year, results have been post-processed to account for short-term averaging periods, according to the follow:

- For annual averaging periods, result have been post-processed using the factor n/8760, where ‘n’ is the total operating hours within an annual period.
- For averaging periods of 24 hours or 8 hours, results have been post-processed using the factor n/24, or n/8, where ‘n’ is the total operating hours within the relevant period.

The maximum number of generators that may be running at any one time will be three during normal operation.

Figure 2.1 - Emission Points Visualisation



2.2 Meteorology

For meteorological data to be suitable for dispersion modelling purposes, a number of meteorological parameters need to be measured on an hourly basis. These parameters include wind speed, wind direction, cloud cover and temperature. There are only a limited number of monitoring sites where the required meteorological measurements are made. The year of meteorological data that is used for a modelling assessment can also have a significant effect on ground level concentrations.

This assessment has utilised meteorological data recorded at Newcastle meteorological station during across a five-year period (2018 to 2022). Newcastle meteorological station is located approximately 26.1 km to the northwest of the site and offers data in a suitable format for the model. Figure 2.2 – Figure 2.6 illustrate the frequency of wind directions and wind speeds for the years considered.

ADMS cannot, as standard, model calm weather conditions, since this results in a discontinuity produced by a 'divide by zero' calculation. Most Gaussian plume models simply skip lines of meteorological data where calm conditions occur. Met lines will also be skipped where any of the required meteorological input parameters are missing. The generally accepted best practice requirement is to ensure that no more than 10% of meteorological data is omitted from the model run.

Table 2.4 demonstrates that this requirement was not satisfied for the meteorological 'met' data years proposed for the assessment. As such, the model was run with the 'Calms' module applied, which adjusts the default minimum wind speed from 0.75 m/s to 0.3 m/s, allowing the model to include calculations for an increased number of met lines. This is presented in Table 2.4.

Table 2.4 – Meteorological Data Capture – No Calms

Year	Number of met lines used	Number of lines with calm conditions	Number of lines with inadequate data	Number of non-calm met lines with wind speed less than the minimum value of 0.75 m/s	Percentage of lines used
2018	7900	320	209	331	93.8
2019	8200	200	104	256	95.9
2020	8239	292	9	244	97.1
2021	7834	389	131	406	93.9
2022	8266	237	9	248	97.1

Figure 2.2 - 2018 Newcastle Wind Rose

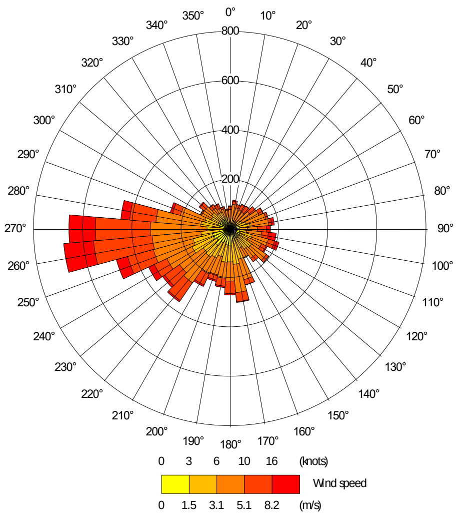


Figure 2.3 - 2019 Newcastle Wind Rose

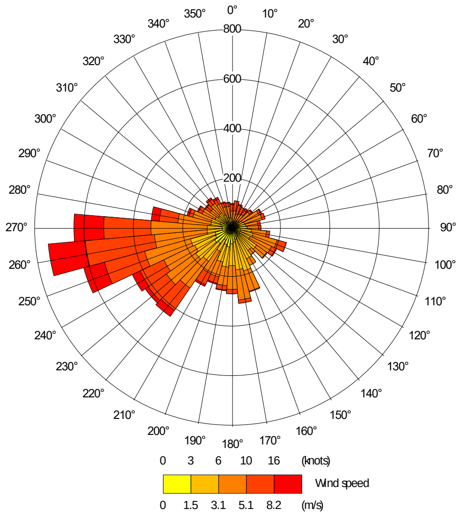


Figure 2.4 - 2020 Newcastle Wind Rose

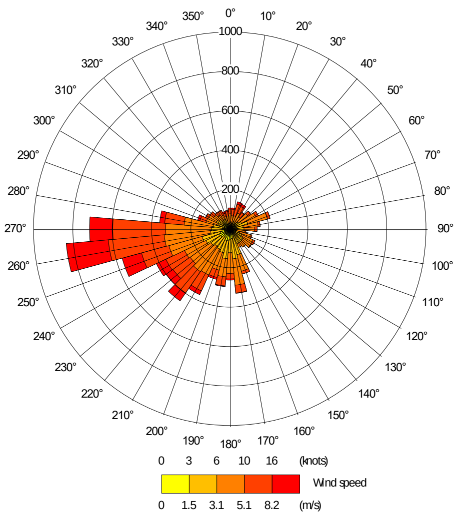


Figure 2.5 - 2021 Newcastle Wind Rose

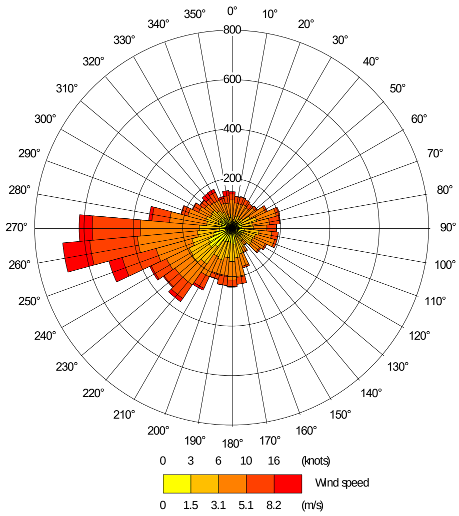
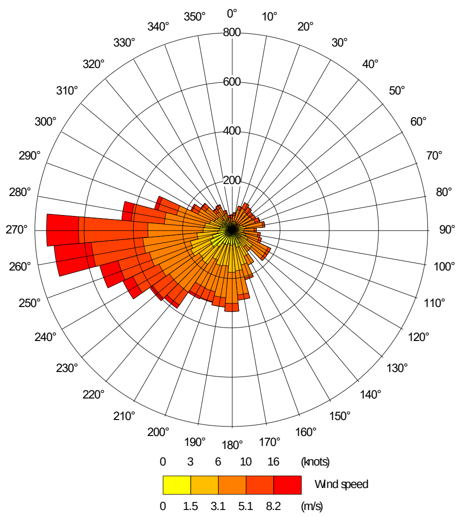


Figure 2.6 - 2022 Newcastle Wind Rose



2.3 Surface Characteristics

The predominant surface characteristics and land use in a model domain have an important influence in determining turbulent fluxes and, hence, the stability of the boundary layer and atmospheric dispersion. Factors pertinent to this determination are detailed below.

2.3.1 Surface Roughness

Roughness length, z_0, 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 approximately 10% of the height of the main surface features. Thus, it follows that surface roughness is higher in urban and congested areas than in rural and open areas. Oke (1987) and CERC (2003) suggest typical roughness lengths for various land use categories (Table 2.5).

