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Air quality assessment for four CHP engines at Green Tye Farm, Much Hadham

Draft report

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1 Summary

CERC was commissioned by Wiser Environment Ltd to carry out an air quality assessment for emissions to air from four CHP engines at Green Tye Farm, Much Hadham, in Hertfordshire.

The dispersion of emissions of nitrogen oxides (NO_x), sulphur dioxide (SO_2), carbon monoxide (CO) and Volatile Organic Compounds (VOCs) from the four CHP engines was carried out using the ADMS 6 model (version 6.0.2.7). Hourly sequential meteorological data were obtained from the Met Office Andrewsfield station, for the years 2019 to 2023 inclusive. The modelling used stack data provided by the client and took into account the effect of site buildings on the dispersion of pollutants.

Ground level concentrations of NO_x, NO_2, SO_2, CO and VOCs were calculated for comparison with the air quality objectives for human health and critical levels for the protection of vegetation and ecosystems. Nitrogen and acid deposition rates were calculated for comparison with critical loads for the protection of vegetation and ecosystems.

1.1 Human health

Although the maximum offsite annual average and hourly average NO_2 PCs are not screened out, the PECs are well below the objective values, for all five years of meteorological data. The maximum offsite annual average PEC is 29% of the objective, which reduces to 21% at the nearest residential receptor. The maximum offsite hourly average NO_2 PEC is 36% of the objective value. The hourly average PCs are screened out at all residential receptors.

Although the maximum predicted 15-minute, hourly, and daily average SO_2 concentrations at offsite locations are not screened out, the PECs are well below the objective values for all five years of meteorological data. The maximum offsite 15-minute, hourly, and daily average SO_2 PECs are 20%, 14%, and 22% of the relevant objective values, respectively. The SO_2 PCs for all averaging periods are screened out at all residential receptors.

All predicted concentrations of CO outside the site boundary are screened out as they are less than 10% of the objective for the protection of human health.

There are no air quality objectives for VOCs as a group of pollutants. The VOCs are likely to consist mainly of methane, for which there are no air quality standards for the protection of human health.

1.2 Vegetation and ecosystems

1.2.1 Critical levels

The annual and daily average PCs of NO_x and the annual average PC of SO_2 are screened out as insignificant for all years of meteorological data at Lee Valley Ramsar/SPA and at most of the areas of Ancient Woodland and LWSs.

The annual average PCs of NO_x are not screened out at the following four sites:

- Sidehill Wood AW;
- Hillcrest Meadow LWS;
- Green Tye Pond LWS; and
- Dane Wood LWS.

At these four sites, taking into account background concentrations for each location, the resulting PECs are between 35% and 38% of the annual average critical level for NO_x.

The daily average PCs of NO_x are not screened out at:

- Hillcrest Meadow LWS; and
- Green Tye Pond LWS.

The maximum daily average NO_x PCs are 11% and 23% of the critical level at these sites, respectively.

The annual average PCs of SO_2 are screened out at all sites except Green Tye Pond LWS. Taking into account the background concentration at this site, the resulting PEC is 4% of the annual average critical level for SO_2.

1.2.2 Critical loads

The contribution to nitrogen and acid deposition is screened out as insignificant for all sites for which relevant critical load information is available.

2 Introduction

CERC was commissioned by Wiser Environment Ltd to carry out an air quality assessment for four CHP engines at Green Tye Farm, Much Hadham, in Hertfordshire.

The assessment was carried out using the ADMS 6 dispersion model. The model inputs and the results of the dispersion modelling are described in this report.

Section 3 presents the air quality objectives with which the modelled results are to be compared. Details of the assessment area, including a description of the site, are given in Section 4, along with background concentrations for the area. Section 5 describes the site layout and emissions. The meteorological data input to the modelling are described in Section 6.

Sections 7 to 9 set out the results of the dispersion modelling:

- Section 7 sets out the results of the assessment against objectives for the protection of human health;
- Section 8 sets out the results of the assessment against critical levels for the protection of vegetation and ecosystems; and
- Section 9 sets out the results of the assessment against critical loads for the protection of vegetation and ecosystems.

A discussion of the implications of the results is provided in Section 10. Finally, a description of the ADMS model used in the assessment is given in Appendix A.

3 Air quality objectives

3.1 Air quality standards for the protection of human health

UK air quality objectives for nitrogen dioxide (NO_2), carbon monoxide (CO) and sulphur dioxide (SO_2), set for the protection of human health, are summarised in Table 3.1. The objectives are taken from *The Air Quality Standards Regulations 2010* and the UK *Air Quality Strategy*. The objective values take into account the effects of each pollutant on the health of those who are most sensitive to air quality.

Table 3.1: Air Quality Objectives

	Value (µg/m^3)	Description of standard
NO_2	200	1-hour mean not to be exceeded more than 18 times a year (modelled as 99.79th percentile)
	40	Annual mean
CO	10,000	Maximum daily running 8-hour mean
SO_2	350	1-hour mean not to be exceeded more than 24 times a year (modelled as 99.73rd percentile)
	125	24-hour mean not to be exceeded more than 3 times a year (modelled as 99.18th percentile)
	266	15-minute mean not to be exceeded more than 35 times a year (modelled as 99.9th percentile)

The short-term standards considered are specified in terms of the number of times during a year that a concentration measured over a short period of time is permitted to exceed a specified value. For example, the concentration of NO_2 measured as the average value recorded over a one-hour period is permitted to exceed the concentration of 200 µg/m^3 up to 18 times per year. Any more exceedences than this during a one-year period would represent a breach of the objective.

It is convenient to model objectives of this form in terms of the equivalent percentile concentration value. A percentile is the concentration below which lie a specified percentage of concentration measurements. For example, taking the NO_2 objective, allowing 18 exceedences per year is equivalent to not exceeding for 8742 hours or for 99.79% of the year. This is therefore equivalent to the 99.79th percentile value.

There are no air quality objectives for VOCs as a group of pollutants. The VOCs are likely to consist mainly of methane, for which there are no air quality standards for the protection of human health.

3.2 Critical levels for the Protection of Vegetation and Ecosystems

The critical levels for the Protection of Vegetation and Ecosystems, as set out in the Environment Agency's *AQTAG06* document,[1] are summarised in Table 3.2.

Table 3.2: Critical levels for the Protection of Vegetation and Ecosystems

	Critical level (µg/m^3)	Comment
SO_2	20	annual mean
NO_x	30	annual mean
	75	daily mean

[1] Environment Agency AQTAG06 *Detailed air dispersion modelling approach in support of stage 1 and stage 2 Habitats Regulations Assessment*, updated version, approved July 2025

4 Site location and surrounding area

Green Tye Farm is situated in a rural area approximately 1.5 km east of Much Hadham, as shown in Figure 4.1.

Concentrations were calculated on a grid of output points and at a set of nine receptors representing the nearest residential properties, as shown on Figure 4.1. Further details of these locations are presented in Table 4.1.

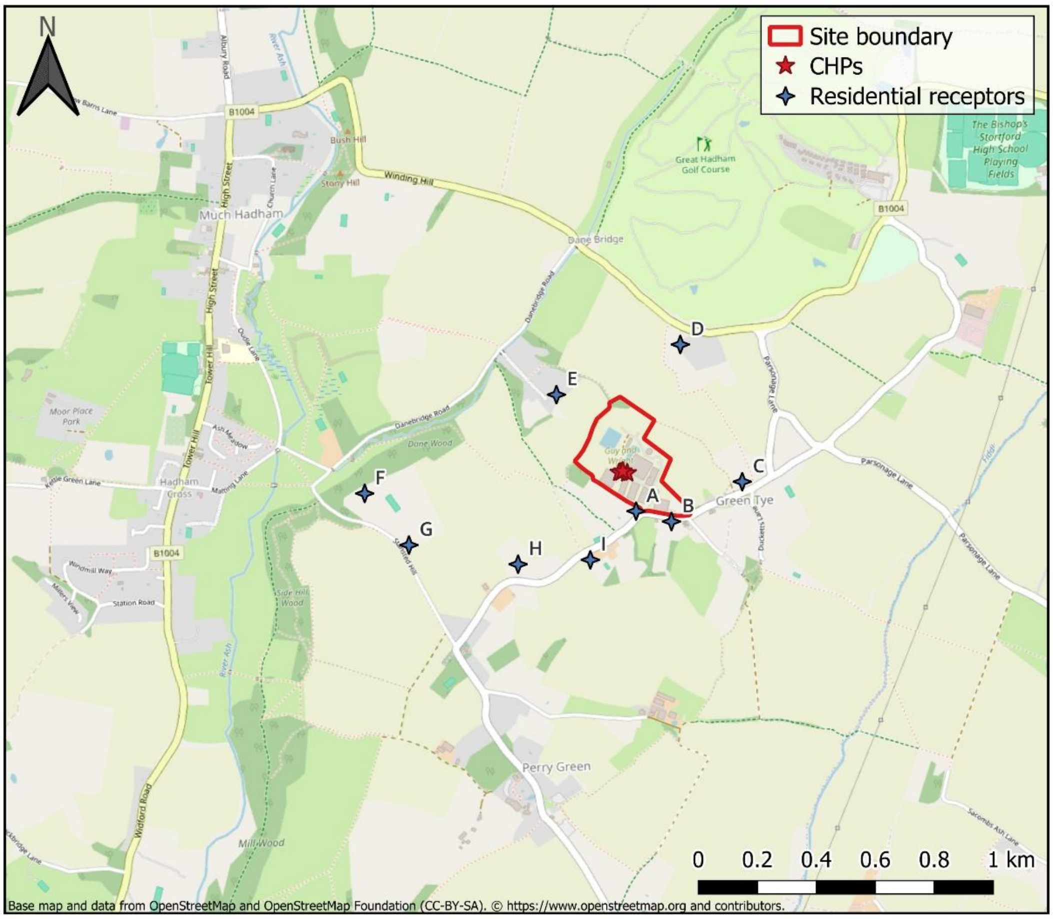

Figure 4.1: Site location

Table 4.1: Residential receptor locations

Receptor ID	Description	Distance from stacks	Direction from stacks	OSGB X,Y coordinates (m)
A	Redmire Cottage	125 m	south	544210, 218445
B	Hoplands House	225 m	south east	544330, 218410
C	Green Tye Farm	400 m	east	544570, 218545
D	Spring Farm	480 m	north east	544360, 219010
E	Hillcrest	345 m	north west	543940, 218840
F	Daneswood	870 m	west	543290, 218505
G	Daneswood Cottage	760 m	south west	543440, 218330
H	Ardbrin	475 m	south west	543810, 218265
I	Grudds Farm	315 m	south west	544055, 218280

4.1 Ecologically sensitive sites

Air quality assessments are required to quantify the impact at ecologically sensitive sites. In particular, Environment Agency guidance recommends assessing the impact at any Special Protection Areas (SPA), Special Areas of Conservation (SAC) and Ramsar sites within 10 km of the source and any Sites of Special Scientific Interest (SSSI), National Nature Reserves (NNR), Local Nature Reserves (LNR), Local Wildlife Sites (LWS) or areas of Ancient Woodland within 2 km of the modelled emissions sources.

There are no SSSIs, LNRs or NNRs within 2 km of the farm.

Lee Valley SPA and Ramsar site is approximately 8.5 km from the farm. There are four areas of Ancient Woodland and 12 LWSs within 2 km of the farm; some of these areas are both Ancient Woodland and LWSs.

The areas of Ancient Woodland and the nearest parts of the Ramsar / SPA are shown on Figure 4.2. The LWSs are shown on Figure 4.3.

