Air Quality Assessment of Emissions to Atmosphere from East Cambridgeshire District Council Crematorium

P2015

A Report Prepared for
The CDS Group Ltd
by
ADM Ltd
Old Chambers
93-94 West Street
Farnham Surrey, GU9 7EB
Tel: +44 (0)1252 720842
Email: post@ADMLtd.com
Web: www.AboutAir.com

Principal Author: David Harvey BSc, MBA, FIAQM
Client: The CDS Group Ltd

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1 INTRODUCTION

The CDS Group Ltd has commissioned Atmospheric Dispersion Modelling Ltd (ADM Ltd) to an air quality assessment of emissions to atmosphere from the proposed East Cambridgeshire Crematorium.

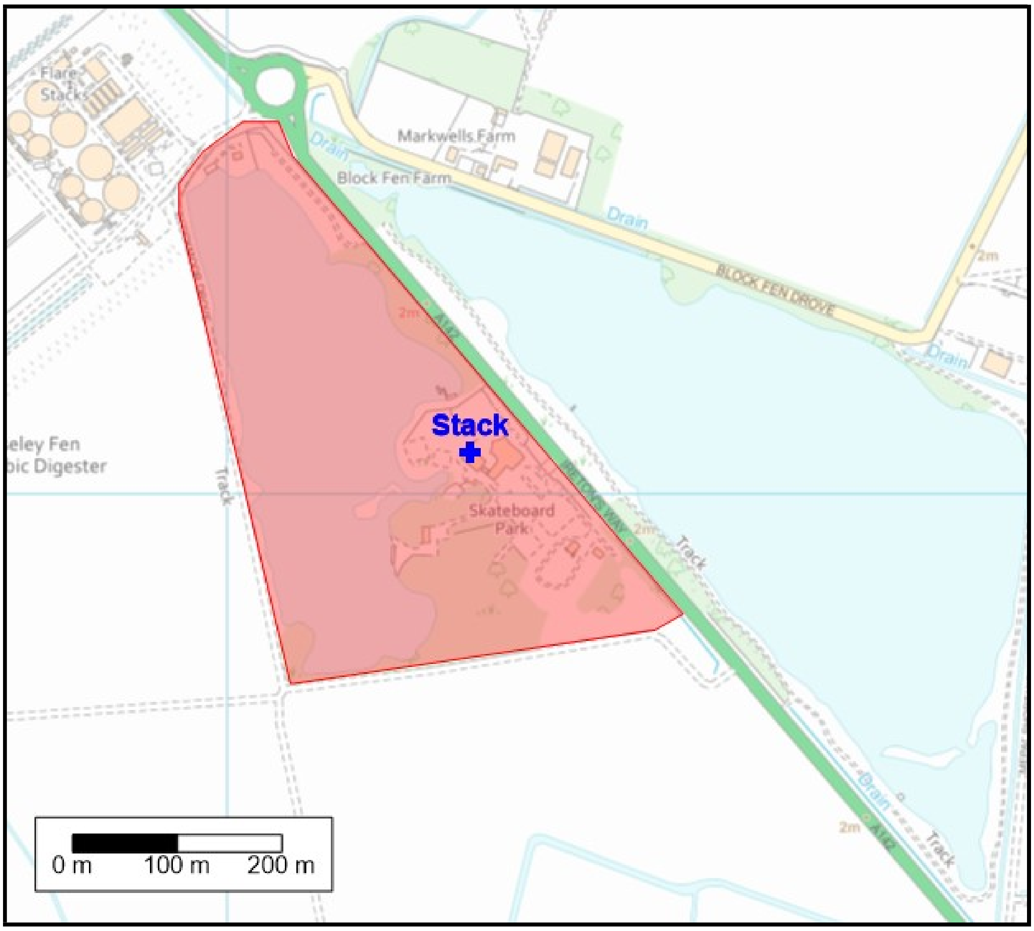
1.1 About the Author

The modelling and assessment presented in this report were undertaken by David Harvey MBA BSc FIAQM, who has 30 years' experience in air quality, dispersion modelling and assessment, which includes works on numerous crematoria. Mr Harvey is a Director of ADM Ltd, a company he founded in 1997 and is a Fellow of the Institute of Air Quality Management (FIAQM). Fellowship is for '*professionals who have had a distinguished career in the field of air quality*'. Mr Harvey has given expert evidence at Public Inquiries on air quality, dust and odour. He has prepared evidence for a House of Commons Select Committee on three occasions and also for the High Court on odour nuisance.

1.2 Site Location

Figure 1.1 shows the location of the proposed East Cambridgeshire crematorium and the stack.

Figure 1.1 Location of Proposed East Cambridgeshire Crematorium Stack



The ADMS 5.2 dispersion model has been used to make predictions of ground-level concentrations of the following pollutants released to atmosphere from the crematorium:

- Oxides of nitrogen (NO_x)
- Sulphur dioxide (SO_2)
- Particulate matter (PM_{10})
- Carbon monoxide (CO)
- Hydrogen chloride (HCl)
- Mercury (Hg)

1.3 Comparison of Electric and Gas Cremators

Although traditionally, UK cremators have been gas-fuelled the proposed cremator will, however, be electric which is now mandatory for a number of European countries. The electric cremators are designed to be highly efficient, reaching a temperature and remaining at that temperature which then minimises energy consumption. The electric cremators in the proposed facility will run on a green energy tariff, releasing around 90% less carbon than a conventional gas cremator with only carbon from the combustion of the body and the coffin entering the local environment.

In addition to the benefits in terms of reduced emissions of carbon, the use of an electric cremator will reduce emissions of atmospheric pollutants as there will be no emissions from the combustion of natural gas. This is illustrated by the following table, which shows the exhaust gas volume flow rates for a gas and an electric cremator. Also shown is the emission limit for PM_{10} and the PM_{10} emission rate at the emission limit.

Table 1.1 Actual and Normalised Flow Rates for Gas and Electric Cremators

Parameter	Gas	Electric
Exhaust gas oxygen content (% v/v dry)	11.5	15.7
Exhaust gas water content (% v/v)	13.3	9.0
Flue gas emission temperature (deg C)	110	120
Actual volumetric flow rate ($Am^3\ s^{-1}$)	0.50	0.52
Normalised volumetric flow ($Nm^3\ s^{-1}$) (a)	**0.29**	**0.17**
PM_{10} emission limit concentration ($mg\ Nm^{-3}$) (a)	20	20
PM_{10} emission rate ($mg\ s^{-1}$)	5.9	3.5
(a) Corrected for: temperature; 273 k; pressure; 101.3kPa (1 atmosphere); dry; 11% v/v O_2.		

Table 1.1 shows that for PM_{10} emissions, at their emission limit, the electric cremator gives rise to an emission rate of PM_{10} that is 40% less than that for a gas-fired cremator. The same applies to all the pollutants released to the atmosphere at their emission limits.

The impact of the emissions (ie the resulting ground-level concentrations) depends on the pollutant emission rate ($mg\ s^{-1}$) and not the emission concentration ($mg\ Nm^{-3}$). The lower normalised flow rate for electric cremators results in lower pollutant emission rates; this, in turn, allows for a lower stack height than would be required for a gas-fired cremator.