Table 2.5 - Typical Surface Roughness Lengths for Various Land Use Categories

Type of Surface	z_0 (m)
Ice	0.00001
Smooth snow	0.00005
Smooth sea	0.0002
Lawn grass	0.01
Pasture	0.2
Isolated settlement (farms, trees, hedges)	0.4
Parkland, woodlands, villages, open suburbia	0.5-1.0
Forests/cities/industrialised areas	1.0-1.5
Heavily industrialised areas	1.5-2.0

Increasing surface roughness increases turbulent mixing in the lower boundary layer. This can often have conflicting impacts in terms of ground level concentrations:

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

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

2.3.2 Surface Energy Budget

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

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

The latent heat flux is dependent upon the amount of moisture present at the surface. The Priestly-Taylor parameter can be used to represent the amount of moisture available for evaporation:

$$\alpha = \frac{1}{S(B+1)}$$

Where:

α = Priestly-Taylor parameter (dimensionless)

$$S = \frac{s}{s+\gamma}$$

$$s = \frac{de}{dT}$$

e_s = Saturation specific humidity (kg H_2O / kg dry air)

T = Temperature (K)

$$\gamma = \frac{c_{pw}}{\lambda}$$

c_{pw} = Specific heat capacity of water (kJ kg^{-1} K^{-1})

λ = Specific latent heat of vaporisation of water (kJ kg^{-1})

B = Bowen ratio (dimensionless)

Areas where moisture availability is greater will experience a greater proportion of incoming solar radiation released back to atmosphere in the form of latent heat, leaving less available in the form of sensible heat and, thus, decreasing convective turbulence. Holstag and van Ulden (1983) suggest values of 0.45 and 1.0 for dry grassland and moist grassland respectively.

2.3.3 Selection of Appropriate Surface Characteristic Parameters for the Site

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

> *"…the energy budget calculations had relatively little impact on the overall uncertainty"*

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

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

From examination of 1:10,000 Ordnance Survey maps, it can be seen that within the immediate vicinity of the site, land use is predominately commercial and residential with more open land to the northeast. Consequently, a composite surface roughness length of 1.0 m has been deemed appropriate to take account of the respective land use categories in the model domain. For the meteorological site, a surface roughness of 0.5 m has been utilised given the representative land use categories in this area.

2.4 Buildings

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

Details of the buildings included in the model are provided in Table 2.6. Chemviron was used as the main building in the model for all generators.

Table 2.6 - Modelled Buildings

Name	Centre Easting (m)	Centre Northing (m)	Height (m)	Length / Diameter (m)	Width (m)	Angle (º)
Chemviron	433237.90	548966.25	9	43.1	40.6	205
Sekura_1	433310.79	548969.78	7	52.8	25.2	208
Sekura_2	433333.33	548949.43	9	89.6	29.1	208
Screwfix	433251.96	549034.72	5.5	27.0	69.1	206

2.5 Terrain

The concentrations of an emitted pollutant found in elevated, complex terrain differ from those found in simple level terrain. There have been numerous studies on the effects of topography on atmospheric flows. A summary of the main effects of terrain on atmospheric flow and dispersion of pollutants are summarised below:

- Plume interactions with windward facing terrain features;
    - Plume interactions with terrain features whereby receptors on hills at a similar elevation to the stack experience elevated concentrations.
    - Direct impaction of the plume on hill slopes in stable conditions.
    - Flow over hills in neutral conditions can experience deceleration forces on the upwind slope, reducing the rate of dispersion and increasing concentrations.
- Plume interactions with lee sides of terrain features; and
    - Regions of recirculation behind steep terrain features can rapidly force pollutants towards the ground culminating in elevated concentrations.
    - Releases into the lee of a hill in stable conditions can also be recirculated, resulting in increased ground level concentrations.
- Plume interactions within valleys.

- Releases within steep valleys experience restricted lateral dispersion due to the valley sidewalls. During stable overnight conditions, inversion layers develop within the valley essentially trapping all emitted pollutants. Following sunrise and the erosion of the inversion, elevated ground level concentrations can result during fumigation events.

- Convective circulations in complex terrain due to differential heating of the valley side walls can lead to the impingement of plumes due to crossflow onto the valley sidewalls and the subsidence of plume centrelines, both having the impact of increasing ground level concentrations.

These effects are most pronounced when the terrain gradients exceed 1 in 10, i.e., a 100 m change in elevation per 1 km step in the horizontal plane. In the model domain the terrain around the site does not exceed this criterion and terrain has therefore been excluded within the model.

2.6 Modelled Domain and Receptors

2.6.1 Modelled Domain

A 2 km x 2 km Cartesian grid centred on the site was modelled, with an approximate receptor resolution of 10 m, to assess the impact of atmospheric emissions from the site on local air quality. This grid resolution has been selected to ensure that all local receptors are within the gridded area and the resolution is such that the maximum impact will be identified.

2.6.2 Human Receptors

The receptors considered were chosen based on locations where people may be located and judged in terms of the likely duration of their exposure to pollutants and proximity to the site, following the guidance given in Section 4 of this report. Details of the locations of human receptors are given in Table 2.7 and illustrated Figure 2.7 below. Human receptors have been modelled at a height of 1.5 m, representative of the normal 'breathing zone' height.

The majority of human receptors are locations where both long-term and short-term pollutant averaging periods will apply (see Table 4.2).

Workplace locations have been excluded in accordance with the guidance from Environmental Protection UK and the Air Quality Standards Regulations 2010. These guidance documents are detailed in Section 4 of this report.

Table 2.7 - Modelled Human Receptors

ID	Receptor Description	Easting (m)	Northing (m)	Height (m)
H1	Residential	433742	548688	1.5
H2	Residential	433774	548811	1.5
H3	Residential	433963	548645	1.5
H4	Residential	433815	549108	1.5
H5	Residential	433914	549004	1.5
H6	School	433790	549506	1.5
H7	Residential	433444	549351	1.5
H8	Residential	433338	549488	1.5
H9	Residential	433254	549649	1.5
H10	Residential	433457	549643	1.5
H11	Residential	432921	549753	1.5
H12	Residential	432935	549613	1.5
H13	Residential	432862	549504	1.5
H14	Residential	432734	549614	1.5
H15	Residential	432656	549441	1.5
H16	Residential	432477	549320	1.5
H17	Residential	432489	549213	1.5
H18	Residential	432752	549150	1.5
H19	Residential	432029	547486	1.5
H20	Residential	432653	547256	1.5
H21	Residential	433184	547681	1.5
H22	Residential	433688	548347	1.5

Figure 2.7 - Location of Modelled Human Receptors

2.6.3 Ecological Receptors

The Environment Agency's AER Guidance provides the following detail regarding consideration of ecological receptors:

- Check if there are any of the following within 10 km of your site (within 15 km if you operate a large electric power station or refinery):
  - Special Protection Areas (SPAs)
  - Special Areas of Conservation (SACs)
  - Ramsar Sites (protected wetlands)
- Check if there are any of the following within 2 km of your site:
  - Sites of Special Scientific Interest (SSSIs)
  - Local Nature Sites (ancient woods, Local Wildlife Sites (LWS), Sites of Nature Conservation Importance (SNCIs) and national and Local Nature Reserves (LNR)).

Following the above guidance, Table 2.8 and Figure 2.8 and Figure 2.9 provide details of five ecological receptor points which have been considered within this assessment.

Table 2.8 - Modelled Ecological Receptors

ID	Receptor Description	Easting (m)	Northing (m)	Height (m)
E1	Joe's Pond SSSI	432904	548753	0
E2	Joe's Pond SSSI	432934	548678	0
E3	Joe's Pond SSSI	432970	548592	0
E4	Hetton Bogs SSSI	434158	548561	0
E5	Hetton Bogs SSSI/LNR	434318	548593	0
E6	Rough Dene LWS	435083	548971	0
E7	Hetton Bogs West LWS	434170	548516	0
E8	Morton Wood LWS	431917	549656	0
E9	Hetton Park LWS	434745	548555	0
E10	Houghton Hill Cut and Scarp LWS	434040	550432	0
E11	Rainton Meadows LWS	432161	548856	0
E12	Redburn Marsh LWS	432636	549244	0
E13	Robin House and Moorsley Marsh LWS	434047	547193	0
E14	Hetton Houses Wood AW	434333	548549	0
E15	Fencehouses Wood AW	431920	549655	0
E16	Rough Dene AW	435105	548982	0
E17	Durham Coast SAC/SPA	442036	551603	0
E18	Durham Coast SAC/SPA	441434	553958	0
E19	Northumbria Coast SPA	442524	550535	0

The Atmospheric Pollution Information System (APIS) tool has identified no habitats or features sensitive to Nitrogen at Joe's Pond SSSI, and therefore no critical load (CL) exists for this designation.