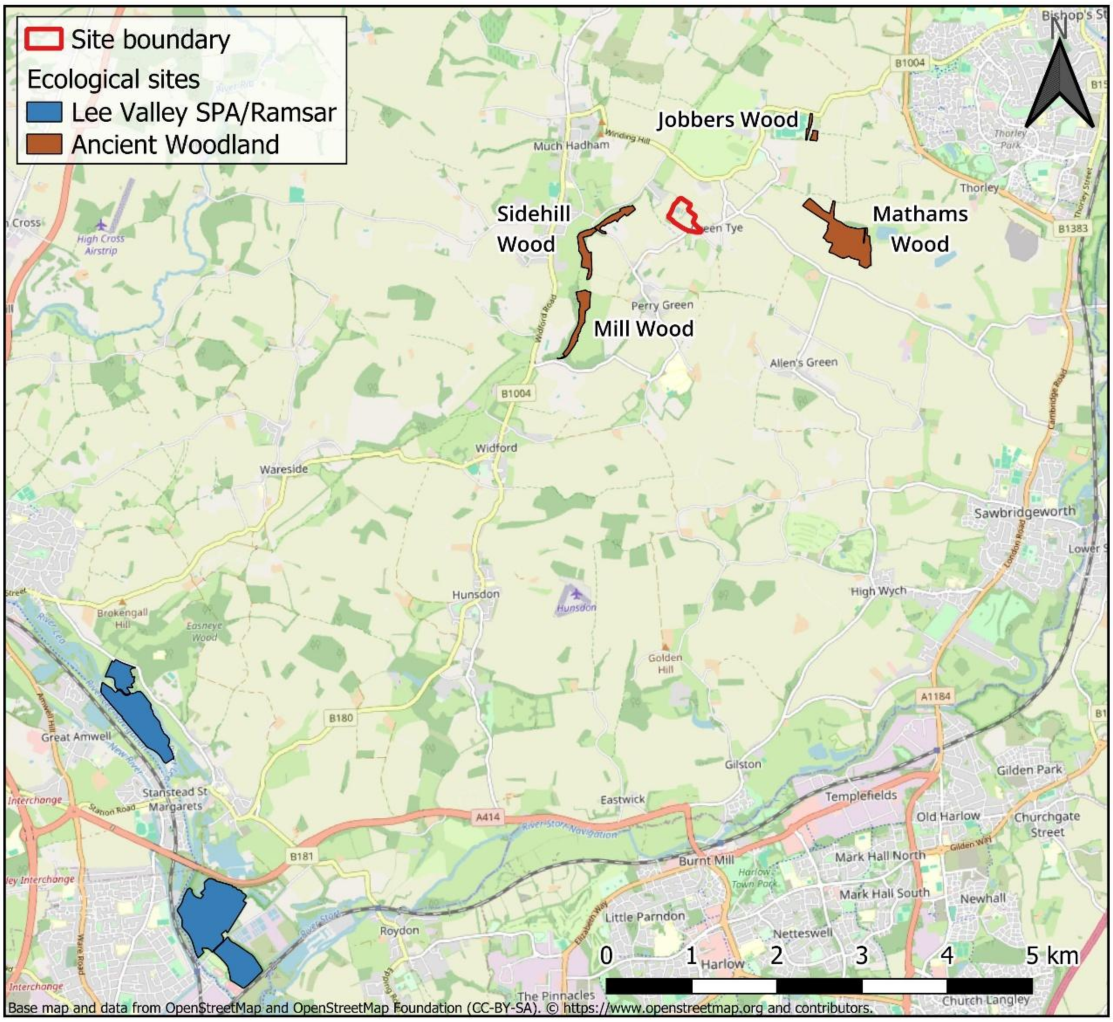

Figure 4.2: Locations of Lee Valley Ramsar/SPA and areas of Ancient Woodland

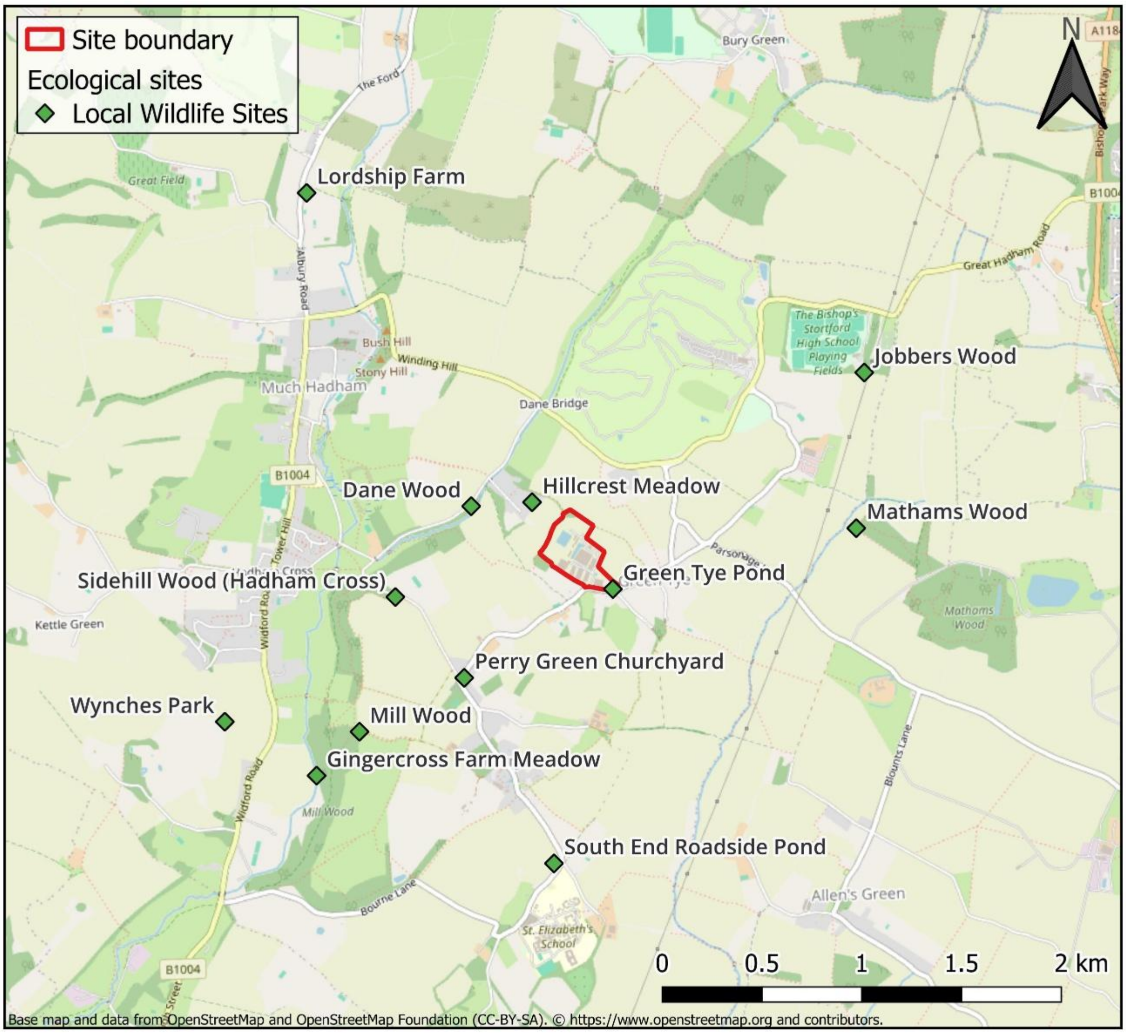

Figure 4.3: Locations of Local Wildlife Sites

4.2 Local air quality

A good indication of the sensitivity of a particular area is whether it has been declared an Air Quality Management Area (AQMA). An AQMA is an area in which one or more air quality objectives are not likely to be achieved, for which the local authority is obliged to prepare a plan to improve air quality. East Hertfordshire Council has declared three AQMAs, in Bishop's Stortford, Sawbridgeworth and Hertford respectively, due to high levels of NO_2 from road traffic emissions. The nearest of these is the AQMA in Sawbridgeworth, over 5 km south east of Green Tye Farm. Air quality around Green Tye Farm is therefore expected to be good.

4.3 Background concentrations

Local background concentrations of carbon monoxide (CO) for the year 2010 and sulphur dioxide (SO_2) and nitrogen dioxide (NO_2) for the year 2024 were obtained from the UK AIR Air Information Resource background mapping[2]. These values are provided on a 1 km grid basis; Table 4.2 presents annual average concentrations for the grid square containing Green Tye Farm.

Table 4.2: Annual average background concentrations (µg/m³)

Year	CO	NO_2	SO_2
2010	210	-	-
2024	-	6.5	0.78

For the assessment of ecologically sensitive sites, background concentrations of SO_2 and nitrogen oxides (NO_x) for the period 2020-2022 were obtained for the area from the APIS[3] web site. Table 4.3 presents background concentrations for each of the sensitive ecological sites.

[2] https://uk-air.defra.gov.uk/data/gis-mapping/ (accessed 25/11/25)
[3] https://www.apis.ac.uk/app (accessed 25/11/25)

Table 4.3: APIS background concentrations (µg/m³)

Grid square	Ecologically sensitive site	NO_x	SO_2
537500, 212500	Lee Valley SPA/Ramsar	13.4	1.3
538500, 209500		16.7	2.0
542500, 217500	Wynches Park LWS, Gingercross Farm Meadow LWS	10.3	0.9
542500, 220500	Lordship Farm LWS	9.6	0.8
543500, 217500	Mill Wood AW/LWS, Perry Green Churchyard LWS	10.2	0.9
543500, 218500	Sidehill Wood AW/LWS, Hillcrest Meadow LWS, Dane Wood LWS	10.1	0.9
544500, 217500	South End Roadside Pond LWS	10.2	0.9
544500, 218500	Green Tye Pond LWS	10.1	0.9
545500, 218500	Mathams Wood AW/LWS	10.3	0.9
545500, 219500	Jobbers Wood AW/LWS	10.3	0.9

4.4 Surface roughness

A surface roughness length is used in the model to characterise the surrounding area in terms of the effects it will have on wind speed and turbulence, which are key components of the modelling. A surface roughness value of 0.3 m was used for the modelled area, which represents the agricultural land use around the farm. A surface roughness value of 0.2 m was used for the Met Office Andrewsfield station. See Section 6 for further information regarding the meteorological data used in the modelling.

5 Modelled stack and emissions data

5.1 Modelled stacks

Emissions from the four CHP engine stacks have been modelled assuming continuous emissions throughout the year. Emission rates have been calculated based on the appropriate Emission Limit Values (ELVs); for NO_x and SO_2, these come from the Medium Combustion Plant Directive[4], for CO and VOCs, these values were provided by the client. This should represent a conservative modelling case, so long as the ELVs are met.

Table 5.1 shows the modelled CHP engine stack parameters. Table 5.2 shows the modelled emission rates.

The four CHP engines are MWM engines, running on biogas, and will be supplied and maintained by Edina. CHP engines 1 and 2 are rated at 600 kW, and CHP engines 3 and 4 are rated at 200 kW. However, the same emissions data have been assumed for CHP engines 3 and 4 as for CHP engine 1.

Note that the CHP engines may run with or without the heat exchanger. The case with the heat exchanger has been modelled, as this is the worst case with regard to efflux temperature and velocity.

Table 5.1: CHP engine stack parameters

Parameter	CHP engine 1	CHP engine 2	CHP engine 3	CHP engine 4
Stack location (x,y)	544160, 218577	544153, 218576	544180, 218574	544165, 218580
Stack height (m)	6.1	7.6	6.1	6.8
Diameter (m)	0.273	0.273	0.273	0.273
Temperature (°C)	180	180	180	180
Normalised volume flow rate[5] (m^3/hr)	1864	2237	1864	1864
Actual volume flow rate (m^3/hr)	3495	4183	3495	3495
Exit velocity (m/s)	16.6	19.9	16.6	16.6

Table 5.2: CHP engine stack emission rates

s	NO_x	SO_2	CO	VOCs
ELV[5] (mg/Nm^3)	190	60 / 40 [6]	1400	1000
Emission rates for CHP engines 1 and 3 (g/s)	0.098	0.031	0.725	0.518
Emission rates for CHP engine 2 (g/s)	0.118	0.037	0.870	0.621
Emission rates for CHP engine 4 (g/s)	0.098	0.021	0.725	0.518

[4] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32015L2193
[5] At 273.15 K, 101.3 kPa, 5% oxygen, dry
[6] 60 mg/Nm^3 for existing CHP engines (engines 1-3); 40 mg/Nm^3 for new CHP engines (engine 4)

5.2 Modelled buildings

Buildings that are relatively close to the modelled stack and taller than one third of the stack height can have an effect on dispersion, by disturbing wind flows and increasing turbulence. Increased concentrations can also occur when pollutants are entrained into the region downwind of a building, but concentrations are consequently decreased further away as the plume, travelling downstream, is further diluted.

The parameters of the buildings included in the modelling are given in Table 5.3. Buildings data were taken from the previous modelling assessment carried out by CERC for this site (*'FM1173_Wiser_CERC_R2_21Mar18'*).

Table 5.3: Modelled building data

Name	Coordinates of building centre		Height (m)	Length (m)	Width (m)	Angle of length to north (°)	Main building for source
	x	y					
Tank 1	544179	218567	3	9	4	118	-
Tank 2	544192	218561	3	16	3.5	115	-
Tank 3	544210	218553	3	16	3.5	115	-
Greenhouse 1	544224	218594	6	68	65	119	-
Greenhouse 2	544122.5	218557	4	46	49	120	-
Greenhouse 3	544169	218526	4	20	55	111	-
Greenhouse 4	544204	218513	6	26	54	111	-
Greenhouse 5	544237	218500	4	21	55	111	-
Engine room 1	544159	218573	3	14	3	115	CHP 1
Engine room 2	544165	218574	3	12.5	2.5	115	CHP 2
Engine room 3	544184.5	218571.5	4.5	15	8	115	CHP 3, 4
Building	544199	218563	4.5	15	5	115	-
Anaerobic digester plant	544275	218575	5	21	34	114	-
Farm buildings	544262	218547	7	23	28	114	-
Accommodation	544128.5	218593	4	12	10.5	118	-

For each modelled source, ADMS 6 allows a main building to be selected that is expected to have greatest impact on the dispersion from that stack. The main building chosen for each CHP was the adjacent engine room; for CHP 4, this was Engine Room 3. These main buildings were selected based on the distance between each stack and site buildings, and their relative heights.

The modelled buildings and stacks are shown on Figure 5.1.