1.4 Structure of Report

The remainder of this report is structured as follows:

- Section 2 – provides a description of the assessment criteria
- Section 3 - presents and assesses the existing air quality
- Section 4 - describes the modelling methodology
- Section 5 - presents the predicted concentrations
- Section 6 - provides a summary and conclusions

2 PLANNING CONTEXT, ASSESSMENT AND SIGNIFICANCE CRITERIA

2.1 Introduction

This section presents the planning context for air quality, together with relevant air quality legislation and guidance. Also presented is a description of the pollutants assessed together with the assessment and significance levels.

2.2 Planning Context

2.2.1 European Legislation

Local authorities currently have no statutory obligation to assess air quality against European limit values but are encouraged to do so. To assist with longer-term planning and the assessment of development proposals in their local areas, Defra's Technical Guidance LAQM TG16 for Local Authorities provides guidance on how to assess against the time-frame of the European limit values (1).

The Air Quality (England) Regulations 2000 (SI 2000 No. 928) and Air Quality (England) (Amendment) Regulations 2002 (SI 2002 No. 3043) include national air quality objectives which, in most cases, are numerically synonymous with the European limit values although they may have different compliance target dates and can apply to different locations. The air quality objectives are for specific use by local authorities when undertaking their Local Air Quality Management (LAQM) duties in pursuit of Part IV of the Environment Act 1995.

Of principal concern to this assessment is nitrogen dioxide (NO_2).

2.2.2 National Legislation and Guidance

The Government's policy on air quality within the UK is set out in the Air Quality Strategy for England, Scotland, Wales & Northern Ireland Strategy (AQS), published in July 2007 in accordance with the requirements of Part IV of the Environment Act 1995. The Air Quality Strategy (AQS) sets out a framework to reduce adverse health effects from air pollution and ensures that international commitments are met. The AQS sets standards and objectives for pollutants to protect human health, vegetation and ecosystems.

Many of the objectives in the Air Quality Strategy (AQS) were made statutory in England with the Air Quality (England) (Amendment) Regulations 2002 for Local Air Quality Management (LAQM).

2.2.3 Review and Assessment

Under Part IV of the Environment Act 1995, local planning authorities must review and assess the air quality within their area by way of staged appraisals; with the aim of meeting the objectives by target dates defined in the Air Quality (England) (Amendment) Regulations. Where the air quality objectives have

(1) DEFRA (April 2016) Local Air Quality Management, Technical Guidance LAQM TG16.

not been achieved the local planning, authority is required to designate an AQMA and to draw up an air quality action plan (AQAP) towards achieving air quality objectives in the future.

The Department for Environment, Food and Rural Affairs (Defra) has published technical guidance for use by local planning authorities in their review and assessment work [(1)].

2.2.4 National Planning Policy Framework

In March 2012 the Department of Communities and Local Government published the first National Planning Policy Framework (NPPF). The NPPF was updated in July 2018 and included the following policies on air quality.

- The planning system should actively manage patterns of growth in support of these objectives. Significant development should be focused on locations which are or can be made sustainable, through limiting the need to travel and offering a genuine choice of transport modes. This can help to reduce congestion and emissions and improve air quality and public health.

- Planning policies and decisions should sustain and contribute towards compliance with relevant limit values or national objectives for pollutants, taking into account the presence of Air Quality Management Areas and Clean Air Zones, and the cumulative impacts from individual sites in local areas. Opportunities to improve air quality or mitigate impacts should be identified, such as through traffic and travel management, and green infrastructure provision and enhancement. So far as possible these opportunities should be considered at the plan-making stage, to ensure a strategic approach and limit the need for issues to be reconsidered when determining individual applications. Planning decisions should ensure that any new development in Air Quality Management Areas and Clean Air Zones is consistent with the local air quality action plan

The National Planning Practice Guidance (NPPG) for air quality is available on the NPPG web site [(2)]. The NPPG states that '*air quality concerns can be relevant to neighbourhood planning*'.

2.2.5 District Councils

The location of the proposed crematorium is within East Cambridgeshire District Council but close to the border of Fenland District Council.

(1) DEFRA (April 2016) Local Air Quality Management, Technical Guidance LAQM TG16.
(2) http:\\planningguidance.planningportal.gov.uk.

As part of the ongoing requirements of the Environment Act 1995 to review and assess air quality:

- East Cambridgeshire District Council have not declared any Air Quality Management Areas (AQMAs).

- Fenland District Council have declared four AQMAs

None of these AQMAs are in the study area for this assessment, and therefore, emissions from the proposed crematorium will not affect the AQMAs or associated Air Quality Action Plans (AQAPs).

2.2.6 Development Control: Planning for Air Quality

In January 2017 the Institute for Air Quality Management (IAQM) and Environmental Protection UK (EPUK) published an update to its guidance document that contains a framework for air quality consideration to be accounted for in local development control [(1)]. The EPUK/IAQM guidance has been taken into account when undertaking this assessment.

2.3 Description of Pollutants

This section describes the principal pollutants considered in this assessment which are:

- Oxides of nitrogen (NO_x)
- Sulphur dioxide (SO_2)
- Particulate matter (PM_{10})
- Carbon monoxide (CO)
- Hydrogen chloride (HCl)
- Mercury (Hg)

2.3.1 Nitrogen Dioxide (NO_2)

Where road traffic is the dominant source of air pollution, which is usually the case in urban environments, Local Authorities have found that the objectives for nitrogen dioxide (NO_2) and particulate matter (PM_{10}) are the most difficult to achieve. It is also generally the case that, where annual average concentrations of nitrogen dioxide (NO_2) and fine particulate matter (PM_{10}) meet their respective objectives and where there are no other local significant sources of air pollution, concentrations of all other pollutants in the air quality strategy will also be achieved.

Nitrogen dioxide (NO_2) is a reddish-brown gas (at sufficiently high concentrations) and occurs as a result of the oxidation of nitric oxide (NO), which in turn originates from the combination of atmospheric nitrogen (N_2) and oxygen (O_2) during combustion processes. In terms of ground-level concentrations in many parts of the United Kingdom, concentrations of

(1) IAQM (2017) Land-Use Planning & Development Control: Planning for Air Quality.

nitrogen dioxide (NO_2) are dominated by emissions from road transport. This applies particularly in urban areas, where traffic densities are at their highest.

Both the coffin/casket and the body contain nitrogen and are a source of NO_x. In addition, for gas-fuelled cremators, thermal NO_x is generated as a result of the combustion of natural gas.

2.3.2 Sulphur Dioxide (SO_2)

Sulphur dioxide (SO_2) is a colourless gas which is produced from some natural processes, notably volcanoes, but is associated most strongly with the combustion of fossil fuels containing sulphur. When coal burning was more widespread in the UK than it is at present, sulphur dioxide (SO_2) concentrations were monitored extensively. Since coal has ceased to be used as a common fuel in homes, concentrations of sulphur dioxide (SO_2) in urban areas have fallen dramatically. Partly as a result of this improvement, sulphur dioxide (SO_2) is not regarded as a serious threat to air quality in the way it once was.

