Environmental Permit Application - Oxford Sewage Treatment Works

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Environmental Permit Application - Oxford Sewage Treatment Works

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Executive summary

Under the Industrial Emissions Directive (IED), the anaerobic digestion assets at Oxford Sewage Treatment Works (STW) require an Environmental Permit (EP). The scope of the EP includes all treatment stages and incorporates directly associated activities such as the operating combined heat and power (CHP) gas engines and boilers.

Thames Water Utilities Limited operates a STW near the city of Oxford, Oxfordshire (OX4 4HG). These operations include; an existing Caterpillar (Cat) biogas fuelled Combined Heat and Power (CHP) engine (with a thermal input capacity of 2.466 MWth), two biogas fuelled Jenbacher CHP engines (each with a thermal input capacity of 2.016 MWth) and two new duel-fuelled Yorkshireman boilers (each with a thermal input capacity of 4.71 MWth) as set out in the tables below.

It should be noted the new Yorkshireman boilers have replaced the two inoperable 2.33 MWth (combined 4.66 MWth) boilers (emission source reference A12 and A13) and a long-term hire boiler (thermal input capacity of 3.8 MWth) on-site.

Plant name (emission source)	NACE code	Plant manufacturer	Model name	Easting	Northing	Date operation started	Rated thermal input of the medium combustion plant or generator (MWth)	Main fuel type used	Secondary fuel type used
CHP engine (A1)	5	Caterpillar	-	454277	201986	Pre 20th Dec 2018	2.466	Biogas	-
CHP engine 1 (A10)	5	Jenbacher	-	454252	202004	Pre 20th Dec 2018	2.016	Biogas	-
CHP engine 2 (A11)	5	Jenbacher	-	454252	202004	Pre 20th Dec 2018	2.016	Biogas	-
Boiler 1 (A31)	5	Yorkshireman	-	454271	202110	Nov 2023	4.71	Biogas (modelled)	Natural gas
Boiler 2 (A32)	5	Yorkshireman	-	454272	202110	Nov 2023	4.71	Biogas (modelled)	Natural gas

The Air Quality Impact Assessment presented within this report is required to support the EP application and assesses the potential for significant air quality effects from the operation of the CHP engines and replacement boilers at the Oxford STW.

The potential impacts were determined for the following aspect:

- the potential impact on human health due to emissions of pollutants, including nitrogen dioxide (NO_2); carbon monoxide (CO); sulphur dioxide (SO_2), total volatile organic compounds (TVOCs) and particulate matter (PM_{10}, particles with an aerodynamic diameter of 10 microns or less and $PM_{2.5}$, particles with an aerodynamic diameter of 2.5 microns or less); and
- the potential impact on vegetation and ecosystems due to emissions of oxides of nitrogen (NOx) and SO_2.

Human receptors

The assessment indicates that the predicted off-site concentrations and predicted concentrations at sensitive human receptors do not exceed any relevant long-term or short-term Environmental Quality Standard (EQS).

The results indicate that for annual mean NO_2, PM_{10} and $PM_{2.5}$ concentrations, the respective process contributions (PCs) are either less than 1% of the relevant long-term environmental quality standard (EQS), or where the PC is greater than 1%, the corresponding predicted environmental concentration (PEC) is below 70% of the long-term EQS and the impact is considered 'not significant'.

It is noted the maximum annual mean NO_2 PC, predicted at R12, which represents a residential property adjacent to the western boundary of the site, is elevated. Further analysis indicates that the CHP engine (emission reference point A1) contributes approximately 34% of the annual mean NO_2 PC predicted at R12.

This assessment has been carried out on the assumption that the CHP engines and boilers operate continuously at maximum load throughout the year (i.e. 8,760 hours). This is a conservative assumption as, in practice, the CHP engines and boilers will have periods of shut-down and maintenance and may not always operate at maximum load. Furthermore, the Cat CHP engine only operates when there is sufficient biogas, typically operating for no more than 2,190 hours per year. When factoring the annual mean NO_2 PC to include typical operation of the Cat CHP engine, the PC as a percentage of the relevant EQS at R12 reduces from 10.3% to 7.7%.

At the nearby City of Oxford Air Quality Management Area (AQMA), the maximum annual mean NO_2 PC is 8.8 $\mu g/m^3$, which equates to 21.9% of the relevant EQS. This PC is predicted at National Grid Reference (NGR) E 454307 N 202206, which is located north of the site in hedgerow between Grenoble Road and a carpark. The maximum PC at the assessed sensitive receptors within the AQMA is 2.6 $\mu g/m^3$, which is predicted at R20 representing a residential property approximately 520 m north of the Cat CHP engine stack. This PC equates to 6.6% of the relevant EQS. When factoring the annual mean NO_2 PC to include typical operation of the Cat CHP engine, the PC as a percentage of the relevant EQS at R20 reduces from 6.6% to 5.2%.

For short-term NO_2, CO, SO_2 and fine particulate matter concentrations, the PCs are either less than 10% of the relevant EQS, or where the PC is greater than 10%, the PEC is below 70% of the short-term EQS and the impact is considered 'not significant'.

For TVOCs, the annual mean and 24-hour mean concentrations were predicted to exceed the relevant EQS for benzene (C_6H_6). However, this assessment assumes all TVOCs emitted by the assessed combustion plant are C_6H_6. This is an overly conservative assumption, and C_6H_6, if present in the exhaust gases, would constitute only a very small proportion of total TVOC emissions (e.g. less than 1%). Therefore, informed by a wider understanding of the properties of biogas, the emissions of TVOCs is considered 'not significant'.

Therefore, when considering the conservative approach to the assessment and based on professional judgement, the emissions of assessed pollutants at sensitive human receptor locations and modelled off-site locations is considered 'not significant'.

Protected conservation areas

For critical levels, at the assessed European designated sites, the annual mean NOx and SO_2 PCs are less than 1% of the relevant critical level and the effect is considered 'insignificant'. At Littlemore Railways Cutting SSSI, the annual mean SO_2 PC is just above 1% (i.e. 1.3%) of the relevant critical load value. However, as discussed previously, the Cat CHP engine only operates when there is sufficient biogas. Therefore, the predicted critical level values presented are likely to be higher than would reasonably be expected.

At the assessed local nature sites, the annual mean NOx and SO_2 PCs are less than 100% of the relevant critical level and the effect is considered 'insignificant'.

For the maximum 24-hour mean critical level for NOx, the results indicate that at the assessed European designated sites & SSSI and the local nature sites, the PCs are less than 10% and 100%, respectively, of the relevant critical level, and the effect is also considered 'insignificant'.

For critical loads, the results indicate that at the assessed European designated sites and the local nature sites, the PCs are less than 1% and 100%, respectively, of the relevant critical load value for acid and nutrient nitrogen deposition and the impact can be described as 'insignificant' as per Environment Agency guidance.

Summary

Based on the above assessment, it is concluded that the operation of the assessed combustion plant are acceptable from an air quality perspective.

Contents

Appendices

1. Introduction

1.1 Background

Under the Industrial Emissions Directive (IED)[1] (European Union, 2010), the anaerobic digestion assets at Oxford Sewage Treatment Works (STW), require an Environmental Permit (EP). The scope of anaerobic digestion activities for EP includes all treatment stages and incorporates directly associated activities such as the operating combined heat and power (CHP) gas engines and boilers.

Thames Water Utilities Limited (hereafter 'Thames Water') currently operates one biogas fuelled Caterpillar (Cat) CHP engine (with a thermal input capacity of 2.466 MWth), two biogas fuelled Jenbacher engines (each with a thermal input capacity of 2.016 MWth) and two new duel-fuelled[2] Yorkshireman boilers (each with a thermal input capacity of 4.71 MWth) at its STW near the city of Oxford, Oxfordshire (OX4 4HG) (hereafter 'the site'). It should be noted the new Yorkshireman boilers have replaced the two inoperable 2.33 MWth (combined 4.66 MWth) boilers[3] and long-term hire boiler (thermal input capacity of 3.8 MWth) on-site.

Jacobs UK Limited (hereafter 'Jacobs') has carried out an Air Quality Impact Assessment (AQIA) on behalf of Thames Water to assess the potential impact of emissions from the existing CHP engines and replacement boilers.

1.2 Study Outline

This AQIA is required to support the EP application and assesses the likely significant air quality effects of emissions to air from the CHP engines and boilers at the site. The air quality assessment has been carried out following the relevant Environment Agency guidance (Environment Agency, 2021; 2023;). The AQIA considers:

- the potential impact on human health due to emissions of pollutants. The pollutants considered include nitrogen dioxide (NO_2); carbon monoxide (CO); sulphur dioxide (SO_2), total volatile organic compounds (TVOCs) and particulate matter (PM_{10}, particles with an aerodynamic diameter of 10 microns or less and $PM_{2.5}$, particles with an aerodynamic diameter of 2.5 microns or less); and
- the potential impact on vegetation and ecosystems due to emissions of oxides of nitrogen (NOx) and SO_2.

The site boundary (represented by the approximate site fenceline) is presented in Figure 1.

This report draws upon information provided from the following parties:

- Thames Water;
- ADM Ltd (meteorological data supplier);
- SOCOTEC (responsible for monitoring the assessed CHP engines);
- Yorkshireman boilers (the assessed boiler manufacturer);
- Centre for Ecology and Hydrology (CEH);
- Department for Environment, Food and Rural Affairs (Defra);
- South Oxfordshire District Council; and
- Oxford City Council.

This report includes a description of the emission sources, description of methodology and significance criteria, a review of the baseline conditions including an exploration of the existing environment of the site and surrounding area, an evaluation of results and the potential impact of emissions on human health and protected conservation areas during operation and, finally, conclusions of the assessment.

1 European Directive 2010/75/EU.

2 Dual fuelled utilising biogas (primary fuel) or natural gas.

3 Emission source reference A12 and A13 in the existing Combined Heat and Power Plant and Standby Diesel Generators Environmental Permit (EPR/MP3038LQ/V005)

2. Emission Sources

2.1 Emission Sources to Air

The location of the assessed CHP engines (emission point reference A1, A10 and A11) and new replacement boilers (emission point reference A31 and A32) are presented in Figure 1.

The CHP engines and boilers (when utilising biogas) are fuelled by biogas generated from the site's anaerobic digestion process and emissions were modelled on this basis. As discussed previously, the new boilers are a dual-fuel design and can run on biogas or natural gas. However, for this assessment they have been modelled utilising biogas as this gives a worst-case scenario for emissions of NOx, typically the pollutant of main concern. The modelling only considers emissions from the CHP engines and boilers and no other emission points to air at the site have been included in the assessment. It should be noted there are four on-site emergency stand-by generators, which operate for less than 50 hours per year (outside of any running to support genuine emergencies). The diesel fuelled generators (with a thermal input capacity of between1.583 MWth and 2.7 MWth) do not form part of the scope for this air dispersion modelling assessment.

Table 2-1 presents the emissions sources to air considered in this assessment.

Table 2-1: Combustion plant considered in this assessment

Parameters	Cat CHP engine (2.466 MWth)	Jenbacher CHP engine 1 (2.016 MWth)	Jenbacher CHP engine 2 (2.016 MWth)	Yorkshireman boiler 1 (4.71 MWth)	Yorkshireman boiler 2 (4.71 MWth)
Modelled fuel	Biogas	Biogas	Biogas	Biogas	Biogas
Emission point reference	A1	A10	A11	A31	A32

This assessment has been carried out on the assumption that the CHP engines and boilers operate continuously at maximum load throughout the year (i.e. 8,760 hours). This is a conservative assumption as in practice, the CHP engines and boilers will have periods of shut-down and maintenance and may not always operate at maximum load. Furthermore, the Cat CHP engine (emission point reference A1) only operates when there is sufficient biogas available, typically operating for no more than 2,190 hours per year (Thames Water, 2023).

However, for predicted modelled concentrations, it is assumed the assessed combustion plant operate continuously as this approach ensures that the worst-case or maximum long-term (i.e. annual mean) and short-term modelled concentrations are quantified (further consideration of this is provided in Appendix A).

2.2 Emissions Data

2.2.1 Emission concentration of pollutants

For the assessed CHP engines, the NOx emission concentrations were obtained from the site's existing Combined Heat and Power Plant and Standby Diesel Generators Environmental Permit (EPR/MP3038LQ/V005)[4]. This represents a conservative approach to the assessment as the NOx emission concentrations applied as a basis of the assessment are higher than the monitored NOx emission concentrations from the assessed CHP engines (SOCOTEC, 2023a; 2023b; 2023c).

The CO emission concentration applied was derived from the Environment Agency's guidance *'Guidance for monitoring landfill gas engine emissions'* (Environment Agency, 2010). The CO emission concentration applied as a basis of the assessment is also higher than the monitored CO emission concentrations (SOCOTEC, 2023a; 2023b; 2023c).

For TVOC, the emission concentrations were obtained from the indicative on-site monitoring of the assessed CHP engines (SOCOTEC, 2023a; 2023b; 2023c).

For SO_2, in the absence of a specific emission limit value, the SO_2 emission concentration typically used in similar permit applications for biogas fuelled engines has been applied.

4 This permit will be merged and remain in place as Directly Associated Activities (DAAs).

For particulates, in the absence of a specific emission limit value, the emission concentration was derived from a previous study of landfill gas engines (Land Quality Management Ltd, 2002).

For the new replacement boilers, as a worst-case approach to the assessment, the NOx emission concentration is based on the permitted emission limit values for the two removed 2.33 MWth boilers. This is a conservative approach as the NOx emission concentration applied as a basis of the assessment is considerably higher than the boilers anticipated NOx emission concentration (Thames Water, 2023). The SO_2 emission concentration was obtained from the Medium Combustion Plant Directive (MCPD) EU/2015/2193[5] (European Union, 2015) for new MCP other than engines and gas turbines, which is likely to be considerably higher than the actual SO_2 emission concentration.

For CO and TVOC, in the absence of a specific emission limit value when utilising biogas, the CO emission concentration was obtained from the value for natural gas from Defra's Process Guidance Note 1/3,*'Statutory Guidance for Boilers and Furnaces 20-50MW thermal input'* (Defra, 2012) and the TVOC emission concentration was derived from the Environment Agency's guidance '*Guidance for monitoring landfill gas engine emissions'*, (Environment Agency, 2010).

2.2.2 Other emission parameters

For the Cat CHP engine (emission point reference A1), the exhaust volumetric flow, exhaust gas temperature and moisture content were obtained from on-site monitoring of the CHP engine (SOCOTEC, 2023a). The oxygen content used in the model is based on professional judgement.

For the remaining assessed CHP engines (emission point reference A11 and A12), the exhaust gas volumetric flows were determined using stoichiometric calculations based on the combustion of biogas fuel at the maximum thermal input rating of the assessed combustion plant. In the absence of information regarding exhaust gas temperature, oxygen and moisture content of the combustion plant, the data used in the model is based on professional judgment acquired from previous work involving biogas fuelled CHP engines of a similar thermal input capacity.

For the boilers, the exhaust gas volumetric flow and temperature were obtained from the boiler manufacturer data sheet (Yorkshireman, 2023). In the absence of information regarding oxygen and moisture content of the combustion plant, the data used in the model is based on professional judgment acquired from previous work involving biogas fuelled boilers of a similar thermal input capacity.

The emissions inventory of releases to air from the CHP engines and boilers are provided in Appendix A.

5 European Parliament and the Council of the European Union, Medium Combustion Plant Directive EU/2015/2193 of 25 November 2015 on the limitation of emissions of certain pollutants into the air from medium combustion plants and as transposed into Schedule 25A of The Environmental Permitting (England and Wales) (Amendment) Regulations 2018 (United Kingdom (UK) Government, 2018)).

3. Assessment Methodology

This section presents a summary of the methodology used for the assessment of the potential impacts of the site. A full description of the study inputs and assumptions are provided in Appendix A.

3.1 Assessment Location

For this assessment, 24 of the closest sensitive human receptors (such as residential properties and a school) near the site were identified for modelling purposes. The location of these receptors are presented in Figure 2. Furthermore, the nearby City of Oxford Air Quality Management Area (AQMA) (see Section 4.2) was also included in the assessment.

In line with the Environment Agency guidance '*Air emissions risk assessment for your environmental permit*' (Environment Agency, 2023), it is necessary to identify protected conservation areas within the following distances from the site:

- European sites (i.e. Special Area of Conservation (SAC), Special Protection Area (SPA) and Ramsar sites) within 10 km; and
- Site of Special Scientific Interest (SSSI) and local nature sites (i.e. ancient woodlands, local wildlife sites (LWS) and national and local nature reserves (NNR and LNR)), within 2 km.

