Environmental Permit Application - Barnhurst Sewage Treatment Works

Air Quality Impact Assessment

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Severn Trent Water Limited

Environmental Permit Application - Barnhurst Sewage Treatment Works

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Contents

Executive Summary

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

Severn Trent Water Limited operate a STW near the city of Wolverhampton, (WV8 1XU). These operations include one existing JMC 316 GS-B.L (D25) CHP engine (with a thermal input capacity of 2.1 MW_{th}) and three existing Broxley boilers (each with a thermal input capacity of between 0.7 MW_{th} and 0.8 MW_{th}).

Assessed Combustion Plant

Medium Combustion Plant (MCP) Information				
MCP specific identifier*	Barnhurst- CHP 1	Barnhurst – Boiler 1	Barnhurst – Boiler 2	Barnhurst – Boiler 3
12-digit grid reference or latitude/longitude	E 389839 N 302118	E 389846 N 302079[1]		
Rated thermal input (MW) of the MCP	2.1	0.7	0.7	0.8
Type of MCP (diesel engine, gas turbine, other engine or other MCP)	Gas engine	Boiler	Boiler	Boiler
Type of fuels used: gas oil (diesel), natural gas, gaseous fuels other than natural gas	Biogas	Dual fuelled (biogas / gas-oil). Modelled with biogas.	Dual fuelled (biogas / gas-oil). Modelled with biogas.	Dual fuelled (biogas / gas-oil). Modelled with biogas.
Date when the new MCP was first put into operation (DD/MM/YYYY)	02/03/2017	Pre-2010	Pre-2010	Pre-2010
Sector of activity of the MCP or the facility in which it is applied (NACE code**)	E.37.00	E.37.00	E.37.00	E.37.00
Expected number of annual operating hours of the MCP and average load in use	8,760 (modelled)	8,760 (modelled)	8,760 (modelled)	8,760 (modelled)
Where the option of exemption under Article 6(8) is used the operator (as identified on Form A) should sign a declaration here that the MCP will not be operated more than the number of hours referred to in this paragraph	N / A	N / A	N / A	

Note 1: The boilers exhaust gases exit via a shared stack.

The Environmental Permit application is collated to include the required forms: Part A, B2.5 and F1. As the site has a CHP engine, the information required to complete Appendix 1 of application form Part B2.5 is included within this document.

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 engine and boilers at the Barnhurst STW.

The potential impacts were determined for the following aspects.

- 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 (TVOC's) 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).
- The potential impact on vegetation and ecosystems due to emissions of oxides of nitrogen (NOx) and SO_2.

This assessment has been carried out on the assumption that the CHP engine would operate continuously at maximum load throughout the year (i.e. 8,760 hours) and the boilers will operate simultaneously for 1,500 hours per year. In practice, the boilers only ever operate simultaneously when the CHP engine is not operating. Furthermore, during the summer months, the boilers rarely operate and during the winter months, only one boiler is operational for approximately 12 hours each day. Furthermore, the assessed plant may not always operate at maximum load.

Human receptors

The assessment indicates that the predicted modelled off-site concentrations and predicted concentrations at sensitive human receptors do not exceed any relevant long-term or short-term air quality objective or guideline. At sensitive human receptor locations, the predicted long-term (i.e. annual mean) NO_2 and particulate (PM_{10} and $PM_{2.5}$) contributions are considered 'not significant'. For short-term NO_2, PM_{10}, SO_2 and CO concentrations at modelled off-site locations and sensitive human receptor locations, the contributions are also considered 'not significant'.

In the absence of an Environmental Quality Standard (EQS) for TVOC's, comparison of the annual mean and 24-hour mean predicted concentrations have been made against the annual mean and 24-hour mean environmental quality standard for benzene (C_6H_6). This represents a worst-case scenario for VOCs because it assumes all VOC contributions comprise benzene. For annual mean and maximum 24-hour mean TVOC concentrations at a sensitive human receptor location, the respective PECs exceed the relevant standard for benzene.

However, TVOC emissions from the assessed combustion plant will largely comprise unburnt methane gas from the biogas fuel (up to 75% composition (Naskeo Environment, 2009)), which is not directly harmful to human health. If the contribution of methane (CH_4) is removed from the process contribution, there would be no exceedance of the relevant standard. Therefore, when considering the conservative approach to the assessment and based on professional judgement, the contribution of TVOC's is considered 'not significant'.

This assessment has been carried out on the assumption that the CHP engine and boilers would operate continuously at maximum load throughout the year (i.e. 8,760 hours). However, the boilers are unlikely to operate simultaneously and for more than 6,000 hours per year. Furthermore, the assessed plant may not always operate at maximum load.

Protected conservation areas

For critical levels at the assessed local nature sites, the results indicate that the respective annual mean NOx and SO_2 PCs are less than 100% of the long-term environmental standard and the impact can also be described as 'insignificant'.

For the 24-hour mean critical level for NOx, the results indicate that the short-term NOx PCs are less than 100%, of the short-term environmental standard and can be described as 'insignificant'. The conservative approach adopted throughout this assessment means that, based on professional judgement, it is not considered likely that there would be unacceptable impacts to air quality at the assessed protected conservation areas as a consequence of the operation of the assessed CHP engine and boilers with regard to ambient concentrations of NOx and SO_2.

For acid deposition and nutrient nitrogen deposition, the results indicate that the respective PCs at the assessed local nature sites are less than 100% of the long-term environmental standard for protected conservation areas and the impact can be described as 'insignificant' as Environment Agency guidance (Environment Agency, 2021a).

As discussed above, the conservative approach adopted for this assessment means the predicted concentrations presented are likely to be higher than would reasonably be expected.

Summary

Based on the above assessment, it is concluded that the assessed CHP engine and boilers are acceptable from an air quality perspective.

1. Introduction

1.1 Background

Under the Industrial Emissions Directive (IED)[1] the anaerobic digestion assets at Barnhurst Sewage Treatment Works (STW) are required to be included in an Environmental Permit (EP). The scope of anaerobic digestion activities includes all treatment stages and incorporates directly associated activities such as a combined heat and power (CHP) gas engine and boilers.

Severn Trent Water Limited (hereafter 'Severn Trent') currently operates one biogas fuelled Jenbacher JMC 316 GS-B.L (D25) CHP engine (with a thermal input capacity of 2.1 MW_{th}) and three duel-fuelled[2] boilers (with thermal input capacities of between 0.7 MW_{th} and 0.8 MW_{th}) at the Barnhurst STW (WV8 1XU) (hereafter 'the site'). Jacobs UK Limited (hereafter 'Jacobs') has carried out an Air Quality Impact Assessment (AQIA) on behalf of Severn Trent to assess the potential impact of emissions from the existing CHP engine and 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 engine and boilers at the site. The air quality assessment has been carried out following the relevant Environment Agency guidance (Environment Agency, 2021a; 2021b). The AQIA considers the following.

- 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 (TVOC's) 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).
- The potential impact on vegetation and ecosystems due to emissions of oxides of nitrogen (NOx) and SO_2.

In order to support the Medium Combustion Plant Directive (MCPD) EU/2015/2193[3] and Specified Generators (Schedule 25A and 25B) Environment Permit (EP) application, the site was previously modelled in 2018. The previous assessment only considered the existing CHP engine. This assessment now includes the existing on-site boilers.

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

This report draws upon information provided from the following parties:

- Severn Trent;
- ADM Ltd;
- Centre for Ecology and Hydrology (CEH);
- GE Jenbacher GmbH & Co OG (Jenbacher)
- City of Wolverhampton Council (CWC); and
- Department for Environment, Food and Rural Affairs (Defra).

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 gas-oil.
[3] 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.

2. Emission Sources

2.1 Emission Sources to Air

The location of the assessed CHP engine (emission point reference A1) and boilers (emission point reference A2, A3 & A4) are presented in Figure 1.

The CHP engine and boilers (when utilising biogas) are fuelled by biogas generated from the sites' anaerobic digestion process and emissions were modelled on this basis. As discussed previously, the boilers are a dual-fuel design and can run on biogas or gas-oil. 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 engine and boilers and no other emission points to air at the site have been included in the assessment.

Table 1 presents the emission sources to air considered in this assessment.

Table 1: Combustion plant to be assessed

Parameters	JMC 316 (D25) GS-B.L CHP engine (2.1 MW_{th})	Broxley boiler (0.7 MW_{th})	Broxley boiler (0.7 MW_{th})	Broxley boiler (0.8 MW_{th})
Modelled fuel	Biogas	Biogas	Biogas	Biogas
Emission point	A1	A2	A3	A4

This assessment has been carried out on the assumption that the CHP engine and boilers would operate continuously at maximum load throughout the year (i.e. 8,760 hours). This is a conservative assumption as, in practice, the CHP engine will have periods of shut-down and maintenance and may not always operate at maximum load. Furthermore, the boilers are unlikely to operate simultaneously and for more than 6,000 hours per year. However, for predicted short-term modelled concentrations, it is assumed all assessed combustion plant operate continuously and simultaneously as this approach ensures that the worst-case or maximum short-term modelled concentrations are quantified (further consideration of this is provided in Appendix A).

2.2 Emissions Data

It should be noted from the 1st January 2030, certain pollutant emission concentrations from the assessed combustion plant must adhere to emission concentration limits as set out in the Medium Combustion Plant Directive (MCPD) EU/2015/2193[3] (European Union, 2015) and as transposed into Schedule 25A of The Environmental Permitting (England and Wales) (Amendment) Regulations 2018 (UK Government, 2018).

For the assessed CHP engine, the NOx, CO and TVOC emission concentrations were derived from the Environment Agency's '*Guidance for monitoring landfill gas engine emissions*' (Environment Agency, 2010). For SO_2, the emission concentration applied in the assessment is derived from monitoring of the biogas (and more specifically hydrogen sulphide (H_2S))[4] at the Barnhurst site (Severn Trent, 2021). Further consideration of this is provided in Appendix B. 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 boilers, as a worst-case approach to the assessment, the NOx emission concentration is based on the emission limit values for existing MCP other than engines and gas turbines as regulated under the MCPD[3]. For SO_2, the emission concentration applied in the assessment is derived from monitoring of the biogas (and more specifically H_2S)[4] at the Barnhurst site (Severn Trent, 2021). For CO and TVOC, in the absence of a specific emission limit value, the CO emission concentration was obtained from Defra's Process Guidance Note 1/3, *'Statutory Guidance for Boilers and Furnaces 20-50MW thermal input'* (Defra, 2012) and the TVOC emission

[4] A maximum H_2S concentration of 38 mg/m^3 was recorded on-site between 1st December 2020 and 1st December 2021. Further information on the conversion of H_2S to SO_2 is provided in Appendix B.

concentration was derived from the Environment Agency's '*Guidance for monitoring landfill gas engine emissions*' (Environment Agency, 2010).

For the assessed CHP engine, the exhaust gas volumetric flow, exhaust gas temperature and moisture content were obtained from the Jenbacher gas engine Technical Description JMC 316 GS-B.L (D25) datasheet (Jenbacher, 2016). In the absence of information regarding oxygen content, 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 was determined using stoichiometric calculations based on the combustion of biogas at the maximum thermal input rating of the respective boiler. In the absence of information regarding temperature, oxygen and moisture content of the boilers, the data used in the model is based on professional judgement acquired from previous work involving biogas fuelled boilers of a similar thermal input capacity.

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

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, 28 of the closest sensitive human receptors (such as residential properties, schools, residential care homes and Public Rights of Way (PRoW)) near the site were identified for modelling purposes. The location of these receptors are presented in Figure 2.

In line with the Environment Agency guidance '*Air emissions risk assessment for your environmental permit*' (Environment Agency, 2021a), 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; Pendeford Wood ancient woodland; Smestow Valley LNR; Shropshire Union Canal LWS; Staffordshire and Worcestershire Canal LWS; Land at Pendeford Lane LWS; Droveway Former Tip (Pendeford Wood) LWS; Rakegate Wood LWS; Oxley Sidings LWS; Barnhurst Lane (land off) LWS; Bushbury Sidings LWS; The Holdings at Oxley North LWS; Dunstall Park Racecourse The Holdings at Oxley South LWS; Aldersley Stadium LWS; Sandy Lane LWS and St Michaels and All Angels Churchyard LWS have been included in the assessment. It should be noted there are no European sites within 10 km of the site based on the CHP engine stack location National Grid Reference (NGR) E 389839 N 302118.

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 local authorities and 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, 2021a).

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

1) Information on plant location and stack parameters were supplied by Severn Trent (Severn Trent, 2021). Information on the CHP engine and the boilers were obtained from various sources as described in Section 2.2.
2) Five years of hourly sequential data recorded at the Birmingham Airport meteorological station (2016 – 2020 inclusive) were used for the assessment (ADM Ltd, 2021).
3) Information on the main buildings located on-site, which could influence dispersion of emissions from the CHP engine and boiler stacks, were estimated from Defra's environmental open-data applications and datasets (Defra, 2021a) and Google Earth (Google Earth, 2021).

4) The maximum predicted concentrations (at a modelled height of 1.5 m or 'breathing zone') at the assessed sensitive human receptor locations R1 – R24 (representing long-term exposure at residential properties) 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 R25 - R28 (representing national cycle route 81), 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.
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) to provide the total 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, 2021a) 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 area. Details of the deposition assessment methodology are provided in Appendix C.

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 2. Relevant Environmental Assessment Levels (EALs) set out in the Environment Agency guidance (Environment Agency, 2021a) are also included in Table 2 where these supplement the AQOs.

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

Table 2: 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[3]	Annual mean
TVOC[1]	5[2]	Annual mean
	30	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 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.
Note 3: Amendment to the Air Quality Standards Regulations 2010 as per the Environment (Miscellaneous Amendments) (EU Exit) Regulations 2020 (UK Government, 2020).

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, 2021b);
- 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, 2021b);
- 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, 2021a).

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 (Environment Agency, 2021a).

Table 3: 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 APIS website. Critical Loads are defined on the APIS website (Centre for Ecology and Hydrology, 2021) 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 4. Where both short and tall vegetation type is assumed to inhabit the assessed local nature sites, the acid grassland and coniferous woodland habitat feature was selected on the APIS website which are generally the most sensitive short and tall vegetation type to nutrient nitrogen and acid deposition.