Figure 2.8 - Location of Assessed Ecological Receptors (1)

Figure 2.9 - Location of Assessed Ecological Receptors (2)

2.7 Deposition

The predominant route by which emissions to air will affect land in the vicinity of a process is by deposition of atmospheric emissions. Potential ecological receptors can be sensitive to the deposition of pollutants, particularly nitrogen and sulphur compounds, which can affect the character of the habitat through eutrophication and acidification.

Deposition processes in the form of dry and wet deposition remove material from a plume and alter the plume concentration. Dry deposition occurs when particles are brought to the surface by gravitational settling and turbulence. They are then removed from the atmosphere by deposition on the land surface. Wet deposition occurs due to rainout (within cloud) scavenging and washout (below cloud) scavenging of the material in the plume. These processes lead to a variation with downwind distance of the plume strength and may alter the shape of the vertical concentration profile as dry deposition only occurs at the surface.

Near to sources of pollutants (< 2 km), dry deposition is the predominant removal mechanism (Fangmeier et al. 1994). Dry deposition may be quantified from the near-surface plume concentration and the deposition velocity (Chamberlin and Chadwick, 1953);

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

where:

F_d = dry deposition flux (µg m^{-2} s^{-1})

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

$C(x, y, 0)$ = ground level concentration (µg/m^3)

Assuming irreversible uptake, the total wet deposition rate is found by integrating through a vertical column of air;

$$F_w = \int_0^z \Lambda C \, dz$$

where;

F_w = wet deposition flux (µg m^{-2} s^{-1})

Λ = washout co-efficient (s^{-1})

C = local airborne concentration (µg/m^3)

z = height (m)

The washout co-efficient is an intrinsic function of the rate of rainfall.

Environment Agency guidance AQTAG06 (Environment Agency, 2014) recommends deposition velocities for various pollutants, according to land use classification (Table 2.9).

Table 2.9 - Recommended Deposition Velocities

Pollutant	Deposition Velocity (m s^{-1})	
	Short Vegetation	Long Vegetation/Forest
NO_x	0.0015	0.003
SO_2	0.012	0.024
Source: Environment Agency (2014) 'Technical Guidance on Detailed Modelling Approach for an Appropriate Assessment for Emissions to Air', AQTAG06 Updated Version (March 2014)'		

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

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

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

The critical loads used to assess the impact of compounds deposited to land which result in eutrophication and acidification are expressed in terms of kilograms of nitrogen deposited per hectare per year (kg N ha^{-1} y^{-1}) and kilo equivalents deposited per hectare per year (keq ha^{-1} y^{-1}). To enable a direct comparison against the critical loads, the modelled total wet and dry deposition flux (µg m^{-2} s^{-1}) must be converted into an equivalent value.

For a continuous release, the annual deposition flux of nitrogen can be expressed as:

$$F_{NTot} = \left(\frac{K_2}{K_3}\right) \cdot t \cdot \sum_{i=1}^{T} F_i \left(\frac{M_N}{M_i}\right)$$

where:

F_{NYot} = Annual deposition flux of nitrogen (kg N ha^{-1} y^{-1})

K_2 = Conversion factor for m^2 to ha (= 1x104 m^2 ha^{-1})

K_3 = Conversion factor for µg to kg (= 1x109 µg kg^{-1})

t = Number of seconds in a year (= 3.1536x107 s y^{-1})

i = 1,2,3…….T

T = Total number of nitrogen containing compounds

F = Modelled deposition flux of nitrogen containing compound (µg m^{-2} s^{-1})

M_N = Molecular mass of nitrogen (kg)

M = Molecular mass of nitrogen containing compound (kg)

The unit eq (1 keq ≡ 1,000 eq) refers to molar equivalent of potential acidity resulting from e.g. sulphur, oxidised and reduced nitrogen, as well as base cations. Conversion units are provided in AQTAG(06):

- 1 keq ha^{-1} y^{-1} = 14 kg N ha^{-1} y^{-1}
- 1 keq ha^{-1} y^{-1} = 32 kg S ha^{-1} y^{-1}

For the purposes of this assessment, dry deposition rates of nitrogen and acidic equivalents at the identified ecological receptors have been calculated by applying the 'long vegetation' deposition velocities (as detailed in Table 2.9) to the modelled annual mean concentrations of NO_x and SO_2. Wet deposition has not been assessed since this is not a significant contributor to total deposition over shorter ranges (Fangmeier et al., 1994; Environment Agency, 2006).

2.8 Other Treatments

Specialised model treatments, for short-term (puff) releases, coastal models, fluctuations or photochemistry were not used in this assessment.

2.9 Conversion of NO to NO_2

Emissions of NO_x from combustion processes are predominantly in the form of nitric oxide (NO). Excess oxygen in the combustion gases and further atmospheric reactions cause the oxidation of NO to NO_2. NO_x chemistry in the lower troposphere is strongly interlinked in a complex chain of reactions involving Volatile Organic Compounds (VOCs) and Ozone (O_3). Two of the key reactions interlinking NO and NO_2 are detailed below:

$$NO_2 + hv \xrightarrow{O_2} NO + O_3 \qquad (R_1)$$

$$NO + O_3 \longrightarrow NO_2 + O_2 \qquad (R_2)$$

Where *hv* is used to represent a photon of light energy (i.e., sunlight).

Taken together, reactions R_1 and R_2 produce no net change in O_3 concentrations, and NO and NO_2 adjust to establish a near steady state reaction (photo-equilibrium). However, the presence of VOCs and CO in the atmosphere offer an alternative production route of NO_2 for photolysis, allowing O_3 concentrations to increase during the day with a subsequent decrease in the NO_2:NO_x ratio.

However, at night, the photolysis of NO_2 ceases, allowing reaction R_2 to promote the production of NO_2, at the expense of O_3, with a corresponding increase in the NO_2:NO_x ratio. Similarly, near to an emission source of NO, the result is a net increase in the rate of reaction R_2, suppressing O_3 concentrations immediately downwind of the source, and increasing further downwind as the concentrations of NO begin to stabilise to typical background levels (Gillani and Pliem, 1996).

Given the complex nature of NO_x chemistry, the Environment Agency's Air Quality Modelling and Assessment Unit (AQMAU) have adopted a pragmatic, risk-based approach in determining the conversion rate of NO to NO_2 which dispersion model practitioners can use in their detailed assessments[1]. The AQMAU guidance advises that the source term should be modelled as NO_x (as NO_2) and then suggests a tiered approach when considering ambient NO_2:NO_x ratios:

- **Screening Scenario:** 50 % and 100 % of the modelled NO_x process contributions should be used for short-term and long-term average concentration, respectively. That is, 50 % of the predicted NO_x concentrations should be assumed to be NO_2 for short-term assessments

[1] http://www.environment-agency.gov.uk/static/documents/Conversion_ratios_for__NOx_and_NO2_.pdf

and 100 % of the predicted NO_x concentrations should be assumed to be NO_2 for long-term assessments;

- **Worst Case Scenario:** 35 % and 70 % of the modelled NO_x process contributions should be used for short-term and long-term average concentration, respectively. That is, 35 % of the predicted NO_x concentrations should be assumed to be NO_2 for short-term assessments and 70 % of the predicted NO_x concentrations should be assumed to be NO_2 for long-term assessments; and

- **Case Specific Scenario:** Operators are asked to justify their use of percentages lower than 35 % for short-term and 70 % for long-term assessments in their application reports.

