Air Quality Consultants

Air Quality Assessment for Environmental Permit: Haworth Scouring

August 2024

Experts in air quality management & assessment

Document Control

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1 Introduction

1.1 This report describes the air quality assessment for the proposed Combined Heat and Power (CHP) plant at Haworth Scouring Company, in Bradford. The assessment has been prepared to support the Bespoke Environmental Permit application for the facility, which is made in accordance with the Environmental Permitting Regulations (EPR) (2018). The assessment has been carried out by Air Quality Consultants Ltd on behalf of Haworth Scouring Company.

1.2 The facility currently comprises of one CHP unit and a single boiler, both fuelled by natural gas. The existing plant is used for the drying process, to provide hot water and steam for the industrial washing water and for some space heating. The existing CHP unit and proposed CHP unit, together, are classified a Tranche B specified generator. The site currently holds a Bespoke Environmental Permit which includes the existing boiler and CHP unit. A permit variation will be required to include the proposed CHP unit which will run on biogas. The detailed air dispersion modelling, which a bespoke environmental permit variation requires, is described in this report.

1.3 The assessment focuses on nitrogen dioxide (NO_2). This is the principal pollutant of concern with respect to emissions from plant using natural gas or biogas. Plant using natural gas or desulfurized biogas will not have significant emissions of other pollutants like particulate matter, sulphur dioxide or volatile organic compounds, and emissions of carbon monoxide are considered to be small compared to the environmental standards and not warranting assessment.

1.4 Table 1 gives the site location. Table 2 summarises the modelled scenarios and sensitivity tests that have been carried out. All sources, the existing boiler, existing CHP unit and proposed CHP unit, have been modelled. The contribution from the existing boiler is also included in the background concentrations, which are taken from 2022 monitoring data[1], so the impacts from the existing plant will be somewhat double-counted, thus providing a worst-case assessment.

1.5 The model input files have been packaged as a zip file and sent alongside this report.

Table 1: Site Location

Parameter	Entry
Site Name	Haworth Scouring Company
Site Address	Shelby House, Cashmere Works, Birksland St, Bradford BD3 9SX
Grid Reference (O.S. X,Y) [a]	417900, 432700

[1] Some contribution from the existing CHP unit is also expected as this was installed later in 2022 but will not have been operational for the whole year.

[a] The coordinates refer to the centre of the site, not the point of release, as there are three release locations.

Table 2: Summary of Model Scenarios and Sensitivity Tests

Parameter	Entry
Sources	The dispersion model has been run to predict concentrations relating to emissions from the existing boiler and CHP plant, and the proposed CHP plant separately, as well as the combined effect of all sources.
Year for Baseline Conditions	Most recent year of available measurements/predictions – no improvement assumed into the future (see Section 5)
Operating Hours	**Existing Boiler:** Operational 24 hours, 5 days a week and 47 weeks a year, totalling 5,640 hours per year. **Existing CHP Plant:** Operational 5,360 hours per year. **Proposed CHP Plant:** Operational 5,360 hours per year. The dispersion model has been run assuming continuous operation, with the annual mean outputs scaled to reflect the non-continuous use. Short-term outputs have assumed constant operation and are thus worst-case (see Paragraphs 6.23 and 6.24)
Meteorological Conditions	Five years of meteorological data used. Each modelled separately. Receptor-specific maxima out of the five years are reported (see Section 6)
Building Wake Effects	Model run with and without nearby buildings. Receptor-specific maxima from the two tests are reported (see Section 6)

2 Site Description

Nearby Sensitive Features

2.1 The site is situated in Bradford, 1.3 km east of the city centre. Figure 1 shows the site location, local authority Air Quality Management Areas (AQMA), 2 km and 10 km distance bands and designated ecological sites of relevance. Figure 2 presents the same information but focussing on the area within 2 km of the site only. Table 3 summarises the proximity of nearby sensitive features. There are no Sites of Special Scientific Interest (SSSIs) within 2 km of the site and no Special Areas of Conservation (SACs), Special Protection Areas (SPAs), or Ramsar sites within 10 km of the site. Following guidance from the EA, there is thus no need to consider effects on sensitive ecosystems (EA, 2023b).