Based on these criteria; Oxford Meadows SAC, Little Wittenham SAC & SSSI, Cothill Fen SAC & SSSI, Litttlemore Railways Cuttings SSSI, Sandford Break North Extension LWS, Sandford Brake LWS, Lower Farm Bottom Hay Meadow LWS, Radley Large Wood LWS, Kennington Memorial Field LWS, Fiddlers Elbow Marsh LWS, Heyford Hill Lane Pasture LWS, Bypass Swamp LWS and Wetland south of the Iffley Meadows LWS were included in the assessment.

The location of the assessed protected conservation areas are presented in Figure 3 and further details are set out in Appendix A.

3.2 Overall Methodology

The assessment was carried out using an atmospheric dispersion modelling technique. Atmospheric Dispersion Modelling System (ADMS) version 5.2.4 was used to model releases of the identified substances. The ADMS model predicts the dispersion of operational emissions from a specific source (e.g. a stack), and the subsequent concentrations over an identified area (e.g. at ground level across a grid of receptor points) or at specified points (e.g. a residential property). ADMS was selected because this model is fit for the purpose of modelling the emissions from the type of sources on-site (i.e. point source emissions from a combustion source) and is accepted as a suitable assessment tool by the Environment Agency.

The modelling assessment was undertaken in accordance with the Environment Agency guidance '*Air emissions risk assessment for your environmental permit*' (Environment Agency, 2023).

A summary of the dispersion modelling procedure is set out below.

1. Information on plant location and stack parameters were supplied by Thames Water (Thames Water, 2023). Information on the CHP engines and boilers were obtained from various sources as described in Section 2.2.
2. Five years of hourly sequential data recorded at RAF Benson meteorological station (2016 – 2020 inclusive) were used for the assessment (ADM Ltd, 2021).
3. Information on the main buildings located on-site, that could influence dispersion of emissions from the CHP engines and boiler stacks were estimated from Defra's environmental open-data applications and datasets (Defra, 2023a), on-site photography and Google Earth (Google Earth, 2023).
4. The maximum predicted concentrations (at a modelled height of 1.5 m or 'breathing zone') at the assessed sensitive human receptor locations R1 – R20 (representing long-term exposure at residential properties and a school) were considered for the assessment of annual mean, 24-hour mean, 8-hour mean, 1-hour mean and 15-minute mean pollutant concentrations within the study area. For receptors R21-R24 (representing a bridleway and a Public Rights of Way (PRoW)), only the 1-hour mean and 15-minute mean concentrations were considered. The maximum predicted concentrations at an off-site location in the vicinity of the site were considered for the assessment of short-term (1-hour and 15-minute mean) concentrations. The nearby AQMA (see Section 4.2) was considered for annual mean NO_2 concentrations only.
5. The above information was entered into the dispersion model.

6. The dispersion model was run to provide the Process Contribution (PC). The PC is the estimated maximum environmental concentration of substances due to releases from the process alone. The results were then combined with baseline concentrations (see Section 4.2) to provide the Predicted Environmental Concentration (PEC) of the substances of interest.
7. The PECs were then assessed against the appropriate environmental standards for air emissions for each substance set out in the Environment Agency's guidance (Environment Agency, 2023) document to determine the nature and extent of any potential adverse effects.
8. Modelled concentrations were processed using geographic information system (GIS) software (ArcMap 10.8.1) to produce contour plots of the model results. These are provided for illustrative purposes only; assessment of the model results was based on the numerical values outputted by the dispersion model on the model grid (see Figure 2) and at the specific receptor locations and were processed using Microsoft Excel.
9. The predicted concentrations of NOx and SO_2 were also used to assess the potential impact on critical levels and critical loads (i.e. acid and nutrient nitrogen deposition) (see Section 3.3.2) at the assessed protected conservation areas. Details of the deposition assessment methodology are provided in Appendix B.

In addition to the above, a review of existing ambient air quality in the area was undertaken to understand the baseline conditions at the site and at receptors within the study area. These existing conditions were determined by reviewing the monitoring data already available for the area and other relevant sources of information. The review of baseline air quality is set out in Section 4.

Where appropriate, a conservative approach has been adopted throughout the assessment to increase the robustness of the model predictions. In addition, an analysis of various sensitivity scenarios has also been carried out (see Section 5.3) to determine how changes to model parameters (e.g. differing surface roughness values or modelling without considering buildings) may impact on predicted concentrations at sensitive human receptors and off-site locations.

3.3 Assessment Criteria

3.3.1 Environmental Quality Standards: Human Receptors

In the UK, the focus on local air quality is reflected in the air quality objectives (AQOs) set out in the *Air Quality Strategy for England, Scotland, Wales and Northern Ireland* (AQS) (Defra and the Devolved Administrations, 2007). The AQS stipulates a number of air quality objectives for nine main air pollutants with respect to ambient levels of air quality (Defra, 2007). The AQOs are similar to the limit values that were transposed from the relevant EU directives into UK legislation by The *Air Quality Standards Regulations 2010* (UK Government, 2010). The objectives are based on the current understanding of health effects of exposure to air pollutants and have been specified to control health and environmental risks to an acceptable level. They apply to places where people are regularly present over the relevant averaging period. The objectives set for the protection of human health and vegetation of relevance to the project are summarised in Table 3-1. Relevant Environmental Assessment Levels (EALs) set out in the Environment Agency guidance (Environment Agency, 2023) are also included in Table 3-1 where these supplement the AQOs.

For the purposes of reporting, the AQOs and EALs have been collectively termed as Environmental Quality Standards (EQSs).

Table 3-1: Air quality objectives and environmental assessment levels

Pollutant	EQS (µg/m^3)	Concentration measured as
NO_2	40	Annual mean
	200	1-hour mean, not to be exceeded more than 18 times a year (99.79th percentile)
CO	10,000	Maximum daily 8 hour running mean (100th percentile)
	30,000	Maximum 1-hour mean (100th percentile)
SO_2	125	24-hour mean not to be exceeded more than 3 times a year (99.18th percentile)
	350	1-hour mean not to be exceeded more than 24 times a year (99.73rd percentile)
	266	15-minute mean not to be exceeded more than 35 times a year (99.9th percentile)
PM_{10}	40	Annual mean
	50	24-hour mean, not to be exceeded more than 35 times a year (90.41st percentile)
$PM_{2.5}$	20	Annual mean
TVOC[1]	5[2]	Annual mean

Pollutant	EQS (μg/m^3)	Concentration measured as
	30[2]	Maximum 24-hour mean (100th percentile)

Note 1: VOCs may contain a wide range of organic compounds and it is often difficult to determine or identify each and every compound present. The TVOC emissions from the assessed combustion plant will largely comprise methane (CH_4) which is not directly harmful to human health.
Note 2: For the purposes of this assessment, the annual mean and 24-hour mean AQO for benzene (C_6H_6) has been applied as it is a standard substitute that adequately represents a worst-case scenario for VOCs.

For the assessment of long-term average concentrations (i.e. the annual mean concentrations) at human receptors, impacts were described using the following criteria:

- if the PC is less than 1% of the long-term EQS, the contribution can be considered as 'insignificant' and not representative of a significant effect (i.e. not significant) (Environment Agency, 2021);
- if the PC is greater than 1% of the EQS but the PEC is less than 70% of the long-term air quality objective, based on professional judgement, this would be classed as 'not significant'; and
- where the PC is greater than 1% of the EQS and the PEC is greater than 70% of the EQS, professional judgement is used to determine the overall significance of the effect (i.e. whether the effect would be 'not significant' or 'significant'), taking account of the following:
  - the scale of the changes in concentrations;
  - whether or not an exceedance of an EQS is predicted to arise in the study area where none existed before, or an exceedance area is substantially increased as a result of the development; and
  - uncertainty, including the influence and validity of any assumptions adopted in undertaking the assessment.

For the assessment of short-term average concentrations (e.g. the 1-hour mean NO_2 concentrations, and the 15-minute, 1-hour and 24-hour mean SO_2 concentrations etc.), impacts were described using the following criteria:

- if the PC is less than 10% of the short-term EQS, this would be classed as 'insignificant' and not representative of a significant effect (i.e. not significant) (Environment Agency, 2021);
- if the PC is greater than 10% of the EQS but less than 20% of the headroom between the short-term background concentration and the EQS, based on professional judgement, this can also be described as not significant; and
- where the PC is greater than 10% of the EQS and 20% of the headroom, professional judgement is used to determine the overall significance of the effect (i.e. whether the effect would be not significant or significant) in line with the approach specified above for long-term average concentrations.

Environment Agency guidance recommends that further action will not be required if proposed emissions comply with Best Available Techniques Associated Emission Levels (BAT AELs) and resulting PECs do not exceed the relevant EQS (Environment Agency, 2023).

3.3.2 Environmental Quality Standards: Protected Conservation Areas

Critical levels

The environmental standards set for protected conservation areas of relevance to the project are summarised in Table 3-2 (Environment Agency, 2023).

Table 3-2: Air Quality Objectives and Environmental Assessment Levels for protected conservation areas

Pollutant	EQS (μg/m^3)	Concentration measured as
NOx	30	Annual mean limit value for the protection of vegetation (referred to as the "critical level")
	75	Maximum 24-hour mean for the protection of vegetation (referred to as the "critical level")
SO_2	10	Annual mean limit value for the protection of vegetation (referred to as the "critical level") where lichens or bryophytes are present
	20	Annual mean limit value for the protection of vegetation (referred to as the "critical level") where lichens or bryophytes are not present

Critical loads

Critical loads for pollutant deposition to statutorily designated habitat sites in the UK and for various habitat types have been published by the CEH and are available from the Air Pollution Information System (APIS) website. Critical Loads are defined on the APIS website (Centre for Ecology and Hydrology, 2023) as:

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

Compliance with these benchmarks is likely to result in no significant adverse effects on the natural environment at these locations. The critical loads for the designated habitat sites considered in this assessment are set out in Table 3-3.

For the European designated sites and SSSI, the *Site Relevant Critical Loads* tool function on the APIS website was used to determine the relevant critical loads. For Little Wittenham SAC & SSSI and Littlemore Railways Cutting SSSI, no critical load data were available for the protected conservation areas.

For the assessed local natures sites, the *Search by Location* function on the APIS website was used. Where the likely vegetation type inhabiting the assessed local nature site is unknown, the acid grassland (representing short vegetation type) and / or coniferous woodland habitat feature (representing tall vegetation type) were selected on the APIS website, which is generally the most sensitive short and tall vegetation type to nutrient nitrogen and acid deposition.

The critical loads for the designated habitat sites considered in this assessment are set out in Table 3-3.

Table 3-3: Critical loads for modelled protected conservation areas

Rec ref	Protected conservation area	Habitat feature applied	Vegetation type (for deposition velocity)	Critical load Acid deposition (kEqH+/ha/year)			Nitrogen deposition(kg N/ha/year)
				CLMaxS	CLMinN	CLMaxN	Minimum
H1	Oxford Meadows SAC	Lowland hay meadows	Short	1.620	0.223	2.058	20
H2	Little Wittenham SAC	Freshwater	Short	No critical load data available			No comparable habitat with established critical load estimate available
H3	Cothill Fen SAC	Acid grassland	Short	0.220	0.223	0.443	15
		Unmanaged Broadleafed / coniferous woodland	Tall	0.688	0.142	0.830	10
H4	Littlemore Railways Cutting SSSI	-	-	The site has no features in the APIS database			
H5	Sandford Break North Extension LWS	Coniferous woodland	Tall	0.630	0.142	0.772	5
H6	Sandford Brake LWS	Coniferous woodland	Tall	2.241	0.357	2.598	5
H7	Lower Farm Bottom Hay Meadow LWS	Acid grassland	Short	1.600	0.438	2.038	5
H8	Radley Large Wood LWS	Coniferous woodland	Tall	7.025	0.142	7.167	5
H9	Kennington Memorial Field	Acid grassland	Short	4.100	0.223	4.323	5

Rec ref	Protected conservation area	Habitat feature applied	Vegetation type (for deposition velocity)	Critical load Acid deposition (kEqH+/ha/year)			Nitrogen deposition(kg N/ha/year)
				CLMaxS	CLMinN	CLMaxN	Minimum
H10	Fiddlers Elbow Marsh LWS	Coniferous woodland	Tall	0.658	0.142	0.800	5
H11	Heyford Hill Lane Pasture LWS	Acid grassland	Short	4.100	0.438	4.538	5
H12	Bypass Swamp LWS	Coniferous woodland	Tall	10.698	0.357	11.055	5
H13	Wetland south of Iffley Meadows LWS	Coniferous woodland	Tall	10.698	0.357	11.055	5

Critical load functions for acid deposition are specified on the basis of both nitrogen and sulphur derived acid. The critical load function contains a value for sulphur derived acid and two values for nitrogen derived acid deposition (a minimum and maximum value). The APIS website provides advice on how to calculate the PC (i.e. emissions from the modelled process alone) and the PEC (i.e. the PC added to the existing deposition) as a percentage of the acid critical load function and how to determine exceedances of the critical load function. This guidance was adopted for this assessment. The minimum of the range of nitrogen critical loads was used for the assessment in line with the advice on the APIS website (Centre for Ecology and Hydrology, 2023).

Significance Criteria – European designated sites (i.e. SACs) and SSSI

With regard to concentrations at the assessed designated habitat site, the Environment Agency guidance (Environment Agency, 2023) states emissions can be described as 'insignificant' and no further assessment is required (including the need to calculate PECs) if:

- the short-term PC is less than 10% of the short-term environmental standard for protected conservation areas; or
- the long-term PC is less than 1% of the long-term environmental standard for protected conservation areas.

Where appropriate, the significance of the predicted long-term (annual mean) concentrations or deposition at protected conservation areas were determined in line with Environment Agency guidance (Environment Agency, 2023) summarised as follows:

- Where the PC is less than 1% of the relevant critical level or critical load, the emission is not likely to have a significant effect alone or in combination irrespective of the existing concentrations or deposition rates.
- Where the PC is above 1%, further consideration of existing background concentrations or deposition rates is required, and where the total concentration or deposition is less than 70% of the critical level or critical load, calculated in combination with other committed projects or developments as appropriate, the emission is not likely to have a significant effect.
- Where the contribution is above 1%, and the total concentration or deposition rate is greater than 70% of the critical level or critical load, either alone or in combination with other committed projects or developments, then this may indicate a significant effect and further consideration is likely to be required.

The above approach is used to give a clear definition of what effects can be disregarded as 'insignificant', and which need to be considered in more detail in relation to the predicted annual mean concentrations or deposition.

For short-term mean concentrations (i.e. the 24-hour mean critical level for NOx) where the PC is less than 10% of the critical level then it would be regarded as 'insignificant'. A potentially significant effect would be identified where the short-term PC from the modelled sources would lead to the total concentration exceeding the critical level. Further consideration is likely to be required in this situation.

Significance Criteria – Local nature sites (i.e. LWS)

The relevant significance criteria for these protected conservation areas are set out below.

With regard to concentrations or deposition rates at local nature sites, the Environment Agency guidance (Environment Agency, 2023) states emissions can be described as 'insignificant' and no further assessment is required (including the need to calculate PECs) if:

- the short-term PC is less than 100% of the short-term environmental standard for protected conservation areas; or
- the long-term PC is less than 100% of the long-term environmental standard for protected conservation areas.

The above approach is used to give a clear definition of what effects can be disregarded as 'insignificant', and which need to be considered in more detail in relation to the predicted annual mean concentrations or deposition.

4. Existing Environment

4.1 Location

The site is situated approximately 5 km south-southeast from the centre of the city of Oxford, Oxfordshire and is located within the local authority of South Oxfordshire District Council and adjacent to the Oxford local authority boundary. The area surrounding the site is a mixture of agricultural, residential and commercial land use. A Special Educational Needs and Disabilities (SEND) School (represented by 'R2' in the assessment) is approximately 620 m east of the Cat CHP engine (based on the stack location).

There are several sensitive human receptors in the vicinity of the site in respect of potential air emissions from the process. The most relevant sensitive receptors have been identified from local mapping and are summarised in Appendix A and presented in Figure 2. The nearest modelled residential property is approximately 210 m southwest of the Cat CHP engine (based on the stack location). The nearest modelled receptor represents a bridleway approximately 180 m southwest of the Cat CHP engine stack at its closest point.