Sulphur dioxide (SO_2) is a potent respiratory irritant when inhaled at high concentrations, both in laboratory conditions and during air pollution episodes; especially for asthmatics.

Cremation will give rise to minimal emissions of sulphur dioxide (SO_2) given low levels of sulphur in the coffin and body.

2.3.3 Particulate Matter (PM)

Particulate matter (PM) is a term used to describe all suspended matter, sometimes referred to as total suspended particulate matter. Sources of particulate matter (PM) in the air include combustion processes and road transport. Chemical processes in the air can also lead to the formation of particles. Both PM_{10} and $PM_{2.5}$ are the subject of health concerns because of the ability to penetrate and remain deep within the lungs due to their small size (<10 μg and <2.5 μm).

Cremation will give rise to particulate matter (PM) which is minimised by ensuring complete combustion and then further reduced by mercury abatement.

2.3.4 Carbon Monoxide (CO)

Carbon monoxide (CO), is a colourless and odourless gas. Carbon monoxide (CO) combines with haemoglobin in the blood to form the compound carboxyhaemoglobin, which prevents the normal transmission of oxygen into the bloodstream and can lead to a range of symptoms as the concentration increases.

All combustion processes give rise to carbon monoxide (CO), which is minimised by control measures to ensure complete combustion.

2.3.5 Hydrogen Chloride (HCl)

Hydrogen chloride (HCl) is a colourless gas at room temperature, which dissociates readily in water, forming an acidic solution. Sources of hydrogen chloride (HCl) include combustion of coal and waste incineration.

Hydrogen chloride (HCl) arises mostly from the salt content in bodies. Hydrogen chloride (HCl) emissions are minimised by careful control of coffin materials and its contents other than the body itself. Mercury abatement further lessens emissions of hydrogen chloride (HCl).

2.3.6 Mercury (Hg)

Mercury (Hg) is classed as a heavy metal and has high toxicity. As an elementary substance, mercury is persistent and cannot be degraded into harmless products. It will therefore be permanently recycled in the physical, chemical and biological processes in the environment. Mercury (Hg) is present in dental amalgam. Since 2012 all new crematoria have been required to have mercury abatement which reduces mercury emissions by 90-98%.

2.4 Assessment Criteria

This section describes the criteria used to assess the impacts on air quality of emissions to the atmosphere from the proposed crematorium

Table 2.1 shows the assessment criteria used in this assessment to assess the impacts on human health.

Table 2.1 Air Quality Assessment Levels (AQAL)

Substance	Averaging time	Assessment Criteria ($\mu g\ m^{-3}$)
Particulate matter (PM_{10})	Annual mean	40
	90.4th %ile of 24-hour means	50
Hydrogen chloride (HCl)	Maximum hourly mean	750
Carbon monoxide (CO)	Maximum 8 hourly mean	10,000
Sulphur dioxide (SO_2)	99.9th percentile of 15 minute	266
	99.7th percentile of hourly means	350
	99.2nd percentile of 24 hour	125
Nitrogen dioxide (NO_2)	Annual mean	40
	99.8th percentile of hourly means	200
Mercury (Hg)	Annual mean	0.25
	Maximum hourly mean	7.5

2.5 Significance Criteria

The impact refers to the change that is predicted to take place to the prevailing environment as a result of the proposed crematorium.

The significance of an impact is generally determined by the combination of the 'sensitivity' and/or 'value' of the affected environmental receptor, and the predicted "extent" and/or "magnitude" of the impact or change. The impact descriptors used in this assessment are taken from the IAQM/EPUK guidance for planning and air quality [(1)]. The assessment of significance ultimately relies on professional judgement, although comparing the extent of the impact with criteria and standards specific to each environmental topic can guide this judgement.

Details of impact descriptors used in this assessment are shown in **Table 2.2** It should be noted that the IAQM/EPUK impact descriptors refer to permanent changes in air quality brought about by a development and not short-term or temporary changes. They also refer to locations where there is relevant exposure and not therefore necessarily the location of the maximum impact. The criteria, therefore, are only appropriate for changes to annual average concentrations at locations where there is relevant exposure; ie not generally the point of maximum impact.

Table 2.2 IAQM/EPUK Air Quality Impact Descriptors for Individual Receptors

Long Term Average Concentration at Receptor in Assessment Year	% Change in Concentration Relative to Air Quality Assessment Level (AQAL)			
	1	**2-5**	**6-10**	**>10**
75% or less of AQAL [(a)]	Negligible	Negligible	Slight	Moderate
76-94% of AQAL	Negligible	Slight	Moderate	Moderate
95-102% of AQAL	Slight	Moderate	Moderate	Substantial
102%-109% of AQAL	Moderate	Moderate	Substantial	Substantial
110% or more of AQAL	Moderate	Substantial	Substantial	Substantial

Note: Changes less than 0.5% are Negligible.
(a) Air Quality Assessment Level (AQAL).

The IAQM guidance on significance shown in **Table 2.2** is only applicable to long term/annual average impacts where there is relevant exposure.

With regard to short term impacts the IAQM guidance states:

Where such peak short term concentrations from an elevated source are in the range 11-20% of the relevant AQAL, then their magnitude can be described as small, those in the range 21-50% medium and those above 51% as large. These are the maximum concentrations experienced in any year and the severity of this impact can be described as slight, moderate and substantial respectively.

The Environment Agency's (EA) risk assessment guidance includes a test for insignificance of impacts [(2)]. The guidance states that the process contribution

(1) IAQM (May 2017) Land-Use Planning& Development Control: Planning for Air Quality.
(2) https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit .

(PC) can be considered as insignificant if:

- The long term PC is <1% of the assessment criteria
- The short term PC is < 10% of the assessment criteria

This is not to say that if these thresholds are exceeded the process contribution (PC) is significant, just that it cannot be ruled out as being insignificant.

For the assessment of significance, this assessment uses the IAQM guidance.

3 AMBIENT AIR QUALITY DATA

3.1 Introduction

This section presents a description of the ambient air quality in the region of the proposed crematorium.

The criteria used throughout this assessment are compared to the incremental increase occurring due to emissions to the atmosphere from the proposed crematorium, and therefore an accurate determination of the prevailing concentration is not necessary. However, estimates of the prevailing background concentrations are presented for completeness.

3.2 Measured Data

There are no measured data in the location of the proposed crematorium that are representative of the prevailing air quality.

3.3 Estimated Background Concentrations

The Department for Environment Food and Rural Affair (Defra) have provided estimates of the background concentrations for a number of pollutants for a number of years on a 1 km grid resolution for the whole of the UK. The OS grid reference closest to the crematorium is 542500,283500.

Table 3.1 provides a summary of all the relevant annual average pollutant concentrations used in this assessment and the source of the data.

