Environmental Monitoring Solutions Ltd

Holmfirth Dyers – Environmental Permit Application

Air Quality Dispersion Modelling Report

September 2022

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Table of Contents

List of Tables

List of Figures

Executive Summary

Bureau Veritas has been commissioned by Environmental Monitoring Solutions Ltd (EMS), on behalf of Holmfirth Dyers Ltd to undertake a detailed air quality assessment for operations at their dye processing facility on Dunford Road, Holmfirth.

Detailed dispersion modelling has been undertaken for operational emissions to air from the existing plant, using ADMS dispersion modelling software. Release rates for Nitrogen Oxide (NO_x), Particulate Matter 10 (PM_{10}), Sulphur Dioxide (SO_2), Volatile Organic Compounds (VOCs) and Formaldehyde (CH_2O) for all plant emissions included within the assessment have been derived using information provided by EMS.

The assessment concludes that, under the anticipated operating profile of the plant, all concentrations in air at human receptors are predicted to be below the relevant assessment level and no exceedances are predicted. For ecological receptors, with regard to concentrations in air, concentrations at all receptors are predicted to be below the relevant assessment level. With regards to deposition, contribution from the plant is extremely small. The exceedances reported occur due to existing background levels already being in exceedance prior to the introduction of the plant.

It can be considered, therefore, that the air quality impacts of the plant at Holmfirth Dyers Ltd in Holmfirth can be considered as not significant for human and ecological receptors.

1 Introduction

Bureau Veritas has been commissioned by Environmental Monitoring Solutions Ltd (EMS), on behalf of Holmfirth Dyers Ltd, to undertake a detailed air quality assessment to support an Environmental Permit (EP) application for operations at their dye works processing facility in Dunford, Holmfirth. The site location is presented in Figure 1.1.

The requirement for an air quality assessment was prompted by the Environment Agency (EA) after an H1 risk assessment indicated that dispersion modelling would be required in order to evaluate the potential air quality impacts arising from emissions of Nitrogen Oxides (NO_x (as NO_2)), Particulate Matter (PM_{10} and $PM_{2.5}$) and Volatile Organic Compounds (VOCs) from two emission points to air on the Site. This report presents the methodology, input parameters and results of the dispersion modelling undertaken as part of this assessment.

1.1 Process Description

Holmfirth Dyers Ltd is a textiles company based out of Dunford Rd, Holmfirth.

There are several emission points to air from the facility, comprising boilers, tumblers and process vents. This assessment focusses on three emission points to air, in order to determine air quality impacts from the Site in support of their Environmental Permit (EP) application.

1.2 Scope of Assessment

It is understood that there are three emission points to air to be modelled, scoped into the dispersion modelling assessment using the H1 tool. These are as follows:

- 1 stack (reference A1b) for NO_x, VOCs
- 1 stack (reference A1c) for NO_x, VOCs and PM_{10}
- 1 stack (reference A2) for NO_x, VOCs, PM_{10}, SO_2 and CH_2O

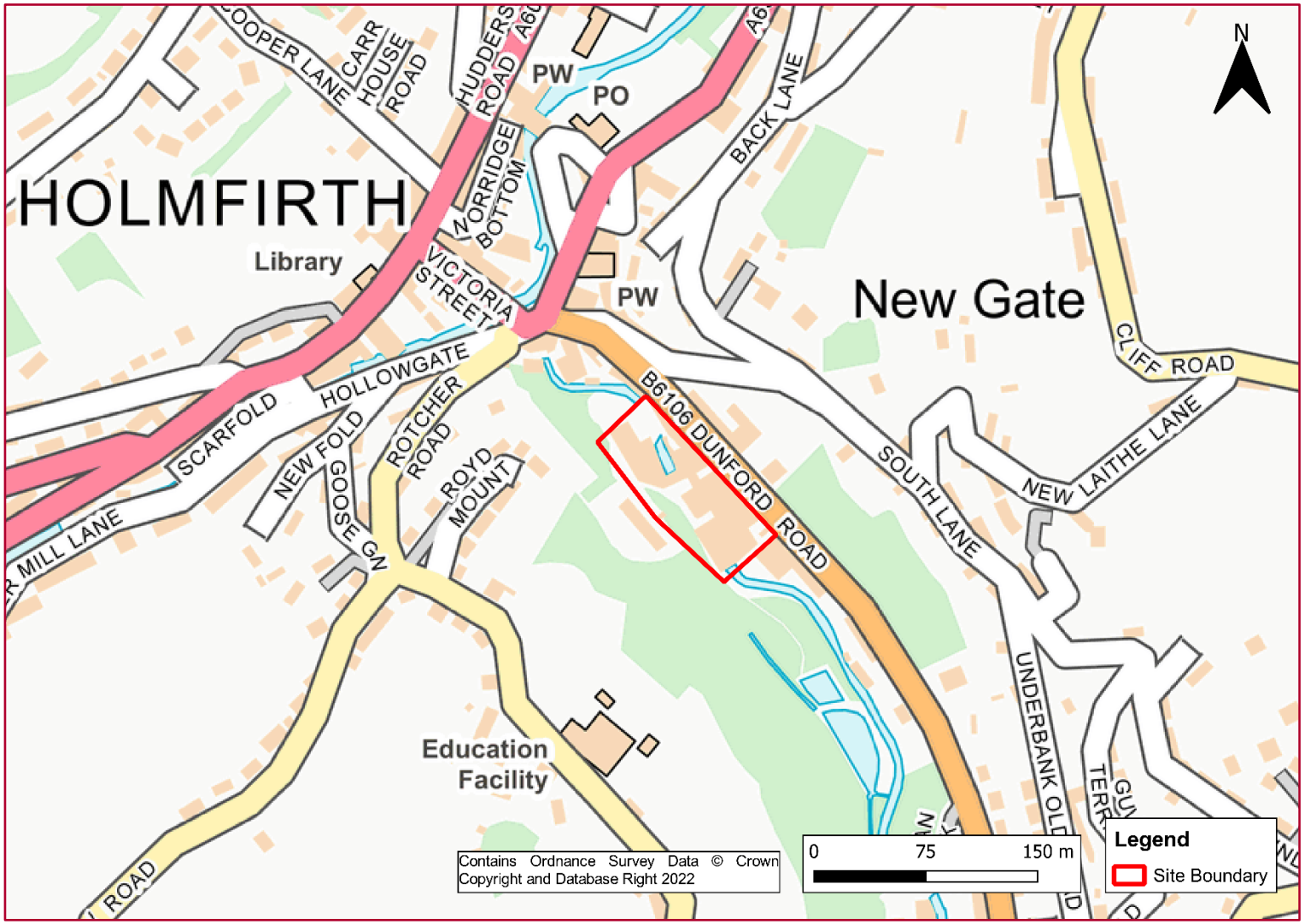
1.3 Site Description

The Site is located on Dunford Road, Holmfirth, approximately 150 m south of Holmfirth town centre, within the jurisdiction of Kirklees Metropolitan Council. The surrounding land use mainly compromises local shops and residential properties behind the Site and also north east and south of the Site.

In terms of sensitive receptors, the closest residential receptor is within ~15 m of the Site boundary at its closest point. The closest ecological receptor is an ancient woodland, located 900 m from the Site boundary to the south west of Site.

The Site location is shown in Figure 1.1.

Figure 1.1 – Site Location



2 Dispersion Modelling Methodology

ADMS 5.2 has been used for the dispersion modelling of process emissions from the Site. ADMS 5 is an advanced atmospheric dispersion model that has been developed and validated by Cambridge Environmental Research Consultants (CERC). The model has been used extensively throughout the UK for regulatory compliance purposes and is accepted as an appropriate air quality modelling tool by the Environment Agency 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 including, among others, data describing the local area, meteorological measurements and emissions data. The data used in modelling the emissions are given in the following sections of this chapter.

2.1 Process Emissions

Details of the emission points to air to be assessed at the Site have been provided to Bureau Veritas by EMS. Appropriate emission rates have been informed by stack emission testing results, with the testing having been undertaken in October 2019 and June 2022.

The parameters and emissions rates used within the assessment for each stack emission source are detailed in Table 2.1 and Table 2.2, with the locations of each of the emission points illustrated in Figure 2.6.

Table 2.1 – Model Input Parameters

ID	Description	X coordinate	Y coordinate	Stack Height (m)	Flue Diameter (m)	Efflux Temperature (°C)	Flow Rate (Am^3/h)	Flow Rate (Nm^3/h)	Velocity (m/s)	Reference Conditions
A1b	Boiler 2	414310	408044	29	0.9	182	14577	6280	6.56	273k, 101.3kPa, Dry, 3% O_2
A1c	Tumbler	414310	408044	29	0.9	63	10131	8330	6.56	273k, 101.3kPa, Wet Gas
A2	Polyester FR Treated	414369	408019	12.5	0.9	43	24768	20723	10.85	273K, 101.3kPa without correction for water vapour

All input data provided by EMS.

