Environmental Permit Application – Stanley Downton Sewage Treatment Works

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Severn Trent Water Limited

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Environmental Permit Application – Stanley Downton Sewage Treatment Works

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Executive summary

Under the Industrial Emissions Directive (IED), the anaerobic digestion assets at Stanley Downton 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 combined heat and power (CHP) gas engine and boilers.

Severn Trent Water Limited operates a STW near the village of Stanley Downton, Gloucestershire (GL10 3QX). These operations include; an existing Combined Heat and Power (CHP) engine (with a thermal input capacity of 0.6 MW_{th}) and two existing duel fuelled boilers (each with a thermal input capacity of 0.4 MW_{th}) as set out in the table below.

Medium Combustion Plant Information			
MCP specific identifier (emission source reference)	CHP engine 1 (A1)	Boiler 1 (A2)	Boiler 2 (A3)
12 - digit grid reference or latitude/longitude	E 379159 N 204580	E 379167 N 204560	E 379168 N 204560
Rated thermal input (MW) of the MCP	0.6	0.4	0.4
Type of MCP (diesel engine, gas turbine, other engine or other MCP)	Gas engine	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.
Date when the new MCP was first put into operation (DD/MM/YYYY)	2015	Pre-2010	Pre-2010
Sector of activity of the MCP or the facility in which it is applied (NACE code**)	E37.00	E37.00	E37.00
Expected number of annual operating hours of the MCP and average load in use	Modelled continuously (i.e. 8,760 hours) at maximum load	Modelled continuously (i.e. 8,760 hours) at maximum load	Modelled continuously (i.e. 8,760 hours) at maximum load
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

The application is collated to include the required application forms Part A, C3 and F1. As the site has a CHP engine, the information required for application form Part B2.5, Appendix 1 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 Stanley Downton STW.

The potential impacts were determined for the following aspect:

- 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); and
- the potential impact on vegetation and ecosystems due to emissions of oxides of nitrogen (NOx) and SO_2.

Human receptors

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

For TVOCs, exceedances of the annual mean and 24-hour mean EQS for C_6H_6 were predicted. However, it is an unrealistic assumption that total TVOCs emitted by the combustion plant are C_6H_6. If present in the exhaust gases, C_6H_6 would constitute only a very small proportion of total TVOC emissions (e.g. less than 1%). Therefore, it is likely there would be no exceedance of EQSs associated with TVOC emissions and based on professional judgement, the emissions of TVOCs is considered 'not significant'.

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

Protected conservation areas

For critical levels, at the assessed European designated site and local nature sites, the annual mean NOx and SO_2 PCs are less than 1% and 100%, respectively, of the relevant critical level and the effect is considered 'insignificant'. For the maximum 24-hour mean critical level for NOx, the results indicate that at the assessed European designated site and local nature sites, the PC's are less than 10% and 100% of the relevant critical level, respectively, and the effect is also considered 'insignificant'.

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

Summary

This assessment has been carried out on the assumption that the CHP engine and boilers would operate continuously at maximum load all year. This is a conservative assumption as, in practice, the CHP engine and boilers would 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.

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

Contents

Executive summary ..... **iii**
1. Introduction **1**
1.1 Background 1
1.2 Study Outline 1
2. Emission Sources **2**
2.1 Emission Sources to Air 2
2.2 Emissions Data 2
3. Assessment Methodology **4**
3.1 Assessment Location 4
3.2 Overall Methodology 4
3.3 Assessment Criteria 5
4. Existing Environment **10**
4.1 Location 10
4.2 Local Air Quality Management 10
4.3 Existing Deposition Rates 12
5. Results **14**
5.1 Human Receptors 14
5.2 Protected Conservation Areas 16
5.3 Sensitivity Analysis 21
6. Conclusions **23**
6.1 Human receptors 23
6.2 Protected conservation areas 23
6.3 Summary 23
7. References **24**
8. Figures **26**

Appendices

Appendix A. Dispersion Model Input Parameters **32**
A.1 Emission Parameters 32
A.2 Dispersion Model Inputs 33
A.2.1 Structural influences on dispersion 33
A.3 Other model inputs 33
A.3.1 Meteorological Data 33
A.3.2 Model Domain/Study Area 35
A.3.3 Treatment of oxides of nitrogen 36
A.3.4 Calculation of PECs 36
A.3.5 Modelling Uncertainty 36
A.3.6 Conservative Assumptions 37
Appendix B. Calculating Acid and Nitrogen Deposition **38**

B.1 Methodology 38
Appendix C. Results at Sensitive Human Locations 39

1. Introduction

1.1 Background

Under the Industrial Emissions Directive (IED)[1], the anaerobic digestion assets at Stanley Downton 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 (hereafter 'Severn Trent') currently operates one biogas fuelled CHP engine (with a thermal input capacity of 0.6 MW_{th}) and two duel-fuelled[2] boilers (each with a thermal input capacity of 0.4 MW_{th}) at its STW near the village of Stanley Downton, Gloucestershire (GL10 3QX) (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, 2021; 2022;). The AQIA considers:

- the potential impact on human health due to emissions of pollutants. The pollutants considered include nitrogen dioxide (NO_2); carbon monoxide (CO); sulphur dioxide (SO_2), total volatile organic compounds (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); and
- the potential impact on vegetation and ecosystems due to emissions of oxides of nitrogen (NOx) and SO_2.

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

This report draws upon information provided from the following parties:

- Severn Trent;
- ADM Ltd;
- Centre for Ecology and Hydrology (CEH);
- Department for Environment, Food and Rural Affairs (Defra); and
- Stroud District Council (SDC).

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.

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 and A3) are presented in Figure 1.

The CHP engine and boilers (when utilising biogas) are fuelled by biogas generated from the site's anaerobic digestion process and emissions were modelled on this basis. As discussed previously, the 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 is the primary fuel and 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 2-1 presents the emissions sources to air considered in this assessment.

Table 2-1: Combustion plant considered in this assessment

Parameters	CHP engine (0.6 MW_{th})	Boiler 1 (0.4 MW_{th})	Boiler 2 (0.4 MW_{th})
Modelled fuel	Biogas	Biogas	Biogas
Emission point reference	A1	A2	A3

This assessment has been carried out on the assumption that the CHP engine and boilers operate continuously at maximum load throughout the year (i.e. 8,760 hours). This is a conservative assumption as in practice, the CHP 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 modelled concentrations, it is assumed all assessed combustion plant operate continuously as this approach ensures that the worst-case or maximum long-term (i.e. annual mean) and short-term modelled concentrations are quantified (further consideration of this is provided in Appendix A).

2.2 Emissions Data

2.2.1 Emission concentration of pollutants

For the assessed CHP engine, the NOx, CO and TVOC emission concentrations were derived from the Environment Agency's guidance *'Guidance for monitoring landfill gas engine emissions'* (Environment Agency, 2010). For SO_2, in the absence of a specific emission limit value, the SO_2 emission concentration typically used in similar permit applications for biogas fuelled CHP engines has been applied. This is a conservative approach to the assessment as in practice, the CHP engine SO_2 emission concentration is likely to be lower than that applied in the model. 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 and SO_2 emission concentration is based on the emission limit values for existing medium combustion plant (MCP) other than engines and gas turbines as regulated under 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 (United Kingdom (UK) Government, 2018)). For CO and TVOC, in the absence of a specific emission limit value, the CO emission concentration was obtained from the value for natural gas from Defra's Process Guidance Note 1/3,*'Statutory Guidance for Boilers and Furnaces 20-50MW thermal input'* (Defra, 2012) and the TVOC emission concentration was derived from the Environment Agency's guidance '*Guidance for monitoring landfill gas engine emissions*', (Environment Agency, 2010).

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.

2.2.2 Other emission parameters

For the CHP engine and boilers, the exhaust gas volumetric flow was determined using stoichiometric calculations based on the combustion of biogas fuel at the maximum thermal input rating of the assessed combustion plant. In the absence of information regarding temperature, oxygen and moisture content of the combustion plant, the data used in the model is based on professional judgment acquired from previous work involving biogas fuelled CHP engine and boilers of a similar thermal input capacity.

The emissions inventory of releases to air from the CHP engine and boilers are 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, 16 of the closest sensitive human receptors (such as residential properties 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, 2022), 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; Severn Estuary Ramsar & SPA; Severn Estuary SAC; Rodborough Common SAC; three parcels of ancient woodland (one of which is also a LWS) and six further LWSs were included in the assessment.

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

3.2 Overall Methodology

The assessment was carried out using an atmospheric dispersion modelling technique. Atmospheric Dispersion Modelling System (ADMS) version 5.2.4 was used to model releases of the identified substances. The ADMS model predicts the dispersion of operational emissions from a specific source (e.g. a stack), and the subsequent concentrations over an identified area (e.g. at ground level across a grid of receptor points) or at specified points (e.g. a residential property). ADMS was selected because this model is fit for the purpose of modelling the emissions from the type of sources on-site (i.e. point source emissions from a combustion source) and is accepted as a suitable assessment tool by 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, 2022).

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, 2022). Information on the CHP engine and boilers were obtained from various sources as described in Section 2.2.
2. Five years of hourly sequential data recorded at the Pershore meteorological station (2016 – 2020 inclusive) were used for the assessment (ADM Ltd, 2021).
3. Information on the main buildings located on-site, that could influence dispersion of emissions from the CHP engine and boiler stacks were estimated from on-site photography, Defra's environmental open-data applications and datasets (Defra, 2022a) and Google Earth (Google Earth, 2022).
4. The maximum predicted concentrations (at a modelled height of 1.5 m or 'breathing zone') at the assessed sensitive human receptor locations R1 – R10 (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 R11-R16 (representing a PRoW which runs adjacent to the northern, eastern and southern boundary of the site), 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 4.2) to provide the Predicted Environmental Concentration (PEC) of the substances of interest.
7. The PECs were then assessed against the appropriate environmental standards for air emissions for each substance set out in the Environment Agency's guidance (Environment Agency, 2022) document to determine the nature and extent of any potential adverse effects.
8. Modelled concentrations were processed using geographic information system (GIS) software (ArcMap 10.8.1) to produce contour plots of the model results. These are provided for illustrative purposes only; assessment of the model results was based on the numerical values outputted by the dispersion model on the model grid (see Figure 2) and at the specific receptor locations and were processed using Microsoft Excel.
9. The predicted concentrations of NOx and SO_2 were also used to assess the potential impact on critical levels and critical loads (i.e. acid and nutrient nitrogen deposition) (see Section 3.3.2) at the assessed protected conservation areas. Details of the deposition assessment methodology are provided in Appendix B.

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

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

3.3 Assessment Criteria

3.3.1 Environmental Quality Standards: Human Receptors

In the UK, the focus on local air quality is reflected in the air quality objectives (AQOs) set out in the *Air Quality Strategy for England, Scotland, Wales and Northern Ireland* (AQS) (Defra and the Devolved Administrations, 2007). The AQS stipulates a number of air quality objectives for nine main air pollutants with respect to ambient levels of air quality (Defra, 2007). The AQOs are similar to the limit values that were transposed from the relevant EU directives into UK legislation by The *Air Quality Standards Regulations 2010* (UK Government, 2010). The objectives are based on the current understanding of health effects of exposure to air pollutants and have been specified to control health and environmental risks to an acceptable level. They apply to places where people are regularly present over the relevant averaging period. The objectives set for the protection of human health and vegetation of relevance to the project are summarised in Table 3-1. Relevant Environmental Assessment Levels (EALs) set out in the Environment Agency guidance (Environment Agency, 2022) are also included in Table 3-1 where these supplement the AQOs.