In line with the AQMAU guidance, this assessment has therefore used a NO_x to NO_2 ratio of 70% for long term average concentrations, 35% for short term concentrations.

3 Existing Ambient Data

3.1 Local Air Quality Management

Sunderland City Council ("the Council") under its Local Air Quality Management (LAQM) obligations, continually reviews and assesses concentrations of key air pollutants in the borough to ascertain the requirement, or otherwise, to declare an AQMA. The Council have no declared AQMAs within its jurisdiction.

The most recent publicly available monitoring data has been collated from the Council's Air Quality 2022 Annual Status Report[2], which contains monitoring data for 2021.

3.1.1 Monitoring Data

The Council undertook automatic (continuous) monitoring of pollutants at three sites and at 34 non-automatic (passive) monitoring locations in 2021. Two of the passive monitoring locations are within 3 km of the site. Table 3.1 contains the annual mean NO_2 concentration results for the diffusion tubes sites within 3 km of the site, for the years 2017 to 2021.

Table 3.1 - NO_2 Diffusion Tube Monitoring Results

Site Name	X	Y	Site Type	Annual Mean Concentration (µg/m^3)				
				2017	2018	2019	2020	2021
125: 45 Station Road	435415	547029	Roadside	29.9	22.3	26.1	22.8	20.3
141: Junction Dairy Lane & Front Street	432542	549640	Roadside	-	-	-	20.4	18.6
N.B. Data taken from Sunderland City Council's 2022 Annual Status Report.								

Current monitoring results show that recent and current concentrations of NO_2 in the area local to the site are comfortably compliant with the annual mean NO_2 Air Quality Strategy objective.

3.2 Defra Mapped Background Concentrations

Defra maintains a nationwide model of existing and future background air quality concentrations at a 1 km grid square resolution. The datasets include annual average concentration estimates for NO_x, NO_2, PM_{10}, $PM_{2.5}$, CO and SO_2 and benzene. The model used is empirical in nature: it uses the National Atmospheric Emissions Inventory (NAEI) emissions to model the concentrations of pollutants at the centroid of each 1 km grid square but then calibrates these concentrations in relation to actual monitoring data.

3.2.1 Background Concentrations used in the Assessment

Annual mean background concentrations at the assessed human and ecological receptor locations have been derived from the Defra background maps for the 1 km grid square in which they are located.

The annual average process contribution is added to the annual average background concentration to give a total concentration at each receptor location. This total concentration can then be compared against the relevant Air Quality Standard/Objective (AQS/O) and the likelihood of an exceedance determined.

[2] Sunderland City Council, 2022, Air Quality Annual Status Report. Available here: https://www.sunderland.gov.uk/media/27829/Air-quality-report-2022/pdf/Sunderland_ASR_2022.pdf?m=638001411091870000

It is not technically rigorous to add predicted short-term or percentile concentrations to ambient background concentrations not measured over the same averaging period, since peak contributions from different sources would not necessarily coincide in time or location. Without hourly ambient background monitoring data available it is difficult to make an assessment against the achievement or otherwise of the short-term AQS/O. For the current assessment, conservative short-term ambient levels have been derived by applying a factor of two to the annual mean background data as per the recommendation in Environment Agency guidance[3]. Those background annual mean concentrations used in the assessment are detailed in Table 3.2.

Table 3.2 - Background Annual Mean Concentrations used in the Assessment

Grid square (E, N)	Annual Mean Pollutant Concentrations (µg/m^3)		
	NO_x [a]	NO_2 [a]	C_6H_6 [b]
433500, 548500	11.19	8.66	0.382
433500, 549500	14.44	10.92	0.400
432500, 549500	11.34	8.76	0.399
432500, 547500	10.38	8.07	0.357
433500, 547500	9.89	7.71	0.354
432500, 548500	10.05	7.82	0.385
434500, 548500	10.29	8.00	0.373
434500, 550500	12.52	9.61	0.421
434500, 547500	9.36	7.32	0.353
442500, 551500	8.33	6.55	0.321
441500, 553500	10.23	7.96	0.364
442500, 550500	8.55	6.71	0.321

[a] 2018 reference annual mean background concentration of NO_2, NO_x, PM_{10} and $PM_{2.5}$ taken from Defra's UK Air Quality Archive (1 km x 1 km grid squares) for 2022.
[b] Background concentration of C_6H_6 taken from Defra's UK Air Quality Archive (1 km x 1 km grid squares) 2001 background maps for 2010.

3.3 Background Deposition Rates

Estimated background deposition rates of nutrient nitrogen and total acid deposition for the UK are available via the Air Pollution Information Service (APIS) website (http://www.apis.ac.uk). Table 3.3 provides estimated deposition rates for the ecological receptors considered in this study, as obtained from the APIS website. It should be noted that the level of uncertainty associated with these modelled estimates is relatively high and the results are presented from the model across the UK on a 5 km grid square resolution.

Table 3.3 - Estimated Background Deposition Rates

ID	Designation	Background Nitrogen Deposition (kg N ha^{-1} y^{-1})	Background Nitric Acid Deposition (keq ha^{-1} y^{-1})	Background Sulphuric Acid Deposition (keq ha^{-1} y^{-1})
E1	Joe's Pond SSSI	13.28	0.95	0.13
E2	Joe's Pond SSSI	13.28	0.95	0.13
E3	Joe's Pond SSSI	13.28	0.95	0.13
E4	Hetton Bogs SSSI	13.28	0.95	0.13
E5	Hetton Bogs SSSI/LNR	13.28	0.95	0.13

[3] GOV.uk, 22nd March 2023, Air emissions risk assessment for your environmental permit. Available here: https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit

ID	Designation	Background Nitrogen Deposition (kg N ha^{-1} y^{-1})	Background Nitric Acid Deposition (keq ha^{-1} y^{-1})	Background Sulphuric Acid Deposition (keq ha^{-1} y^{-1})
E6	Rough Dene LWS	13.11	0.94	0.14
E7	Hetton Bogs West LWS	13.15	0.94	0.14
E8	Morton Wood LWS	21.70	1.55	0.17
E9	Hetton Park LWS	13.15	0.94	0.14
E10	Houghton Hill Cut and Scarp LWS	12.17	0.93	0.14
E11	Rainton Meadows LWS	13.22	0.94	0.14
E12	Redburn Marsh LWS	13.16	0.94	0.14
E13	Robin House and Moorsley Marsh LWS	13.22	0.94	0.13
E14	Hetton Houses Wood AW	21.59	1.54	0.17
E15	Fencehouses Wood AW	21.70	1.55	0.17
E16	Rough Dene AW	21.51	1.54	0.16
E17	Durham Coast SAC/SPA	11.04	0.79	0.14
E18	Durham Coast SAC/SPA	11.04	0.79	0.14
E19	Northumbria Coast SPA	10.86	0.84	0.13
Source: Air Pollution Information Service (APIS) website (http://www.apis.ac.uk)				

3.4 Sensitivity Analysis and Uncertainty

Wherever possible, this assessment has used worst-case scenarios, which will exaggerate the impact of the emissions on the surrounding area, including emissions, operational profile, ambient concentrations, meteorology and surface roughness. This assessment has considered the years predicting the highest ground-level concentrations at the nearest sensitive receptor for comparison with the AQS objectives.

Sensitivity analysis has been undertaken for a number of model input parameters to investigate the results of the model with respect to changes in buildings and surface roughness.

