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Air quality assessment to support a permit variation for a Small Waste Incineration Plant, Wing Complex, Buckinghamshire

Draft report

Prepared for
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CERC

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1 Summary

Cambridge Environmental Research Consultants Ltd (CERC) was commissioned by Wiser Environment Ltd (Wiser) to carry out an air quality assessment to support the application for a permit variation to Buckinghamshire Council for a Small Waste Incineration Plant (SWIP) Permit at Wing Complex. Buckinghamshire.

A dispersion modelling assessment of combustion emissions was carried out using the ADMS model (version 6.0.2.0). Wiser provided all site, stack and emissions data.

The impact on air quality of stack emissions has been shown to be acceptable, as summarised below.

1.1 Human health impacts

The Process Contributions (PCs) of the following pollutants are screened out, as they are less than 1% of the long-term or 10% of the short-term air quality standard, as appropriate:

- sulphur dioxide (SO_2) (24-hour average only)
- Total Organic Carbon (modelled as benzene; 24-hour average only)
- particulates
- carbon monoxide
- hydrogen chloride
- hydrogen fluoride
- mercury; antimony; lead; chromium; copper; manganese; nickel (hourly average only); and vanadium

The PCs of the following pollutants are not screened out but, when the background concentration is taken into account, the Predicted Environmental Concentration (PEC) is well below the air quality standard:

- nitrogen dioxide (NO_2)
- sulphur dioxide (SO_2) (15-minute and hourly average)
- annual average Total Organic Carbon (modelled as benzene)
- benzo(a)pyrene
- cadmium; thallium; arsenic; cobalt; and nickel (annual average)

The maximum predicted daily intake due to inhalation of dioxins, furans and dioxin-like PCBs is 0.7% of the Tolerable Daily Intake.

1.2 Ecological impacts

- The PCs of nitrogen oxides (NO_x), SO_2 and daily average hydrogen fluoride are screened out at all of the designated conservation areas, as they are less than 1% of the long-term or 10% of the short-term critical level, as appropriate.
- The PCs to weekly average hydrogen fluoride concentrations are not screened out at either of the areas, but the critical level is not exceeded.
- The PCs to nitrogen and acid deposition are screened out at all of the designated conservation areas, as they are less than 1% of the most stringent site-specific critical load.

2 Introduction

Cambridge Environmental Research Consultants Ltd (CERC) was commissioned by Wiser Environment Ltd (Wiser) to carry out an air quality assessment to support the application for a permit variation to Buckinghamshire Council for a Small Waste Incineration Plant (SWIP) Permit at Wing Complex. Buckinghamshire.

Section 3 presents the air quality standards relevant to this assessment. Details of the site location and surrounding area are given in Section 4, along with background concentrations for the area.

Section 5 presents the stack and building data used as input to the model, and Section 6 presents the meteorological data. Section 7 presents results for human health impacts. Section 8 and Section 9 present concentration and deposition results, respectively, for ecological impacts.

A discussion of the conclusions of the assessment is presented in Section 10. Finally, a description of the ADMS model used in the assessment is given in Appendix A.

3 Air quality standards

3.1 Protection of human health

UK air quality objectives for nitrogen dioxide (NO_2), particulate matter (PM_{10} and $PM_{2.5}$), carbon monoxide (CO), lead, benzene, polyaromatic hydrocarbons (PAHs) 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 Strategy for England, Scotland, Wales and Northern Ireland*, July 2007, and are the subject of Statutory Instrument 2000 No. 928, *The Air Quality (England) Regulations 2000*, which came into force on 6th April 2000. The objective values are set at a European level, and take into account the effects of each pollutant on the health of those who are most sensitive to air quality.

Table 3.1: UK air quality objectives for the protection of human health (µg/m³)

Substance	Limit value	Reference period and allowed exceedences
NO_2	200	hourly mean not to be exceeded more than 18 times a year (modelled as 99.79th percentile)
	40	annual mean
PM_{10}	50	daily mean not to be exceeded more than 35 times a year (modelled as 90.41st percentile)
	40	annual mean
$PM_{2.5}$	20	annual mean
CO	10,000	8-hour running average across a 24 hour period
Lead	0.25	annual mean
Benzene	5	annual mean
PAHs [1]	0.00025	annual mean
SO_2	350	hourly mean not to be exceeded more than 24 times a year (modelled as 99.73rd percentile)
	125	daily mean not to be exceeded more than 3 times per year (modelled as 99.18th percentile)
	266	15 minute average not to be exceeded more than 35 times per year (modelled as 99.9th percentile)

A number of the air quality objectives are specified in terms of the number of times during a year that a concentration measured over a short period of time (for example, 15 minutes, 1 hour or 24-hours, as appropriate) 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/m³ up to 18 times per year. Any more exceedences than this during a one-year period would represent a breach of the objective.

[1] Specifically benzo(a)pyrene

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, consider the 98th percentile of one-hour concentrations over a year. Taking all of the 8760 one-hour concentration values that occur in a year, the 98th percentile value is the concentration below which 98% of those concentrations lie. Or, in other words, it is the concentration exceeded by 2% (100 – 98) of those hours, that is, 175 hours per year. Taking the NO_2 objective considered above, 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.

Where air quality objectives do not exist, long-term (annual average) and short-term (maximum hourly or 24-hour average) Environmental Assessment Levels (EALs)[2] for the protection of human health are used, as presented in Table 3.2. There are short-term EALs for carbon monoxide and benzene, in addition to the air quality objectives for those pollutants. Some long-term EALs are now expressed as 24-hour average long-term standards. In these cases, the 24-hour average concentrations averaged over a longer time period (assumed to be a year) should not exceed the standard.

Target values exist for some pollutants, as presented in Table 3.3.

For dioxins and furans, the UK Committee of Toxicity (COT) sets a threshold-based Tolerable Daily Intake (TDI) of 2 pg I-TEQ kg^{-1} day^{-1}.[3] Exposure by inhalation only is considered in this assessment.

[2] https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit
[3] https://cot.food.gov.uk/sites/default/files/2021-03/Dioxin%20interim%20position%20statement_0.pdf

Table 3.2: Environmental Assessment Levels (EALs) (µg/m³)

	Long-term	Short-term (hourly unless otherwise stated)
Carbon monoxide	-	30,000
Benzene	See Table 3.1	30 (24-hour)
Cadmium [4]	See Table 3.3	0.03 (24-hour)
Thallium	0.006 [5]	-
Mercury [4]	0.06 (24-hour)	0.6
Antimony [6]	5	150
Chromium [4]	0.00025 (chromium VI)	2 (24-hour; chromium III)
Cobalt	0.006 [5]	-
Copper [4]	0.05 (24-hour)	-
Manganese [4]	0.15	1500
Nickel [7]	See Table 3.3	0.7
Vanadium	-	1 (24-hour)
Hydrogen chloride (HCl)	-	750
Hydrogen fluoride (HF)	16 (monthly)	160
Polychlorinated biphenols (PCBs)	0.2	6

Table 3.3: Target Values (µg/m³)
Lower objective or EAL value to be used, where one exists

	Long-term	Short-term (hourly unless otherwise stated)
Cadmium [8]	0.005	See Table 3.2
Arsenic	0.006	-
Nickel [7]	0.02	See Table 3.2
Polycyclic aromatic hydrocarbons (PAHs) [1]	0.001 (See Table 3.1)	-

[4] Metal and its compounds
[5] Assumed to be the same as for arsenic, as the long-term (8-hour) Workplace Exposure Levels are the same
[6] Antimony and its compounds, except antimony trisulphide and antimony trioxide
[7] Nickel and its compounds, except nickel carbonyl
[8] Metal and its compounds

3.2 Protection of vegetation and ecosystems

Critical levels for the protection of vegetation and ecosystems, as set out in the Environment Agency's guidance for environmental permits, are summarised in Table 3.4.

The guidance recommends the assessment of:

- Special Protection Areas (SPAs)[9], Special Areas of Conservation (SACs)[10] and Ramsar[11] sites within 10 km of the installation; and
- Sites of Special Scientific Interest (SSSIs)[12], National Nature Reserves (NNRs)[12], Local Nature Reserves (LNRs)[13], local wildlife sites and ancient woodland within 2 km of the installation.

Table 3.4: Critical levels for the Protection of Vegetation and Ecosystems (µg/m³)

Pollutant	Critical Level	Comment
SO_2	10	annual mean (for sensitive lichen and bryophytes communities)
	20	annual mean (for all higher plants - all other ecosystems)
NO_x	30	annual mean
	75	daily mean
HF	0.5	weekly mean
	5	daily mean

[9] Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora
[10] Council Directive 79/409/EEC on the conservation of wild birds
[11] International Convention on Wetlands of International Importance especially as Waterfowl Habitat
[12] Declared by the statutory country conservation agencies, which have a duty under the Wildlife and Countryside Act 1981
[13] Declared under the National Parks and Access to the Countryside Act 1949 by local authorities after consultation with the relevant statutory nature conservation agency

4 Assessment area

4.1 Site location and surrounding area

Wing Complex is situated in a rural area approximately 5km west of Leighton Buzzard. Figure 4.1 shows the location of the site.

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 stack emissions modelling. A surface roughness value of 0.3 metres was used for the modelled area, which represents the land use around the site. A surface roughness value of 0.3 metres was also used for the meteorological station. See Section 6 for further information regarding the meteorological data used in the modelling. In the ADMS model, the stability of the atmosphere is represented by the Monin-Obukhov parameter, which has the dimension of length. The effect of the urban heat island is that, in stable conditions, the Monin-Obukhov length will never fall below some minimum value; the larger the urban area, the larger the minimum value. The model default value of 1 metre was used for both the modelled area and meteorological site, representative of a rural area.

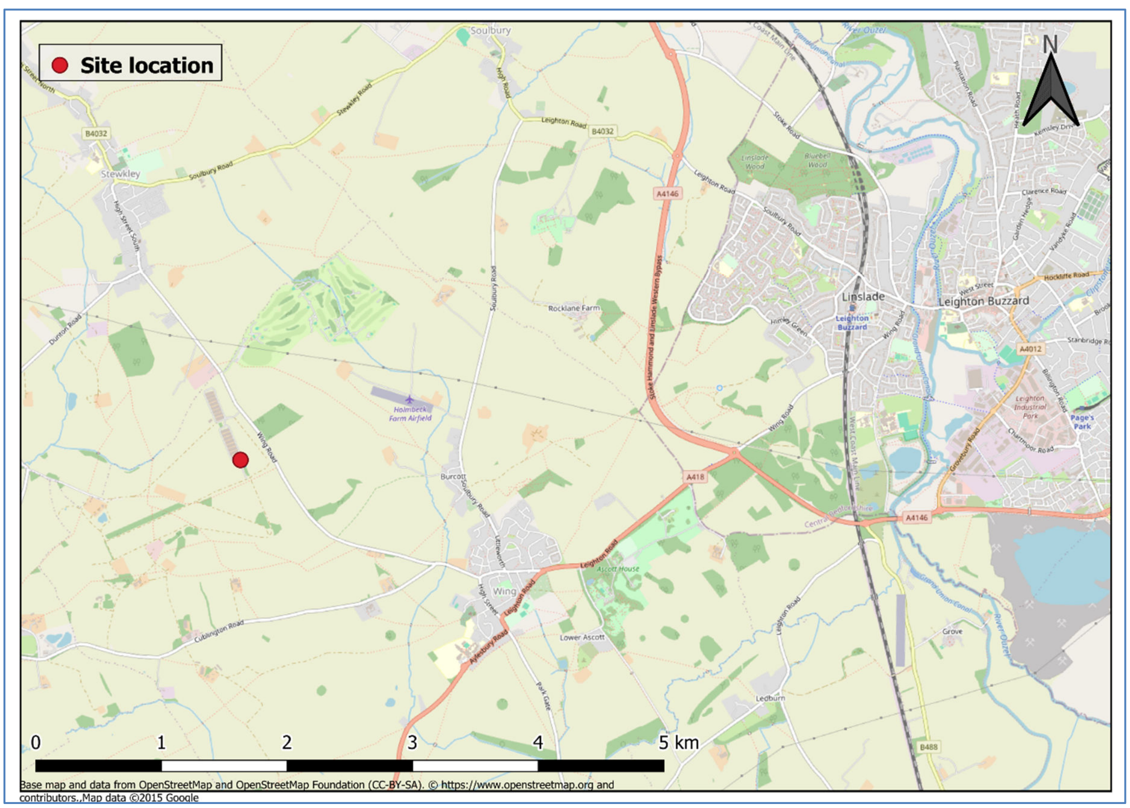

Figure 4.1: Location of site

4.2 Sensitive receptors for human health impact

Model output was generated at ground level on an output grid centred on the site, with concentration values calculated at points 10 m apart, capturing the maximum predicted concentrations across the modelled area.

Model output was also generated at locations of specific sensitive receptors. These locations are set out in Table 4.1 and shown on Figure 4.2.

Table 4.1: Sensitive human health receptors

Name	Type	Distance/direction	Location (x,y)
Wing Complex 1	Residential	Within 200 m south west	486185, 223740
Wing Complex 2	Residential		486190, 223720
Wing Complex 3	Residential		486195, 223695
Wing Complex 4	Residential		486180, 223690
Wing Complex 5	Residential		486160, 223680
Wing Complex 6	Residential		486140, 223670
Burcott Lodge Farm	Residential	1100 m north east	487035, 224500
Blackthorn Nursery	Residential	800 m north	485960, 224545
Lydcote Hause	Residential	1200 m north west	485070, 224300
South Tinkers Hole Farm	Residential	1250 m south west	485400, 222835

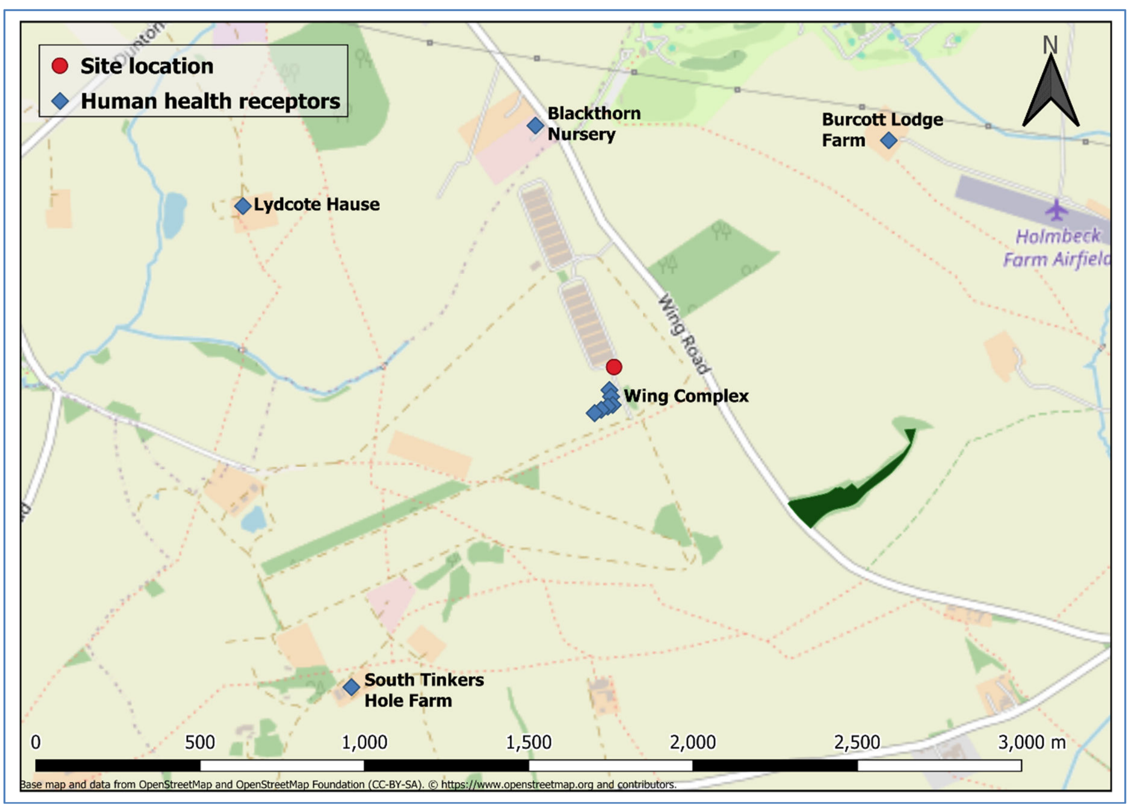

Figure 4.2: Sensitive receptors for human health impacts

4.3 Sensitive receptors for the protection of vegetation and ecosystems

Model output was calculated at designated conservation areas within 10 km of the modelled stack, at which potentially sensitive ecosystems were identified. These are summarised in Table 4.2 and shown on Figure 4.3.