Table 2.2 – Model Pollutant Emission Rates

ID	NO_x (mg/m^3)	NO_x (g/s)	PM_{10} (mg/m^3)	PM_{10} (g/s)	SO_2 (mg/m^3)	SO_2 (g/s)	VOC (mg/m^3)	VOC (g/s)	Benzene (mg/m^3)	Benzene (g/s)	Data Source
A1b	181	**0.3157**	-	-	-	-	4.9	0.009	-	-	Envirocare
A1c	1.8	**0.0002**	1.4	0.0002	-	-	76.6	0.011	-	-	Envirocare
A2	4.8	**0.0012**	4.1	0.0011	11.2	0.003	13	0.003	1.5	0.0004	Socotec

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 including wind speed, wind direction, cloud cover and temperature. In addition to meteorological parameters effecting predicted concentrations, the year of meteorological data that is used for a modelling assessment can also have a significant effect on ground level concentrations.

Five complete years of meteorological data have been utilised within the modelling of pollutants to take the year-by-year variations within the dataset into account. This assessment has utilised meteorological data recorded at Emley Moor meteorological station across the period 2016 to 2020. The Emley Moor station is located approximately 10 km to the north-east of the Site and is considered representative of the meteorological conditions experienced at the Site. The following figures 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 2.3 demonstrates that this requirement is satisfied for the meteorological 'met' data years used in the assessment.

Table 2.3 – Meteorological Data Capture

Year	Number of met lines used	Number of lines with calm conditions	Number of lines with inadequate data	Percentage of lines used
2016	8536	22	59	97.4
2017	8563	5	92	97.8
2018	8191	9	414	93.5
2019	8353	35	205	95.4
2020	8614	15	13	98.3

Figure 2.1 – 2016 Emley Moor Wind Rose

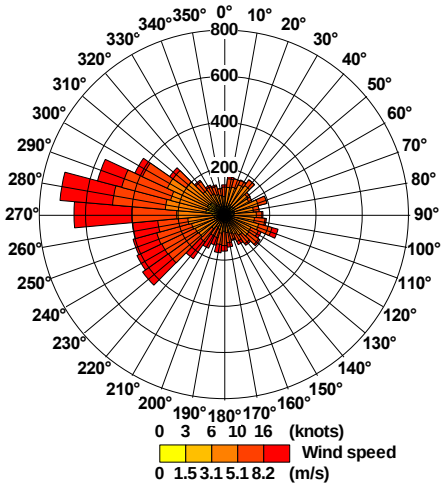


Figure 2.2 – 2017 Emley Moor Wind Rose

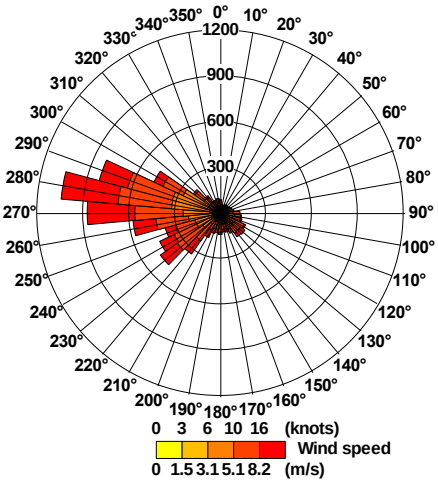


Figure 2.3 – 2018 Emley Moor Wind Rose

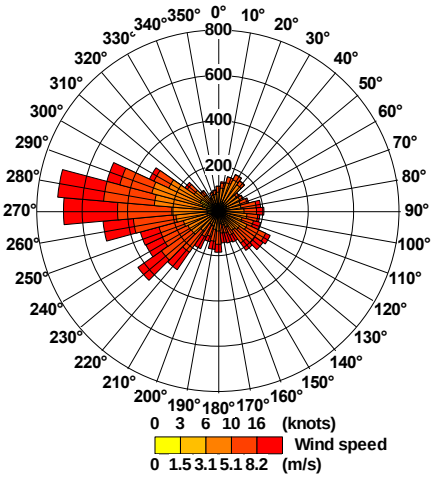


Figure 2.4 – 2019 Emley Moor Wind Rose

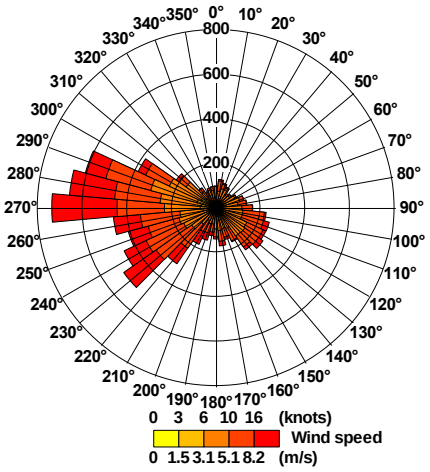


Figure 2.5 – 2020 Emley Moor Wind Rose

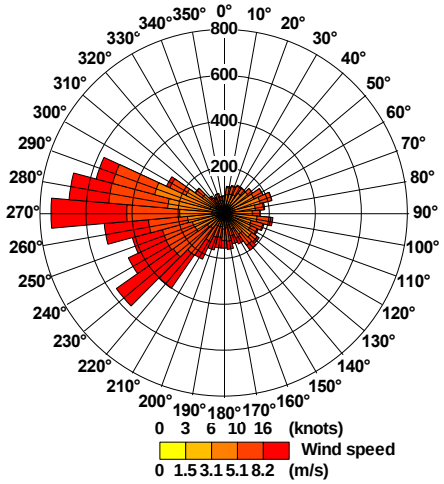
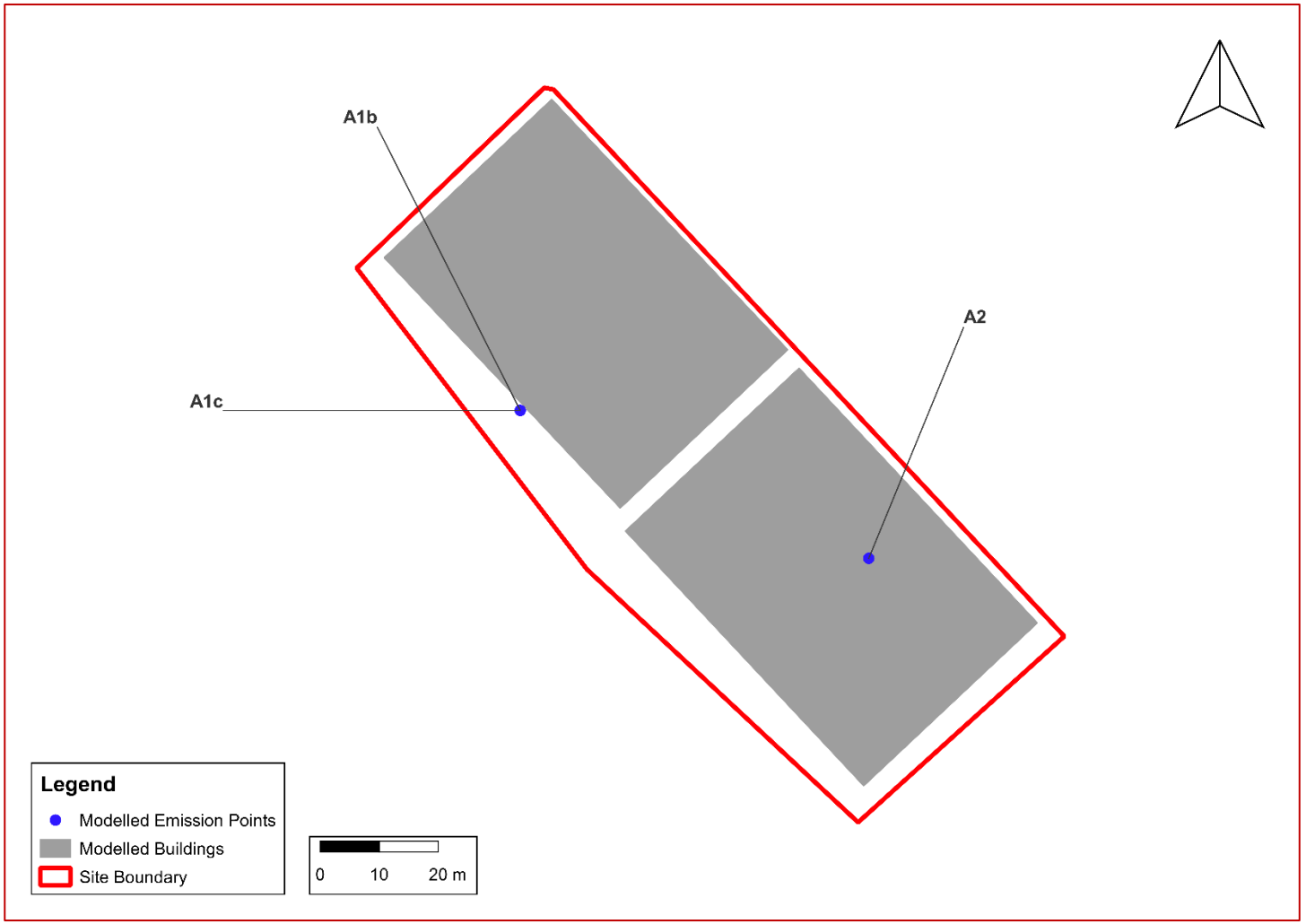


Figure 2.6 – Modelled Emission Points and Modelled Buildings Visualisation



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 as presented within Table 2.4.