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

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

Pollutant	EQS ($\mu g/m^3$)	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)

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

Note 1: VOCs may contain a wide range of organic compounds and it is often difficult to determine or identify each and every compound present. The TVOC emissions from the assessed combustion plant will largely comprise methane (CH_4) which is not directly harmful to human health.
Note 2: For the purposes of this assessment, the annual mean and 24-hour mean AQO for benzene (C_6H_6) has been applied as it is a standard substitute that adequately represents a worst-case scenario for VOCs.
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, 2021);
- if the PC is greater than 1% of the EQS but the PEC is less than 70% of the long-term air quality objective, based on professional judgement, this would be classed as 'not significant'; and
- where the PC is greater than 1% of the EQS and the PEC is greater than 70% of the EQS, professional judgement is used to determine the overall significance of the effect (i.e. whether the effect would be 'not significant' or 'significant'), taking account of the following:
  - the scale of the changes in concentrations;
  - whether or not an exceedance of an EQS is predicted to arise in the study area where none existed before, or an exceedance area is substantially increased as a result of the development; and
  - uncertainty, including the influence and validity of any assumptions adopted in undertaking the assessment.

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

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

Environment Agency guidance recommends that further action will not be required if proposed emissions comply with Best Available Techniques Associated Emission Levels (BAT AELs) and resulting PECs do not exceed the relevant EQS (Environment Agency, 2022).

3.3.2 Environmental Quality Standards: Protected Conservation Areas

Critical levels

The environmental standards set for protected conservation areas of relevance to the project are summarised in Table 3-2 (Environment Agency, 2022).

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

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

Critical loads

Critical loads for pollutant deposition to statutorily designated habitat sites in the UK and for various habitat types have been published by the CEH and are available from the Air Pollution Information System (APIS) website. Critical Loads are defined on the APIS website (Centre for Ecology and Hydrology, 2022) as:

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

Compliance with these benchmarks is likely to result in no significant adverse effects on the natural environment at these locations. The critical loads for the designated habitat sites considered in this assessment are set out in Table 3-3. For the assessed European designated sites, the Site Relevant Critical Loads tool function on the APIS website was used to determine the relevant critical loads.

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

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

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

Rec ref	Protected conservation area	Habitat feature applied	Vegetation type (for deposition velocity)	Critical load			
				Acid deposition (kEqH+/ha/year)			Nitrogen deposition(kg N/ha/year)
				CLMaxS	CLMinN	CLMax N	Minimum
H1	Ancient & Semi-Natural Woodland (ID 1416123) / Five Acre Grove LWS	Broadleaved Deciduous Woodland	Tall	10.788	0.214	11.002	10
H2	Ancient & Semi-Natural Woodland (ID 1416122)	Broadleaved Deciduous Woodland	Tall	2.309	0.357	2.666	10
H3	Five Acre Grove AW	Broadleaved Deciduous Woodland	Tall	2.309	0.357	2.666	10
H4	Severn Estuary Ramsar/SPA	Pioneer, low-mid, mid-upper saltmarshes	Short	No critical load data available			20

Rec ref	Protected conservation area	Habitat feature applied	Vegetation type (for deposition velocity)	Critical load			
				Acid deposition (kEqH+/ha/year)			Nitrogen deposition(kg N/ha/year)
				CLMaxS	CLMinN	CLMax N	Minimum
H5	Severn Estuary SAC	Estuaries	Short	No critical load data available			20
H6	Rodborough Common SAC	Semi-Natural Dry Grasslands	Short	4.000	0.856	4.856	15
H7	Bond's Mill Bank LWS	Calcareous grassland	Short	4.000	0.928	4.928	5
		Coniferous woodland	Tall	10.770	0.214	10.984	5
H8	River Frome LWS	Coniferous woodland	Tall	2.309	0.357	2.666	5
H9	Stonehouse Newt Pond LWS	Bogs	Short	0.215	0.321	0.536	5
		Coniferous woodland	Tall	10.770	0.214	10.984	5
H10	Stroudwater Canal LWS	Fen, Marsh and Swamp	Short	This habitat is not sensitive to acidity			10
		Coniferous woodland	Tall	10.770	0.214	10.984	5
H11	Wickster's Brook and Ditch (part) LWS	Coniferous woodland	Tall	4.458	0.142	4.600	5
H12	Wickster's Brook, Bath Road, Eastington LWS	Acid grassland	Short	1.610	0.223	1.833	5
	Ancient & Semi-Natural Woodland (ID 1416123) / Five Acre Grove LWS	Coniferous woodland	Tall	4.458	0.142	4.600	5

Critical load functions for acid deposition are specified on the basis of both nitrogen and sulphur derived acid. The critical load function contains a value for sulphur derived acid and two values for nitrogen derived acid deposition (a minimum and maximum value). The APIS website provides advice on how to calculate the PC (i.e. emissions from the modelled process alone) and the PEC (i.e. the PC added to the existing deposition) as a percentage of the acid critical load function and how to determine exceedances of the critical load function. This guidance was adopted for this assessment. The minimum of the range of nitrogen critical loads was used for the assessment in line with the advice on the APIS website (Centre for Ecology and Hydrology, 2022).

Significance Criteria – European designated sites

With regard to concentrations at the assessed designated habitat site, the Environment Agency guidance (Environment Agency, 2022) states emissions can be described as 'insignificant' and no further assessment is required (including the need to calculate PECs) if:

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

Where appropriate, the significance of the predicted long-term (annual mean) concentrations or deposition at protected conservation areas were determined in line with Environment Agency guidance (Environment Agency, 2022) summarised as follows:

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

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

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

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

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, 2022) states emissions can be described as 'insignificant' and no further assessment is required (including the need to calculate PECs) if:

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

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

4. Existing Environment

4.1 Location

The site is situated approximately 0.9 km west-northwest from the centre of the village of Stanley Downton, Gloucestershire and is located within the administrative borough of Stroud. The area surrounding the site generally comprises agricultural fields with infrequent residential properties surrounding the site. The Great Western railway line runs adjacent to the 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 400 m northeast of the CHP engine (based on the stack location). The nearest modelled receptor represents a PRoW footpath that runs adjacent to the southern boundary of the site approximately 110 m from the CHP engine stack at its closest point.

4.2 Local Air Quality Management

A review of baseline air quality was carried out prior to undertaking the air quality assessment. This was carried out to determine the availability of baseline air quality data recorded in the vicinity of the site and also if data from other regional or national sources such as the UK Air Information Resource (UK-AIR) (Defra, 2022b) website could be used to represent background concentrations of the relevant pollutants in the vicinity of the site.

SDC has not currently declared an AQMA within its administrative boundary. The nearest AQMA to the site, termed 'Painswick Road AQMA', was declared by Gloucester City Council for elevated concentrations of annual mean NO_2 in 2007. This AQMA is approximately 13.4 km northeast of the site and is not considered further in the assessment due to its distance from the site.

SDC also carries out regular assessments and monitoring of air quality within the borough as part of the Local Air Quality Management (LAQM) process. The most recent Air Quality Annual Status Report (Stroud District Council, 2021) was reviewed to determine the concentrations of NO_2 and particulates in the vicinity for the site. It should be noted that none of the other assessed pollutants are monitored by SDC. Table 4-1 presents information on the nearest monitoring locations to the site. It should be noted Table 4-1 presents the 2019 monitored annual mean NO_2 concentrations as this dataset is the latest available representative data not affected by the Covid pandemic and related travel restrictions.

Table 4-1: Nearest monitoring locations to the site

Site ID	Description	Site type	Location	Distance and direction from CHP engine stack	Pollutants monitored	2019 Annual mean concentration (µg/m^3)
Automatic monitoring						
Hardwicke	Hardwicke	Suburban	E 380203 N 212842	8.3 km, N	PM_{10}, $PM_{2.5}$	10.1 (PM_{10}) 6.4 ($PM_{2.5}$)
Haresfield	Haresfield	Rural	E 381324 N 210015	5.9 km, NNE	PM_{10}, $PM_{2.5}$	8.6 (PM_{10}) 5.8 ($PM_{2.5}$)
Non-automatic monitoring (diffusion tubes)						
44	Oldends Lane - Stonehouse	Roadside	E 380548 N 205948	1.9 km, NE	NO_2	14.1 (2020)

Site ID	Description	Site type	Location	Distance and direction from CHP engine stack	Pollutants monitored	2019 Annual mean concentration ($\mu g/m^3$)
45	Moreton Hill	Rural	E 381872 N 206279	3.2 km, ENE	NO_2	7.9
41	Westward Road - Ebley	Roadside	E 382845 N 204720	3.7 km, E	NO_2	23.3
46	Standish Lane	Rural	E 379342 N 208604	4.0 km, N	NO_2	10.9
39	Westwrad Road - Cainscross	Roadside	E 383471 N 204988	4.3 km, E	NO_2	21.7

The monitoring locations presented in Table 4-1 are not considered representative of conditions experienced at the site due to monitoring site type and /or distance from the site.

For the assessed pollutants, information on background air quality in the vicinity of the site were obtained from Defra background map datasets (Defra, 2022b). The 2018-based background maps by Defra are estimates based upon the principal local and regional sources of emissions and ambient monitoring data. For SO_2 and CO concentrations, the 2001-based background maps were used. For TVOC concentrations, the 2010-based background maps for C_6H_6 were used. These background concentrations are presented in Table 4-2.

As it is necessary to determine the potential impact of emissions from the site at the assessed protected conservation areas, the background concentrations of NOx and SO_2 were also identified. These background concentrations were also obtained from the Defra background map datasets (Defra, 2022b) and are displayed in Table 4-2.

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

Pollutant	Annual mean concentration ($\mu g/m^3$)	Description
Human receptors		
NO_2	7.5 – 13.1	Defra 1 km x 1 km background map value for the assessed sensitive human receptor locations, 2022 map concentration
CO	111 - 120	Defra 1 km x 1 km background map value for the assessed sensitive human receptor locations, 2001 based map concentration
PM_{10}	12.2 – 12.8	Defra 1 km x 1 km background map value for the assessed sensitive human receptor locations, 2022 map concentration
$PM_{2.5}$	7.8 – 8.4	Defra 1 km x 1 km background map value for the assessed sensitive human receptor locations, 2022 map concentration
SO_2	2.0 – 3.0	Defra 1 km x 1 km background map value for the assessed sensitive human receptor locations, 2001 based map concentration
C_6H_6	0.21 – 0.24	Defra 1 km x 1 km background map value for the assessed sensitive human receptor locations, 2010 map concentration

Pollutant	Annual mean concentration (µg/m^3)	Description
Protected conservation areas		
NOx	7.2 – 17.9	Defra 1 km x 1 km background map value for the assessed protected conservation areas, 2022 map concentration
SO2	2.0 – 3.0	Defra 1 km x 1 km background map value for the assessed sensitive human receptor locations, 2001based 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, 2022).