Table 4.2: Designated conservation areas

Name	Designation	Distance (direction)
Blackend Spinney	Ancient Woodland	1.4 km north east
Unnamed	Ancient Woodland	0.7 km south east

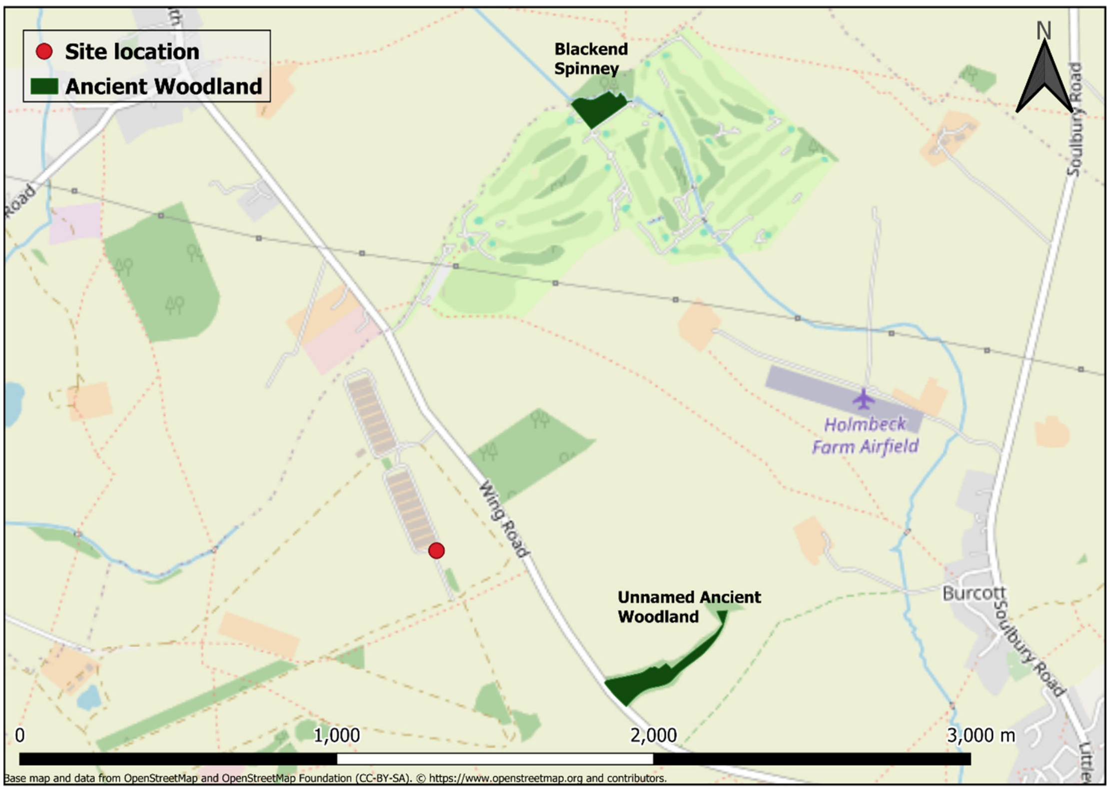

Figure 4.3: Locations of designated conservation areas within 10 km

4.4 Local air quality

4.4.1 AQMAs and monitoring sites

Buckinghamshire Council has declared several Air Quality Management Areas (AQMA). However, the closest of these are more than 10 km south west of the SWIP site, in Aylesbury.

There are no background monitoring sites within 5 km of the SWIP site.

4.4.2 Mapped background data

Background concentrations of carbon monoxide (CO) for the year 2010 and benzene, sulphur dioxide (SO_2), nitrogen oxides (NO_x), nitrogen dioxide (NO_2) and particulates (PM_{10}) for the year 2023 were obtained from the background air pollution maps provided by Defra under the Modelling of Ambient Air Quality (MAAQ).[14]

These values are provided on a 1 km grid basis; Table 4.3 presents annual average concentrations for the grid square containing the SWIP site (centred on 486500, 223500).

Table 4.3: Background concentrations of NO_2, PM_{10}, $PM_{2.5}$, benzene, SO_2 and CO ($\mu g/m^3$)

Grid square (x,y)	NO_2	PM_{10}	$PM_{2.5}$	Benzene	SO_2	CO
486500, 223500	5.9	12.4	6.6	0.310	0.9	0.204

These values were used as estimates of the background concentrations of pollutants in this assessment.

4.4.3 Background data for heavy metals

Metals are measured as part of Defra's Heavy Metals Network[15]; the nearest monitoring location is Fenny Compton, around 55 km north west of the site. For antimony, the nearest monitoring location is Wytham Wood, around 45 km south west of the site, but data are less recent.

Total gaseous mercury is measured as part of Defra's Rural Mercury network[16]. The nearest monitoring location is Chilbolton Observatory, around 100 km south west of the site.

Annual average concentrations of these metals, for the most recent year of measurement in each case, are presented in Table 4.4.

No background data could be found for thallium.

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[14] https://uk-air.defra.gov.uk/data/pcm-data
[15] https://uk-air.defra.gov.uk/networks/network-info?view=metals
[16] https://uk-air.defra.gov.uk/networks/network-info?view=rm

Table 4.4: Monitored concentrations of heavy metals (ng/m³) (Fenny Compton unless otherwise specified)

Pollutant	Concentration	Year
Gaseous mercury (Chilbolton Observatory)	1.43	2024
Cadmium	0.07	2024
Antimony (Wytham Wood)	0.86	2013
Arsenic	0.57	2024
Lead	2.70	2024
Chromium	0.98	2024
Cobalt	0.04	2024
Copper	2.03	2024
Manganese	2.11	2024
Nickel	0.35	2024
Vanadium	0.51	2024

4.4.4 Background data for other pollutants

HCl is measured as part of Defra's Acid Gases and Aerosol Network[17]; the nearest monitoring location is Rothamsted, around 25 km to the south east of the site.

PAHs are measured as part of Defra's Polycyclic Aromatic Hydrocarbons (PAH) Network[18], and dioxins and PCBs are measured as part of Defra's Toxic Organic Micro Pollutants (TOMPs) Network[19]. In both cases, the nearest monitoring locations are in London, around 60 km to the south east.

Annual average concentrations of these pollutants, for the most recent year of measurement in each case, are presented in Table 4.5.

Table 4.5: Monitored concentrations of other pollutants

Pollutant	Monitoring location	Concentration	Year
HCl	Rothamsted	0.28 μg/m³	2015
PAHs	London Nobel House	0.06 ng/m³	2009
Dioxins	London Nobel House	0.024 pg/m³	2016
PCBs	London Nobel House	119 pg/m³	2016

No background data could be found for hydrogen fluoride.

[17] https://uk-air.defra.gov.uk/networks/network-info?view=aganet
[18] https://uk-air.defra.gov.uk/networks/network-info?view=pah
[19] https://uk-air.defra.gov.uk/data/tomps-data

4.4.5 Background data at designated conservation areas

Mapped background data for NO_x and SO_2 at the locations of the designated conservation areas, taken from the Air Pollution Information System (APIS) website,[20] are shown in Table 4.6. These values represent three-year averages, over the period 2020 to 2022.

Table 4.6: Background concentrations for designated conservation areas (µg/m³)

Name	NO_x	SO_2
Blackend Spinney	9.3	0.9
Unnamed		

[20] http://www.apis.ac.uk/search-location

5 Modelled stack and emissions data

5.1 Emission Limit Values

Unless otherwise noted, Emission Limit Values (ELVs) for the assessment were taken from *Environmental permitting technical guidance PG13/1(21), Reference document for the operation of small waste incineration plants (SWIPs)*.

Table 5.1 presents the half-hourly ELVs used to calculate concentrations for comparison with air quality standards with an averaging time of one hour or less.

Table 5.1: Half-hourly ELVs

Pollutant	Emission concentration (mg/Nm^3) [21]
NO_x	400
SO_2	200
CO	100
HCl	60
HF	4

Table 5.2 presents the daily ELVs, used to calculate concentrations for comparison with air quality standards with an averaging time of one day or more.

For benzo(a)pyrene, the assumed emission concentration in Table 5.2 was taken from Figure 8.121 of the 2019 Waste Incineration BREF[22], which shows that the maximum value recorded at a UK plant was 0.2 $\mu g/Nm^3$.

Table 5.2: Daily ELVs

Pollutant	Emission concentration (mg/Nm^3) [21]
NO_x	200
SO_2	50
Total dust	10
Total Organic Carbon (TOC)	10
HCl	10
HF	1
Benzo(a)pyrene	0.0002
Mercury	0.05
Cadmium and thallium	0.05 (total)
Sb, As, Pb, Cr, Co, Cu, Mn, Ni and V [23]	0.5 (total)
Dioxins, furans and dioxin-like PCBs	0.1 ng/Nm^3

[21] Normalised conditions: 0°C, dry gas, 11% oxygen
[22] https://eippcb.jrc.ec.europa.eu/sites/default/files/2020-01/JRC118637_WI_Bref_2019_published_0.pdf
[23] Antimony, arsenic, lead, chromium, cobalt, copper, manganese, nickel, vanadium

5.2 Modelled stack

A single emissions scenario was modelled, representing continuous operation with emission rates based on the ELVs described above. Table 5.3 presents the modelled stack data.

Table 5.3: Stack details

Location (OSGB)	486199, 223810
Height (m)	17.525
Diameter (m)	0.524
Actual volume flow rate (m^3/hr)	17657
Normalised volume flow rate (Nm^3/hr) [21]	11406
Velocity (m/s)	22.7
Temperature (°C)	169

Table 5.4 presents the emissions data, based on half-hourly ELVs, used to calculate concentrations for comparison with air quality standards with an averaging time of one hour or less.

Table 5.4: Emission rates based on half hour ELVs

Pollutant	Emission concentration (mg/Nm^3) [21]	Emission rate (g/s)
NO_x	400	1.267
SO_2	200	0.634
CO	100	0.317
HCl	60	0.190
HF	4	0.013

Table 5.5 presents the emissions data, based on daily ELVs, used to calculate concentrations for comparison with air quality standards with an averaging time of one day or more.

There are no air quality standards for Total Organic Carbon (TOC). In line with Environment Agency guidance, it is assumed that 100% of the emitted TOC is benzene and the predicted concentrations are compared against the air quality standards for benzene.

Table 5.5: Emission rates based on daily ELVs

Pollutant	Emission concentration (mg/Nm^3) [21]	Emission rate (g/s)
NO_x	200	0.634
SO_2	50	0.158
Total dust [24]	10	0.032
Total Organic Carbon (as benzene)[25]	10	0.035
HCl	10	0.032
HF	1	0.003
Benzo(a)pyrene	0.0002	6.3×10^{-7}
Mercury	0.05	0.00016
Cadmium and thallium	0.05 (total)	0.00016
Sb, As, Pb, Cr, Co, Cu, Mn, Ni and V [26]	0.5 (total)	0.0016
Dioxins, furans and dioxin-like PCBs	0.1 ng/Nm^3	3.17×10^{-10}

Figure 5.1 presents the location of the modelled stack and building, described in Section 5.3. The site boundary and the receptors representing the houses on Wing Complex are also shown.

Figure 5.1: Locations of modelled stack and building

[24] Particulate matter emissions were assumed to be 100% PM_{10} and 100% $PM_{2.5}$, as a worst case
[25] Multiplying ELV for Total Organic Carbon by 72/66 for mass emission rate of benzene
[26] Antimony, arsenic, lead, chromium, cobalt, copper, manganese, nickel, vanadium

5.3 Modelled buildings

Buildings that are relatively close to the modelled stack and higher 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 can be consequently decreased further away as the plume, travelling downstream, is further diluted.

Table 5.6 presents the buildings data used and Figure 5.1 shows the locations of the modelled building and stack.

Table 5.6: Site buildings data

Name	Coordinates of building centre (x,y)	Height (m)	Length (m)	Width (m)	Angle of length to north (°)
Boiler building	486217, 223797	13.9	68	21	337

6 Meteorological data

Modelling was carried out using hourly sequential meteorological data obtained from Luton Airport for the five years 2020 to 2024 inclusive. This meteorological station is located approximately 25 km to the east of the SWIP site.

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

Figure 6.1 shows wind roses for Luton, giving the frequency of occurrence of wind from different directions for a number of wind speed ranges, for the five years 2020 to 2024.

Table 6.1: Summary of meteorological data used

Year	Percentage used	Parameter	Minimum	Maximum	Mean
2020	98.4	Temperature (°C)	-3.0	34.0	10.8
		Wind speed (m/s)	0	17.0	4.9
		Cloud cover (oktas)	0	8	4
2021	96.8	Temperature (°C)	-5.0	30.0	10.3
		Wind speed (m/s)	0	16.5	4.4
		Cloud cover (oktas)	0	8	4
2022	98.7	Temperature (°C)	-7.0	39.0	11.4
		Wind speed (m/s)	0	23.2	4.4
		Cloud cover (oktas)	0	8	3
2023	98.9	Temperature (°C)	-5.0	31.0	10.9
		Wind speed (m/s)	0	16.5	4.7
		Cloud cover (oktas)	0	8	4
2024	95.4	Temperature (°C)	-5.0	30.0	10.9
		Wind speed (m/s)	0	19.6	4.6
		Cloud cover (oktas)	0	8	4

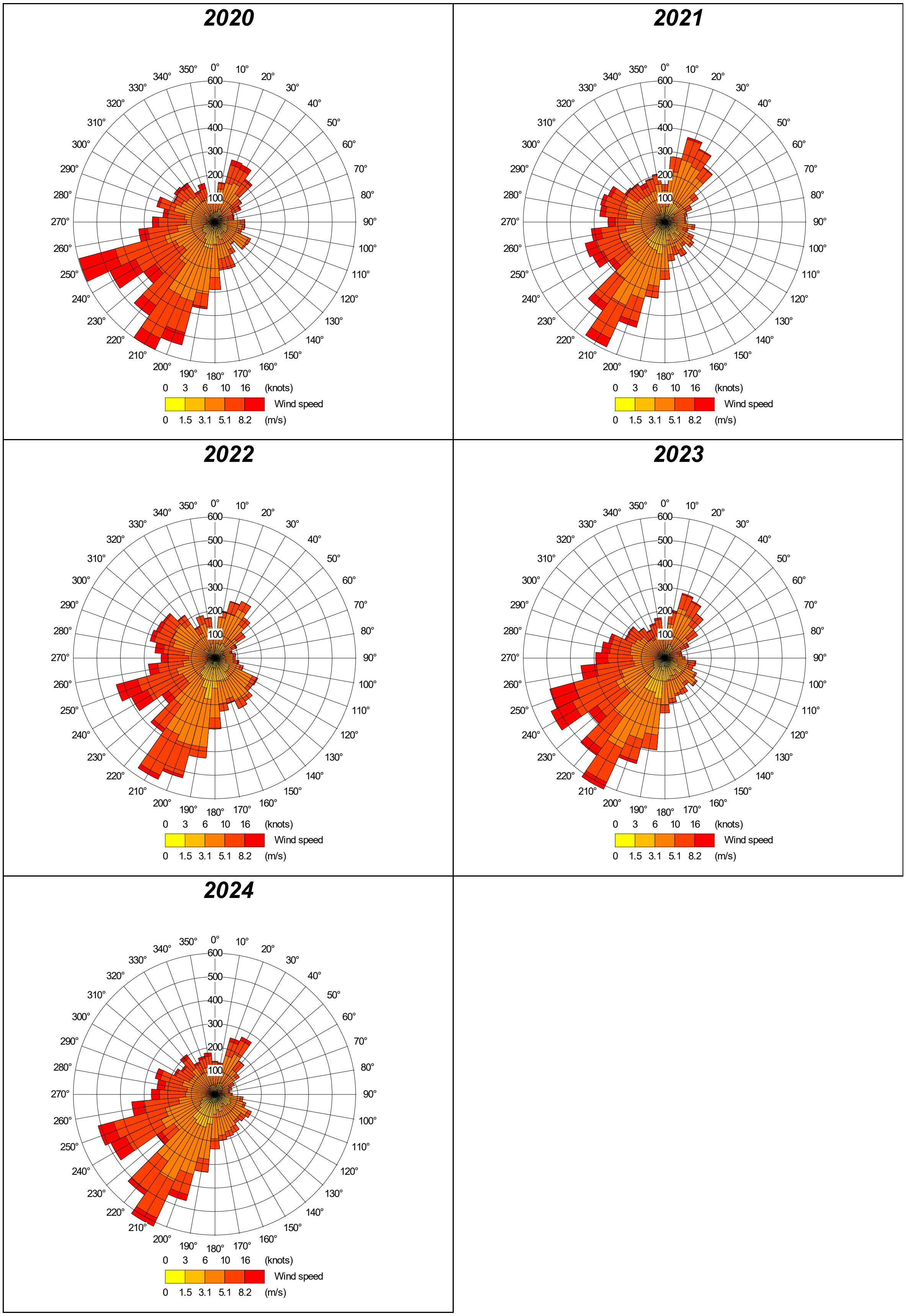

Figure 6.1: Wind roses for Luton Airport

7 Impact of stack emissions on human health

Modelling was carried out to predict the Process Contribution (PC) to ground level concentrations of each relevant pollutant from the modelled SWIP. The significance of the total pollutant release was assessed by comparing the PC to the relevant air quality objective or EAL. 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.[2] For short-term standards, including percentiles, the Agency considers the release to be insignificant if the PC is less than 10% of the air quality standard.[2] 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) for that substance is calculated. For long-term standards, the PEC is calculated by adding the PC to the estimated background concentration of the pollutant. For short-term standards, including percentiles, the PEC is calculated by adding the PC to twice the estimated background concentration of the pollutant.

For the assessment of human health effects, all maximum concentrations represent the maximum offsite concentrations; that is, concentrations within the site boundary were excluded.

7.1 Predicted concentrations of nitrogen dioxide

Nitrogen oxides (NO_x) comprise nitric oxide (NO) and nitrogen dioxide (NO_2). Only NO_2 is considered in statutory air quality objectives for the protection of human health; the NO_x critical levels for the Protection of Vegetation and Ecosystems are considered in Section 8.1.

The PC to NO_2 concentrations depends on the chemical reactions taking place to form NO and NO_2. For direct comparison against the objectives for NO_2, an empirical relationship defined by the Environment Agency was therefore used to calculate the NO_2 PEC. This method assumes that a fixed proportion of the PC of NO_x is NO_2 (70% for the annual average and 35% for the 99.79th percentile of hourly averages).