4.2 Local Air Quality Management

A review of baseline air quality was carried out prior to undertaking the air quality assessment. This was carried out to determine the availability of baseline air quality data recorded in the vicinity of the site and also if data from other regional or national sources such as the UK Air Information Resource (UK-AIR) (Defra, 2023b) website could be used to represent background concentrations of the relevant pollutants in the vicinity of the site.

As part of the Local Air Quality Management (LAQM) process, South Oxfordshire District Council has declared three AQMAs within its administrative boundary. The nearest of these AQMAs to the site, declared by South Oxfordshire District Council, is termed 'Wallingford AQMA', which was declared for elevated concentrations of annual mean NO_2 in 2006. This AQMA is approximately 14 km southeast of the site and has not been included in the assessment due to its distance from the site. However, Oxford County Council has declared a city-wide AQMA (termed 'The City of Oxford AQMA') for elevated concentrations of annual mean NO_2. As the City of Oxford AQMA is adjacent to the northern boundary of the site, it has been included in the assessment accordingly.

South Oxfordshire District Council and Oxford County Council also carry out regular assessments and monitoring of air quality within the respective boroughs as part of the LAQM process. The most recent Air Quality Annual Status Reports (South Oxfordshire District Council, 2022) (Oxford City Council, 2022) were reviewed to determine the concentrations of NO_2 and particulates in the vicinity for the site. It should be noted that none of the other assessed pollutants are monitored by South Oxfordshire District Council and Oxford County Council. Table 4-1 presents information on the nearest monitoring locations to the site and includes the 2019 monitored annual mean concentrations as this dataset is the latest available representative data not affected by the Covid pandemic and related travel restrictions.

Table 4-1: Nearest monitoring locations to the site

Site ID	Description	Site type	Location	Distance and direction from Cat CHP engine stack	Pollutants monitored	2019 Annual mean concentration (µg/m³)
Automatic monitoring						
CM1	AURN Oxford Centre	Roadside	E 451359 N 206157	5.09 km, NW	NO_2	42
CM2	Oxford High Street	Roadside	E 451677 N 206272	5.01 km, NNW	NO_2, PM_{10}	40 (NO_2) 19 (PM_{10})
CM3	AURN St Ebbes	Urban Background	E 451118 N 205353	4.62 km, NW	NO_2, PM_{10}, $PM_{2.5}$	16 (NO_2) 14 (PM_{10}) 9 ($PM_{2.5}$)
Non-automatic monitoring (diffusion tubes)						

Site ID	Description	Site type	Location	Distance and direction from Cat CHP engine stack	Pollutants monitored	2019 Annual mean concentration (µg/m³)
DT7	Oxford Road / Between Towns Road	Roadside	E 454472 N 204246	2.27 km, N	NO_2	32
DT8	Oxford Road (Cowley) LP13	Roadside	E 454355 N 204296	2.31 km, N	NO_2	31
DT80	Hollow way Road	Roadside	E 454651 N 204270	2.32 km, N	NO_2	37

Automatic monitoring location 'CM1' and 'CM2' and the non-automatic monition locations are not considered representative of conditions experienced at the site due to the monitoring site type and / or respective distance from the site. However, automatic monitoring location 'CM3', which is an urban background site (and located within the City of Oxford AQMA) (see Figure 2), is considered representative of conditions experienced at the site. Therefore, as a conservative approach to the assessment, the 2019 annual mean NO_2 concentration recorded at 'CM3' was applied to all assessed sensitive human receptor locations (see Table 4-2). The actual annual mean NO_2 concentrations experienced at these receptors is likely to be lower.

For the remaining assessed pollutants, information on background air quality in the vicinity of the site were obtained from Defra background map datasets (Defra, 2023b). The 2018-based background maps by Defra are estimates based upon the principal local and regional sources of emissions and ambient monitoring data. For SO_2 and CO concentrations, the 2001-based background maps were used. For TVOC concentrations, the 2010-based background maps for C_6H_6 were used. These background concentrations are presented in Table 4-2.

As it is necessary to determine the potential impact of emissions from the site at the assessed protected conservation areas, the background concentrations of NOx and SO_2 were also identified. These background concentrations were also obtained from the Defra background map datasets (Defra, 2023b) and are displayed in Table 4-2.

Table 4-2: Background concentrations: adopted for use in assessment for human receptors and protected conservation areas

Pollutant	Annual mean concentration (µg/m³)	Description
Human receptors		
NO_2	16.0	Automatic monitoring location CM3, 2019 annual mean NO_2 concentration (Oxford City Council, 2022)
CO	148 – 289	Defra 1 km x 1 km background map value for the assessed sensitive human receptor locations, 2001 based map concentration
PM_{10}	13.7 – 15.0[1]	Defra 1 km x 1 km background map value for the assessed sensitive human receptor locations, 2023 map concentration
$PM_{2.5}$	8.7 – 10.0[1]	Defra 1 km x 1 km background map value for the assessed sensitive human receptor locations, 2023 map concentration
SO_2	4.2 – 7.5	Defra 1 km x 1 km background map value for the assessed sensitive human receptor locations, 2001 based map concentration
C_6H_6	0.32 – 0.60	Defra 1 km x 1 km background map value for the assessed sensitive human receptor locations, 2010 map concentration
Protected conservation areas		
NOx	10.7 – 18.3	Defra 1 km x 1 km background map value for the assessed protected conservation areas, 2023 map concentration
SO_2	2.5 – 7.5	Defra 1 km x 1 km background map value for the assessed sensitive human receptor locations, 2001 based map concentration

Note 1: Maximum Defra background map values are higher than 2019 annual mean PM_{10} and $PM_{2.5}$ concentrations recorded at automatic monitoring location CM3.

The long-term background concentrations were doubled to estimate the short-term background concentrations in line with the Environment Agency guidance (Environment Agency, 2023).

4.3 Existing Deposition Rates

Existing acid and nutrient nitrogen deposition levels were obtained from APIS (Centre for Ecology and Hydrology, 2023). As a conservative approach to the assessment, it is assumed the vegetation type selected is present at the specific modelled location within the assessed protected conservation area. The existing deposition values at the assessed ecological designations are set out in Table 4-3.

Table 4-3: Existing deposition at modelled habitat sites

Rec ref	Protected conservation area	Vegetation type (for deposition velocity)	Existing deposition rates	
			Existing acid deposition (kEqH+/ha/year)	Existing nutrient N deposition (kg N/ha/year)
			Nitrogen and sulphur	Nitrogen
H1	Oxford Meadows SAC	Short	1.42	18.90
H2	Little Wittenham SAC	Short	-	18.80
H3	Cothill Fen SAC	Short	1.40	18.80
		Tall	2.50	33.50
H4	Littlemore Railways Cutting SSSI	Short	-	-
H5	Sandford Break North Extension LWS	Tall	2.48	32.59
H6	Sandford Brake LWS	Tall	2.48	32.59
H7	Lower Farm Bottom Hay Meadow LWS	Short	1.42	18.14
H8	Radley Large Wood LWS	Tall	2.48	32.52
H9	Kennington Memorial Field	Short	1.42	18.14
H10	Fiddlers Elbow Marsh LWS	Tall	2.48	32.52
H11	Heyford Hill Lane Pasture LWS	Short	1.42	18.14
H12	Bypass Swamp LWS	Tall	2.48	32.52
H13	Wetland south of Iffley Meadows LWS	Tall	2.48	32.52

5. Results

5.1 Human Receptors

The results presented below are the maximum modelled concentrations predicted at any of the 24 assessed sensitive human receptor locations, 'The City of Oxford AQMA' and the maximum modelled concentrations at any off-site location for the five years of meteorological data used in the study.

The results of the dispersion modelling are set out in Table 5-1, which presents the following information:

- EQS (i.e. the relevant air quality standard);
- estimated annual mean background concentration (see Section 4) that is representative of the baseline;
- PC, the maximum modelled concentrations due to the emissions from the assessed combustion plant;
- PEC, the maximum modelled concentration due to process emissions combined with estimated baseline concentrations;
- PC and PEC as a percentage of the EQS; and
- PC as a percentage of headroom (i.e. the PC as a percentage of the difference between the short-term background concentration and the EQS, for short-term predictions only).

The full results at assessed human receptor locations are presented in Appendix C.

Table 5-1: Results of detailed assessment

Pollutant	Averaging period	Assessment location	Location where maximum PC predicted	EQS (µg/m^3)	Baseline air quality level (µg/m^3)	PC (µg/m^3)	PEC (µg/m^3)	PC / EQS (%)	PEC / EQS (%)	PC as a percentage of headroom (%)
CO	Maximum 8-hour running mean	Sensitive locations	R13	10,000	577.3	116.2	693.5	1.2%	6.9%	1.2%
	Maximum 1-hour mean	Maximum off-site	E 454197 N 201976	30,000	577.3	254.1	831.4	0.8%	2.8%	0.9%
		Sensitive locations	R12	30,000	577.3	152.7	730.0	0.5%	2.4%	0.5%
NO_2	Annual mean	Sensitive locations	R12	40	16.0	4.1	20.1	10.3%	50.3%	-
		The City of Oxford AQMA	E 454307 N 202206	40	-	8.8	-	21.9%	-	-
		Sensitive location within The City of Oxford AQMA	R20	40	16.0	2.6	18.6	6.6%	46.6%	-
	1-hour mean (99.79th percentile)	Maximum off-site	E 454307 N 202186	200	32.0	34.7	66.7	17.4%	33.4%	20.7%
		Sensitive locations	R21	200	32.0	23.0	55.0	11.5%	27.5%	13.7%
SO_2	24-hour mean (99.18th percentile)	Sensitive locations	R12	125	14.8	25.9	40.7	20.7%	32.6%	23.5%
	1-hour mean (99.73rd percentile)	Maximum off-site	E 454307 N 202186	350	8.7	60.0	68.7	17.2%	19.6%	17.6%
		Sensitive locations	R21	350	14.8	37.6	52.4	10.8%	15.0%	11.2%
	15-minute mean (99.9th percentile)	Maximum off-site	E 454307 N 202186	266	8.7	64.5	73.2	24.3%	27.5%	25.1%
		Sensitive locations	R21	266	14.8	41.8	56.6	15.7%	21.3%	16.6%
PM_{10}	Annual mean	Sensitive locations	R12	40	14.2	0.09	14.3	0.2%	35.8%	-
	24-hour mean (90.41st percentile)	Sensitive locations	R12	50	28.4	0.39	28.8	0.8%	57.6%	1.8%
$PM_{2.5}$	Annual mean	Sensitive locations	R12	20	9.1	0.09	9.2	0.4%	46.0%	-
TVOC	Annual mean	Sensitive locations	R12	5 (C_6H_6)	0.6	22.0	22.6	439.4%	451.5%	-
	Maximum 24-hour mean	Sensitive locations	R13	30 (C_6H_6)	1.2	177.0	178.2	589.9%	593.9%	614.7%

Note 1: For annual mean NO_2, PM_{10} and $PM_{2.5}$ and TVOC concentrations, 24-hour mean PM_{10} and SO_2 concentrations and 8-hour mean CO concentrations, R21 – R24 have been omitted from analysis as these receptor locations represent a bridleway and a PRoW (i.e. short-term exposure only). The full results are presented in Appendix D.

The results in Table 5-1 indicate that the predicted modelled off-site concentrations and predicted concentrations at sensitive human receptors do not exceed any relevant long-term or short-term EQS.

Table 5-1 indicates that for annual mean NO_2, PM_{10} and $PM_{2.5}$ concentrations, the respective PCs are either less than 1% of the relevant long-term EQS or where the PCs are above 1% of the relevant EQS (i.e. NO_2), the PEC is less than 70% of the relevant EQS and the impacts are considered 'not significant' as per Environment Agency guidance (Environment Agency, 2023).

It is noted the maximum annual mean NO_2 PC, predicted at R12, which represents a residential property (a static caravan) adjacent to the western boundary of the site, is elevated. Further analysis indicates that the Cat CHP engine (emission reference point A1) contributes approximately 34% of the annual mean NO_2 PC predicted at R12.

This assessment has been carried out on the assumption that the CHP engines and boilers operate continuously at maximum load throughout the year (i.e. 8,760 hours). This is a conservative assumption as, in practice, the CHP engines and boilers will have periods of shut-down and maintenance and may not always operate at maximum load. Furthermore, the Cat CHP engine only operates when there is sufficient biogas, typically operating for no more than 2,190 hours per year. When factoring the annual mean NO_2 PC to include typical operation of the Cat CHP engine, the PC as a percentage of the relevant EQS at R12 reduces from 10.3% to 7.7%.

At the nearby City of Oxford AQMA, the maximum annual mean NO_2 PC is 8.8 $\mu g/m^3$, which equates to 21.9% of the relevant EQS. This PC is predicted at NGR E 454307 N 202206, which is located north of the site in hedgerow between Grenoble Road and a carpark. The maximum PC at the assessed sensitive receptors within the AQMA is 2.6 $\mu g/m^3$, which is predicted at R20 representing a residential property approximately 520 m north of the Cat CHP engine stack. This PC equates to 6.6% of the relevant EQS. When factoring the annual mean NO_2 PC to include typical operation of the Cat CHP engine, the PC as a percentage of the relevant EQS at R20 reduces from 6.6% to 5.2%.

For short-term NO_2, CO, SO_2 and particulate concentrations, the PCs are either less than 10% of the relevant EQS or where the PCs are above 10% of the relevant EQS, the respective PEC is less than 70% of the relevant EQS and the impacts are considered 'not significant'.

For annual mean TVOC concentrations at a sensitive human receptor location, the maximum PC of 22.0 $\mu g/m^3$ is predicted at R12. The corresponding PEC exceeds the annual mean EQS for C_6H_6.

For maximum 24-hour mean TVOCs concentrations at a sensitive human receptor location, the maximum PC is 177.0 $\mu g/m^3$, which is predicted at R13 representing a static caravan approximately 210 m southwest of the Cat CHP engine stack. The PEC exceeds the 24-hour mean EQS for C_6H_6.

This assessment assumes all TVOCs emitted by the assessed combustion plant are C_6H_6. This is an overly conservative assumption, and C_6H_6, if present in the exhaust gases, would constitute only a very small proportion of total TVOC emissions (e.g. less than 1%). Therefore, informed by a wider understanding of the properties of biogas, the emissions of TVOCs is considered 'not significant'.

The conservative approach adopted throughout the assessment means the predicted concentrations presented in Table 5-1 are likely to be higher than would reasonably be expected.

Isopleths (see Figures 4 and 5) have been produced for annual mean and 1-hour mean (99.79th percentile) NO_2 concentrations. The figures are based on the year of meteorological data which resulted in the highest PC at a sensitive human receptor location.

5.2 Protected Conservation Areas

5.2.1 Assessment against Critical Levels

The environmental effects of releases from the site at the assessed protected conservation areas has been determined by comparing predicted concentrations of released substances with the EQSs for the protection of vegetation (critical levels) (see Table 3-2). The results of the detailed modelling at the assessed protected conservation areas are shown in Table 5-2. The results presented are the maximum predicted concentrations at the modelled locations for the five years of meteorological data used in the study area.

For SO_2 PCs, the relevant EQS was based on the assumption that lichens and bryophytes were present at the assessed protected conservation areas, therefore adopting the lower critical level of 10 μg/m³ (compared to 20 μg/m³) as a conservative approach.