4.3 Existing Deposition Rates

Existing acid and nutrient nitrogen deposition levels were obtained from APIS (Centre for Ecology and Hydrology, 2022). As a conservative approach to the assessment, it is assumed the vegetation type selected is present at the specific modelled location within the assessed protected conservation area. The existing deposition values at the assessed ecological designations are set out in Table 4-3.

Table 4-3: Existing deposition at modelled habitat sites

Rec ref	Protected conservation area	Vegetation type (for deposition velocity)	Existing deposition rates		
			Existing acid deposition (kEqH+/ha/year)		Existing nutrient N deposition (kg N/ha/year)
			Nitrogen	Sulphur	Nitrogen
H1	Ancient & Semi-Natural Woodland (ID 1416123) / Five Acre Grove LWS	Tall	2.35	0.16	32.90
H2	Ancient & Semi-Natural Woodland (ID 1416122)	Tall	2.35	0.16	32.90
H3	Five Acre Grove AW	Tall	2.35	0.16	32.90
H4	Severn Estuary Ramsar/SPA	Short	No critical load data available		9.80
H5	Severn Estuary SAC	Short	No critical load data available		10.20
H6	Rodborough Common SAC	Short	1.54	0.16	21.50
H7	Bond's Mill Bank LWS	Short	1.29	0.17	18.06
		Tall	2.25	0.20	31.50
H8	River Frome LWS	Tall	2.35	0.16	32.90
H9	Stonehouse Newt Pond LWS	Short	1.29	0.17	18.06
		Tall	2.25	0.20	31.50

Rec ref	Protected conservation area	Vegetation type (for deposition velocity)	Existing deposition rates Existing acid deposition (kEqH+/ha/year) Nitrogen	Sulphur	Existing nutrient N deposition (kg N/ha/year) Nitrogen
H10	Stroudwater Canal LWS	Short	1.29	0.17	18.06
		Tall	2.25	0.20	31.50
H11	Wickster's Brook and Ditch (part) LWS	Tall	2.35	0.16	32.90
H12	Wickster's Brook, Bath Road, Eastington LWS	Short	1.35	0.13	18.90
		Tall	2.35	0.16	32.90

5. Results

5.1 Human Receptors

The results presented below are the maximum modelled concentrations predicted at any of the 16 assessed sensitive human receptor locations and the maximum modelled concentrations at any off-site location for the five years of meteorological data used in the study.

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

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

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

Table 5-1: Results of detailed assessment

Pollutant	Averaging period	Assessment location	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	R5	10,000	226	50.3	276.1	0.5%	2.8%	0.5%
	Maximum 1-hour mean	Maximum off-site	-	30,000	226	419.7	645.5	1.4%	2.2%	1.4%
		Sensitive locations	R12	30,000	226	420.4	646.2	1.4%	2.2%	1.4%
NO_2	Annual mean	Sensitive locations	R1	40	8.9	0.8	9.7	2.0%	24.2%	-
	1-hour mean (99.79th percentile)	Maximum off-site	-	200	17.8	44.7	62.5	22.4%	31.3%	24.5%
		Sensitive locations	R12	200	17.8	44.2	62.0	22.1%	31.0%	24.3%
SO_2	24-hour mean (99.18th percentile)	Sensitive locations	R1	125	4.2	3.5	7.7	2.8%	6.2%	2.9%
	1-hour mean (99.73rd percentile)	Maximum off-site	-	350	4.2	90.1	94.2	25.7%	26.9%	26.0%
		Sensitive locations	R12	350	4.2	88.5	92.7	25.3%	26.5%	25.6%
	15-minute mean (99.9th percentile)	Maximum off-site	-	266	4.2	102.6	106.7	38.6%	40.1%	39.2%
		Sensitive locations	R12	266	4.2	101.1	105.2	38.0%	39.6%	38.6%
PM_{10}	Annual mean	Sensitive locations	R1	40	12.2	0.02	12.2	<0.1%	30.6%	-
	24-hour mean (90.41st percentile)	Sensitive locations	R1	50	24.4	0.04	24.5	0.1%	48.9%	0.2%
$PM_{2.5}$	Annual mean	Sensitive locations	R1	20	7.9	0.02	7.9	0.1%	39.4%	-
TVOC	Annual mean	Sensitive locations	R1	5 (C_6H_6)	0.2	3.1	3.3	62.2%	66.7%	-
	Maximum 24-hour mean	Sensitive locations	R5	30 (C_6H_6)	0.4	**38.4**	**38.9**	128.0%	129.5%	130.0%

Bold denotes an exceedance of the relevant EQS.

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, R11 – R16 have been omitted from analysis as these receptor locations represent a PRoW (i.e. short-term exposure only). The full results are presented in Appendix D.

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

Table 5-1 indicates that for annual mean NO_2, PM_{10} and $PM_{2.5}$ concentrations, the respective PCs are less than 1% of the relevant long-term EQS and where the PCs are above 1% of the relevant EQS (i.e. NO_2), the PEC is less than 70% of the relevant EQS and the impacts are considered 'not significant' as per Environment Agency guidance (Environment Agency, 2022).

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

For annual mean TVOC concentrations at a sensitive human receptor location, the maximum PC of 3.1 µg/m^3 is predicted at R1 which represents a residential property approximately 400 m northeast of the CHP engine stack. The PC equates to 62.2% of the relevant EQS for C_6H_6.

For maximum 24-hour mean TVOCs concentrations at a sensitive human receptor location, the maximum PC is 38.4 µg/m^3, which is predicted at R5 representing a residential property approximately 530 m southeast of the CHP engine stack. The 24-hour mean PC and PEC exceeds the C_6H_6 24-hour mean standard when adopting a worst-case approach, which assumes all TVOCs emitted by the combustion plant are C_6H_6 in the absence of EQSs for TVOC. This is an unrealistic assumption and C_6H_6, if present in the exhaust gases, would constitute only a very small proportion of total TVOC emissions (e.g. less than 1%).

Therefore, it is likely there would be no exceedance of EQSs associated with TVOC emissions and based on professional judgement, the emissions of TVOCs is considered 'not significant'.

Summary

The results in Table 5-1 indicate that the predicted modelled off-site concentrations and predicted concentrations at sensitive human receptors do not exceed any relevant long-term or short-term EQS. Furthermore, the conservative approach adopted throughout the assessment means the predicted concentrations presented in Table 5-1 are likely to be higher than would reasonably be expected.

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

5.2 Protected Conservation Areas

5.2.1 Assessment against Critical Levels

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

For SO_2 PCs, the relevant EQS was based on the assumption that lichens and bryophytes were present at the assessed protected conservation areas, therefore adopting the lower critical level of 10 µg/m^3 as a conservative approach.

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

Rec ref	Protected Conservation Area	EQS (µg/m^3)	Background concentration (µg/m^3)	PC (µg/m^3)	PEC (µg/m^3)	PC/EQS (%)	PEC/EQS (%)
Annual mean NOx concentrations							
H1	Ancient & Semi-Natural Woodland (ID 1416123) / Five Acre Grove LWS	30	9.6	0.7	10.3	2.5%	34.5%
H2	Ancient & Semi-Natural Woodland (ID 1416122)		11.6	0.5	12.1	1.6%	40.2%
H3	Five Acre Grove AW		11.6	0.3	11.9	1.0%	39.6%
H4	Severn Estuary Ramsar/SPA		7.2	0.01	7.2	<0.1%	24.0%
H5	Severn Estuary SAC		7.2	0.01	7.2	<0.1%	24.0%
H6	Rodborough Common SAC		8.8	0.02	8.9	0.1%	29.5%
H7	Bond's Mill Bank LWS		17.9	0.7	18.6	2.4%	62.0%
H8	River Frome LWS		11.6	1.0	12.6	3.4%	42.0%
H9	Stonehouse Newt Pond LWS		17.9	0.3	18.1	0.9%	60.5%
H10	Stroudwater Canal LWS		17.9	0.7	18.6	2.5%	62.1%
H11	Wickster's Brook and Ditch (part) LWS		9.7	0.2	9.9	0.6%	33.0%
H12	Wickster's Brook, Bath Road, Eastington LWS		9.7	0.1	9.9	0.4%	32.9%
Annual mean SO_2 concentrations							
H1	Ancient & Semi-Natural Woodland (ID 1416123) / Five Acre Grove LWS	10	2.0	0.5	2.5	5.4%	25.0%
H2	Ancient & Semi-Natural Woodland (ID 1416122)		2.1	0.3	2.4	3.5%	24.3%
H3	Five Acre Grove AW		2.1	0.2	2.3	2.2%	23.0%
H4	Severn Estuary Ramsar/SPA		2.3	0.01	2.3	0.1%	23.1%
H5	Severn Estuary SAC		2.3	0.01	2.3	0.1%	23.1%
H6	Rodborough Common SAC		2.2	0.01	2.2	0.1%	21.7%
H7	Bond's Mill Bank LWS		3.0	0.5	3.5	5.2%	35.3%
H8	River Frome LWS		2.1	0.7	2.8	7.4%	28.2%
H9	Stonehouse Newt Pond LWS		3.0	0.2	3.2	1.9%	32.0%
H10	Stroudwater Canal LWS		3.0	0.5	3.6	5.4%	35.5%
H11	Wickster's Brook and Ditch (part) LWS		2.0	0.1	2.1	1.2%	21.0%
H12	Wickster's Brook, Bath Road, Eastington LWS		2.0	0.1	2.1	0.9%	20.7%
Maximum 24-hour mean NOx concentrations							
H1	Ancient & Semi-Natural Woodland (ID 1416123) / Five Acre Grove LWS	75	19.2	9.0	28.2	12.0%	37.6%
H2	Ancient & Semi-Natural Woodland (ID 1416122)		23.2	10.5	33.7	14.0%	44.9%
H3	Five Acre Grove AW		23.2	5.7	28.9	7.6%	38.5%
H4	Severn Estuary Ramsar/SPA		14.4	0.3	14.6	0.4%	19.5%
H5	Severn Estuary SAC		14.4	0.3	14.7	0.4%	19.5%

Rec 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 (%)
H6	Rodborough Common SAC		17.7	0.3	17.9	0.3%	23.9%
H7	Bond's Mill Bank LWS		35.8	3.9	39.6	5.1%	52.8%
H8	River Frome LWS		23.2	6.7	29.9	9.0%	39.9%
H9	Stonehouse Newt Pond LWS		35.8	2.1	37.9	2.8%	50.5%
H10	Stroudwater Canal LWS		35.8	3.9	39.7	5.2%	52.9%
H11	Wickster's Brook and Ditch (part) LWS		19.5	4.8	24.3	6.5%	32.4%
H12	Wickster's Brook, Bath Road, Eastington LWS		19.5	1.7	21.1	2.2%	28.1%

The results in Table 5-2 indicate that at the assessed European designated sites and local nature sites, the annual mean NOx and SO_2 PCs are less than 1% and 100%, respectively, of the relevant critical level and the effect is considered 'insignificant' as per Environment Agency guidance (Environment Agency, 2022).

For the maximum 24-hour mean critical level for NOx, the results indicate that at the assessed European designated sites and local nature sites, the PC's are less than 10% and 100%, respectively, of the relevant critical level and the effect is also considered 'insignificant' as per Environment Agency guidance (Environment Agency, 2022).

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, 2022). Further information on the assessment of deposition is provided in Appendix B. The full detailed modelled results are displayed in Table 5-3 and Table 5-4.