Table 7.1 shows the maximum offsite annual average NO_2 PCs, using meteorological data for the five years 2020 to 2024.

The maximum offsite annual average NO_2 PC is 2.6 $\mu g/m^3$, 7% of the air quality objective of 40 $\mu g/m^3$. Including the background concentration of 5.9 $\mu g/m^3$, maximum offsite annual average PECs are below the air quality objective.

Table 7.2 shows the maximum offsite 99.79th percentile of hourly average NO_2 PCs, using meteorological data for the five years 2020 to 2024. The maximum offsite annual average NO_2 PC is 39 $\mu g/m^3$, 20% of the air quality objective of 200 $\mu g/m^3$. Including the background concentration, maximum offsite annual average PECs are below the air quality objective.

Figure 7.1 and Figure 7.2 show contour plots of annual and hourly the average NO_2 PCs, based on the year of meteorological data giving rise to the highest predicted concentration in each case.

Table 7.1: Maximum offsite PCs to annual average NO_2 concentrations ($\mu g/m^3$)

Year	AQO	PC (NO_x)	PC (NO_2)[27]	PC % of AQO	Screened out?	Background NO_2	PEC (NO_2)	PEC % of AQO	Location (x,y)
2020	40	3.7	2.6	7	No	5.9	8.5	21	486300, 223960
2021		3.4	2.4	6			8.3	21	486160, 223700
2022		3.4	2.4	6			8.3	21	486310, 223750
2023		3.7	2.6	7			8.5	21	486320, 223930
2024		3.6	2.5	6			8.4	21	486300, 223960

Table 7.2: Maximum offsite PCs to 99.79th percentile of hourly average NO_2 concentrations ($\mu g/m^3$)

Year	AQO	PC (NO_x)	PC (NO_2)[28]	PC % of AQO	Screened out?	Background NO_2	PEC (NO_2)	PEC % of AQO	Location (x,y)
2020	200	107	37	19	No	11.8	49	25	486100, 223850
2021		107	37	19			49	25	486100, 223850
2022		109	38	19			50	25	486100, 223850
2023		110	39	20			51	26	486100, 223850
2024		112	39	20			51	26	486100, 223850

[27] 70% of long-term NO_x PC
[28] 35% of long-term NO_x PC

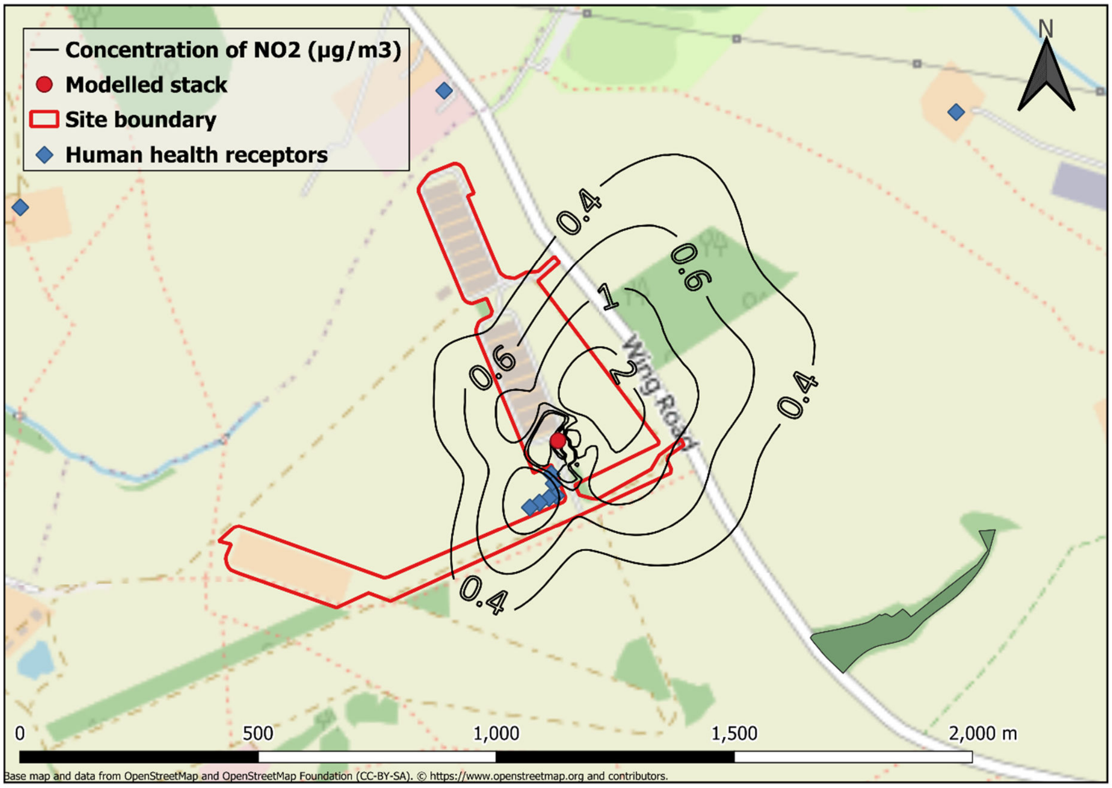

Figure 7.1: Contour plot of annual average NO_2 concentrations

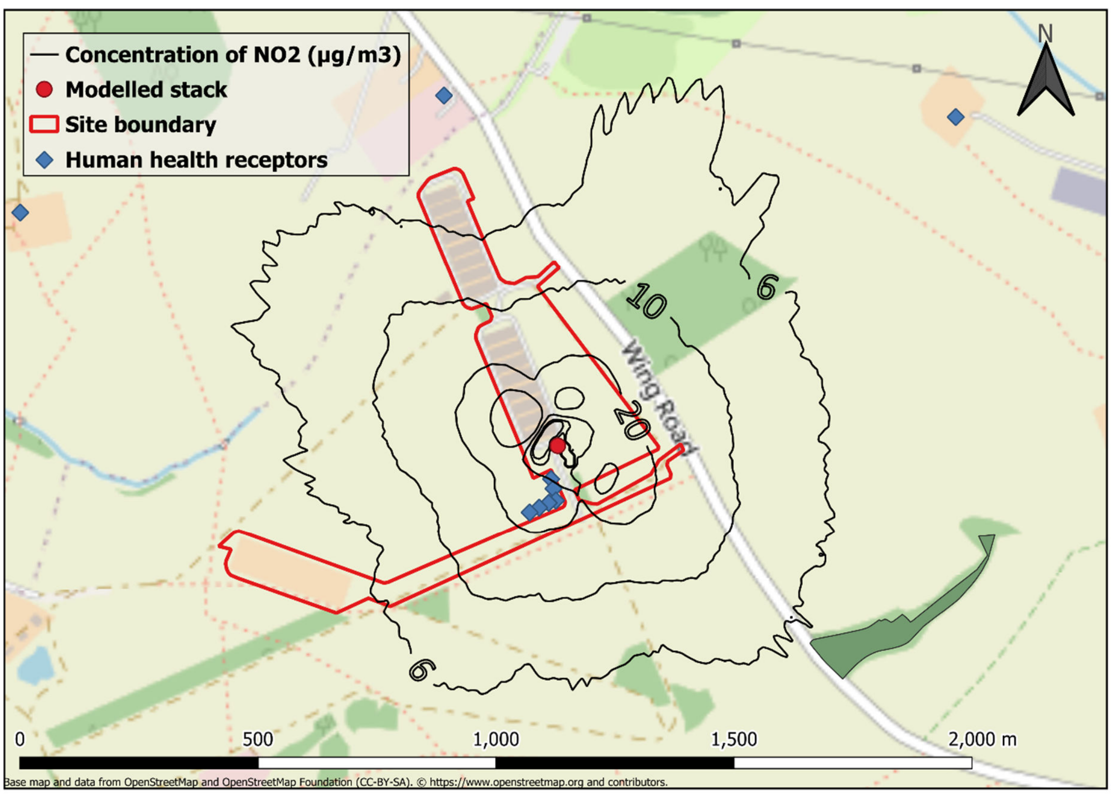

Figure 7.2: Contour plot of hourly average NO_2 concentrations

7.1.1 Concentrations at sensitive human health receptors

As the maximum offsite average NO_2 PCs are not screened out, Table 7.3 and Table 7.4 show the annual and hourly average values at the sensitive human health receptors. For each receptor, the maximum value over the five years of meteorological data is presented. These impacts are screened out at all receptors, except those close to the site, on the Wing Complex itself. There are no exceedences of the air quality objectives for NO_2.

Table 7.3: PCs to annual average NO_2 concentrations (µg/m³) at receptors

Receptor	AQO	PC			Screened out?	Background NO_2	PEC (NO_2)	PEC % of AQO
		NO_x	NO_2	% of AQO				
Burcott Lodge	40	0.2	0.1	0.3	Yes	-	-	-
Blackthorn Nursery		0.2	0.1	0.3				
Lydcote Hause		0.1	0.1	0.3				
South Tinkers Hole Farm		0.1	0.1	0.3				
Wing Complex 1		1.1	0.8	2	No	11.8	12.6	32
Wing Complex 2		2.2	1.5	4			13.3	33
Wing Complex 3		2.6	1.8	5			13.6	34
Wing Complex 4		3.1	2.2	6			14.0	35
Wing Complex 5		3.2	2.2	6			14.0	35
Wing Complex 6		2.9	2.0	5			13.8	35

Table 7.4: PCs to hourly average NO_2 concentrations (µg/m³) at receptors

Receptor	AQO	PC			Screened out?	Background NO_2	PEC (NO_2)	PEC % of AQO
		NO_x	NO_2	% of AQO				
Burcott Lodge	200	10	4	2	Yes	-	-	-
Blackthorn Nursery		11	4	2				
Lydcote Hause		11	4	2				
South Tinkers Hole Farm		8	3	2				
Wing Complex 1		56	20	10				
Wing Complex 2		74	26	13	No	23.6	40	20
Wing Complex 3		80	28	14			52	26
Wing Complex 4		80	28	14			52	26
Wing Complex 5		77	27	14			51	26
Wing Complex 6		71	25	13			49	25

7.2 Predicted concentrations of sulphur dioxide

Using meteorological data for the five years 2020 to 2024:

- Table 7.5 shows the maximum offsite 15-minute average PCs of SO_2;
- Table 7.6 shows the maximum calculated hourly average PCs of SO_2; and
- Table 7.7 shows the maximum calculated 24-hour average PCs of SO_2.

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

Year	AQO	PC	PC % of AQO	Screened out?	Background	PEC	PEC % of AQO	Location (x,y)
2020	266	62	23	No	1.8	64	24	486100, 223850
2021		61	23			63	24	486100, 223850
2022		62	23			64	24	486100, 223850
2023		62	23			64	24	486100, 223850
2024		63	24			65	24	486100, 223850

Table 7.6: Maximum offsite PCs to 99.73rd percentile of hourly average SO_2 concentrations (µg/m^3)

Year	AQO	PC	PC % of AQO	Screened out?	Background	PEC	PEC % of AQO	Location (x,y)
2020	350	53	15	No	1.8	55	16	486100, 223850
2021		53	15			55	16	486100, 223850
2022		54	15			56	16	486100, 223850
2023		54	15			56	16	486100, 223850
2024		56	16			57	16	486100, 223850

Table 7.7: Maximum offsite PCs to 99.18th percentile of daily average SO_2 concentrations (µg/m^3)

Year	AQO	PC	PC % of AQO	Screened out?	Location (x,y)
2020	125	8	6	Yes	486100, 223840
2021		8	6		486150, 223710
2022		8	6		486100, 223850
2023		7	6		486150, 223720
2024		8	6		486160, 223710

- The maximum offsite 15-minute average SO_2 PC is 63 µg/m^3, 24% of the air quality objective of 266 µg/m^3. Including the background concentration of 1.8 µg/m^3, these impacts are below the air quality objective.
- The maximum offsite hourly average SO_2 PC is 56 µg/m^3, 16% of the air quality objective of 350 µg/m^3. Including the background concentration of 1.8 µg/m^3, these impacts are below the air quality objective.
- The maximum offsite 24-hour average SO_2 PCs are screened out as they are less than 10% of the air quality objective of 125 µg/m^3.

Figure 7.3 and Figure 7.4 show contour plots of 15-minute and hourly average SO_2 PCs, respectively based on the year of meteorological data giving rise to the highest predicted concentration.

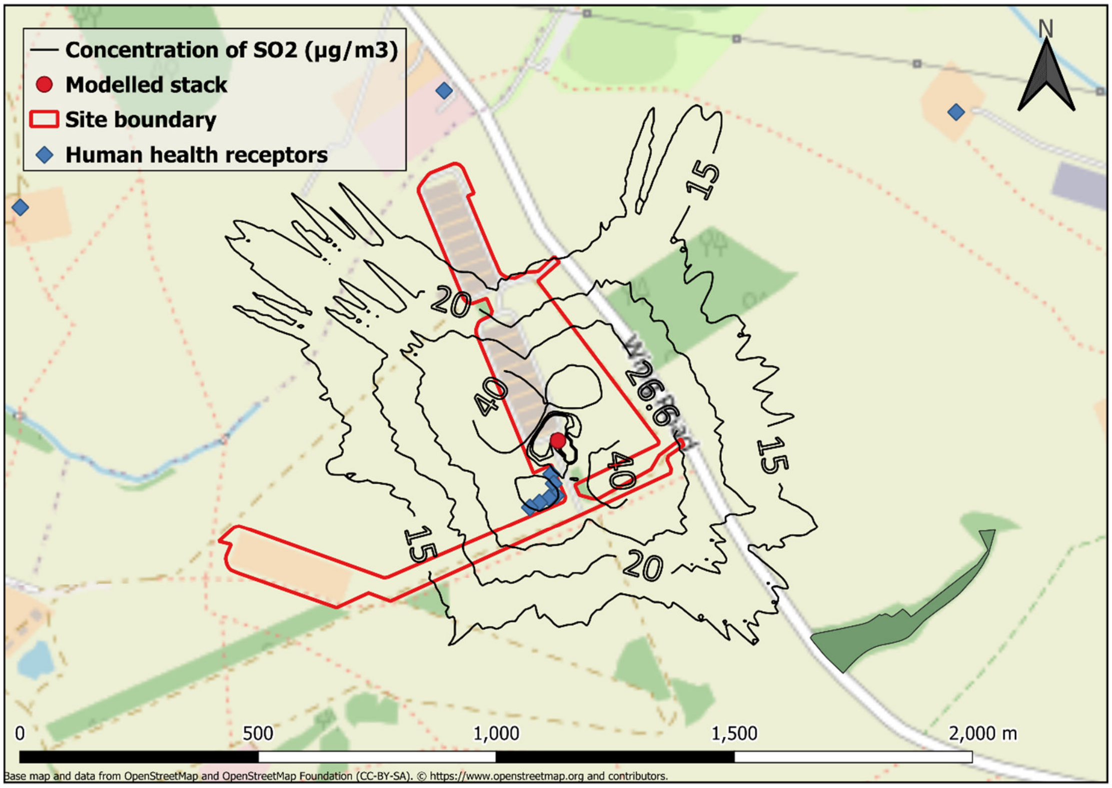

Figure 7.3: Contour plot of 15-minute average SO_2 concentrations

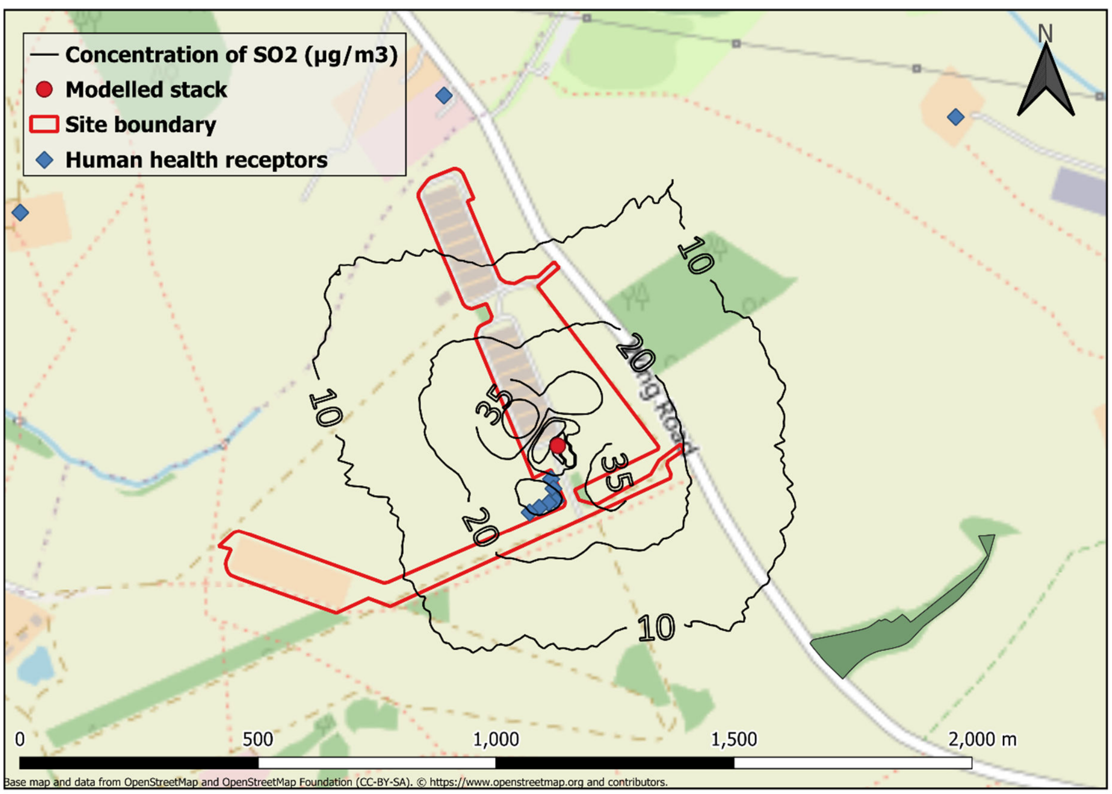

Figure 7.4: Contour plot of hourly average SO_2 concentrations

7.2.1 Concentrations at sensitive human health receptors

As the maximum offsite 15-minute and hourly average SO_2 PCs are not screened out, Table 7.8 and Table 7.9 show the values at the sensitive human health receptors. For each receptor, the maximum value over the five years of meteorological data is presented.