Table 3.1 Estimated Annual Average Background Pollutant Concentrations (OS Grid Reference: 542500,283500)

Pollutant	Background Concentration	Unit	Data Source
Nitrogen dioxide (NO_2)	6.7	μg m^{-3}	Defra 2021 estimate
Oxides of nitrogen (NO_x)	8.8	μg m^{-3}	Defra 2021 estimate
Particulate matter (PM_{10})	16.2	μg m^{-3}	Defra 2021 estimate
Sulphur dioxide (SO_2)	2.1	μg m^{-3}	Defra 2001 estimate
Carbon monoxide (CO)	0.22	mg m^{-3}	Defra 2001 estimate
Hydrogen chloride (HCl)	0.24	μg m^{-3}	Measured 2013 Stoke Ferry
Mercury (Hg)	1.73	ng m^{-3}	Measured 2006 Monkswood

(a) https://uk-air.defra.gov.uk/data/non-auto-data
(b) http://www.pollutantdeposition.ceh.ac.uk/heavy_metals

Table 3.2 shows the estimated background concentrations as a percentage of the assessment criteria.

Table 3.2 Estimated Annual Average Background Pollutant Concentrations Compared to Assessment Criteria

Pollutant	Background Concentration	Assessment Criteria	Unit	Percentage of Assessment Criteria (%)
Nitrogen dioxide (NO_2)	6.7	40	$\mu g\ m^{-3}$	17%
Particulate matter (PM_{10})	16.2	40	$\mu g\ m^{-3}$	41%
Sulphur dioxide (SO_2)	2.1	-	$\mu g\ m^{-3}$	-
Carbon monoxide (CO)	0.22	-	$mg\ m^{-3}$	-
Hydrogen chloride (HCl)	0.24	-	$\mu g\ m^{-3}$	-
Mercury (Hg)	1.73	250	$ng\ m^{-3}$	0.7%

Table 3.2 shows that all the estimated background annual average concentrations are less than the assessment criteria and not of concern to human health.

4 METHODOLOGY

4.1 Introduction

This section describes the methodology and assumptions made for the air quality assessment. Also described are the emissions data used.

4.2 Emissions Data

Table 4.1 and Table 4.2 show the parameters which describe the physical properties of emissions from the crematorium stack, as required for the definition of the emissions in dispersion modelling terms.

Table 4.1 Emissions and Physical Properties, Crematorium Stack

Parameter	Value
Number of stacks	1
Number of flues	1
OS Grid Reference (m)	542233 283041
Release height above ground level (m)	7.0
Actual volumetric flow rate ($Am^3\ s^{-1}$)	0.52
Exhaust gas oxygen content (% v/v dry)	15.7
Exhaust gas water content (% v/v)	9.0
Flue diameter (m)	0.2
Exit velocity ($m\ s^{-1}$)	16.6
Flue gas emission temperature (deg C)	120
Normalised volumetric flow ($Nm^3\ s^{-1}$) [a]	0.17
(a) Corrected for: temperature; 273 k; pressure; 101.3kPa (1 atmosphere); dry; 11% v/v O_2.	

Table 4.2 shows both the pollutant emission concentrations and emission rates. The emission concentrations are the emission limits as specified in Defra's process guidance note 5/2 (12) for crematoria [(1)].

Table 4.2 Pollutant Emission Concentration and Rates PG5/2(12)

Pollutant	Concentration [(a)]	Emission Rate
Oxides of Nitrogen (NO_x as NO_2) [(b)]	300 $mg\ Nm^{-3}$	0.052 $g\ s^{-1}$
Sulphur Dioxide (SO_2)	50 $mg\ Nm^{-3}$	0.0087 $g\ s^{-1}$
Particulate Matter (PM_{10})	20 $mg\ Nm^{-3}$	0.0035 $g\ s^{-1}$
Carbon Monoxide (CO)	100 $mg\ Nm^{-3}$	0.017 $g\ s^{-1}$
Hydrogen Chloride (HCl)	30 $mg\ Nm^{-3}$	0.0052 $g\ s^{-1}$
Mercury (Hg)	50 $\mu g\ Nm^{-3}$	0.0087 $mg\ s^{-1}$
(a) Corrected for: Temperature; 273 K; Pressure; 101.3 kPa (1 atmosphere); dry; 11% v/v O_2. (b) No emission limit for NO_x is specified in Defra PG 5/2 (12).		

It is conservatively assumed that there will be continuous emissions to atmosphere from 9 am to 5 pm, Monday to Friday which equates to a maximum of about 1,300 cremations per year.

(1) Defra (September 2012) Process Guidance Note 5/2 (12) Statutory Guidance for Crematoria.

4.3 Receptors

Predictions are made of ground-level concentrations using a grid of receptors. The receptor grid is 1,000 m by 1,000 m with grid spacing of 10 m. Making predictions using a grid of receptors allows the maximum impact to be determined and also allows the predicted ground-level concentrations to be presented as contour plots.

In addition to predictions made using a grid of receptors, predictions are made at six specific receptors selected to be representative of locations where there is relevant exposure such as residential properties.

For the purpose of Local Air Quality Management (LAQM), the Air Quality Strategy Objectives (AQS) only apply where there is relevant exposure. This is defined as being where members of the public are regularly present and are likely to be exposed for a period of time, appropriate to the averaging period of the objective. For the annual average objective, locations of relevant exposure include residential properties, schools and hospitals.

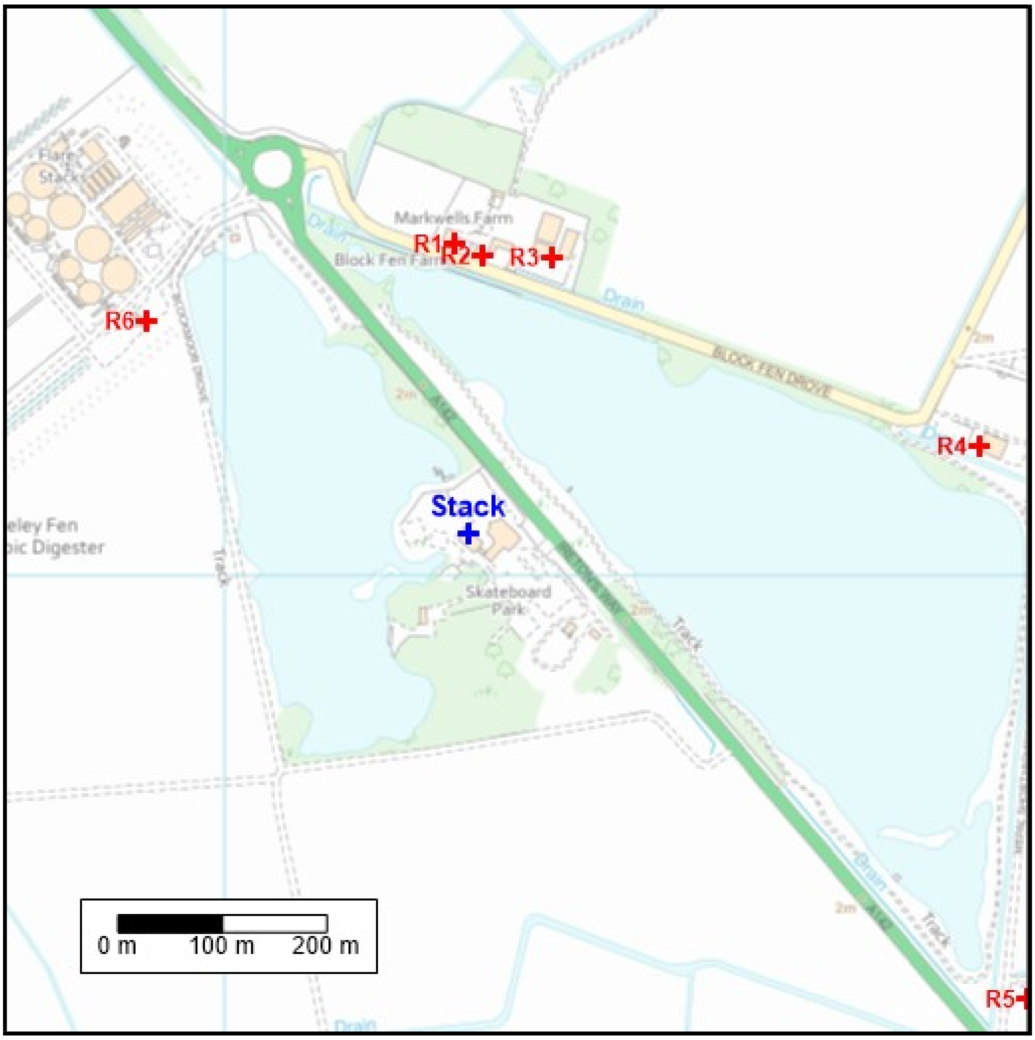
Table 4.3 presents details of the specific receptors included in the modelling which have been selected because of their potential for relevant exposure.