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

Ref	Habitat	Vegetation type (for deposition velocity)	Critical load (CL) (kEqH+/ha/year)			Existing acid deposition (kEqH+/ha/year)					
			CLMaxS	CLMinN	CLMaxN	Existing deposition (N)	Existing deposition (S)	PC	PEC	PC/CL (%)	PEC/CL (%)
H1	Ancient & Semi-Natural Woodland (ID 1416123) / Five Acre Grove LWS	Tall	10.788	0.214	11.002	2.35	0.16	0.139	2.65	1.3%	24%
H2	Ancient & Semi-Natural Woodland (ID 1416122)	Tall	2.309	0.357	2.666	2.35	0.16	0.089	2.60	3.4%	98%
H3	Five Acre Grove AW	Tall	2.309	0.357	2.666	2.35	0.16	0.055	2.57	2.1%	96%
H4	Severn Estuary Ramsar/SPA	Short	No critical load data available					0.001	-	-	-
H5	Severn Estuary SAC	Short	No critical load data available					0.001	-	-	-
H6	Rodborough Common SAC	Short	4.000	0.856	4.856	1.54	0.16	0.001	1.69	<0.1%	35%
H7	Bond's Mill Bank LWS	Short	4.000	0.928	4.928	1.29	0.17	0.067	1.53	1.4%	31%
		Tall	10.770	0.214	10.984	2.25	0.20	0.134	2.58	1.2%	24%
H8	River Frome LWS	Tall	2.309	0.357	2.666	2.35	0.16	0.189	2.70	7.1%	101%
H9	Stonehouse Newt Pond LWS	Short	0.215	0.321	0.536	1.29	0.17	0.025	1.48	4.6%	277%
		Tall	10.770	0.214	10.984	2.25	0.20	0.049	2.50	0.4%	23%
H10	Stroudwater Canal LWS	Short	No critical load data available			1.29	0.17	0.069	1.53	-	-
		Tall	10.770	0.214	10.984	2.25	0.20	0.138	2.59	1.3%	24%
H11	Wickster's Brook and Ditch (part) LWS	Tall	4.458	0.142	4.600	2.35	0.16	0.032	2.54	0.7%	55%
H12	Wickster's Brook, Bath Road, Eastington LWS	Short	1.610	0.223	1.833	1.35	0.13	0.012	1.49	0.7%	81%
		Tall	4.458	0.142	4.600	2.35	0.16	0.024	2.53	0.5%	55%

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

Ref	Habitat	Vegetation type (for deposition velocity)	Minimal Critical Load (CL)	Existing nutrient deposition (kgN/ha-year)				
				Existing deposition	PC	PEC	PC/CL (%)	PEC/CL(%)
H1	Ancient & Semi-Natural Woodland (ID 1416123) / Five Acre Grove LWS	Tall	10	32.90	0.151	33.05	1.5%	331%
H2	Ancient & Semi-Natural Woodland (ID 1416122)	Tall	10	32.90	0.096	33.00	1.0%	330%
H3	Five Acre Grove AW	Tall	10	32.90	0.059	32.96	0.6%	330%
H4	Severn Estuary Ramsar/SPA	Short	20	9.80	0.001	9.80	<0.1%	49%
H5	Severn Estuary SAC	Short	20	10.20	0.001	10.20	<0.1%	51%
H6	Rodborough Common SAC	Short	15	21.50	0.002	21.50	<0.1%	143%
H7	Bond's Mill Bank LWS	Short	5	18.06	0.072	18.13	1.4%	363%
		Tall	5	31.50	0.145	31.64	2.9%	633%
H8	River Frome LWS	Tall	5	32.90	0.205	33.10	4.1%	662%
H9	Stonehouse Newt Pond LWS	Short	5	18.06	0.027	18.09	0.5%	362%
		Tall	5	31.50	0.053	31.55	1.1%	631%
H10	Stroudwater Canal LWS	Short	10	18.06	0.075	18.13	0.7%	181%
		Tall	5	31.50	0.149	31.65	3.0%	633%
H11	Wickster's Brook and Ditch (part) LWS	Tall	5	32.90	0.035	32.93	0.7%	659%
H12	Wickster's Brook, Bath Road, Eastington LWS	Short	5	18.90	0.013	18.91	0.3%	378%
		Tall	5	32.90	0.026	32.93	0.5%	659%

The results in Table 5-3 and Table 5-4 indicate that at the assessed European designated sites and local nature sites, the PCs are less than 1% and 100%, respectively, of the relevant critical load value for acid and nutrient nitrogen deposition and the impact can be described as 'insignificant' as per Environment Agency guidance (Environment Agency, 2022).

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

5.3 Sensitivity Analysis

A sensitivity study was undertaken to see how changes to the surface roughness and omission of the buildings in the 2017 model (which predicted the highest annual mean NO_2 concentrations at sensitive human receptor locations), the 2016 model (which predicted the highest 1-hour mean NO_2 concentrations at sensitive human receptor locations) and 2018 model (which predicted the highest 1-hour mean NO_2 concentrations at modelled off-site locations) may impact on predicted concentrations at sensitive human receptors and off-site locations. The results of the sensitivity analysis are presented in Table 5-5 to Table 5-7.

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

Pollutant	Averaging period	Assessment location	Original PC (surface roughness 0.4 m) (µg/m^3)	Surface roughness length 0.1 m				
				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	0.8	1.0	9.9	2.4%	24.6%	0.4%
	1 hour mean (99.79th percentile)	Maximum off-site	44.7	62.0	79.8	31.0%	39.9%	8.6%
		Sensitive locations	44.2	59.2	76.9	29.6%	38.5%	7.5%

The results in Table 5-5 indicate that the change to maximum predicted annual mean concentrations for NO_2 is negligible when using a surface roughness value of 0.1 m compared to the original value of 0.4 m. For 1-hour mean (99.79th percentile) NO_2 concentrations at an off-site location and sensitive human receptor location, the PCs are higher. However, a surface roughness of 0.1 m (representing root crops) is not considered representative of the site and surrounding area.

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

Pollutant	Averaging period	Assessment location	Original PC (surface roughness 0.4 m) (µg/m^3)	Surface roughness length 1 m				
				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	0.8	0.8	9.7	1.9%	24.1%	-0.1%
	1 hour mean (99.79th percentile)	Maximum off-site	44.7	38.0	55.7	19.0%	27.9%	-3.4%
		Sensitive locations	44.2	36.1	53.9	18.0%	26.9%	-4.1%

The results in Table 5-6 indicate that the change to maximum predicted annual mean concentrations for NO_2 is negligible when using a surface roughness value of 1 m compared to the original value of 0.4 m. For 1-hour mean (99.79th percentile) NO_2 concentrations at an off-site location and sensitive human receptor locations, the PC's were lower modelling with an increased surface roughness value of 1 m. However, a surface roughness of 1 m (representing a large city centre location with built-up areas and tall buildings) is not considered representative of the site and surrounding area.

Table 5-7: Sensitivity analysis - no buildings

Pollutant	Averaging period	Assessment location	Original PC (with buildings) (µg/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	0.8	0.8	9.7	1.9%	24.1%	-0.1%
	1 hour mean (99.79th percentile)	Maximum off-site	44.7	18.8	36.6	9.4%	18.3%	-13.0%
		Sensitive locations	44.2	18.1	35.9	9.1%	17.9%	-13.0%

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

6. Conclusions

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

6.1 Human receptors

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

For TVOCs, exceedances of the 24-hour mean EQS for C_6H_6 were predicted. However, as discussed previously, it is an unrealistic assumption that total TVOCs emitted by the combustion plant are C_6H_6. If present in the exhaust gases, C_6H_6 would constitute only a very small proportion of total TVOC emissions (e.g. less than 1%). Therefore, it is likely there would be no exceedance of EQSs associated with TVOC emissions and based on professional judgement, the emissions of TVOCs is considered 'not significant'.

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

6.2 Protected conservation areas

For critical levels, at the assessed European designated sites and local nature sites, the annual mean NOx and SO_2 PCs are less than 1% and 100%, respectively, of the relevant critical level and the effect is considered 'insignificant'. For the maximum 24-hour mean critical level for NOx, the results indicate that at the assessed European designated sites and local nature sites, the PC's are less than 10% and 100% of the relevant critical level, respectively, and the effect is also considered 'insignificant'.

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

6.3 Summary

This assessment has been carried out on the assumption that the CHP engine and boilers would operate continuously at maximum load all year. This is a conservative assumption as, in practice, the CHP engine and boilers would 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.

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

7. References

ADM Ltd (2021). Hourly sequential meteorological data for Pershore meteorological station 2016-2020 [online] Further information available at: http://www.aboutair.com/met-data.htm.

Air Quality Technical Advisory Group (AQTAG) (2014). AQTAG 06 Technical Guidance on Detailed Modelling Approach for an Appropriate Assessment for Emissions to Air, updated version approved March 2014.

Centre for Ecology and Hydrology (CEH) (2022). Air Pollution Information System [online] Available at: http://www.apis.ac.uk [Accessed August 2022].

Department for Environment, Food and Rural Affairs (Defra) (2007). The Air Quality Strategy for England, Scotland, Wales and Northern Ireland. Vol 1. London: Defra.

Department for Environment, Food and Rural Affairs (Defra) (2012). Process Guidance Note 1/3,'Statutory Guidance for Boilers and Furnaces 20-50MW thermal input. June 2012.

Department for Environment, Food and Rural Affairs (Defra) (2022a). Environmental open-data applications and datasets. [online] Available at: http://uk-air.defra.gov.uk [Accessed August 2022].

Department for Environment, Food and Rural Affairs (Defra) (2022b). UK Air Information Resource. [online] Available at: http://uk-air.defra.gov.uk [Accessed August 2022].

Environment Agency (2010). Guidance for monitoring landfill gas engine emissions LFTGN08 v2 2010. [online] Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/321617/LFTGN08.pdf [Accessed August 2022]

Environment Agency (2021). Environmental permitting: air dispersion modelling report. [online] Available at: https://www.gov.uk/guidance/environmental-permitting-air-dispersion-modelling-reports [Accessed August 2022]

Environment Agency (2022). Air emissions risk assessment for your environmental permit. [online] Available at: https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit [Accessed August 2022]

Google Earth (2022). Available at http://www.google.com/earth/index.html. [online] [Accessed August 2022]

Land Quality Management Limited (2002). Landfill Gas Engine Exhaust and Flare Emissions, Final Report. September 2002

Severn Trent Water Limited (2022). Data and information provided to Jacobs via email communication, August 2022.