3.4.1 Buildings

A sensitivity analysis has been undertaken to investigate the impact of modelling with and without buildings on the modelled results. Results have been normalised by the value obtained from the parameter resulting in the highest ground level process contribution at any modelled receptor location and are presented in Table 3.4.

Table 3.4 - Building Inclusion Sensitivity Analysis

Buildings	Normalised Maximum Ground Level Concentration	
	NO_x Annual Mean	NO_x 99.79 Percentile of 1-Hour Mean
With Buildings	0.93	0.90
Without Buildings	1.00	1.00

From the above predicted ground level concentrations, the inclusion of buildings in the model results in a lower or similar concentrations for both averaging periods. The model used in this assessment included buildings in order to demonstrate a robust assessment.

3.4.2 Surface Roughness

A sensitivity analysis has been undertaken to investigate the impact of modelling with different surface roughness lengths. Results have been normalised by the value obtained from the parameter resulting in the highest ground level process contribution at any modelled receptor location and are presented below.

Table 3.5 – Surface Roughness Sensitivity Analysis

Parameter	Normalised Maximum Ground Level Concentration	
	NO_x Annual Mean	NO_x 99.79 Percentile of 1-Hour Mean
0.3 m	0.90	0.93
0.5 m	0.94	0.97
1 m	0.98	1.00
1.5 m	1.00	0.97

From the above predicted ground level concentrations, it can be seen that for the annual mean averaging period, a surface roughness of 1.5 m results in the highest results. However, for the 1-hour mean, a surface roughness length of 1.0 m predicts the highest result.

Given the characteristics of the surface roughness at the site, a surface roughness value of 0.5 m has been used.

3.4.3 Meteorological Year Sensitivity Testing

Results in this assessment are presented for the meteorological year resulting in the highest concentrations at any receptor location, as a worst-case assumption. The worst-case meteorological year was determined separately for long and short-term concentrations at the worst-case receptor location for each pollutant, thus the worst-case data has been reported within Section 5.

For information, a table showing the inter-year variability of met conditions at the worst-case human receptor is provided below. The results have been normalised against the maximum value. At the worst-case human receptor, it demonstrates that 2022 provides the worst-case conditions for long-term and short-term means, respectively. However, this can vary by receptor, hence the consideration of the worst-case meteorological year by receptor, as described above.

Table 3.6 - Inter-year Variability in Concentration (Normalised)

Receptor	Annual Mean NOx					1-hour Mean NOx				
	2018	2019	2020	2021	2022	2018	2019	2020	2021	2022
H7	0.84	0.88	0.93	0.89	1.00	0.99	0.97	0.99	0.99	1.00

3.4.4 Model Uncertainty

Dispersion modelling is inherently uncertain but is nonetheless a useful tool in plume footprint visualisation and prediction of ground level concentrations. The use of dispersion models has been widely used in the UK for both regulatory and compliance purposes for a number of years and is an accepted approach for this type of assessment.

4 Relevant Legislation and Guidance

4.1 UK Legislation

4.1.1 The Air Quality Standards Regulations 2010

The Air Quality Standards Regulations 2010 (the 'Regulations') came into force on the 11th June 2010. The limit values in the Regulations are listed as 'Air Quality Standards' (AQS) with attainment dates.

These standards are legally binding concentrations of pollutants in the atmosphere which can broadly be taken to achieve a certain level of environmental quality. The standards are based on the assessment of the effects of each pollutant on human health including the effects of sensitive groups or on ecosystems.

The Regulations define ambient air as;

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

With direction provided in Schedule 1, Part 1, Paragraph 2 as to where compliance with the AQS' does not need to be assessed:

> *"Compliance with the limit values directed at the protection of human health does not need to be assessed 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."*

4.1.2 Air Quality Strategy: framework for local authority delivery

The 2023 Air Quality Strategy for England, provides a framework for improving air quality at a national and local level and supersedes the previous strategy published in 2007 for England.

Central to the Air Quality Strategy are health-based criteria for certain air pollutants; these criteria are based on medical and scientific reports on how and at what concentration each pollutant affects human health. The objectives derived from these criteria are policy targets often expressed as a maximum ambient concentration not to be exceeded, without exception or with a permitted number of exceedances, within a specified timescale.

The AQOs, based on a selection of the objectives in the Air Quality Strategy, were incorporated into UK legislation through the Air Quality Regulations 2000, as amended.

Paragraph 4(2) of The Air Quality (England) Regulations 2000 states:

> *"The achievement or likely achievement of an air quality objective prescribed by paragraph (1) shall be determined by reference to the quality of air at locations –*
>
> *a) which are situated outside of buildings or other natural or man-made structures above or below ground; and*
>
> *b) where members of the public are regularly present*

Consequently, compliance with the AQOs should focus on areas where members of the general public are present over the entire duration of the concentration averaging period specific to the relevant objective.

4.1.3 Environment Act 2021

The Environment Act 2021 came into force on 9^{th} November 2021, with Part 4 of the Act (and associated Schedules 11 and 12) reserved for matters pertaining to air quality.

The Environment Act 2021 includes amendments to Environment Act 1995 (further detail in Section 4.2) the Clean Air Act 1993 to give Local Authorities more power. It also requires the Secretary of State to set at least one long-term target in relation to air quality and, in addition, a short-term legally binding target to reduce $PM_{2.5}$.

4.2 Local Air Quality Management

Part IV of the Environment Act 1995 requires that Local Authorities periodically review air quality within their individual areas. As previously discussed, this Act has now been amended and supplemented by the Environment Act 2021 Schedule 11. Defra have said: “Responsibility for tackling local air pollution will now be shared with designated relevant public authorities, all tiers of local government and neighbouring authorities.”

This process of Local Air Quality Management (LAQM) is an integral part of delivering the Government’s AQOs.

To carry out an air quality Review and Assessment under the LAQM process, the Government recommends a three-stage approach. This phased review process uses initial simple screening methods and progresses through to more detailed assessment methods of modelling and monitoring in areas identified to be at potential risk of exceeding the objectives in the Regulations.

Review and assessments of local air quality aim to identify areas where national policies to reduce vehicle and industrial emissions are unlikely to result in air quality meeting the Government’s AQOs by the required dates.

For the purposes of determining the focus of Review and Assessment, Local Authorities should have regard to those locations where members of the public are likely to be regularly present and are likely to be exposed over the averaging period of the objective.

Where the assessment indicates that some or all of the objectives may be potentially exceeded, the Local Authority has a duty to declare an AQMA. The declaration of an AQMA requires the Local Authority to implement an Air Quality Action Plan (AQAP), to reduce air pollution concentrations so that the required AQOs are met.

4.3 Other Guideline Values

In the absence of statutory standards for the other prescribed substances that may be found in the emissions, there are several sources of applicable air quality guidelines.

4.3.1 Air Quality Guidelines for Europe, the World Health Organisation (WHO)

The updated WHO Global Air Quality Guidelines (WHO, 2021) provides a basis for protecting public health from adverse effects of air pollutants and to eliminate or reduce exposure to those pollutants that are known or likely to be hazardous to human health or well-being. These guidelines are intended to provide guidance and information to international, national and local authorities making risk management decisions, particularly in setting air quality standards.

4.3.2 Air Emissions Risk Assessment (AERA) Guidance

The Environment Agency's AER Guidance provides a step-by-step approach for undertaking an air emissions risk assessment for an environmental permit. The guidance expands on how to compare the impact of the potential emissions from a site with reference to the Air Quality Standards Regulations 2020 Limit Values and Target Values, the UK Air Quality Strategy Objectives and Environmental Assessment Levels (EALs). This guidance is not to be used if the risk assessment tool is being used.