Figure 5.1: Site layout showing relative locations of modelled sources and buildings

6 Meteorological data

Modelling was carried out using hourly sequential meteorological data obtained from the Met Office Andrewsfield station, for the years 2019 to 2023 inclusive. The station is located approximately 25 km east of Green Tye Farm. These data give a good representation of the meteorological conditions at the modelled location.

A surface roughness length of 0.2 metres was used to characterise the Andrewsfield meteorological station. The value is representative of agricultural areas, considered appropriate for the surrounding land use.

The hours of meteorological data used in the analysis exclude hours of calm, hours of variable wind direction and unavailable data. A summary of the data used is given below in Table 6.1. The ADMS meteorological pre-processor, written by the UK Met Office, uses the meteorological data to calculate the parameters required by the model.

Table 6.1: Summary of meteorological data used

Year	Percentage used	Parameter	Minimum	Maximum	Mean
2019	96.8	Temperature (°C)	-6.2	34.5	10.6
		Wind speed (m/s)	0	17.5	4.1
		Cloud cover (oktas)	0	8	4.5
2020	98.1	Temperature (°C)	-2.4	33.7	11.1
		Wind speed (m/s)	0	17.5	4.5
		Cloud cover (oktas)	0	8	4.3
2021	95.0	Temperature (°C)	-4.0	29.0	10.4
		Wind speed (m/s)	0	16.5	3.9
		Cloud cover (oktas)	0	8	5.0
2022	97.3	Temperature (°C)	-10.1	36.2	11.4
		Wind speed (m/s)	0	21.1	4.0
		Cloud cover (oktas)	0	8	4.2
2023	96.6	Temperature (°C)	-5.1	31.6	11.1
		Wind speed (m/s)	0	16.5	4.2
		Cloud cover (oktas)	0	8	4.8

Figure 6.1 shows wind roses for Andrewsfield for the years 2019 to 2023, giving the frequency of occurrence of wind from different directions for a number of wind speed ranges.

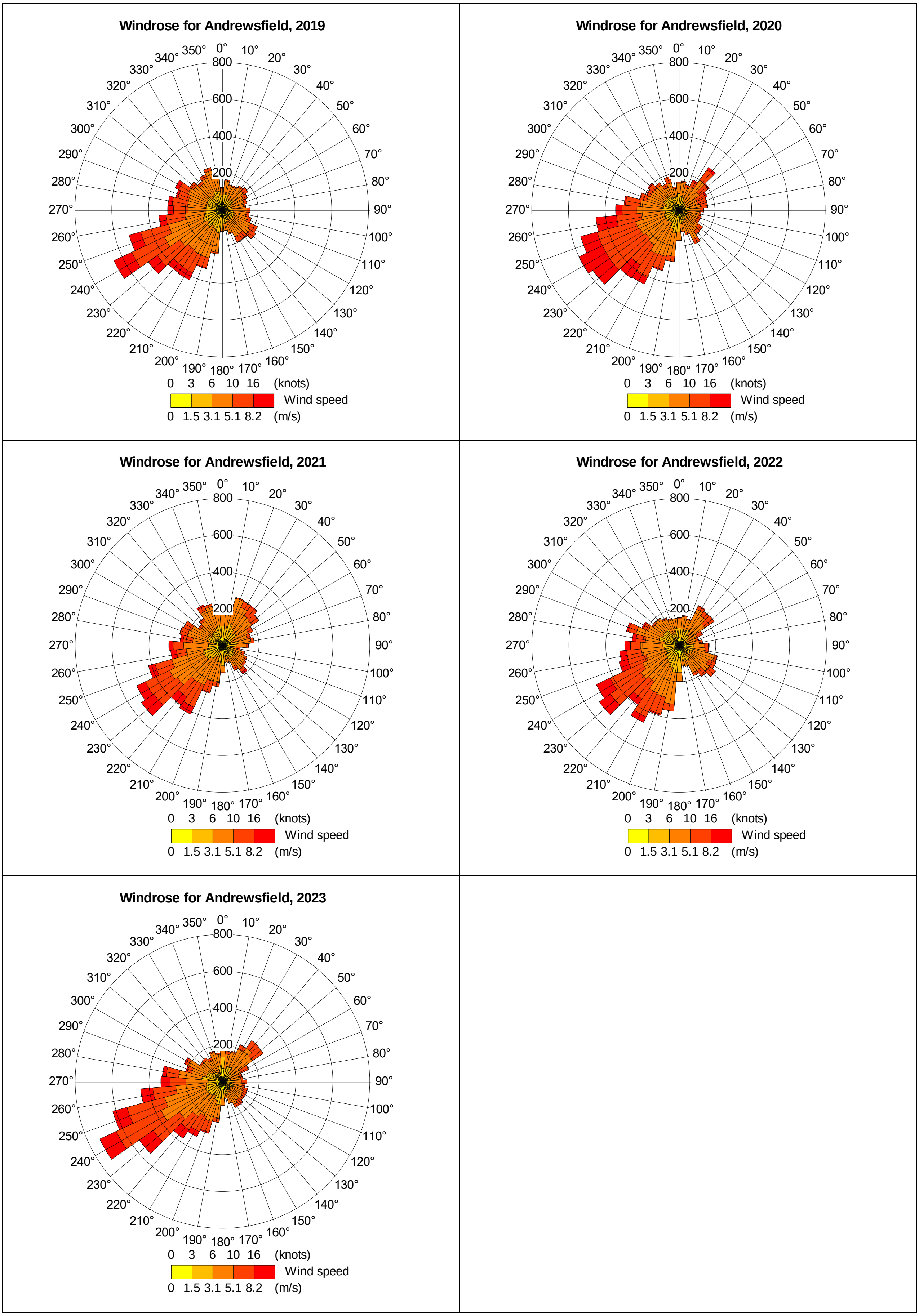

Figure 6.1: Wind roses for Andrewsfield

7 Consideration of objectives for the protection of human health

Ground-level concentrations were calculated on an output grid extending 2 km by 2 km, capturing the maximum predicted offsite concentrations, with a resolution of 10 m, as well as at a set of nine residential receptors.

Modelling was carried out to predict the Process Contribution (PC) to concentrations of NO_2, SO_2, CO and VOCs.

Nitrogen oxides (NO_x) comprise nitric oxide (NO) and nitrogen dioxide (NO_2); only NO_2 poses a threat to human health. The PC to NO_2 concentrations depends on the concentrations of NO_x due to other sources in the area and the chemical reactions taking place between NO and NO_2.

An empirical relationship defined by the Environment Agency was used to calculate the NO_2 PEC, for direct comparison against the objectives for NO_2. This method assumes that a fixed proportion of the PC (and contribution from the existing boilers) of NO_x is NO_2 (70% for the annual average and 35% for the 99.79^{th} percentile of hourly averages). The NO_2 PEC is calculated by adding the annual average NO_2 background concentration to the annual average NO_2 PC, and twice the annual average background concentration of NO_2 to the 99.79^{th} percentile of hourly average PC.

The significance of the total pollutant release was assessed by comparing the PC to the relevant air quality objective. For long-term objectives, the Environment Agency considers the release to be insignificant if the PC is less than 1% of the air quality standard[7]. For short-term objectives, including percentiles, the Agency considers the release to be insignificant if the PC is less than 10% of the air quality standard. Where a release is insignificant, the pollutant is screened out and no further assessment of levels of that pollutant undertaken. Where a release is significant, the Predicted Environmental Concentration (PEC) was calculated.

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

7.1 NO_2 concentrations

Table 7.1 shows the maximum annual average Process Contributions (PCs) and Predicted Environmental Concentrations (PECs) of NO_2 using meteorological data for the years 2019 to 2023, at offsite locations across the modelled area. The PCs exceed the Environment Agency screening criterion of 1% of the objective value, so the PECs were calculated using a background concentration of 6.5 µg/m^3. Predicted concentrations are well below the objective for all five years of meteorological data.

Table 7.1: Maximum annual average NO_2 PCs and PECs (µg/m^3), offsite

Year	Objective value	PC					PEC	
		NO_x	NO_2[8]	% of objective	Screened out?	Location (x, y)	NO_2	% of objective
2019	40	6.6	4.6	12	No	544280, 218660	11.1	28
2020		6.6	4.6	12		544280, 218660	11.1	28
2021		6.7	4.7	12		544110, 218520	11.2	28
2022		5.9	4.1	10		544110, 218520	10.6	27
2023		7.3	5.1	13		544280, 218660	11.6	29

Table 7.2 presents the maximum annual average PCs and PECs of NO_2 at each of the sensitive receptors, over the five years of meteorological data. The PCs exceed the Environment Agency screening criterion of 1% of the objective value at six of the receptors, so the PECs were calculated. Predicted concentrations are well below the objective value.

Table 7.2: Maximum annual average NO_2 PCs and PECs (µg/m^3), residential receptors

Receptor	Objective value	PC				PEC	
		NO_x	NO_2[8]	% of objective	Screened out?	NO_2	% of objective
Redmire Cottage	40	2.9	2.0	5	No	8.5	21
Hoplands House		1.4	1.0	3	No	7.5	19
Green Tye Farm		0.9	0.6	2	No	7.1	18
Spring Farm		0.8	0.6	2	No	7.1	18
Hillcrest		0.7	0.5	1	No	7.0	18
Daneswood		0.1	0.1	< 1	Yes	-	-
Daneswood Cottage		0.2	0.1	< 1	Yes	-	-
Ardbrin		0.5	0.4	1	Yes	-	-
Grudds Farm		1.1	0.8	2	No	7.3	18

[8] Assuming 70% of total NO_x PC for long-term concentrations

A contour plot of the PC to annual average NO_2 concentrations, based on 2023 meteorological data, is shown in Figure 7.1. The highest predicted concentrations occur close to the modelled sources, around the site buildings.

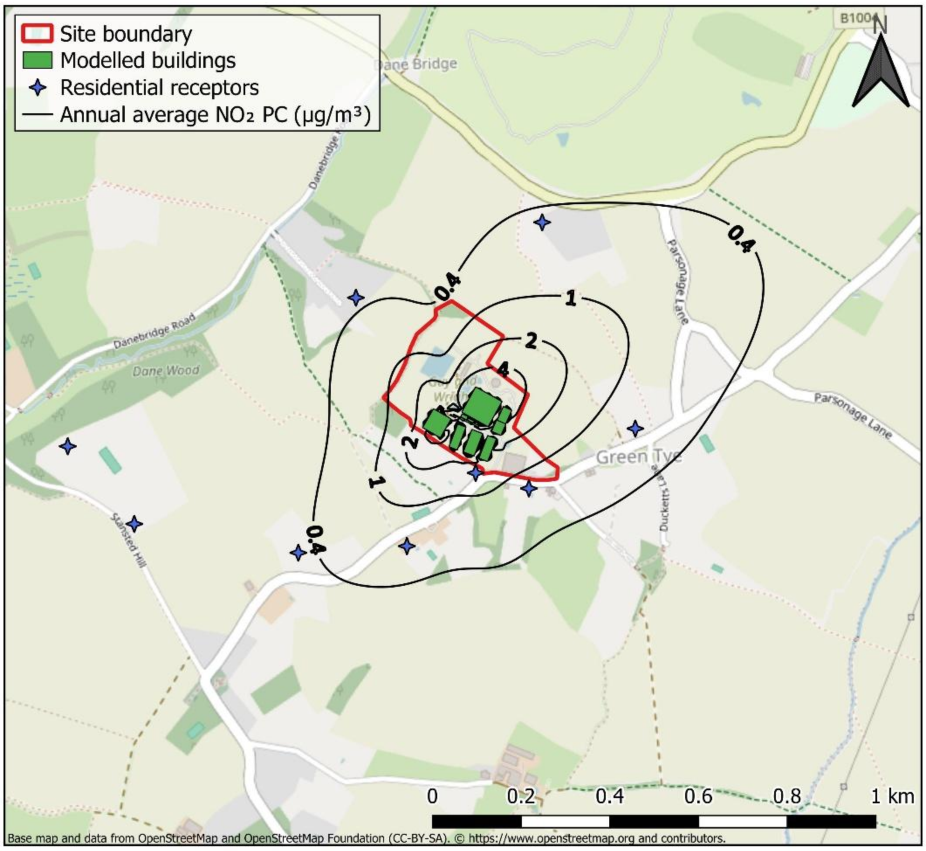

Figure 7.1: Annual average NO_2 PC (µg/m³), 2023 meteorological data

Table 7.3 shows the maximum short-term PCs and PECs of NO_2 using meteorological data for the years 2019 to 2023, across the modelled area. The PCs exceed the Environment Agency screening criterion of 10% of the objective value, so the PECs were calculated using double the long-term background concentration, 13 µg/m³. There are no predicted exceedences; the maximum PEC is 71 µg/m³, 36% of the objective value.

Table 7.3: Maximum 99.79th percentile of hourly average NO_2 PCs and PECs (µg/m³), offsite

Year	Objective value	PC					PEC	
		NO_x	NO_2[9]	% of objective	Screened out?	Location (x, y)	NO_2	% of objective
2019	200	158	55	28	No	544100, 218530	68	34
2020		162	57	29		544100, 218530	70	35
2021		163	57	29		544100, 218530	70	35
2022		165	58	29		544100, 218530	71	36
2023		163	57	29		544100, 218530	70	35

[9] Assuming 35% of total NO_x PC for short-term concentrations

Table 7.4 presents the maximum short-term PCs and PECs of NO_2 at each of the sensitive receptors, over the five years of meteorological data. The PCs are less than 10% of the objective value, so are screened out.