Table 2.4 – 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 to a conclusion, 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 and satellite imagery, it can be seen that within the immediate vicinity of the site, land use is predominately residential to the east and west with a town centre north of the Site. In addition, completing an examination of the location of the meteorological station the surrounding area is predominantly open grassland. Consequently, a composite surface roughness length of 1 m was used in the model to account for the different surface roughness lengths within the model domain and a surface roughness length of 0.2 m around the meteorological site.

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.

The inclusion of buildings within the model can lead to a significant increase in predicted ground concentrations as plume dispersion is hindered by the presence of buildings and plume grounding occurs closer to the site than would otherwise be expected. Details of the building included within the model are presented within Table 2.5, with the building's location presented within Figure 2.6.

Table 2.5 – Modelled Buildings

Name	Centre Easting (m)	Centre Northing (m)	Height (m)	Length / Diameter (m)	Width (m)	Angle (º)
Building 1	414321	408062	8	58.23	39.02	136.65
Building 2	414363	408016	8	40.30	59.03	226.87

2.5 Model Domain and Receptors

2.5.1 Model Domain

To assess the impact of atmospheric emissions from the site on local air quality, pollutant concentrations were output to a 2 km x 2 km Cartesian grid centred on the site, with an approximate receptor resolution of 10 m. 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.

2.5.2 Human Receptors

The discrete receptors considered were chosen based on 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 3.5 of this report. Details of the locations of human receptors are presented in Table 2.6, and illustrated in Figure 2.7 below.

Receptors H1 – H4 have been modelled at a greater height than the typical 'breathing zone' due to these properties being located on a hillside, making them higher relative to the ground level of the Site.

Table 2.6 – Assessed Human Receptors

ID	Receptor Description	Easting (m)	Northing (m)	Height (m)
H1	25 Back Lane – HD9 1HJ	414414	408129	10

ID	Receptor Description	Easting (m)	Northing (m)	Height (m)
H2	Back Lane	414418	408148	15
H3	37 South Lane – HD9 1HJ	414488	408067	10
H4	53 South Lane – HD9 1EB	414537	408012	10
H5	90 Dunford Road – HD9 2DR	414449	407948	1.5
H6	39 Dunford Road – HD9 2DR	414513	407912	1.5
H7	20 Royd Mount – HD9 2QZ	414239	408052	1.5
H8	3 Cartworth Rd – HD9 2ST	414213	407967	1.5
H9	Holmfirth Junior, Infant, and Nursery School – HD9 2RG	414296	407886	1.5
H10	38 Cartworth Rd – HD9 2RG	414309	407823	1.5
H11	56 Dunford Road – HD9 2DP	414303	408029	1.5
H12	21 Dunford Road – HD9 2DP	414392	408048	1.5

2.5.3 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, Sites of Nature Conservation Importance (SNCIs) and national and local nature reserves).

Following the above guidance, upon reviewing the Defra's MAGIC mapping website[1], the ecological receptors considered in the assessment are provided in Table 2.7 and Figure 2.7.

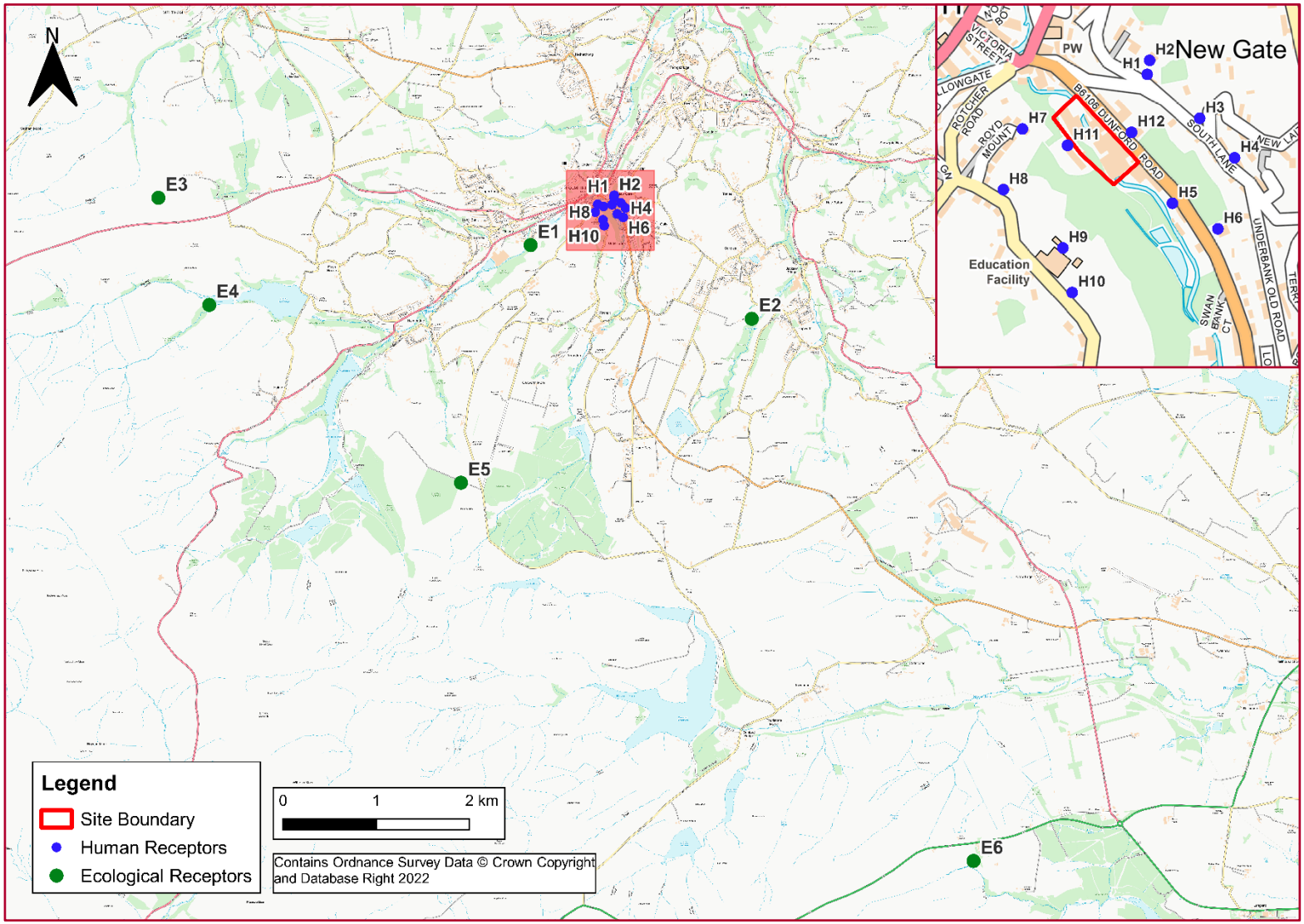
Table 2.7 – Assessed Ecological Receptors

ID	Receptor Description	Easting (m)	Northing (m)	Height (m)
E1	Ancient Woodland 1	413520	407614	0
E2	Ancient Woodland 2	415892	406825	0
E3	Special Protection Areas (England) – PEAK DISTRICT MOORS Special Areas of Conservation (England) – South Pennine Moors	409527	408121	0
E4	Special Protection Areas (England) – PEAK DISTRICT MOORS Special Areas of Conservation (England) – South Pennine Moors	410073	406973	0

[1] MAGIC website - https://magic.defra.gov.uk/home.htm

ID	Receptor Description	Easting (m)	Northing (m)	Height (m)
E5	Special Protection Areas (England) – PEAK DISTRICT MOORS Special Areas of Conservation (England) – South Pennine Moors	412773	405067	0
E6	Special Protection Areas (England) – PEAK DISTRICT MOORS Special Areas of Conservation (England) – South Pennine Moors	418271	401012	0

Figure 2.7 – Location of Modelled Receptors



2.6 Deposition

2.6.1 Nitrogen and Acid Deposition

The predominant route by which emissions will affect land in the vicinity of a process is by deposition of atmospheric emissions. Ecological receptors can potentially be sensitive to the deposition of pollutants, particularly nitrogen 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[2] recommends deposition velocities for various pollutants, according to land use classification (Table 2.8).

Table 2.8 – 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

[2] Technical Guidance on Detailed Modelling Approach for an Appropriate Assessment for Emissions to Air', AQTAG06, Environment Agency (2014), Updated Version (March 2014)'

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).