4.3.3 Environmental Assessment Levels (EALs)

The Environment Agency's AER Guidance provides methods for quantifying the environmental impacts of emissions to all media. The AER guidance contains long and short-term Environmental Assessment Levels (EALs) and Environmental Quality Standards (EQS) for releases to air derived from a number of published UK and international sources. For the pollutants considered in this study, these EALs and EQS are equivalent to the AQS and AQOs set in force by the Air Quality Strategy for England, Scotland Wales and Northern Ireland.

4.4 Air Quality Impacts of the Process

The atmospheric emissions of a number of pollutants have been identified as requiring detailed dispersion modelling. The emitted pollutants of primary concern to the local environment are:

- Oxides of nitrogen (NO_x as NO_2); and,
- Benzene (C_6H_6).

A brief description of each pollutant is given in Table 4.1.

Table 4.1 - Summary of the Pollutants Assessed

Pollutant	Description and effect on human health and the environment	Principal Sources
Oxides of Nitrogen (NO_X) [A, B, C]	Nitrogen dioxide (NO_2) and Nitric oxide (NO) are both collectively referred to as oxides of Nitrogen (NO_X). It is NO_2 that is associated with adverse effects on human health. Most atmospheric emissions are in the form of NO which is converted to NO_2 in the atmosphere through reactions with Ozone. The oxidising properties of NO_2 theoretically could damage lung tissue, and exposure to very high concentrations of NO_2 can lead to inflammation of lung tissue, affect the ability to fight infection. The greatest impact of NO_2 is on individuals with asthma or other respiratory conditions, but consistent impacts on these individuals is at levels of greater than 564 µg/m^3, much higher than typical UK ambient concentrations.	All combustion processes produce NO_X emissions, and the principal source of NO_X is road transport, which accounted for 32% of total UK emissions in 2008. Emissions from power stations contributed a further 20%.
Benzene (C_6H_6) [A, D]	Benzene (C_6H_6) is a common air pollutant present at higher concentrations in industrial areas. Prolonged exposure to Benzene is associated with adverse health effects, particularly in the respiratory and neurological systems. Long term exposure is associated with cancers such as leukaemia and damage to DNA.	Benzene is present in many manufacturing processes and quickly evaporates if released into the environment. Major sources include vehicle exhaust emissions and petrol related industries.

A Defra, 2021, Part IV of the Environment Act 1995 Local Air Quality Management: Technical Guidance LAQM.TG(22).

B Harrison, R.M., *Air Pollution: Sources, Concentrations and Measurements*. In: Harrison, R.M., 2000, *Pollution: Causes, Effects and Controls*, 4th Edition Royal Society of Chemistry.

C Walters, S. and Ayers, J., *The Health Effects of Air Pollution*. In: Harrison, R.M., 2000, *Pollution: Causes, Effects and Controls*, 4th Edition Royal Society of Chemistry.

D Public Health England, 14th August 2019, *Guidance, Benzene: General Information*

4.5 Criteria Appropriate to the Assessment

Table 4.2 sets out those AQS, AQOs and EALs that are relevant to the assessment with regard to human receptors.

Table 4.2 - Air Quality Standards, Objectives and Environmental Assessment Levels

Pollutant	AQS/AQO/ EAL	Averaging Period	Value (µg/m^3)
Nitrogen dioxide (NO_2)	AQS	Annual mean	40
	AQS	1-hour mean, not more than 18 Exceedances a year (equivalent of 99.79 Percentile)	200
Benzene (C_6H_6)	EAL	Annual Mean	5
	EAL	24-hour mean	30

4.6 Critical Levels and Critical Loads Relevant to the Assessment of Ecological Receptors

A summary of the relevant AQS and EAL that apply to the emissions from the plant and their impact on ecological receptors are given in Table 4.3.

Table 4.3 - Relevant Air Quality Standards and Environmental Assessment Levels for Ecological Receptors

Pollutant	AQS/EAL	Averaging Period	Value ($\mu g/m^3$)
Oxides of nitrogen (NO_x)	AQS	Annual mean	30
Oxides of nitrogen (NO_x)	Target	Daily mean	75
	WHO Assessment Level	Daily mean	200*
*Where O_3 and SO_2 are not present above their respective critical levels.			

The Air Pollution Information System (APIS) website[4] provides specific information on the potential effects of nitrogen deposition on relevant to habitats of the ecological receptors considered in this assessment, is presented in

Table **4.4**.

Table 4.4 - Typical Habitat and Species Information Concerning Nitrogen Deposition from APIS

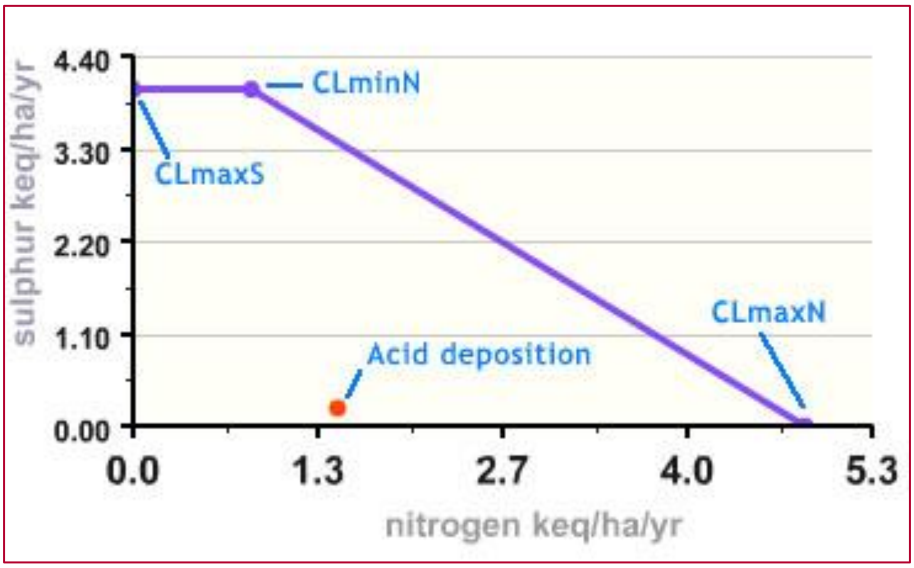
Habitat and Species Specific Information	Critical Load (kg N ha^{-1} yr^{-1})	Specific Information Concerning Nitrogen Deposition
Saltmarsh	30-40	Many saltmarshes receive large nutrient loadings from river and tidal inputs. It is unknown whether other types of species-rich saltmarsh would be sensitive to nitrogen deposition. Increase in late-successional species, increased productivity but only limited information available for this type of habitat.
Littoral Sediments	20 - 30	Increase late successional species, increase productivity increase in dominance of graminoids.
Coastal Stable Dune Grasslands	10-20	Foredunes receive naturally high nitrogen inputs. Key concerns of the deposition of nitrogen in these habitats relate to changes in species composition.
Alkaline Fens and Reed beds	10-35	Nitrogen deposition provides fertilization. Increase in tall graminoids (grasses or Carex species) resulting in loss of rare species and decrease in diversity of subordinate plant species.
Temperate and boreal forests	10-20	Increased nitrogen deposition in mixed forests increases susceptibility to secondary stresses such as drought and frost, can cause reduced crown growth. Also can reduce the diversity of species due to increased growth rates of more robust plants.
Hay Meadow	20-30	The key concerns are related to changes in species composition following enhanced nitrogen deposition. Indigenous species will have evolved under conditions of low nitrogen availability. Enhanced Nitrogen deposition will favour those species that can increase their growth rates and competitive status e.g. rough grasses such as false brome grass (Brachypodium pinnatum) at the expense of overall species diversity. The overall threat from competition will also depend on the availability of propagules
Acid Grasslands	10-25	Nitrogen deposition provides fertilization to acid grasslands, this increase robust grass growth that may limit other species reducing diversity.
Raised bog and blanket bog	5-10	Nitrogen deposition provides fertilization, this increase robust vegetation growth that may limit other species reducing diversity
Oak Woodland	10-15	Increased nitrogen deposition in Oak forests increases susceptibility to secondary stresses such as drought and frost, can cause reduced crown growth

Information relating specifically to acid deposition is provided using three critical load parameters:

- $CL_{max}S$: the maximum critical load of sulphur, above which sulphur alone would be considered to cause an exceedance;
- $CL_{min}N$: a measure of the ability of the habitat/ecosystem to 'consume' deposited nitrogen; and
- $CL_{max}N$: the maximum critical load of nitrogen, above which nitrogen alone would be considered to cause an exceedance.