Table 5-2: Results of detailed assessment at assessed protected conservation sites for annual mean NOx and SO_2 concentrations and for maximum 24-hour mean NOx concentrations

Rec ref	Protected Conservation Area	EQS (μg/m³)	Background concentration (μg/m³)	PC (μg/m³)	PEC (μg/m³)	PC/EQS (%)	PEC/EQS (%)
Annual mean NOx concentrations							
H1	Oxford Meadows SAC	30	17.4	0.03	17.4	0.1%	58.0%
H2	Little Wittenham SAC & SSSI		11.7	0.03	11.8	0.1%	39.2%
H3	Cothill Fen SAC & SSSI		10.7	0.02	10.7	0.1%	35.8%
H4	Littlemore Railways Cutting SSSI		16.5	0.23	16.7	0.8%	55.7%
H5	Sandford Break North Extension LWS		14.1	0.33	14.4	1.1%	47.9%
H6	Sandford Brake LWS		12.4	0.41	12.9	1.4%	42.8%
H7	Lower Farm Bottom Hay Meadow LWS		14.2	0.36	14.6	1.2%	48.7%
H8	Radley Large Wood LWS		15.5	0.09	15.6	0.3%	52.1%
H9	Kennington Memorial Field		16.1	0.08	16.2	0.3%	54.0%
H10	Fiddlers Elbow Marsh LWS		14.8	0.18	15.0	0.6%	49.9%
H11	Heyford Hill Lane Pasture LWS		18.3	0.16	18.4	0.5%	61.5%
H12	Bypass Swamp LWS		18.3	0.13	18.4	0.4%	61.4%
H13	Wetland south of Iffley Meadows LWS		18.3	0.11	18.4	0.4%	61.3%
Annual mean SO_2 concentrations							
H1	Oxford Meadows SAC	10	2.8	0.02	2.8	0.2%	27.8%
H2	Little Wittenham SAC & SSSI		7.3	0.02	7.3	0.2%	73.0%
H3	Cothill Fen SAC & SSSI		2.5	0.01	2.5	0.1%	25.3%
H4	Littlemore Railways Cutting SSSI		4.6	0.13	4.7	1.3%	47.1%
H5	Sandford Break North Extension LWS		4.2	0.19	4.4	1.9%	43.7%
H6	Sandford Brake LWS		7.5	0.24	7.7	2.4%	77.0%
H7	Lower Farm Bottom Hay Meadow LWS		3.5	0.21	3.7	2.1%	36.8%
H8	Radley Large Wood LWS		3.5	0.05	3.6	0.5%	35.5%
H9	Kennington Memorial Field		3.8	0.05	3.8	0.5%	38.4%
H10	Fiddlers Elbow Marsh LWS		3.6	0.11	3.7	1.1%	36.9%
H11	Heyford Hill Lane Pasture LWS		3.4	0.09	3.5	0.9%	34.8%
H12	Bypass Swamp LWS		3.4	0.08	3.5	0.8%	34.7%
H13	Wetland south of Iffley Meadows LWS		3.4	0.07	3.5	0.7%	34.6%
Maximum 24-hour mean NOx concentrations							
H1	Oxford Meadows SAC	75	34.7	0.5	35.2	0.6%	46.9%
H2	Little Wittenham SAC & SSSI		23.5	0.6	24.1	0.8%	32.1%
H3	Cothill Fen SAC & SSSI		21.4	0.5	21.9	0.6%	29.2%
H4	Littlemore Railways Cutting SSSI		33.0	4.3	37.2	5.7%	49.6%
H5	Sandford Break North Extension LWS		28.1	3.6	31.7	4.8%	42.3%
H6	Sandford Brake LWS		24.9	4.3	29.2	5.8%	39.0%

Rec ref	Protected Conservation Area	EQS ($\mu g/m^3$)	Background concentration ($\mu g/m^3$)	PC ($\mu g/m^3$)	PEC ($\mu g/m^3$)	PC/EQS (%)	PEC/EQS (%)
H7	Lower Farm Bottom Hay Meadow LWS		28.5	3.4	31.9	4.5%	42.5%
H8	Radley Large Wood LWS		31.0	2.0	33.0	2.6%	44.0%
H9	Kennington Memorial Field		32.2	2.9	35.2	3.9%	46.9%
H10	Fiddlers Elbow Marsh LWS		29.6	4.2	33.7	5.6%	45.0%
H11	Heyford Hill Lane Pasture LWS		36.6	3.0	39.5	4.0%	52.7%
H12	Bypass Swamp LWS		36.6	2.5	39.1	3.3%	52.1%
H13	Wetland south of Iffley Meadows LWS		36.6	2.1	38.6	2.7%	51.5%

The results in Table 5-2 indicate that at the assessed European designated sites, the annual mean NOx and SO_2 PCs are less than 1% of the relevant critical level and the effect is considered 'insignificant' as per Environment Agency guidance (Environment Agency, 2023).

For Littlemore Railways Cutting SSSI, the annual mean SO_2 PC is just above 1% (i.e. 1.3%) of the relevant critical load value. Further analysis indicates that the Cat CHP engine contributes approximately 16% of the annual mean SO_2 PC predicted at Littlemore Railways Cutting SSSI.

As discussed previously, the Cat CHP engine only operates when there is sufficient biogas, typically operating for no more than 2,190 hours per year. Therefore, the predicted critical level values presented in Table 5-2 are likely to be higher than would reasonably be expected.

At the assessed local nature sites, the annual mean NOx and SO_2 PCs are less than 100% of the relevant critical level and the effect is considered 'insignificant' as per Environment Agency guidance (Environment Agency, 2023).

For the maximum 24-hour mean critical level for NOx, the results indicate that at the assessed European designated sites & SSSI and local nature sites, the PCs are less than 10% and 100%, respectively, of the relevant critical level and the effect is considered 'insignificant' as per Environment Agency guidance (Environment Agency, 2023).

5.2.2 Assessment against Critical Loads

The rate of deposition of acidic compounds and nitrogen containing species have been estimated at the assessed protected conservation areas. This allows the potential for adverse effects to be evaluated by comparison with critical loads for acid and nutrient nitrogen deposition. The assessment took account of emissions of NOx and SO_2 only.

Critical load functions for acid deposition are specified on the basis of both nitrogen-derived acid and sulphur-derived acid. This information, including existing deposition levels at habitat sites, is available from APIS (Centre for Ecology and Hydrology, 2023). Further information on the assessment of deposition is provided in Appendix B. The full detailed modelled results are displayed in Table 5-3 and Table 5-4.

Table 5-3: Modelled acid deposition at assessed protected conservation areas

Ref	Habitat	Vegetation type (for deposition velocity)	Critical load (CL) (kEqH+/ha/year)			Existing acid deposition (kEqH+/ha/year)				
			CLMaxS	CLMinN	CLMaxN	Existing deposition (N) (S)	PC	PEC	PC/CL (%)	PEC/CL (%)
H1	Oxford Meadows SAC	Short	1.620	0.223	2.058	1.42	0.002	1.42	0.1%	69%
H2	Little Wittenham SAC & SSSI	-	No critical load data available			-	0.004	-	-	-
H3	Cothill Fen SAC & SSSI	Short	0.220	0.223	0.443	1.40	0.001	1.40	0.3%	316%
		Tall	0.688	0.142	0.830	2.50	0.003	2.50	0.3%	302%
H4	Littlemore Railways Cutting SSSI	-	The selected site has no features in the APIS database			-	0.035	0.04	-	-
H5	Sandford Break North Extension LWS	Tall	0.630	0.142	0.772	2.48	0.050	2.53	6.5%	328%
H6	Sandford Brake LWS	Tall	2.241	0.357	2.598	2.48	0.062	2.54	2.4%	98%
H7	Lower Farm Bottom Hay Meadow LWS	Short	1.600	0.438	2.038	1.42	0.027	1.45	1.3%	71%
H8	Radley Large Wood LWS	Tall	7.025	0.142	7.167	2.48	0.014	2.49	0.2%	35%
H9	Kennington Memorial Field	Short	4.100	0.223	4.323	1.42	0.006	1.43	0.1%	33%
H10	Fiddlers Elbow Marsh LWS	Tall	0.658	0.142	0.800	2.48	0.028	2.51	3.5%	313%
H11	Heyford Hill Lane Pasture LWS	Short	4.100	0.438	4.538	1.42	0.012	1.43	0.3%	32%
H12	Bypass Swamp LWS	Tall	10.698	0.357	11.055	2.48	0.020	2.50	0.2%	23%
H13	Wetland south of Iffley Meadows LWS	Tall	10.698	0.357	11.055	2.48	0.018	2.50	0.2%	23%

Table 5-4: Modelled nitrogen deposition at assessed protected conservation area

Ref	Habitat	Vegetation type (for deposition velocity)	Minimal Critical Load (CL)	Existing nutrient deposition (kgN/ha-year)				
				Existing deposition	PC	PEC	PC/CL (%)	PEC/CL(%)
H1	Oxford Meadows SAC	Short	20	18.90	0.003	18.90	0.01%	95%
H2	Little Wittenham SAC & SSSI	No comparable habitat with established critical load estimate available		18.80	0.006	18.81	-	-
H3	Cothill Fen SAC & SSSI	Short	15	18.80	0.002	18.80	0.01%	125%
		Tall	10	33.50	0.004	33.50	0.04%	335%
H4	Littlemore Railways Cutting SSSI	The selected site has no features in the APIS database			0.046	-	-	-
H5	Sandford Break North Extension LWS	Tall	5	32.59	0.066	32.66	1.32%	653%
H6	Sandford Brake LWS	Tall	5	32.59	0.082	32.67	1.63%	653%
H7	Lower Farm Bottom Hay Meadow LWS	Short	5	18.14	0.036	18.18	0.72%	364%
H8	Radley Large Wood LWS	Tall	5	32.52	0.019	32.54	0.37%	651%
H9	Kennington Memorial Field	Short	5	18.14	0.008	18.15	0.17%	363%
H10	Fiddlers Elbow Marsh LWS	Tall	5	32.52	0.037	32.56	0.74%	651%
H11	Heyford Hill Lane Pasture LWS	Short	5	18.14	0.016	18.16	0.31%	363%
H12	Bypass Swamp LWS	Tall	5	32.52	0.027	32.55	0.54%	651%
H13	Wetland south of Iffley Meadows LWS	Tall	5	32.52	0.023	32.54	0.46%	651%

The results in Table 5-3 and Table 5-4 indicate that at the assessed European designated sites, the PCs are less than 1% of the relevant critical load value for acid and nutrient nitrogen deposition and the impact can be described as ‘insignificant’ as per Environment Agency guidance (Environment Agency, 2023). As discussed previously, no critical load data was available on the APIS website (Centre for Ecology and Hydrology, 2023) for Little Wittenham SAC & SSSI and Littlemore Railways Cutting SSSI.

At the assessed local nature sites, the PCs are less than 100% of the relevant critical load value for acid and nutrient nitrogen deposition and the impact can also be described as ‘insignificant’ as per Environment Agency guidance (Environment Agency, 2023).

It should be noted acid and nitrogen deposition rates currently exceed their relevant critical loads at the majority of assessed protected conservation areas. However, this is a relatively common situation at protected conservation areas across the UK due to the high baseline deposition rates.

5.3 Sensitivity Analysis

A sensitivity study was undertaken to see how changes to the surface roughness and omission of the buildings in the 2018 model (which predicted the highest annual mean concentrations at sensitive human receptor locations), 2016 model (which predicted the highest 1-hour mean NO_2 concentrations at sensitive human receptor locations) and 2019 model (which predicted the highest 1-hour mean NO_2 concentrations at modelled off-site locations) may impact on predicted concentrations at sensitive human receptors and off-site locations. The results of the sensitivity analysis are presented in Table 5-5 to Table 5-7.

Table 5-5: Sensitivity analysis - fixed surface roughness of 0.1 m

Pollutant	Averaging period	Assessment location	Original PC (surface roughness 0.5 m) ($\mu g/m^3$)	Surface roughness length 0.1 m				
				PC ($\mu g/m^3$)	PEC ($\mu g/m^3$)	PC/EQS	PEC/EQS	% difference in PC/EQS compared to original
NO_2	Annual mean	Sensitive locations	4.1	4.0	20.0	10.0%	50.0%	-0.3%
	1 hour mean (99.79th percentile)	Maximum off-site	34.7	37.4	69.4	18.7%	34.7%	1.3%
		Sensitive locations	23.0	23.2	55.2	11.6%	27.6%	0.1%

The results in Table 5-5 indicate that the change to maximum predicted annual mean concentrations for NO_2 is negligible when using a surface roughness value of 0.1 m compared to the original value of 0.5 m. For 1-hour mean (99.79th percentile) NO_2 concentrations at an off-site location and sensitive human receptor location, the PCs are marginally higher. However, a surface roughness of 0.1 m (representing root crops) is not considered representative of the site and surrounding area.

Table 5-6: Sensitivity analysis - fixed surface roughness of 1 m

Pollutant	Averaging period	Assessment location	Original PC (surface roughness 0.5 m) ($\mu g/m^3$)	Surface roughness length 1 m				
				PC ($\mu g/m^3$)	PEC ($\mu g/m^3$)	PC/EQS	PEC/EQS	% difference in PC/EQS compared to original
NO_2	Annual mean	Sensitive locations	4.1	4.3	20.3	10.8%	50.8%	0.5%
	1 hour mean (99.79th percentile)	Maximum off-site	34.7	32.9	64.9	16.5%	32.5%	-0.9%
		Sensitive locations	23.0	22.5	54.5	11.3%	27.3%	-0.3%

The results in Table 5-6 indicate that the change to maximum predicted annual mean concentrations for NO_2 is negligible when using a surface roughness value of 1 m compared to the original value of 0.5 m. For 1-hour mean (99.79th percentile) NO_2 concentrations at an off-site location and sensitive human receptor location, the PCs were slightly lower when modelling with an increased surface roughness value of 1 m. However, a surface roughness of 1 m (representing a large city centre location with built-up areas and tall buildings) is not considered representative of the site and surrounding area.

Table 5-7: Sensitivity analysis - no buildings

Pollutant	Averaging period	Assessment location	Original PC (with buildings) (µg/m³)	No buildings				
				PC (µg/m³)	PEC (µg/m³)	PC/EQS	PEC/EQS	% difference in PC/EQS compared to original
NO_2	Annual mean	Sensitive locations	4.1	3.8	19.8	9.4%	49.4%	-0.9%
	1 hour mean (99.79th percentile)	Maximum off-site	34.7	23.9	55.9	12.0%	28.0%	-5.4%
		Sensitive locations	23.0	21.4	53.4	10.7%	26.7%	-0.8%

The results in Table 5-7 indicate that the differences between the maximum predicted concentrations with and without the buildings is such that including buildings within the model is the preferred option for this study, to maintain a more realistic, and conservative, approach.

6. Conclusions

This report has assessed the potential air quality impacts associated with the operation of the biogas fuelled CHP engines and replacement boilers at the Oxford STW. The predicted impacts were assessed against the relevant air quality standards and guidelines for the protection of human health and protected conservation areas.

6.1 Human receptors

The assessment indicates that the predicted off-site concentrations and predicted concentrations at sensitive human receptors do not exceed any relevant long-term or short-term EQSs.

The results indicate that for annual mean NO_2, PM_{10} and $PM_{2.5}$ concentrations, the respective PCs are either less than 1% of the relevant long-term EQS, or where the PC is greater than 1%, the PEC is below 70% of the long-term EQS and the impact is considered 'not significant'.

It is noted the maximum annual mean NO_2 PC, predicted at R12 is elevated. Further analysis indicates that the Cat CHP engine (emission reference point A1) contributes approximately 34% of the annual mean NO_2 PC predicted at R11.

This assessment has been carried out on the assumption that the CHP engines and boilers operate continuously at maximum load throughout the year (i.e. 8,760 hours). This is a conservative assumption as, in practice, the CHP engines and boilers will have periods of shut-down and maintenance and may not always operate at maximum load. Furthermore, the Cat CHP engine only operates when there is sufficient biogas, typically operating for no more than 2,190 hours per year. When factoring the annual mean NO_2 PC to include typical operation of the Cat CHP engine, the PC as a percentage of the relevant EQS at R12 reduces from 10.3% to 7.7%.

At the nearby City of Oxford AQMA, the maximum annual mean NO_2 PC is 8.8 $\mu g/m^3$, which equates to 21.9% of the relevant EQS and is predicted north of the site in hedgerow between Grenoble Road and a carpark. The maximum PC at the assessed sensitive receptors within the AQMA is 2.6 $\mu g/m^3$, which equates to 6.6% of the relevant EQS.

For short-term NO_2, CO, SO_2 and particulate concentrations, the PCs are either less than 10% of the relevant EQS, or where the PC is greater than 10%, the PEC is below 70% of the short-term EQS and the impact is considered 'not significant'.

The annual mean and maximum 24-hour mean TVOC PCs exceed the relevant EQS for C_6H_6. However, this assessment assumes all TVOCs emitted by the assessed combustion plant are C_6H_6. This is an overly conservative assumption, and C_6H_6, if present in the exhaust gases, would constitute only a very small proportion of total TVOC emissions (e.g. less than 1%). Therefore, informed by a wider understanding of the properties of biogas, the emissions of TVOCs is considered 'not significant'.

Therefore, when considering the conservative approach to the assessment and based on professional judgement, the emissions of assessed pollutants at sensitive human receptor locations and modelled off-site locations is considered 'not significant'.