Table 2.9 – Deposition Conversion Factors

Pollutant	Chemical Element	Conversion Factor µg/m²/s [of Pollutant] → kg/ha/yr [of Chemical Element]
NO_x (as NO_2)	Nitrogen (N)	95.9
SO_2	Sulphur (S)	157.7

Table 2.10 – Acidification Conversion Factors

Chemical Element	Conversion Factor µg/m²/s [of Pollutant] → keq/ha/yr [of Chemical Element]
Nitrogen (N)	6.84
Sulphur	9.84

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 2.8) to the modelled annual mean concentrations of NO_x. 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).

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 2.11 provides the 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 coarse 5 km grid square resolution.

Table 2.11 – Estimated Background Deposition Rates

ID	Background Nitrogen Deposition (kg N ha^{-1} y^{-1})	Background Acid N Deposition (keq ha^{-1} y^{-1})	Background Acid S Deposition (keq ha^{-1} y^{-1})
E1	30.80	2.2	0.34
E2	31.64	2.26	0.34
E3	37.00	2.60	0.40
E4	37.00	2.60	0.40
E5	37.00	2.60	0.40
E6	37.00	2.60	0.40

Source: Air Pollution Information Service (APIS) website (http://www.apis.ac.uk)

2.7 Other Treatments

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

2.8 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 nitrogen dioxide (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:

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

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

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[3]. 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 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.

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

In addition, AER guidance for air dispersion modelling reports states that worst case scenario conversion ratios of 35% for short-term average concentrations and 70% for long-term average concentrations should be applied for combustion processes.

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

3 Relevant Legislation and Guidance

3.1 UK Legislation

3.1.1 The Air Quality Standards Regulations 2010

The Air Quality Standards Regulations 2010 (the 'Regulations') came into force on the 11th June 2010 and transpose Directive 2008/50/EC into UK legislation. The Directive's limit values are transposed into the Regulations as 'Air Quality Standards' (AQS) with attainment dates in line with the Directive.

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.

Similar to Directive 2008/50/EC, 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."*

3.1.2 The Air Quality Strategy for England, Scotland, Wales and Northern Ireland

The 2007 Air Quality Strategy for England, Scotland Wales and Northern Ireland provides a framework for improving air quality at a national and local level and supersedes the previous strategy published in 2000.

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. At paragraph 22 of the 2007 Air Quality Strategy, the point is made that the objectives are:

> *"…a statement of policy intentions or policy targets. As such, there is no legal requirement to meet these objectives except where they mirror any equivalent legally binding limit values…"*

The AQS objectives, 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 AQS objectives 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.

3.2 Local Air Quality Management

Part IV of the Environment Act 1995 (as amended 2021) requires that Local Authorities periodically review air quality within their individual areas. This process of Local Air Quality Management (LAQM) is an integral part of delivering the Government's AQS objectives.

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 AQS objectives.

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 AQS objectives 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 AQS 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 AQS objectives are met.

3.3 Environmental Permitting Regulations (EPR)

The Environmental Permitting Regulations (England and Wales)[4], which came into force on 6 April 2010 (replacing the 2007 Regulations), was amended in 2017 to include the Medium Combustion Plant Directive (MCPD). The MCPD forms part of the European Union's Clean Air Policy Package (2013) for medium sized combustion plants with emissions of between 1 and 50 MW_{th} input. Through regulating emissions of SO_2, NO_x and dust into the air, the MCPD aims to reduce air pollution and lessen the risks to human health and the environment that they may cause.

The EPR provides a single regulatory framework transposing EU Directives (Industrial Emissions Directive and Medium Combustion Plant Directive) into UK legislation, by defining the permitting and compliance system for industry and regulators.

3.4 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] The Environmental Permitting Regulations (England and Wales) 2010, Statutory Instrument No 675, The Stationary Office Limited

3.4.1 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 objectives set in force by the AQS for England, Scotland, Wales and Northern Ireland.

3.5 Criteria Appropriate to the Assessment

Table 3.1 sets out those air quality standards and objectives that are relevant to the assessment with regard to human receptors. In the absence of data pertaining to the species contained within the VOCs emissions, these have been treated as 100% benzene within the assessment, as per Environment Agency guidance[5].

Table 3.1 – Air Quality Standards and Objectives appropriate to the Assessment

Pollutant	AQS/AQO/EAL	Averaging Period	Value ($\mu g\ m^{-3}$)
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
Particulate Matter (PM_{10})	AQS	Annual mean	40
	EAL	24-hour mean, not more than 35 exceedances per year (equivalent of 90.41 Percentile)	50
Sulphur Dioxide (SO_2)	AQS	1-hour mean not to be exceeded more than 24 times a year (equivalent to 99.73 percentile)	350
	AQS	24-hour mean, not to be exceeded more than 3 times a year (equivalent to 99.18 percentile)	125
	AQS	15-min mean, not to be exceeded more than 35 times a year (equivalent to 99.9 percentile)	266
Benzene	AQS	Annual mean	5
	AQO	24-hour mean	30

3.6 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 3.2.

[5] https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit

Table 3.2 – 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
Sulphur dioxide (SO_2)	AQS	Annual mean	20

The Air Pollution Information System (APIS) website[6] provides specific information on the potential effects of nitrogen deposition on various habitats and species. This information, relevant to habitats of some of the ecological receptors considered in this assessment, is presented in Table 3.3.

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

Table 3.3 – Typical Habitat and Species Information Concerning Nitrogen Deposition from APIS

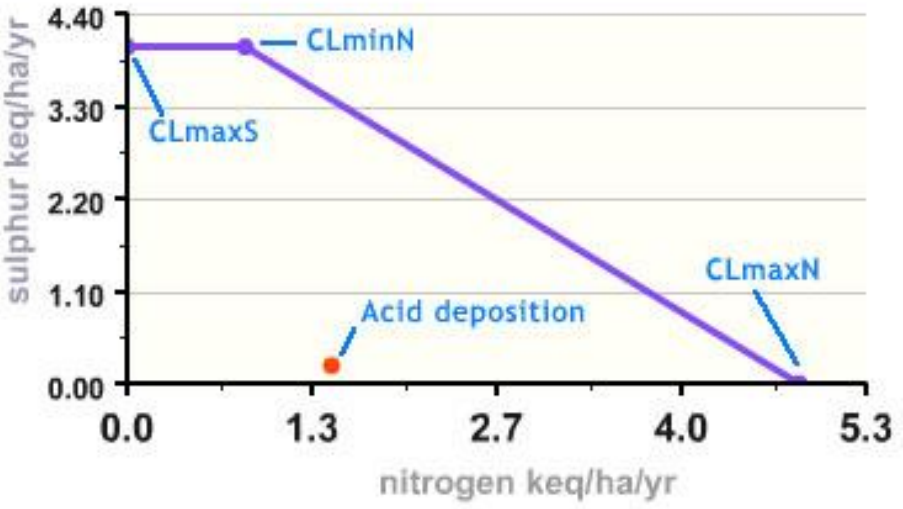
Habitat and Species Specific Information	Critical Load (kg N ha^{-1} yr^{-1})	Specific Information Concerning Nitrogen Deposition
Saltmarsh	30-40	Many saltmarshes receive large nutrient loadings from river and tidal inputs. It is unknown whether other types of species-rich saltmarsh would be sensitive 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 3.1. 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 3.1 - Critical Load Function (sourced from APIS)



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

4 Existing Ambient Data

4.1 Local Air Quality Management

The Site is located within the jurisdiction of Kirklees Metropolitan Council (Kirklees). The most recent publicly available monitoring data in Kirklees is provided in the 2022 Annual Status Report (ASR)[7]. The ASR shows that Kirklees have declared ten Air Quality Management Areas (AQMA), declared for exceedances of the NO_2 annual mean AQS objective and the PM_{10} 24 Hour Mean AQS objective in AQMA 2 Scouthhill. The closest AQMA is located approximately 8.1 km north of Holmfirth Dyers site boundary.

In 2021, Kirklees Metropolitan Council undertook automatic monitoring at 2 sites, non-automatic (passive) monitoring was undertaken at 104 sites for NO_2. The closest monitoring stations to the Dye Works is located on the A635/B6106 junction, approximately 82 m north of the site boundary at its closest point.

There are two monitoring sites located on the A635/B6106 junction, with two further sites located on the A6024, all sites are classed as 'Roadside' sites, with annual mean NO_2 concentrations for 2021 of 20.0 µg/m^3 at K96 and 21.4 µg/m^3 K99, below the annual mean limit of 40 µg/m^3.

Due to the site classes of the Council's monitoring sites and the fact that only NO_2 is monitored, background data for this assessment has been taken from the Defra background maps, detailed below.

4.2 Background Concentrations used in the Assessment

Defra maintains a nationwide model of existing and future background air quality concentrations on 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.

Annual mean background concentrations of NO_x, NO_2 and PM_{10}/$PM_{2.5}$ have been obtained from the Defra 2018-based background maps[8], for the assessment year of 2022 (based on the current year), using the 1 km grid squares which cover the modelled area.

The modelled concentrations are 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 and the likelihood of an exceedance determined.