Stroud District Council (2021). 2021 Air Quality Annual Status Report (ASR), November 2021, Stroud District Council

UK Government (2010). The Air Quality Standards Regulations 2010. Available at https://www.legislation.gov.uk/uksi/2010/1001/contents/made [online] [Accessed September 2022]

UK Government (2018). The Environmental Permitting (England and Wales) (Amendment) Regulations 2018 Available at https://www.legislation.gov.uk/uksi/2018/110/made online] [Accessed August 2022]

UK Government (2020). The Environment (Miscellaneous Amendments) (EU Exit) Regulations 2020. Available at https://www.legislation.gov.uk/uksi/2020/1313/contents/made [online] [Accessed August 2022]

United States Environmental Protection Agency (US EPA) (2022). Available at https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors. [online] [Accessed August 2022]

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: Protected conservation areas

Figure 4: Annual mean nitrogen dioxide process contributions, 2017 meteorological data

Figure 5: 1-hour mean (99.79th percentile) nitrogen dioxide process contributions, 2020 meteorological data

N

A1

A2

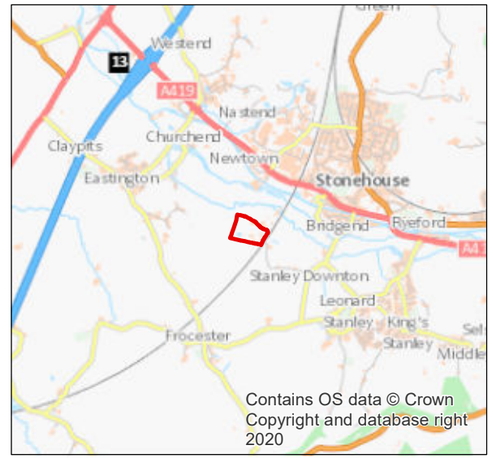
A3

Track

0 0.0425 0.085 0.17 Kilometers

Legend

- Approximate site fenceline
- Modelled stack locations
- Modelled buildings



Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	14/09/2022	Initial Issue	DH	GW	GW	RB

Jacobs

Client: SEVERN TRENT

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

Drawing Title: APPROXIMATE SITE FENCELINE, MODELLED STACK LOCATIONS AND MODELLED BUILDINGS

Drawing Status: FINAL

Scale @ A3	1:1,700	DO NOT SCALE
Jacobs No.	B1958992	Rev 0
Client No.		

Drawing Number: FIGURE 1

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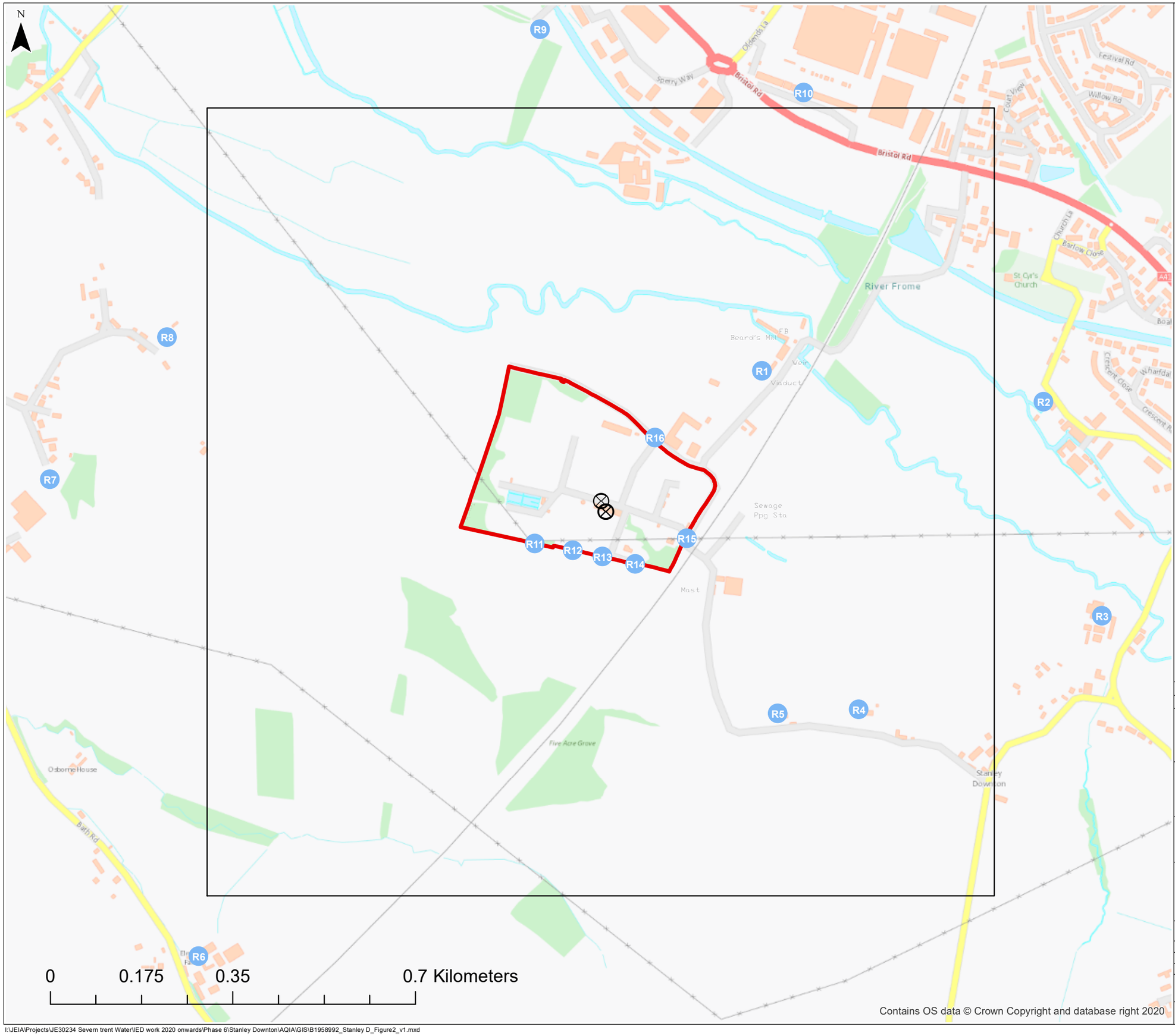
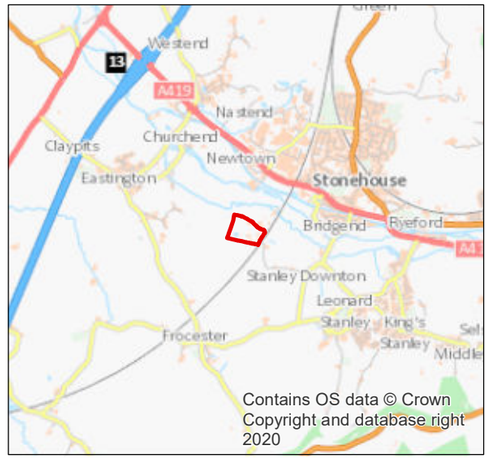


Legend

- Approximate site fenceline
- Modelled stack locations
- Extent of modelled grid
- R1 Sensitive human receptor locations



Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	14/09/2022	Initial Issue	DH	GW	GW	RB

Jacobs

Client: SEVERN TRENT

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

Drawing Title: EXTENT OF MODELLED GRID AND SENSITIVE HUMAN RECEPTOR LOCATIONS

Drawing Status: FINAL

Scale @ A3	1:7,000	DO NOT SCALE
Jacobs No.	B1958992	Rev 0
Client No.		

Drawing Number: FIGURE 2

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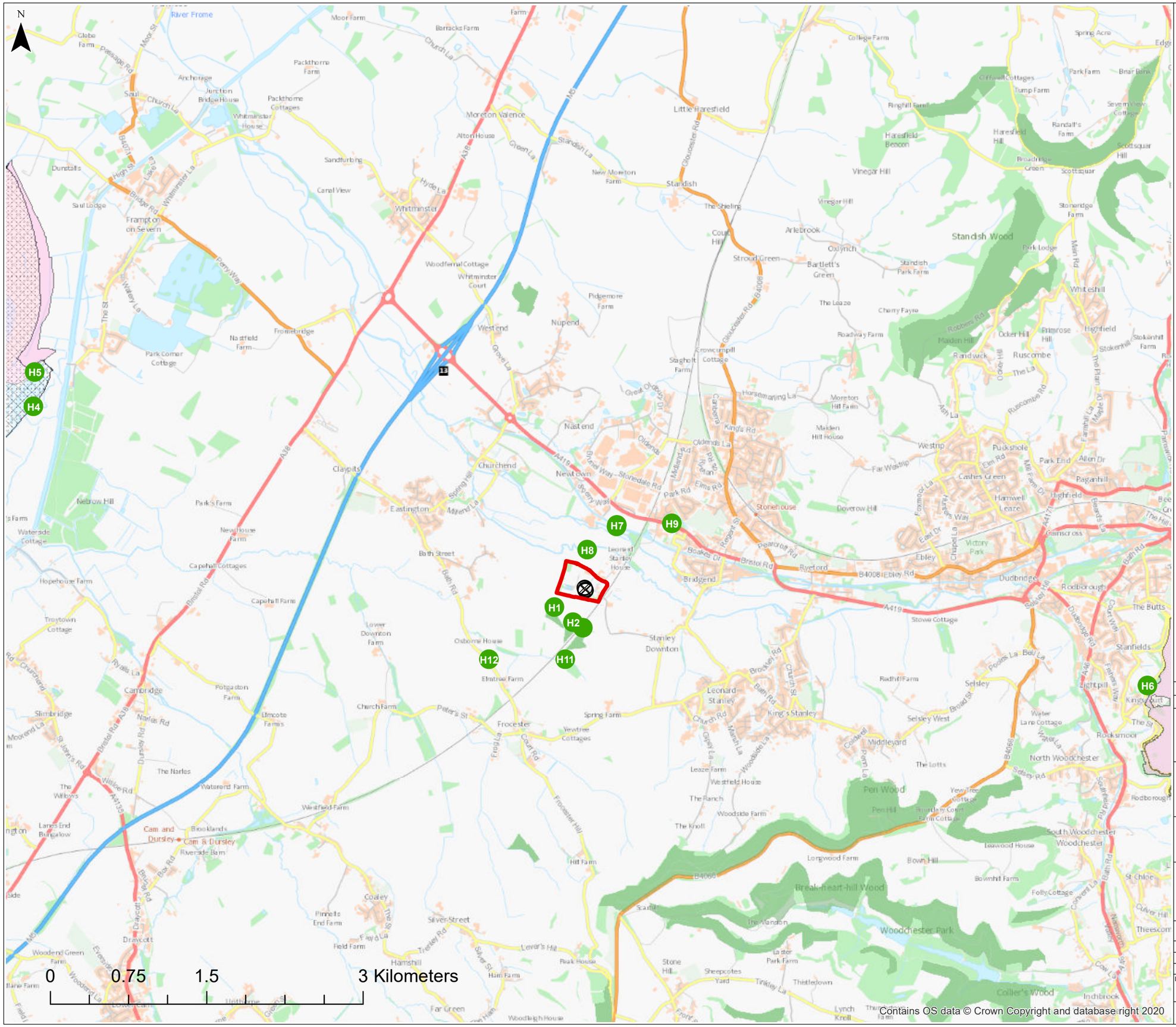

Legend

- Approximate site fenceline
- Modelled stack locations
- Special Area of Conservation (SAC)
- Special Protection Area (SPA)
- Ramsar
- Ancient woodland (AW)
- H1 Protected conservation area

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	14/09/2022	Initial Issue	DH	GW	GW	RB

Jacobs

Client: SEVERN TRENT

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

Drawing Title: PROTECTED CONSERVATION AREAS

Drawing Status: FINAL

Scale @ A3	1:35,000	DO NOT SCALE
Jacobs No.	B1958992	Rev 0
Client No.		