Table 4: Critical loads for modelled protected conservation areas

Receptor 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	Pendeford Wood ancient woodland	Coniferous woodland	Tall	2.588	0.142	2.730	5
H2	Smestow Valley LNR	Acid grassland	Short	0.480	0.223	0.703	5
		Coniferous woodland	Tall	1.094	0.142	1.236	5
H3a	Shropshire Union Canal LWS	Acid grassland	Short	0.880	0.438	1.318	5
		Coniferous woodland	Tall	1.503	0.357	1.860	5
H3b		Acid grassland	Short	0.880	0.438	1.318	5
		Coniferous woodland	Tall	1.503	0.357	1.860	5
H3c		Acid grassland	Short	0.890	0.438	1.328	5
		Coniferous woodland	Tall	1.530	0.357	1.887	5
H4	Staffordshire and Worcestershire Canal LWS	Acid grassland	Short	0.890	0.438	1.328	5
H5	Droveway Former Tip (Pendeford Wood) LWS	Acid grassland	Short	0.890	0.438	1.328	5
		Coniferous woodland	Tall	1.530	0.357	1.887	5
H6	Droveway Former Tip (Pendeford Wood) LWS	Acid grassland	Short	0.880	0.438	1.318	5
		Coniferous woodland	Tall	1.503	0.357	1.860	5
H7	Rakegate Wood LWS	Coniferous woodland	Tall	1.531	0.357	1.888	5
H8	Oxley Sidings LWS	Acid grassland	Short	0.890	0.223	1.113	5
		Coniferous woodland	Tall	1.654	0.142	1.796	5
H9	Barnhurst Lane (land off) LWS	Acid grassland	Short	0.88	0.438	1.318	5
		Coniferous woodland	Tall	1.503	0.357	1.86	5

Receptor 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	Bushbury Sidings	Acid grassland	Short	0.89	0.438	1.328	5
		Coniferous woodland	Tall	1.531	0.357	1.888	5
H11	The Holdings at Oxley North LWS	Acid grassland	Short	0.89	0.223	1.113	5
		Coniferous woodland	Tall	1.654	0.142	1.796	5
H12	Dunstall Park Racecourse LWS	Acid grassland	Short	0.89	0.223	1.113	5
		Coniferous woodland	Tall	1.654	0.142	1.796	5
H13	The Holdings at Oxley South LWS	Coniferous woodland	Tall	1.035	0.357	1.392	5
H14	Aldersley Stadium LWS	Coniferous woodland	Tall	1.094	0.142	1.236	5
H15	Sandy Lane LWS	Acid grassland	Short	0.48	0.438	0.917	5
		Coniferous woodland	Tall	1.035	0.357	1.392	5
H16	St.Michael and All Angels Churchyard LWS	Acid grassland	Short	0.48	0.438	0.918	5
		Coniferous woodland	Tall	1.035	0.357	1.392	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 process contribution (PC – emissions from the modelled process alone) and the predicted environmental concentrations (PEC – 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, 2021).

Significance Criteria – Ancient woodland, LNR and 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, 2021a) 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 Site Location

The site is situated approximately 3.4 km north-northwest from the centre of the city of Wolverhampton, Staffordshire. The area surrounding the site generally comprises residential properties and grassland. The Shropshire Union Canal runs adjacent to the northern and eastern boundary of the site.

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 140 m northwest of the CHP engine (based on the CHP engine stack location NGR E 389839 N 302118).

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, 2021b) 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, CWC has declared an air quality management area (AQMA) across the city of Wolverhampton, which also encompasses the site. The AQMA is named 'Wolverhampton AQMA 2005' and was declared for exceedances of the annual mean AQO for NO_2 and elevated concentrations of 24-hour mean PM_{10} in 2005.

CWC also carries out regular assessments and monitoring of air quality within its administrative boundary as part of the LAQM process. The most recent Air Quality Annual Status Report (City of Wolverhampton Council, 2020) and Wolverhampton Council air quality website (City of Wolverhampton Council, 2021) were reviewed to determine concentrations of NO_2 and PM_{10} in the vicinity of the site. It should be noted that none of the other assessed pollutants are monitored by WFDC. Table 5 presents information on the nearest monitoring locations to the site.

Table 5: Nearest monitoring locations to the site

Site ID	Description	Site type	Location	Distance and direction from CHP engine	Pollutants monitored	Annual mean concentration (μg/m^3)
Automatic monitoring						
A4	Stafford Road	Roadside	E 391261 N 302202	1.4 km, E	NO_2, PM_{10}	NO_2 – 23 μg/m^3 (2020) PM_{10} – 16 μg/m^3 (2019)
Non-automatic monitoring (diffusion tubes)						
ST5,6,7	Stafford Road	Roadside	E 391261 N 302202[1]	1.4 km, E	NO_2	NO_2 – 30.3[2] μg/m^3 (2018)

Note 1: Diffusion tubes co-located with continuous analyser 'A4'.

Note 2: Average annual mean NO_2 concentration.

These monitoring locations are not considered representative of the site and surrounding area due to the roadside monitoring location type and respective distance from the site. The monitoring sites are located adjacent to a junction on the A449 (Stafford Road).

For the assessed pollutants, information on background air quality in the vicinity of the site was obtained from Defra background map datasets (Defra, 2021b). 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 6.

As it is necessary to determine the potential impact of emissions from the site on the assessed protected conservation areas, the background concentrations of NOx and SO_2 were also identified for the assessed protected conservation areas. These background concentrations were also obtained from Defra background map datasets (Defra, 2021b) and are displayed in Table 6.

Table 6: Background concentrations: adopted for use in assessment for assessed human receptors and protected conservation areas

Pollutant	Annual mean concentration (µg/m^3)	Description
Human receptors		
NO_2	11.6 – 13.2	Defra 1 km x 1 km background map value for the assessed sensitive human receptor locations, 2021 map concentration
CO	132 – 137	Defra 1 km x 1 km background map value for the assessed sensitive human receptor locations, scaled from 2001-based map to 2021 concentration
PM_{10}	12.0 – 12.3	Defra 1 km x 1 km background map value for the assessed sensitive human receptor locations, 2021 map concentration
$PM_{2.5}$	8.0 – 8.3	Defra 1 km x 1 km background map value for the assessed sensitive human receptor locations, 2021 map concentration
SO_2	3.0 – 3.6	Defra 1 km x 1 km background map value for the assessed sensitive human receptor locations, 2001 map concentration
C_6H_6	0.28 – 0.32	Defra 1 km x 1 km background map value for the assessed sensitive human receptor locations, 2010 map concentration for benzene
Protected conservation areas		
NOx	13.9 – 17.1	Defra 1 km x 1 km background map value for the assessed sensitive human receptor locations, 2021 map concentration
SO_2	3.0 – 3.2	Defra 1 km x 1 km background map value for the assessed sensitive human receptor locations, 2001 map concentration

The long-term background concentrations were doubled to estimate the short-term background concentrations in line with the Environment Agency guidance (Environment Agency, 2021a).

4.3 Existing Deposition Rates

Existing acid and nutrient nitrogen deposition levels were obtained from APIS (Centre for Ecology and Hydrology, 2021). 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 7.

Table 7: Existing deposition at modelled habitat sites

Receptor ref	Protected conservation area	Vegetation type (for deposition velocity)	Existing deposition rates		
			Acid deposition (kEqH+/ha/year)		Nutrient N deposition (kg N/ha/year)
			Nitrogen	Sulphur	Nitrogen
H1	Pendeford Wood ancient woodland	Tall	2.64	0.22	36.96
H2	Smestow Valley LNR	Short	1.54	0.18	21.56
		Tall	2.64	0.22	36.96

5. Results

5.1 Human Receptors

The results presented below are the maximum modelled concentrations predicted at any of the 28 assessed sensitive human receptor locations, the assessed AQMA and the maximum modelled concentration 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 8, 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 D.

Table 8: Results of detailed assessment

Pollutant	Averaging period	Assessment location	Maximum receptor	EQS ($\mu g/m^3$)	Baseline air quality level ($\mu g/m^3$)	PC ($\mu g/m^3$)	PEC ($\mu g/m^3$)	PC / EQS (%)	PEC / EQS (%)	PC as a percentage of headroom (%)
CO	Maximum 8-hour running mean	Sensitive locations	R17	10,000	266	112.6	378.4	1.1%	3.8%	1.2%
	Maximum 1-hour mean	Maximum off-site	-	30,000	264	228.2	492.2	0.8%	1.6%	0.8%
		Sensitive locations	R19	30,000	264	224.2	488.2	0.7%	1.6%	0.8%
NO_2	Annual mean	Sensitive locations	R22	40	11.6	3.3	14.9	8.3%	37.3%	-
	1-hour mean (99.79th percentile)	Maximum off-site	-	200	26.3	23.5	49.8	11.7%	24.9%	13.5%
		Sensitive locations	R27	200	26.3	20.2	46.5	10.1%	23.3%	11.6%
SO_2	24-hour mean (99.18th percentile)	Sensitive locations	R21	125	7.0	3.3	10.3	2.6%	8.3%	2.8%
	1-hour mean (99.73rd percentile)	Maximum off-site	-	350	7.2	5.9	13.1	1.7%	3.7%	1.7%
		Sensitive locations	R27	350	7.2	5.2	12.5	1.5%	3.6%	1.5%
	15-minute mean (99.9th percentile)	Maximum off-site	-	266	7.2	7.8	15.1	3.0%	5.7%	3.0%
		Sensitive locations	R18	266	7.0	7.4	14.4	2.8%	5.4%	2.8%
PM_{10}	Annual mean	Sensitive locations	R22	40	12.0	0.08	12.1	0.2%	30.2%	-
	24-hour mean (90.41st percentile)	Sensitive locations	R21	50	24.0	0.28	24.3	0.6%	48.5%	1.1%
$PM_{2.5}$	Annual mean	Sensitive locations	R22	20	8.0	0.08	8.1	0.4%	40.6%	-
TVOC	Annual mean	Sensitive locations	R21	5 (Benzene)	0.3	13.7	14.0	273.8%	279.5%	-
	Maximum 24-hour mean	Sensitive locations	R21	30 (Benzene)	0.6	121.1	121.7	403.6%	405.5%	411.4%

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, R25 and R28 have been omitted from analysis as these receptor locations represent National Cycle Route 81 (i.e. short-term exposure only). The full results are presented in Appendix D.

The results in Table 8 indicate that the predicted off-site concentrations and predicted concentrations at sensitive human receptors do not exceed any relevant long-term or short-term air quality objective or guideline.

Table 8 indicates that the maximum PC for annual mean NO_2 at a sensitive human receptor location is 3.3 µg/m^3 (equating to 8.3% of the relevant EQS) and is predicted at R22, which represents a residential property approximately 0.16 km north-northwest of the CHP engine stack. The PC is above 1% of the relevant EQS but the PEC is less than 70% of the EQS (i.e. 37.3%) and based on professional judgement, the impact can be classed as 'not significant'. As discussed previously, this assessment assumes the assessed combustion plant operate simultaneously and continuously all year. In practice, all assessed boilers are not likely to operate simultaneously and the assessed plant may not always operate at maximum load. Therefore, when considering the impact on the city-wide 'Wolverhampton AQMA 2005' which encompasses the site, it is concluded that the operation of the assessed CHP engines and boilers are acceptable from an air quality perspective.

For the assessment of 1-hour mean (99.79th percentile) NO_2 concentrations at a sensitive human receptor location, the maximum PC of 20.2 µg/m^3 (which equates to 10.1% of the relevant EQS) is predicted at R27, which represents a National Cycle Route 81 approximately 0.2 km east-northeast of the CHP engine stack. The PC is just above 10% of the short-term EQS but less than 20% of the headroom between the short-term background concentration and the EQS and is considered 'not significant'. For the assessment of 1-hour mean (99.79th percentile) NO_2 concentrations at a modelled off-site location, the maximum PC is 23.5 µg/m^3, which equates to 11.7% of the relevant EQS. The PC is greater than 10% of the short-term EQS but less than 20% of the headroom and based on professional judgement, is considered 'not significant'. This concentration is predicted at NGR E 390039 N 302168, which is adjacent to the eastern boundary of the site by the Shropshire Union canal.

For long-term PM_{10} and $PM_{2.5}$ concentrations, the respective PCs are less than 1% of the relevant long-term EQS and are considered 'insignificant' as per Environment Agency guidance (Environment Agency, 2021a) and therefore 'not significant'. For 24-hour mean (90.41st percentile) PM_{10} concentrations, the PC is less than 10% of the relevant short-term EQS (i.e. 0.6%) and its impact can be described as 'insignificant' and therefore 'not significant'.

For short-term CO concentrations at both sensitive human receptor locations and modelled off-site locations, the respective PCs are less than 10% of the relevant short-term EQS and their impact is considered 'insignificant' and not representative of a significant effect (i.e. not significant).

For 24-hour mean (99.18th percentile) SO_2 concentrations at a sensitive human receptor location, the highest PC of 3.3 µg/m^3 is predicted at R21, which represents a residential property 140 m northwest of the CHP engine stack. The PC is less than 10% of the short-term EQS and is considered 'insignificant' and therefore 'not significant'.

For 1-hour mean (99.73rd percentile) SO_2 concentrations at a sensitive human receptor location and modelled off-site location, the maximum PCs of 5.2 µg/m^3 and 5.9 µg/m^3, respectively, are less than 10% of the short-term EQS and the impact is considered 'insignificant' as per Environment Agency guidance (Environment Agency, 2021a) and therefore 'not significant'. The maximum SO_2 concentration at an off-site location is predicted at NGR E 390029 N 302178, which is adjacent to the eastern boundary of the site by the Shropshire Union canal.

For 15-minute mean (99.9th percentile) SO_2 concentrations at a sensitive human receptor location, the maximum PC of 7.4 µg/m^3 (predicted at R18 which represents a residential property 0.2 km west-southwest of the CHP engine stack) is less than 10% of the short-term EQS and its impact is considered 'insignificant' as per Environment Agency guidance (Environment Agency, 2021a) and therefore 'not significant'. For 15-minute mean (99.9th percentile) SO_2 concentrations at a modelled off-site location, the maximum PC of 7.8 µg/m^3 is also less than 10% of the short-term EQS and its impact is considered 'insignificant' as per Environment Agency guidance (Environment Agency, 2021a) and therefore 'not significant. The maximum SO_2 concentration at an off-site location is predicted at NGR E 390039 N 302168, which is adjacent to the eastern boundary of the site by the Shropshire Union canal.

For annual mean TVOC concentrations at a sensitive human receptor location, the maximum PC is 13.7 μg/m^3 and is predicted at R21. When comparing the PEC against the annual mean EQS for benzene, there is an exceedance of the standard.

For maximum 24-hour mean TVOC concentrations at a sensitive human receptor location, the maximum PC is 121.1 μg/m^3, which is predicted at R21. The PEC of 121.7 μg/m^3 exceeds the benzene 24-hour mean standard.

In the absence of an EQS for TVOC's, comparison of the annual mean and 24-hour mean predicted concentrations have been made against the annual mean and 24-hour mean environmental quality standard for benzene (C_6H_6). This represents a worst-case scenario for VOCs because it assumes all VOC contributions comprise benzene. TVOC emissions from the assessed combustion plant will largely comprise unburnt methane gas from the biogas fuel (up to 75% composition (Naskeo Environment, 2009)), which is not directly harmful to human health. If the contribution of methane (CH_4) is removed from the process contribution, there would be no exceedance of the short-term relevant standard. Therefore, when considering the conservative approach to the assessment and based on professional judgement, the contribution of TVOC's is considered 'not significant'.

Summary

The results in Table 8 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 air quality objective or guideline. Furthermore, the conservative approach adopted throughout the assessment means the predicted concentrations presented in Table 8 are likely to be considerably higher than would reasonably be expected.