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 objective. 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 within the AER Guidance[9]. The annual mean background concentrations used in the assessment are detailed in Table 4.1. In the absence of speciation data for VOCs, background concentrations of benzene have been used as proxy data for total VOCs.

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[7] https://www.kirklees.gov.uk/beta/crime-and-safety/air-pollution.aspx

[8] Defra Background Maps (2021). http://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html

[9] https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit

Table 4.1 – 2022 Background Annual Mean Concentrations used in the Assessment

Grid square (E, N)	Annual Mean Pollutant Concentrations (µg m^{-3})				
	NO_x	NO_2	PM_{10}	SO_2	Benzene
414500,408500	11.62	8.93	9.05	5.38	0.24
414500,408500	11.62	8.93	9.05	5.38	0.24
414500,408500	11.62	8.93	9.05	5.38	0.24
414500,408500	11.62	8.93	9.05	5.38	0.24
414500,407500	8.79	6.88	8.89	4.84	0.23
414500,407500	8.79	6.88	8.89	4.84	0.23
414500,408500	11.62	8.93	9.05	5.38	0.24
414500,407500	8.79	6.88	8.89	4.84	0.23
414500,407500	8.79	6.88	8.89	4.84	0.23
414500,407500	8.79	6.88	8.89	4.84	0.23
414500,408500	11.62	8.93	9.05	5.38	0.24
414500,408500	11.62	8.93	9.05	5.38	0.24
413500,407500	8.92	6.98	9.59	4.76	0.23
415500,406500	7.61	6.00	8.27	4.46	0.23
418500,401500	7.13	5.66	8.31	4.40	0.24

4.3 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.

4.3.1 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 4.2.

Table 4.2 – 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	1.00	1.00
Without buildings	0.99	0.87

From the above predicted ground level concentrations, it can be seen that the inclusion of buildings in the model results in higher concentrations for both averaging periods. The model used in this assessment therefore included buildings in order to demonstrate a robust assessment.

4.3.2 Surface Roughness

A sensitivity analysis has been undertaken to investigate the impact of modelling different surface roughness lengths at the dispersion site of 0.3 m, 0.5 m, and 1.0 m. These are composite surface roughness lengths averaged over the entire model domain.

Results have been normalised by the value obtained from the surface roughness length resulting in the highest ground level process contribution at any modelled receptor location and are presented in Table 4.3 below.

Table 4.3 – Surface Roughness Sensitivity Analysis

Surface Roughness (m)	Normalised Maximum Ground Level Concentration	
	NO_x Annual Mean	NO_x 99.79 Percentile of 1-Hour Mean
0.3	0.80	0.59
0.5	0.89	0.65
1.0	1.00	1.00

The model used in this assessment has used a composite roughness length of 1.0 m. The sensitivity analysis has shown 1.0 m results in the highest concentrations for long-term and 1-hour means. On balance, a roughness length of 1.0 m has shown to be a sensible input to the model on the basis of both the analysis and the surrounding land use within the model domain.

4.3.3 Terrain

A sensitivity analysis has been undertaken to investigate the impact of modelling with and without terrain 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 4.4.

Table 4.4 – Terrain Inclusion Sensitivity Analysis

Terrain	Normalised Maximum Ground Level Concentration	
	NO_x Annual Mean	NO_x 99.79 Percentile of 1-Hour Mean
With terrain	1.00	1.00
Without terrain	0.93	0.53

From the above predicted ground level concentrations, it can be seen that the omission of terrain in the model results in higher concentrations for both averaging periods. The model used in this assessment therefore has not included terrain in order to demonstrate a robust assessment.

4.3.4 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.

One limitation of the assessment relates to the mapped background pollutants concentrations, which do not presently take account of the variations in activity, emissions and concentration associated with lockdown restrictions during COVID-19. It is yet unknown what effect COVID-19 may have on mapped background concentrations, so whilst this is a known limitation, it is considered that the assessment uses the most robust data available to-date.

This assessment has incorporated a number of worst-case assumptions, as described above, which will result in an overestimation of the predicted ground level concentrations from the process.

Therefore, the actual predicted ground level concentrations would be expected to be lower than this and, in some cases, significantly lower.

5 Assessment of Impact

This section sets out the results of the dispersion modelling and compares predicted pollutant concentrations to ambient air quality standards or objectives. 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 standards or objectives.

Results 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 for each receptor location for each pollutant, thus the worst-case data has been reported within the section below.

Table 5.1 below shows the inter-year variability of met conditions at the worst-case human receptor. It demonstrates that 2017 provides the worst-case conditions for long-term concentrations at receptor H3, and 2019 provides the worst-case short-term 1-hour concentrations at receptor H11. However, the worst-case met year does vary by receptor.

Table 5.1 – NO_2 Impacts at the Worst-Case Human Receptors

Receptor	Annual Mean					1-hour Mean				
	2016	2017	2018	2019	2020	2016	2017	2018	2019	2020
H3	0.75	1.00	0.81	0.79	0.79	-	-	-	-	-
H11	-	-	-	-	-	0.96	0.87	0.93	1.00	0.96

5.1 NO_2 Impacts at Human Receptors

Table 5.2 details the results of the impact assessment for NO_2, with an assessment against both the long-term annual mean (40 µg/m^3), and the short term 99.79th Percentile 1-hour mean (200 µg/m^3) Air Quality Assessment Levels.

Table 5.2 – NO_2 Impacts at Human Receptors

Receptor	Annual Mean				99.79th Percentile of 1-Hour Mean			
	PC µg/m^3	PEC µg/m^3	% PC of AQAL	% PEC of AQAL	PC µg/m^3	PEC µg/m^3	% PC of AQAL	% PEC of AQAL
H1	0.99	9.92	2.5%	24.8%	3.84	21.69	1.9%	10.8%
H2	1.05	9.97	2.6%	24.9%	3.61	21.47	1.8%	10.7%
H3	1.32	10.25	3.3%	25.6%	3.23	21.09	1.6%	10.5%
H4	1.02	9.95	2.6%	24.9%	2.46	20.32	1.2%	10.2%
H5	0.81	7.69	2.0%	19.2%	3.52	17.28	1.8%	8.6%
H6	0.64	7.52	1.6%	18.8%	2.43	16.20	1.2%	8.1%
H7	0.55	9.48	1.4%	23.7%	6.14	23.99	3.1%	12.0%
H8	0.57	7.46	1.4%	18.6%	4.12	17.88	2.1%	8.9%
H9	0.43	7.31	1.1%	18.3%	3.64	17.40	1.8%	8.7%
H10	0.33	7.21	0.8%	18.0%	2.70	16.46	1.4%	8.2%
H11	0.40	9.33	1.0%	23.3%	2.66	20.52	1.3%	10.3%
H12	0.87	9.80	2.2%	24.5%	4.85	22.71	2.4%	11.4%

AQAL = Air Quality Assessment Level; PC = Process Contribution; PEC = Predicted Environmental Concentration (PC + Background)

The above tables indicate that long and short-term Predicted Environmental Concentrations (PECs) of NO_2 are below the respective assessment metrics at all applicable human receptors. The model has predicted that the highest PC results will occur at H3, located to the north east of the Site, with

PEC concentrations at 25.6% of the AQAL for annual mean NO_2 and at 12.0% of the AQAL for 1-hour mean NO_2 at H7, located west of the Site.

A concentration isopleth for the 99.79th percentile of the 1-hour mean NO_x process contribution is presented in Appendix A.

5.2 PM_{10} Impacts at Human Receptors

Table 5.3 details the results of the impact assessment for PM_{10} against both the long-term annual mean (40 µg/m^3), and the short-term 90.41 percentile 24-hour mean (50 µg/m^3) Air Quality Assessment Level (AQAL).

Table 5.3 – PM_{10} Impacts at Human Receptors

Receptor	Annual Mean PM_{10}				90.41 Percentile 24-hour Mean PM_{10}			
	PC µg/m^3	PEC µg/m^3	% PC of AQAL	% PEC of AQAL	PC µg/m^3	PEC µg/m^3	% PC of AQAL	% PEC of AQAL
H1	0.30	9.35	0.8%	23.4%	0.92	19.02	1.8%	38.0%
H2	0.25	9.30	0.6%	23.2%	0.73	18.83	1.5%	37.7%
H3	0.35	9.39	0.9%	23.5%	0.74	18.84	1.5%	37.7%
H4	0.25	9.30	0.6%	23.3%	0.55	18.65	1.1%	37.3%
H5	0.36	9.25	0.9%	23.1%	1.00	18.79	2.0%	37.6%
H6	0.21	9.11	0.5%	22.8%	0.58	18.37	1.2%	36.7%
H7	0.15	9.20	0.4%	23.0%	0.64	18.74	1.3%	37.5%
H8	0.11	9.01	0.3%	22.5%	0.51	18.30	1.0%	36.6%
H9	0.09	8.99	0.2%	22.5%	0.40	18.19	0.8%	36.4%
H10	0.06	8.96	0.2%	22.4%	0.28	18.07	0.6%	36.1%
H11	0.48	9.53	1.2%	23.8%	1.39	19.49	2.8%	39.0%
H12	0.39	9.44	1.0%	23.6%	1.15	19.25	2.3%	38.5%

AQAL = Air Quality Assessment Level; PC = Process Contribution; PEC = Predicted Environmental Concentration (PC + Background)

Table 5.3 indicates that long and short term Predicted Environmental Concentrations (PECs) of PM_{10} are comfortably below the respective assessment metrics at all applicable human receptors. The model has predicted that the highest PC results will occur at H11, located to the west of Site, with PEC concentrations at 23.8% of the AQAL for annual mean PM_{10} and at 39.0% of the AQAL for 24-hour mean PM_{10}.