Table 4.3 Receptor Locations

No.	Description	Distance from Stack (km)	OS Grid Reference (m)
R1	Residential	0.3	542221 283318
R2	Residential	0.3	542247 283307
R3	Industrial	0.3	542313 283305
R4	Industrial	0.5	542723 283124
R5	Residential	0.7	542769 282594
R6	Industrial	0.4	541925 283244

Figure 4.1 shows the locations of the receptors, also shown is the location of the stack.

Figure 4.1 Location of Receptors and Stack



4.4 Factors Affecting dispersion

There are a number of factors that will affect how emissions disperse once released to the atmosphere. The four factors having the greatest effect on dispersion are:

- Physical characteristics of the emissions
- Climate
- Terrain
- Building downwash

4.4.1 Physical Characteristics of the Emissions

Provided that the exhaust gases have sufficient velocity at stack exit to overcome the effects of stack tip downwash, which is almost certainly the case for velocities of 15 m s^{-1} or more, the physical characteristics of the flue gases will determine the amount of plume rise and hence the effect on ground level pollutant concentrations. The degree of plume rise usually depends on the greater of the thermal buoyancy or the momentum effects.

4.4.2 Climate

The most important meteorological parameters governing the atmospheric dispersion of pollutants are wind speed, wind direction and atmospheric stability.

- **Wind direction** determines the broad transport of the plume and the sector of the compass into which the plume is dispersed.

- **Wind speed** can affect plume dispersion by increasing the initial dilution of pollutants and inhibiting plume rise.

- **Atmospheric stability** is a measure of the turbulence of the air. For dispersion modelling purposes, one method of classifying stability is by the use of Pasquill stability categories, A to F. Dispersion models, such as ADMS and AERMOD, do not allocate the degree of atmospheric turbulence into six discrete categories (A-F). These models use a parameter known as the Monin-Obukhov length which, together with the wind speed, describes the stability of the atmosphere.

4.4.3 Building Downwash

The presence of buildings can significantly affect the dispersion of atmospheric emissions. Wind blowing around a building distorts the flow and creates zones of turbulence that are greater than if the building were absent. Increased turbulence causes greater plume mixing; the rise and trajectory of the plume may be depressed generally by the flow distortion. For elevated releases such as those from stacks, building downwash leads to higher ground level concentrations closer to the stack than those present if a building was not there. The effects of building downwash are usually only significant where the buildings are more than about 40% of the stack height.

Table 4.4 shows the dimensions of the buildings included in the modelling.

Table 4.4 Dimensions of Buildings Included in the Modelling

Building	Centre (m)		Height (m) [(a)]	Length (m)	Width (m)	Angle (deg) [(b)]
1	542234	283038	6.0 [(c)]	12.3	13.3	48
2	542230	283022	8.0	12.8	22.4	48
3	542243	283026	3.7	8.0	11.5	49

(a) Height above ground level.
(b) Angle building length makes to the north.
(c) Height to top of the parapet. The louvres are a sufficient distance from the stack so as not to affect dispersion.

4.4.4 Nature of the Surface

Terrain

The effects of elevated terrain can affect dispersion when gradients are more than about 10%. The terrain in the region of the proposed crematorium is flat and has been assumed to be flat in the modelling.

Roughness

The nature of the surface can have a significant influence on dispersion by affecting the vertical velocity profile (ie the rate of increase in wind speed for increasing heights above ground level). Also affected is the amount of atmospheric turbulence.

To account for the surrounding nature of the site, a surface roughness length of 0.2 m has been assumed for the dispersion modelling. It is also assumed that this roughness length is also representative of Mildenhall, which is the source of the meteorological data used in this assessment.

4.5 Selection of Suitable Dispersion Model

The dispersion models which are widely used to predict ground-level pollutant concentrations are based on the concept of the time-averaged lateral and vertical concentration of pollutants in a plume being characterised by a Gaussian (1) distribution and the atmosphere is characterised by a number of discrete stability classes. So, called 'new generation' dispersion models have been developed which replace the description of the atmospheric boundary layer as being composed of discrete stability classes with an infinitely variable measure of the surface heat flux, which in turn influences the turbulent structure of the atmosphere and hence the dispersion of a plume.

There are two commercially available dispersion models that are able to predict ground-level concentrations arising from emissions to the atmosphere from elevated point sources (ie stacks) which are described by the Environment Agency (EA) as being 'new generation'.

- AERMOD: The US **A**merican Meteorological Society and **E**nvironmental Protection Agency **R**egulatory Model Improvement Committee developed the dispersion **MOD**del called AERMOD which incorporates the latest understanding of the atmospheric boundary layer.

- Atmospheric Dispersion Modelling System (ADMS): This dispersion model was developed by the UK consultancy CERC. The model allows for the skewed nature of turbulence within the atmospheric boundary layer.

In many respects the models are quite similar and in many situations, generate similar predictions of ground level concentrations.

ADMS 5.2 was selected as the model for use in this assessment because it has been extensively used for assessment work of this nature.

(1) A Gaussian distribution has the appearance of a bell-shaped curve. The maximum concentration occurs on the centre line.