Isopleths (see Figures 4 - 7) have been produced for annual mean and 1-hour mean (99.79th percentile) NO_2 concentrations, 1-hour mean (99.73rd percentile) and 15-minute mean (99.9th percentile) SO_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 have been determined by comparing predicted concentrations of released substances with the EQSs for the protection of vegetation (critical levels) (see Table 3). The results of the detailed modelling at the assessed protected conservation areas are shown in Table 9. The results presented are the maximum predicted concentration at each assessed protected conservation area for the five years of meteorological data used in the study.

For SO_2, the relevant EQS was based on the assumption that lichens and bryophytes were present at each site, therefore adopting a further conservative approach.

Table 9: 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

Ref	Protected Conservation Area	EQS (µg/m^3)	Background concentration (µg/m^3)	PC (µg/m^3)	PEC (µg/m^3)	PC/EQS (%)	PEC/EQS (%)
Annual mean NOx concentrations							
H1	Pendeford Wood ancient woodland	30	13.9	0.3	14.2	0.9%	47.3%
H2	Smestow Valley LNR		17.1	0.6	17.7	1.9%	58.8%
H3a	Shropshire Union Canal LWS		15.5	5.1	20.6	16.9%	68.7%
H3b			15.5	5.5	21.0	18.3%	70.1%
H3c			17.9	5.0	22.9	16.8%	76.4%
H4	Staffordshire and Worcestershire Canal LWS		17.9	1.5	19.4	4.9%	64.5%
H5	Land at Pendeford Lane LWS		18.8	0.3	19.0	0.9%	63.5%
H6	Droveway Former Tip (Pendeford Wood) LWS		15.5	0.4	15.9	1.3%	53.1%
H7	Rakegate Wood LWS		20.5	0.3	20.8	1.0%	69.3%
H8	Oxley Sidings LWS		17.3	0.5	17.7	1.6%	59.1%
H9	Barnhurst Lane (land off) LWS		15.5	0.2	15.7	0.6%	52.4%
H10	Bushbury Sidings LWS		20.5	0.2	20.7	0.6%	68.9%
H11	The Holdings at Oxley North LWS		17.3	0.4	17.7	1.4%	58.9%
H12	Dunstall Park Racecourse LWS		17.3	0.2	17.5	0.7%	58.3%
H13	The Holdings at Oxley South LWS		16.2	0.1	16.4	0.4%	54.5%
H14	Aldersley Stadium LWS		17.1	0.2	17.3	0.6%	57.5%
H15	Sandy Lane LWS		16.2	0.1	16.4	0.5%	54.5%
H16	St.Michael and All Angels Churchyard LWS		16.2	0.1	16.3	0.3%	54.3%
Annual mean SO_2 concentrations							
H1	Pendeford Wood ancient woodland	10	3.0	0.02	3.0	0.2%	29.7%
H2	Smestow Valley LNR		3.2	0.05	3.3	0.5%	32.6%
H3a	Shropshire Union Canal LWS		3.5	0.48	4.0	4.8%	40.0%
H3b			3.5	0.51	4.0	5.1%	40.3%
H3c			3.6	0.47	4.1	4.7%	40.9%
H4	Staffordshire and Worcestershire Canal LWS		3.6	0.14	3.8	1.4%	37.6%
H5	Land at Pendeford Lane LWS		3.3	0.03	3.4	0.3%	33.7%
H6	Droveway Former Tip (Pendeford Wood) LWS		3.5	0.04	3.6	0.4%	35.6%
H7	Rakegate Wood LWS		3.8	0.03	3.8	0.3%	38.3%
H8	Oxley Sidings LWS		3.0	0.04	3.0	0.4%	30.4%
H9	Barnhurst Lane (land off) LWS		3.5	0.02	3.5	0.2%	35.4%
H10	Bushbury Sidings LWS		3.8	0.02	3.8	0.2%	38.2%
H11	The Holdings at Oxley North LWS		3.0	0.04	3.0	0.4%	30.4%
H12	Dunstall Park Racecourse LWS		3.0	0.02	3.0	0.2%	30.2%
H13	The Holdings at Oxley South LWS		2.8	0.01	2.8	0.1%	28.1%
H14	Aldersley Stadium LWS		3.2	0.02	3.2	0.2%	32.3%

Ref	Protected Conservation Area	EQS (µg/m³)	Background concentration (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)
H15	Sandy Lane LWS		2.8	0.01	2.8	0.1%	28.1%
H16	St.Michael and All Angels Churchyard LWS		2.8	0.01	2.8	0.1%	28.1%
Maximum 24-hour mean NOx concentrations							
H1	Pendeford Wood AW	75	27.8	2.2	30.0	2.9%	40.0%
H2	Smestow Valley LNR		34.1	7.4	41.6	9.9%	55.4%
H3a	Shropshire Union Canal LWS		31.1	33.4	64.5	44.6%	86.0%
H3b			31.1	32.2	63.2	42.9%	84.3%
H3c			35.8	29.2	64.9	38.9%	86.5%
H4	Staffordshire and Worcestershire Canal LWS		35.8	11.4	47.2	15.2%	62.9%
H5	Land at Pendeford Lane LWS		37.6	2.5	40.0	3.3%	53.4%
H6	Droveway Former Tip (Pendeford Wood) LWS		31.1	4.2	35.2	5.5%	47.0%
H7	Rakegate Wood LWS		41.0	2.1	43.1	2.8%	57.5%
H8	Oxley Sidings LWS		34.5	5.7	40.2	7.6%	53.7%
H9	Barnhurst Lane (land off) LWS		31.1	2.7	33.7	3.6%	45.0%
H10	Bushbury Sidings		41.0	1.8	42.8	2.4%	57.1%
H11	The Holdings at Oxley North LWS		34.5	3.7	38.3	5.0%	51.0%
H12	Dunstall Park Racecourse LWS		34.5	2.1	36.6	2.8%	48.8%
H13	The Holdings at Oxley South LWS		32.4	2.1	34.5	2.8%	46.1%
H14	Aldersley Stadium LWS		34.1	3.0	37.2	4.1%	49.6%
H15	Sandy Lane LWS		32.4	2.1	34.6	2.8%	46.1%
H16	St.Michael and All Angels Churchyard LWS		32.4	1.3	33.8	1.8%	45.0%

The results in Table 9 indicate that for the assessed local nature sites, the respective annual mean NOx and SO_2 PCs are less than 100% of the long-term environmental standard and the impact can be described as 'insignificant'.

The maximum short-term mean concentrations which were assessed against the 24-hour mean critical level for NOx (i.e. 75 µg/m³) are also presented in Table 9. The results indicate that the respective short-term NOx PCs are less than 100% of the short-term environmental standard and can be described as 'insignificant'.

Summary

The conservative approach adopted throughout this assessment means that, based on professional judgement, it is not considered likely that there would be unacceptable impacts to air quality at the assessed protected conservation areas as a consequence of the operation of the assessed CHP engine and boilers with regard to ambient concentrations of NOx and SO_2.

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, 2021). Further information on the assessment of deposition is provided in Appendix C. The full detailed modelled results are displayed in Table 10 and Table 11.

Table 10: 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)		PC	PEC	PC/CL (%)	PEC/CL(%)
			CLMaxS	CLMinN	CLMaxN	Existing deposition (N)	Existing deposition (S)				
H1	Pendeford Wood AW	Tall	2.588	0.142	2.730	2.64	0.22	0.009	2.87	0.3%	105%
H2	Smestow Valley LNR	Short	0.480	0.223	0.703	1.54	0.18	0.010	1.73	1.5%	246%
		Tall	1.094	0.142	1.236	2.64	0.22	0.021	2.88	1.7%	233%
H3a	Shropshire Union Canal LWS	Short	0.880	0.438	1.318	1.54	0.18	0.093	1.81	7.0%	138%
		Tall	1.503	0.357	1.860	2.64	0.22	0.185	3.05	10.0%	164%
H3b		Short	0.880	0.438	1.318	1.54	0.18	0.100	1.82	7.6%	138%
		Tall	1.503	0.357	1.860	2.64	0.22	0.200	3.06	10.8%	165%
H3c		Short	0.890	0.438	1.328	1.76	0.23	0.092	2.08	6.9%	157%
		Tall	1.530	0.357	1.887	3.02	0.27	0.183	3.47	9.7%	184%
H4	Staffordshire and Worcestershire Canal LWS	Short	0.890	0.438	1.328	1.76	0.23	0.027	2.02	2.0%	152%
H5	Droveway Former Tip (Pendeford Wood) LWS	Short	0.890	0.438	1.328	1.76	0.23	0.005	1.99	0.4%	150%
		Tall	1.530	0.357	1.887	3.02	0.27	0.010	3.30	0.5%	175%
H6	Droveway Former Tip (Pendeford Wood) LWS	Short	0.880	0.438	1.318	1.54	0.18	0.007	1.73	0.5%	131%
		Tall	1.503	0.357	1.860	2.64	0.22	0.014	2.87	0.7%	155%
H7	Rakegate Wood LWS	Tall	1.531	0.357	1.888	3.02	0.27	0.011	3.30	0.6%	175%
H8	Oxley Sidings LWS	Short	0.890	0.223	1.113	1.76	0.23	0.009	2.00	0.8%	180%
		Tall	1.654	0.142	1.796	3.02	0.27	0.017	3.31	1.0%	184%
H9	Barnhurst Lane (land off) LWS	Short	0.880	0.438	1.318	1.54	0.18	0.003	1.72	0.2%	131%
		Tall	1.503	0.357	1.860	2.64	0.22	0.006	2.87	0.3%	154%
H10	Bushbury Sidings LWS	Short	0.890	0.438	1.328	1.76	0.23	0.003	1.99	0.2%	150%
		Tall	1.531	0.357	1.888	3.02	0.27	0.006	3.30	0.3%	175%

Ref	Habitat	Vegetation type (for deposition velocity)	Critical load (CL) (kEqH+/ha/year)			Existing acid deposition (kEqH+/ha/year)		PC	PEC	PC/CL (%)	PEC/CL(%)
			CLMaxS	CLMinN	CLMaxN	Existing deposition (N)	Existing deposition (S)				
H11	The Holdings at Oxley North LWS	Short	0.890	0.223	1.113	1.76	0.23	0.007	2.00	0.7%	179%
		Tall	1.654	0.142	1.796	3.02	0.27	0.015	3.30	0.8%	184%
H12	Dunstall Park Racecourse LWS	Short	0.890	0.223	1.113	1.76	0.23	0.004	1.99	0.4%	179%
		Tall	1.654	0.142	1.796	3.02	0.27	0.008	3.30	0.4%	184%
H13	The Holdings at Oxley South LWS	Tall	1.035	0.357	1.392	2.64	0.22	0.005	2.86	0.3%	206%
H14	Aldersley Stadium LWS	Tall	1.094	0.142	1.236	2.64	0.22	0.007	2.87	0.5%	232%
H15	Sandy Lane LWS	Short	0.480	0.438	0.917	1.54	0.18	0.002	1.72	0.3%	188%
		Tall	1.035	0.357	1.392	2.64	0.22	0.005	2.86	0.4%	206%
H16	St.Michael and All Angels Churchyard LWS	Short	0.480	0.438	0.918	1.54	0.18	0.001	1.72	0.2%	188%
		Tall	1.035	0.357	1.392	2.64	0.22	0.003	2.86	0.2%	206%

Table 11: Modelled nitrogen deposition at assessed protected conservation areas

Ref	Habitat	Vegetation type (for deposition velocity)	Existing nutrient deposition (kgN/ha-year)		PC	PEC	PC/CL (%)	PEC/CL(%)
			Minimal Critical Load (CL)	Existing deposition				
H1	Pendeford Wood AW	Tall	5	36.96	0.053	37.01	1.1%	740%
H2	Smestow Valley LNR	Short	5	21.56	0.059	21.62	1.2%	432%
		Tall	5	36.96	0.117	37.08	2.3%	742%
H3a	Shropshire Union Canal LWS	Short	5	21.56	0.510	22.07	10.2%	441%
		Tall	5	36.96	1.020	37.98	20.4%	760%
H3b		Short	5	21.56	0.554	22.11	11.1%	442%
		Tall	5	36.96	1.109	38.07	22.2%	761%

Ref	Habitat	Vegetation type (for deposition velocity)	Existing nutrient deposition (kgN/ha-year)		PC	PEC	PC/CL (%)	PEC/CL(%)
			Minimal Critical Load (CL)	Existing deposition				
H3c		Short	5	24.64	0.508	25.15	10.2%	503%
		Tall	5	42.28	1.016	43.30	20.3%	866%
H4	Staffordshire and Worcestershire Canal LWS	Short	5	24.64	0.149	24.79	3.0%	496%
H5	Droveway Former Tip (Pendeford Wood) LWS	Short	5	24.64	0.027	24.67	0.5%	493%
		Tall	5	42.28	0.054	42.33	1.1%	847%
H6	Droveway Former Tip (Pendeford Wood) LWS	Short	5	21.56	0.038	21.60	0.8%	432%
		Tall	5	36.96	0.077	37.04	1.5%	741%
H7	Rakegate Wood LWS	Tall	5	42.28	0.060	42.34	1.2%	847%
H8	Oxley Sidings LWS	Short	5	24.64	0.048	24.69	1.0%	494%
		Tall	5	42.28	0.096	42.38	1.9%	848%
H9	Barnhurst Lane (land off) LWS	Short	5	21.56	0.018	21.58	0.4%	432%
		Tall	5	36.96	0.036	37.00	0.7%	740%
H10	Bushbury Sidings LWS	Short	5	24.64	0.017	24.66	0.3%	493%
		Tall	5	42.28	0.034	42.31	0.7%	846%
H11	The Holdings at Oxley North LWS	Short	5	24.64	0.041	24.68	0.8%	494%
		Tall	5	42.28	0.083	42.36	1.7%	847%
H12	Dunstall Park Racecourse LWS	Short	5	24.64	0.022	24.66	0.4%	493%
		Tall	5	42.28	0.044	42.32	0.9%	846%
H13	The Holdings at Oxley South LWS	Tall	5	36.96	0.027	36.99	0.5%	740%
H14	Aldersley Stadium LWS	Tall	5	36.96	0.037	37.00	0.7%	740%
H15	Sandy Lane LWS	Short	5	21.56	0.014	21.57	0.3%	431%
		Tall	5	36.96	0.027	36.99	0.5%	740%
H16	St.Michael and All Angels Churchyard LWS	Short	5	21.56	0.008	21.57	0.2%	431%
		Tall	5	36.96	0.016	36.98	0.3%	740%

The results in Table 10 and Table 11 indicate that for the assessed local nature sites, the respective PCs for acid and nutrient nitrogen deposition are less than 100% of the relevant long-term environmental standard for protected conservation areas and the impact can be described as 'insignificant' as Environment Agency guidance (Environment Agency, 2021a).

It should be noted acid and nitrogen deposition rates currently exceed their relevant critical loads in the majority of the 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 and 1-hour mean (99.79th percentile) NO_2 concentrations at a modelled off-site location) and 2017 model (which predicted the highest 1-hour mean (99.79th percentile) NO_2 concentrations at a sensitive human receptor location) may impact on predicted concentrations at sensitive human receptors and off-site locations. The results of the sensitivity analysis are presented in Table 12, Table 13 and Table 14.