A concentration isopleth for the 90.41th percentile of the 1-hour mean PM_{10} process contribution is presented in Appendix A.

5.1 SO_2 Impacts at Human Receptors

Table 5.4 details the results of the impact assessment for SO_2 against both the 99.73rd percentile 1-hour mean (350 µg/m³), and the 99.18th percentile 24-hour mean (125 µg/m³) AQAL.

Table 5.4 – SO_2 Impacts at Human Receptors

Receptor	99.73 Percentile 1-hour SO_2				99.18 Percentile 24-hour Mean SO_2			
	PC µg/m³	PEC µg/m³	% PC of AQAL	% PEC of AQAL	PC µg/m³	PEC µg/m³	% PC of AQAL	% PEC of AQAL
H1	6.28	17.04	1.8%	4.9%	3.86	14.62	3.1%	11.7%
H2	7.51	18.27	2.1%	5.2%	3.20	13.96	2.6%	11.2%
H3	6.12	16.88	1.7%	4.8%	2.88	13.64	2.3%	10.9%
H4	3.90	14.66	1.1%	4.2%	1.98	12.74	1.6%	10.2%
H5	5.86	15.54	1.7%	4.4%	4.48	14.16	3.6%	11.3%
H6	3.96	13.64	1.1%	3.9%	2.39	12.07	1.9%	9.7%
H7	6.42	17.18	1.8%	4.9%	2.99	13.75	2.4%	11.0%
H8	4.60	14.28	1.3%	4.1%	2.02	11.70	1.6%	9.4%
H9	3.64	13.32	1.0%	3.8%	2.03	11.71	1.6%	9.4%
H10	3.29	12.97	0.9%	3.7%	1.45	11.13	1.2%	8.9%
H11	16.23	26.99	4.6%	7.7%	6.66	17.42	5.3%	13.9%
H12	10.44	21.20	3.0%	6.1%	5.45	16.21	4.4%	13.0%

AQAL = Air Quality Assessment Level; PC = Process Contribution; PEC = Predicted Environmental Concentration (PC + Background)

This indicates that long and short term Predicted Environmental Concentrations (PECs) of SO_2 are comfortably below the respective assessment metrics at all applicable human receptors. The model has predicted that the highest results will occur at H11, with concentrations at 7.7% of the AQAL for 1-hour mean SO_2 and at 13.9% of the AQAL for 24-hour mean SO_2.

A concentration isopleth for the 99.73rd percentile of the 1-hour mean SO_2 process contribution is presented in Appendix A.

5.2 VOC Impacts at Human Receptors

Table 5.5 details the results of the impact assessment for VOC against both annual mean (5 µg/m³), and the 24-hour mean (30 µg/m³) AQAL. These are the AQALs for benzene, this was used for the assessment of total VOCs since specification of VOCs was not available.

Table 5.5 – VOC Impacts at Human Receptors

Receptor	Annual Mean VOC				24-hour Mean VOC			
	PC µg/m³	PEC µg/m³	% PC of AQAL	% PEC of AQAL	PC µg/m³	PEC µg/m³	% PC of AQAL	% PEC of AQAL
H1	1.79	2.28	35.8%	45.5%	7.42	7.91	24.7%	26.4%
H2	1.67	2.16	33.5%	43.2%	7.28	7.77	24.3%	25.9%
H3	2.13	2.62	42.6%	52.3%	6.70	7.19	22.3%	24.0%
H4	1.58	2.07	31.7%	41.4%	6.53	7.01	21.8%	23.4%
H5	1.72	2.18	34.5%	43.6%	9.19	9.65	30.6%	32.2%
H6	1.18	1.64	23.7%	32.8%	6.15	6.61	20.5%	22.0%
H7	1.10	1.59	22.1%	31.8%	15.61	16.10	52.0%	53.7%

Receptor	Annual Mean VOC				24-hour Mean VOC			
	PC µg/m³	PEC µg/m³	% PC of AQAL	% PEC of AQAL	PC µg/m³	PEC µg/m³	% PC of AQAL	% PEC of AQAL
H8	0.94	1.40	18.9%	28.0%	9.50	9.95	31.7%	33.2%
H9	0.69	1.15	13.8%	22.9%	6.87	7.33	22.9%	24.4%
H10	0.47	0.93	9.5%	18.6%	4.91	5.37	16.4%	17.9%
H11	1.56	2.05	31.2%	40.9%	8.59	9.08	28.6%	30.3%
H12	1.99	2.48	39.8%	49.5%	6.82	7.31	22.7%	24.4%

AQAL = Air Quality Assessment Level; PC = Process Contribution; PEC = Predicted Environmental Concentration (PC + Background)

Table 5.5 indicates that long and short term Predicted Environmental Concentrations (PECs) of VOCs are comfortably below the respective assessment metrics at all applicable human receptors. The model has predicted that the highest PEC results will occur at H3, with concentrations at 52.3% of the AQAL for the annual mean of benzene and at 53.7% of the AQAL for 1-hour mean of benzene at H7, located west of the Site.

A concentration isopleth for the annual mean VOC process contribution is presented in Appendix A.

5.1 CH_2O Impacts at Human Receptors

Table 5.6 details the results of the impact assessment for CH_2O against both the annual mean (5 µg/m³) and 30 minute mean (100 µg/m³) AQAL. The PEC for formaldehyde has not been calculated owing to the lack of background data.

Table 5.6 – CH_2O Impacts at Human Receptors

Receptor	Annual Mean CH_2O				30 Minute Mean CH_2O			
	PC µg/m³	PEC µg/m³	% PC of AQAL	% PEC of AQAL	PC µg/m³	PEC µg/m³	% PC of AQAL	% PEC of AQAL
H1	0.11	-	2.1%	-	1.12	-	1.1%	-
H2	0.08	-	1.7%	-	1.77	-	1.8%	-
H3	0.12	-	2.4%	-	1.21	-	1.2%	-
H4	0.09	-	1.7%	-	0.79	-	0.8%	-
H5	0.13	-	2.5%	-	1.30	-	1.3%	-
H6	0.07	-	1.5%	-	0.67	-	0.7%	-
H7	0.05	-	1.0%	-	2.81	-	2.8%	-
H8	0.04	-	0.7%	-	0.95	-	1.0%	-
H9	0.03	-	0.6%	-	0.86	-	0.9%	-
H10	0.02	-	0.4%	-	0.86	-	0.9%	-
H11	0.18	-	3.5%	-	3.40	-	3.4%	-
H12	0.14	-	2.8%	-	2.89	-	2.9%	-

AQAL = Air Quality Assessment Level; PC = Process Contribution; PEC = Predicted Environmental Concentration (PC + Background)

Table 5.6 indicates that long and short term Predicted Environmental Concentrations (PECs) of CH_2O are comfortably below the respective assessment metrics at all applicable human receptors. The model has predicted that the highest PC results will occur at H11, with concentrations at 3.5% of the annual mean AQAL and at 3.4% of the 30 minute mean AQAL.

5.2 NO_X Impacts at Ecological Receptors

Table 5.7 details the results of the impact assessment for NO_x, with an assessment against both the long-term annual mean (30 µg/m^3), and the short term 24-hour mean (75 µg/m^3), collectively termed Critical Levels (CL_e), for ecological receptors.

Table 5.7 – NO_x Impacts at Ecological Receptors

Receptor	Annual Mean				24-hour Mean			
	PC µg/m^3	PEC µg/m^3	% PC of CL_e	% PEC of CL_e	PC µg/m^3	PEC µg/m^3	% PC of CL_e	% PEC of CL_e
E1	0.07	8.99	0.2%	30.0%	1.09	18.93	1.5%	25.2%
E2	0.04	7.65	0.1%	25.5%	0.50	15.72	0.7%	21.0%
E3	<0.01	7.52	<0.1%	25.1%	0.12	15.14	0.2%	20.2%
E4	<0.01	7.10	<0.1%	23.7%	0.11	14.30	0.2%	19.1%
E5	0.01	6.91	<0.1%	23.0%	0.19	13.99	0.2%	18.7%
E6	<0.01	7.14	<0.1%	23.8%	0.05	14.32	0.1%	19.1%

CL_e = Critical Level; PC = Process Contribution; PEC = Predicted Environmental Concentration (PC + Background)

The above table indicates that long-term annual mean Predicted Environmental Concentrations (PECs) of NO_x are comfortably below the respective assessment metrics at all ecological receptors considered in the assessment, with results no more than 30.0% of the annual mean and 25.2% of the 24 hour mean CL_e.