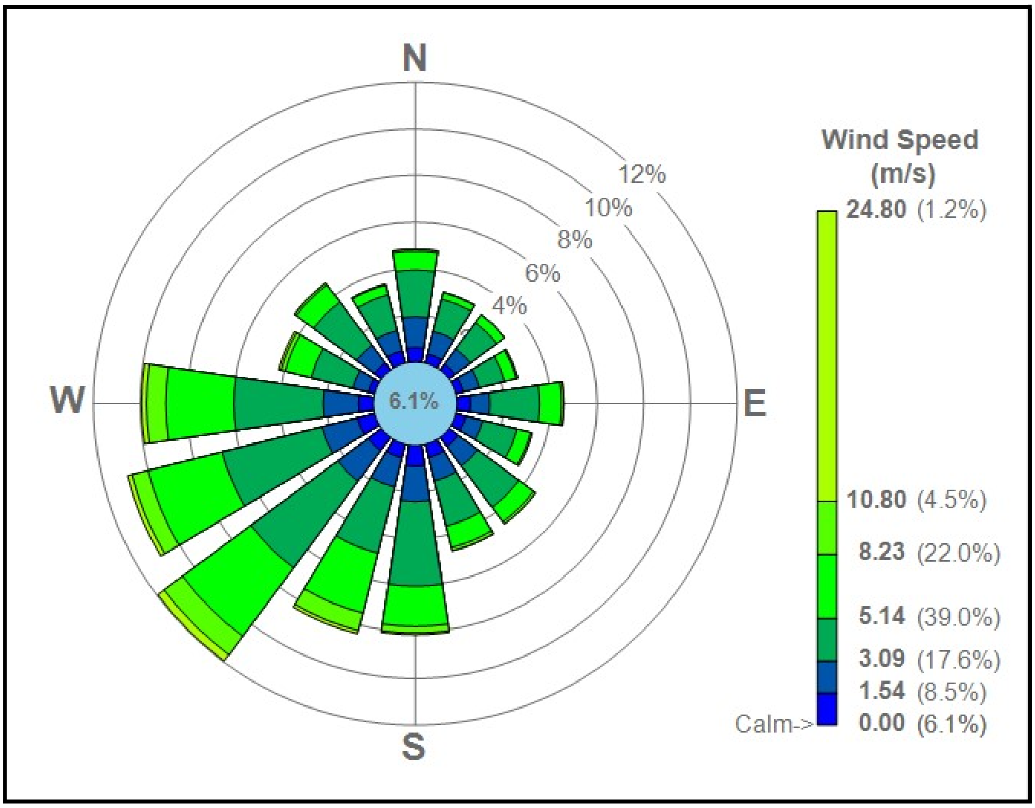
4.6 Meteorological Data

An important input to the dispersion model is the meteorological data. These data are important in determining the location of the maximum concentrations and their magnitude.

The closest observing station where data is available is Mildenhall which is 28 km away. Five years of hourly meteorological data for 2015-2019 have been used in this assessment.

Figure 4.2 shows the wind rose for Mildenhall for 2015-2019, which shows that the prevailing wind is from the south-west, which will transport emissions to the north-east.

Figure 4.2 Wind Rose from Mildenhall (2015-2019)



4.7 Percentage Oxidation of Nitric Oxide (NO) to Nitrogen Dioxide (NO_2)

Oxides of nitrogen (NO_x) emitted to atmosphere as a result of gas combustion will consist largely of nitric oxide (NO), a relatively innocuous substance. Once released into the atmosphere, nitric oxide is oxidised to nitrogen dioxide (NO_2), which is of concern with respect to health and other impacts. The proportion of nitric oxide oxidised to nitrogen dioxide depends on a number of factors and the oxidation is limited by the availability of oxidants, such as ozone (O_3).

An oxidation of 50% has been assumed for oxidation of nitric oxide (NO) to nitrogen dioxide (NO_2) for short-term concentrations. For predictions of annual averages, it is assumed that 100% of the oxides of nitrogen (NO_x) are in the form of nitrogen dioxide (NO_2). These assumptions are recommended by the Environment Agency (EA) [1].

(1) https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit#detailed-modelling.

5 PREDICTIONS AND ASSESSMENT OF IMPACTS

5.1 Introduction

This section presents the D1 stack height calculation and the incremental increase in ground-level concentrations predicted to occur as a consequence of emissions to the atmosphere from the operation of the proposed crematorium. Predictions are presented, and an assessment made of the routine emissions to the atmosphere.

5.2 Modelling and Assessment of Emissions

5.2.1 Nitrogen Dioxide (NO_2)

The principal pollutant released to atmosphere from the proposed crematorium is the oxides of nitrogen (NO_x) which will progressively oxidise to nitrogen dioxide (NO_2) in the atmosphere.

Table 5.1 shows the predicted annual average ground level process concentration (PC) of nitrogen dioxide (NO_2) at the specific receptors and at the point of maximum impacts for each of the five years of meteorological data. Also shown are the total concentration, the incremental impact from the crematorium plus the prevailing background. This can be referred to as the Predicted Environmental Concentration (PEC).

Table 5.1 ADMS 5.2 Predicted Annual Average Concentrations of Nitrogen Dioxide (NO_2, $\mu g\ m^{-3}$) (a)

Location	Predicted Increment Concentration (Process Contribution, PC)						Max PC + Background (Predicted Environmental Conc. PEC)	Maximum Increment (PC) as Percentage of AQAL (%) (b)
	2015	2016	2017	2018	2019	Max		
R1	0.03	0.03	0.03	0.04	0.04	0.04	6.7	0.1%
R2	0.03	0.04	0.04	0.04	0.04	0.04	6.7	0.1%
R3	0.04	0.04	0.04	0.05	0.05	0.05	6.7	0.1%
R4	0.02	0.02	0.03	0.02	0.02	0.03	6.7	0.1%
R5	0.01	0.01	0.01	0.01	0.01	0.01	6.7	0.0%
R6	0.02	0.02	0.01	0.02	0.02	0.02	6.7	0.0%
Grid Maximum	**1.81**	**1.73**	**1.77**	**2.00**	**1.73**	**2.00**	**8.7**	**5.0%**
Air Quality Assessment Level (AQAL)						**40**		

(a) Assumes 100% oxidation.
(b) Air Quality Assessment Level (AQAL)

Table 5.1 shows that the maximum predicted annual average ground-level concentrations of nitrogen dioxide (NO_2) concentrations is 2.0 $\mu g\ m^{-3}$ which is 5.0% of the Air Quality Assessment Level (AQAL) of 40 $\mu g\ m^{-3}$.

The IAQM/EPUK significance criteria are applicable to locations where there is relevant exposure and are only applicable to annual average concentrations. Defra's TG16 guidance gives the following examples of where there is relevant exposure to annual average objectives

- Building facades of residential properties
- School
- Hospital
- Care homes

Examples given of where there is not relevant exposure to annual average objectives include; gardens of residential properties, hotels and kerbside sites.

Table 5.2 shows the IAQM/EPUK significance criteria based on the year of meteorological data that gives rise to the highest impact.

Table 5.2 IAQM/EPUK Significance Criteria; Nitrogen Dioxide (NO_2, $\mu g\ m^{-3}$)

No.	Predicted Increment (PC)	Increase as %age of AQAL (%)	PEC [(a)]	PEC as %age of AQAL	Impact Descriptor
R1	0.04	0.1%	6.7	16.9%	Negligible
R2	0.04	0.1%	6.7	16.8%	Negligible
R5	0.01	0.0%	6.7	16.8%	Negligible
(a) Predicted Environmental Concentration (PEC)					

Table 5.2 shows that the impact descriptor is 'negligible' at all the receptor locations where there is relevant exposure to annual average concentration (eg residential properties).