Table 12: Sensitivity analysis - fixed surface roughness of 0.1 m

Pollutant	Averaging period	Assessment location	Original PC (surface roughness 0.6 m) (µg/m³)	Surface roughness length 0.1 m				
				PC (µg/m³)	PEC (µg/m³)	PC/EQS	PEC/EQS	% difference in PC/EQS compared to original
NO_2	Annual mean	Sensitive locations	3.3	3.0	14.7	7.6%	36.7%	-0.7%
	1 hour mean (99.79th percentile)	Maximum off-site	46.7	53.1	76.3	26.5%	38.2%	3.2%
		Sensitive locations	20.2	25.6	51.9	12.8%	25.9%	2.7%

The results in Table 12 indicate that the change to maximum predicted annual mean concentrations for NO_2 is lower when using a surface roughness value of 0.1 m compared to the original value of 0.6 m. For 1-hour mean (99.79th percentile) NO_2 concentrations at a sensitive human receptor location and modelled off-site location, the PCs were higher when using a reduced surface roughness value of 0.1 m. However, a surface roughness of 0.1 m (representing root crops) is not considered representative of the site and surrounding area.

Table 13: Sensitivity analysis - fixed surface roughness of 1 m

Pollutant	Averaging period	Assessment location	Original PC (surface roughness 0.6 m) (µg/m³)	Surface roughness length 1 m				
				PC (µg/m³)	PEC (µg/m³)	PC/EQS	PEC/EQS	% difference in PC/EQS compared to original
NO_2	Annual mean	Sensitive locations	3.3	3.4	15.0	8.5%	37.6%	0.3%
	1 hour mean (99.79th percentile)	Maximum off-site	46.7	44.1	67.4	22.1%	33.7%	-1.3%
		Sensitive locations	20.2	19.5	45.8	9.7%	22.9%	-0.3%

The results in Table 13 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 0.6 m. For 1-hour mean (99.79th percentile) NO_2 concentrations at an off-site location and sensitive human receptor location, the PCs were 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 14: Sensitivity analysis - no buildings

Pollutant	Averaging period	Assessment location	Original PC (with buildings) (µg/m^3)	No buildings				
				PC (µg/m^3)	PEC (µg/m^3)	PC/EQS	PEC/EQS	% difference in PC/EQS compared to original
NO_2	Annual mean	Sensitive locations	3.3	3.3	14.9	8.2%	37.3%	-0.1%
	1 hour mean (99.79th percentile)	Maximum off-site	46.7	40.6	63.9	20.3%	31.9%	-3.0%
		Sensitive locations	20.2	18.8	45.1	9.4%	22.5%	-0.7%

The results in Table 14 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 engine and boilers at the Barnhurst STW. The predicted impacts were assessed against the relevant air quality standards and guidelines for the protection of human health (referred to in the report as EQSs) and protected conservation areas (referred to as critical levels and critical loads).

Human receptors

The assessment indicates that the predicted modelled off-site concentrations and predicted concentrations at sensitive human receptors do not exceed any relevant long-term or short-term air quality objective or guideline. At sensitive human receptor locations, the predicted long-term (i.e. annual mean) NO_2 and particulate (PM_{10} and $PM_{2.5}$) contributions are considered 'not significant'. For short-term NO_2, PM_{10}, SO_2 and CO concentrations at modelled off-site locations and sensitive human receptor locations, the contributions are also considered 'not significant'. For long-term and short-term TVOC concentrations, the conservative approach adopted throughout this assessment means that based on professional judgement, the contribution is considered 'not significant'.

In the absence of an EQS for TVOC's, comparison of the annual mean and 24-hour mean predicted concentrations have been made against the annual mean and 24-hour mean environmental quality standard for benzene (C_6H_6). This represents a worst-case scenario for VOCs because it assumes all VOC contributions comprise benzene. For annual mean and maximum 24-hour mean TVOC concentrations at a sensitive human receptor location, the respective PECs exceed the relevant standard for benzene.

However, TVOC emissions from the assessed combustion plant will largely comprise unburnt methane gas from the biogas fuel (up to 75% composition (Naskeo Environment, 2009)), which is not directly harmful to human health. If the contribution of methane (CH_4) is removed from the process contribution, there would be no exceedance of the relevant standard. Therefore, when considering the conservative approach to the assessment and based on professional judgement, the contribution of TVOC's is considered 'not significant'.

This assessment has been carried out on the assumption that the CHP engine and boilers would operate continuously at maximum load throughout the year (i.e. 8,760 hours). However, the boilers are unlikely to operate simultaneously and for more than 6,000 hours per year. Furthermore, the assessed plant may not always operate at maximum load.

Protected conservation areas

For critical levels at the assessed local nature sites, the results indicate that the respective annual mean NOx and SO_2 PCs are less than 100% of the long-term environmental standard and the impact can also be described as 'insignificant'.

For the 24-hour mean critical level for NOx, the results indicate that the short-term NOx PCs are less than 100%, of the short-term environmental standard and can be described as 'insignificant'. The conservative approach adopted throughout this assessment means that, based on professional judgement, it is not considered likely that there would be unacceptable impacts to air quality at the assessed protected conservation areas as a consequence of the operation of the assessed CHP engine and boilers with regard to ambient concentrations of NOx and SO_2.

For acid deposition and nutrient nitrogen deposition, the results indicate that the respective PCs at the assessed local nature sites are less than 100% of the long-term environmental standard for protected conservation areas and the impact can be described as 'insignificant' as Environment Agency guidance (Environment Agency, 2021a).

As discussed above, the conservative approach adopted for this assessment means the predicted concentrations presented are likely to be higher than would reasonably be expected.

Summary

Based on the above assessment, it is concluded that the assessed CHP engine and boilers 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 and sensitive human receptor locations

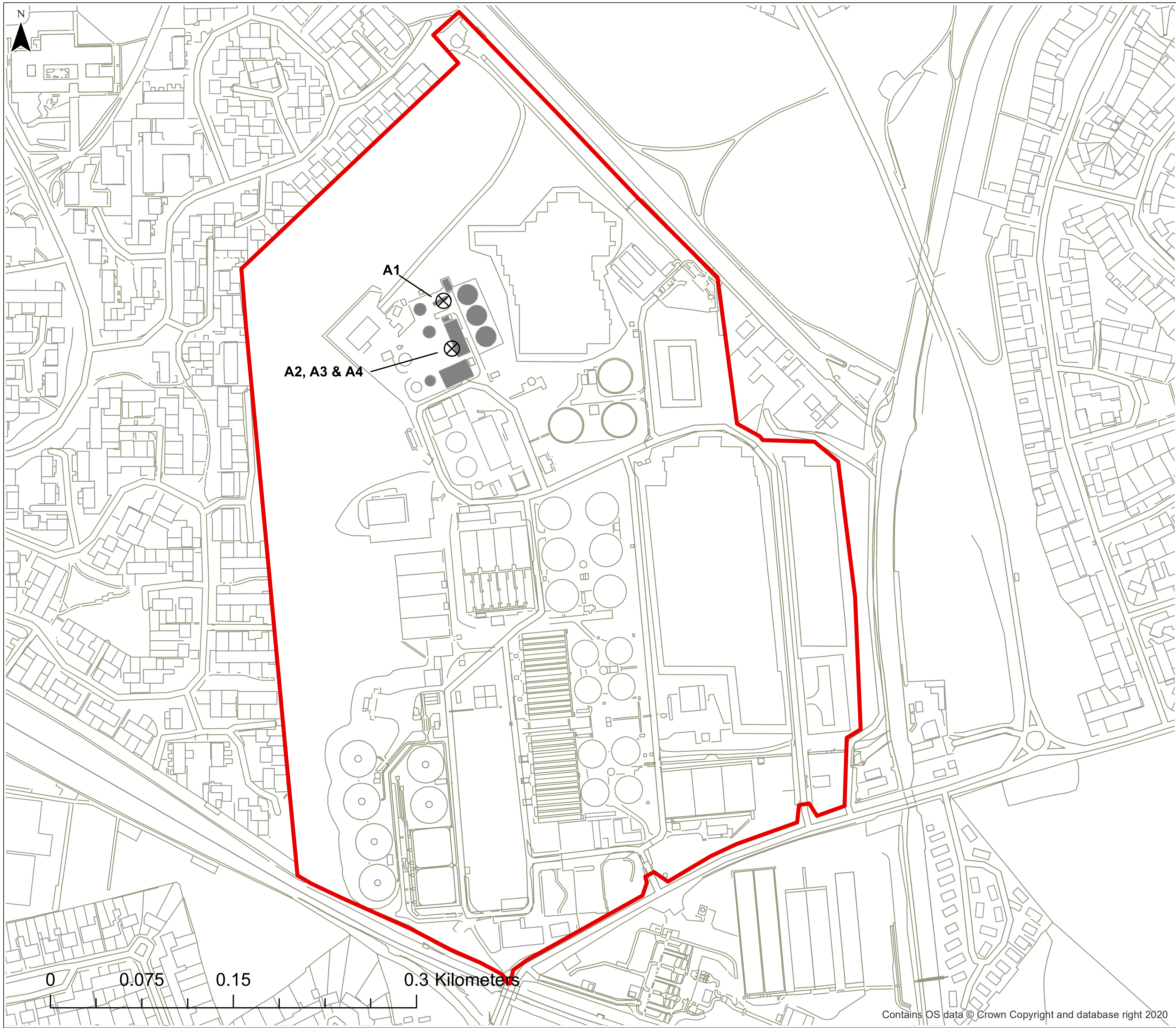
Figure 3: Assessed protected conservation areas

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

Figure 5: 1-hour mean (99.79th percentile) nitrogen dioxide process contributions, 2017 meteorological data

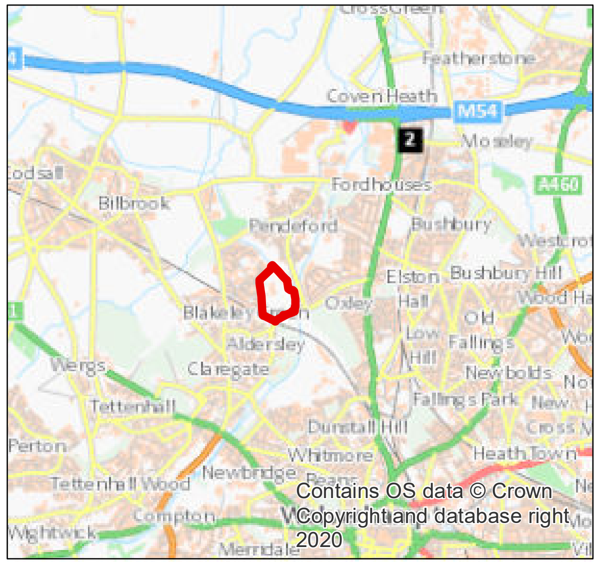
Figure 6: 1-hour mean (99.73rd percentile) sulphur dioxide process contributions, 2020 meteorological data

Figure 7: 15-minute mean (99.9th percentile) sulphur 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	14/12/2021	Initial Issue	DH	GW	GW	MM

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

Drawing Title

APPROXIMATE SITE FENCELINE, MODELLED STACK LOCATIONS AND MODELLED BUILDINGS

Drawing Status: FINAL

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Jacobs No.	B1958992	Rev	0
Client No.			

Drawing Number

FIGURE 1

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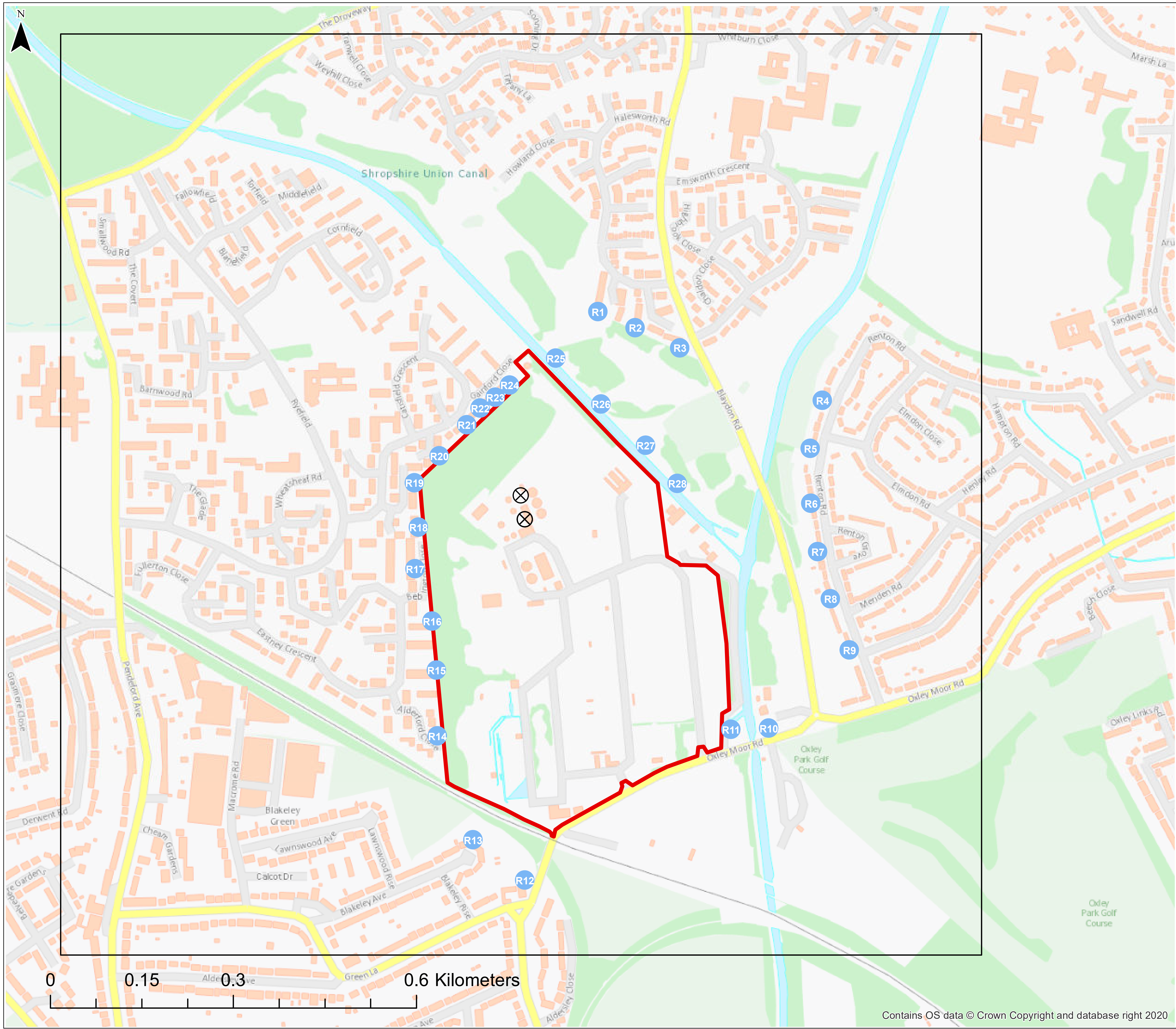
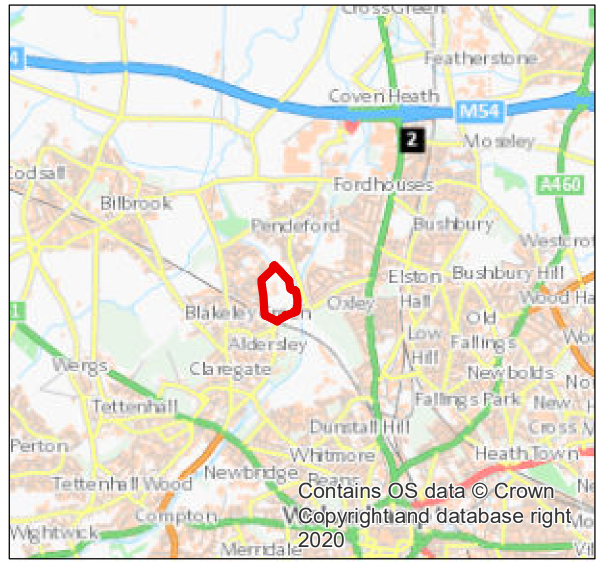


Legend

- Approximate site fenceline
- Modelled stack locations
- Extent of modelled grid
- Sensitive human receptor locations



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Jacobs

Client

SEVERN TRENT

Project

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

Drawing Title

EXTENT OF MODELLED GRID AND SENSITIVE HUMAN RECEPTOR LOCATIONS

Drawing Status

FINAL

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Client No.			