Drawing Number: FIGURE 3

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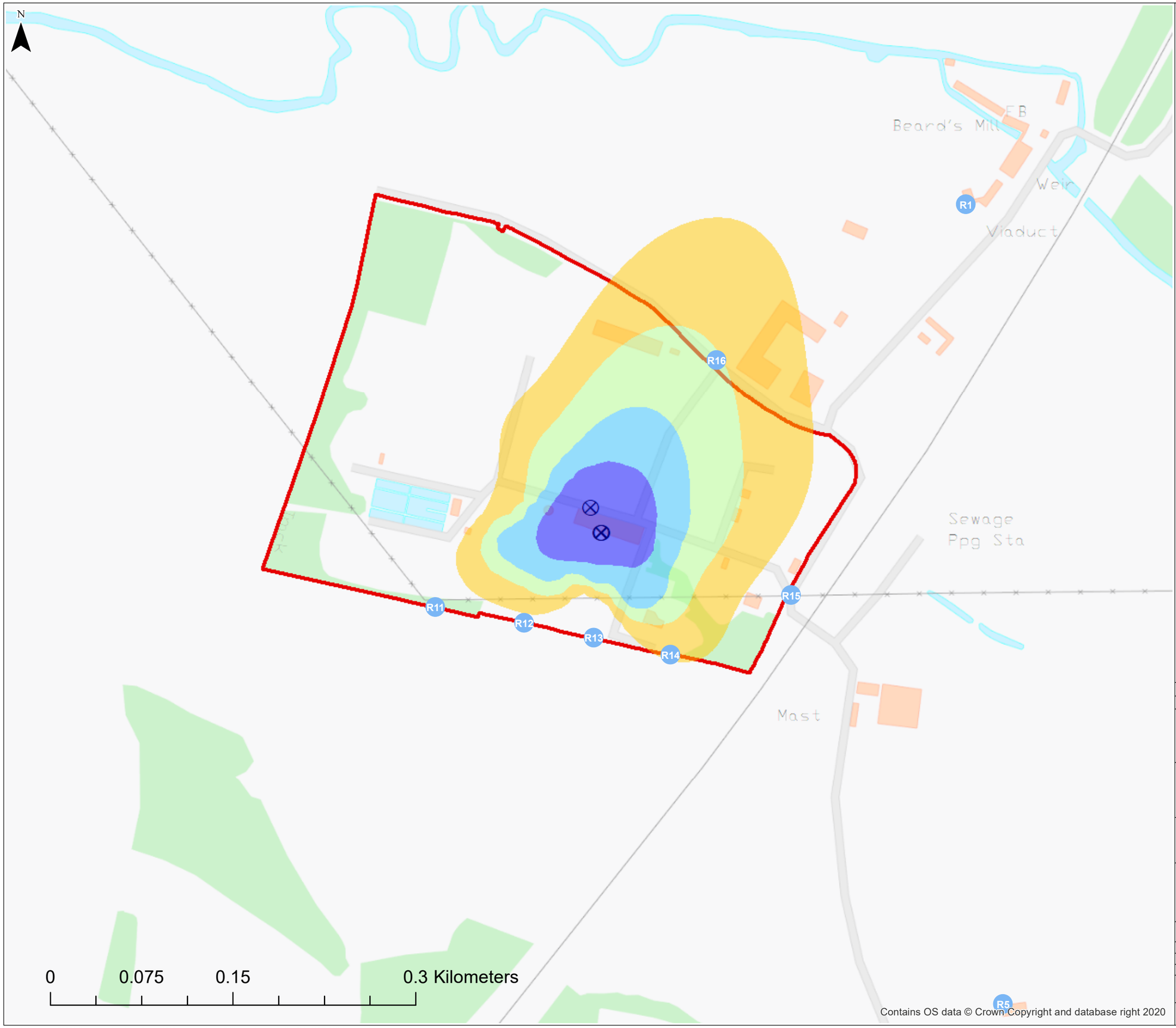

Legend

- Approximate site fenceline
- Modelled stack locations
- R1 Sensitive human receptor locations

Annual mean nitrogen dioxide process contributions (µg/m^3)

- 0 - 2
- 2 - 4
- 4 - 10
- 10 - 60
- 60 - 2,203

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	14/09/2022	Initial Issue	DH	GW	GW	RB

Jacobs

Client: SEVERN TRENT

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

Drawing Title: ANNUAL MEAN NITROGEN DIOXIDE PROCESS CONTRIBUTIONS, 2017 METEOROLOGICAL DATA

Drawing Status: FINAL

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Client No.		

Drawing Number: FIGURE 4

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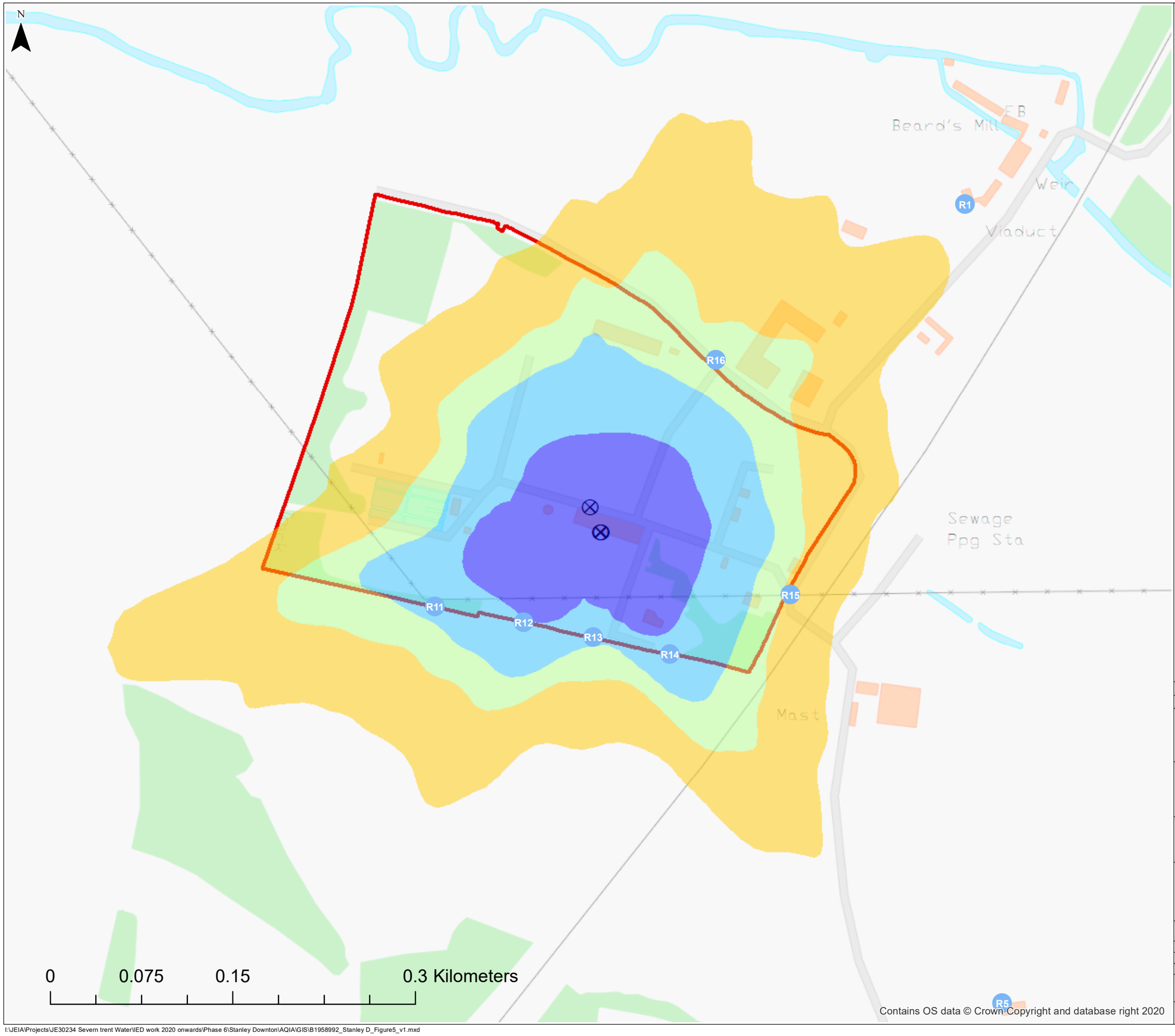

Legend

- Approximate site fenceline
- Modelled stack locations
- R1 Sensitive human receptor locations

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

- 0 - 10
- 10 - 15
- 15 - 20
- 20 - 50
- 50 - 15,423

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	14/09/2022	Initial Issue	DH	GW	GW	RB

Jacobs

Client: SEVERN TRENT

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

Drawing Title: 1-HOUR MEAN (99.79th PERCENTILE) NITROGEN DIOXIDE PROCESS CONTRIBUTIONS, 2020 METEOROLOGICAL DATA

Drawing Status: FINAL

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Jacobs No.	B1958992	Rev 0
Client No.		

Drawing Number: FIGURE 5

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Appendix A. Dispersion Model Input Parameters

A.1 Emission Parameters

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

Table A-1. Dispersion modelling parameters

Parameters	Unit	CHP engine (0.6 MW_{th})	Boiler 1 (0.4 MW_{th})	Boiler 2 (0.4 MW_{th})
Modelled fuel	-	Biogas	Biogas	Biogas
Emission point	-	A1	A2	A3
Assessed annual operation hours	Hours	8,760	8,760	8,760
Stack location	m	E 379159 N 204580	E 379167 N 204560[3]	E 379168 N 204560[3]
Stack height	m	5.71	9.87	9.87
Stack diameter	m	0.23	0.40	0.40
Effective stack diameter	m	3.23[2]	-	-
Flue gas temperature	°C	180	150	150
Efflux velocity	m/s	19.7 (0.1 modelled)[2]	2.6	2.6
Moisture content of exhaust gas	%	11.4	10.0	10.0
Oxygen content of exhaust gas (dry)	%	8.4	3.0	3.0
Volumetric flow rate (actual)	m^3/s	0.820	0.326	0.326
Volumetric flow rate (normal)[1]	Nm^3/s	0.927	0.189	0.189
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)
NOx emission rate	g/s	0.172	0.047	0.047
CO emission concentration[1]	mg/Nm^3	519	100	100
CO emission rate	g/s	0.482	0.019	0.019
PM_{10} / $PM_{2.5}$ emission concentration[1]	mg/Nm^3	2.7	5.0	5.0
PM_{10} / $PM_{2.5}$ emission rate	g/s	0.002	0.001	0.001
SO_2 emission concentration[1]	mg/Nm^3	130	200	200
SO_2 emission rate	g/s	0.120	0.038	0.038
TVOC emission concentration[1]	mg/Nm^3	371	1,126	1,126
TVOC emission rate	g/s	0.344	0.213	0.213

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: As the CHP engine stack is capped, an effective stack diameter was applied in the model based on the volumetric flow rate (actual) divided by an assumed efflux velocity of 0.1 m/s.