These impacts are screened out at all receptors, except those close to the site, on the Wing Complex itself. There are no exceedences of the air quality objectives for SO_2.

Table 7.8: PCs to 15-minute average SO_2 concentrations ($\mu g/m^3$) at receptors

Receptor	AQO	PC	% of AQO	Screened out?	Background	PEC	PEC % of AQO
Burcott Lodge	266	9	3	Yes	-	-	-
Blackthorn Nursery		10	4				
Lydcote Hause		9	3				
South Tinkers Hole Farm		7	3				
Wing Complex 1		36	14	No	1.8	38	14
Wing Complex 2		41	15			43	16
Wing Complex 3		43	16			45	17
Wing Complex 4		45	17			47	18
Wing Complex 5		43	16			45	17
Wing Complex 6		41	15			43	16

Table 7.9: PCs to hourly average SO_2 concentrations ($\mu g/m^3$) at receptors

Receptor	AQO	PC	% of AQO	Screened out?	Background	PEC	PEC % of AQO
Burcott Lodge	350	5	1	Yes	-	-	-
Blackthorn Nursery		5	1				
Lydcote Hause		5	1				
South Tinkers Hole Farm		4	1				
Wing Complex 1		26	7				
Wing Complex 2		35	10				
Wing Complex 3		38	11	No	1.8	40	11
Wing Complex 4		39	11			41	12
Wing Complex 5		38	11			40	11
Wing Complex 6		35	10	Yes	-	-	-

7.3 Predicted concentrations of Total Organic Carbon (as benzene)

There are no air quality standards for Total Organic Carbon (TOC). In line with Environment Agency guidance, it is assumed that 100% of the emitted TOC is benzene and the predicted concentrations are compared against the air quality standards for benzene.

Table 7.10 shows the maximum offsite annual average PCs of benzene, using meteorological data for the five years 2020 to 2024.

Table 7.10: Maximum offsite PCs to annual average benzene concentrations (µg/m^3)

Year	AQO	PC	PC % of AQO	Screened out?	Background	PEC	PEC % of AQO	Location (x,y)
2020		0.20	4			0.51	10	486300, 223960
2021		0.19	4			0.50	10	486160, 223700
2022	5	0.19	4	No	0.31	0.50	10	486310, 223750
2023		0.20	4			0.51	10	486320, 223930
2024		0.20	4			0.51	10	486300, 223960

The maximum offsite annual average benzene PC is 0.20 µg/m^3, 4% of the air quality objective of 5 µg/m^3. Including the background concentration of 0.31 µg/m^3, maximum offsite annual average PECs are below the air quality objective.

Table 7.11 shows the maximum offsite daily average benzene PCs, using meteorological data for the five years 2020 to 2024. These impacts are screened out, as they are less than 10% of the EAL.

Table 7.11: Maximum PCs to 24-hour average benzene concentrations (µg/m^3)

Year	EAL	PC	PC % of EAL	Screened out?	Location (x,y)
2020		2.1	7		486100, 223840
2021		1.9	6		486280, 223720
2022	30	2.2	7	Yes	486100, 223850
2023		1.8	6		486160, 223710
2024		2.4	8		486100, 223850

Figure 7.5 shows a contour plot of annual average benzene PCs, based on meteorological data for the year giving rise to the highest predicted concentration.

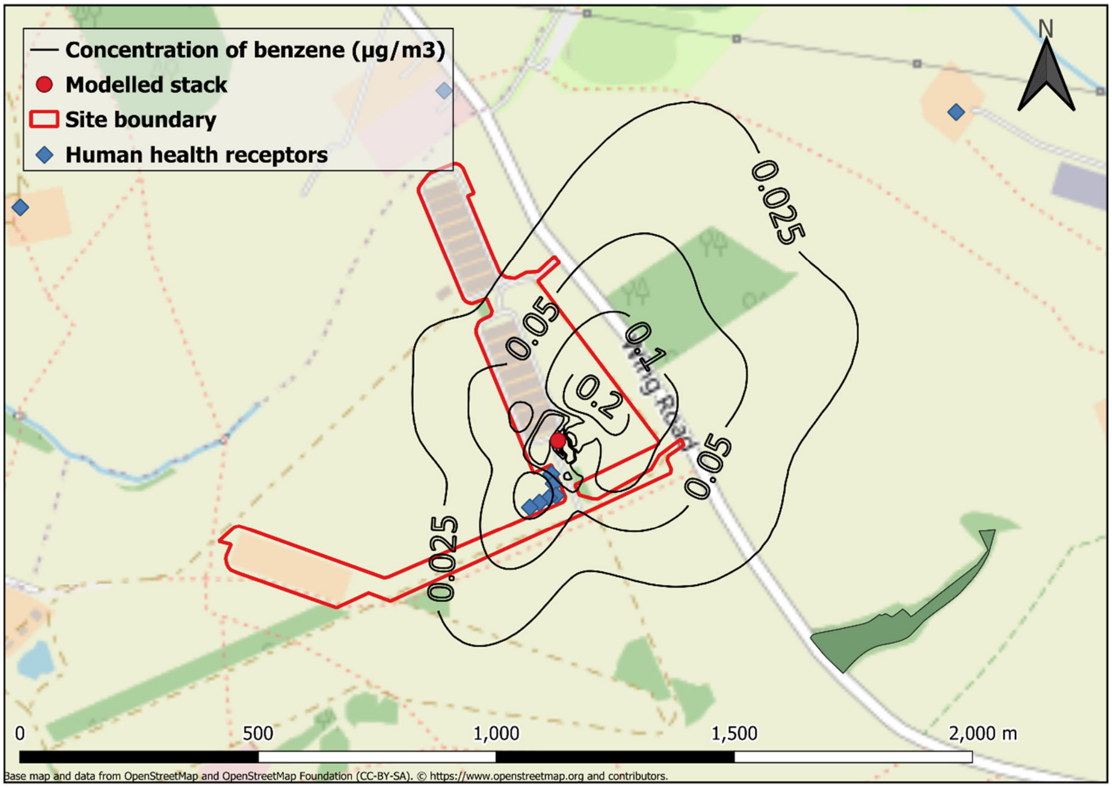

Figure 7.5: Contour plot of annual average benzene concentrations

7.3.1 Concentrations at sensitive human health receptors

As the maximum offsite annual average benzene PCs are not screened out, Table 7.12 shows the values at the sensitive human health receptors. For each receptor, the maximum value over the five years of meteorological data is presented.

These impacts are screened out at all receptors, except those close to the site, on the Wing Complex itself. There are no exceedences of the air quality objective for benzene.

Table 7.12: PCs to annual average benzene concentrations (µg/m³) at receptors

Receptor	AQO	PC	% of AQO	Screened out?	Background	PEC	PEC % of AQO
Burcott Lodge	5	0.01	0.2	Yes	-	-	-
Blackthorn Nursery		0.01	0.2				
Lydcote Hause		0.01	0.2				
South Tinkers Hole Farm		0.01	0.2				
Wing Complex 1		0.06	1.2	No	0.310	0.37	7
Wing Complex 2		0.12	2.4			0.43	9
Wing Complex 3		0.14	2.8			0.45	9
Wing Complex 4		0.17	3.4			0.48	10
Wing Complex 5		0.17	3.4			0.48	10
Wing Complex 6		0.16	3.2			0.47	9

7.4 Predicted concentrations of particulates

It is assumed that 100% of the emitted particulates are PM_{10} and $PM_{2.5}$, in each case.

Table 7.13 shows the maximum offsite annual average PCs of particulates, using meteorological data for the five years 2020 to 2024. These impacts are screened out as they are less than 1% of the objectives for both PM_{10} and $PM_{2.5}$.

Table 7.13: Maximum offsite PCs to annual average concentrations of particulates (µg/m³)

Year	AQO	PC	PC % of PM_{10} AQO	PC % of $PM_{2.5}$ AQO	Screened out?	Location (x,y)
2020	40 (PM_{10}) 20 ($PM_{2.5}$)	0.19	0.5	1.0	Yes	486300, 223960
2021		0.17	0.4	0.9		486160, 223700
2022		0.17	0.4	0.9		486310, 223750
2023		0.18	0.3	0.9		486320, 223930
2024		0.18	0.5	0.9		486300, 223960

Table 7.14 shows the maximum offsite 24-hour average PM_{10} PCs, using meteorological data for the five years 2020 to 2024. These impacts are screened out, as they are less than 10% of the air quality objective.

Table 7.14: Maximum PCs to 24-hour average PM_{10} concentrations (µg/m³)

Year	AQO	PC	PC % of AQO	Screened out?	Location (x,y)
2020	50	0.71	1.4	Yes	486150, 223710
2021		0.73	1.5		486160, 223700
2022		0.62	1.2		486310, 223750
2023		0.63	1.3		486150, 223710
2024		0.60	1.2		486310, 223750

As all offsite particulate PCs are screened out, impacts at the receptor locations are not presented for this pollutant.

7.5 Predicted concentrations of carbon monoxide

Table 7.15 shows the maximum offsite 8-hour average PCs of carbon monoxide, using meteorological data for the five years 2020 to 2024. These impacts are screened out as they are less than 10% of the air quality objective.

Table 7.15: Maximum offsite PCs to 8-hour average CO concentrations (µg/m³)

Year	AQO	PC	PC % of AQO	Screened out?	Location (x,y)
2020	10,000	25	0.3	Yes	486090, 223880
2021		24	0.2		486100, 223850
2022		25	0.3		486110, 223830
2023		24	0.2		486090, 223870
2024		26	0.3		486100, 223850

Table 7.16 shows the maximum offsite hourly average CO PCs, using meteorological data for the five years 2020 to 2024. These impacts are screened out, as they are less than 10% of the EAL.

Table 7.16: Maximum offsite PCs to hourly average CO concentrations (µg/m³)

Year	EAL	PC	PC % of EAL	Screened out?	Location (x,y)
2020	30,000	31	0.1	Yes	486180, 223750
2021		29	0.1		486190, 223740
2022		29	0.1		486100, 223850
2023		31	0.1		486190, 223740
2024		32	0.1		486180, 223750

As all offsite CO PCs are screened out, impacts at the receptor locations are not presented for this pollutant.

7.6 Predicted concentrations of hydrogen chloride

Table 7.17 shows the maximum offsite hourly average PCs of HCl, using meteorological data for the five years 2020 to 2024.

These impacts are screened out as they are less than 10% of the EAL for HCl.

Table 7.17: Maximum offsite PCs to hourly average HCl concentrations (µg/m³)

Year	EAL	PC	PC % of EAL	Screened out?	Location (x,y)
2020	750	18.5	2.5	Yes	486090, 223880
2021		17.5	2.3		486100, 223850
2022		17.4	2.3		486110, 223830
2023		18.7	2.5		486090, 223870
2024		19.4	2.6		486100, 223850

As all offsite HCl PCs are screened out, impacts at the receptor locations are not presented for this pollutant.

7.7 Predicted concentrations of hydrogen fluoride

Table 7.18 shows the maximum offsite monthly average PCs of HF, using meteorological data for the five years 2020 to 2024.

These impacts are screened out as they are less than 1% of the monthly average EAL for HF.

Table 7.18: Maximum offsite PCs to monthly average HF concentrations (µg/m³)

Year	EAL	PC	PC % of EAL	Screened out?	Location (x,y)
2020	16	0.035	0.2	Yes	486290, 223970
2021		0.039	0.2		486150, 223720
2022		0.040	0.3		486160, 223710
2023		0.045	0.3		486140, 223720
2024		0.030	0.2		486320, 223930

Table 7.19 shows the maximum offsite hourly average PCs of HF, using meteorological data for the five years 2020 to 2024.

These impacts are screened out as they are less than 10% of the hourly average EAL for HF.

Table 7.19: Maximum offsite PCs to hourly average HF concentrations (µg/m³)

Year	EAL	PC	PC % of EAL	Screened out?	Location (x,y)
2020	160	1.3	0.8	Yes	486090, 223880
2021		1.2	0.8		486100, 223850
2022		1.2	0.8		486110, 223830
2023		1.3	0.8		486090, 223870
2024		1.3	0.8		486100, 223850

As all offsite HF PCs are screened out, impacts at the receptor locations are not presented for this pollutant.

7.8 Predicted concentrations of benzo(a)pyrene

Table 7.20 shows the maximum offsite monthly average PCs of benzo(a)pyrene, using meteorological data for the five years 2020 to 2024. Note that these concentrations of benzo(a)pyrene are presented in units of ng/m^3.

The maximum offsite annual average benzo(a)pyrene PC is 0.004 ng/m^3, 1.6% of the air quality objective of 0.25 ng/m^3. Including the background concentration of 0.06 µg/m^3, maximum offsite annual average PECs are below the air quality objective.

Table 7.20: Maximum offsite PCs to annual average benzo(a)pyrene concentrations (ng/m^3)

Year	AQO	PC	PC % of AQO	Screened out?	Background	PEC	PEC % of AQO	Location (x,y)
2020	0.25	0.004	1.6	No	0.06	0.064	26	486300, 223960
2021		0.003	1.2			0.063	25	486160, 223700
2022		0.003	1.2			0.063	25	486310, 223750
2023		0.004	1.6			0.064	26	486320, 223930
2024		0.004	1.6			0.064	26	486300, 223960

Figure 7.6 shows a contour plot of annual average benzo(a)pyrene PCs, based on meteorological data for the year giving rise to the highest predicted concentration.

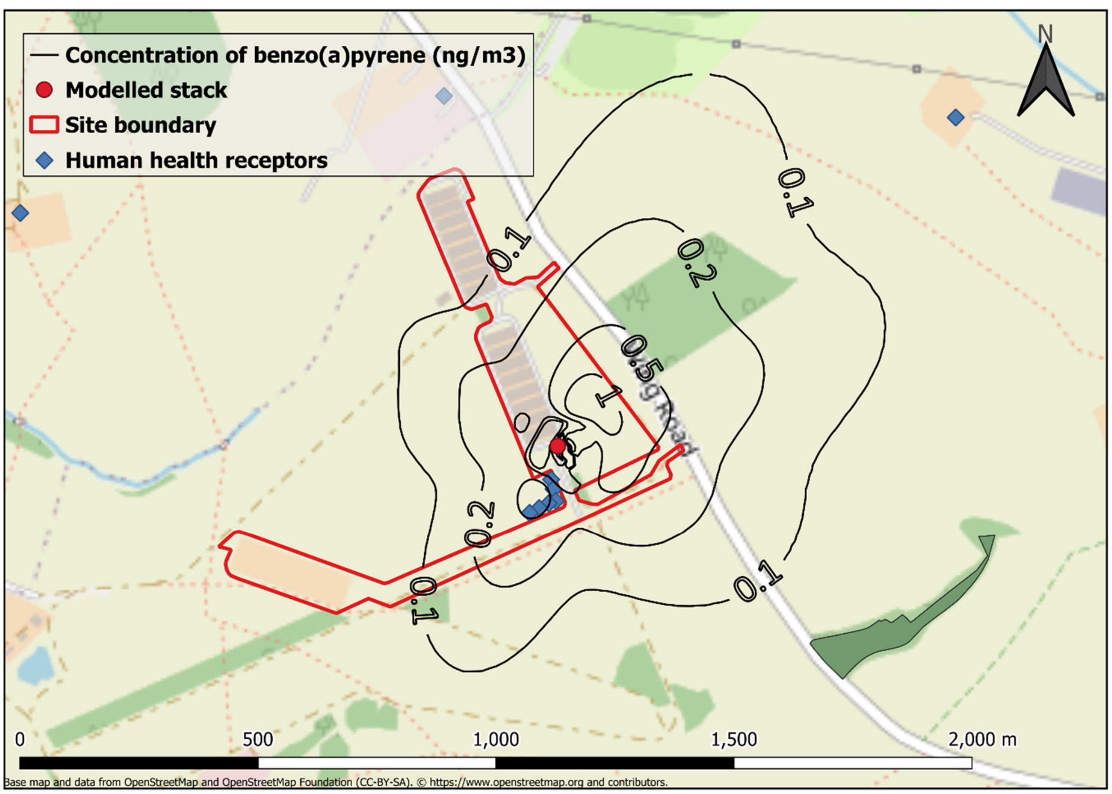

Figure 7.6: Contour plot of annual average benzo(a)pyrene concentrations

7.8.1 Concentrations at sensitive human health receptors

As the maximum offsite annual average benzo(a)pyrene PCs are not screened out, Table 7.21 shows the values at the sensitive human health receptors. For each receptor, the maximum value over the five years of meteorological data is presented.

These impacts are screened out at all receptors, except some of those close to the site on the Wing Complex itself. There are no exceedences of the air quality objective for benzo(a)pyrene.