6.2 Protected conservation areas

For critical levels, at the assessed European designated sites, the annual mean NOx and SO_2 PCs are less than 1% of the relevant critical level and the effect is considered 'insignificant'. At Littlemore Railways Cutting SSSI, the annual mean SO_2 PC is just above 1% (i.e. 1.3%) of the relevant critical load value. However, as discussed previously, the Cat CHP engine only operates when there is sufficient biogas. Therefore, the predicted critical level values presented are likely to be higher than would reasonably be expected.

At the assessed local nature sites, the annual mean NOx and SO_2 PCs are less than 100% of the relevant critical level and the effect is considered 'insignificant'.

For the maximum 24-hour mean critical level for NOx, the results indicate that at the assessed European designated sites & SSSI and the local nature sites, the PCs are less than 10% and 100%, respectively, of the relevant critical level, and the effect is also considered 'insignificant'.

For critical loads, the results indicate that at the assessed European designated sites and the local nature sites, the PCs are less than 1% and 100%, respectively, of the relevant critical load value for acid and nutrient nitrogen deposition and the impact can be described as ‘insignificant’ as per Environment Agency guidance.

6.3 Summary

Based on the above assessment, it is concluded that the operation of the assessed combustion plant are acceptable from an air quality perspective.

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8. Figures

Figure 1: Approximate site fenceline, modelled stack locations and modelled buildings

Figure 2: Extent of modelled grid, AQMA, sensitive human receptor locations and automatic monitoring location

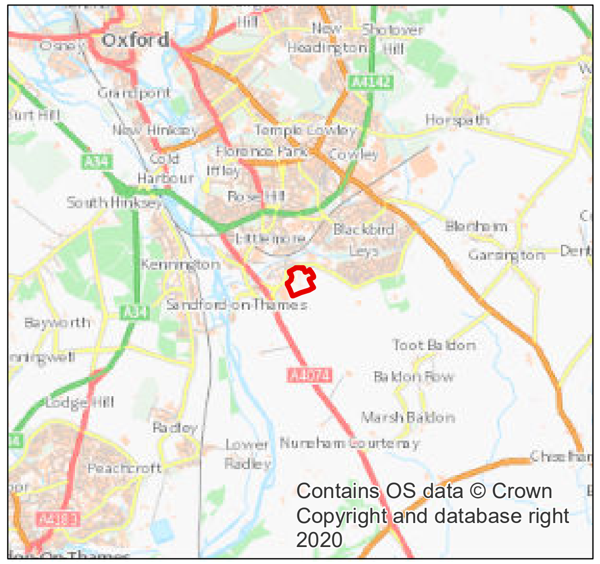
Figure 3: Protected conservation areas

Figure 4: Annual mean nitrogen dioxide process contributions, 2018 meteorological data

Figure 5: 1-hour mean (99.79^{th} percentile) nitrogen dioxide process contributions, 2016 meteorological data

Legend

- Approximate site fenceline
- Modelled stack locations
- Modelled buildings



Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	22/03/2023	Initial Issue	DH	GW	GW	HG

Jacobs

Client

Thames Water

Project

ENVIRONMENTAL PERMIT APPLICATION -
OXFORD SEWAGE TREATMENT WORKS
AIR QUALITY IMPACT ASSESSMENT

Drawing Title

APPROXIMATE SITE FENCELINE, MODELLED
STACK LOCATIONS AND MODELLED BUILDINGS

Drawing Status

FINAL

Scale @ A3	1:2,000	DO NOT SCALE	
Jacobs No.	B22849AZ	Rev	0
Client No.			

Drawing Number

FIGURE 1

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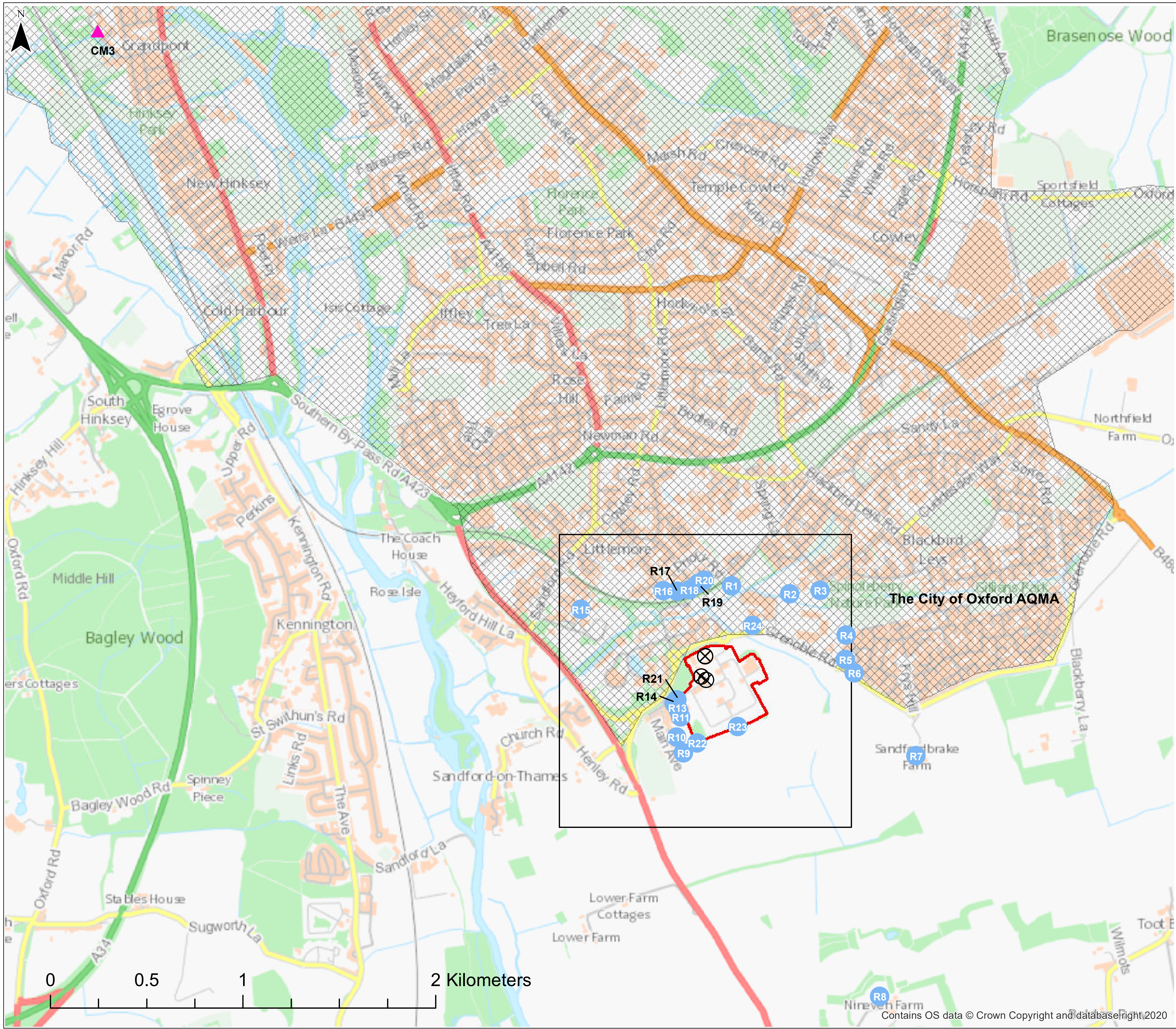
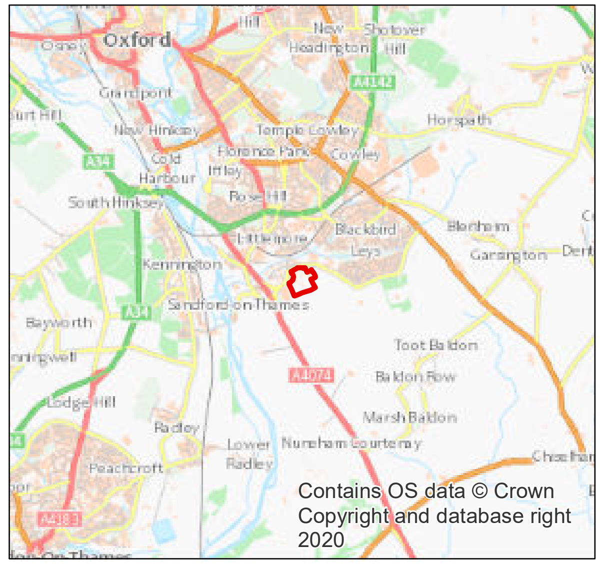


Legend

- Approximate site fenceline
- Modelled stack locations
- Extent of modelled grid
- Air Quality Management Area (AQMA)
- Sensitive human receptor locations
- Automatic monitoring location



Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	11/04/2023	Initial Issue	DH	GW	GW	MM

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Client: Thames Water

Project: ENVIRONMENTAL PERMIT APPLICATION - OXFORD SEWAGE TREATMENT WORKS AIR QUALITY IMPACT ASSESSMENT

Drawing Title: EXTENT OF MODELLED GRID, AQMA, SENSITIVE HUMAN RECEPTOR LOCATIONS AND AUTOMATIC MONITORING LOCATION

Drawing Status: FINAL

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Drawing Number: FIGURE 2

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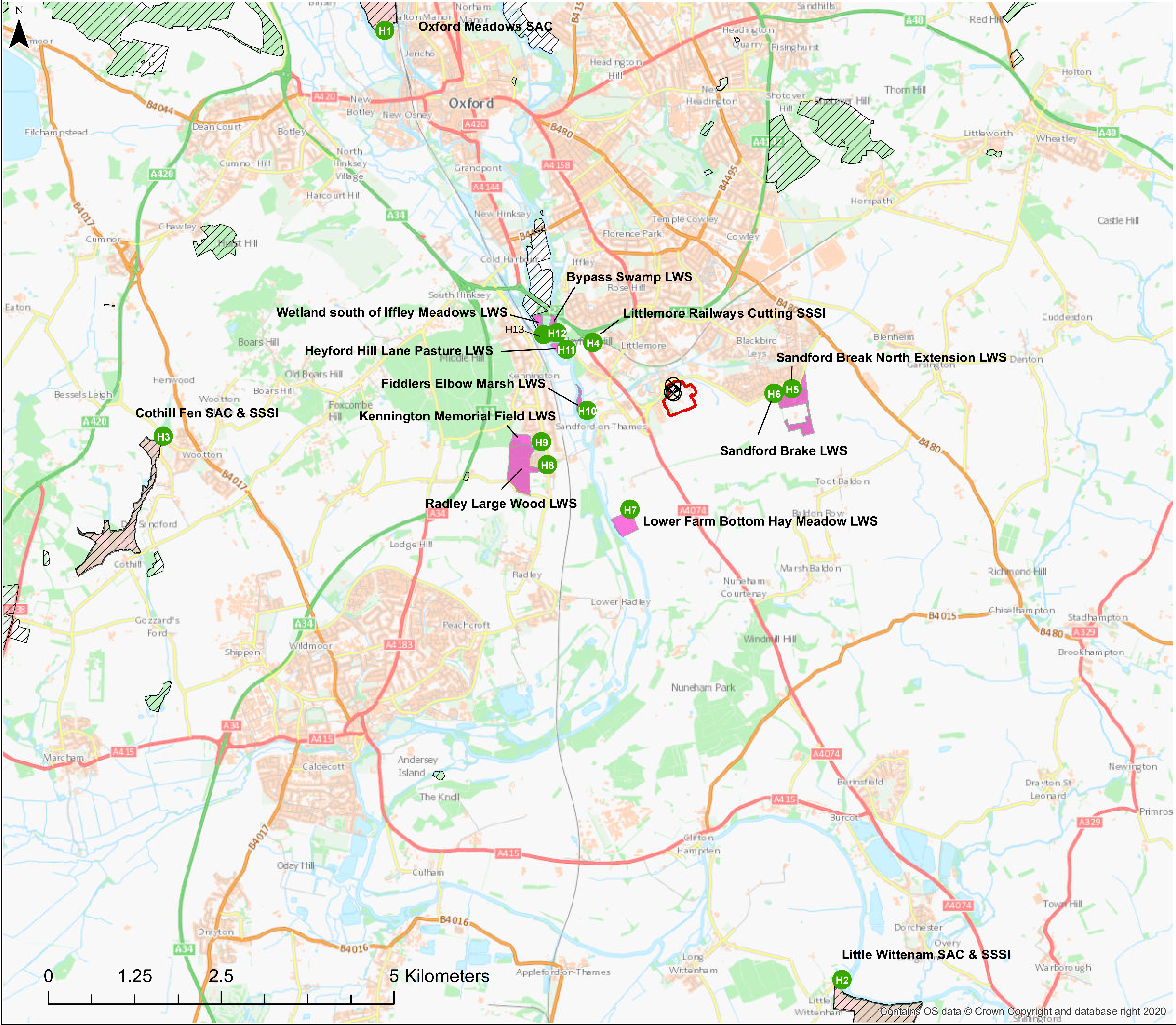
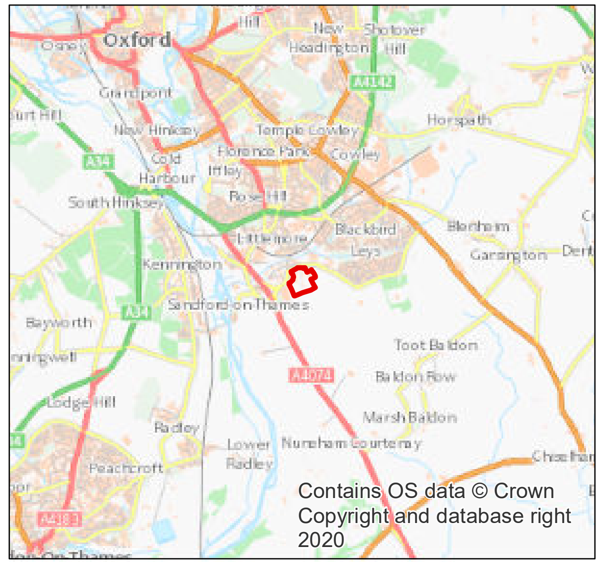


Legend

- Approximate site fenceline
- Modelled stack locations
- Special Area of Conservation
- Sites of Special Scientific Interest (SSSI)
- Local wildlife sites (LWS)
- Protected conservation area



Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
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Jacobs

Client: Thames Water

Project: ENVIRONMENTAL PERMIT APPLICATION - OXFORD SEWAGE TREATMENT WORKS AIR QUALITY IMPACT ASSESSMENT

Drawing Title: PROTECTED CONSERVATION AREAS

Drawing Status: FINAL

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Client No.		