The impacts at all receptors can be considered insignificant and no further assessment is required.

5.3 SO_2 Impacts at Ecological Receptors

Table 5.8 details the results of the impact assessment for SO_2, with an assessment against the long-term annual mean (20 µg/m^3) CL_e for ecological receptors.

Table 5.8 – SO_2 Impacts at Ecological Receptors

Receptor	Annual Mean			
	PC µg/m^3	PEC µg/m^3	% PC of CL_e	% PEC of CL_e
E1	0.02	4.78	0.1%	23.9%
E2	0.01	4.47	0.1%	22.4%
E3	<0.01	4.20	<0.1%	21.0%
E4	<0.01	4.32	<0.1%	21.6%
E5	<0.01	4.39	<0.1%	22.0%
E6	<0.01	4.40	<0.1%	22.0%

CL_e = Critical Level; PC = Process Contribution; PEC = Predicted Environmental Concentration (PC + Background)

The above table indicates that annual term Predicted Environmental Concentrations (PECs) of SO_2 are comfortably below the respective assessment metric at all ecological receptors considered in the assessment, with results no more than 23.9% of the CL_e.

5.4 Deposition Impacts at Ecological Receptors

The impact assessment for ecological receptors also includes an assessment of pollutants deposited to land in the form of nitrogen deposition and acid deposition. Nitrogen deposition results are shown in Table 5.9 whilst the results for acid deposition are shown in Table 5.10.

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[10]. 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 results for nitrogen deposition show that no exceedances are predicted. The PC makes up less than 0.2% of the overall result at all ecological locally-designated receptors considered and less than 0.1% at internationally designated sites, so the contribution from the plant can be considered not significant. Where exceedances occur, these are due to the existing background.

Table 5.9 – Nitrogen Deposition Rates at Ecological Receptors

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}
E1	10	0.02	0.2%	30.80	30.84	308%
E2	10	0.01	0.1%	31.64	31.66	317%
E3	5	<0.01	<0.1%	37.00	37.00	740%
E4	5	<0.01	<0.1%	37.00	37.00	740%
E5	5	<0.01	0.1%	37.00	37.01	740%
E6	5	<0.01	0.0%	37.00	37.00	740%

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)

With regards to acid deposition results, again the contribution from the Site is very low and no exceedances are predicted in terms of the PC. Where exceedances occur, these are due to the existing background.

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

Table 5.10 – Acid Deposition Rates at Ecological Receptors

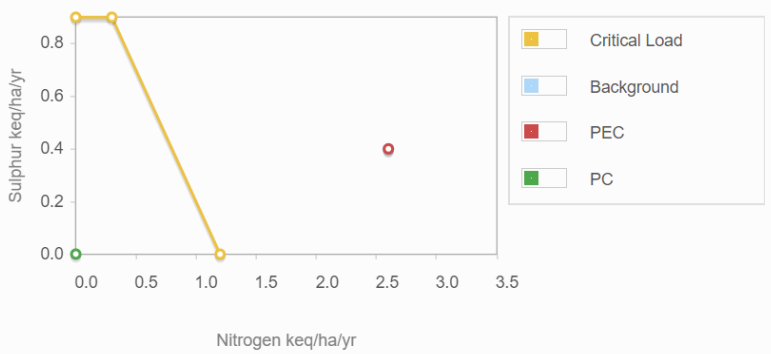
Receptor ID	S PC	N PC	S Background	N Background	S PEC	N PEC	PC (% of CL function)	Background (% of CL function)	PEC (% of CL function)	Impact
E1	0.01	<0.01	0.34	2.20	0.35	2.20	0.40	151.1	151.5	Not significant
E2	<0.01	<0.01	0.34	2.26	0.34	2.26	0.22	139.5	139.7	Not significant
E3	<0.01	<0.01	0.40	2.60	0.40	2.60	0.02	254.0	254.0	Not significant
E4	<0.01	<0.01	0.40	2.60	0.40	2.60	0.04	254.0	254.1	Not significant
E5	<0.01	<0.01	0.40	2.60	0.40	2.60	0.01	66.1	66.1	Not significant
E6	<0.01	<0.01	0.40	2.60	0.40	2.60	0.01	66.1	66.1	Not significant

CL = Critical Load
PEC = Predicted environmental concentration (PC + background)

Figure 5.1 – Critical Load Function Output for Worst-Case Receptor, E4

Source	Exceedance (keq/ha/yr)	% of CL function*
Process Contribution (PC)	no exceedance of CL function	0
Background	1.8	250
Predicted Environmental Concentration (PEC)	1.8	250

* % of CL function is calculated after the value of PEC relative to CLminN is taken into account. See detailed explanation for further information and justification.



6 Conclusions

Bureau Veritas has been commissioned by Environmental Monitoring Solutions Ltd (EMS), on behalf of Holmfirth Dyers Ltd to undertake a detailed air quality assessment to support a new Environmental Permit (EP) variation application for operations at their dye processing facility in Holmfirth, West Yorkshire.

Detailed dispersion modelling has been undertaken for operational emissions to air from the existing plant, using ADMS dispersion modelling software. Release rates for NO_x, PM_{10} VOCs, SO_2 and CH_2O for three emission points to air have been included within the assessment, which have been derived using information provided by EMS.

The assessment concludes that, under the anticipated operating profile of the plant, all concentrations in air at human receptors are predicted to be below the relevant assessment level and no exceedances are predicted. For ecological receptors, with regard to concentrations in air, concentrations, all of the receptors are predicted to be below the relevant assessment level. With regards to deposition, contribution from the plant is extremely small and exceedances occur due to existing background levels already being in exceedance.

It can be considered, therefore, that the air quality impacts of the plant at the Holmfirth Dye Works site in Holmfirth can be considered as not significant for human and ecological receptors.

Appendices

Appendix A: Contour Plots

Contour plots have been provided for those pollutants and averaging periods which appear to be the most onerous in terms of compliance.

Figure A.1 – 99.79th Percentile 1-Hour Mean NO_2 Process Contribution Isopleth (µg/m^3) for 2019

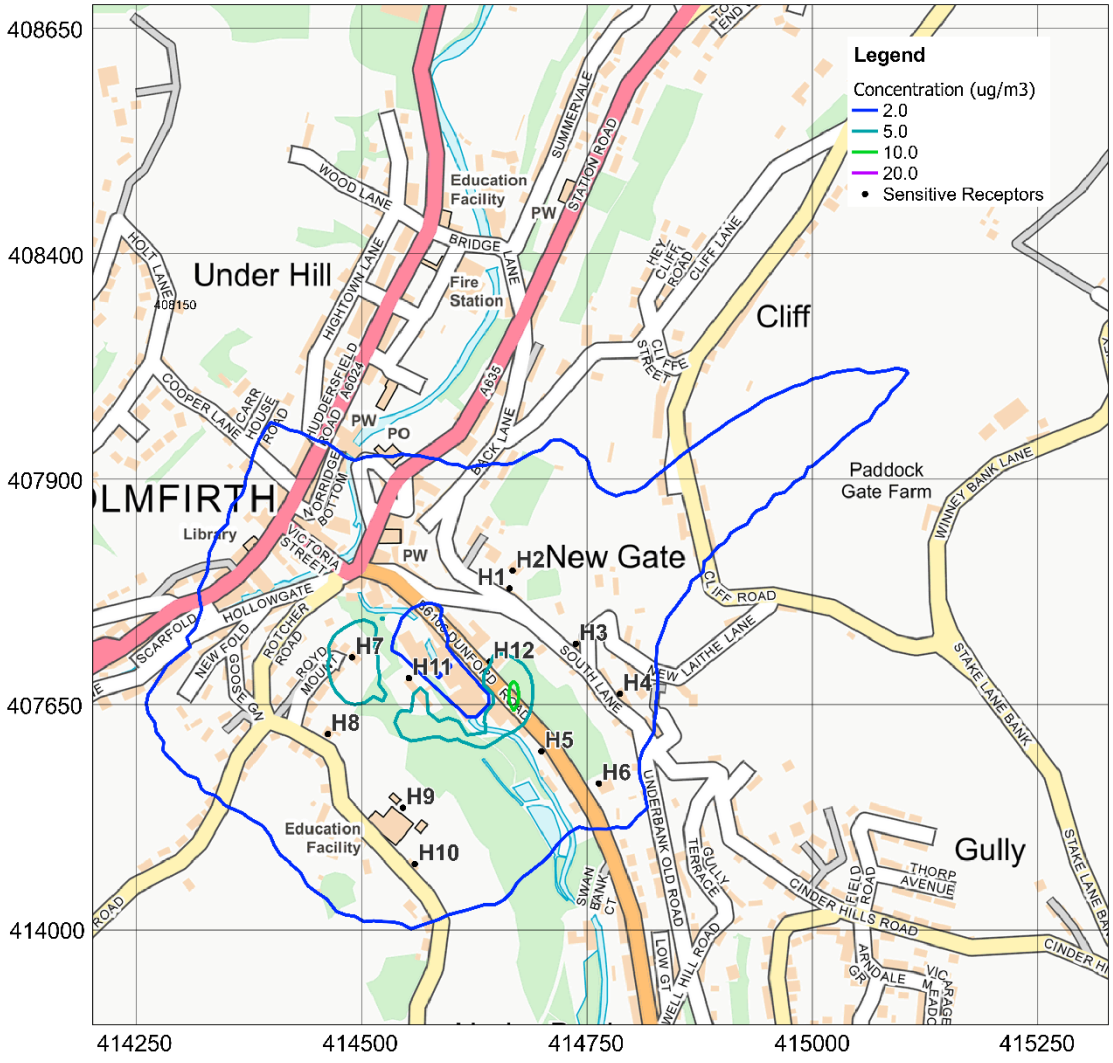


Figure A.2 – 99.73rd Percentile 1-Hour Mean SO_2 Process Contribution Isopleth (µg/m³) for 2019