Drawing Number

FIGURE 2

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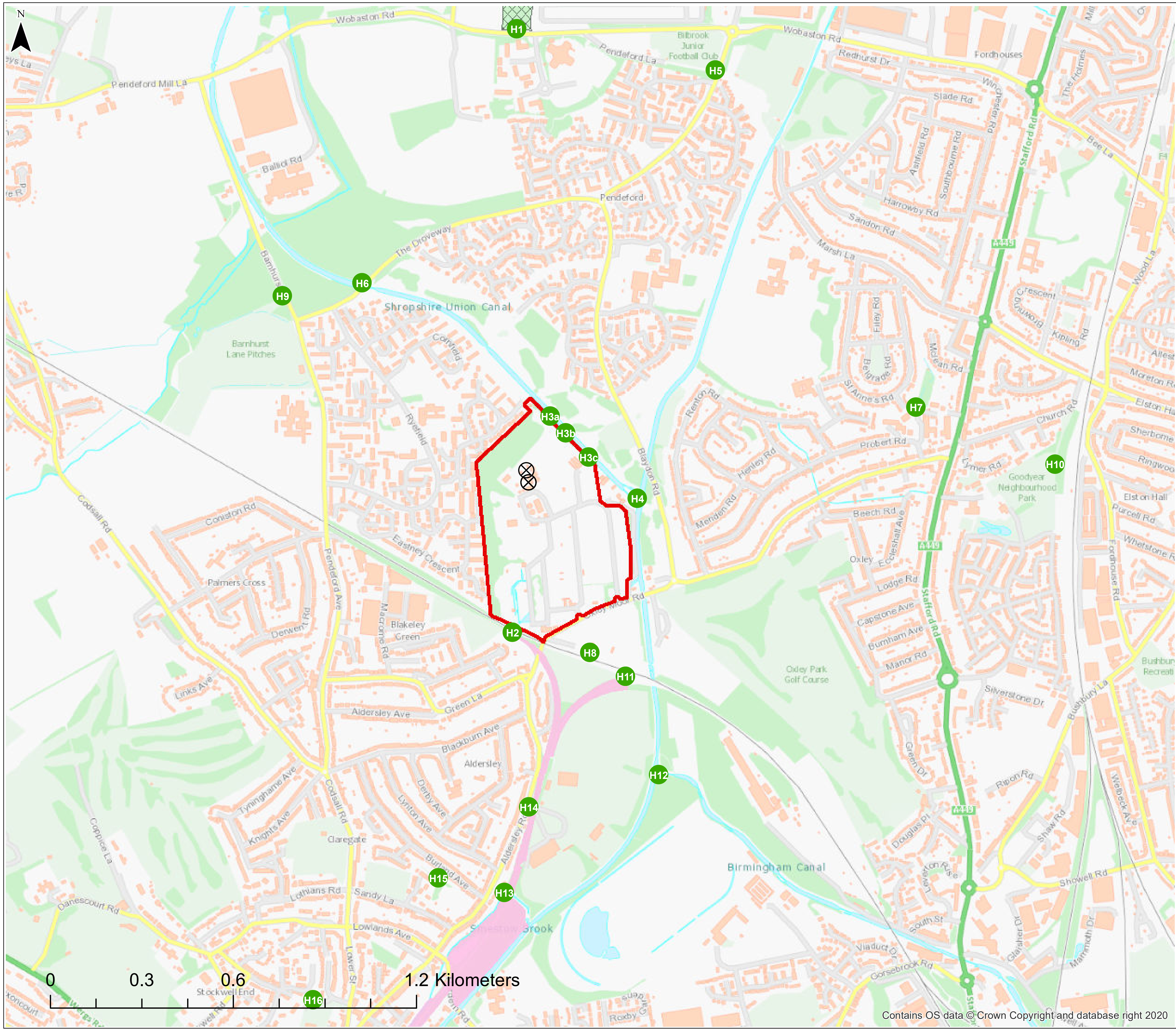
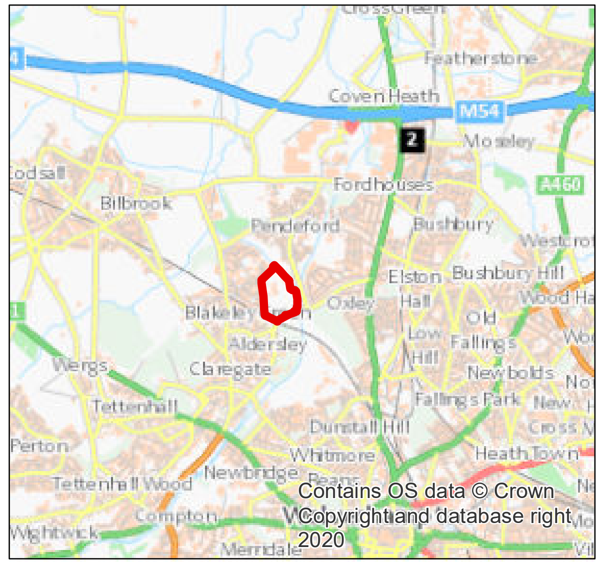


Legend

- Approximate site fenceline
- Modelled stack locations
- Local Nature Reserve (LNR)
- Ancient Woodland
- Assessed protected conservation area locations



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

Drawing Title: ASSESSED PROTECTED CONSERVATION AREAS

Drawing Status: FINAL

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Jacobs No.	B1958992	Rev 0
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Drawing Number: FIGURE 3

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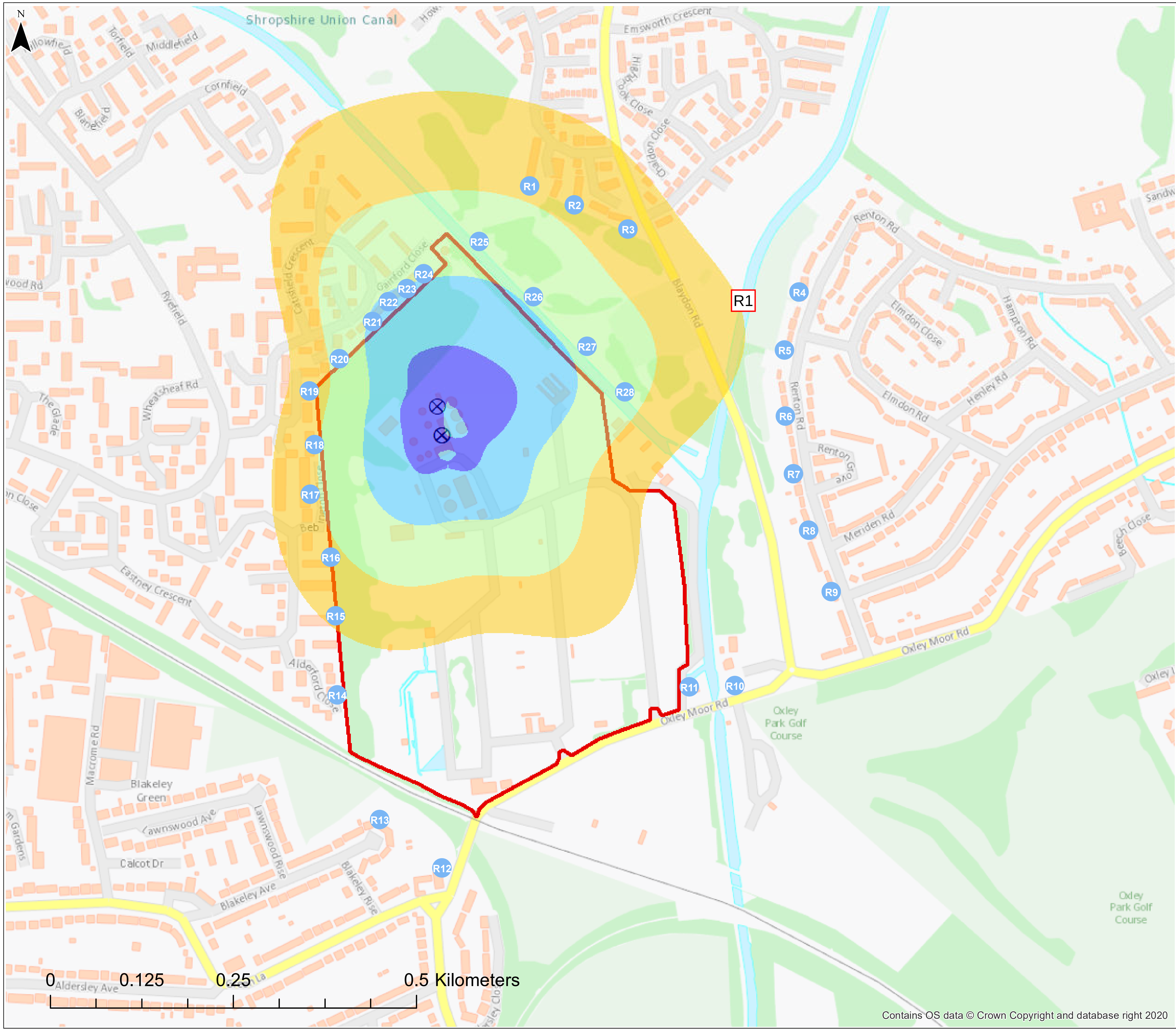

Legend

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

Annual mean nitrogen dioxide process contributions (µg/m³)

- 0 - 0.9
- 0.9 - 1.5
- 1.5 - 3
- 3 - 7
- 7 - 25.5

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Jacobs

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

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

Drawing Status: FINAL

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Jacobs No.	B1958992	Rev	0
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Drawing Number: FIGURE 4

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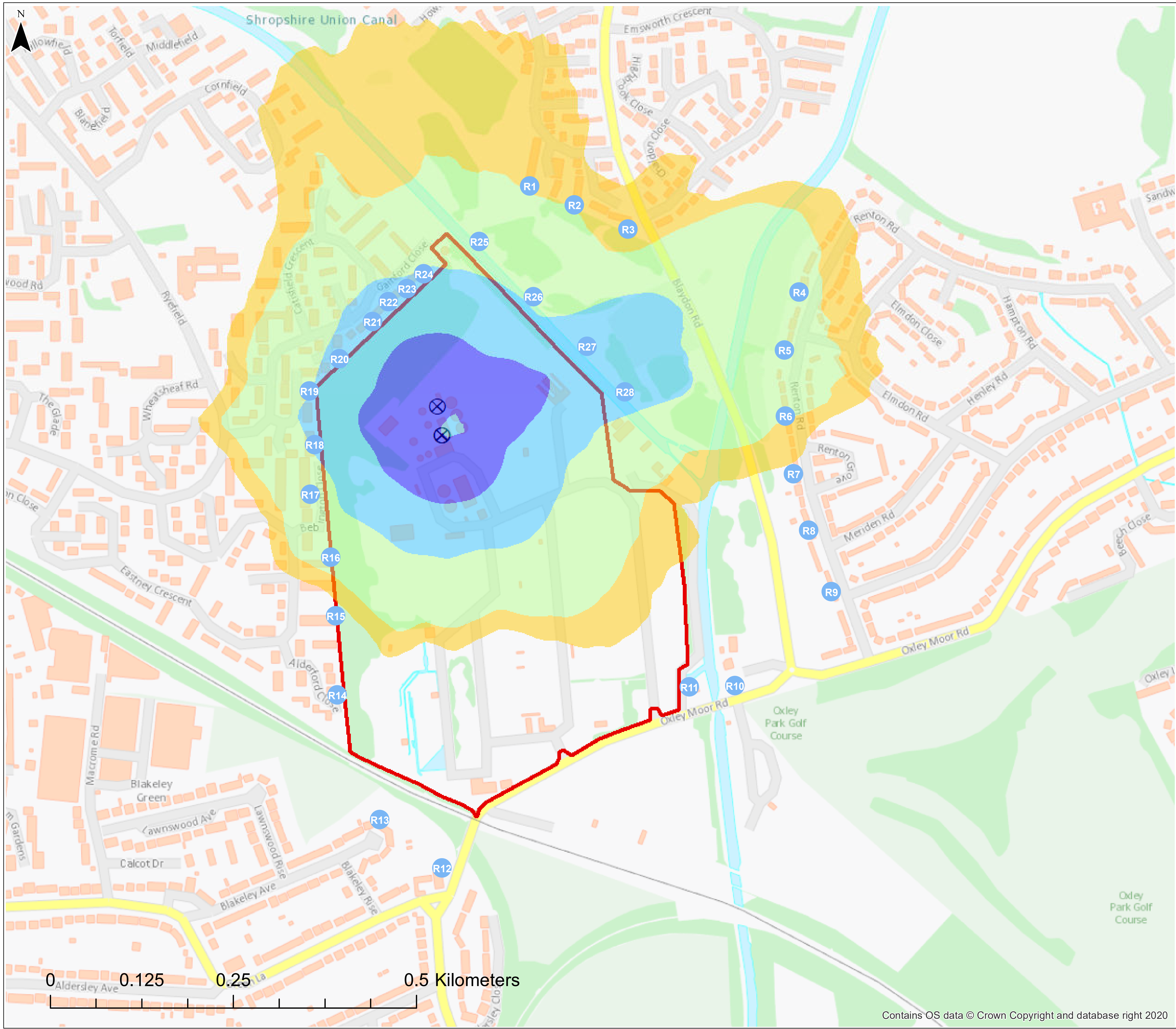

Legend

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

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

- 0 - 8
- 8 - 9
- 9 - 15
- 15- 27
- 27 - 107

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
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Project: ENVIRONMENTAL PERMIT APPLICATION - BARNHURST SEWAGE TREATMENT WORKS AIR QUALITY IMPACT ASSESSMENT