Drawing Number: FIGURE 3

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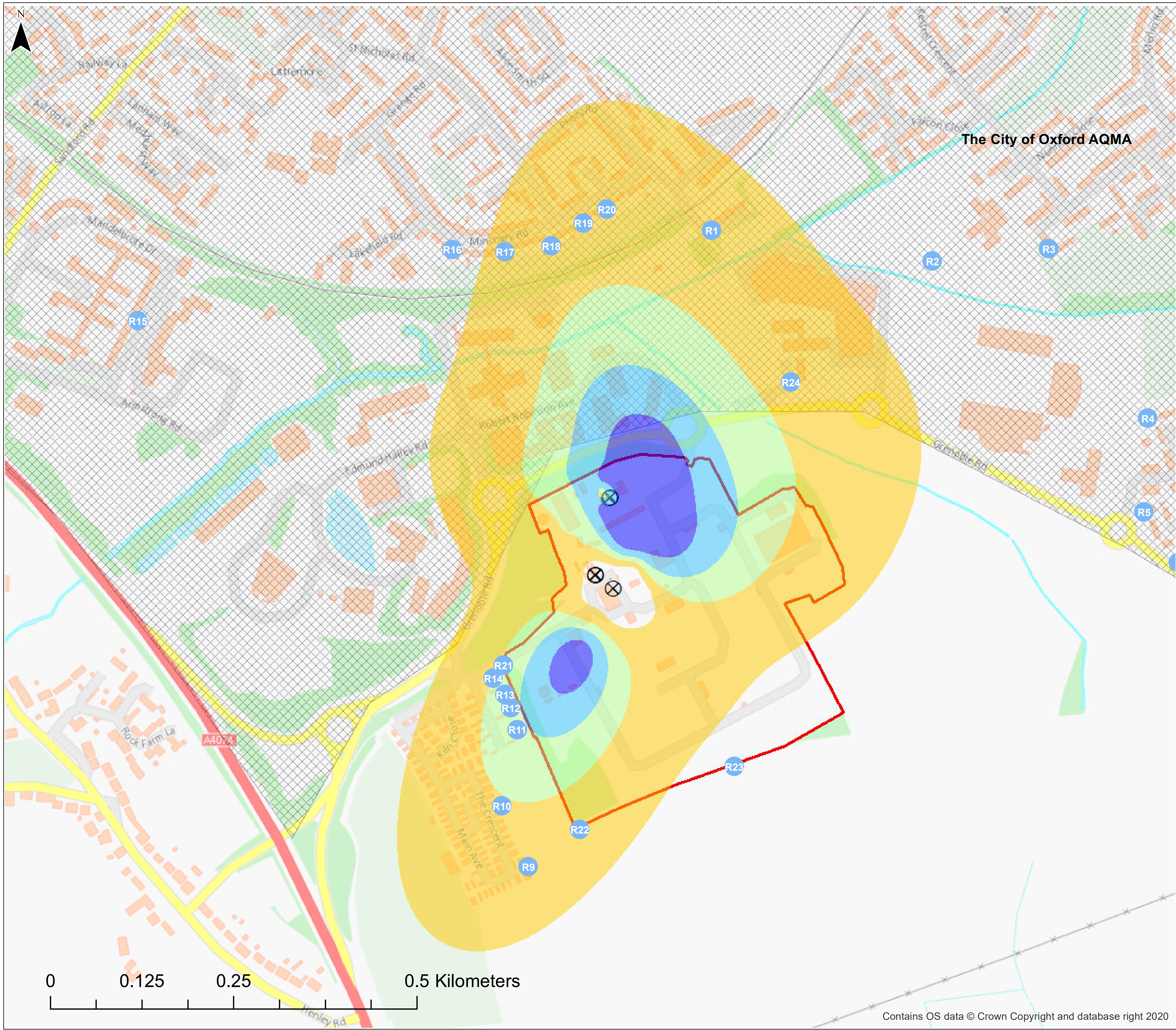
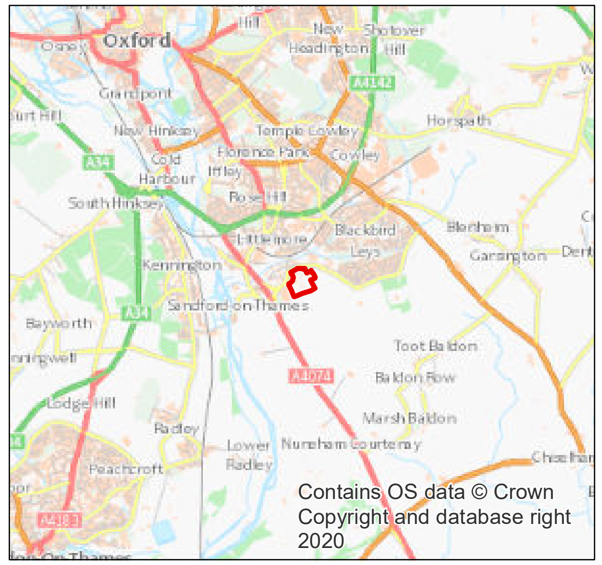


Legend

- Approximate site fenceline
- Modelled stack locations
- Air Quality Management Area (AQMA)
- Sensitive human receptor locations

Annual mean nitrogen dioxide process contributions (µg/m³)

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10.5



Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	03/04/2023	Initial Issue	DH	GW	GW	HG

Jacobs

Client: Thames Water

Project: ENVIRONMENTAL PERMIT APPLICATION - OXFORD SEWAGE TREATMENT WORKS AIR QUALITY IMPACT ASSESSMENT

Drawing Title: ANNUAL MEAN NITROGEN DIOXIDE PROCESS CONTRIBUTIONS, 2018 METEOROLOGICAL DATA

Drawing Status: FINAL

Scale @ A3	1:5,000	DO NOT SCALE
Jacobs No.	B22849AZ	Rev 0
Client No.		

Drawing Number: FIGURE 4

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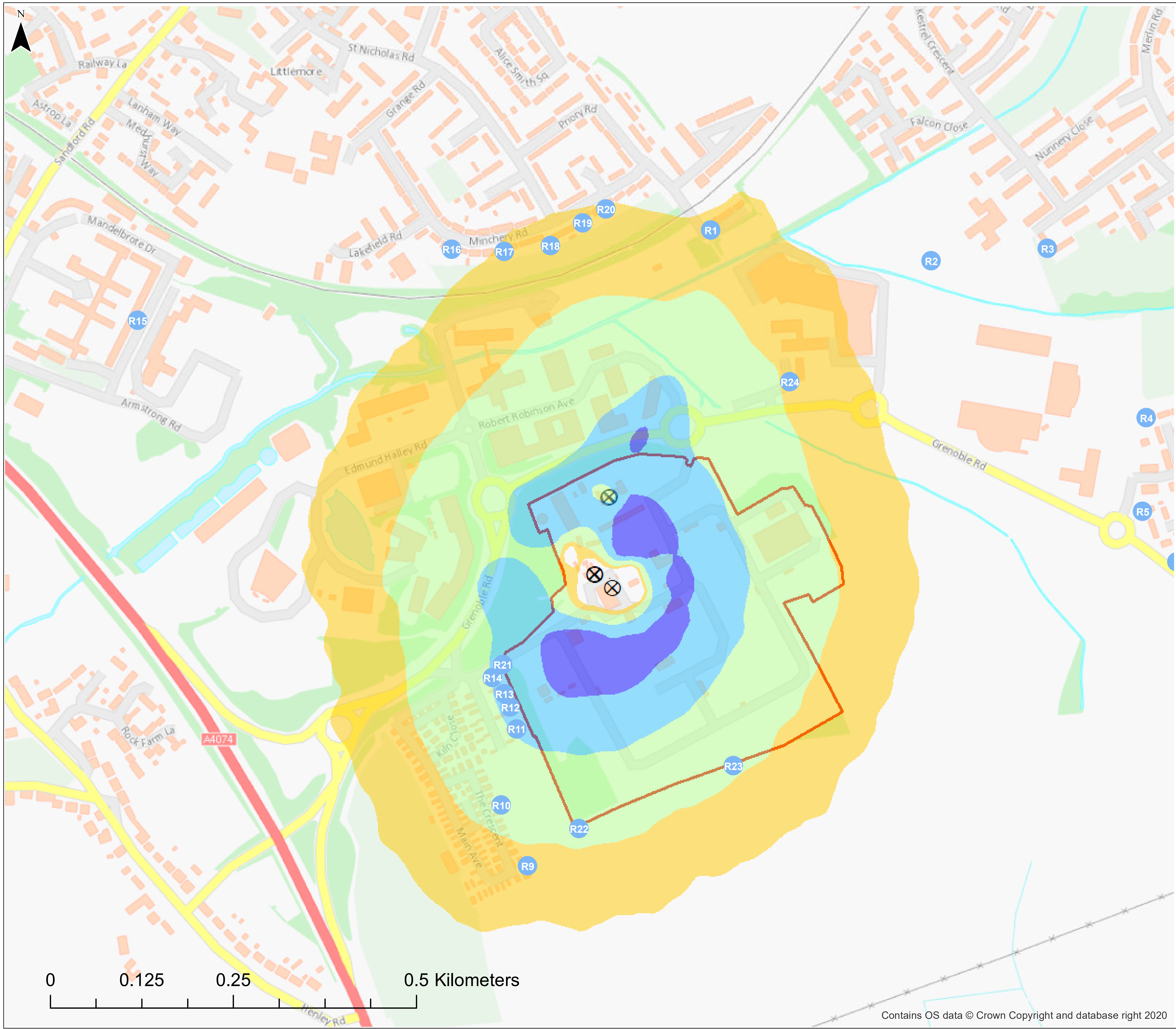
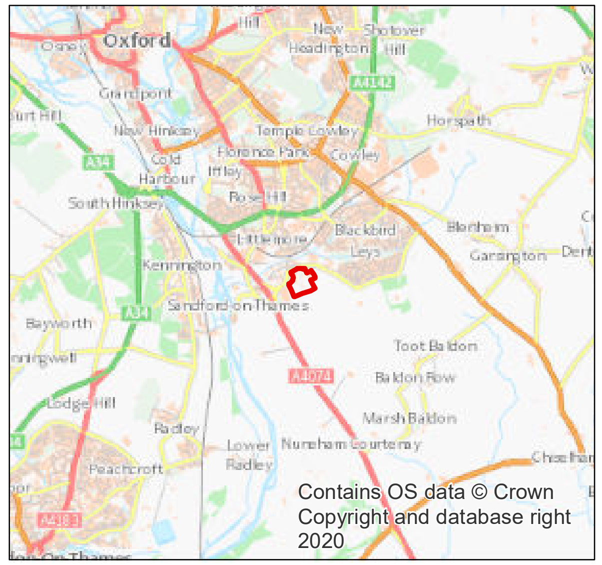


Legend

- Approximate site fenceline
- Modelled stack locations
- Sensitive human receptor locations

1-hour mean (99.79th percentile) nitrogen dioxide process contributions (µg/m^3)

- 0 - 15
- 15 - 20
- 20 - 30
- 30 - 40
- 40 - 50.7



Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	03/04/2023	Initial Issue	DH	GW	GW	HG

Jacobs

Client: Thames Water

Project: ENVIRONMENTAL PERMIT APPLICATION - OXFORD SEWAGE TREATMENT WORKS AIR QUALITY IMPACT ASSESSMENT

Drawing Title: 1-HOUR MEAN (99.79th PERCENTILE) NITROGEN DIOXIDE PROCESS CONTRIBUTIONS, 2018 METEOROLOGICAL DATA

Drawing Status: FINAL

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Drawing Number: FIGURE 5

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Appendix A. Dispersion Model Input Parameters

A.1 Emission Parameters

The emissions data used to represent the site for the scenario described in Section 2 are set out in Table A-1.

Table A-1. Dispersion modelling parameters

Parameters	Unit	Cat CHP engine (2.466 MWth)	Jenbacher CHP 1 (2.016 MWth)	Jenbacher CHP 2 (2.016 MWth)	Yorkshireman boiler 1 (4.71 MWth)	Yorkshireman boiler 2 (4.71 MWth)
Modelled fuel	-	Biogas	Biogas	Biogas	Biogas	Biogas
Emission point	-	A1	A10	A11	A31	A32
Assessed annual operation hours	Hours	8,760	8,760	8,760	8,760	8,760
Stack location	m	E 454277, N 201984	E 454252, N 202004[2]	E 454252, N 202004[2]	E 454271 N 202110[3]	E 454272 N 202110[3]
Stack height	m	14.00	15.00	15.00	18.00	18.00
Stack diameter	m	0.30	0.30	0.30	0.60	0.60
Flue gas temperature	°C	400	164	164	133	133
Efflux velocity	m/s	22.3	35.9	35.9	15.5	15.5
Moisture content of exhaust gas	%	7.0	7.7	7.7	6.2	6.2
Oxygen content of exhaust gas (dry)	%	8.3	8.3	8.3	5	5
Volumetric flow rate (actual)	m^3/s	1.575	2.539	2.539	4.388	4.388
Volumetric flow rate (normal)[1]	Nm^3/s	1.680	3.115	3.115	2.459	2.459
NOx emission concentration[1]	mg/Nm^3	383	186	186	150	150
NOx emission rate	g/s	0.644	0.578	0.578	0.369	0.369
CO emission concentration[1]	mg/Nm^3	519	519	519	100	100
CO emission rate	g/s	0.873	1.618	1.618	0.246	0.246
PM_{10} / $PM_{2.5}$ emission concentration[1]	mg/Nm^3	2.7	2.7	2.7	5.0	5.0
PM_{10} / $PM_{2.5}$ emission rate	g/s	0.004	0.008	0.008	0.012	0.012
SO_2 emission concentration[1]	mg/Nm^3	130	130	130	100	100
SO_2 emission rate	g/s	0.218	0.405	0.405	0.246	0.246
TVOC emission concentration[1]	mg/Nm^3	439	687	774	1,126	1,126
TVOC emission rate	g/s	0.737	2.139	2.412	2.769	2.769

Note 1: Normalised flows and concentrations presented at 273 K, 101.3 kPa, dry gas and oxygen content of 15% (CHP engines) or 3% (boilers).

Note 2: As the Jenbacher CHP engines waste gas exits via a shared stack, an aai file was used in the model to represent a single plume.

Note 3: As the new replacement boilers waste gas exits via a shared stack, an aai file was used in the model to represent a single plume.

A.2 Dispersion Model Inputs

A.2.1 Structural influences on dispersion

The main structures within the site which have been included in the model to reflect the existing site layout are identified within Table A-2. A sensitivity study has been carried out to assess the sensitivity of the model to using the buildings module.

Table A-2. Building parameters

Building	Modelled building shapes	Length (m)	Width / diameter (m)	Height (m)	Angle of length to north	Centre point co-ordinates	
						Easting	Northing
Engine House 1	Rectangular	37.50	20.50	4.53	153	454272	201977
Engine House 2	Rectangular	21.30	14.00	8.23	153	454270	201974
Engine 2 & 3 housing	Rectangular	13.79	9.13	5.61	152	454248	202012
Primary Digester 1	Circular	-	13.48	15.59	-	454220	202031
Pre THP Dewatering Feed Buffer Tank	Rectangular	19.82	4.67	13.44	152	454261	202108
Boiler House	Rectangular	16.95	7.20	6.93	152	454272	202110
Cake Import facility	Rectangular	11.50	9.50	9.02	151	454291	202120
Primary Digester 2	Circular	-	13.26	16.16		454214	202047
Temp Trailer boiler	Rectangular	13.25	2.57	5.53	62	454278	202098
Digester PRV 1	Circular	-	23.78	10.11	-	454315	201982
Digester PRV 2	Circular	-	23.78	9.92	-	454303	202007

A.3 Other model inputs

Other model input parameters are presented in Table A-3.

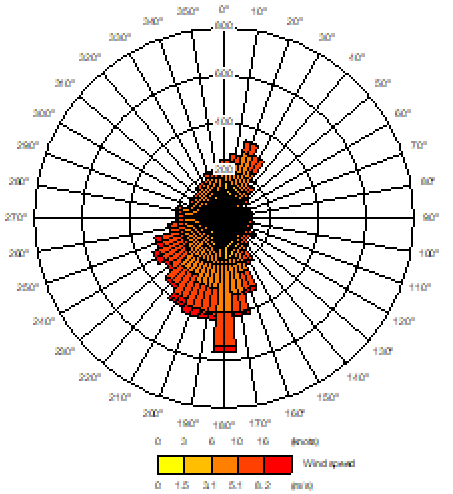
Table A-3. Other model inputs

Parameter	Value used	Comments
Surface roughness length for dispersion site	0.5 m	This is appropriate for the dispersion site where the surrounding local land-use is a mixture of open grassland and residential and commercial premises. A sensitivity study has been carried out with fixed surface roughness values of 0.1 m and 1.0 m.
Surface roughness length at meteorological station site	0.4 m	This is appropriate for an area where the local land-is relatively flat such as RAF Benson meteorological station.
Minimum Monin-Obukhov Length	1 m	Typical values for the dispersion site
Surface Albedo	0.23 m	Typical values for the dispersion site
Priestley-Taylor Parameter	1 m	Typical values for the dispersion site
Terrain	Not included	Guidance for the use of the ADMS model suggests that terrain is normally incorporated within a modelling study when the gradient exceeds 1:10. As the gradient in the vicinity of the site does not exceed 1:10, a terrain file was not included in the modelling.
Meteorological data	RAF Benson meteorological station, 2016 - 2020	RAF Benson meteorological station is located approximately 20.7 km northwest of the site and is considered the closest most representative meteorological monitoring station to the site.
Combined flue option	Yes	As the Jenbacher CHP engines waste gas exits via a shared stack and the new replacement boilers waste gas exits via a shared stack, an aai file was used in the model to represent a single plume.

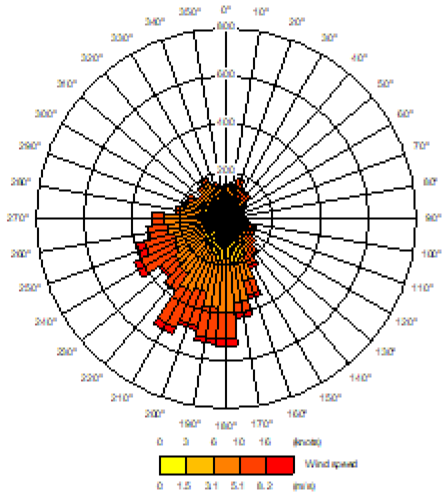
A.3.1 Meteorological Data

The wind roses for each year of meteorological data utilised in the assessment are shown below.