Table 5.3 shows the predicted 99.8th percentile concentration at the specific receptors and at the point of maximum impact for each of the five years of meteorological data.

Table 5.3 ADMS 5.2 Predicted 99.8th Percentile of Hourly Average Concentrations of Nitrogen Dioxide (NO_2, $\mu g\ m^{-3}$) [(a)]

No.	Predicted Increment (Process Contribution, PC)						Max PC + Background (Predicted Environmental Conc. PEC) [(b)]	Maximum Increment (PC) as Percentage of AQAL (%) [(c)]
	2015	2016	2017	2018	2019	Max		
R1	1.0	1.2	1.1	1.2	1.1	1.2	14.6	0.6%
R2	1.2	1.2	1.1	1.3	1.2	1.3	14.7	0.6%
R3	1.1	1.1	1.1	1.2	1.2	1.2	14.6	0.6%
R4	0.5	0.5	0.8	0.5	0.5	0.8	14.2	0.4%
R5	0.2	0.3	0.3	0.2	0.4	0.4	13.8	0.2%
R6	0.7	0.9	0.6	0.8	0.6	0.9	14.3	0.4%
Grid Maximum	**19.3**	**19.2**	**18.3**	**19.4**	**18.5**	**19.4**	**32.8**	**9.7%**
Air Quality Assessment Level (AQAL)						**200**		

(a) Assumes 50% oxidation.
(b) Defra guidance TG4(00); NO_2 99.8th + 2 x annual average NO_2 background.
(c) Air Quality Assessment Level (AQAL).

Table 5.3 shows that the maximum predicted 99.8th percentile of hourly average nitrogen dioxide (NO_2) concentrations is 19.4 $\mu g\ m^{-3}$ which is 9.7% of the Air Quality Assessment Level (AQAL) of 200 μg m^{-3}. When combined with the prevailing background the maximum Predicted Environmental Concentration (PEC) is 32.8 μg m^{-3} which is significantly less than the assessment level of 200 μg m^{-3} and therefore not of concern to human health. The short-term impact at all the locations can be screened out as being insignificant using the Environment Agency's guidance of 10%.

Tables 5.2 and Table 5.3 show that at the specific receptors, the predicted incremental increase in concentrations of nitrogen dioxide (NO_2) occurring due to emissions from the proposed crematorium are not of concern to human health.

The following figures are presented to illustrate the distribution of concentrations of nitrogen dioxide (NO_2). Predictions are presented for 2018 meteorological data as this is the year which gives rise to the highest annual average incremental concentrations. The predictions are for the Process Contributions (PC).

- **Figure 5.1;** Annual Average
- **Figure 5.2**; 99.8th percentile of hourly averages

The figures show that peak predicted increments to ground level concentrations occur within 100 m of the crematorium stack.

Figure 5.1 ADMS 5.2 Predicted Annual Average Ground Level Concentrations of the Nitrogen Dioxide (NO_2); 2018 Meteorological Data ($\mu g\ m^{-3}$); Assuming 100% Oxidation

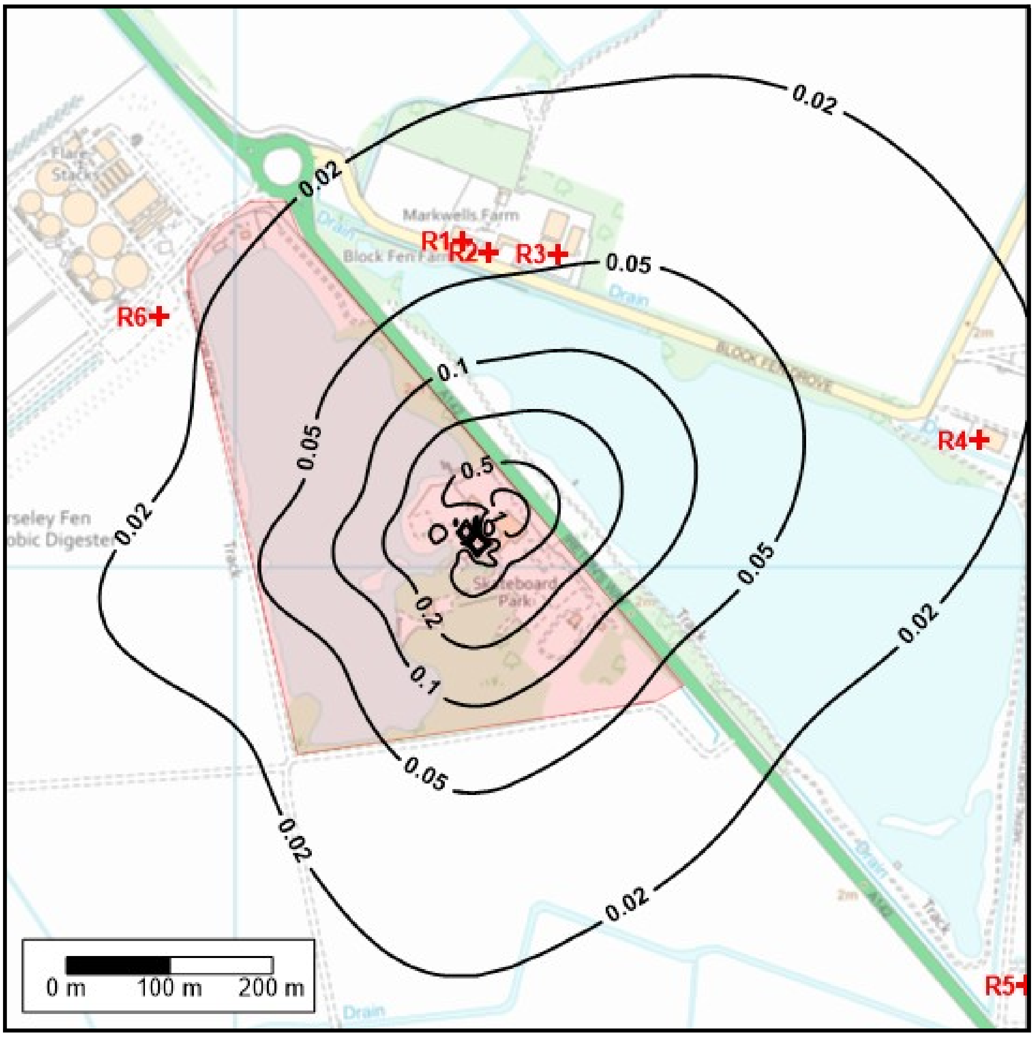
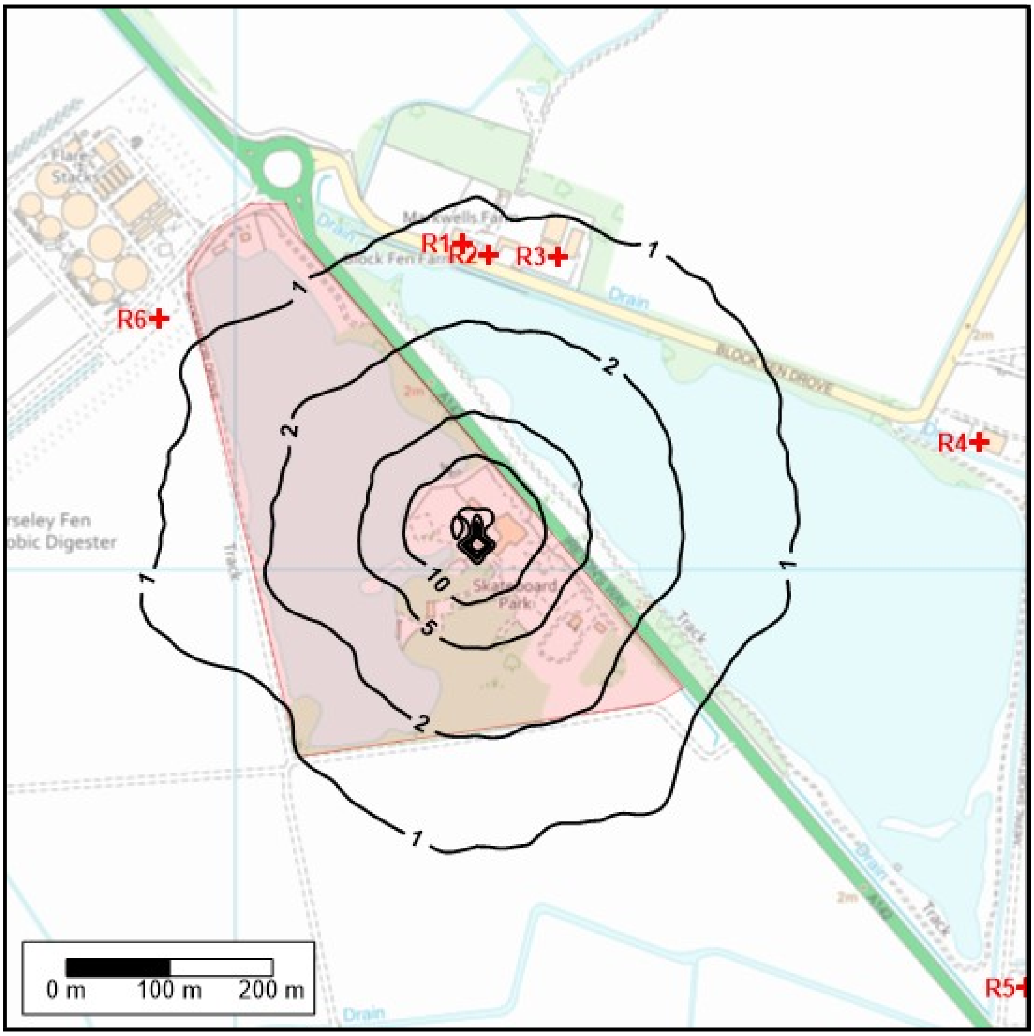