Drawing Title: 1-HOUR MEAN (99.79th PERCENTILE) NITROGEN DIOXIDE PROCESS CONTRIBUTIONS, 2017 METEOROLOGICAL DATA

Drawing Status: FINAL

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Drawing Number: FIGURE 5

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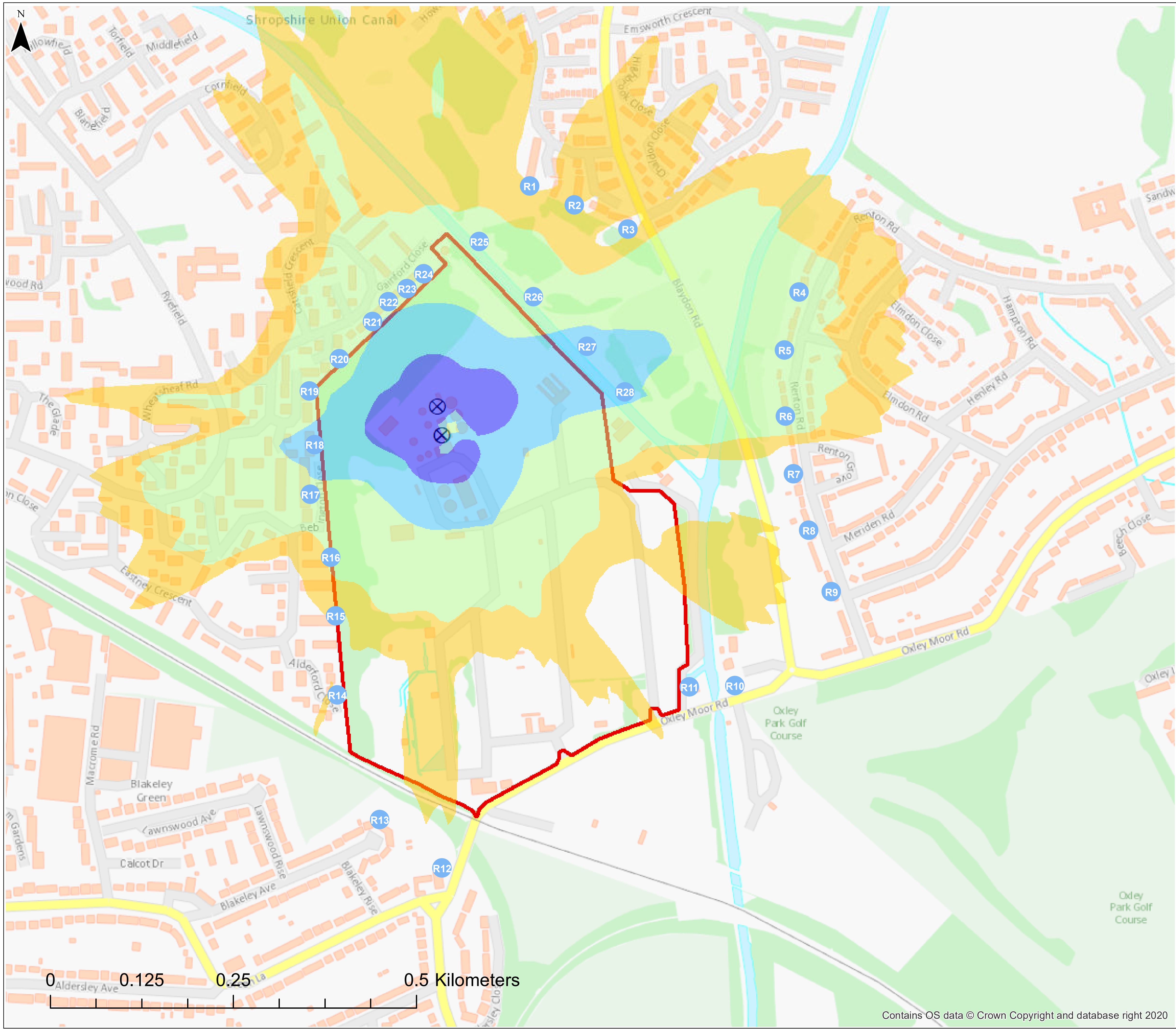

Legend

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

15-minute mean (99.9th percentile) sulphur dioxide process contributions (µg/m³)

- 0 - 3
- 3 - 3.5
- 3.5 - 6
- 6 - 10
- 10 - 37.2

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	14/12/2021	Initial Issue	DH	GW	GW	MM

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Client: SEVERN TRENT

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

Drawing Title: 15-MINUTE MEAN (99.9th PERCENTILE) SULPHUR DIOXIDE PROCESS CONTRIBUTIONS, 2016 METEOROLOGICAL DATA

Drawing Status: FINAL

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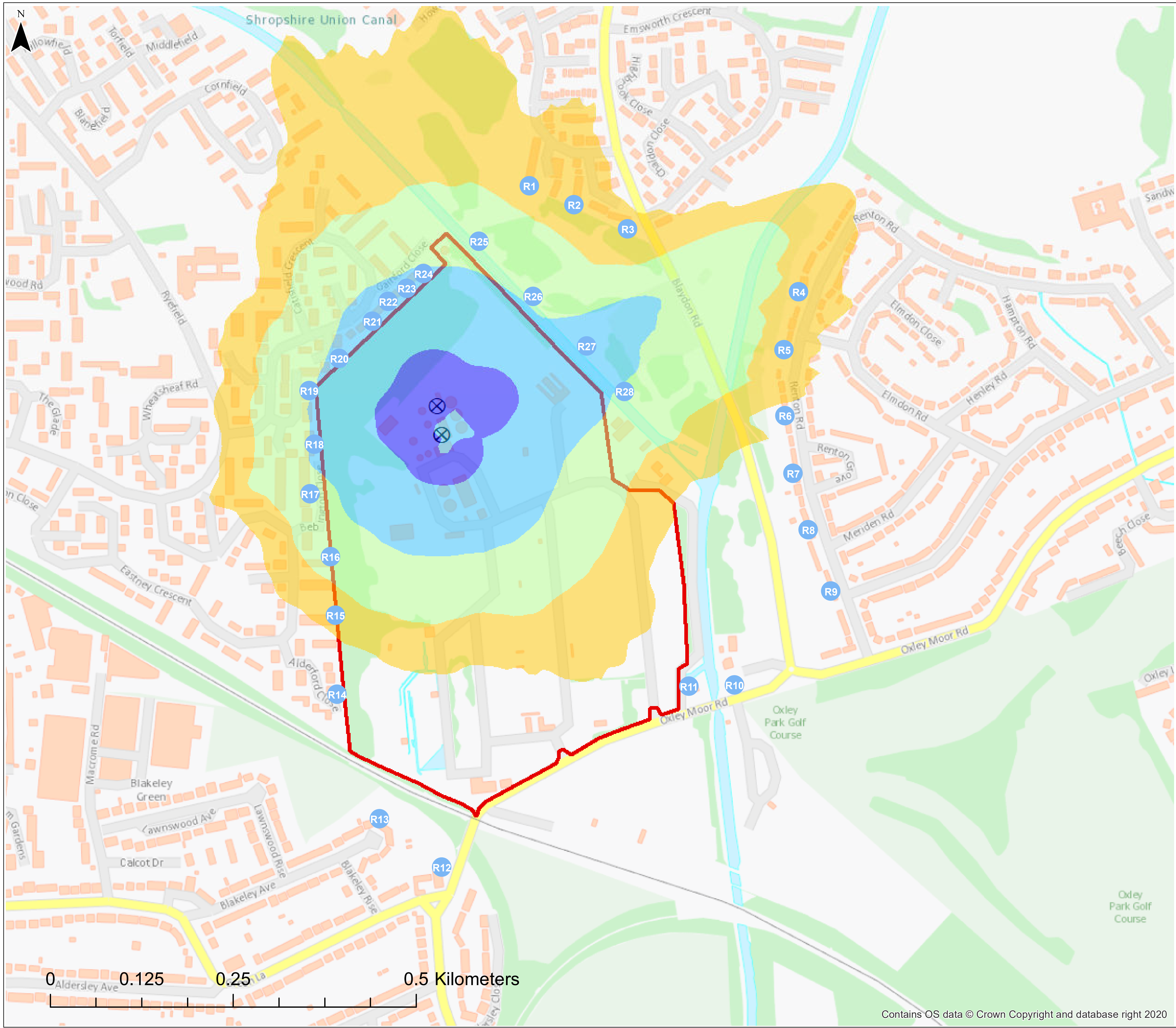
Drawing Number: FIGURE 7



Legend

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

1-hour mean (99.73rd percentile) sulphur dioxide process contributions (µg/m³)

- 0 - 2
- 2 - 2.5
- 2.5 - 4
- 4 - 9
- 9 - 31.9

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	14/12/2021	Initial Issue	DH	GW	GW	MM

Jacobs

Client: SEVERN TRENT

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

Drawing Title: 1-HOUR MEAN (99.73rd PERCENTILE) SULPHUR DIOXIDE PROCESS CONTRIBUTIONS, 2020 METEOROLOGICAL DATA

Drawing Status: FINAL

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Drawing Number: FIGURE 6

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 is set out in Table A.1. Emission limits as set out in the MCPD[3] for existing combustion plant are also presented in Table A.1 where relevant.

Table A.1 Dispersion modelling parameters

Parameters	Unit	JMC 316 (D25) GS-B.L CHP engine (2.1 MW_{th})	Broxley boiler (0.7 MW_{th})	Broxley boiler (0.7 MW_{th})	Broxley boiler (0.8 MW_{th})
Modelled fuel	-	Biogas	Biogas	Biogas	Biogas
Emission point	-	A1	A2	A3	A4
Assessed operation hours	Hours	8,760	8,760	8,760	8,760
Stack location	m	E 389839 N 302118	E 389846 N 302079[2]		
Stack position	-	Vertical	Vertical		
Stack height	m	7.00	6.80		
Stack diameter	m	0.40	0.30	0.30	0.30
Flue gas temperature	°C	180	150	150	150
Efflux velocity	m/s	16.4	8.9	8.9	9.9
Moisture content of exhaust gas	%	11.4	10.0	10.0	10.0
Oxygen content of exhaust gas (dry)	%	8.4	3.0	3.0	3.0
Volumetric flow rate (actual)	m^3/s	2.066	0.631	0.631	0.702
Volumetric flow rate (normal)[1]	Nm^3/s	2.338	0.367	0.367	0.407
NOx emission concentration[1]	mg/Nm^3	186 (190 after 1st January 2030)	250 (250 after 1st January 2030)	250 (250 after 1st January 2030)	250 (250 after 1st January 2030)
NOx emission rate	g/s	0.434	0.092	0.092	0.102
CO emission concentration[1]	mg/Nm^3	519	100	100	100
CO emission rate	g/s	1.215	0.037	0.037	0.041
PM_{10} / $PM_{2.5}$ emission concentration[1]	mg/Nm^3	2.7	5.0	5.0	5.0
PM_{10} / $PM_{2.5}$ emission rate	g/s	0.006	0.002	0.002	0.002
SO_2 emission concentration[1]	mg/Nm^3	19 (60 after 1st January 2030)	19 (200 after 1st January 2030)	19 (200 after 1st January 2030)	19 (200 after 1st January 2030)
SO_2 emission rate	g/s	0.045	0.007	0.007	0.008
TVOC emission concentration[1]	mg/Nm^3	371	1,126	1,126	1,126
TVOC emission rate	g/s	0.868	0.413	0.413	0.459

Note 1: Normalised flows and concentrations presented at 273 K, 101.3 kPa, dry gas and oxygen content of 15% (CHP engine) or 3% (boilers).
Note 2: The boilers exhaust gases exit via a shared stack, therefore, an aai file was used in the model to represent the effects of 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 Modelled building parameters

Building	Modelled building shapes	Length / diameter (m)	Width (m)	Height (m)	Angle of length to north	Centre point co-ordinates	
						Easting	Northing
Digester Tank[1]	Circular	16.80	-	14.10	-	389859	302123
CHP engine housing	Rectangular	12.20	2.90	2.60	63	389836	302118
Building 2	Rectangular	10.00	5.00	3.40	155	389842	302131
Building 3	Rectangular	5.00	3.50	3.40	65	389841	302103
Digester Tank	Circular	16.80	-	14.10	-	389866	302106
Tank	Circular	10.00	-	10.70	-	389820	302111
Tank	Circular	10.00	-	8.70	-	389827	302093
Boiler House	Rectangular	11.00	29.00	3.80	67	389850	302088
Digester Tank[2]	Circular	16.80	-	14.10	-	389874	302089
Building 10	Rectangular	24.50	15.10	7.50	65	389849	302058
Tank	Circular	8.40	-	6.70	-	389828	302052

Note 1: Modelled as the main building for emission point A1.
Note 2: Modelled as the main building for emission points A2, A3 & A4.

A.2.2 Other Model Inputs

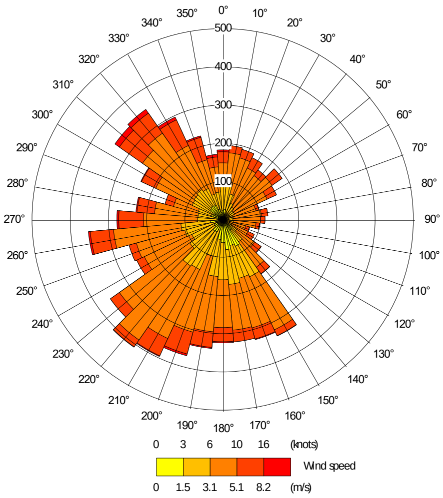
Table A.3: Other model inputs applied

Parameter	Value used	Comments
Surface roughness length for dispersion site	0.6 m	This is appropriate for the dispersion site where the local land-use range is typically suburban. 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	0.6 m	This is appropriate for an area where the local land-is relatively built-up such as at the location for the Birmingham Airport 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	Birmingham Airport meteorological station, 2016 - 2020	Birmingham Airport meteorological station is located approximately 32.8 km east-southeast of the site and is considered the closest most representative meteorological monitoring station to the site.
Combined flue option	Yes	The boilers exhaust gases exit via a shared stack, therefore, an aai file was used in the model to represent the effects of a single plume.