Table 7.21: PCs to annual average benzo(a)pyrene concentrations (ng/m^3) at receptors

Receptor	AQO	PC	% of AQO	Screened out?	Background	PEC	PEC % of AQO
Burcott Lodge	0.25	0.0002	0.1	Yes	-	-	-
Blackthorn Nursery		0.0002	0.1				
Lydcote Hause		0.0001	< 0.1				
South Tinkers Hole Farm		0.0001	< 0.1				
Wing Complex 1		0.0011	0.4				
Wing Complex 2		0.0022	0.9				
Wing Complex 3		0.0026	1.0	No	0.06	0.063	25
Wing Complex 4		0.0031	1.2			0.063	25
Wing Complex 5		0.0032	1.3			0.063	25
Wing Complex 6		0.0029	1.2			0.063	25

7.9 Predicted concentrations of mercury

Table 7.22 shows the maximum offsite 24-hour (long-term) average PCs of mercury, using meteorological data for the five years 2020 to 2024.

These impacts are screened out as they are less than 1% of the 24-hour (long-term) average EAL for mercury.

Table 7.22: Maximum offsite PCs to 24-hour (long-term) average mercury concentrations (µg/m³)

Year	EAL	PC	PC % of EAL	Screened out?	Location (x,y)
2020	0.25	0.0009	0.4	Yes	486300, 223960
2021		0.0009	0.4		486160, 223700
2022		0.0009	0.4		486310, 223750
2023		0.0009	0.4		486320, 223930
2024		0.0009	0.4		486300, 223960

Table 7.23 shows the maximum offsite hourly average PCs of mercury, using meteorological data for the five years 2020 to 2024.

These impacts are screened out as they are less than 10% of the hourly average EAL for mercury.

Table 7.23: Maximum offsite PCs to hourly average mercury concentrations (µg/m³)

Year	EAL	PC	PC % of EAL	Screened out?	Location (x,y)
2020	7.5	0.016	0.2	Yes	486090, 223880
2021		0.015	0.2		486100, 223850
2022		0.015	0.2		486110, 223830
2023		0.016	0.2		486090, 223870
2024		0.016	0.2		486100, 223850

As all offsite PCs of mercury are screened out, impacts at the receptor locations are not presented for this pollutant.

7.10 Predicted concentrations of cadmium

Table 7.24 shows the maximum offsite annual average PCs of cadmium, using meteorological data for the five years 2020 to 2024. Note that these concentrations of cadmium are presented in units of ng/m^3.

The maximum offsite annual average cadmium PC is 0.9 ng/m^3, 18% of the target value of 5 ng/m^3. Including the background concentration of 0.07 ng/m^3, maximum offsite annual average PECs are below the target value.

Figure 7.7 shows a contour plot of annual average cadmium PCs, based on the year of meteorological data giving rise to the highest predicted concentration.

Table 7.24: Maximum offsite PCs to annual average cadmium concentrations (ng/m^3)

Year	Target value	PC	PC % of target value	Screened out?	Background	PEC	PEC % of target value	Location (x,y)
2020	5	0.9	18	No	0.07	0.97	19	486300, 223960
2021		0.9	18			0.97	19	486160, 223700
2022		0.9	18			0.97	19	486310, 223750
2023		0.9	18			0.97	19	486320, 223930
2024		0.9	18			0.97	19	486300, 223960

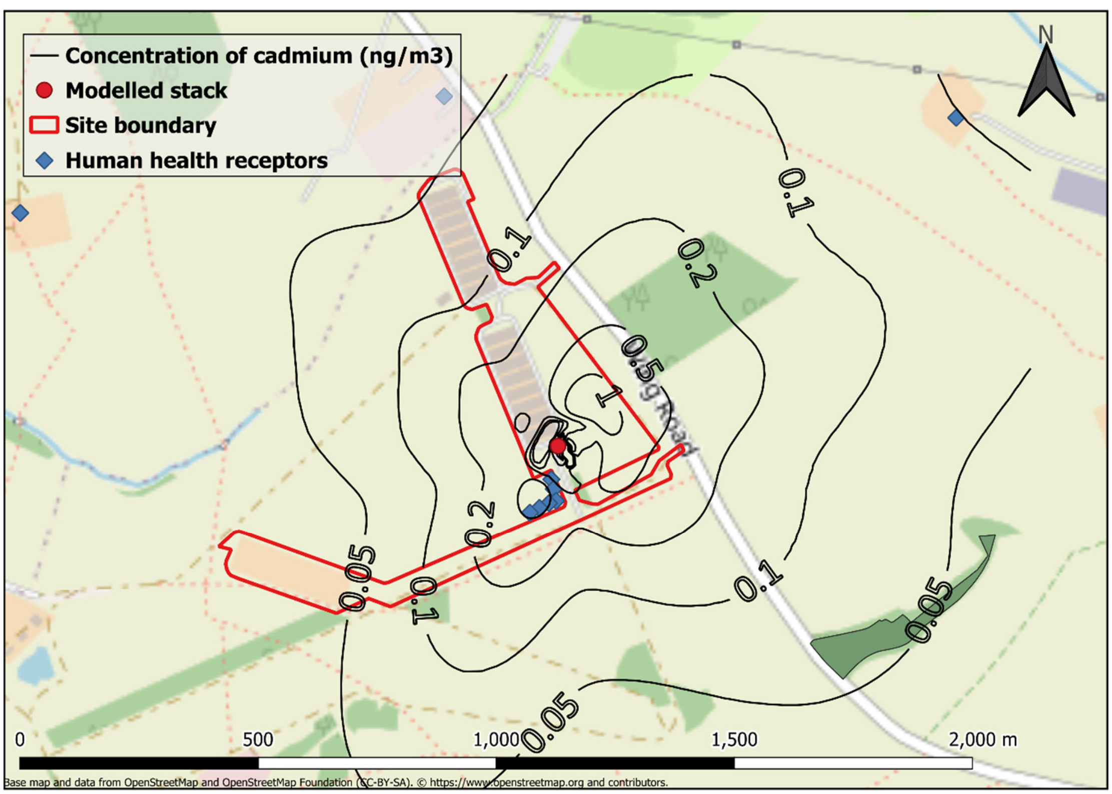

Figure 7.7: Contour plot of annual average cadmium concentrations

Table 7.25 shows the maximum offsite 24-hour average PCs of cadmium, using meteorological data for the five years 2020 to 2024.

The maximum offsite 24-hour average cadmium PC is 11 ng/m^3, 37% of the EAL of 30 ng/m^3. Including the background concentration, maximum offsite annual average PECs are below the EAL.

Figure 7.8 shows a contour plot of 24-hour average cadmium PCs, based on the year of meteorological data giving rise to the highest predicted concentration.

Table 7.25: Maximum offsite PCs to 24-hour average cadmium concentrations (ng/m^3)

Year	EAL	PC	% of EAL	Screened out?	Background	PEC	PEC % of EAL	Location (x,y)
2020	30	10	33	No	0.07	10	33	486100, 223840
2021		9	30			9	30	486280, 223720
2022		10	33			10	33	486100, 223850
2023		8	27			8	27	486160, 223710
2024		11	37			11	37	486100, 223850

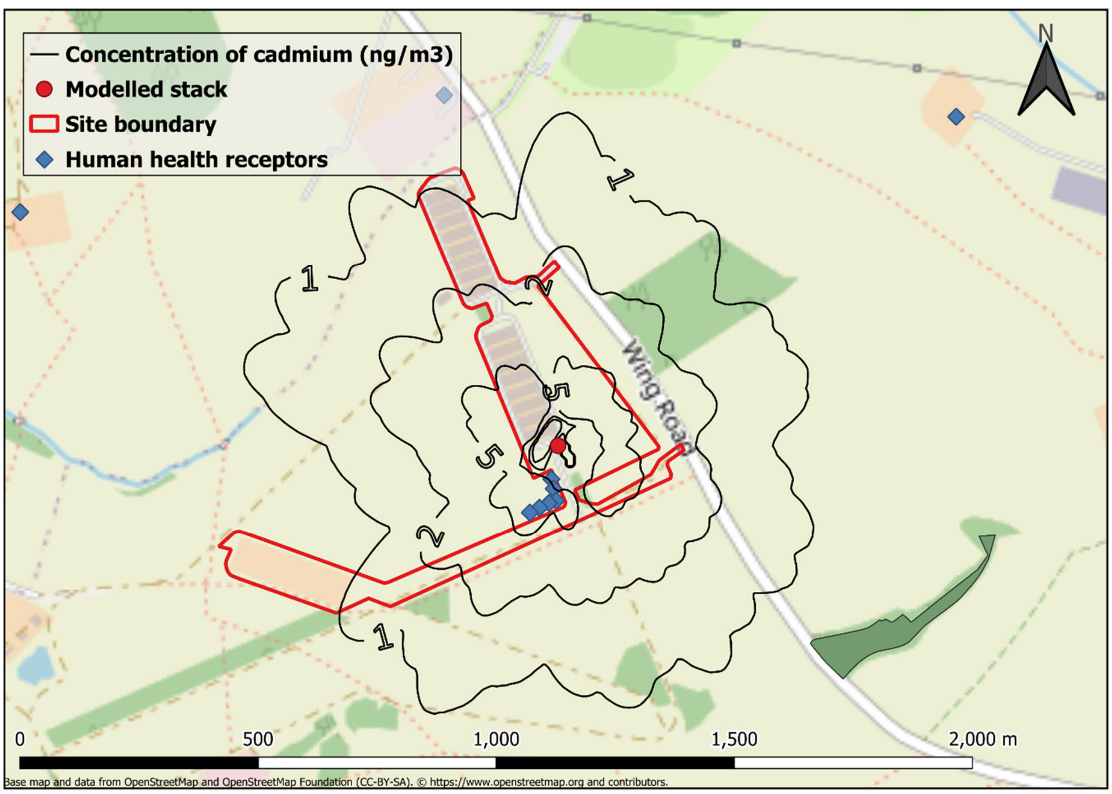

Figure 7.8: Contour plot of 24-hour average cadmium concentrations

7.10.1 Concentrations at sensitive human health receptors

As the maximum offsite cadmium PCs are not screened out, Table 7.26 and Table 7.27 show the annual and 24-hour average values, respectively, at the sensitive human health receptors. For each receptor, the maximum value over the five years of meteorological data is presented.

These impacts are screened out at some of the receptors, but not at Burcott Lodge or at locations close to the site on the Wing Complex itself. There are no exceedences of the air quality standards for cadmium.

Table 7.26: PCs to annual average cadmium concentrations (ng/m^3) at receptors

Receptor	Target value	PC	% of AQO	Screened out?	Background	PEC	PEC % of AQO
Burcott Lodge	5	0.06	1.2	No	0.07	0.13	3
Blackthorn Nursery		0.04	0.8	Yes	-	-	-
Lydcote Hause		0.02	0.4				
South Tinkers Hole Farm		0.03	0.6				
Wing Complex 1		0.28	6	No	0.07	0.35	7
Wing Complex 2		0.55	11			0.62	12
Wing Complex 3		0.65	13			0.72	14
Wing Complex 4		0.77	15			0.84	17
Wing Complex 5		0.80	16			0.87	17
Wing Complex 6		0.73	15			0.80	16

Table 7.27: PCs to 24-hour average cadmium concentrations (ng/m^3) at receptors

Receptor	EAL	PC	% of AQO	Screened out?	Background	PEC	PEC % of AQO
Burcott Lodge	30	0.4	1.3	Yes	-	-	-
Blackthorn Nursery		0.6	2.0				
Lydcote Hause		0.5	1.7				
South Tinkers Hole Farm		0.3	1.0				
Wing Complex 1		4.8	16	No	0.07	4.9	16
Wing Complex 2		7.6	25			7.7	26
Wing Complex 3		7.5	25			7.6	26
Wing Complex 4		7.7	26			7.8	26
Wing Complex 5		7.9	26			8.0	27
Wing Complex 6		7.4	25			7.5	25

7.11 Predicted concentrations of thallium

There are no air quality standards for thallium. As the long-term Workplace Exposure Level (WEL) for thallium is the same as that for arsenic, annual average PCs for thallium are compared against the long-term EAL for arsenic, for this assessment.

Table 7.28 shows the maximum offsite annual average PCs of thallium, using meteorological data for the five years 2020 to 2024. Note that these concentrations of thallium are presented in units of ng/m^3.

The maximum offsite annual average thallium PC is 0.9 ng/m^3, 15% of the EAL of 6 ng/m^3. As no background concentration data could be found, the PEC is assumed equal to the PC.

Figure 7.9 shows a contour plot of annual average thallium PCs, based on the year of meteorological data giving rise to the highest concentration.

Table 7.28: Maximum offsite PCs to annual average thallium concentrations (ng/m^3)

Year	EAL	PC = PEC	PC or PEC % of EAL	Screened out?	Location (x,y)
2020	6	0.9	15	No	486300, 223960
2021		0.9	15		486160, 223700
2022		0.9	15		486310, 223750
2023		0.9	15		486320, 223930
2024		0.9	15		486300, 223960

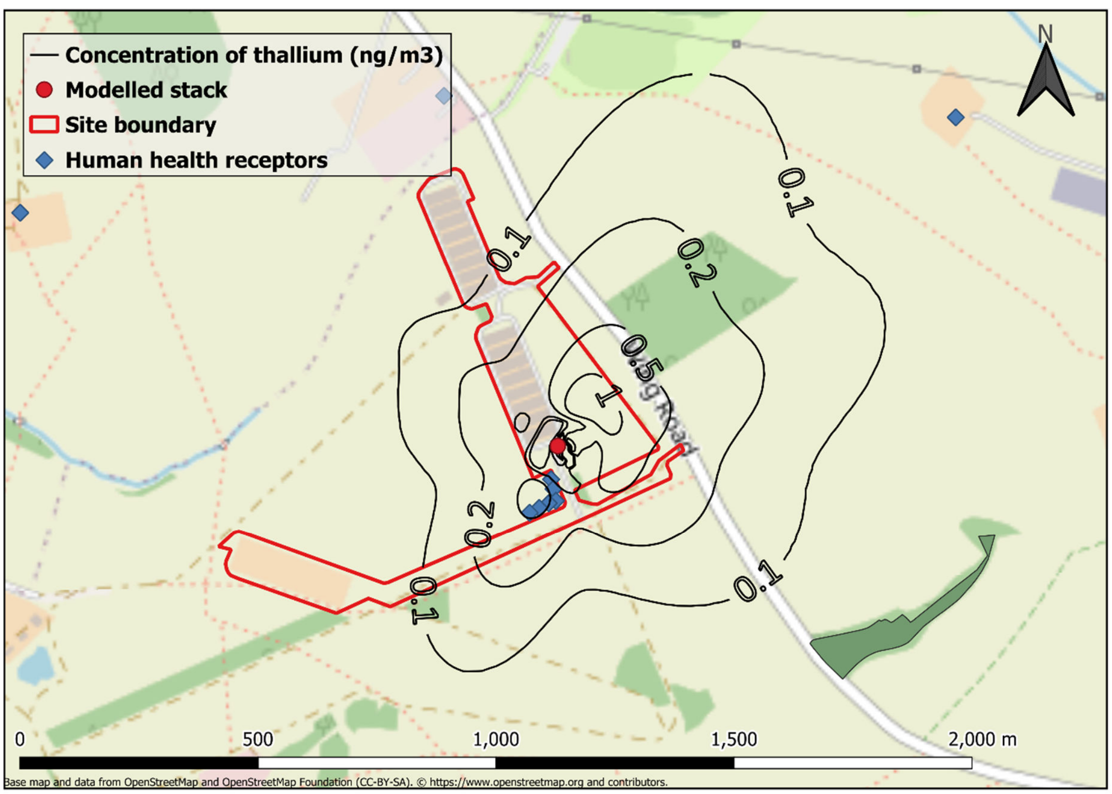

Figure 7.9: Contour plot of annual average thallium concentrations

7.11.1 Concentrations at sensitive human health receptors

As the maximum offsite thallium PCs are not screened out, Table 7.29 shows the annual average values, respectively, at the sensitive human health receptors. For each receptor, the maximum value over the five years of meteorological data is presented.

These impacts are screened out at all receptors, except those close to the site on the Wing Complex itself. There are no exceedences of the EAL for thallium.

Table 7.29: PCs to annual average thallium concentrations (ng/m^3) at receptors

Receptor	EAL	PC = PEC	% of AQO	Screened out?
Burcott Lodge	6	0.06	1.0	Yes
Blackthorn Nursery		0.04	0.7	
Lydcote Hause		0.02	0.3	
South Tinkers Hole Farm		0.03	0.5	
Wing Complex 1		0.28	5	No
Wing Complex 2		0.55	9	
Wing Complex 3		0.65	11	
Wing Complex 4		0.77	13	
Wing Complex 5		0.80	13	
Wing Complex 6		0.73	12	

7.12 Predicted concentrations of antimony

Table 7.30 shows the maximum offsite annual average PCs of antimony, using meteorological data for the five years 2020 to 2024.

These impacts are screened out as they are less than 1% of the annual average EAL for antimony.

Table 7.30: Maximum offsite PCs to annual average antimony concentrations (µg/m³)

Year	EAL	PC	PC % of EAL	Screened out?	Location (x,y)
2020	5	0.009	0.2	Yes	486300, 223960
2021		0.009	0.2		486160, 223700
2022		0.008	0.2		486310, 223750
2023		0.009	0.2		486320, 223930
2024		0.009	0.2		486300, 223960

Table 7.31 shows the maximum offsite hourly average PCs of antimony, using meteorological data for the five years 2020 to 2024.