These three parameters define the critical load function, as illustrated in Figure 4.1. The region under the three-node line represents results where critical loads are not exceeded, whereas combinations of deposition above this line would be considered an exceedance.

Figure 4.1 - Critical Load Function (sourced from APIS)



Source: http://www.apis.ac.uk/clf-guidance

[4] http://www.apis.ac.uk/

5 Assessment Results

This section sets out the results of the dispersion modelling and compares predicted ground level concentrations to ambient air quality standards. The predicted concentrations resulting from the process are presented with background concentrations and the percentage contribution that the predicted environmental concentrations would make towards the relevant Air Quality Assessment Level (AQAL), i.e., the relevant Air Quality Standard or Objective (AQS/AQO) or Environmental Assessment Level (EAL).

Results are presented for the meteorological year resulting in the highest concentrations at any receptor location, as a worst-case assumption. Results that exceed the relevant AQAL are underlined within the results tables.

5.1 Model Results for Annual Mean Metrics

Results assessed against annual mean metrics for NO_x, NO_2, and C_6H_6 need to take account total annual running hours, as they can all take place over the corresponding proportion of the year.

As such, results for annual mean metrics have been presented separately to short-term metrics, taking account of the cumulative annual operating hours. Summary results are presented in Table 5.1 for the worst-case receptor for each parameter. Full results tables are contained in Appendix B.

5.1.1 Concentrations in Air – Operational

The summary results show that annual mean results for NO_2 and benzene at human receptors and annual mean results for NO_x at ecological receptors are all comfortably below the relevant AQAL.

In terms of human receptors, the maximum long-term results were at receptor H7 (see Appendix B), located within 460 m of the site at Dunelm Drive. The maximum result at any ecological receptor (in terms of PEC) is predicted to occur at Houghton Hill Cut and Scarp LWS (E10), located 1.6 km northeast of the site.

Table 5.1 - Maximum Annual Mean Concentrations in Air at Human and Ecological Receptors – Operational

Parameter	Annual Mean				
	AQAL µg/m³	PC µg/m³	PEC µg/m³	% PC OF AQAL	% PEC OF AQAL
Human Receptors					
Annual mean NO_2	40	0.65	11.57	1.6	28.9
Annual mean C_6H_6	5	0.38	0.78	7.6	15.6
Ecological Receptors					
Annual mean NO_x	30	0.09	12.61	0.3	42.0
AQAL = Air Quality Assessment Level PC = Process Contribution PEC = Predicted Environmental Concentration (PC + background)					

5.1.2 Deposition – All Scenarios

The impact assessment for ecological receptors also includes an assessment of pollutants deposited to land in the form of nitrogen deposition and acid deposition. These are also based on annual mean metrics, as such, these results are presented in full in Table 5.2 for nitrogen deposition and Table 5.3 for acid deposition.

The results for acid deposition are presented in line with the Critical Load Function Tool as contained on the Air Pollution Information System (APIS) website[5]. As described on APIS: "the Critical Load Function is a three-node line on a graph representing the acidity critical load. Combinations of deposition above this line would exceed the critical load, while all areas below or on the line represent an "envelope of protection" where critical loads are not exceeded". Therefore, where 'no exceedance' is stated with regards to acid deposition, it denotes no exceedance of the critical load function.

The APIS tool has identified no habitats or features sensitive to Nitrogen at Joe's Pond SSSI, and therefore no critical load (CL) exists for this designation. For the provided Local Wildlife Sites and Ancient woodlands, although no CL exists for these designations, these have been selected based on the co-ordinates of the designation and the relevant habitat. There is no defined comparable acid critical load class for the receptors located at both the Durham Coast SAC/SPA (E17 and E18) and the Northumbria Coast SPA (E19), therefore acid deposition has not been assessed at these locations.

The results for nitrogen deposition show no exceedances at any ecological receptors at Hetton Bogs SSSI and LNR. Exceedances are seen at all considered receptors within the Local Wildlife Sites (E6-E13), the Ancient Woodlands (E14-E16) and the SPAs and SACs (E17-E19). The maximum total predicted environmental deposition rate is 263.4% of the CL at E7. This is due to the background deposition rate at all receptors being relatively high when compared to the minimum CL. When taking the PC, this makes up less than 1% of the overall result at all ecological receptors, so the contribution from the plant can be considered not significant. In the same manner, all results for acid deposition can be described as not significant.

Table 5.2 - Nitrogen Deposition Rates at Ecological Receptors – Operational

Receptor ID	CL (kg N ha^{-1} yr^{-1})	PC (kg N ha^{-1} yr^{-1})	%PC of CL_{min} (%)	Background Deposition rate (kg N ha^{-1} yr^{-1})	PEDR (kg N ha^{-1} yr^{-1})	%PEDR of CL_{min}
E4	15	0.02	0.1	13.28	13.3	88.7
E5	15	0.02	0.1	13.28	13.3	88.7
E6	10	0.02	0.1	13.11	13.1	131.2
E7	5	0.02	0.1	13.15	13.2	263.4
E8	10	0.01	0.1	21.70	21.7	217.2
E9	10	0.02	0.4	13.15	13.2	131.6
E10	10	0.02	0.2	12.17	12.2	121.8
E11	10	0.01	0.1	13.22	13.2	132.3
E12	10	0.01	0.1	13.16	13.2	131.9
E13	10	0.01	0.1	13.22	13.2	132.2
E14	10	0.03	0.3	21.59	21.6	216.2
E15	10	<0.01	<0.1	21.70	21.7	217.2
E16	10	0.03	0.3	21.51	21.5	215.4
E17	10	<0.01	<0.1	11.04	11.04	110.4
E18	10	<0.01	<0.1	11.04	11.04	110.4
E19	10	<0.01	<0.1	10.86	10.86	108.6

CL = Critical load – *the CL selected for each designated site relates to its most N-sensitive habitat (or a similar surrogate) listed on the site citation for which data on Critical Loads are available and is also based on a precautionary approach using professional judgement.*

PC = Process contribution

PEDR = Predicted environmental deposition rate (PC + background)

[5] http://www.apis.ac.uk/critical-load-function-tool

Table 5.3 – Acid Deposition Rates at Ecological Receptors

Receptor ID	PC	Background	PEC	PC (% of CL function)	Background (% of CL function)	PEC (% of CL function)	Impact
E1	<0.1	1.0	1.0	<0.1	3.3	3.3	Not significant
E2	<0.1	1.0	1.0	<0.1	3.3	3.3	Not significant
E3	<0.1	1.0	1.0	<0.1	3.3	3.3	Not significant
E4	<0.1	1.0	1.0	<0.1	3.3	3.3	Not significant
E5	<0.1	1.0	1.0	<0.1	3.3	3.3	Not significant
E6	<0.1	0.9	0.9	<0.1	22.2	22.3	Not significant
E7	<0.1	0.9	0.9	0.3	218.2	218.4	Not significant
E8	<0.1	1.6	1.6	<0.1	69.3	69.4	Not significant
E9	<0.1	0.9	0.9	<0.1	3.5	3.5	Not significant
E10	<0.1	0.9	0.9	<0.1	22.0	22.1	Not significant
E11	<0.1	0.9	0.9	<0.1	3.5	3.5	Not significant
E12	<0.1	0.9	0.9	<0.1	3.5	3.5	Not significant
E13	<0.1	0.9	0.9	<0.1	3.3	3.3	Not significant
E14	<0.1	1.5	1.5	0.1	68.8	68.9	Not significant
E15	<0.1	1.6	1.6	<0.1	69.3	69.4	Not significant
E16	<0.1	1.5	1.5	0.1	109.7	109.9	Not significant
CL = Critical load PEC = Predicted environmental concentration (PC + background) No exceedance as per the output of the critical load function tool available on APIS							

5.2 Short-term Model Results

Table 5.4 details the results of the short-term impact assessment results. The summary table provides the maximum result at any receptor for each pollutant and averaging period. The full results are contained within Appendix B.