Table 7.4: Maximum 99.79th percentile of hourly average NO_2 PCs (µg/m^3), residential receptors

Receptor	Objective value	PC			
		NO_x	NO_2[9]	% of objective	Screened out?
Redmire Cottage	200	46.9	16.4	8	Yes
Hoplands House		28.5	10.0	5	Yes
Green Tye Farm		18.7	6.5	3	Yes
Spring Farm		16.1	5.6	3	Yes
Hillcrest		18.8	6.6	3	Yes
Daneswood		7.8	2.7	1	Yes
Daneswood Cottage		7.8	2.7	1	Yes
Ardbrin		15.2	5.3	3	Yes
Grudds Farm		22.1	7.7	4	Yes

A contour plot of the PC to 99.79th percentile of hourly average NO_2 concentrations, based on 2022 meteorological data, is shown in Figure 7.2. The highest predicted concentrations occur close to the modelled sources, around the site buildings.

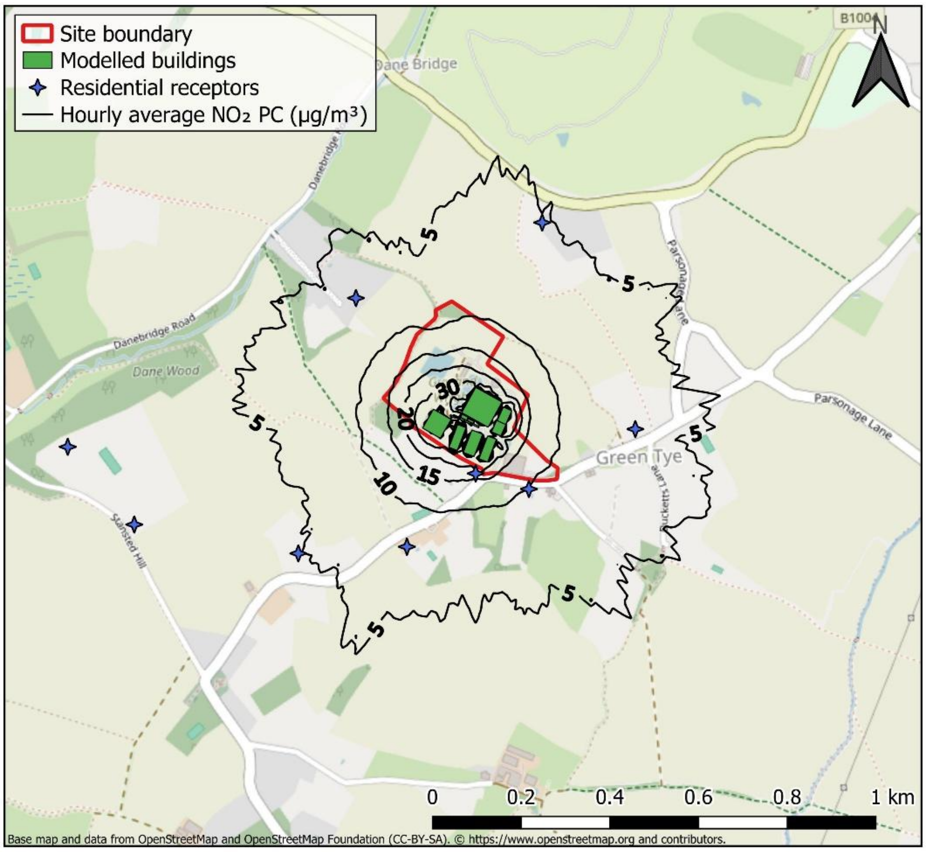

Figure 7.2: Hourly average NO_2 PC (µg/m^3), 2022 meteorological data

7.2 SO_2 concentrations

Table 7.5 shows the maximum 15-minute average PCs and PECs of SO_2 using meteorological data for the years 2019 to 2023, at offsite locations across the modelled area.

The SO_2 PCs exceed the Environment Agency screening criterion of 10% of the objective value, so the PECs were calculated using double the long-term background concentration, 1.6 µg/m^3. Predicted concentrations are well below the objective for all five years of meteorological data.

Table 7.5: Maximum 99.9th percentile of 15-minute average SO_2 PCs and PECs (µg/m^3)

Year	Objective value	PC				PEC	
		SO_2	% of objective	Screened out?	Location (x, y)	SO_2	% of objective
2019	266	48.7	18	No	544100, 218530	50.3	19
2020		49.4	19		544100, 218530	51.0	19
2021		49.9	19		544100, 218530	51.5	19
2022		50.4	19		544100, 218530	52.0	20
2023		49.6	19		544100, 218530	51.2	19

Table 7.6 shows the maximum 15-minute average PCs of SO_2 over the five years of meteorological data, at residential receptors. The PCs are screened out, as they are less than 10% of the objective value.

Table 7.6: Maximum 99.9th percentile of 15-minute average SO_2 PCs (µg/m^3), residential receptors

Receptor	Objective value	PC		
		SO_2	% of objective	Screened out?
Redmire Cottage	266	15.4	6	Yes
Hoplands House		10.4	4	Yes
Green Tye Farm		8.8	3	Yes
Spring Farm		7.4	3	Yes
Hillcrest		8.1	3	Yes
Daneswood		3.8	1	Yes
Daneswood Cottage		4.1	2	Yes
Ardbrin		7.3	3	Yes
Grudds Farm		9.0	3	Yes

Table 7.7 shows the maximum hourly average PCs and PECs of SO_2 using meteorological data for the years 2019 to 2023, at offsite locations across the modelled area.

The SO_2 PCs exceed the Environment Agency screening criterion of 10% of the objective value, so the PECs were calculated using double the long-term background concentration, 1.6 µg/m^3. Predicted concentrations are well below the objective for all five years of meteorological data.

Table 7.7: Maximum 99.73rd percentile of hourly average SO_2 PCs and PECs (µg/m^3)

Year	Objective value	PC				PEC	
		SO_2	% of objective	Screened out?	Location (x, y)	SO_2	% of objective
2019	350	44.6	13	No	544100, 218530	46.2	13
2020		45.9	13		544100, 218530	47.5	14
2021		46.0	13		544100, 218530	47.6	14
2022		46.9	13		544100, 218530	48.5	14
2023		46.5	13		544100, 218530	48.1	14

Table 7.8 shows the maximum hourly average PCs of SO_2 over the five years of meteorological data, at residential receptors. The PCs are screened out, as they are less than 10% of the objective value.

Table 7.8: Maximum 99.73rd percentile of hourly average SO_2 PCs (µg/m^3), residential receptors

Receptor	Objective value	PC		
		SO_2	% of objective	Screened out?
Redmire Cottage	350	13.6	4	Yes
Hoplands House		8.0	2	Yes
Green Tye Farm		5.3	2	Yes
Spring Farm		4.6	1	Yes
Hillcrest		5.4	2	Yes
Daneswood		2.1	1	Yes
Daneswood Cottage		1.9	1	Yes
Ardbrin		4.2	1	Yes
Grudds Farm		6.3	2	Yes

Table 7.9 shows the maximum daily average PCs and PECs of SO_2 using meteorological data for the years 2019 to 2023, at offsite locations across the modelled area.

The SO_2 PCs exceed the Environment Agency screening criterion of 10% of the objective value, so the PECs were calculated using double the long-term background concentration, 1.6 μg/m³. Predicted concentrations are well below the objective for all five years of meteorological data.

Table 7.9: Maximum 99.18th percentile of daily average SO_2 PCs and PECs (μg/m³)

Year	Objective value	PC				PEC	
		SO_2	% of objective	Screened out?	Location (x, y)	SO_2	% of objective
2019	125	22.6	18	No	544100, 218530	24.2	19
2020		21.4	17		544110, 218520	23.0	18
2021		21.6	17		544110, 218520	23.2	19
2022		23.0	18		544100, 218530	24.6	20
2023		25.8	21		544110, 218520	27.4	22

Table 7.10 shows the maximum daily average PCs of SO_2 over the five years of meteorological data, at residential receptors. The PCs are screened out, as they are less than 10% of the objective value.

Table 7.10: Maximum 99.18th percentile of daily average SO_2 PCs and PECs (μg/m³), residential receptors

Receptor	Objective value	PC		
		SO_2	% of objective	Screened out?
Redmire Cottage	125	8.7	7	Yes
Hoplands House		3.8	3	Yes
Green Tye Farm		1.9	2	Yes
Spring Farm		1.6	1	Yes
Hillcrest		2.0	2	Yes
Daneswood		0.5	< 1	Yes
Daneswood Cottage		0.6	< 1	Yes
Ardbrin		1.5	1	Yes
Grudds Farm		3.1	2	Yes

Contour plots of the PCs to the 99.9th percentile of 15-minute average, the 99.73rd percentile of hourly average and the 99.18th percentile of daily average SO_2 concentrations, based on the worst case year of meteorological data in each case, are shown in Figures 7.3 to 7.5.