Note 3: As the boiler stacks are in close proximity to each other, 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. Building parameters

Building	Modelled building shapes	Length (m)	Width / diameter (m)	Height (m)	Angle of length to north	Centre point co-ordinates	
						Easting	Northing
Building 1	Rectangular	56.10	15.95	5.50	109	379175	204566
Tank 1	Circular	-	10.50	5.82	-	379143	204543
Tank 2	Circular	-	10.55	5.82	-	379175	204532
Tank 3	Circular	-	10.55	5.82	-	379186	204529
Tank 4	Circular	-	10.55	5.82	-	379164	204536
Tank 5	Circular	-	10.60	5.82	-	379154	204539
Tank 6	Circular	-	6.44	4.60	-	379159	204555
Tank 7	Circular	-	6.50	4.60	-	379184	204548
Tank 8	Circular	-	6.45	4.60	-	379193	204545
Tank 9	Circular	-	12.49	12.37	-	379126	204558
Tank 10	Circular	-	12.49	12.37	-	379109	204564

A.3 Other model inputs

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

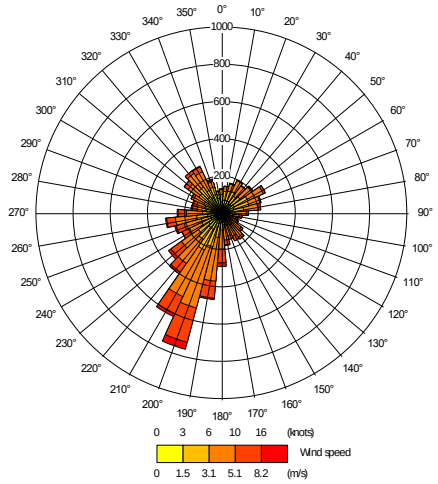
Table A-3. Other model inputs

Parameter	Value used	Comments
Surface roughness length for dispersion site	0.4 m	This is appropriate for the dispersion site where the surrounding local land-use is generally agricultural in nature. 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	0.3 m	This is appropriate for an area where the local land-is relatively flat such as at Pershore 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	Pershore meteorological station, 2016 - 2020	Pershore meteorological station is located approximately 49 km east-northeast of the site and is considered the closest most representative meteorological monitoring station to the site.
Combined flue option	Yes	As the boiler stacks are in close proximity to each other, an aai file was used in the model to represent the effects of a single plume.

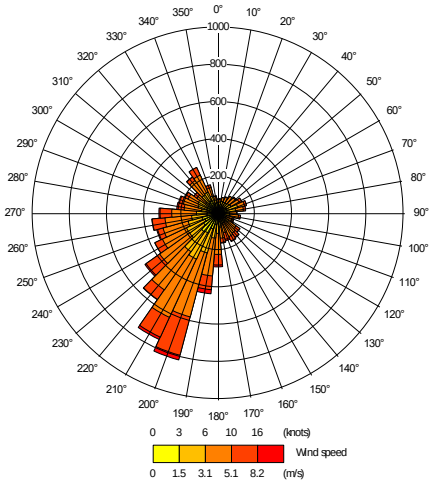
A.3.1 Meteorological Data

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

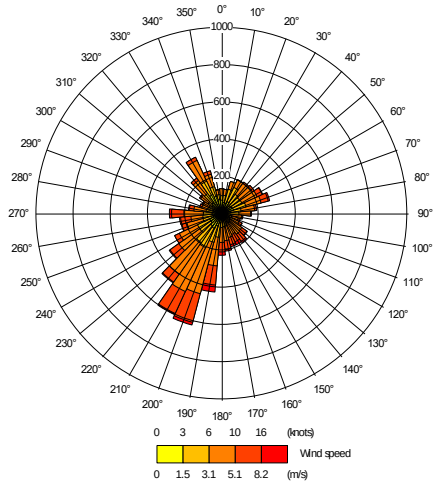
Pershore meteorological station, 2016



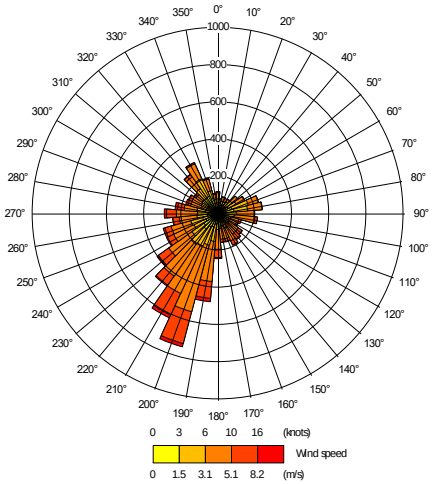
Pershore meteorological station, 2017



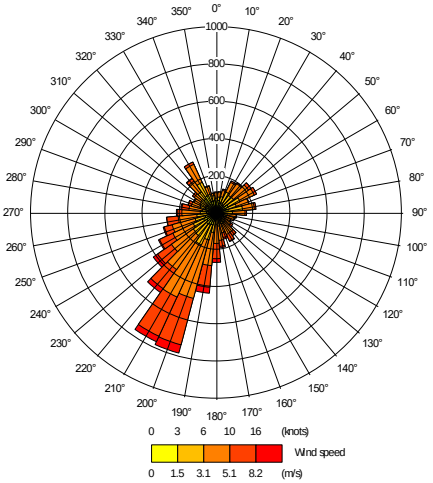
Pershore meteorological station, 2018



Pershore meteorological station, 2019



Pershore meteorological station, 2020



A.3.2 Model Domain/Study Area

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

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

Table A-4. Modelled grid parameters

	Start	Finish	Number of grid points	Grid spacing (m)
Easting	378409	379909	151	10
Northing	203830	205330	151	10
Grid height	1.5	1.5	1	-

As well as the modelled grid, the potential impact at 16 sensitive human receptors (e.g. exposure locations such as residential properties and a PRoW) and 12 protected conservation areas within the required study area were assessed. The receptor locations are shown in Figure 2 and Figure 3 and further details of the human receptor locations and protected conservation areas are provided in Table A-5 and Table A-6 respectively.

Table A-5. Assessed sensitive human receptor

Receptor	Description	Grid reference		Distance from the CHP engine stack (km)	Direction from the CHP engine stack
		Easting	Northing		
R1	Residential property off Bristol Road	379468	204829	0.40	NE
R2	Residential property on Church Lane	380008	204770	0.87	ENE
R3	Residential property on Downton Road	380120	204359	0.99	ESE
R4	Residential property off Downton Road	379653	204180	0.64	SE
R5	Residential property off Downton Road	379498	204172	0.53	SE
R6	Residential property on Bath Road	378387	203706	1.17	SW
R7	Residential property off Bath Road	378102	204621	1.06	W
R8	Residential property off Bath Road	378327	204894	0.89	WNW
R9	Residential property off Bristol Road	379042	205485	0.91	N
R10	Residential property off Bristol Road	379548	205363	0.87	NNE
R11	PRoW	379032	204498	0.15	WSW
R12	PRoW	379105	204485	0.11	SSW
R13	PRoW	379162	204473	0.11	S
R14	PRoW	379225	204459	0.14	SSE
R15	PRoW	379324	204508	0.18	ESE
R16	PRoW	379263	204701	0.16	NE

Table A-6. Assessed protected conservation area locations

Receptor	Description	Grid reference		Distance from the CHP engine stack (km)	Direction from the CHP engine stack
		Easting	Northing		
H1	Ancient & Semi-Natural Woodland (ID 1416123) / Five Acre Grove LWS	378874	204391	0.34	WSW
H2	Ancient & Semi-Natural Woodland (ID 1416122)	379051	204246	0.35	SSW
H3	Five Acre Grove AW	379144	204194	0.39	S
H4	Severn Estuary Ramsar/SPA	373876	206319	5.56	WNW
H5	Severn Estuary SAC	373887	206649	5.66	WNW
H6	Rodborough Common SAC	384560	203638	5.48	E
H7	Bond's Mill Bank LWS	379473	205180	0.68	NNE
H8	River Frome LWS	379185	204943	0.36	N
H9	Stonehouse Newt Pond LWS	379999	205194	1.04	NE
H10	Stroudwater Canal LWS	379467	205167	0.66	NNE
H11	Wickster's Brook and Ditch (part) LWS	378975	203892	0.71	SSW
H12	Wickster's Brook, Bath Road, Eastington LWS	378244	203890	1.15	SW

A.3.3 Treatment of oxides of nitrogen

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

A.3.4 Calculation of PECs

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

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

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

A.3.5 Modelling Uncertainty

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

- The quality of the model output depends on the accuracy of the input data enter the model. Where model input data are a less reliable representation of the true situation, the results are likely to be less accurate.

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

A.3.6 Conservative Assumptions

The conservative assumptions adopted in this study are summarised below.

- The CHP engine and boilers were assumed to operate for 8,760 hours each calendar year but in practice, the combustion plant will have periods of shut-down and maintenance and may not always operate at maximum load. Furthermore, the boilers are unlikely to operate simultaneously and for more than 6,000 hours per year.
- The study is based on emissions being continuously at the emission limits and calculated emissions specified.
- The maximum predicted concentrations at any residential areas as well as off-site locations were considered for the assessment of short-term concentrations and the maximum predicted concentrations at any residential areas were considered for assessment of annual mean concentrations within the air quality study area. Concentrations at other locations will be less than the maximum values presented.
- The highest predicted concentrations obtained using any of the five different years of meteorological data have been used in this assessment. During a typical year the ground level concentrations are likely to be lower.
- It was assumed that 100% of the particulate matter emitted from the plant is in the PM10 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 PM2.5 size fraction. The actual proportion will be less than 100%.
- It was assumed the vegetation type selected for the respective protected conservation areas is present at the specific modelled location where the highest PC was predicted.

Appendix B. Calculating Acid and Nitrogen Deposition

B.1 Methodology

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

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

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

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

Dry deposition flux ($\mu g/m^2/s$) = ground level concentration ($\mu g/m^3$) x deposition velocity (m/s)

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

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

Table B-1. Recommended dry deposition velocities

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

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

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

$\mu g/m^2/s$ of species	Conversion factor to kg N/ha/yr
NO_2	95.9

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

$\mu g/m^2/s$ of species	Conversion factor to keq/ha/yr
NO_2	6.84
SO_2	9.84

Appendix C. Results at Sensitive Human Locations

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

Receptor ID	Baseline air quality level ($\mu g/m^3$)	Maximum 8-hour running mean					Maximum 1-hour mean				
		EQS ($\mu g/m^3$)	PC ($\mu g/m^3$)	PEC ($\mu g/m^3$)	PC/EQS (%)	PEC/EQS (%)	EQS ($\mu g/m^3$)	PC ($\mu g/m^3$)	PEC ($\mu g/m^3$)	PC/EQS (%)	PEC/EQS (%)
R1	226	10,000	41.7	267	0.4%	2.7%	30,000	93.0	319	0.3%	1.1%
R2	226		17.9	244	0.2%	2.4%		38.3	264	0.1%	0.9%
R3	226		12.3	238	0.1%	2.4%		30.9	257	0.1%	0.9%
R4	226		20.7	247	0.2%	2.5%		61.3	287	0.2%	1.0%
R5	226		50.3	276	0.5%	2.8%		80.4	306	0.3%	1.0%
R6	222		11.5	234	0.1%	2.3%		27.4	250	0.1%	0.8%
R7	240		12.1	252	0.1%	2.5%		29.8	270	0.1%	0.9%
R8	240		15.0	255	0.1%	2.6%		37.3	277	0.1%	0.9%
R9	230		17.0	247	0.2%	2.5%		35.5	266	0.1%	0.9%
R10	230		15.8	246	0.2%	2.5%		39.5	270	0.1%	0.9%
R11	226		127.9	354	1.3%	3.5%		287.4	513	1.0%	1.7%
R12	226		253.0	479	2.5%	4.8%		420.4	646	1.4%	2.2%
R13	226		115.2	341	1.2%	3.4%		174.9	401	0.6%	1.3%
R14	226		195.9	422	2.0%	4.2%		375.9	602	1.3%	2.0%
R15	226		80.9	307	0.8%	3.1%		178.2	404	0.6%	1.3%
R16	226		154.8	381	1.5%	3.8%		197.6	423	0.7%	1.4%