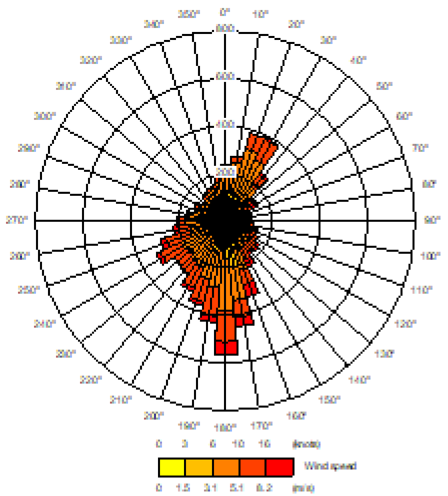
RAF Benson meteorological station, 2016



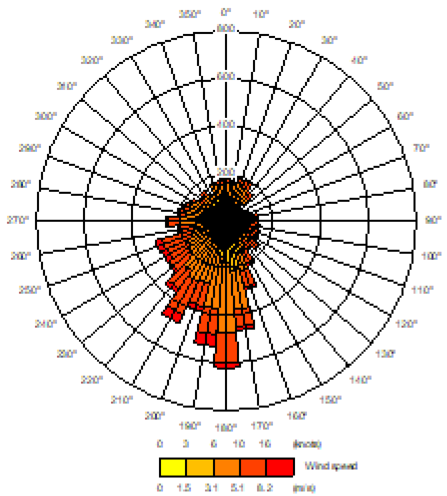
RAF Benson meteorological station, 2017



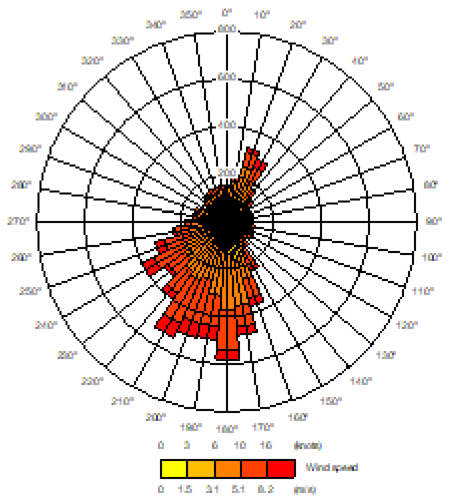
RAF Benson meteorological station, 2018



RAF Benson meteorological station, 2019



RAF Benson meteorological station, 2020



A.3.2 Model Domain/Study Area

The ADMS model calculates the predicted concentrations based on a user defined grid system. Generally, the larger the study area, the greater the distance between the grid calculation points and the lower the resolution of the dispersion model predictions. This is to be offset against the need to encompass an appropriately wide area within the dispersion modelling study to capture the dispersion of the stack emissions.

The modelled grid was specified as a 1.5 km x 1.5 km grid with calculation points every 10 m (i.e. 151 points along each grid axis) with a grid height of 1.5 m. This size of grid was selected to provide a good grid resolution and also encompass a sufficient area so that the maximum predicted concentrations would be determined. The area within the site boundary was excluded from the modelled grid as it is not accessible to the general public. The modelled grid parameters are presented in Table A-4.

Table A-4. Modelled grid parameters

	Start	Finish	Number of grid points	Grid spacing (m)
Easting	453527	455027	151	10
Northing	201236	202736	151	10
Grid height	1.5	1.5	1	-

As well as the modelled grid, the potential impact at 24 sensitive human receptors (e.g. exposure locations such as residential properties, a school, bridleway AND PRoW), and 13 protected conservation areas within the required study area were assessed. The receptor locations are shown in Figure 2 and Figure 3 and further details of the human receptor locations and protected conservation areas are provided in Table A-5 and Table A-6 respectively. For the City of Oxford AQMA, those grid points presented in Table A-4, which encompass the AQMA, were used to determine the maximum annual mean NO_2 concentration.

Table A-5. Assessed sensitive human receptor

Receptor	Description	Grid reference		Distance from the Cat CHP engine stack (km)	Direction from the Cat CHP engine stack
		Easting	Northing		
R1	Residential property on Priory Road	454411	202473	0.50	NNE
R2	Special educational needs and disabilities (SEND) School	454712	202431	0.62	NE
R3	Residential property on Knights Road	454871	202448	0.75	NE
R4	Residential property on Emperor Gardens	455006	202217	0.76	ENE
R5	Residential property on Nettlebed Mead	455001	202089	0.73	E
R6	Residential property on Verbena Way	455048	202020	0.77	E
R7	Residential property off Grenoble Road	455368	201590	1.16	ESE
R8	Residential property off A4074	455180	200343	1.88	SSE
R9	Residential property on The Crescent	454161	201605	0.40	SSW
R10	Residential property on The Crescent	454125	201688	0.33	SSW
R11	Residential property on The Crescent	454146	201792	0.23	SW
R12	Residential property on The Crescent	454137	201822	0.22	SW
R13	Residential property on The Crescent	454129	201840	0.21	SW
R14	Residential property on The Crescent	454113	201862	0.21	SW
R15	Residential property on Mandelbrote Drive	453628	202350	0.74	WNW
R16	Residential property on Minchery Road	454057	202447	0.51	NNW
R17	Residential property on Minchery Road	454129	202444	0.48	NNW
R18	Residential property on Minchery Road	454192	202452	0.47	N
R19	Residential property on Minchery Road	454236	202483	0.50	N
R20	Residential property on Minchery Road	454268	202502	0.52	N
R21	Bridleway	454127	201880	0.18	SW
R22	Bridleway	454231	201656	0.33	S
R23	Bridleway	454442	201742	0.29	SE
R24	PRoW	454519	202266	0.37	NE

Table A-6. Assessed protected conservation area locations

Receptor	Description	Grid reference		Distance from the Cat CHP engine stack (km)	Direction from the Cat CHP engine stack
		Easting	Northing		
H1	Oxford Meadows SAC	450101	207232	6.70	NW
H2	Little Wittenham SAC & SSSI	456716	193492	8.84	SSE
H3	Cothill Fen SAC & SSSI	446895	201359	7.41	W
H4	Littlemore Railways Cutting SSSI	453115	202712	1.37	WNW
H5	Sandford Break North Extension LWS	455996	202044	1.72	E
H6	Sandford Brake LWS	455732	201978	1.45	E
H7	Lower Farm Bottom Hay Meadow LWS	453650	200301	1.80	SSW
H8	Radley Large Wood LWS	452452	200945	2.10	WSW
H9	Kennington Memorial Field	452369	201276	2.04	WSW

Receptor	Description	Grid reference		Distance from the Cat CHP engine stack (km)	Direction from the Cat CHP engine stack
		Easting	Northing		
H10	Fiddlers Elbow Marsh LWS	453029	201731	1.27	WSW
H11	Heyford Hill Lane Pasture LWS	452730	202617	1.67	WNW
H12	Bypass Swamp LWS	452592	202858	1.90	WNW
H13	Wetland south of Iffley Meadows LWS	452397	202831	2.06	WNW

A.3.3 Treatment of oxides of nitrogen

It was assumed that 70% of NOx emitted from the assessed combustion plant will be converted to NO_2 at ground level in the vicinity of the site, for determination of the annual mean NO_2 concentrations, and 35% of emitted NOx will be converted to NO_2 for determination of the hourly mean NO_2 concentrations, in line with guidance provided by the Environment Agency (Environment Agency, 2021). This approach is likely to overestimate the annual mean NO_2 concentrations considerably at the most relevant assessment locations close to the site.

A.3.4 Calculation of PECs

In the case of long-term mean concentrations, it is relatively straightforward to combine modelled process contributions with baseline air quality levels, as long-term mean concentrations due to plant emissions could be added directly to long-term mean baseline concentrations.

It is not possible to add short-period peak baseline and process concentrations directly. This is because the conditions which give rise to peak ground-level concentrations of substances emitted from an elevated source at a particular location and time are likely to be different to the conditions which give rise to peak concentrations due to emissions from other sources.

As described in the Environment Agency guidance (Environment Agency, 2021), for most substances the short-term peak PC values are added to twice the long-term mean baseline concentration to provide a reasonable estimate of peak concentrations due to emissions from all assessed sources.

A.3.5 Modelling Uncertainty

There are always uncertainties in dispersion models, in common with any environmental modelling study, because a dispersion model is an approximation of the complex processes which take place in the atmosphere. Some of the key factors which lead to uncertainty in atmospheric dispersion modelling are as follows.

- The quality of the model output depends on the accuracy of the input data enter the model. Where model input data are a less reliable representation of the true situation, the results are likely to be less accurate.
- The meteorological data sets used in the model are not likely to be completely representative of the meteorological conditions at the site. However, the most suitable available meteorological data was chosen for the assessment.
- Models are generally designed on the basis of data obtained for large scale point sources and may be less well validated for modelling emissions from smaller scale sources.
- The dispersion of pollutants around buildings is a complex scenario to replicate. Dispersion models can take account of the effects of buildings on dispersion; however, there will be greater uncertainty in the model results when buildings are included in the model.
- Modelling does not specifically take into account individual small-scale features such as vegetation, local terrain variations and off-site buildings. The roughness length (zo) selected is suitable to take general account of the typical size of these local features within the model domain.
- To take account of these uncertainties and to ensure the predictions are more likely to be over-estimates than under-estimates, the conservative assumptions described below have been used for this assessment.

A.3.6 Conservative Assumptions

The conservative assumptions adopted in this study are summarised below.

- The CHP engines and boilers were assumed to operate for 8,760 hours each calendar year but in practice, the combustion plant will have periods of shut-down and maintenance and may not always operate at maximum load. Furthermore, the Cat CHP engine (emission point reference A1) only operates when there is sufficient biogas available, typically operating for no more than 2,190 hours per year.
- The study is based on emissions being continuously at the emission limits and calculated emissions specified.
- The maximum predicted concentrations at any residential areas as well as off-site locations were considered for the assessment of short-term concentrations and the maximum predicted concentrations at any residential areas were considered for assessment of annual mean concentrations within the air quality study area. Concentrations at other locations will be less than the maximum values presented.
- The highest predicted concentrations obtained using any of the five different years of meteorological data have been used in this assessment. During a typical year the ground level concentrations are likely to be lower.
- It was assumed that 100% of the particulate matter emitted from the plant is in the PM_{10} size fraction. The actual proportion will be less than 100%.
- It was assumed that 100% of the particulate matter emitted from the plant is in the $PM_{2.5}$ size fraction. The actual proportion will be less than 100%.
- It was assumed the vegetation type selected for the respective protected conservation areas is present at the specific modelled location where the highest PC was predicted.
- This assessment assumes all TVOCs emitted by the combustion plant are C_6H_6 in the absence of EQSs for TVOC.

Appendix B. Calculating Acid and Nitrogen Deposition

B.1 Methodology

Nitrogen and acid deposition have been predicted using the methodologies presented in the Air Quality Technical Advisory Group (AQTAG) guidance note: AQTAG 06 '*Technical Guidance on Detailed Modelling Approach for an Appropriate Assessment for Emissions to Air*' (AQTAG, 2014).

When assessing the deposition of nitrogen, it is important to consider the different deposition properties of nitric oxide and nitrogen dioxide. It is generally accepted that there is no wet or dry deposition arising from nitric oxide in the atmosphere. Thus, it is normally necessary to distinguish between nitric oxide (NO) and nitrogen dioxide in a deposition assessment. In this case, the conservative assumption that 70% of the oxides of nitrogen are in the form of nitrogen dioxide was adopted.

Information on the existing nitrogen and acid deposition was obtained from the APIS database (Centre for Ecology and Hydrology, 2022). Information on the deposition critical loads for the European designated sites and SSSI and were also obtained from the APIS database using the Site Relevant Critical Load function.

The annual dry deposition flux can be obtained from the modelled annual average ground level concentration via use of the formula:

Dry deposition flux (µg/m^2/s) = ground level concentration (µg/m^3) x deposition velocity (m/s)

(where µg refers to µg of the chemical species under consideration).

The deposition velocities for various chemical species recommended for use (AQTAG, 2014) are shown below in Table B-1.

Table B-1. Recommended dry deposition velocities

Chemical species	Recommended deposition velocity (m/s)	
NO_2	Grassland (short)	0.0015
	Forest (tall)	0.003
SO_2	Grassland (short)	0.012
	Forest (tall)	0.024

To convert the dry deposition flux from units of µg/m^2/s (where µg refers to µg of the chemical species) to units of kg N/ha/yr (where kg refers to kg of nitrogen) multiply the dry deposition flux by the conversion factors shown in Table B-2. To convert dry deposition flux to acid deposition multiply by factors shown in Table B-3.

Table B-2. Dry deposition flux conversion factors for nutrient nitrogen deposition

µg/m^2/s of species	Conversion factor to kg N/ha/yr
NO_2	95.9

Table B-3. Dry deposition flux conversion factors for acidification

µg/m^2/s of species	Conversion factor to keq/ha/yr
NO_2	6.84
SO_2	9.84

Appendix C. Results at Sensitive Human Locations

Table C-1. Results of detailed assessment at sensitive human receptor locations for maximum 8-hour mean and 1-hour mean CO predicted concentrations

Receptor ID	Baseline air quality level (µg/m^3)	Maximum 8-hour running mean					Maximum 1-hour mean				
		EQS (µg/m^3)	PC (µg/m^3)	PEC (µg/m^3)	PC/EQS (%)	PEC/EQS (%)	EQS (µg/m^3)	PC (µg/m^3)	PEC (µg/m^3)	PC/EQS (%)	PEC/EQS (%)
R1	303	10,000	50.8	354	0.5%	3.5%	30,000	67.7	371	0.2%	1.2%
R2	303		34.6	338	0.3%	3.4%		54.5	358	0.2%	1.2%
R3	303		27.4	330	0.3%	3.3%		48.8	352	0.2%	1.2%
R4	296		25.5	321	0.3%	3.2%		48.0	344	0.2%	1.1%
R5	296		32.4	328	0.3%	3.3%		49.1	345	0.2%	1.1%
R6	296		32.7	329	0.3%	3.3%		48.0	344	0.2%	1.1%
R7	565		20.4	585	0.2%	5.9%		34.2	599	0.1%	2.0%
R8	530		23.1	553	0.2%	5.5%		24.1	554	0.1%	1.8%
R9	577		68.6	646	0.7%	6.5%		75.0	652	0.2%	2.2%
R10	577		77.5	655	0.8%	6.5%		97.7	675	0.3%	2.2%
R11	577		105.3	683	1.1%	6.8%		126.2	703	0.4%	2.3%
R12	577		109.5	687	1.1%	6.9%		152.7	730	0.5%	2.4%
R13	577		116.2	693	1.2%	6.9%		133.5	711	0.4%	2.4%
R14	577		111.6	689	1.1%	6.9%		135.2	712	0.5%	2.4%
R15	317		26.4	343	0.3%	3.4%		51.6	368	0.2%	1.2%
R16	303		49.2	352	0.5%	3.5%		62.9	366	0.2%	1.2%
R17	303		60.1	363	0.6%	3.6%		83.0	386	0.3%	1.3%
R18	303		58.3	361	0.6%	3.6%		84.6	388	0.3%	1.3%
R19	303		63.0	366	0.6%	3.7%		65.3	368	0.2%	1.2%
R20	303		53.9	357	0.5%	3.6%		80.9	384	0.3%	1.3%
R21	577		121.1	698	1.2%	7.0%		147.7	725	0.5%	2.4%
R22	577		80.7	658	0.8%	6.6%		91.9	669	0.3%	2.2%
R23	577		79.4	657	0.8%	6.6%		92.2	669	0.3%	2.2%
R24	303		68.2	371	0.7%	3.7%		82.7	386	0.3%	1.3%

Table C-2. Results of detailed assessment at sensitive human receptor locations for annual mean and 1-hour mean (99.79th percentile) NO_2 predicted concentrations