These impacts are screened out as they are less than 10% of the hourly average EAL for antimony.

Table 7.31: Maximum offsite PCs to hourly average antimony concentrations (µg/m³)

Year	EAL	PC	PC % of EAL	Screened out?	Location (x,y)
2020	150	0.16	0.1	Yes	486090, 223880
2021		0.15	0.1		486100, 223850
2022		0.15	0.1		486110, 223830
2023		0.16	0.1		486090, 223870
2024		0.16	0.1		486100, 223850

As all offsite PCs of antimony are screened out, impacts at the receptor locations are not presented for this pollutant.

7.13 Predicted concentrations of arsenic

Table 7.32 shows the maximum offsite annual average PCs of arsenic, using meteorological data for the five years 2020 to 2024. Note that these concentrations of arsenic are presented in units of ng/m^3.

The maximum offsite annual average arsenic PC is 9.3 ng/m^3, which exceeds the EAL of 6 ng/m^3. These results assume that 100% of the nine emitted metals is arsenic.

Table 7.32: Maximum offsite PCs to annual average arsenic concentrations (ng/m^3) - metals ELV

Year	EAL	PC	PC % of EAL	Screened out?	Location (x,y)
2020	6	9.3	155	No	486300, 223960
2021		8.6	143		486160, 223700
2022		8.5	142		486310, 223750
2023		9.3	155		486320, 223930
2024		9.0	150		486300, 223960

Table 7.33 shows the maximum offsite annual average PCs of arsenic when an emission concentration of 0.025 mg/Nm^3 is assumed, instead of 0.5 mg/Nm^3. This emission concentration is the maximum value taken from Appendix A of Environment Agency *Guidance on assessing Group 3 metal stack emissions from incinerators*.[29]

Using this revised emission rate, the maximum offsite annual average arsenic PC is 0.465 ng/m^3, 8% of the EAL of 6 ng/m^3. Including the background concentration of 0.7 ng/m^3, maximum offsite annual average PECs are below the EAL.

Figure 7.10 shows a contour plot of annual average arsenic PCs, based on the year of meteorological data giving rise to the highest predicted concentration.

Table 7.33: Maximum offsite PCs to annual average arsenic concentrations (ng/m^3) – reduced emission concentration

Year	EAL	PC	PC % of EAL	Screened out?	Background	PEC	% PEC of EAL	Location (x,y)
2020	6	0.46	8	No	0.57	1.0	17	486300, 223960
2021		0.43	7			1.0	17	486160, 223700
2022		0.42	7			1.0	17	486310, 223750
2023		0.46	8			1.0	17	486320, 223930
2024		0.45	8			1.0	17	486300, 223960

There is no short-term (hourly or 24-hour average) air quality standard for arsenic.

[29] https://assets.publishing.service.gov.uk/media/5a80dd59ed915d74e6230e2d/LIT_7349.pdf

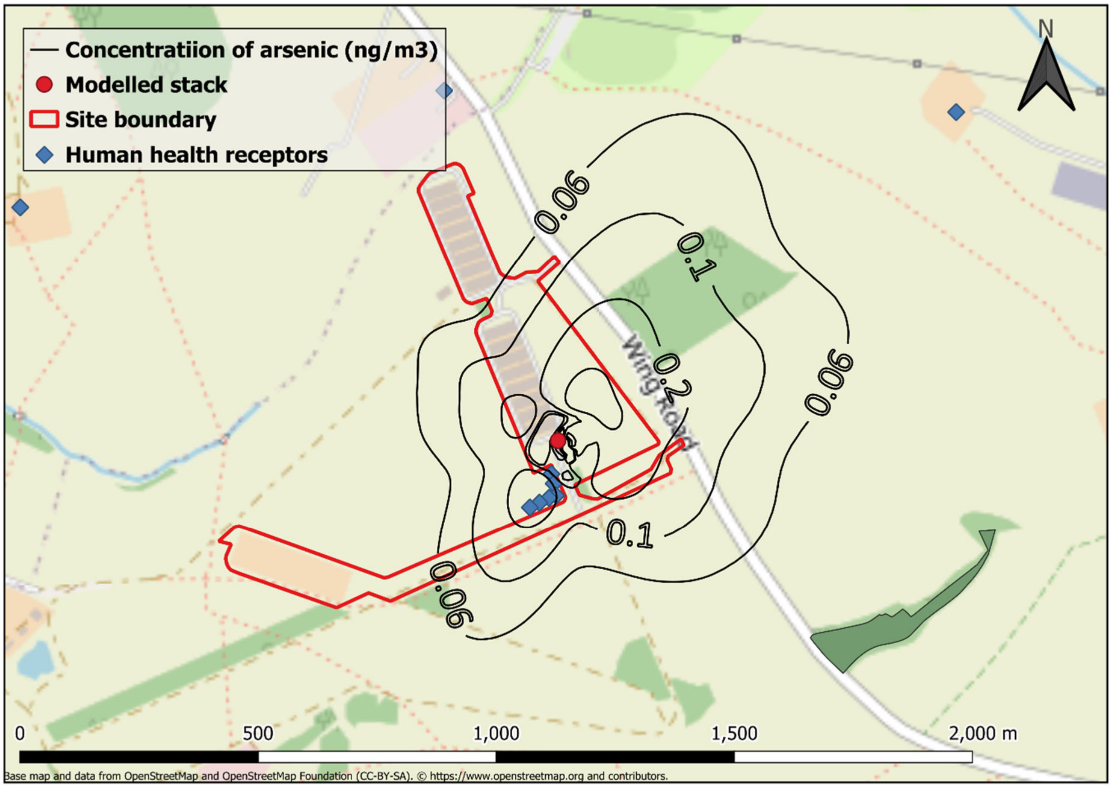

Figure 7.10: Contour plot of annual average arsenic concentrations

7.13.1 Concentrations at sensitive human health receptors

As the maximum offsite arsenic PCs are not screened out, Table 7.34 shows the annual average values at the sensitive human health receptors. For each receptor, the maximum value over the five years of meteorological data is presented. These results assume an emission concentration of 0.025 mg/Nm^3 for arsenic, as in Table 7.33.

These impacts are screened out at all receptors, except those close to the site on the Wing Complex itself. There are no exceedences of the EAL for arsenic.

Table 7.34: PCs to annual average arsenic concentrations (ng/m^3) at receptors – reduced emission concentration

Receptor	EAL	PC	% of AQO	Screened out?	Background	PEC	PEC % of AQO
Burcott Lodge	6	0.03	0.5	Yes	-	-	-
Blackthorn Nursery		0.02	0.3				
Lydcote Hause		0.01	0.2				
South Tinkers Hole Farm		0.02	0.3				
Wing Complex 1		0.14	2.3	No	0.57	0.71	12
Wing Complex 2		0.28	4.7			0.85	14
Wing Complex 3		0.33	5.5			0.90	15
Wing Complex 4		0.39	6.5			0.96	16
Wing Complex 5		0.40	6.7			0.97	16
Wing Complex 6		0.36	6.0			0.93	16

7.14 Predicted concentrations of lead

Table 7.35 shows the maximum offsite annual average PCs of lead, using meteorological data for the five years 2020 to 2024.

The maximum offsite annual average lead PC is 0.009 µg/m^3, 4% of the EAL of 0.25 µg/m^3. These results assume that 100% of the nine emitted metals is lead.

Table 7.35: Maximum PCs to annual average lead concentrations (µg/m^3) – metals ELV

Year	AQO	PC	% of AQO	Screened out?	Location (x,y)
2020	0.25	0.009	4	No	486300, 223960
2021		0.009	4		486160, 223700
2022		0.008	4		486310, 223750
2023		0.009	4		486320, 223930
2024		0.009	4		486300, 223960

Table 7.36 shows the maximum offsite annual average PCs of lead when an emission concentration of 0.0503 mg/Nm^3 is assumed, instead of 0.5 mg/Nm^3. This emission concentration is the maximum value taken from Appendix A of Environment Agency *Guidance on assessing Group 3 metal stack emissions from incinerators*.[30]

Table 7.36: Maximum PCs to annual average lead concentrations (µg/m^3) – reduced emission concentration

Year	AQO	PC	% of AQO	Screened out?	Location (x,y)
2020	0.25	0.0009	0.4	Yes	486300, 223960
2021		0.0009	0.4		486160, 223700
2022		0.0008	0.4		486310, 223750
2023		0.0009	0.4		486320, 223930
2024		0.0009	0.4		486300, 223960

Using this revised emission rate, these impacts are screened out as they are less than 1% of the annual average AQO for lead.

There is no short-term (hourly or 24-hour average) air quality standard for lead.

[30] https://assets.publishing.service.gov.uk/media/5a80dd59ed915d74e6230e2d/LIT_7349.pdf

7.15 Predicted concentrations of chromium

Table 7.37 shows the maximum offsite annual average PCs of chromium, using meteorological data for the five years 2020 to 2024. Note that these concentrations of chromium are presented in units of ng/m^3.

The maximum offsite annual average chromium PC is 9.3 ng/m^3, which exceeds the EAL for chromium VI of 0.25 ng/m^3. These results assume that 100% of the nine emitted metals is chromium and that 100% of the emitted chromium is chromium VI.

Table 7.37: Maximum PCs to annual average chromium concentrations (ng/m^3) – metals ELV

Year	EAL (Cr VI)	PC (total Cr)	% of EAL	Screened out?	Location (x,y)
2020	0.25	9.3	3720	No	486300, 223960
2021		8.6	3440		486160, 223700
2022		8.5	3400		486310, 223750
2023		9.3	3720		486320, 223930
2024		9.0	3600		486300, 223960

Table 7.38 shows the maximum offsite annual average PCs of chromium when an emission concentration of 1.3 x 10^{-4} mg/Nm^3 is assumed for chromium VI, instead of 0.5 mg/Nm^3. This emission concentration is the maximum value taken from Appendix A of Environment Agency *Guidance on assessing Group 3 metal stack emissions from incinerators*.[29]

Using this revised emission rate, these impacts are screened out as they are less than 1% of the annual average EAL for chromium VI.

Table 7.38: Maximum PCs to annual average chromium VI concentrations (ng/m^3) – reduced emission concentration

Year	EAL (Cr VI)	PC (Cr VI)	% of EAL	Screened out?	Location (x,y)
2020	0.25	0.002	0.8	Yes	486300, 223960
2021		0.002	0.8		486160, 223700
2022		0.002	0.8		486310, 223750
2023		0.002	0.8		486320, 223930
2024		0.002	0.8		486300, 223960

Table 7.39 shows the maximum offsite 24-hour average PCs of chromium, using meteorological data for the five years 2020 to 2024. Note that these concentrations of chromium are presented in units of µg/m^3.

The maximum offsite 24-hour average chromium PC is 0.044 µg/m^3, 2% of the EAL of 2 µg/m^3. These results assume that 100% of the nine emitted metals is chromium and that 100% of the emitted chromium is chromium III.

Table 7.39: Maximum PCs to 24-hour average chromium concentrations (µg/m^3) – metals ELV

Year	EAL (Cr III)	PC	PC % of EAL	Screened out?	Location (x,y)
2020	2	0.098	5	No	486100, 223840
2021		0.088	4		486280, 223720
2022		0.100	5		486100, 223850
2023		0.084	4		486160, 223710
2024		0.112	6		486100, 223850

Table 7.40 shows the maximum offsite 24-hour average PCs of chromium when an emission concentration of 0.092 mg/Nm^3 is assumed for chromium III, instead of 0.5 mg/Nm^3. This emission concentration is the maximum value taken from Appendix A of Environment Agency *Guidance on assessing Group 3 metal stack emissions from incinerators*.[29]

Using this revised emission rate, these impacts are screened out as they are less than 10% of the 24-hour average EAL for chromium III.

Table 7.40: Maximum PCs to 24-hour average chromium concentrations (µg/m^3) – reduced emission concentration

Year	EAL (Cr III)	PC	PC % of EAL	Screened out?	Location (x,y)
2020	2	0.018	0.9	Yes	486100, 223840
2021		0.016	0.8		486280, 223720
2022		0.018	0.9		486100, 223850
2023		0.015	0.8		486160, 223710
2024		0.021	1.1		486100, 223850

As the offsite PCs of chromium are screened out, impacts at the receptor locations are not presented for this pollutant.

7.16 Predicted concentrations of cobalt

There are no air quality standards for cobalt. As the long-term WEL for cobalt is the same as that for arsenic, annual average PCs for cobalt are compared against the long-term EAL for arsenic, for this assessment.

Table 7.41 shows the maximum offsite annual average PCs of cobalt, using meteorological data for the five years 2020 to 2024. Note that these concentrations of cobalt are presented in units of ng/m^3.

The maximum offsite annual average cobalt PC is 9.3 ng/m^3, which exceeds the EAL of 6 ng/m^3. These results assume that 100% of the nine emitted metals is cobalt.

Table 7.41: Maximum PCs to annual average cobalt concentrations (ng/m^3) – metals ELV

Year	EAL	PC	PC % of EAL	Screened out?	Location (x,y)
2020	6	9.3	155	No	486300, 223960
2021		8.6	143		486160, 223700
2022		8.5	142		486310, 223750
2023		9.3	155		486320, 223930
2024		9.0	150		486300, 223960

Table 7.42 shows the maximum offsite annual average PCs of cobalt when an emission concentration of 0.0056 mg/Nm^3 is assumed, instead of 0.5 mg/Nm^3. This emission concentration is the maximum value taken from Appendix A of Environment Agency *Guidance on assessing Group 3 metal stack emissions from incinerators*.[29]

Using this revised emission rate, the maximum offsite annual average cobalt PC is 0.104 ng/m^3, 1.7% of the EAL of 6 ng/m^3. Including the background concentration of 0.04 ng/m^3, maximum offsite annual average PECs are below the EAL.

Table 7.42: Maximum PCs to annual average cobalt concentrations (ng/m^3) – reduced emission concentration

Year	EAL	PC	PC % of EAL	Screened out?	Background	PEC	% PEC of EAL	Location (x,y)
2020	6	0.104	1.7	No	0.04	0.144	2.4	486300, 223960
2021		0.096	1.6			0.136	2.3	486160, 223700
2022		0.095	1.6			0.135	2.3	486310, 223750
2023		0.104	1.7			0.144	2.4	486320, 223930
2024		0.101	1.7			0.141	2.4	486300, 223960

Figure 7.11 shows a contour plot of annual average cobalt PCs, based on the year of meteorological data giving rise to the highest predicted concentration.

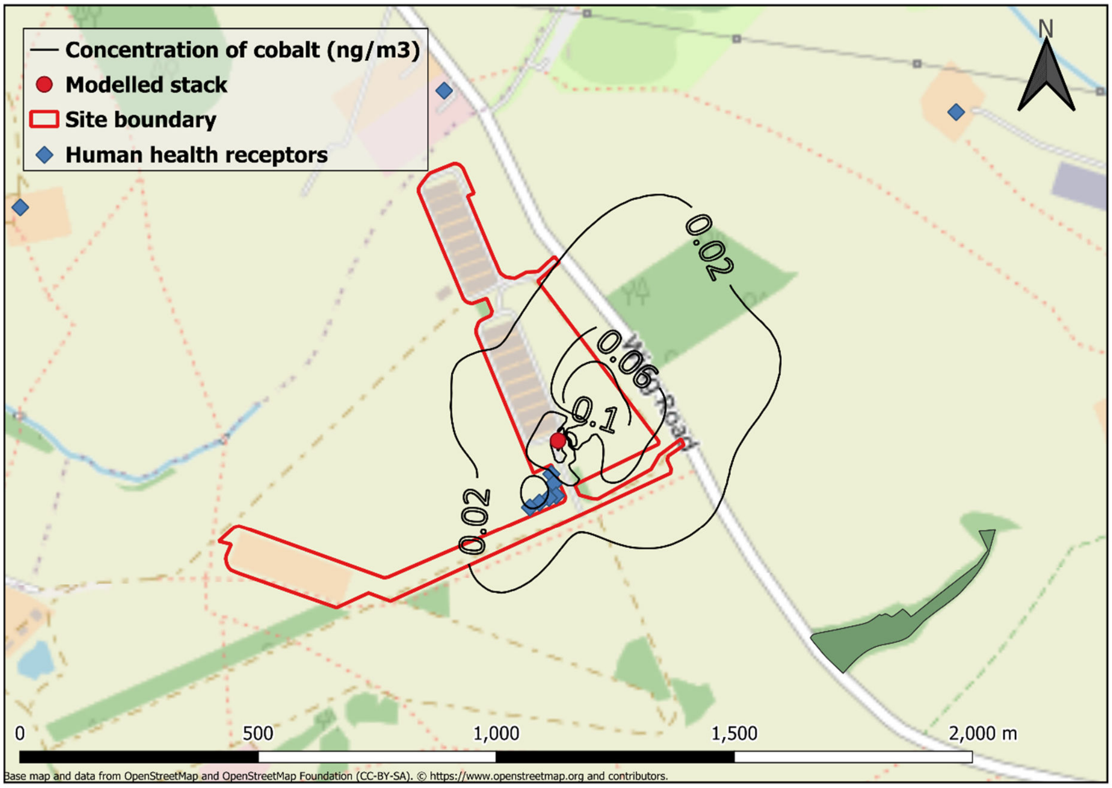

Figure 7.11: Contour plot of annual average cobalt concentrations

7.16.1 Concentrations at sensitive human health receptors

As the maximum offsite cobalt PCs are not screened out, Table 7.43 shows the annual average values at the sensitive human health receptors. For each receptor, the maximum value over the five years of meteorological data is presented. These results assume an emission concentration of 0.0056 mg/Nm^3 for cobalt, as in Table 7.42.