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

Receptor ID	Annual mean						99.79th percentile of 1-hour mean					
	Baseline air quality level (µg/m³)	EQS (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)	EQS (µg/m³)	Baseline air quality level (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)
R1	8.9	40	0.8	9.7	2.0%	24.2%	200	17.8	8.8	26.5	4.4%	13.3%
R2	8.0		0.2	8.2	0.4%	20.5%		16.1	3.0	19.1	1.5%	9.5%
R3	8.0		0.1	8.1	0.2%	20.3%		16.1	1.8	17.9	0.9%	9.0%
R4	8.9		0.2	9.1	0.4%	22.7%		17.8	3.7	21.4	1.8%	10.7%
R5	8.9		0.3	9.2	0.7%	22.9%		17.8	4.8	22.6	2.4%	11.3%
R6	7.6		0.1	7.6	0.2%	19.1%		15.1	2.0	17.2	1.0%	8.6%
R7	7.5		0.1	7.6	0.2%	18.9%		15.0	2.2	17.1	1.1%	8.6%
R8	7.5		0.1	7.6	0.2%	18.9%		15.0	2.1	17.1	1.1%	8.5%
R9	13.1		0.1	13.2	0.3%	33.1%		26.2	2.8	29.1	1.4%	14.5%
R10	13.1		0.4	13.5	0.9%	33.7%		26.2	4.9	31.1	2.4%	15.6%
R11	8.9		2.2	11.1	5.6%	27.8%		17.8	23.4	41.2	11.7%	20.6%
R12	8.9		3.6	12.5	9.1%	31.3%		17.8	44.2	62.0	22.1%	31.0%
R13	8.9		1.8	10.7	4.5%	26.8%		17.8	22.3	40.0	11.1%	20.0%
R14	8.9		2.7	11.6	6.8%	29.0%		17.8	35.0	52.7	17.5%	26.4%
R15	8.9		1.3	10.2	3.3%	25.6%		17.8	15.9	33.6	7.9%	16.8%
R16	8.9		4.2	13.1	10.5%	32.7%		17.8	20.2	38.0	10.1%	19.0%

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

Receptor ID	99.18th percentile of 24-hour mean						99.73rd percentile of 1-hour mean					
	Baseline air quality level (µg/m³)	EQS (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)	EQS (µg/m³)	Baseline air quality level (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)
R1	4.2	125	3.5	7.7	2.8%	6.2%	350	4.2	16.6	20.7	4.7%	5.9%
R2	5.0		1.2	6.2	0.9%	4.9%		5.0	5.4	10.4	1.6%	3.0%
R3	5.0		0.8	5.7	0.6%	4.6%		5.0	3.3	8.3	0.9%	2.4%
R4	4.2		2.3	6.4	1.8%	5.1%		4.2	6.5	10.7	1.9%	3.0%
R5	4.2		2.9	7.1	2.3%	5.7%		4.2	9.1	13.3	2.6%	3.8%
R6	4.0		0.9	4.8	0.7%	3.9%		4.0	3.8	7.7	1.1%	2.2%
R7	3.9		1.0	4.9	0.8%	3.9%		3.9	4.0	7.9	1.1%	2.3%
R8	3.9		1.1	5.0	0.8%	4.0%		3.9	3.9	7.8	1.1%	2.2%
R9	6.0		1.0	7.0	0.8%	5.6%		6.0	5.1	11.1	1.5%	3.2%
R10	6.0		1.8	7.8	1.4%	6.2%		6.0	9.3	15.3	2.6%	4.4%
R11	4.2		23.0	27.2	18.4%	21.7%		4.2	46.6	50.8	13.3%	14.5%
R12	4.2		43.6	47.8	34.9%	38.2%		4.2	88.5	92.7	25.3%	26.5%
R13	4.2		21.7	25.9	17.4%	20.7%		4.2	44.8	48.9	12.8%	14.0%
R14	4.2		31.0	35.2	24.8%	28.2%		4.2	69.2	73.3	19.8%	21.0%
R15	4.2		9.9	14.1	7.9%	11.3%		4.2	31.9	36.0	9.1%	10.3%
R16	4.2		15.6	19.7	12.4%	15.8%		4.2	37.2	41.4	10.6%	11.8%

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

Receptor ID	99.9th percentile of 15-minute mean					
	Baseline air quality level (µg/m³)	EQS (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)
R1	4.2	266	33.2	37.4	12.5%	14.1%
R2	5.0		12.4	17.4	4.7%	6.5%
R3	5.0		9.7	14.7	3.6%	5.5%
R4	4.2		15.9	20.1	6.0%	7.5%
R5	4.2		27.3	31.4	10.3%	11.8%
R6	4.0		9.1	13.0	3.4%	4.9%
R7	3.9		8.4	12.3	3.2%	4.6%
R8	3.9		10.8	14.7	4.1%	5.5%
R9	6.0		10.8	16.8	4.1%	6.3%
R10	6.0		18.3	24.3	6.9%	9.1%
R11	4.2		56.1	60.2	21.1%	22.6%
R12	4.2		101.1	105.2	38.0%	39.6%
R13	4.2		53.0	57.2	19.9%	21.5%
R14	4.2		80.6	84.8	30.3%	31.9%
R15	4.2		40.9	45.0	15.4%	16.9%
R16	4.2		63.8	67.9	24.0%	25.5%

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

Receptor ID	Annual mean						90.41st percentile of 24-hour mean					
	Baseline air quality level (µg/m³)	EQS (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)	EQS (µg/m³)	Baseline air quality level (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)
R1	12.2	40	0.02	12.2	<0.1%	30.6%	50	24.4	0.04	24.5	0.1%	48.9%
R2	12.4		0.00	12.4	<0.1%	31.0%		24.8	0.01	24.8	<0.1%	49.6%
R3	12.4		0.00	12.4	<0.1%	31.0%		24.8	0.01	24.8	<0.1%	49.6%
R4	12.2		0.00	12.2	<0.1%	30.5%		24.4	0.01	24.4	<0.1%	48.9%
R5	12.2		0.01	12.2	<0.1%	30.5%		24.4	0.02	24.4	<0.1%	48.9%
R6	12.4		0.00	12.4	<0.1%	31.0%		24.8	0.01	24.8	<0.1%	49.6%
R7	12.2		0.00	12.2	<0.1%	30.5%		24.4	0.01	24.4	<0.1%	48.8%
R8	12.2		0.00	12.2	<0.1%	30.5%		24.4	0.01	24.4	<0.1%	48.8%
R9	12.8		0.00	12.8	<0.1%	32.0%		25.6	0.01	25.6	<0.1%	51.3%
R10	12.8		0.01	12.8	<0.1%	32.1%		25.6	0.02	25.7	<0.1%	51.3%
R11	12.2		0.04	12.3	0.1%	30.6%		24.4	0.20	24.6	0.4%	49.2%
R12	12.2		0.07	12.3	0.2%	30.7%		24.4	0.31	24.7	0.6%	49.5%
R13	12.2		0.04	12.3	0.1%	30.6%		24.4	0.15	24.6	0.3%	49.2%
R14	12.2		0.05	12.3	0.1%	30.7%		24.4	0.25	24.7	0.5%	49.3%
R15	12.2		0.03	12.2	0.1%	30.6%		24.4	0.09	24.5	0.2%	49.0%
R16	12.2		0.09	12.3	0.2%	30.7%		24.4	0.19	24.6	0.4%	49.2%

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

Receptor ID	Annual mean					
	Baseline air quality level ($\mu g/m^3$)	EQS ($\mu g/m^3$)	PC ($\mu g/m^3$)	PEC ($\mu g/m^3$)	PC/EQS (%)	PEC/EQS (%)
R1	7.9	25	0.02	7.9	0.1%	39.4%
R2	8.1		0.00	8.1	<0.1%	40.4%
R3	8.1		0.00	8.1	<0.1%	40.4%
R4	7.9		0.00	7.9	<0.1%	39.4%
R5	7.9		0.01	7.9	<0.1%	39.4%
R6	7.8		0.00	7.8	<0.1%	39.0%
R7	7.8		0.00	7.8	<0.1%	38.9%
R8	7.8		0.00	7.8	<0.1%	38.9%
R9	8.4		0.00	8.4	<0.1%	41.9%
R10	8.4		0.01	8.4	<0.1%	41.9%
R11	7.9		0.04	7.9	0.2%	39.6%
R12	7.9		0.07	7.9	0.4%	39.7%
R13	7.9		0.04	7.9	0.2%	39.5%
R14	7.9		0.05	7.9	0.3%	39.6%
R15	7.9		0.03	7.9	0.1%	39.5%
R16	7.9		0.09	8.0	0.4%	39.8%

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

Receptor ID	Annual mean						100th percentile of maximum 24-hour mean					
	Baseline air quality level (µg/m³)	EQS (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)	EQS (µg/m³)	Baseline air quality level (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC/EQS (%)	PEC/EQS (%)
R1	0.2	5 (Benzene)	3.1	3.3	62.2%	66.7%	30 (Benzene)	0.4	15.5	16.0	51.7%	53.2%
R2	0.2		0.7	0.9	13.8%	18.4%		0.5	5.3	5.7	17.6%	19.1%
R3	0.2		0.3	0.6	6.7%	11.3%		0.5	3.9	4.3	12.9%	14.5%
R4	0.2		0.7	0.9	13.5%	18.0%		0.4	11.0	11.4	36.6%	38.1%
R5	0.2		1.0	1.2	19.8%	24.3%		0.4	38.4	38.9	128.0%	129.5%
R6	0.2		0.3	0.5	5.8%	10.0%		0.4	5.8	6.2	19.4%	20.7%
R7	0.2		0.3	0.6	6.8%	11.6%		0.5	7.8	8.3	25.9%	27.5%
R8	0.2		0.3	0.5	5.8%	10.6%		0.5	5.1	5.5	16.9%	18.5%
R9	0.2		0.4	0.6	8.4%	13.0%		0.5	4.4	4.9	14.8%	16.3%
R10	0.2		1.4	1.6	27.0%	31.6%		0.5	7.7	8.1	25.6%	27.1%
R11	0.2		8.2	8.4	163.8%	168.3%		0.4	89.1	89.5	296.9%	298.4%
R12	0.2		13.4	13.6	267.8%	272.2%		0.4	184.2	184.6	613.9%	615.4%
R13	0.2		7.4	7.7	148.5%	153.0%		0.4	124.4	124.9	414.8%	416.3%
R14	0.2		10.3	10.5	206.1%	210.5%		0.4	153.2	153.6	510.5%	512.0%
R15	0.2		5.3	5.5	105.4%	109.9%		0.4	47.7	48.1	158.8%	160.3%
R16	0.2		16.3	16.6	326.6%	331.1%		0.4	67.0	67.5	223.4%	224.9%