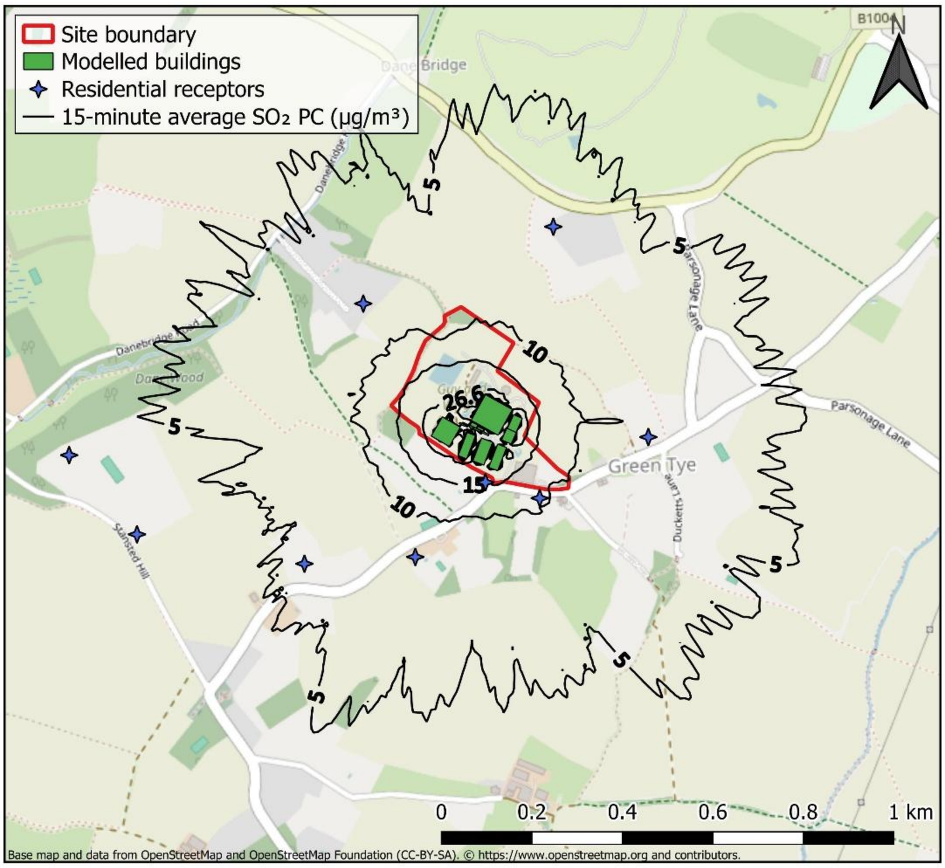

Figure 7.3: 15-minute average SO_2 PC (µg/m³), 2022 meteorological data

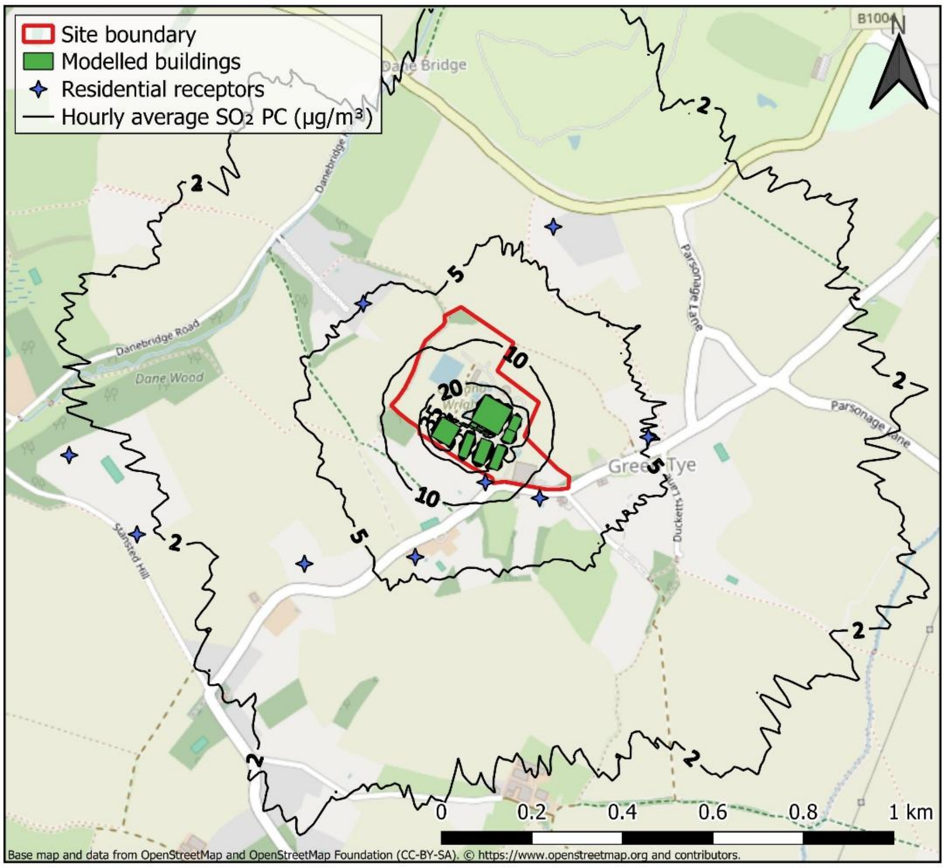

Figure 7.4: Hourly average SO_2 PC (µg/m³), 2022 meteorological data

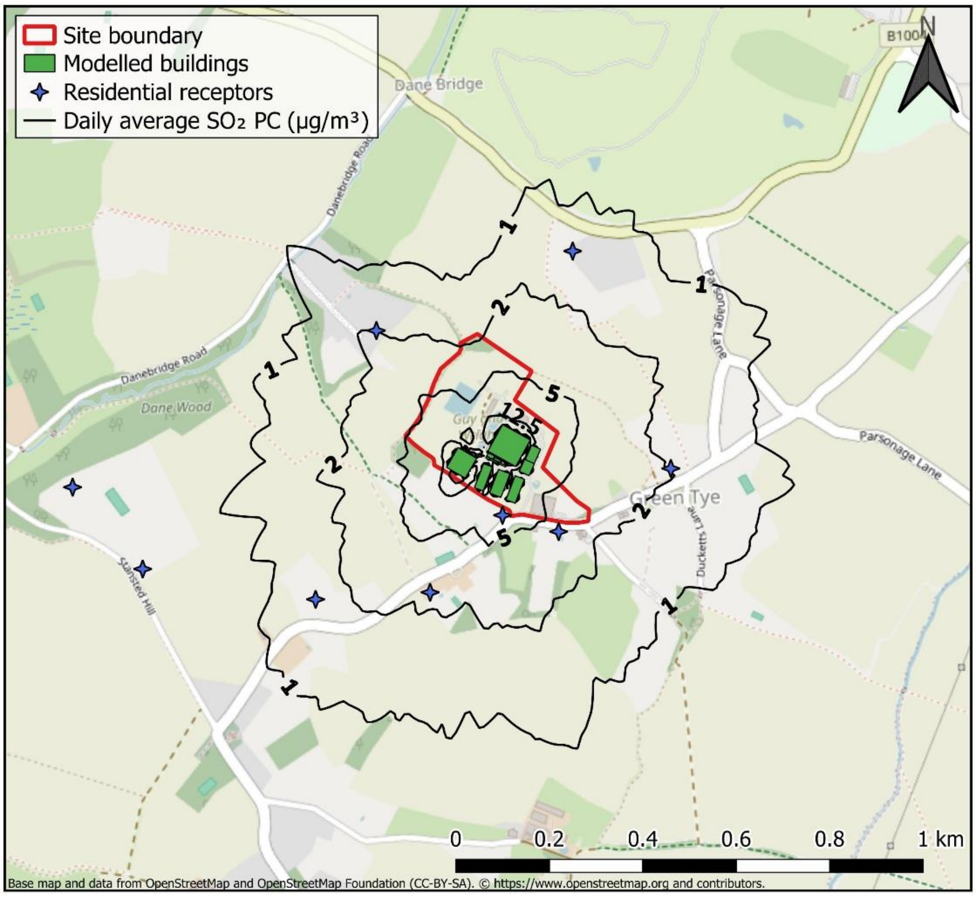

Figure 7.5: Daily average SO_2 PC (µg/m³), 2023 meteorological data

7.3 CO concentrations

Table 7.11 shows the maximum 8-hour average PCs of CO using meteorological data for the years 2019 to 2023, at offsite locations across the modelled area.

The CO PCs are screened out as they are lower than the Environment Agency screening criterion of 10% of the objective value.

Table 7.11: Maximum daily running 8-hour average CO PCs (µg/m³)

Year	Objective value	PC			
		CO	% of objective	Screened out?	Location (x, y)
2019	10,000	828	8	Yes	544100, 218530
2020		939	9		544100, 218530
2021		894	9		544100, 218530
2022		916	9		544100, 218530
2023		966	10		544100, 218530

7.4 VOC concentrations

Tables 7.12 and 7.13 show the maximum annual and hourly average PCs of VOCs, respectively, using meteorological data for the years 2019 to 2023, at offsite locations across the modelled area. There are no air quality objectives for VOCs as a group of pollutants. The VOCs are likely to consist mainly of methane, for which there are no air quality standards for the protection of human health.

Table 7.12: Maximum annual average VOC PCs (µg/m³)

Year	Concentration of VOCs	Location (x, y)
2019	35	544280, 218660
2020	35	544280, 218660
2021	36	544110, 218520
2022	31	544110, 218520
2023	38	544280, 218660

Table 7.13: Maximum hourly average VOC PCs (µg/m³)

Year	Concentration of VOCs	Location (x, y)
2019	916	544100, 218530
2020	920	544100, 218530
2021	921	544100, 218530
2022	923	544100, 218530
2023	924	544100, 218530

8 Consideration of critical levels for the Protection of Vegetation and Ecosystems

Concentrations of NO_x and SO_2 were calculated at the location of all identified ecologically sensitive sites for comparison with critical levels for the protection of vegetation and ecosystems.

The significance of the total pollutant release was assessed by comparing the PC to the relevant critical level. For long-term standards, the Environment Agency considers the release to be insignificant if the PC is less than 1% of the air quality standard[7]. For short-term standards, the Agency considers the release to be insignificant if the PC is less than 10% of the air quality standard. Where a release is insignificant, the pollutant is screened out and no further assessment of levels of that pollutant undertaken. Where a release is significant, the Predicted Environmental Concentration (PEC) was calculated.

8.1 NO_x concentrations

Table 8.1 shows the maximum annual average PCs and PECs of NO_x within the ecologically sensitive sites, using meteorological data for the years 2019 to 2023.

The annual average PCs are screened out as insignificant for all years of meteorological data at Lee Valley Ramsar/SPA and at most of the areas of Ancient Woodland and LWSs.

The PCs are not screened out at the following four sites:

- Sidehill Wood AW (one out of the five modelled years);
- Hillcrest Meadow LWS;
- Green Tye Pond LWS; and
- Dane Wood LWS (two out of the five modelled years).

The PCs are less than 5% of the critical level at these sites. Taking into account a background concentration for each location, the resulting PECs at these sites are between 35% and 38% of the annual average critical level for NO_x.

Table 8.1: Maximum annual average NO_x concentrations at ecologically sensitive sites ($\mu g/m^3$)

Site	Year	Critical level	PC	PC as % of critical level	Screened out?	Background	PEC	PEC as % of critical level
Lee Valley Ramsar/ SPA	2019	30	0.01	< 0.1	Yes	-	-	-
	2020		0.01					
	2021		0.01					
	2022		0.01					
	2023		0.01					
Sidehill Wood AW	2019	30	0.27	0.9	Yes	10.1	-	-
	2020		0.21	0.7	Yes		-	-
	2021		0.18	0.6	Yes		-	-
	2022		0.31	1.0	No		10.4	35
	2023		0.21	0.7	Yes		-	-
Hillcrest Meadow LWS	2019	30	0.6	2.1	No	10.1	10.7	35 - 36
	2020		0.6	1.9			10.7	
	2021		0.5	1.7			10.6	
	2022		0.6	2.0			10.7	
	2023		0.5	1.6			10.6	
Green Tye Pond LWS	2019	30	1.4	5	No	10.1	11.5	37 - 38
	2020		1.1	4			11.2	
	2021		1.1	4			11.2	
	2022		1.2	4			11.3	
	2023		1.1	4			11.2	
Perry Green Churchyard LWS	2019	30	0.2	0.6	Yes	-	-	-
	2020		0.2	0.7				
	2021		0.3	0.8				
	2022		0.2	0.7				
	2023		0.2	0.8				
Dane Wood LWS	2019	30	0.33	1.1	No	10.1	10.4	35
	2020		0.21	0.7	Yes		-	-
	2021		0.22	0.7	Yes		-	-
	2022		0.36	1.2	No		10.5	35
	2023		0.22	0.7	Yes		-	-
Mathams Wood AW/LWS	2019	30	0.1	0.4	Yes	-	-	-
	2020		0.1	0.5				
	2021		0.1	0.4				
	2022		0.1	0.4				
	2023		0.2	0.5				
Jobbers Wood AW/LWS	2019	30	0.2	0.5	Yes	-	-	-
	2020		0.1	0.4				
	2021		0.1	0.5				
	2022		0.1	0.4				
	2023		0.2	0.5				

Table 8.1: continued

Site	Year	Critical level	PC	PC as % of critical level	Screened out?	Background	PEC	PEC as % of critical level
Mill Wood AW/LWS	2019	30	0.08	0.3	Yes	-	-	-
	2020		0.08	0.3				
	2021		0.10	0.3				
	2022		0.08	0.3				
	2023		0.09	0.3				
Sidehill Wood (Hadham Cross) LWS	2019	30	0.11	0.4	Yes	-	-	-
	2020		0.12	0.4				
	2021		0.14	0.5				
	2022		0.10	0.3				
	2023		0.10	0.3				
Lordship Farm LWS	2019	30	0.05	0.2	Yes	-	-	-
	2020		0.04	0.1				
	2021		0.04	0.1				
	2022		0.05	0.2				
	2023		0.04	0.1				
Gingercross Farm Meadow LWS	2019	30	0.07	0.2	Yes	-	-	-
	2020		0.06	0.2				
	2021		0.08	0.3				
	2022		0.06	0.2				
	2023		0.07	0.2				
Wynches Park LWS	2019	30	0.04	0.1	Yes	-	-	-
	2020		0.04	0.1				
	2021		0.05	0.2				
	2022		0.04	0.1				
	2023		0.04	0.1				
South-End Roadside Pond	2019	30	0.07	0.2	Yes	-	-	-
	2020		0.07	0.2				
	2021		0.10	0.3				
	2022		0.07	0.2				
	2023		0.08	0.3				

Table 8.2 shows the maximum daily average PCs of NO_x within the ecologically sensitive sites, using meteorological data for the years 2019 to 2023. As advised by the Environment Agency, the background concentration of NO_x has not been added to the daily average PC.

The daily average PCs are screened out as insignificant for all years of meteorological data at Lee Valley Ramsar/SPA, all areas of Ancient Woodland, and the majority of LWSs.

The PCs are not screened out at the following two sites:

- Hillcrest Meadow LWS (two of the five modelled years); and
- Green Tye Pond LWS.

The maximum PCs are 11% and 23% of the critical level at these sites, respectively.

Table 8.2: Maximum daily average NO_x concentrations at ecologically sensitive sites ($\mu g/m^3$)

Site	Year	Critical level	PC	PC as % of critical level	Screened out?
Lee Valley Ramsar/ SPA	2019	75	0.2	< 1	Yes
	2020		0.2		
	2021		0.3		
	2022		0.3		
	2023		0.3		
Sidehill Wood AW	2019	75	4.4	6	Yes
	2020		3.5	5	
	2021		2.5	3	
	2022		5.0	7	
	2023		3.5	5	
Hillcrest Meadow LWS	2019	75	6.4	9	Yes
	2020		8.5	11	No
	2021		6.7	9	Yes
	2022		6.1	8	Yes
	2023		7.9	11	No
Green Tye Pond LWS	2019	75	14.8	20	No
	2020		10.9	15	
	2021		10.8	14	
	2022		11.9	16	
	2023		17.5	23	
Perry Green Churchyard LWS	2019	75	2.4	3	Yes
	2020		2.4	3	
	2021		2.2	3	
	2022		2.6	3	
	2023		2.6	3	
Dane Wood LWS	2019	75	4.1	5	Yes
	2020		3.5	5	
	2021		2.8	4	
	2022		5.1	7	
	2023		3.0	4	
Mathams Wood AW/LWS	2019	75	0.9	1	Yes
	2020		1.0	1	
	2021		1.0	1	
	2022		1.3	2	
	2023		1.2	2	
Jobbers Wood AW/LWS	2019	75	1.0	1	Yes
	2020		0.7	1	
	2021		1.0	1	
	2022		1.1	1	
	2023		1.2	2	

Table 8.2: continued

Site	Year	Critical level	PC	PC as % of critical level	Screened out?
Mill Wood AW/LWS	2019	75	1.3	2	Yes
	2020		0.9	1	
	2021		1.5	2	
	2022		1.1	1	
	2023		1.0	1	
Sidehill Wood (Hadham Cross) LWS	2019	75	1.8	2	Yes
	2020		2.0	3	
	2021		2.2	3	
	2022		1.6	2	
	2023		1.9	3	
Lordship Farm LWS	2019	75	0.7	1	Yes
	2020		0.6	1	
	2021		1.0	1	
	2022		0.6	1	
	2023		0.5	1	
Gingercross Farm Meadow LWS	2019	75	1.1	1	Yes
	2020		0.7	1	
	2021		1.2	2	
	2022		0.8	1	
	2023		0.8	1	
Wynches Park LWS	2019	75	0.6	1	Yes
	2020		0.5	1	
	2021		0.6	1	
	2022		0.5	1	
	2023		0.7	1	
South-End Roadside Pond	2019	75	1.0	1	Yes
	2020		1.4	2	
	2021		1.2	2	
	2022		1.2	2	
	2023		1.5	2	

8.2 SO_2 concentrations

Table 8.3 shows the maximum annual average PCs and PECs of SO_2 within the ecologically sensitive sites, using meteorological data for the years 2019 to 2023.