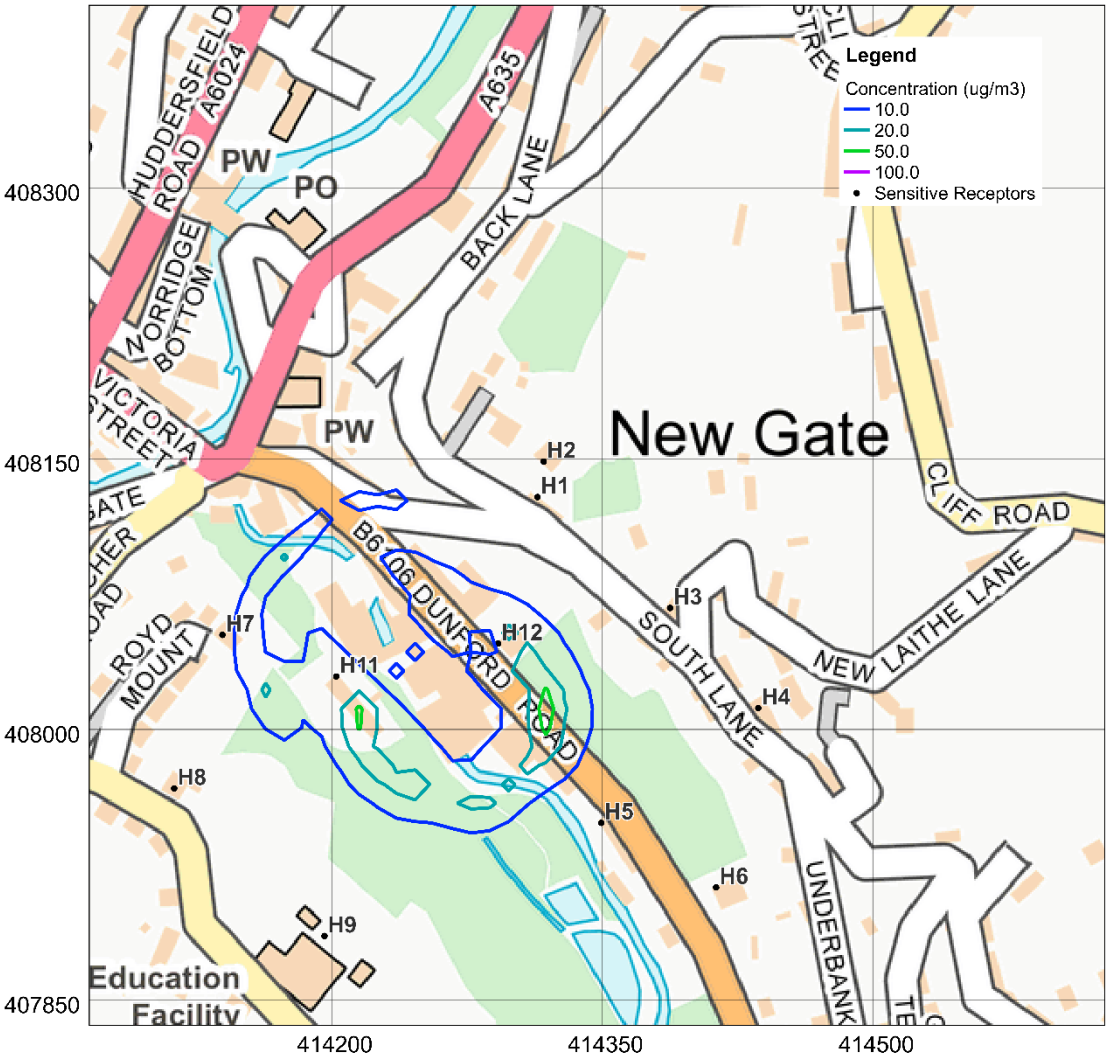


Figure A.3 – 90.4th Percentile 24-Hour Mean PM_{10} Process Contribution Isopleth (µg/m3) for 2019

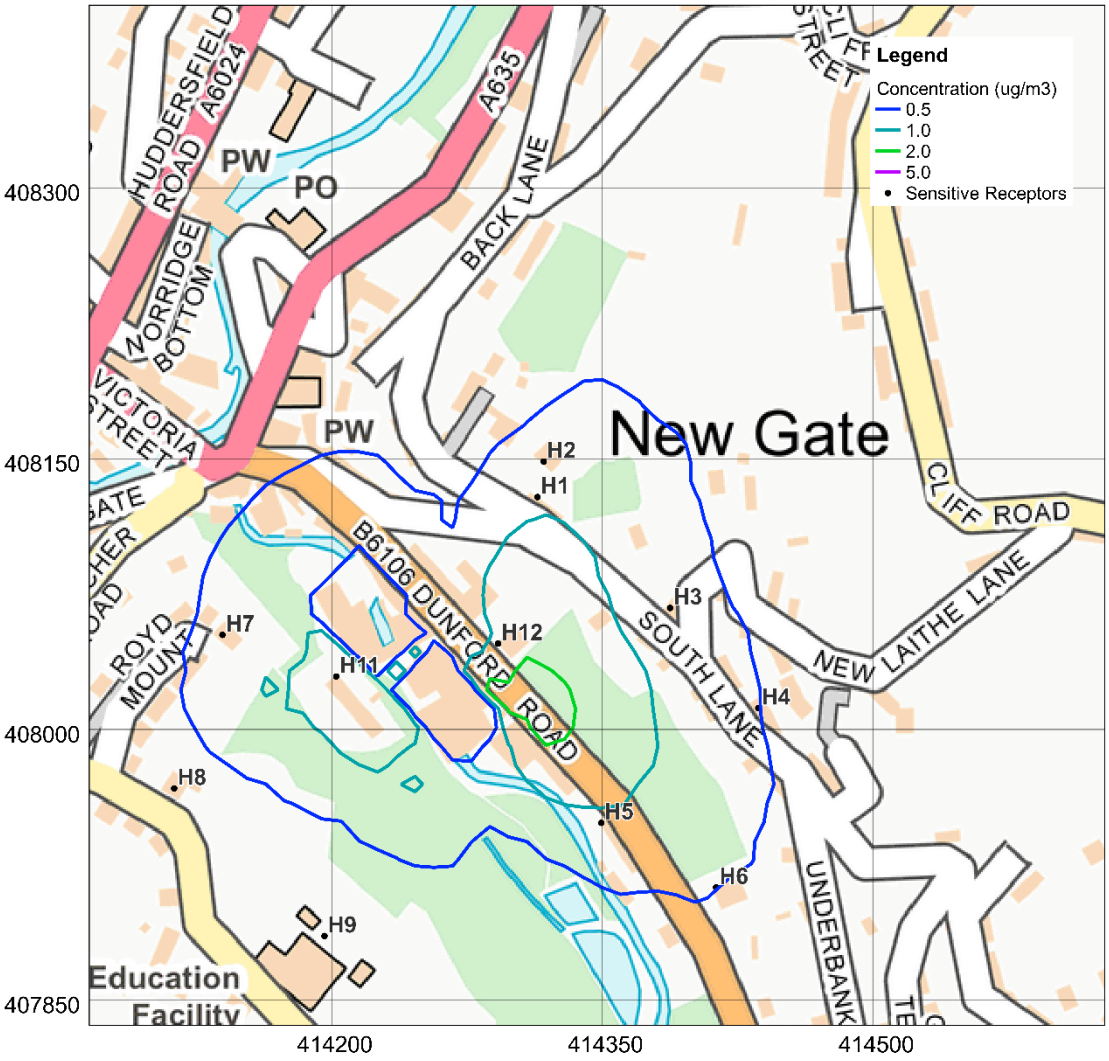


Figure A.4 – Annual Mean VOC Process Contribution Isopleth (µg/m^3) for 2017

Appendix B:
Model Files