Receptor ID	Annual mean						99.79th percentile of 1-hour mean					
	Baseline air quality level (µg/m³)	EQS (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)	EQS (µg/m³)	Baseline air quality level (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)
R1	16.0	40	2.6	18.6	6.5%	46.5%	200	32.0	12.7	44.7	6.3%	22.3%
R2	16.0		1.4	17.4	3.6%	43.6%		32.0	9.1	41.1	4.6%	20.6%
R3	16.0		1.0	17.0	2.6%	42.6%		32.0	7.2	39.2	3.6%	19.6%
R4	16.0		0.9	16.9	2.2%	42.2%		32.0	7.2	39.2	3.6%	19.6%
R5	16.0		0.9	16.9	2.1%	42.1%		32.0	7.4	39.4	3.7%	19.7%
R6	16.0		0.7	16.7	1.8%	41.8%		32.0	7.3	39.3	3.7%	19.7%
R7	16.0		0.2	16.2	0.6%	40.6%		32.0	4.9	36.9	2.5%	18.5%
R8	16.0		0.1	16.1	0.3%	40.3%		32.0	2.9	34.9	1.5%	17.5%
R9	16.0		2.0	18.0	5.0%	45.0%		32.0	13.1	45.1	6.6%	22.6%
R10	16.0		2.8	18.8	6.9%	46.9%		32.0	16.2	48.2	8.1%	24.1%
R11	16.0		4.1	20.1	10.2%	50.2%		32.0	22.1	54.1	11.1%	27.1%
R12	16.0		4.1	20.1	10.3%	50.3%		32.0	22.9	54.9	11.5%	27.5%
R13	16.0		3.9	19.9	9.6%	49.6%		32.0	22.8	54.8	11.4%	27.4%
R14	16.0		3.2	19.2	8.0%	48.0%		32.0	21.8	53.8	10.9%	26.9%
R15	16.0		0.4	16.4	1.1%	41.1%		32.0	6.1	38.1	3.1%	19.1%
R16	16.0		1.3	17.3	3.2%	43.2%		32.0	10.6	42.6	5.3%	21.3%
R17	16.0		2.0	18.0	4.9%	44.9%		32.0	11.6	43.6	5.8%	21.8%
R18	16.0		2.5	18.5	6.3%	46.3%		32.0	12.4	44.4	6.2%	22.2%
R19	16.0		2.6	18.6	6.6%	46.6%		32.0	11.8	43.8	5.9%	21.9%
R20	16.0		2.6	18.6	6.6%	46.6%		32.0	11.6	43.6	5.8%	21.8%
R21	16.0		3.4	19.4	8.6%	48.6%		32.0	23.0	55.0	11.5%	27.5%
R22	16.0		2.1	18.1	5.1%	45.1%		32.0	15.6	47.6	7.8%	23.8%
R23	16.0		1.3	17.3	3.3%	43.3%		32.0	15.1	47.1	7.6%	23.6%
R24	16.0		3.3	19.3	8.3%	48.3%		32.0	14.5	46.5	7.3%	23.3%

Receptor ID	Annual mean						99.79th percentile of 1-hour mean					
	Baseline air quality level (µg/m³)	EQS (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)	EQS (µg/m³)	Baseline air quality level (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)
The City of Oxford AQMA			8.8	-	21.9%	-	-					

Table C-3. Results of detailed assessment at sensitive human receptor locations for 24-mean (99.18th percentile) and 1-hour mean (99.73rd percentile) SO_2 predicted concentrations

Receptor ID	99.18th percentile of 24-hour mean						99.73rd percentile of 1-hour mean					
	Baseline air quality level (µg/m³)	EQS (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)	EQS (µg/m³)	Baseline air quality level (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)
R1	8.7	125	10.8	19.4	8.6%	15.6%	350	8.7	21.1	29.8	6.0%	8.5%
R2	8.7		5.9	14.5	4.7%	11.6%		8.7	14.8	23.4	4.2%	6.7%
R3	8.7		4.8	13.5	3.9%	10.8%		8.7	11.8	20.5	3.4%	5.8%
R4	8.4		4.7	13.0	3.7%	10.4%		8.4	11.4	19.7	3.2%	5.6%
R5	8.4		4.3	12.7	3.5%	10.2%		8.4	11.9	20.2	3.4%	5.8%
R6	8.4		3.8	12.1	3.0%	9.7%		8.4	12.1	20.5	3.5%	5.8%
R7	14.9		1.8	16.8	1.5%	13.4%		14.9	7.8	22.7	2.2%	6.5%
R8	14.0		1.1	15.1	0.9%	12.1%		14.0	4.4	18.4	1.3%	5.2%
R9	14.8		11.4	26.2	9.1%	20.9%		14.8	20.7	35.5	5.9%	10.1%
R10	14.8		15.4	30.2	12.3%	24.2%		14.8	25.7	40.5	7.3%	11.6%
R11	14.8		23.9	38.7	19.1%	31.0%		14.8	35.0	49.8	10.0%	14.2%
R12	14.8		25.9	40.7	20.7%	32.6%		14.8	36.4	51.2	10.4%	14.6%
R13	14.8		25.1	39.9	20.1%	32.0%		14.8	36.4	51.2	10.4%	14.6%
R14	14.8		20.7	35.5	16.6%	28.4%		14.8	35.5	50.3	10.1%	14.4%
R15	9.2		4.7	13.8	3.7%	11.1%		9.2	9.8	19.0	2.8%	5.4%

Receptor ID	99.18th percentile of 24-hour mean						99.73rd percentile of 1-hour mean					
	Baseline air quality level (µg/m³)	EQS (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)	EQS (µg/m³)	Baseline air quality level (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)
R16	8.7		8.5	17.2	6.8%	13.7%		8.7	17.2	25.8	4.9%	7.4%
R17	8.7		10.2	18.9	8.2%	15.1%		8.7	19.0	27.6	5.4%	7.9%
R18	8.7		11.8	20.4	9.4%	16.3%		8.7	20.5	29.2	5.9%	8.3%
R19	8.7		11.5	20.1	9.2%	16.1%		8.7	19.5	28.2	5.6%	8.1%
R20	8.7		11.4	20.1	9.2%	16.1%		8.7	19.3	28.0	5.5%	8.0%
R21	14.8		22.4	37.2	17.9%	29.7%		14.8	37.6	52.4	10.8%	15.0%
R22	14.8		13.1	27.9	10.5%	22.3%		14.8	24.7	39.5	7.1%	11.3%
R23	14.8		11.5	26.3	9.2%	21.1%		14.8	23.8	38.6	6.8%	11.0%
R24	8.7		12.2	20.9	9.8%	16.7%		8.7	24.4	33.0	7.0%	9.4%

Table C-4. Results of detailed assessment at sensitive human receptor locations for 15-minute mean (99.9th percentile) SO_2 predicted concentrations

Receptor ID	99.9th percentile of 15-minute mean					
	Baseline air quality level (µg/m³)	EQS (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)
R1	8.7	266	28.0	36.6	10.5%	13.8%
R2	8.7		19.4	28.1	7.3%	10.5%
R3	8.7		17.1	25.8	6.4%	9.7%
R4	8.4		15.9	24.2	6.0%	9.1%
R5	8.4		16.0	24.4	6.0%	9.2%
R6	8.4		16.8	25.2	6.3%	9.5%
R7	14.9		13.7	28.7	5.2%	10.8%
R8	14.0		9.2	23.2	3.5%	8.7%
R9	14.8		25.2	40.0	9.5%	15.1%
R10	14.8		31.2	46.0	11.7%	17.3%

Receptor ID	99.9th percentile of 15-minute mean					
	Baseline air quality level (µg/m³)	EQS (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)
R11	14.8		39.9	54.7	15.0%	20.5%
R12	14.8		40.5	55.3	15.2%	20.8%
R13	14.8		39.5	54.3	14.9%	20.4%
R14	14.8		38.5	53.3	14.5%	20.0%
R15	9.2		13.5	22.6	5.1%	8.5%
R16	8.7		20.7	29.3	7.8%	11.0%
R17	8.7		22.8	31.4	8.6%	11.8%
R18	8.7		24.5	33.2	9.2%	12.5%
R19	8.7		24.0	32.7	9.0%	12.3%
R20	8.7		23.9	32.5	9.0%	12.2%
R21	14.8		41.8	56.6	15.7%	21.3%
R22	14.8		29.3	44.1	11.0%	16.6%
R23	14.8		27.4	42.2	10.3%	15.9%
R24	8.7		26.8	35.4	10.1%	13.3%

Table C-5. Results of detailed assessment at sensitive human receptor locations for annual mean and 24-hour mean (90.41st) percentile) PM_{10} predicted concentrations

Receptor ID	Annual mean						90.41st percentile of 24-hour mean					
	Baseline air quality level (µg/m³)	EQS (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)	EQS (µg/m³)	Baseline air quality level (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)
R1	14.4	40	0.07	14.5	0.17%	36.2%	50	28.8	0.18	29.0	0.4%	58.0%
R2	14.4		0.04	14.4	0.09%	36.1%		28.8	0.11	28.9	0.2%	57.8%
R3	14.4		0.03	14.4	0.06%	36.1%		28.8	0.07	28.9	0.1%	57.7%
R4	14.6		0.02	14.6	0.05%	36.6%		29.2	0.06	29.3	0.1%	58.6%

Receptor ID	Annual mean						90.41st percentile of 24-hour mean					
	Baseline air quality level (µg/m³)	EQS (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)	EQS (µg/m³)	Baseline air quality level (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)
R5	14.6		0.02	14.6	0.05%	36.6%		29.2	0.06	29.3	0.1%	58.6%
R6	14.6		0.02	14.6	0.04%	36.6%		29.2	0.05	29.3	0.1%	58.6%
R7	13.8		0.01	13.8	0.01%	34.5%		27.6	0.02	27.6	0.0%	55.2%
R8	13.7		0.00	13.7	0.01%	34.3%		27.4	0.01	27.5	0.0%	54.9%
R9	14.2		0.04	14.3	0.10%	35.6%		28.4	0.15	28.6	0.3%	57.2%
R10	14.2		0.06	14.3	0.14%	35.7%		28.4	0.25	28.7	0.5%	57.4%
R11	14.2		0.09	14.3	0.21%	35.8%		28.4	0.36	28.8	0.7%	57.6%
R12	14.2		0.09	14.3	0.22%	35.8%		28.4	0.39	28.8	0.8%	57.6%
R13	14.2		0.09	14.3	0.22%	35.8%		28.4	0.36	28.8	0.7%	57.6%
R14	14.2		0.08	14.3	0.19%	35.7%		28.4	0.33	28.8	0.7%	57.5%
R15	15.0		0.01	15.0	0.03%	37.6%		30.0	0.04	30.1	0.1%	60.2%
R16	14.4		0.03	14.4	0.07%	36.1%		28.8	0.10	28.9	0.2%	57.8%
R17	14.4		0.05	14.4	0.11%	36.1%		28.8	0.15	29.0	0.3%	57.9%
R18	14.4		0.06	14.5	0.15%	36.2%		28.8	0.19	29.0	0.4%	58.0%
R19	14.4		0.06	14.5	0.16%	36.2%		28.8	0.20	29.0	0.4%	58.0%
R20	14.4		0.07	14.5	0.16%	36.2%		28.8	0.19	29.0	0.4%	58.0%
R21	14.2		0.08	14.3	0.21%	35.8%		28.4	0.36	28.8	0.7%	57.6%
R22	14.2		0.04	14.3	0.10%	35.6%		28.4	0.15	28.6	0.3%	57.2%
R23	14.2		0.03	14.2	0.07%	35.6%		28.4	0.12	28.6	0.2%	57.1%
R24	14.4		0.08	14.5	0.21%	36.2%		28.8	0.24	29.0	0.5%	58.1%

Table C-6. Results of detailed assessment at sensitive human receptor locations for annual mean $PM_{2.5}$ predicted concentrations

Receptor ID	Annual mean					
	Baseline air quality level (µg/m^3)	EQS (µg/m^3)	PC (µg/m^3)	PEC (µg/m^3)	PC/EQS (%)	PEC/EQS (%)
R1	9.7	25	0.07	9.8	0.3%	48.8%
R2	9.7		0.04	9.7	0.2%	48.7%
R3	9.7		0.03	9.7	0.1%	48.6%
R4	9.9		0.02	9.9	0.1%	49.7%
R5	9.9		0.02	9.9	0.1%	49.7%
R6	9.9		0.02	9.9	0.1%	49.7%
R7	9.0		0.01	9.0	0.0%	45.0%
R8	8.7		0.00	8.7	0.0%	43.7%
R9	9.1		0.04	9.1	0.2%	45.7%
R10	9.1		0.06	9.2	0.3%	45.8%
R11	9.1		0.09	9.2	0.4%	46.0%
R12	9.1		0.09	9.2	0.4%	46.0%
R13	9.1		0.09	9.2	0.4%	46.0%
R14	9.1		0.08	9.2	0.4%	45.9%
R15	10.0		0.01	10.0	0.1%	50.0%
R16	9.7		0.03	9.7	0.1%	48.6%
R17	9.7		0.05	9.7	0.2%	48.7%
R18	9.7		0.06	9.8	0.3%	48.8%
R19	9.7		0.06	9.8	0.3%	48.8%
R20	9.7		0.07	9.8	0.3%	48.8%
R21	9.1		0.08	9.2	0.4%	46.0%
R22	9.1		0.04	9.1	0.2%	45.7%
R23	9.1		0.03	9.1	0.1%	45.7%
R24	9.7		0.08	9.8	0.4%	48.9%

Table C-7. Results of detailed assessment at sensitive human receptor locations for annual mean and maximum 24-hour mean TVOC predicted concentrations

Receptor ID	Annual mean						100th percentile of maximum 24-hour mean					
	Baseline air quality level (µg/m³)	EQS (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)	EQS (µg/m³)	Baseline air quality level (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)
R1	0.3	5 (Benzene)	16.4	16.7	327.1%	333.8%	30 (Benzene)	0.7	102.3	103.0	341.1%	343.3%
R2	0.3		8.7	9.0	173.9%	180.5%		0.7	58.8	59.4	195.8%	198.1%
R3	0.3		6.2	6.6	124.7%	131.3%		0.7	39.4	40.0	131.3%	133.5%
R4	0.3		5.2	5.5	104.0%	110.4%		0.6	34.6	35.2	115.2%	117.4%
R5	0.3		4.8	5.1	96.2%	102.7%		0.6	34.7	35.3	115.5%	117.7%
R6	0.3		4.0	4.3	80.4%	86.8%		0.6	34.1	34.8	113.8%	116.0%
R7	0.6		1.4	2.0	27.9%	39.6%		1.2	21.3	22.4	70.9%	74.8%
R8	0.5		0.6	1.1	12.2%	22.6%		1.0	11.0	12.1	36.8%	40.3%
R9	0.6		10.2	10.8	203.0%	215.1%		1.2	122.1	123.3	407.1%	411.1%
R10	0.6		14.2	14.8	284.1%	296.2%		1.2	131.1	132.3	436.9%	440.9%
R11	0.6		21.0	21.6	419.5%	431.6%		1.2	154.0	155.2	513.2%	517.2%
R12	0.6		22.0	22.6	439.4%	451.5%		1.2	173.2	174.4	577.2%	581.2%
R13	0.6		21.5	22.1	430.0%	442.1%		1.2	177.0	178.2	589.9%	593.9%
R14	0.6		19.0	19.6	379.8%	391.9%		1.2	174.5	175.7	581.7%	585.7%
R15	0.3		2.5	2.8	49.3%	56.1%		0.7	44.0	44.7	146.7%	149.0%
R16	0.3		7.3	7.7	146.4%	153.0%		0.7	69.2	69.9	230.8%	233.0%
R17	0.3		11.2	11.6	224.6%	231.2%		0.7	80.4	81.0	267.9%	270.1%
R18	0.3		15.0	15.3	299.8%	306.5%		0.7	103.0	103.6	343.2%	345.4%
R19	0.3		15.8	16.1	315.6%	322.3%		0.7	101.5	102.1	338.2%	340.4%
R20	0.3		16.0	16.3	319.1%	325.7%		0.7	96.0	96.6	319.8%	322.0%
R21	0.6		20.7	21.3	413.1%	425.2%		1.2	185.7	186.9	618.9%	622.9%
R22	0.6		10.0	10.6	200.4%	212.4%		1.2	118.4	119.6	394.6%	398.6%
R23	0.6		6.6	7.2	132.7%	144.8%		1.2	103.4	104.6	344.8%	348.8%
R24	0.3		20.3	20.7	407.0%	413.6%		0.7	124.7	125.3	415.5%	417.8%