These impacts are screened out at all receptors, except those close to the site on the Wing Complex itself. There are no exceedences of the EAL for cobalt.

Table 7.43: PCs to annual average cobalt concentrations (ng/m^3) at receptors - reduced emission concentration

Receptor	AQO	PC	% of AQO	Screened out?	Background	PEC	PEC % of AQO
Burcott Lodge	6	0.007	0.1	Yes	-	-	-
Blackthorn Nursery		0.004	< 0.1				
Lydcote Hause		0.002	< 0.1				
South Tinkers Hole Farm		0.003	< 0.1				
Wing Complex 1		0.031	0.5				
Wing Complex 2		0.062	1.0	No	0.04	0.102	1.7
Wing Complex 3		0.073	1.2			0.113	1.9
Wing Complex 4		0.086	1.4			0.126	2.1
Wing Complex 5		0.090	1.5			0.130	2.2
Wing Complex 6		0.082	1.4			0.122	2.0

7.17 Predicted concentrations of copper

Table 7.44 shows the maximum offsite 24-hour (long-term) average PCs of copper, using meteorological data for the five years 2020 to 2024.

The maximum offsite 24-hour average (long-term) copper PC is 0.009 µg/m^3, 18% of the EAL of 0.05 µg/m^3. These results assume that 100% of the nine emitted metals is copper.

Table 7.44: Maximum PCs to 24-hour average (long-term) copper concentrations (µg/m^3)

Year	EAL	PC	PC % of EAL	Screened out?	Background	PEC	% PEC of EAL	Location (x,y)
2020	0.05	0.009	18	No	0.002	0.011	22	486300, 223960
2021		0.009	18			0.011	22	486160, 223700
2022		0.008	16			0.010	20	486310, 223750
2023		0.009	18			0.011	22	486320, 223930
2024		0.009	18			0.011	22	486300, 223960

Table 7.45 shows the maximum offsite annual average PCs of copper when an emission concentration of 0.029 mg/Nm^3 is assumed, instead of 0.5 mg/Nm^3. This emission concentration is the maximum value taken from Appendix A of Environment Agency *Guidance on assessing Group 3 metal stack emissions from incinerators*.[29]

Using this revised emission rate, these impacts are screened out as they are 1% of the annual average EAL for copper.

There is no short-term (hourly or 24-hour average) air quality standard for copper.

Table 7.45: Maximum PCs to 24-hour average (long-term) copper concentrations (µg/m^3) – reduced emission concentration

Year	EAL	PC	PC % of EAL	Screened out?	Location (x,y)
2020	0.05	0.0005	1	Yes	486300, 223960
2021		0.0005	1		486160, 223700
2022		0.0005	1		486310, 223750
2023		0.0005	1		486320, 223930
2024		0.0005	1		486300, 223960

7.18 Predicted concentrations of manganese

Table 7.46 shows the maximum offsite annual average PCs of manganese, using meteorological data for the five years 2020 to 2024.

The maximum offsite annual average manganese PC is 0.009 µg/m^3, 6% of the EAL of 0.15 µg/m^3. These results assume that 100% of the nine emitted metals is manganese.

Table 7.46: Maximum PCs to annual average manganese concentrations (µg/m^3)

Year	EAL	PC	PC % of EAL	Screened out?	Background	PEC	% PEC of EAL	Location (x,y)
2020	0.15	0.009	6	No	0.002	0.011	7	486300, 223960
2021		0.009	6			0.011	7	486160, 223700
2022		0.008	6			0.010	7	486310, 223750
2023		0.009	6			0.011	7	486320, 223930
2024		0.009	6			0.011	7	486300, 223960

Table 7.47 shows the maximum offsite annual average PCs of manganese when an emission concentration of 0.06 mg/Nm^3 is assumed, instead of 0.5 mg/Nm^3. This emission concentration is the maximum value taken from Appendix A of Environment Agency *Guidance on assessing Group 3 metal stack emissions from incinerators*.[29]

Using this revised emission rate, these impacts are screened out as they are less than 1% of the annual average EAL for manganese.

Table 7.47: Maximum PCs to annual average manganese concentrations (µg/m^3) – reduced emission concentration

Year	EAL	PC	PC % of EAL	Screened out?	Location (x,y)
2020	0.15	0.001	0.7	Yes	486300, 223960
2021		0.001	0.7		486160, 223700
2022		0.001	0.7		486310, 223750
2023		0.001	0.7		486320, 223930
2024		0.001	0.7		486300, 223960

Table 7.48 shows the maximum offsite hourly average PCs of manganese, using meteorological data for the five years 2020 to 2024. These impacts are screened out as they are less than 10% of the hourly average EAL for manganese.

Table 7.48: Maximum PCs to hourly average manganese concentrations (µg/m^3)

Year	EAL	PC	PC % of EAL	Screened out?	Location (x,y)
2020	1500	0.156	< 0.1	Yes	486090, 223880
2021		0.147	< 0.1		486100, 223850
2022		0.147	< 0.1		486110, 223830
2023		0.157	< 0.1		486090, 223870
2024		0.164	< 0.1		486100, 223850

7.19 Predicted concentrations of nickel

Table 7.49 shows the maximum offsite annual average PCs of nickel, using meteorological data for the five years 2020 to 2024.

The maximum offsite annual average nickel PC is 0.009 µg/m³, 45% of the target value of 0.02 µg/m³. These results assume that 100% of the nine emitted metals is nickel.

Table 7.49: Maximum PCs to annual average nickel concentrations (µg/m³)

Year	Target value	PC	PC % of target value	Screened out?	Location (x,y)
2020	0.02	0.009	45	No	486300, 223960
2021		0.009	45		486160, 223700
2022		0.008	40		486310, 223750
2023		0.009	45		486320, 223930
2024		0.009	45		486300, 223960

Table 7.50 shows the maximum offsite annual average PCs of nickel when an emission concentration of 0.015 mg/Nm³ is assumed, instead of 0.5 mg/Nm³. This emission concentration is the mean[31] value taken from Appendix A of Environment Agency *Guidance on assessing Group 3 metal stack emissions from incinerators*.[29]

Using this revised emission rate, the maximum offsite annual average nickel PC is 0.0003 µg/m³, 1.5% of the target value of 0.02 µg/m³. Including the background concentration of 0.00004 µg/m³, maximum offsite annual average PECs are below the target value.

Table 7.50: Maximum PCs to annual average nickel concentrations (µg/m³) – reduced emission concentration

Year	Target value	PC	PC % of target value	Screened out?	Background	PEC	% PEC of EAL	Location (x,y)
2020	0.02	0.0003	1.5	No	3.5×10^{-4}	0.00065	3.3	486300, 223960
2021		0.0003	1.5			0.00065	3.3	486160, 223700
2022		0.0002	1.0			0.00055	2.8	486310, 223750
2023		0.0003	1.5			0.00065	3.3	486320, 223930
2024		0.0003	1.5			0.00065	3.3	486300, 223960

Figure 7.12 shows a contour plot of annual average nickel PCs, based on the year of meteorological data giving rise to the highest predicted concentration.

[31] Note that, for nickel, the maximum value is an outlier

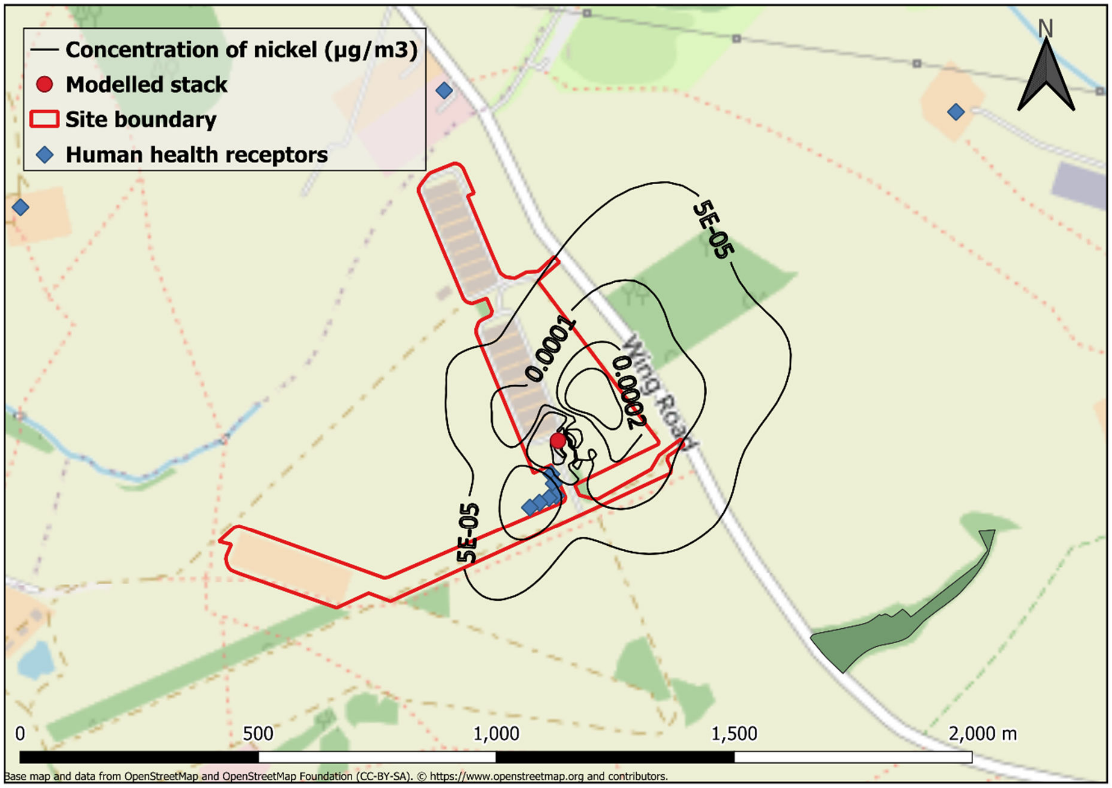

Figure 7.12: Contour plot of annual average nickel concentrations

Table 7.51 shows the maximum offsite hourly average PCs of nickel, using meteorological data for the five years 2020 to 2024.

The maximum offsite hourly average nickel PC is 0.164 µg/m^3, 23% of the EAL of 0.7 µg/m^3. These results assume that 100% of the nine emitted metals is nickel.

Table 7.51: Maximum PCs to hourly average nickel concentrations (µg/m^3)

Year	EAL	PC	PC % of EAL	Screened out?	Location (x,y)
2020	0.7	0.156	22	No	486090, 223880
2021		0.147	21		486100, 223850
2022		0.147	21		486110, 223830
2023		0.157	22		486090, 223870
2024		0.164	23		486100, 223850

Table 7.52 shows the maximum offsite hourly average PCs of nickel when an emission concentration of 0.015 mg/Nm^3 is assumed, instead of 0.5 mg/Nm^3. This emission concentration is the mean value taken from Appendix A of Environment Agency *Guidance on assessing Group 3 metal stack emissions from incinerators*.[29]

Using this revised emission rate, these impacts are screened out as they are less than 10% of the hourly average EAL for nickel.

Table 7.52: Maximum PCs to hourly average nickel concentrations (µg/m³) – reduced emission concentration

Year	EAL	PC	PC % of EAL	Screened out?	Location (x,y)
2020	0.7	0.005	0.7	Yes	486090, 223880
2021		0.004	0.6		486100, 223850
2022		0.004	0.6		486110, 223830
2023		0.005	0.7		486090, 223870
2024		0.005	0.7		486100, 223850

7.19.1 Concentrations at sensitive human health receptors

As the maximum offsite annual average nickel PCs are not screened out, Table 7.53 shows the annual average values at the sensitive human health receptors. For each receptor, the maximum value over the five years of meteorological data is presented.

These impacts are screened out at all receptors, except those close to the site on the Wing Complex itself. There are no exceedences of the target value for nickel.

Table 7.53: PCs to annual average nickel concentrations (µg/m³) at receptors – reduced emission concentration

Receptor	Target value	PC	% of AQO	Screened out?	Background	PEC	PEC % of AQO
Burcott Lodge	0.02	0.00002	0.1	Yes	-	-	-
Blackthorn Nursery		0.00001	0.1				
Lydcote Hause		0.00001	0.1				
South Tinkers Hole Farm		0.00001	0.1				
Wing Complex 1		0.00008	0.4				
Wing Complex 2		0.00017	0.9				
Wing Complex 3		0.00020	1.0				
Wing Complex 4		0.00023	1.2	No	3.5×10^{-4}	0.00058	2.9
Wing Complex 5		0.00024	1.2			0.00059	3.0
Wing Complex 6		0.00022	1.1			0.00057	2.9

7.20 Predicted concentrations of vanadium

There is no long-term (annual average) air quality standard for vanadium.

Table 7.54 shows the maximum offsite 24-hour average PCs of vanadium, using meteorological data for the five years 2020 to 2024.

These impacts are screened out as they are less than 10% of the 24-hour average EAL for vanadium.

Table 7.54: Maximum PCs to 24-hour average vanadium concentrations (µg/m³)

Year	EAL	PC	PC % of EAL	Screened out?	Location (x,y)
2020	1	0.0098	1.0	Yes	486100, 223840
2021		0.0088	0.9		486280, 223720
2022		0.0100	1.0		486100, 223850
2023		0.0084	0.8		486160, 223710
2024		0.0112	1.1		486100, 223850

As all offsite PCs of vanadium are screened out, impacts at the receptor locations are not presented for this pollutant.

7.21 Predicted concentrations of dioxins, furans and dioxin-like PCBs

Dioxins, furans and dioxin-like PCBs are referred to collectively as dioxins throughout this section.

The method and values for inhalation rate and body weight used in this assessment are taken from an HMIP (Her Majesty's Inspectorate of Pollution) report[32]. The impact descriptors in the EPUK and IAQM guidance are not suitable for application to this pollutant.

In the UK, the Committee of Toxicity (COT) sets a threshold-based Tolerable Daily Intake (TDI) for dioxins of 2 pg I-TEQ kg^{-1} day^{-1}. Exposure by inhalation only was considered in this assessment.

The maximum daily intake due to inhalation, INH is given by:

$$INH = (C \times IR) / BW$$

where:
C is the maximum daily average concentration in air in pg/m^3, calculated using ADMS and including an estimate of background concentration;
IR is the inhalation rate, assumed to be 0.83 m^3/hr or 19.92 m^3/day; and
BW is body weight, assumed to be 70 kg.

Table 7.55 shows the maximum predicted daily average concentration of dioxins, together with the location at which it occurs, and the daily intake due to inhalation calculated from that value, using meteorological data for the five years 2020 to 2024.

The results show that the maximum predicted daily intake due to inhalation is 0.7% of the TDI.

[32] Risk Assessment of Dioxin Releases from Municipal Waste Incineration processes, HMIP, 1996

Table 7.55: Maximum predicted concentrations and intake due to inhalation of dioxins

Year	Maximum daily average PC (pg/m³)	Background concentration (pg/m³)	Maximum daily average PEC (pg/m³)	Max daily intake due to inhalation (pg I-TEQ kg^{-1} day^{-1})	TDI (pg I-TEQ kg^{-1} day^{-1})	% of TDI	Location (x,y)
2020	0.020	0.024	0.044	0.013	2	0.7	486100, 223840
2021	0.018		0.042	0.012		0.6	486280, 223720
2022	0.020		0.044	0.013		0.7	486100, 223850
2023	0.017		0.041	0.012		0.6	486160, 223710
2024	0.022		0.046	0.013		0.7	486100, 223850

8 Consideration of concentrations for the protection of vegetation and ecosystems

Modelling was carried out to predict the maximum PC to the ground level concentrations of nitrogen oxide (NO_x), sulphur dioxide (SO_2) and hydrogen fluoride (HF) at the designated conservation areas. Note that the maximum concentrations quoted are the maximum values occurring at locations relevant to the standard under consideration. This means that, for comparison against critical levels for the Protection of Vegetation and Ecosystems, only those values predicted within the sensitive habitat sites were included.

The significance of the total pollutant release was assessed by comparing the PC to the relevant critical level. For long-term critical levels, the Environment Agency considers the release to be insignificant if the PC is less than 1% of the critical level. For short-term critical levels, the Agency considers the release to be insignificant if the PC is less than 10% of the critical level. Where a release is insignificant the pollutant is screened out and no further assessment undertaken.

Where a release is significant, the Predicted Environmental Concentration (PEC) for that substance is calculated by adding the PC to the estimated background concentration of the pollutant.

8.1 Predicted concentrations of nitrogen oxides

Table 8.1 shows the maximum predicted daily average PCs to ground level concentrations of NO_x at the designated conservation areas, calculated using meteorological data for the five years 2020 to 2024.

Table 8.1: Maximum predicted daily average NO_x concentration ($\mu g/m^3$)

Site name	Critical level	Year	PC	PC % of critical level	Screened out?
Blackend Spinney AW	75	2020	1.1	2	Yes
		2021	1.2	2	
		2022	1.2	2	
		2023	1.3	2	
		2024	1.1	2	
Unnamed AW	75	2020	3.7	5	Yes
		2021	3.7	5	
		2022	4.4	6	
		2023	3.6	5	
		2024	2.8	4	

The daily average NO_x PCs are screened out, as they are less than 10% of the critical level.

Table 8.2 shows the maximum predicted annual average PCs to ground level concentrations of NO_x at the designated conservation areas, calculated using meteorological data for the five years 2020 to 2024.