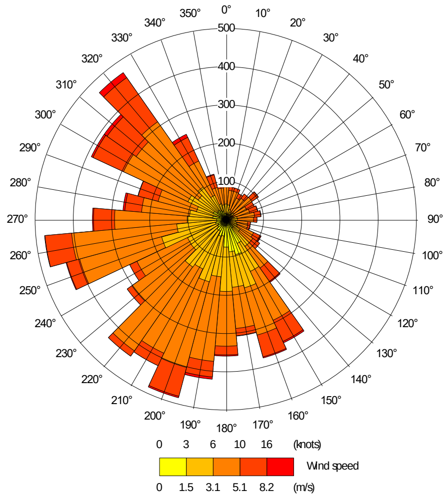
A.2.3 Meteorological Data – Wind Roses

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

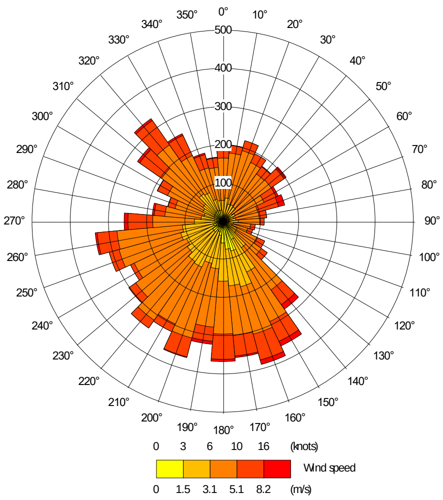
Birmingham Airport meteorological station, 2016



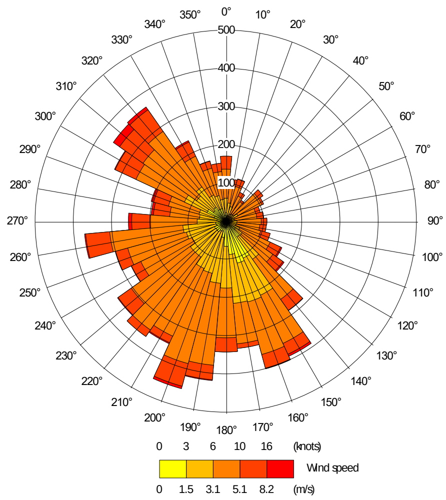
Birmingham Airport meteorological station, 2017



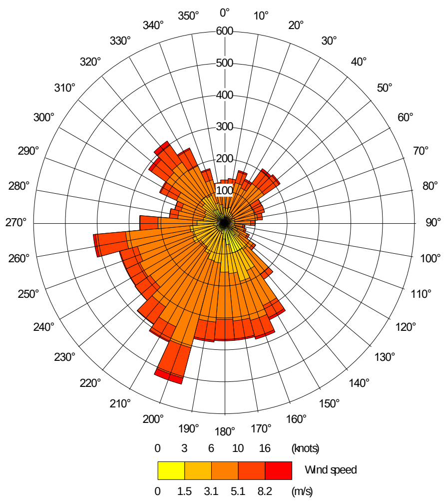
Birmingham Airport meteorological station, 2018



Birmingham Airport meteorological station, 2019



Birmingham Airport meteorological station, 2020



A.2.4 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	389089	390589	151	10
Northing	301368	302868	151	10
Grid height	1.5	1.5	1	-

As well as the modelled grid, the potential impact at 28 sensitive human receptors (e.g. exposure locations such as residential properties and a cycle path) and two 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 receptor locations are provided in Table A.5 and Table A.6.

Table A.5: Assessed sensitive human receptor locations

Receptor	Description	Grid reference		Distance from CHP engine stack (km)	Direction from CHP engine stack
		Easting	Northing		
R1	Residential property on Portswood Close	389966	302418	0.33	NNE
R2	Residential property on Chandlers Close	390027	302392	0.33	NE
R3	Residential property on Chandlers Close	390100	302359	0.36	NE
R4	Residential property on Renton Road	390334	302273	0.52	ENE
R5	Residential property on Renton Road	390314	302194	0.48	E
R6	Residential property on Renton Road	390315	302104	0.48	E
R7	Residential property on Renton Road	390326	302025	0.50	E
R8	Residential property on Renton Road	390347	301948	0.54	ESE
R9	Residential property on Renton Road	390378	301864	0.60	ESE
R10	Residential property on Oxley Moor Road	390246	301736	0.56	SE
R11	Residential property on Oxley Moor Road	390184	301734	0.52	SE
R12	Residential property on Green Lane	389846	301487	0.63	S
R13	Residential property on Blakeley Avenue	389761	301553	0.57	S
R14	Residential property on Alderford Close	389703	301723	0.42	SSW
R15	Residential property on Eastney Crescent	389701	301831	0.32	SSW
R16	Residential property on Eastney Crescent	389694	301911	0.25	SW
R17	Residential property on Bebington Close	389666	301997	0.21	SW
R18	Residential property on Coldridge Close	389672	302065	0.175	WSW
R19	Residential property on Coldridge Close	389665	302138	0.175	W

Receptor	Description	Grid reference		Distance from CHP engine stack (km)	Direction from CHP engine stack
		Easting	Northing		
R20	Residential property on Hilsea Close	389706	302182	0.15	WNW
R21	Residential property on Catisfield Crescent	389751	302233	0.14	NW
R22	Residential property on Catisfield Crescent	389773	302260	0.16	NNW
R23	Residential property on Gainford Close	389798	302278	0.16	NNW
R24	Residential property on Gainford Close	389821	302298	0.18	N
R25	National Cycle Route 81	389897	302342	0.23	NNE
R26	National Cycle Route 81	389971	302267	0.20	NE
R27	National Cycle Route 81	390044	302199	0.22	ENE
R28	National Cycle Route 81	390096	302137	0.26	E

Table A.6: Assessed protected conservation area locations

Receptor	Description	Grid reference		Distance from CHP engine stack (km)	Direction from CHP engine stack
		Easting	Northing		
H1	Pendeford Wood AW	389808	303563	1.45	N
H2	Smestow Valley LNR	389794	301586	0.53	S
H3a	Shropshire Union Canal LWS	389918	302294	0.19	NNE
H3b		389968	302239	0.18	NE
H3c		390044	302160	0.21	ENE
H4	Staffordshire and Worcestershire Canal LWS	390203	302025	0.38	ESE
H5	Land at Pendeford Lane LWS	390459	303428	1.45	NNE
H6	Droveway Former Tip (Pendeford Wood) LWS	389301	302731	0.82	NW
H7	Rakegate Wood LWS	391117	302324	1.29	E
H8	Oxley Sidings LWS	390048	301520	0.63	SSE
H9	Barnhurst Lane (land off) LWS	389040	302688	0.98	NW
H10	Bushbury Sidings LWS	391573	302137	1.73	E
H11	The Holdings at Oxley North LWS	390165	301442	0.75	SSE
H12	Dunstall Park Racecourse LWS	390273	301119	1.09	SSE
H13	The Holdings at Oxley South LWS	389767	300733	1.39	S
H14	Aldersley Stadium LWS	389848	301014	1.10	S
H15	Sandy Lane LWS	389551	300781	1.37	SSW
H16	St.Michael and All Angels Churchyard LWS	389140	300382	1.87	SSW

A.2.5 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, 2021b). This approach is likely to overestimate the annual mean NO_2 concentrations considerably at the most relevant assessment locations close to the site.

A.2.6 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, 2021a), 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 sources.

A.2.7 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 (z_o) selected is suitable to take general account of the typical size of these local features within the model domain; and
- 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.2.8 Conservative Assumptions

The conservative assumptions adopted in this study are summarised below.

- The CHP engine and boilers were assumed to operate at maximum load for 8,760 hours each calendar year but in practice, the CHP engine will have periods of shut-down and maintenance and may not always operate at maximum load. Furthermore, in practice, the boilers are not likely to operate simultaneously.
- 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 each assessed protected conservation area is present at the specific modelled location.

Appendix B. Biogas H_2S concentration and conversion to SO_2

When biogas is combusted in the assessed CHP engine and boilers, H_2S is oxidised to water and sulphur oxides (SOx). The mass balance equation published in US EPA AP-42 guidance (EPA, 2021), shown below, can be used to calculate the input of sulphur on the basis of the molecular ratio between the daughter and parent species. Where SO_2 is the daughter spies of the parent species (i.e. the sulphur containing compounds in the raw gas H_2S).

Figure B-1: Biogas H_2S conversion to SO_2 (SLR, 2010)

$$Mass_D\ (mg) = Mass_P\ (mg) * MM * (DE\%/100\%)$$

$Mass_D$	is the mass of Daughter Species (mg)
$Mass_P$	is the mass of Parent Species (mg)
MM	is the ratio of molecular mass e.g. $SO_2 : H_2S$
DE%	is the destruction efficiency of the emitted gas

In order to calculate the SO_2 concentration in the engine emissions, the equation must consider mass flow of AD gas and a dilution factor to account for combustion air in engine emissions, hence the calculation is:

$$Eng_{Emis}\ Conc_D\ (mg/m^3) = Conc_P\ (mg/m^3) * MM * (DE\%/100\%) / DF$$

$Eng_{Emi}\ Conc_D$	is the engine emission concentration of Daughter Species (mg/Nm^3)
$Conc_P$	is the mass of Parent Species (mg/m^3)
DF	is the dilution factor (for the Jenbacher 320 of 6.9 at 50% methane)
MM	is the ratio of molecular mass (for $SO_2 : H_2S$ this is 1.88)
DE%	is the destruction efficiency of the emitted gas (99%)

Note: the dilution factor (DF) of 6.9 has been applied for the assessed CHP engine and boilers.

Comparison of calculated SO_2 concentrations against measured SO_2 concentrations was undertaken for the Severn Trent site at Wanlip (SLR, 2010). The greatest underprediction of calculated SO_2 against measured SO_2 concentrations was 24% and therefore this value has been incorporated into the calculation shown above as follows:

Figure B-2 - Incorporation of 24% underprediction between calculated and measured SO_2 concentrations

$$Eng_{Emis}\ Conc_D\ (mg/m^3) = Conc_P\ (mg/m^3) * MM * (DE\%/100\%) / DF * 1.24$$

This provides a conservative approach to the estimation of SO_2 with emission rates around 1.24 times that of the average trend.

Appendix C. Calculating Acid and Nitrogen Deposition

C.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 (NO) and NO_2. It is generally accepted that there is no wet or dry deposition arising from NO in the atmosphere. Thus, it is normally necessary to distinguish between NO and NO_2 in a deposition assessment. In this case, the conservative assumption that 70% of the NOx are in the form of NO_2 was adopted.

Information on the existing nitrogen and acid deposition was obtained from the APIS database (Centre for Ecology and Hydrology, 2021). Information on the deposition critical loads for each habitat site was 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 in the AQTAG guidance note (AQTAG, 2014) are shown below in Table C.1.

Table C.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 C.2. To convert dry deposition flux to acid deposition (keq/ha/yr), multiply the concentrations by the factors shown in Table C.3.

Table C.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 C.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 D. Results at Sensitive Human Locations

Table D.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/m³)	Maximum 8-hour running mean					Maximum 1-hour mean				
		EQS (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)	EQS (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)
R1	264	10,000	43.3	307	0.4%	3.1%	30,000	58.7	323	0.2%	1.1%
R2	272		40.5	313	0.4%	3.1%		50.9	323	0.2%	1.1%
R3	272		37.0	309	0.4%	3.1%		59.3	331	0.2%	1.1%
R4	272		35.2	307	0.4%	3.1%		69.6	342	0.2%	1.1%
R5	272		38.7	311	0.4%	3.1%		81.3	353	0.3%	1.2%
R6	272		34.0	306	0.3%	3.1%		67.2	339	0.2%	1.1%
R7	272		31.4	303	0.3%	3.0%		65.9	338	0.2%	1.1%
R8	274		28.5	302	0.3%	3.0%		42.7	317	0.1%	1.1%
R9	274		22.1	296	0.2%	3.0%		39.4	313	0.1%	1.0%
R10	274		22.9	297	0.2%	3.0%		43.0	317	0.1%	1.1%
R11	274		34.6	308	0.3%	3.1%		44.8	319	0.1%	1.1%
R12	266		21.1	287	0.2%	2.9%		38.3	304	0.1%	1.0%
R13	266		23.7	290	0.2%	2.9%		41.8	308	0.1%	1.0%
R14	266		27.3	293	0.3%	2.9%		47.0	313	0.2%	1.0%
R15	266		38.4	304	0.4%	3.0%		59.3	325	0.2%	1.1%
R16	266		50.3	316	0.5%	3.2%		67.3	333	0.2%	1.1%
R17	266		112.6	378	1.1%	3.8%		176.1	442	0.6%	1.5%
R18	264		91.4	355	0.9%	3.6%		151.2	415	0.5%	1.4%
R19	264		84.1	348	0.8%	3.5%		224.2	488	0.7%	1.6%
R20	264		91.3	355	0.9%	3.6%		140.0	404	0.5%	1.3%
R21	264		96.9	361	1.0%	3.6%		141.0	405	0.5%	1.4%
R22	264		89.3	353	0.9%	3.5%		131.6	396	0.4%	1.3%
R23	264		85.8	350	0.9%	3.5%		104.6	369	0.3%	1.2%
R24	264		76.4	340	0.8%	3.4%		98.3	362	0.3%	1.2%
R25	264		59.4	323	0.6%	3.2%		86.6	351	0.3%	1.2%
R26	264		66.5	331	0.7%	3.3%		94.5	359	0.3%	1.2%

Receptor ID	Baseline air quality level (µg/m³)	Maximum 8-hour running mean					Maximum 1-hour mean				
		EQS (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)	EQS (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)
R27	272		76.4	348	0.8%	3.5%		122.6	395	0.4%	1.3%
R28	272		78.0	350	0.8%	3.5%		112.3	384	0.4%	1.3%

Table D.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	11.6	40	1.7	13.3	4.2%	33.3%	200	23.3	9.5	32.7	4.7%	16.4%
R2	13.2		1.6	14.8	4.1%	37.1%		26.3	9.0	35.3	4.5%	17.7%
R3	13.2		1.4	14.5	3.4%	36.4%		26.3	8.7	35.1	4.4%	17.5%
R4	13.2		0.9	14.1	2.2%	35.1%		26.3	10.0	36.3	5.0%	18.2%
R5	13.2		1.0	14.1	2.4%	35.4%		26.3	10.6	36.9	5.3%	18.5%
R6	13.2		0.9	14.0	2.1%	35.1%		26.3	9.3	35.6	4.6%	17.8%
R7	13.2		0.7	13.9	1.7%	34.6%		26.3	7.6	34.0	3.8%	17.0%
R8	12.8		0.6	13.3	1.4%	33.4%		25.5	6.3	31.8	3.2%	15.9%
R9	12.8		0.5	13.3	1.3%	33.2%		25.5	6.8	32.3	3.4%	16.2%
R10	12.8		0.7	13.4	1.7%	33.6%		25.5	5.8	31.3	2.9%	15.7%
R11	12.8		0.7	13.5	1.8%	33.7%		25.5	7.0	32.5	3.5%	16.3%
R12	12.6		0.3	13.0	0.8%	32.4%		25.3	5.6	30.9	2.8%	15.4%
R13	12.6		0.4	13.0	0.9%	32.6%		25.3	5.5	30.8	2.7%	15.4%
R14	12.6		0.6	13.3	1.6%	33.2%		25.3	7.4	32.7	3.7%	16.3%
R15	12.6		1.0	13.6	2.4%	34.0%		25.3	8.9	34.2	4.5%	17.1%
R16	12.6		1.3	14.0	3.3%	34.9%		25.3	11.5	36.8	5.8%	18.4%
R17	12.6		1.3	14.0	3.4%	35.0%		25.3	14.3	39.6	7.1%	19.8%
R18	11.6		1.4	13.0	3.5%	32.6%		23.3	17.5	40.7	8.7%	20.4%
R19	11.6		1.3	12.9	3.2%	32.3%		23.3	15.4	38.7	7.7%	19.3%
R20	11.6		2.1	13.7	5.2%	34.3%		23.3	18.0	41.2	9.0%	20.6%