The annual average PCs are screened out as insignificant for all years of meteorological data at Lee Valley Ramsar/SPA and at all areas of Ancient Woodland and LWSs, except for Green Tye Pond LWS.

The maximum PC is 2% of the critical level. Taking into account the background concentration, the resulting PEC is 4% of the annual average critical level for SO_2.

Table 8.3: Maximum annual average SO_2 concentrations at ecologically sensitive sites ($\mu g/m^3$)

Site	Year	Critical level	PC	PC as % of critical level	Screened out?	Background	PEC	PEC as % of critical level
Lee Valley Ramsar/ SPA	2019	20	0.004	< 0.1	Yes	-	-	-
	2020		0.003					
	2021		0.004					
	2022		0.004					
	2023		0.004					
Sidehill Wood AW	2019	20	0.08	0.4	Yes	-	-	-
	2020		0.06	0.3				
	2021		0.05	0.3				
	2022		0.09	0.5				
	2023		0.06	0.3				
Hillcrest Meadow LWS	2019	20	0.18	0.9	Yes	-	-	-
	2020		0.17	0.9				
	2021		0.15	0.8				
	2022		0.18	0.9				
	2023		0.14	0.7				
Green Tye Pond LWS	2019	20	0.40	2	No	0.9	1.3	4
	2020		0.32	2			1.2	
	2021		0.33	2			1.2	
	2022		0.34	2			1.2	
	2023		0.32	2			1.2	
Perry Green Churchyard LWS	2019	20	0.05	0.3	Yes	-	-	-
	2020		0.06	0.3				
	2021		0.07	0.4				
	2022		0.06	0.3				
	2023		0.07	0.4				
Dane Wood LWS	2019	20	0.10	0.5	Yes	-	-	-
	2020		0.06	0.3				
	2021		0.06	0.3				
	2022		0.10	0.5				
	2023		0.06	0.3				

Table 8.3: continued

Site	Year	Critical level	PC	PC as % of critical level	Screened out?	Background	PEC	PEC as % of critical level
Mathams Wood AW/LWS	2019	20	0.04	0.2	Yes	-	-	-
	2020		0.04	0.2				
	2021		0.04	0.2				
	2022		0.04	0.2				
	2023		0.04	0.2				
Jobbers Wood AW/LWS	2019	20	0.04	0.2	Yes	-	-	-
	2020		0.04	0.2				
	2021		0.04	0.2				
	2022		0.03	0.2				
	2023		0.05	0.3				
Mill Wood AW/LWS	2019	20	0.02	0.1	Yes	-	-	-
	2020		0.02	0.1				
	2021		0.03	0.2				
	2022		0.02	0.1				
	2023		0.03	0.2				
Sidehill Wood (Hadham Cross) LWS	2019	20	0.03	0.2	Yes	-	-	-
	2020		0.04	0.2				
	2021		0.04	0.2				
	2022		0.03	0.2				
	2023		0.03	0.2				
Lordship Farm LWS	2019	20	0.01	0.1	Yes	-	-	-
	2020		0.01	0.1				
	2021		0.01	0.1				
	2022		0.02	0.1				
	2023		0.01	0.1				
Gingercross Farm Meadow LWS	2019	20	0.02	0.1	Yes	-	-	-
	2020		0.02	0.1				
	2021		0.02	0.1				
	2022		0.02	0.1				
	2023		0.02	0.1				
Wynches Park LWS	2019	20	0.01	0.1	Yes	-	-	-
	2020		0.01	0.1				
	2021		0.01	0.1				
	2022		0.01	0.1				
	2023		0.01	0.1				
South-End Roadside Pond	2019	20	0.02	0.1	Yes	-	-	-
	2020		0.02	0.1				
	2021		0.03	0.2				
	2022		0.02	0.1				
	2023		0.02	0.1				

9 Consideration of critical loads for the protection of vegetation and ecosystems

Material from a plume can be lost to the ground, at the surface of the ground (dry deposition), and through wash out with precipitation (wet deposition). Deposition of pollutants may lead to detrimental effects at sensitive habitats due to acidification and nitrogen eutrophication.

The PC to the nitrogen and acid deposition rates were calculated at the location of all identified ecologically sensitive sites for comparison with critical loads for the protection of vegetation and ecosystems.

The significance of the total pollutant release was assessed by comparing the PC to the relevant critical loads. The Environment Agency considers the release to be insignificant if the PC is less than 1% of the critical load. Where a release is insignificant the impact is screened out and no further assessment undertaken.

9.1 Deposition of nitrogen

9.1.1 Critical loads and existing levels of nitrogen deposition

The APIS web site gives critical load values for specific SPAs. For areas of Ancient Woodland and LWSs, this information must be found by location.

Table 9.1 shows the habitat types, critical loads and total nitrogen deposition values at each of the ecologically sensitive sites. The total nitrogen deposition values presented represent the average deposition over the years 2020-2022, due to existing local sources and background contributions, within the relevant SPA or 1 km grid square.

Note that no critical load information was available for the habitats represented by Lordship Farm LWS, Green Tye Pond LWS or South-End Roadside Pond LWS.

Table 9.1: Total nitrogen deposition (kg N ha^{-1} yr^{-1})

Site name	Habitat type	Relevant Nitrogen critical load Class	Critical load	Total nitrogen deposition
Lee Valley Ramsar/SPA	Fen, marsh and swamp	Rich fens	15 - 25	13.76
Mathams Wood AW/LWS	Broadleaved, mixed and yew woodland	Broadleaved deciduous woodland	10 - 15	25.5
Jobbers Wood AW/LWS	Broadleaved, mixed and yew woodland	Broadleaved deciduous woodland	10 - 15	25.6
Sidehill Wood AW	Broadleaved, mixed and yew woodland	Broadleaved deciduous woodland	10 - 15	25.3
Mill Wood AW/LWS	Broadleaved, mixed and yew woodland	Broadleaved deciduous woodland	10 - 15	25.2
Dane Wood LWS	Broadleaved, mixed and yew woodland	Broadleaved deciduous woodland	10 - 15	25.3
Sidehill Wood (Hadham Cross) LWS	Broadleaved, mixed and yew woodland	Broadleaved deciduous woodland	10 - 15	25.3
Hillcrest Meadow LWS	Neutral grassland	Low and medium altitude hay meadows	10 - 20	13.4
Perry Green Churchyard LWS	Neutral grassland	Low and medium altitude hay meadows	10 - 20	13.3
Gingercross Farm Meadow LWS	Neutral grassland	Low and medium altitude hay meadows	10 - 20	13.3
Wynches Park LWS	Neutral grassland	Low and medium altitude hay meadows	10 - 20	13.3
Lordship Farm LWS	"Building and environs important for protected species" No relevant habitat identified			13.5
Green Tye Pond LWS	Standing open water and canals	No information available		13.5
South-End Roadside Pond LWS	Standing open water and canals	No information available		13.4

9.1.2 Process contribution to nitrogen deposition

The deposition of nitrogen from concentrations of NO_2 (assumed to be 70% of NO_x) was considered.

The Environment Agency Air Quality Modelling and Assessment Unit (AQMAU)[1] recommend dry deposition velocities for grassland and forest: values of 0.0015 m/s and 0.003 m/s, respectively, were used for NO_2, depending on the main habitat identified for each site. Wet deposition for this pollutant was not included, as advised by AQMAU.

The maximum predicted annual PC to deposition rates of nitrogen at each ecologically sensitive site is presented in Table 9.2, together with the PC as a percentage of the most stringent applicable critical load. The PC percentage was calculated using the lower value of the critical load range.

The contribution to nitrogen deposition is screened out as insignificant for all sites for which relevant critical load information is available.

Table 9.2: Maximum calculated nitrogen deposition (kg N ha^{-1} yr^{-1})

Site name	Critical load Class	Critical load	Year	PC	PC as % of critical load	Screened out?
Lee Valley SPA	Rich fens	15 - 25	2019	0.0008	< 0.1	Yes
			2020	0.0006		
			2021	0.0009		
			2022	0.0008		
			2023	0.0008		
Mathams Wood AW/LWS	Broadleaved deciduous woodland	10 - 15	2019	0.023	0.2 - 0.3	Yes
			2020	0.025		
			2021	0.022		
			2022	0.021		
			2023	0.027		
Jobbers Wood AW/LWS	Broadleaved deciduous woodland	10 - 15	2019	0.026	0.2 - 0.3	Yes
			2020	0.023		
			2021	0.024		
			2022	0.020		
			2023	0.028		
Sidehill Wood AW	Broadleaved deciduous woodland	10 - 15	2019	0.051	0.3 - 0.6	Yes
			2020	0.040		
			2021	0.034		
			2022	0.058		
			2023	0.040		
Mill Wood AW/LWS	Broadleaved deciduous woodland	10 - 15	2019	0.014	0.1 - 0.2	Yes
			2020	0.014		
			2021	0.018		
			2022	0.014		
			2023	0.015		

Table 9.2: continued...

Site name	Critical load class	Critical load	Year	PC	PC as % of critical load	Screened out?
Dane Wood LWS	Broadleaved deciduous woodland	10 - 15	2019	0.062	0.4 - 0.7	Yes
			2020	0.040		
			2021	0.040		
			2022	0.067		
			2023	0.042		
Sidehill Wood (Hadham Cross) LWS	Broadleaved deciduous woodland	10 - 15	2019	0.020	0.2	Yes
			2020	0.023		
			2021	0.024		
			2022	0.017		
			2023	0.018		
Hillcrest Meadow LWS	Low and medium altitude hay meadows	10 - 20	2019	0.062	0.5 - 0.6	Yes
			2020	0.057		
			2021	0.049		
			2022	0.060		
			2023	0.046		
Perry Green Churchyard LWS	Low and medium altitude hay meadows	10 - 20	2019	0.016	0.2	Yes
			2020	0.020		
			2021	0.024		
			2022	0.021		
			2023	0.023		
Gingercross Farm Meadow LWS	Low and medium altitude hay meadows	10 - 20	2019	0.006	0.1	Yes
			2020	0.006		
			2021	0.007		
			2022	0.006		
			2023	0.006		
Wynches Park LWS	Low and medium altitude hay meadows	10 - 20	2019	0.004	< 0.1	Yes
			2020	0.004		
			2021	0.004		
			2022	0.003		
			2023	0.003		
Lordship Farm LWS	Not known	-	2019	0.004	-	-
			2020	0.004		
			2021	0.004		
			2022	0.004		
			2023	0.003		
Green Tye Pond LWS	Not known	-	2019	0.137	-	-
			2020	0.107		
			2021	0.113		
			2022	0.114		
			2023	0.108		
South-End Roadside Pond LWS	Not known	-	2019	0.006	-	-
			2020	0.006		
			2021	0.009		
			2022	0.006		
			2023	0.007		

9.2 Acid deposition

9.2.1 Critical loads and existing levels of acid deposition

The APIS web site gives critical load values for specific SPAs. For areas of Ancient Woodland and LWSs, this information must be found by location.

Table 9.3 shows the habitat types, critical loads and total acid deposition values at each of the ecologically sensitive sites. The total acid deposition values presented represent the average deposition over the years 2020-2022, due to existing local sources and background contributions, within the relevant SPA or 1 km grid square. The nitrogen (N) and sulphur (S) contributions are presented.

Note that no critical load information was available for the habitats represented by Lee Valley SPA/Ramsar, Lordship Farm LWS, Green Tye Pond LWS or South-End Roadside Pond LWS.

The critical load function is defined by three quantities to account for the contribution of different species to total acid deposition. CLmaxS is the maximum critical load for acidity expressed in terms of sulphur i.e. when nitrogen deposition is zero; this value also considers non-marine chloride deposition[1]. Similarly, CLmaxN is the maximum critical load of acidity expressed in terms of nitrogen only i.e. when sulphur and non-marine chloride deposition is zero. Finally, CLminN defines a nitrogen deposition level below which additional nitrogen will not acidify the system, due to long-term nitrogen losses in the soil e.g. nitrogen uptake by vegetation.