Table 8.2: Maximum predicted annual average NO_x concentration (µg/m^3)

Site name	Critical level	Year	PC	PC % of critical level	Screened out?
Blackend Spinney AW	30	2020	0.2	0.6	Yes
		2021	0.2	0.6	
		2022	0.2	0.6	
		2023	0.2	0.6	
		2024	0.2	0.6	
Unnamed AW	30	2020	0.3	1.0	Yes
		2021	0.3	1.0	
		2022	0.3	1.0	
		2023	0.2	0.7	
		2024	0.2	0.7	

The annual average NO_x PCs are screened out, as they are no more than 1% of the critical level.

8.2 Predicted concentrations of sulphur dioxide

Table 8.3 shows the maximum predicted annual average PCs to ground level concentrations of SO_2 at the designated conservation areas, calculated using meteorological data for the five years 2020 to 2024.

The annual average SO_2 PCs are screened out at both areas, as they are less than 1% of the critical level.

Table 8.3: Maximum predicted annual average SO_2 concentration (μg/m^3)

Site name	Critical level	Year	PC	PC % of critical level	Screened out?
Blackend Spinney AW	20	2020	0.04	0.2	Yes
		2021	0.04	0.2	
		2022	0.05	0.3	
		2023	0.05	0.3	
		2024	0.05	0.3	
Unnamed AW	20	2020	0.06	0.3	Yes
		2021	0.07	0.4	
		2022	0.08	0.4	
		2023	0.06	0.3	
		2024	0.06	0.3	

8.3 Predicted concentrations of hydrogen fluoride

Table 8.4 shows the maximum predicted daily average PCs to ground level concentrations of hydrogen fluoride (HF) at the designated conservation areas, calculated using meteorological data for the five years 2020 to 2024.

The daily average HF PCs are screened out, as they are less than 10% of the critical level.

Table 8.4: Maximum predicted daily average HF concentration (µg/m³)

Site name	Critical level	Year	PC	PC % of critical level	Screened out?
Blackend Spinney AW	5	2020	0.02	0.4	Yes
		2021	0.03	0.1	
		2022	0.03	0.1	
		2023	0.03	0.1	
		2024	0.02	0.1	
Unnamed AW	5	2020	0.08	1.6	Yes
		2021	0.08	1.6	
		2022	0.09	1.8	
		2023	0.07	1.4	
		2024	0.06	1.2	

Table 8.5 shows the maximum predicted weekly average PCs to ground level concentrations of HF at the designated conservation areas, calculated using meteorological data for the five years 2020 to 2024. No data could be found to estimate a background concentration, so the PEC is assumed equal to the PC.

Table 8.5: Maximum predicted weekly average HF concentration (µg/m³)

Site name	Critical level	Year	PC = PEC	PC / PEC % of critical level	Screened out?
Blackend Spinney AW	0.5	2020	0.010	2.0	No
		2021	0.010	2.0	
		2022	0.010	2.0	
		2023	0.010	2.0	
		2024	0.010	2.0	
Unnamed AW	0.5	2020	0.017	3.4	No
		2021	0.019	3.8	
		2022	0.028	5.6	
		2023	0.022	4.4	
		2024	0.015	3.0	

At Blackend Spinney, the maximum offsite weekly average HF PC is 0.010 µg/m³, 2.0% of the critical level of 0.5 µg/m³. At the Unnamed AW site, the maximum offsite weekly average HF PC is 0.028 µg/m³, 5.6% of the critical level.

Figure 8.1 shows a contour plot of the weekly average HF PCs, based on the year of meteorological data giving rise to the highest predicted concentration.

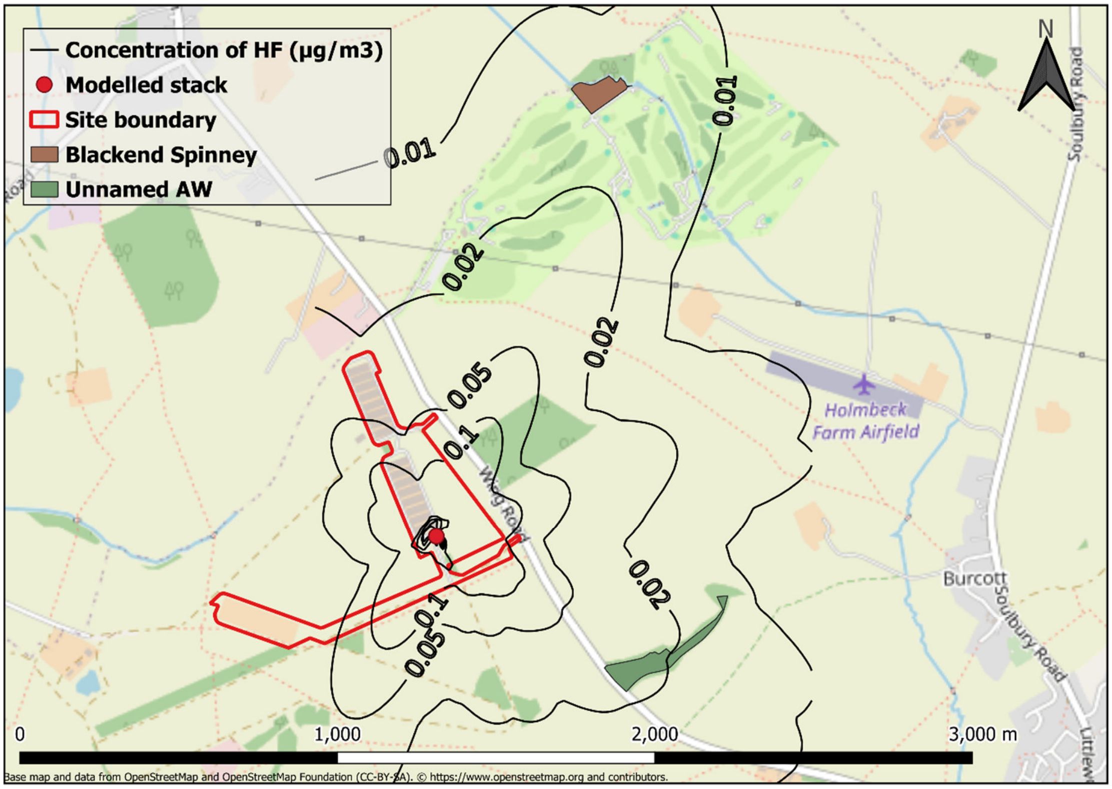

Figure 8.1: Contour plot of weekly average HF concentrations

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.

Modelling was carried out to predict the Process Contribution (PC) to the nitrogen and acid deposition rates from the SWIP site over the designated conservation areas. The significance of the total pollutant release was assessed by comparing the PC to the relevant critical loads. For long-term impacts, as in the case of deposition, 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

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

The Environment Agency Air Quality Modelling and Assessment Unit (AQMAU)[33] recommend dry deposition velocities of 0.003 m/s for NO_2, for forest.

9.1.1 Critical loads and existing levels of nitrogen deposition

The Air Pollution Information System (APIS) website[20] gives critical load values by location, for sites such as Ancient Woodland.

Table 9.1 shows the habitat types, critical loads and total nitrogen deposition values at the designated conservation areas identified in Section 4.3. The total nitrogen deposition values presented represent the average deposition over the years 2020 to 2022, due to existing local sources and background contributions.

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

Area name	Feature name	Relevant nitrogen critical load class	Critical load	Total nitrogen deposition
Blackend Spinney AW	Broadleaved, Mixed and Yew Woodland	Broadleaved, Deciduous Woodland	10- 15	28.69
Unnamed AW				29.03

[33]AQTAG 06, *Technical Guidance on detailed modelling approach for an appropriate assessment for emissions to air*, Environment Agency, March 2014

9.1.2 Process contribution to nitrogen deposition

The maximum predicted annual PC to deposition rates of nitrogen at each designated conservation area is presented in Table 9.2, together with the PC as a percentage of the most stringent critical load applicable to each designated conservation area.

The maximum PCs to nitrogen deposition are screened out at both the designated conservation areas.

Table 9.2: Maximum nitrogen deposition (kg N ha^{-1} yr^{-1}) at designated conservation areas

Site name	Critical load	Year	PC	PC as % of critical load	Screened out?
Blackend Spinney AW	10 - 15	2020	0.0337	0.4	Yes
		2021	0.0326		
		2022	0.0360		
		2023	0.0337		
		2024	0.0343		
Unnamed AW	10 - 15	2020	0.0495	0.6	Yes
		2021	0.0532		
		2022	0.0627		
		2023	0.0453		
		2024	0.0455		

9.2 Acid deposition

9.2.1 Critical loads and existing levels of acid deposition

The APIS website gives critical load values for specific designated conservation areas [20].

Table 9.3 shows the habitat types, critical loads and total acid deposition values at the designated conservation areas identified in Section 4.3.

The Critical Load Function is defined by three quantities to account for the contribution of different species to total acid deposition[20]. 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. 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.

The total acid deposition values presented represent the average deposition over the years 2020 to 2022, due to existing local sources and background contributions. The nitrogen (N) and sulphur (S) contributions are presented.

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

Site name	Feature name	Relevant acidity critical load class	Critical load	Total acid deposition N|S
Blackend Spinney AW	Broadleaved, Mixed and Yew Woodland	Broadleaved/Coniferous Woodland	CLmaxS 10.713 CLminN 0.142 CLmaxN 10.855	2.05|0.17
Unnamed AW			CLmaxS 8.259 CLminN 0.357 CLmaxN 8.616	2.07|0.16

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, plus the additional contributions from SO_2 and HCl.

Dry deposition velocities recommended by AQMAU were used for all pollutants. The dry deposition velocity used for NO_2 is provided in Section 9.1. A dry deposition velocity of 0.024 m/s was used for SO_2.

For HCl, a dry deposition velocity of 0.06 m/s, for grassland was assumed. Wet deposition was also included for HCl, calculated from rainfall in the meteorological data and assuming washout coefficients A=0.0003 and B=0.66, as suggested in the Power Technology report PT/04/BE965/R[34].

The APIS Critical Load Function Tool[35] was used to assess the combined impact of the nitrogen and HCl contributions to acid deposition at each of the designated conservation areas.

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 contribution were also input to the tool. The maximum PCs to the HCl contribution were included as the sulphur contribution, as specified in the AQTAG 06 habitats assessment guidance[33].

Table 9.4 presents the maximum predicted contributions from nitrogen, sulphur and HCl to the acid deposition rates at each designated conservation area.

Table 9.4: Contributions to acid deposition (keq ha^{-1} yr^{-1}) at designated conservation areas

Site name	Year	PC (N)	PC (S)	PC (HCl as H)
Blackend Spinney AW	2020	0.0024	0.0075	0.0032
	2021	0.0023	0.0070	0.0030
	2022	0.0026	0.0078	0.0032
	2023	0.0024	0.0072	0.0031
	2024	0.0024	0.0074	0.0031
Unnamed AW	2020	0.0035	0.0114	0.0047
	2021	0.0038	0.0126	0.0052
	2022	0.0045	0.0147	0.0060
	2023	0.0032	0.0106	0.0044
	2024	0.0032	0.0110	0.0045

[34] Power Technology report *Comparison of ADMS wet deposition against monitored data and assessment of the relevance of HCl deposition from power stations*, SJ Griffiths, September 2004
[35] http://www.apis.ac.uk/critical-load-function-tool

Table 9.5 presents the PC as a percentage of the Critical Load Function, as output from the APIS Critical Load Function Tool, for each identified habitat at each designated conservation area.

According to the Critical Load Function Tool, the maximum PCs to acid deposition are screened out at all designated conservation areas for which critical load information was available.

Table 9.5: Results from APIS Critical Load Function Tool

Site name	Acidity critical load class	PC as % of CL function	Screened out?
Blackend Spinney AW	Broadleaved/Coniferous Woodland	0.1	Yes
Unnamed AW		0.3	Yes

10 Discussion

An air quality assessment was carried out to support the application for a permit variation to Buckinghamshire Council for a Small Waste Incineration Plant (SWIP) Permit at Wing Complex, Buckinghamshire.

The impact on air quality of stack emissions has been shown to be acceptable, as summarised below.

10.1 Human health impacts

The Process Contributions (PCs) of the following pollutants are screened out, as they are less than 1% of the long-term or 10% of the short-term air quality standard, as appropriate:

- sulphur dioxide (SO_2) (24-hour average only)
- Total Organic Carbon (modelled as benzene; 24-hour average only)
- particulates
- carbon monoxide
- hydrogen chloride
- hydrogen fluoride
- mercury; antimony; lead; chromium; copper; manganese; nickel (hourly average only); and vanadium

The PCs of the following pollutants are not screened out but, when the background concentration is taken into account, the Predicted Environmental Concentration (PEC) is well below the air quality standard:

- nitrogen dioxide (NO_2)
- sulphur dioxide (SO_2) (15-minute and hourly average)
- annual average Total Organic Carbon (modelled as benzene)
- benzo(a)pyrene
- cadmium; thallium; arsenic; cobalt; and nickel (annual average)

The maximum predicted daily intake due to inhalation of dioxins, furans and dioxin-like PCBs is 0.7% of the Tolerable Daily Intake.

10.2 Ecological impacts

- The PCs of nitrogen oxides (NO_x), SO_2 and daily average hydrogen fluoride are screened out at all of the designated conservation areas, as they are less than 1% of the long-term or 10% of the short-term critical level, as appropriate.
- The PCs to weekly average hydrogen fluoride concentrations are not screened out at either of the areas, but the critical level is not exceeded.
- The PCs to nitrogen and acid deposition are screened out at all of the designated conservation areas, as they are less than 1% of the most stringent site-specific critical load.

APPENDIX A: Summary of ADMS 6

ADMS, the **A**tmospheric **D**ispersion **M**odelling **S**ystem[36], 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);

[36] 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 the modelling of 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

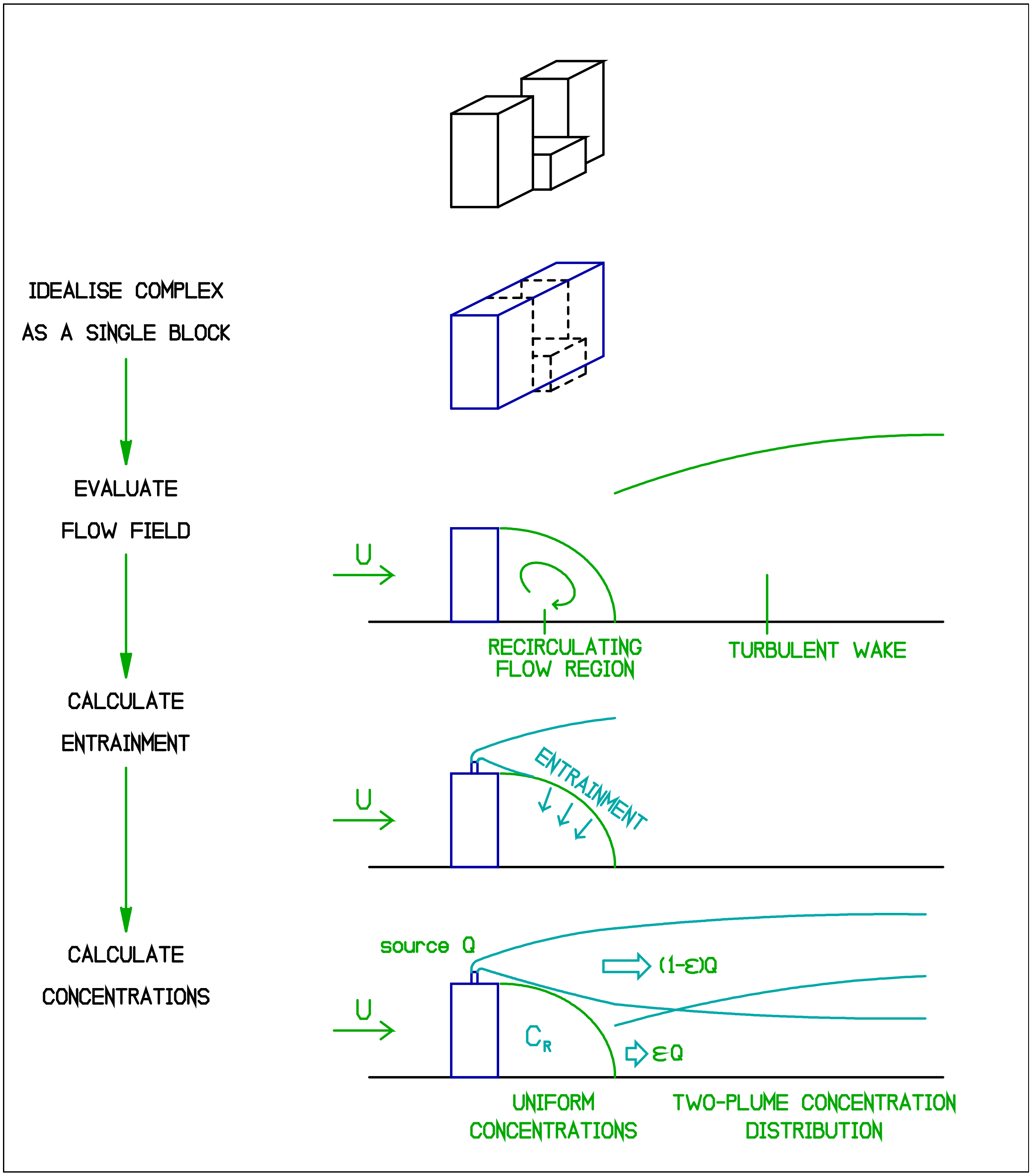

Figure A1: Stages in the modelling of building effects

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 $h\nu$ 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.