Table 5.4 - Short-term Results at Human and Ecological Receptors - Operational

Parameter	Short-term Mean				
	AQAL µg/m^3	PC µg/m^3	PEC µg/m^3	% PC of AQAL	% PEC of AQAL
Human Receptors					
99.79 percentile 1-hour mean NO_2	200	6.9	28.7	3.4	14.4
24-hour mean C_6H_6	30	4.3	4.7	14.4	15.7
Ecological Receptors					
24-hour mean NO_x	75	3.7	26.4	5.0	35.2

Table 5.4 indicates that the results of all the short-term assessment metrics are below the relevant AQAL during operations.

6 Conclusions

Bureau Veritas has been commissioned by Environmental Monitoring Solutions (EMS) to undertake an air quality assessment for three natural gas furnaces at the Chemviron Carbon site in Houghton-le-Spring, Sunderland. This document provides supporting technical information for the application of an Environmental Permit variation on the existing permit (EPR/BT2831IA), which has been issued to Chemviron Carbon Limited. The variation to the existing permit covers the installation of a new carbonisation furnace and activator. The new furnace will be serviced by a relocated emission point. This report should be read in conjunction with Durham – EA Permit V006.

An initial H1 screening assessment was previously submitted as part of the permit variation application. Following submission, the Environment Agency (EA) highlighted the need for detailed modelling of NOx and Benzene. The EA outlined the following requirements for this assessment:

> *"Regarding the air emissions though, the H1 submitted does mean that detailed modelling would be required for benzene and NOx parameters, and therefore acid and nutrient nitrogen deposition too, based on the fact that these parameters do not screen out using H1.*
>
> *Please note that of the receptors you have discussed only Joe's Pond SSSI and Hetton Bogs SSSI are relevant as the SSSI screening distance is 2km. However, the screening distance for European sites (SACs, SPAs) and Ramsar sites is 10km, so these should be included in the detailed modelling if present."*

Release rates for NO_x and benzene (C_6H_6) were derived using information provided by EMS. Due to the operational hours of the furnaces (90% operational per annum), results were post-processed, where relevant, to account for this within each calendar year.

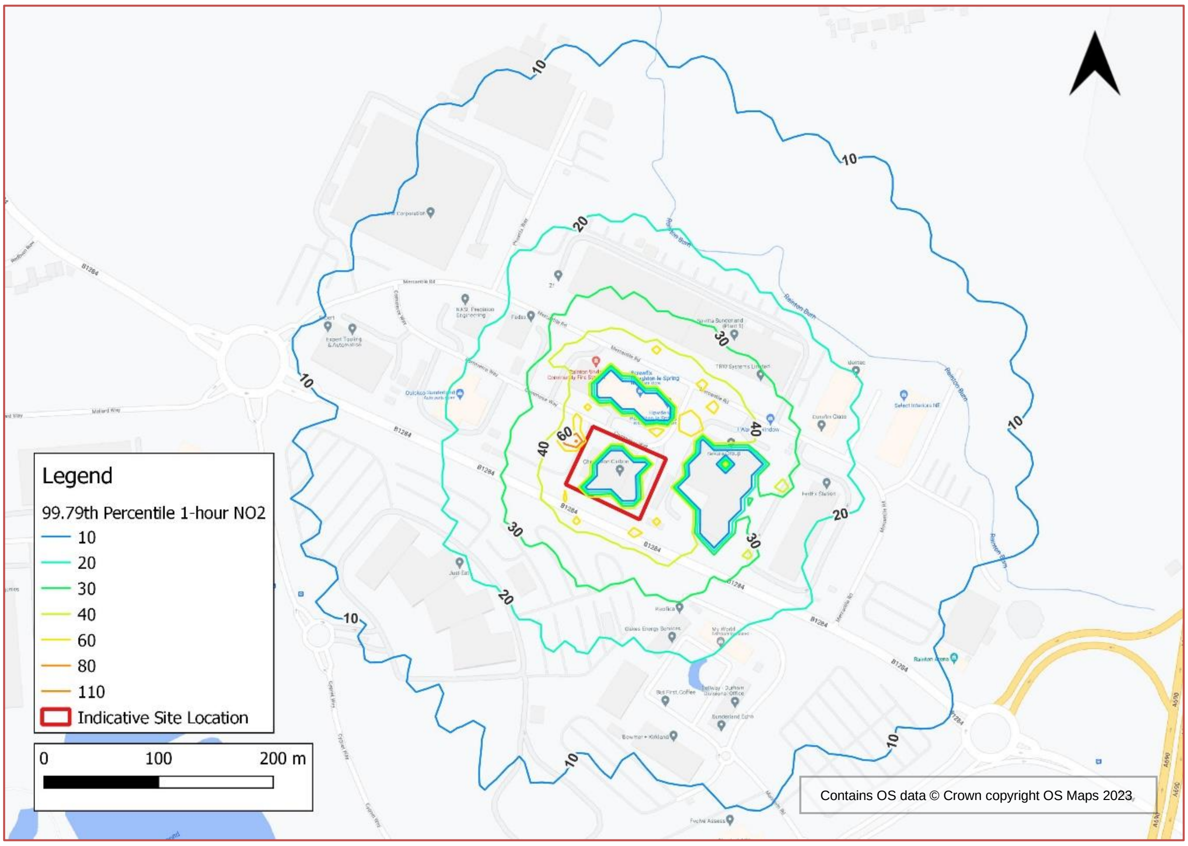
The assessment has resulted in the following conclusions:

- Considering annual mean results, all results at both human and ecological receptors were below the relevant assessment metrics.
- The results for nitrogen deposition show exceedances at some of the considered ecological receptors. The results for nitrogen deposition show no exceedances at Hetton Bogs SSSI and LNR and Joe's Pond SSSI.
- The maximum total predicted environmental nitrogen deposition rate is 263.4% of the CL. This is due to the background deposition rate at all receptors being relatively high when compared to the minimum CL. When taking the PC, this makes up less than 1% of the overall result at all modelled ecological receptors, so the contribution from the plant can be considered not significant. In the same manner, all results at all considered ecological receptor, for acid deposition can be described as not significant.
- Considering short-term results, all results at both human and ecological receptors were below the relevant assessment metrics.
- Due to worst-case conditions being employed throughout the assessment, the modelled predictions are expected to represent the upper limit of concentrations.
- As such, the plant is not expected to have a significant impact on annual mean pollutant concentrations in the surrounding area.

Appendices

Appendix A:
Pollutant Concentration Isopleths

Figure A1 - 99.79th Percentile of 1 hour mean NO_2 PC isopleth during operations (met 2022) (µg/m³)



Appendix B:
Full Results Tables

Appendix C:
Model Files