Table 9.3: Total acid deposition (keq ha^{-1} yr^{-1})

Site name	Feature name	Acidity critical load Class	Critical load	Total acid deposition N | S
Lee Valley SPA/Ramsar	*Anas clypeata, Anas strepera* (North-western Europe)	Freshwater	Feature not sensitive to acidity	0.96 | 0.15
Mathams Wood AW/LWS	Unmanaged woodland	Broadleaved/ coniferous unmanaged woodland	CLmaxS: 10.776 CLminN: 0.214 CLmaxN: 10.99	1.82 | 0.18
Jobbers Wood AW/LWS	Unmanaged woodland	Broadleaved/ coniferous unmanaged woodland	CLmaxS: 10.78 CLminN: 0.214 CLmaxN: 10.994	1.83 | 0.18
Sidehill Wood AW	Unmanaged woodland	Broadleaved/ coniferous unmanaged woodland	CLmaxS: 10.801 CLminN: 0.214 CLmaxN: 11.015	1.81 | 0.17
Mill Wood AW/LWS	Unmanaged woodland	Broadleaved/ coniferous unmanaged woodland	CLmaxS: 10.797 CLminN: 0.214 CLmaxN: 11.011	1.80 | 0.17

Table 9.3: continued

Site name	Feature name	Acidity critical load class	Critical load	Total acid deposition N | S
Dane Wood LWS	Unmanaged woodland	Broadleaved/ coniferous unmanaged woodland	CLmaxS: 10.801 CLminN: 0.214 CLmaxN: 11.015	1.81 | 0.17
Sidehill Wood (Hadham Cross) LWS	Unmanaged woodland	Broadleaved/ coniferous unmanaged woodland	CLmaxS: 10.801 CLminN: 0.214 CLmaxN: 11.015	1.81 | 0.17
Hillcrest Meadow LWS	Calcareous grassland	Calcareous/neutral grassland	CLmaxS: 4 CLminN: 0.928 CLmaxN: 4.928	0.96 | 0.13
Perry Green Churchyard LWS	Calcareous grassland	Calcareous/neutral grassland	CLmaxS: 4 CLminN: 0.928 CLmaxN: 4.928	0.95 | 0.13
Gingercross Farm Meadow LWS	Calcareous grassland	Calcareous/neutral grassland	CLmaxS: 4 CLminN: 0.856 CLmaxN: 4.856	0.95 | 0.13
Wynches Park LWS	Calcareous grassland	Calcareous/neutral grassland	CLmaxS: 4 CLminN: 0.856 CLmaxN: 4.856	0.95 | 0.13
Lordship Farm LWS	"Buildings and environs important for protected species" No relevant habitat identified			0.97 | 0.12
Green Tye Pond LWS	Standing open water and canals	Freshwater	No information provided	0.96 | 0.13
South-End Roadside Pond LWS	Standing open water and canals	Freshwater	No information provided	0.95 | 0.13

9.2.2 Process contribution to acid deposition

The rate of acid deposition calculated in this assessment is based on the PC to acid deposition from nitrogen, presented in Section 9.1. The contributions from SO_2 are also included.

The Environment Agency AQMAU recommend dry deposition velocities for grassland and forest: values of 0.0015 m/s and 0.003 m/s were used for NO_2; and values of 0.012 m/s and 0.024 m/s were used for SO_2, depending on the main habitat identified for each site. Wet deposition for these pollutants was not included, as advised by AQMAU.

The maximum predicted annual PC to acid deposition rates at each ecologically sensitive site is presented in Table 9.4.

Table 9.4: Contributions to acid deposition (keq ha^{-1} yr^{-1}) at ecologically sensitive sites

Site name	Year	PC (N)	PC (S)
Lee Valley Ramsar/SPA	2019	0.00006	0.00015
	2020	0.00004	0.00013
	2021	0.00006	0.00017
	2022	0.00006	0.00016
	2023	0.00006	0.00016
Mathams Wood AW/LWS	2019	0.0016	0.0058
	2020	0.0018	0.0065
	2021	0.0016	0.0054
	2022	0.0015	0.0053
	2023	0.0019	0.0069
Jobbers Wood AW/LWS	2019	0.0019	0.0065
	2020	0.0016	0.0059
	2021	0.0017	0.0060
	2022	0.0015	0.0052
	2023	0.0020	0.0073
Sidehill Wood AW	2019	0.0036	0.0139
	2020	0.0029	0.0109
	2021	0.0024	0.0095
	2022	0.0041	0.0156
	2023	0.0029	0.0111
Mill Wood AW/LWS	2019	0.0010	0.0034
	2020	0.0010	0.0037
	2021	0.0013	0.0044
	2022	0.0010	0.0036
	2023	0.0011	0.0040
Dane Wood LWS	2019	0.0044	0.0167
	2020	0.0029	0.0110
	2021	0.0029	0.0110
	2022	0.0048	0.0182
	2023	0.0030	0.0113

Table 9.4: Continued...

Site name	Year	PC (N)	PC (S)
Sidehill Wood (Hadham Cross) LWS	2019	0.0014	0.0053
	2020	0.0016	0.0058
	2021	0.0017	0.0063
	2022	0.0012	0.0046
	2023	0.0013	0.0048
Hillcrest Meadow LWS	2019	0.0045	0.0189
	2020	0.0041	0.0173
	2021	0.0035	0.0148
	2022	0.0043	0.0181
	2023	0.0033	0.0140
Perry Green Churchyard LWS	2019	0.0012	0.0045
	2020	0.0015	0.0059
	2021	0.0017	0.0069
	2022	0.0015	0.0060
	2023	0.0016	0.0066
Gingercross Farm Meadow LWS	2019	0.0004	0.0014
	2020	0.0004	0.0015
	2021	0.0005	0.0019
	2022	0.0004	0.0015
	2023	0.0004	0.0017
Wynches Park LWS	2019	0.0003	0.0009
	2020	0.0003	0.0010
	2021	0.0003	0.0011
	2022	0.0002	0.0008
	2023	0.0002	0.0009
Lordship Farm LWS	2019	0.0003	0.0010
	2020	0.0003	0.0009
	2021	0.0003	0.0009
	2022	0.0003	0.0010
	2023	0.0002	0.0008
Green Tye Pond LWS	2019	0.0098	0.0426
	2020	0.0077	0.0333
	2021	0.0081	0.0352
	2022	0.0081	0.0349
	2023	0.0077	0.0334
South-End Roadside Pond LWS	2019	0.0004	0.0015
	2020	0.0004	0.0015
	2021	0.0006	0.0022
	2022	0.0004	0.0015
	2023	0.0005	0.0018

The APIS Critical Load Function Tool[3] was used to assess the combined impact of the nitrogen and sulphur contributions to acid deposition at each of the sites.

For each identified habitat, minCLmaxS, minCLmaxN and minCLminN were input to the tool, along with the maximum background deposition, presented in Table 9.3.

The maximum PCs to the nitrogen and sulphur contributions, as presented in Table 9.4, were input to the tool.

Table 9.5 presents the PC as a percentage of the critical load function, as output from the APIS Critical Load Function Tool, at each ecologically sensitive site.

The contribution to acid deposition is screened out as insignificant for all sites for which relevant critical load information is available.

Table 9.5: Results of APIS Critical Load Function Tool

Site name	Feature name	Acidity critical load class	PC as % of CL function	Screened out?
Mathams Wood AW/LWS	Unmanaged woodland	Broadleaved/coniferous unmanaged woodland	0.1	Yes
Jobbers Wood AW/LWS	Unmanaged woodland	Broadleaved/coniferous unmanaged woodland	0.1	Yes
Sidehill Wood AW	Unmanaged woodland	Broadleaved/coniferous unmanaged woodland	0.2	Yes
Mill Wood AW/LWS	Unmanaged woodland	Broadleaved/coniferous unmanaged woodland	0.1	Yes
Dane Wood LWS	Unmanaged woodland	Broadleaved/coniferous unmanaged woodland	0.2	Yes
Sidehill Wood (Hadham Cross) LWS	Unmanaged woodland	Broadleaved/coniferous unmanaged woodland	0.1	Yes
Hillcrest Meadow LWS	Calcareous grassland	Calcareous/neutral grassland	0.5	Yes
Perry Green Churchyard LWS	Calcareous grassland	Calcareous/neutral grassland	0.2	Yes
Gingercross Farm Meadow LWS	Calcareous grassland	Calcareous/neutral grassland	< 0.1	Yes
Wynches Park LWS	Calcareous grassland	Calcareous/neutral grassland	< 0.1	Yes

10 Discussion

Air dispersion modelling of emissions of NO_x, SO_2, CO and VOCs from four CHP engines at Green Tye Farm, Much Hadham, was carried out using ADMS (version 6.0.2.7).

Ground level concentrations of NO_x, NO_2, SO_2, CO and VOCs were calculated for comparison with the air quality objectives for human health and critical levels for the protection of vegetation and ecosystems. Nitrogen and acid deposition rates were calculated for comparison with critical loads for the protection of vegetation and ecosystems.

10.1 Human health

The maximum offsite annual average and hourly average NO_2 PCs are not screened out, though the PECs are well below the objective values for all five years of meteorological data. The maximum offsite annual average PEC is 29% of the objective, which reduces to 21% at the nearest residential receptor. The maximum offsite hourly average NO_2 PEC is 36% of the objective value. The hourly PCs are screened out at all residential receptors.

The maximum predicted 15-minute, hourly, and daily average SO_2 concentrations at offsite locations are not screened out, though the PECs are well below the objective values for all five years of meteorological data. The maximum offsite 15-minute, hourly, and daily average SO_2 PECs are 20%, 14%, and 22% of the relevant objective values, respectively. The SO_2 PCs for all averaging periods are screened out at all residential receptors.

All predicted concentrations of CO outside the site boundary are screened out as they are less than 10% of the objective for the protection of human health.

There are no air quality objectives for VOCs as a group of pollutants.

10.2 Vegetation and ecosystems

10.2.1 Critical levels

The annual and daily average PCs of NO_x and the annual average PC of SO_2 are screened out as insignificant for all years of meteorological data at Lee Valley Ramsar/SPA and at most of the areas of Ancient Woodland and LWSs.

The annual average PCs of NO_x are not screened out at the following four sites:

- Sidehill Wood AW;
- Hillcrest Meadow LWS;
- Green Tye Pond LWS; and
- Dane Wood LWS.

At these four sites, taking into account background concentrations for each location, the resulting PECs are between 35% and 38% of the annual average critical level for NO_x.

The daily average PCs of NO_x are not screened out at:

- Hillcrest Meadow LWS; and
- Green Tye Pond LWS.

The maximum daily average NO_x PCs are 11% and 23% of the critical level at these sites, respectively.

The annual average PCs of SO_2 are not screened out at Green Tye Pond LWS only. Taking into account the background concentration at this site, the resulting PEC is 4% of the annual average critical level for SO_2.

10.2.2 Critical loads

The contribution to nitrogen and acid deposition is screened out as insignificant for all sites for which relevant critical load information is available.

APPENDIX A: Summary of ADMS 6

ADMS, the **A**tmospheric **D**ispersion **M**odelling **S**ystem[10], has been developed to make use of the most up-to-date understanding of the airflow and turbulence behaviour in the lower levels of the atmosphere in an easy-to-use computer modelling system for the dispersion of atmospheric emissions. This allows the impact of emissions from industrial and other facilities to be thoroughly investigated as part of an environmental assessment or for other regulatory purposes. The model is supported on Windows 11 and Windows 10 environments.

ADMS's original sponsors included the Environment Agency, the Health and Safety Executive (HSE) and successor power companies of the CEGB (Central Electricity Generating Board), whilst the Met Office and University of Surrey contributed to its development. The model is now used for regulatory and other purposes in many countries across the world.

The following is a summary of the capabilities and validation of ADMS 6. More details can be found on the CERC web site at www.cerc.co.uk.

The core model calculates the average concentration arising from an emission for a given meteorological condition (for example, wind speed and direction), taking account of plume rise and stack downwash where required. The emission may be released from a single source or from a number of sources. In addition, ADMS is able to:

- calculate long-term concentration statistics, typically for a period of one year, for direct comparison with air quality standards and objectives;
- take into account the often very significant effects that a nearby building can have on the dispersion of emissions;
- model the chemical conversions that occur in the atmosphere between nitric oxide (NO), nitrogen dioxide (NO_2) and ozone (O_3);
- include background concentrations in concentration statistics;
- allow for the effects of complex terrain and changes in surface roughness on wind speed and direction, and on the levels of turbulence in the atmosphere;
- determine the quantities of an emission deposited to the ground by both dry and wet deposition processes;
- include the decay of radioactive emissions and determine the gamma dose at a location received from passing material;
- report the extent to which a moist plume will be visible;
- model sources over the sea, such as oil platforms, using special calculations of surface roughness and heat fluxes;
- output temperature, relative and/or specific humidity, as well as exceedences of temperature and/or humidity thresholds and simultaneous exceedences of temperature and humidity threshold values;
- output concentrations in units of ou_e for odour studies;
- model the effect of a coastline by accounting for the development of an internal convective layer during sea breeze events;
- calculate concentrations and deposition fluxes due to an instantaneous or finite duration release (puffs);

[10] Carruthers DJ, Holroyd RJ, Hunt JCR, Weng W-S, Robins AG, Apsley DD, Thompson DJ and Smith FB, **1994**: UK-ADMS: A new approach to modelling dispersion in the earth's atmospheric boundary layer. J. of Wind Engineering and Industrial Aerodynamics, vol. 52, pp. 139-153, DOI: 10.1016/0167-6105(94)90044-2.