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 (%)
R21	11.6		3.3	14.9	8.1%	37.2%		23.3	19.3	42.5	9.6%	21.3%
R22	11.6		3.3	14.9	8.3%	37.3%		23.3	18.3	41.5	9.1%	20.8%
R23	11.6		3.2	14.8	7.9%	37.0%		23.3	17.2	40.5	8.6%	20.3%
R24	11.6		3.0	14.6	7.5%	36.6%		23.3	16.3	39.6	8.1%	19.8%
R25	11.6		2.6	14.3	6.6%	35.7%		23.3	12.6	35.9	6.3%	17.9%
R26	11.6		3.3	15.0	8.3%	37.4%		23.3	14.3	37.6	7.1%	18.8%
R27	13.2		3.1	16.3	7.7%	40.7%		26.3	20.2	46.5	10.1%	23.3%
R28	13.2		2.5	15.6	6.1%	39.1%		26.3	17.9	44.2	8.9%	22.1%

Table D.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	7.0	125	1.2	8.2	0.9%	6.6%	350	7.0	2.4	9.4	0.7%	2.7%
R2	7.2		1.1	8.4	0.9%	6.7%		7.2	2.3	9.6	0.7%	2.7%
R3	7.2		0.9	8.1	0.7%	6.5%		7.2	2.3	9.5	0.7%	2.7%
R4	7.2		0.6	7.8	0.5%	6.3%		7.2	2.5	9.7	0.7%	2.8%
R5	7.2		0.7	7.9	0.6%	6.3%		7.2	2.5	9.8	0.7%	2.8%
R6	7.2		0.6	7.8	0.5%	6.3%		7.2	2.3	9.6	0.7%	2.7%
R7	7.2		0.6	7.8	0.5%	6.2%		7.2	2.1	9.4	0.6%	2.7%
R8	6.0		0.4	6.4	0.3%	5.1%		6.0	1.6	7.6	0.4%	2.2%
R9	6.0		0.4	6.4	0.3%	5.1%		6.0	1.6	7.6	0.4%	2.2%
R10	6.0		0.5	6.5	0.4%	5.2%		6.0	1.5	7.5	0.4%	2.1%
R11	6.0		0.6	6.6	0.5%	5.3%		6.0	1.7	7.7	0.5%	2.2%
R12	6.4		0.4	6.8	0.3%	5.5%		6.4	1.3	7.7	0.4%	2.2%

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 (%)
R13	6.4		0.5	6.9	0.4%	5.6%		6.4	1.4	7.8	0.4%	2.2%
R14	6.4		0.8	7.2	0.6%	5.8%		6.4	1.9	8.3	0.6%	2.4%
R15	6.4		1.2	7.7	1.0%	6.1%		6.4	2.3	8.7	0.7%	2.5%
R16	6.4		1.5	7.9	1.2%	6.3%		6.4	2.9	9.4	0.8%	2.7%
R17	6.4		1.7	8.2	1.4%	6.5%		6.4	3.4	9.9	1.0%	2.8%
R18	7.0		2.0	9.0	1.6%	7.2%		7.0	4.6	11.6	1.3%	3.3%
R19	7.0		2.0	9.0	1.6%	7.2%		7.0	4.0	11.1	1.2%	3.2%
R20	7.0		2.9	10.0	2.3%	8.0%		7.0	4.8	11.9	1.4%	3.4%
R21	7.0		3.3	10.3	2.6%	8.3%		7.0	5.1	12.2	1.5%	3.5%
R22	7.0		3.1	10.1	2.5%	8.1%		7.0	4.9	11.9	1.4%	3.4%
R23	7.0		3.0	10.0	2.4%	8.0%		7.0	4.6	11.6	1.3%	3.3%
R24	7.0		2.5	9.6	2.0%	7.6%		7.0	4.3	11.3	1.2%	3.2%
R25	7.0		1.8	8.8	1.4%	7.1%		7.0	3.3	10.4	1.0%	3.0%
R26	7.0		2.2	9.2	1.7%	7.4%		7.0	3.8	10.8	1.1%	3.1%
R27	7.2		1.9	9.1	1.5%	7.3%		7.2	5.2	12.5	1.5%	3.6%
R28	7.2		1.6	8.8	1.3%	7.1%		7.2	4.6	11.8	1.3%	3.4%

Table D.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	7.0	266	3.1	10.2	1.2%	3.8%
R2	7.2		3.0	10.3	1.1%	3.9%
R3	7.2		3.1	10.3	1.2%	3.9%
R4	7.2		4.0	11.3	1.5%	4.2%
R5	7.2		4.3	11.5	1.6%	4.3%
R6	7.2		3.8	11.0	1.4%	4.1%

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 (%)
R7	7.2		3.0	10.2	1.1%	3.8%
R8	6.0		2.8	8.8	1.1%	3.3%
R9	6.0		2.8	8.8	1.0%	3.3%
R10	6.0		2.8	8.8	1.1%	3.3%
R11	6.0		3.1	9.1	1.2%	3.4%
R12	6.4		2.6	9.0	1.0%	3.4%
R13	6.4		2.1	8.6	0.8%	3.2%
R14	6.4		2.9	9.3	1.1%	3.5%
R15	6.4		3.0	9.4	1.1%	3.5%
R16	6.4		3.6	10.0	1.4%	3.8%
R17	6.4		5.0	11.4	1.9%	4.3%
R18	7.0		7.4	14.4	2.8%	5.4%
R19	7.0		5.2	12.2	1.9%	4.6%
R20	7.0		5.4	12.4	2.0%	4.7%
R21	7.0		5.8	12.9	2.2%	4.8%
R22	7.0		5.6	12.7	2.1%	4.8%
R23	7.0		5.4	12.5	2.0%	4.7%
R24	7.0		5.1	12.2	1.9%	4.6%
R25	7.0		4.1	11.2	1.5%	4.2%
R26	7.0		4.4	11.5	1.7%	4.3%
R27	7.2		7.2	14.4	2.7%	5.4%
R28	7.2		6.9	14.1	2.6%	5.3%

Table D.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	12.0	40	0.04	12.0	0.10%	30.1%	50	24.0	0.12	24.1	0.2%	48.2%
R2	12.3		0.04	12.3	0.10%	30.9%		24.6	0.11	24.7	0.2%	49.4%
R3	12.3		0.03	12.3	0.08%	30.8%		24.6	0.10	24.7	0.2%	49.4%
R4	12.3		0.02	12.3	0.05%	30.8%		24.6	0.06	24.7	0.1%	49.3%
R5	12.3		0.02	12.3	0.06%	30.8%		24.6	0.07	24.7	0.1%	49.3%
R6	12.3		0.02	12.3	0.05%	30.8%		24.6	0.06	24.7	0.1%	49.3%
R7	12.3		0.02	12.3	0.04%	30.8%		24.6	0.05	24.7	0.1%	49.3%
R8	12.2		0.01	12.2	0.03%	30.6%		24.4	0.04	24.5	0.1%	48.9%
R9	12.2		0.01	12.2	0.03%	30.6%		24.4	0.04	24.5	0.1%	48.9%
R10	12.2		0.02	12.2	0.04%	30.6%		24.4	0.06	24.5	0.1%	49.0%
R11	12.2		0.02	12.2	0.04%	30.6%		24.4	0.06	24.5	0.1%	49.0%
R12	12.2		0.01	12.2	0.02%	30.4%		24.3	0.03	24.4	0.1%	48.7%
R13	12.2		0.01	12.2	0.02%	30.4%		24.3	0.03	24.4	0.1%	48.7%
R14	12.2		0.02	12.2	0.04%	30.5%		24.3	0.06	24.4	0.1%	48.8%
R15	12.2		0.02	12.2	0.06%	30.5%		24.3	0.10	24.4	0.2%	48.9%
R16	12.2		0.03	12.2	0.08%	30.5%		24.3	0.15	24.5	0.3%	49.0%
R17	12.2		0.03	12.2	0.08%	30.5%		24.3	0.14	24.5	0.3%	48.9%
R18	12.0		0.03	12.0	0.08%	30.0%		24.0	0.14	24.1	0.3%	48.2%
R19	12.0		0.03	12.0	0.08%	30.0%		24.0	0.13	24.1	0.3%	48.2%
R20	12.0		0.05	12.0	0.13%	30.1%		24.0	0.20	24.17	0.4%	48.3%
R21	12.0		0.08	12.1	0.19%	30.2%		24.0	0.28	24.3	0.6%	48.5%
R22	12.0		0.08	12.1	0.19%	30.2%		24.0	0.28	24.2	0.6%	48.5%
R23	12.0		0.07	12.1	0.18%	30.1%		24.0	0.24	24.2	0.5%	48.4%
R24	12.0		0.07	12.1	0.17%	30.1%		24.0	0.23	24.2	0.5%	48.4%
R25	12.0		0.06	12.0	0.15%	30.1%		24.0	0.19	24.2	0.4%	48.3%

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 (%)
R26	12.0		0.08	12.1	0.20%	30.2%		24.0	0.23	24.2	0.5%	48.4%
R27	12.3		0.07	12.4	0.18%	30.9%		24.6	0.21	24.8	0.4%	49.6%
R28	12.3		0.06	12.4	0.15%	30.9%		24.6	0.17	24.8	0.3%	49.6%

Table D.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/m³)	EQS (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)
R1	8.0	20	0.04	8.1	0.2%	40.4%
R2	8.3		0.04	8.4	0.2%	41.9%
R3	8.3		0.03	8.4	0.2%	41.9%
R4	8.3		0.02	8.4	0.1%	41.8%
R5	8.3		0.02	8.4	0.1%	41.8%
R6	8.3		0.02	8.4	0.1%	41.8%
R7	8.3		0.02	8.4	0.1%	41.8%
R8	8.2		0.01	8.2	0.1%	41.1%
R9	8.2		0.01	8.2	0.1%	41.1%
R10	8.2		0.02	8.2	0.1%	41.1%
R11	8.2		0.02	8.2	0.1%	41.1%
R12	8.1		0.01	8.2	0.0%	40.8%
R13	8.1		0.01	8.2	0.0%	40.8%
R14	8.1		0.02	8.2	0.1%	40.8%
R15	8.1		0.02	8.2	0.1%	40.9%
R16	8.1		0.03	8.2	0.2%	40.9%
R17	8.1		0.03	8.2	0.2%	40.9%
R18	8.0		0.03	8.1	0.2%	40.4%

Receptor ID	Annual mean					
	Baseline air quality level (µg/m³)	EQS (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)
R19	8.0		0.03	8.1	0.2%	40.4%
R20	8.0		0.05	8.1	0.3%	40.5%
R21	8.0		0.08	8.1	0.4%	40.6%
R22	8.0		0.08	8.1	0.4%	40.6%
R23	8.0		0.07	8.1	0.4%	40.6%
R24	8.0		0.07	8.1	0.3%	40.6%
R25	8.0		0.06	8.1	0.3%	40.6%
R26	8.0		0.08	8.1	0.4%	40.6%
R27	8.3		0.07	8.4	0.4%	42.1%
R28	8.3		0.06	8.4	0.3%	42.0%

Table D.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 24-hour mean					
	Baseline air quality level	EQS (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)	EQS (µg/m³)	Baseline air quality level	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)
R1	0.3	5 (Benzene)	7.1	7.4	141.6%	147.3%	30 (Benzene)	0.6	65.3	65.8	217.6%	219.5%
R2	0.3		7.0	7.3	139.7%	145.7%		0.6	42.5	43.1	141.6%	143.6%
R3	0.3		5.9	6.2	118.3%	124.4%		0.6	38.2	38.8	127.5%	129.5%
R4	0.3		3.8	4.1	75.7%	81.7%		0.6	27.5	28.1	91.8%	93.8%
R5	0.3		4.2	4.5	84.6%	90.6%		0.6	28.3	28.9	94.5%	96.5%
R6	0.3		3.7	4.0	74.5%	80.5%		0.6	22.7	23.3	75.8%	77.8%
R7	0.3		3.0	3.3	59.4%	65.4%		0.6	21.4	22.0	71.2%	73.2%
R8	0.3		2.5	2.8	50.0%	56.3%		0.6	20.2	20.8	67.4%	69.5%
R9	0.3		2.2	2.5	44.6%	50.9%		0.6	17.1	17.8	57.1%	59.2%
R10	0.3		2.9	3.2	58.5%	64.8%		0.6	23.5	24.1	78.2%	80.3%
R11	0.3		3.2	3.6	64.9%	71.2%		0.6	37.7	38.3	125.6%	127.7%
R12	0.3		1.3	1.6	27.0%	32.9%		0.6	22.6	23.2	75.4%	77.3%

Receptor ID	Annual mean						100th percentile of 24-hour mean					
	Baseline air quality level	EQS ($\mu g/m^3$)	PC ($\mu g/m^3$)	PEC ($\mu g/m^3$)	PC/EQS (%)	PEC/EQS (%)	EQS ($\mu g/m^3$)	Baseline air quality level	PC ($\mu g/m^3$)	PEC ($\mu g/m^3$)	PC/EQS (%)	PEC/EQS (%)
R13	0.3		1.6	1.9	32.9%	38.8%		0.6	22.2	22.8	74.2%	76.2%
R14	0.3		2.8	3.1	56.5%	62.4%		0.6	34.9	35.5	116.2%	118.2%
R15	0.3		4.3	4.6	86.2%	92.2%		0.6	45.2	45.8	150.8%	152.8%
R16	0.3		5.8	6.1	116.5%	122.5%		0.6	62.2	62.8	207.5%	209.5%
R17	0.3		5.7	6.0	114.9%	120.9%		0.6	83.0	83.6	276.5%	278.5%
R18	0.3		5.9	6.2	117.6%	123.3%		0.6	89.9	90.4	299.5%	301.4%
R19	0.3		5.6	5.9	112.4%	118.1%		0.6	74.3	74.9	247.8%	249.7%
R20	0.3		9.0	9.3	180.8%	186.5%		0.6	100.7	101.3	335.7%	337.6%
R21	0.3		13.7	14.0	273.8%	279.5%		0.6	121.1	121.7	403.6%	405.5%
R22	0.3		13.7	13.9	273.1%	278.8%		0.6	109.6	110.2	365.4%	367.3%
R23	0.3		13.0	13.2	259.2%	264.9%		0.6	99.4	99.9	331.2%	333.1%
R24	0.3		12.3	12.6	246.2%	251.9%		0.6	82.9	83.4	276.2%	278.1%
R25	0.3		10.9	11.2	217.7%	223.4%		0.6	91.1	91.6	303.5%	305.4%
R26	0.3		14.1	14.4	281.6%	287.3%		0.6	82.0	82.6	273.4%	275.3%
R27	0.3		13.0	13.3	259.3%	265.3%		0.6	66.3	66.9	221.1%	223.1%
R28	0.3		10.8	11.1	215.9%	222.0%		0.6	63.5	64.1	211.8%	213.8%