Figure 5.2 **ADMS 5.2 Predicted 99.8th Percentile of Hourly Average Ground Level Concentrations of Nitrogen Dioxide (NO_2); 2018 Meteorological (μg m^{-3}); Assuming 50% Oxidation**



5.2.2 Remaining Pollutants

The principal pollutant released to the atmosphere is the oxide of nitrogen (NO_x) which forms nitrogen dioxide (NO_2) and has been the focus of this assessment. The distribution of the remaining pollutants will be the same as that for the nitrogen dioxide (NO_2) shown in **Figure 5.1** and **Figure 5.2** and has not been repeated.

Table 5.4 shows the maximum predicted increments to ground level concentrations (Process Contribution, PC) for any of the five years of meteorological data. Also shown are the estimates of background concentrations and the Predicted Environmental Concentration (PEC).

Table 5.4 **ADMS 5.2 Maximum Predicted Incremental Concentrations due to Emissions to the Atmosphere from the Proposed Crematorium ($\mu g\ m^{-3}$, 2015 - 2019 Meteorological Data)**

Pollutant	Averaging Period	The allowed number of Exceedence	PC ($\mu g\ m^{-3}$)	Baseline ($\mu g\ m^{-3}$)	PEC ($\mu g\ m^{-3}$)	AQAL ($\mu g\ m^{-3}$)	PC as Percentage of AQAL (%)	PEC as Percentage of AQAL (%)
Nitrogen dioxide (NO_2)	1 hour	18	19.4	-	32.8	200	9.7%	16.4%
	Annual	-	2.00	6.7	8.7	40	5.0%	21.8%
Particulate matter (PM_{10})	24-hour	35	0.44	-	-	50	0.9%	-
	Annual	-	0.13	16.2	16.33	40	0.3%	40.8%
Sulphur dioxide (SO_2)	15 Min	35	8.79	-	-	266	3.3%	-
	1 hour	24	6.26	-	-	350	1.8%	-
	24-hour	3	1.86	-	-	125	1.5%	-
Carbon monoxide	8 Hour	-	14.4	-	-	10,000	0.1%	-
Hydrogen chloride (HCl)	1 Hour	-	11.3	-	-	750	1.5%	-
Mercury (Hg)	1 hour	-	0.019	-	-	7.5	0.3%	0
	Annual	-	0.00033	0.00173	0.0021	0.25	0.1%	0.8%

Table 5.4 shows that, as a percentage of the short-term air quality assessment level (AQAL), it is the 99.8th percentile of hourly average concentration of nitrogen dioxide (NO_2) of 19.4 $\mu g\ m^{-3}$ which is 9.7% of the assessment criteria that has the largest impact. When combined with the background concentration the PEC (Predicted Environmental Concentration) of 32.8 $\mu g\ m^{-3}$ it is 16.4% of the assessment criteria and therefore not of concern to human health.

For long-term impacts (annual average) again it is nitrogen dioxide (NO_2) that has the greatest impact of 5.0% of the Air Quality Assessment Levels (AQAL) which is not of concern to human health.

Given that as a percentage of the Air Quality Assessment Levels (AQAL) it is nitrogen dioxide (NO_2) that has the largest impact, and this has been shown to be negligible, it follows the impacts of the remaining pollutants are also negligible, and not of concern to human health.

Any impacts on human health or vegetation and ecosystems outside the study area will be negligible.

6 SUMMARY AND CONCLUSIONS

The CDS Group Ltd has commissioned Atmospheric Dispersion Modelling Ltd (ADM Ltd) to undertake an air quality assessment of emissions to atmosphere from the proposed East Cambridgeshire Crematorium.

The cremator will be electric and therefore will have no emissions from the combustion of natural gas which is the case for gas-fired cremators. This, in turn, allows for a lower stack height than would be required for a gas-fired cremator.

The ADMS 5.2 dispersion model has been used to make predictions of ground-level concentrations of the pollutants released to atmosphere from the crematorium stack. The modelling and assessment were for a stack height of 7.0 m and emissions at their emission limits.

The principal conclusion of this assessment is that emissions to the atmosphere at their emission limits from the proposed crematorium gives rise to predicted impacts that are not of concern to human health.