- model short-term fluctuations in concentration due to atmospheric turbulence, particularly important for modelling odours and concentrations for averaging times less than one hour;
- model the effect of building density on near-surface wind and turbulence profiles (urban canopy); and
- model the effect of wind turbines on plume dispersion.

More details of some of these processes are given below, along with a summary of data comparisons that have been used to validate the model.

Dispersion Modelling

ADMS uses boundary layer similarity profiles in which the boundary layer structure is characterised by the height of the boundary layer and the Monin-Obukhov length, a length scale dependent on the friction velocity and the heat flux at the ground. This has significant advantages over earlier methods in which the dispersion parameters did not vary with height within the boundary layer.

In stable and neutral conditions, dispersion is represented by a Gaussian distribution. In convective conditions, the vertical distribution takes account of the skewed structure of the vertical component of turbulence. This is necessary to reflect the fact that, under convective conditions, rising air is typically of limited spatial extent but is balanced by descending air extending over a much larger area. This leads to higher ground-level concentrations than would be given by a simple Gaussian representation.

The formulation of ADMS means that, for a given meteorological condition, as well as determining average concentrations, the model is also able to provide statistical information on concentration fluctuations. This can be particularly important in applications, for example, determining whether or not a dispersing material exceeds flammability or odour detection thresholds.

Emissions

Buoyant emissions, and those with vertical momentum, rise in the atmosphere after emission. This movement, which is referred to as *plume rise*, also results in additional dilution and can result in the emission penetrating the top of the atmospheric boundary layer and being lost from the local area. These effects are included in the modelling using an integral solution of the conservation equations for the plume's mass, momentum and heat. The possibility of entrainment behind the stack, known as *downwash*, which can lower the effective height of the emission, is also included in the calculation.

ADMS can also model emissions represented as:
- lines – for linear sources;
- areas – to represent situations where a source can best be represented as uniformly spread over an area, such as evaporation from an open tank;
- volumes – to represent situations where a source can best be represented as uniformly spread throughout a volume, such as fugitive emissions from a factory complex; and
- jets – to represent situations where emissions are not emitted vertically upwards.

Presentation of Results

For most situations ADMS is used to model the fate of emissions for a large number of different meteorological conditions. Typically, meteorological data are input for every hour during a year or for a set of conditions representing all those occurring at a given location. ADMS uses these individual results to calculate statistics for the whole data set. These are usually average values, including rolling averages, percentiles and the number of hours for which specified concentration thresholds are exceeded. This allows concentrations to be calculated for direct comparison with air quality limits, guidelines and objectives, in whatever form they are specified.

Results can be presented as numerical values at specified locations. In addition, by calculating concentrations over a grid of locations, results can be presented graphically as concentration contours or isopleths. This can be done using an integrated Mapper, which can also be used to visualise, add and edit sources, buildings and output points. The model also links to other software packages, such as Surfer, ArcGIS and MapInfo GIS.

Complex Effects - Buildings

A building or similar large obstruction can affect dispersion in three ways:

1. It deflects the wind flow and therefore the route followed by dispersing material;
2. This deflection increases levels of turbulence, possibly enhancing dispersion; and
3. Material can become entrained in a highly turbulent, recirculating flow region or cavity on the downwind side of the building.

The third effect is of particular importance because it can bring relatively concentrated material down to ground-level near to a source. From experience, this occurs to a significant extent in more than 95% of studies for industrial facilities.

The buildings effects module in ADMS has been developed using extensive published data from scale-model studies in wind-tunnels, CFD modelling and field experiments on the dispersion of pollution from sources near large structures. It has the following stages:

(i) A complex of buildings is reduced to a single wind-aligned rectangular block with the height of the dominant building and representative streamwise and crosswind lengths.

(ii) The disturbed flow field consists of a recirculating flow region in the lee of the building with a diminishing turbulent wake downwind, as shown in Figure A1.

(iii) Concentrations of the entrained part of the plume are uniform within the well-mixed recirculating flow region and based upon the fraction of the release that is entrained.

(iv) Concentrations further downwind in the main wake are the sum of those from two plumes: a ground level plume from the recirculating flow region and an elevated plume from the non-entrained remainder. The turbulent wake reduces plume height and increases turbulent spread.

(v) If the source is directly upwind of the building, the plume will be split into up to three plumes going around and over the building. These plumes are then used in the calculation of the fraction entrained into the cavity and represent the elevated plume for the non-entrained contribution in the main wake

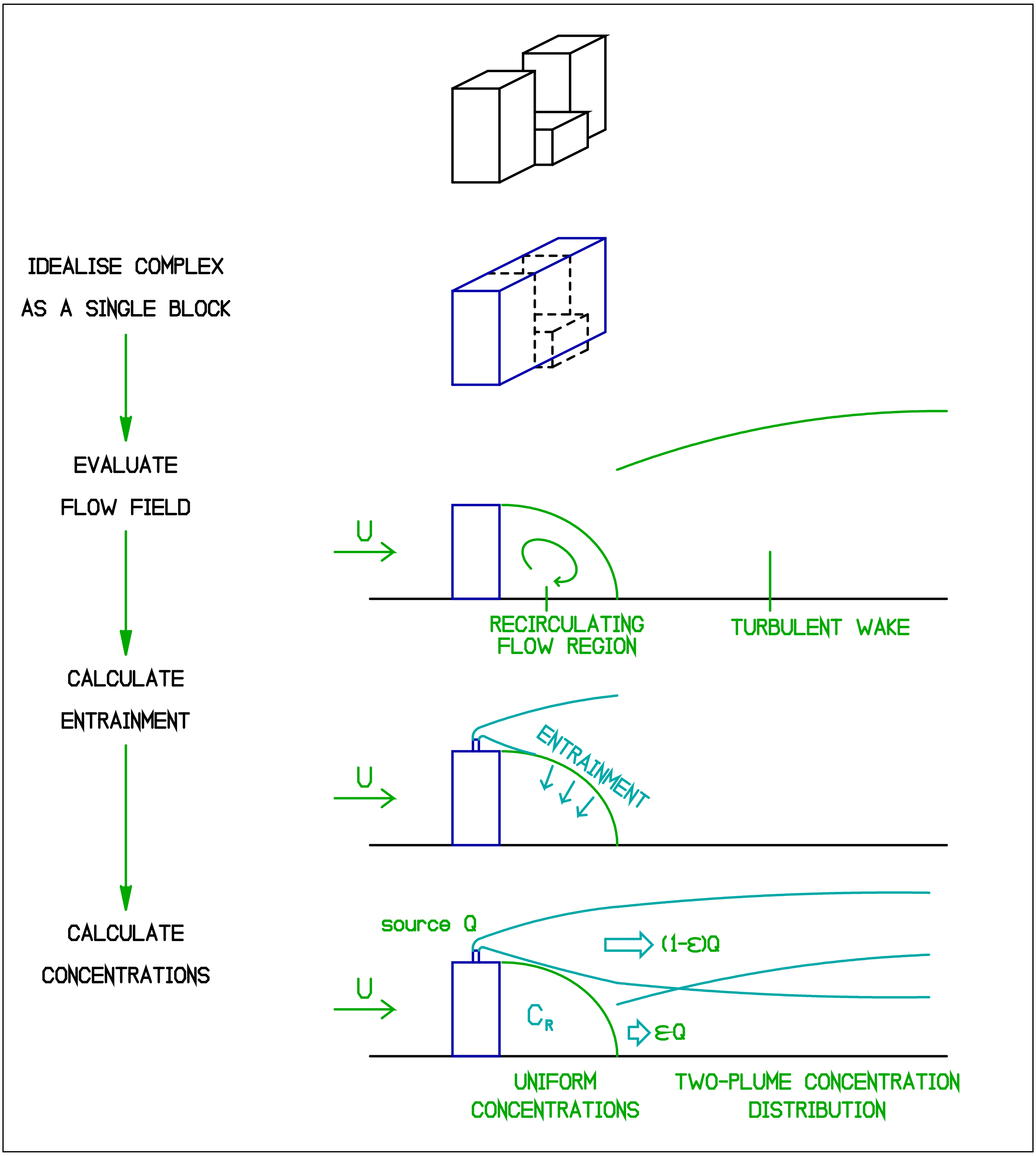

Figure A1: Stages in the modelling of building effects

Complex Effects – NO_x Chemistry

Nitrogen oxides (NO_x) emitted from combustion processes are typically only 5% to 10% nitrogen dioxide (NO_2), with the remainder as nitric oxide (NO). After emission, the NO combines with the ozone (O_3) present in the atmosphere to increase the proportion of NO_2. The key features of the two processes involved can be represented by:

(1) $NO + O_3 \rightarrow NO_2$; and
(2) $NO_2 + h\nu \rightarrow NO + O_3$,

where the role played by oxygen (O and O_2) has been omitted for clarity and hν represents ultra violet radiation. Both of these reactions, which can proceed relatively rapidly, are modelled by ADMS, which only allows the second reaction to occur in daylight. A third reaction $2NO + O_2 \rightarrow 2NO_2$ is also included, though this will not have significant impact on NO and NO_2 concentrations unless the initial NO concentration is sufficiently high and the reaction takes place over a long period of time. Other reactions that involve O_3 and NO_2, such as those with Volatile Organic Compounds (VOCs), have not been included because their reaction times are significantly longer. They would not have any significant effect on concentrations arising from specific industrial emissions.

Complex Effects – Terrain and Roughness

Complex terrain can have a significant impact on wind-flow and consequently on the fate of dispersing material. Primarily, terrain can deflect the wind and therefore change the route taken by dispersing material. Terrain can also increase the levels of turbulence in the atmosphere, resulting in increased dilution of material. This is of particular significance during stable conditions, under which a sharp change with height can exist between flows deflected over hills and those deflected around hills or through valleys. The height of dispersing material is therefore important in determining the route it takes. In addition, areas of reverse flow, similar in form and effect to those occurring adjacent to buildings, can occur on the downwind side of a hill.

Changes in the surface roughness can also change the vertical structure of the boundary layer, affecting both the mean wind and levels of turbulence.

The ADMS Complex Terrain Module models these effects using the wind-flow model FLOWSTAR. This model uses linearised analytical solutions of the momentum and continuity equations, and includes the effects of stratification on the flow. The model is most accurate for hills of moderate slope and can typically be used for gradients up to about 1:2 but may not be reliable close to isolated slopes or escarpments with higher gradients or more generally if large parts of the modelling domain have slopes greater than 1:2. The terrain height is specified at up to 770,000 points that are interpolated by the model onto a regular grid of up to 512 by 512 points. The best results are achieved if the specified data points are regularly spaced. FLOWSTAR has been extensively tested with laboratory and field data.

Regions of reverse flow are treated by assuming that any emissions into the region are uniformly mixed within it. Material then disperses away from the region as if it were a virtual point source. Material emitted elsewhere is not able to enter reverse flow regions.

Deposition

Material in a plume that is close to the ground can be lost to the ground by dry deposition. This process is included in ADMS by using a gravitational settling velocity (which affects particles) and a deposition velocity based on aerodynamic, sub-layer and surface-layer resistance values (which affects gases and particles). The concentration profile within a dispersing plume is then adjusted to take account of the losses at the surface. Dry and wet deposition parameters can be varied spatially, to take into account changes in land use across the modelled area.

Wet deposition is included via a washout coefficient to control the quantity of material incorporated into rain. In addition, for SO_2 and HCl emitted from point sources, the 'Falling Drop' model is available, which includes the kinetics of the uptake of gases, as well as the thermodynamics and chemistry of the dissolution of gases in raindrops.

Radioactivity

For radioactive releases ADMS calculates the transformations within the plume of one isotope into another by radioactive decay. ADMS can also determine the gamma dose received at a location from a dispersing plume.

Visible Plumes

For moist emissions ADMS determines the section of the plume where the liquid water content is sufficient for the plume to be visible. This allows statistics of the frequency and lengths of visible plumes to be calculated.

Data Comparisons – Model Validation

The individual components of ADMS, for example the Buildings Module, have been developed using published scientific data and each component extensively tested to ensure that it provides reliable results. In addition, a very large number of studies have been performed on the accuracy of ADMS for point source emissions.

Among other validation studies, ADMS output has been compared with three flat terrain data sets known as Kincaid, Indianapolis and Prairie Grass, which are available from the US Modellers Data Archive. Each of these datasets has been generally accepted as containing enough measurements of sufficient quality for meaningful validation.

Further details of ADMS and model validation, including a full list of references, are available from the CERC web site at www.cerc.co.uk.