2.2 Based on publicly available information, there are no known permitted Specified Generator arrays operating within 1 km of the site. No sources of emissions to air are identified within 1 km on the UK Pollutant Release and Transfer Register (PRTR) (Defra, 2012).

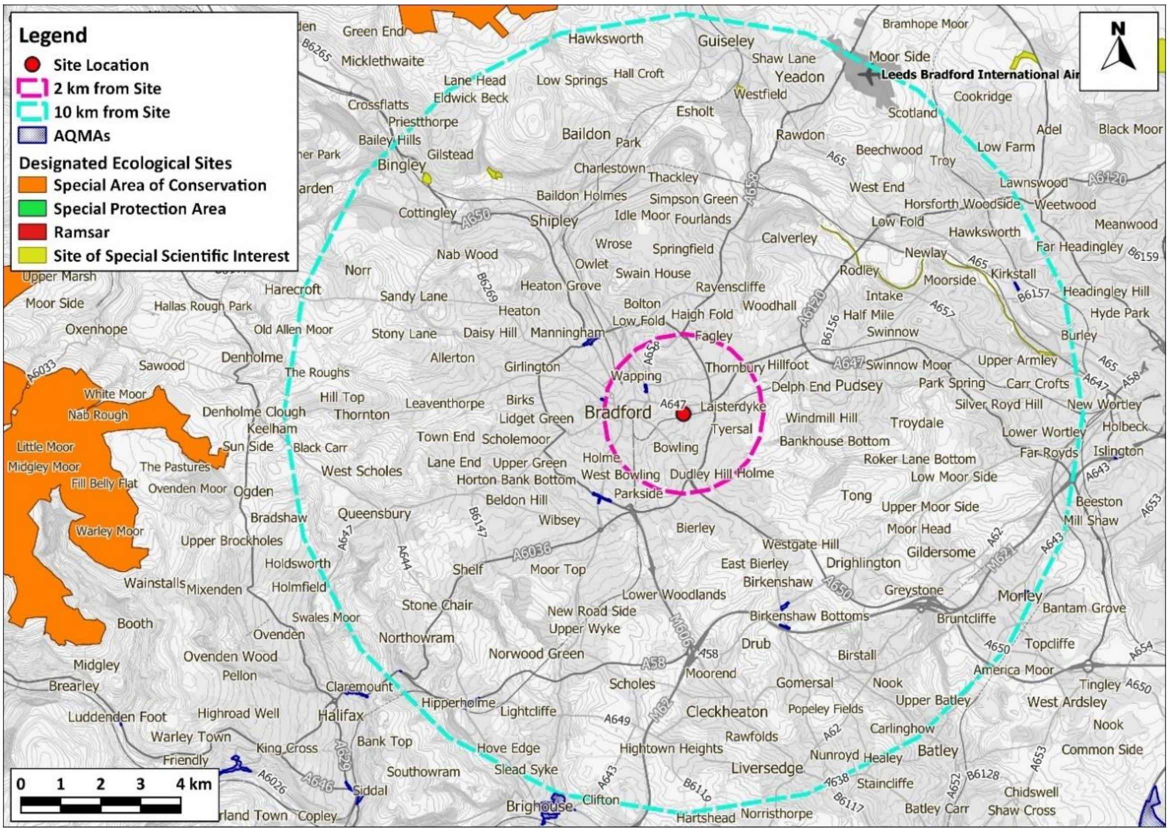

Figure 1: Site Location, AQMAs, SACs, SPAs, Ramsar Sites and SSSIs Within 10 km

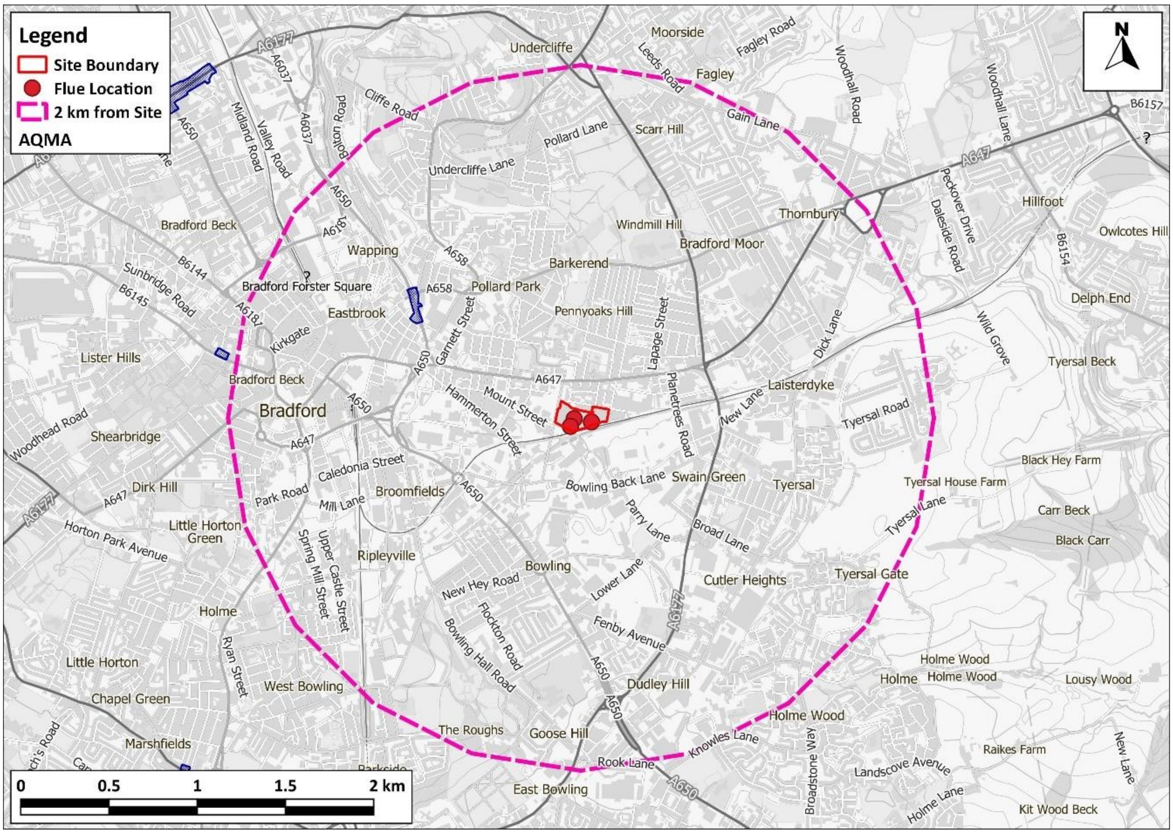

Figure 2: Site Location and AQMAs Within 2 km

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Table 3: Summary of Nearby Sensitive Features

Feature	Description	Distance from Stack
Nearest roadside human receptor	Residential property off A647 Leeds Road, north of site	340 m
Nearest non-roadside human receptor	Residential property off Gibson Street, north of site	140 m
Nearest SSSI	The Leeds – Liverpool Canal SSSI	5,820 m
Nearest SAC, SPA, or Ramsar site	South Pennine Moors SAC	10,500 m
Receptors within the downwash cavity length from the nearest edge/side of the building?	There are receptors on Sewell Road and Gibson Street downwind of the building within the region of potential downwash effects (170 m)	120 m
Sensitive receptor setting	Urban	n/a
Sensitive receptors near an A road or motorway network?	Residential properties off A647 Leeds Road, north of site	310 m
Sensitive receptors within an AQMA declared for NO_2?	Residential property in AQMA No. 4, off Shipley Airedale Road, northwest of site	1,025 m

Topography and Terrain

2.3 Figure 3 shows the terrain across the modelled study area using Ordnance Survey (OS) Terrain 50 data. Gradients within 1 km of the site are generally less than 1 in 10, but there are some steeper gradients at greater distances and within the modelled domain.

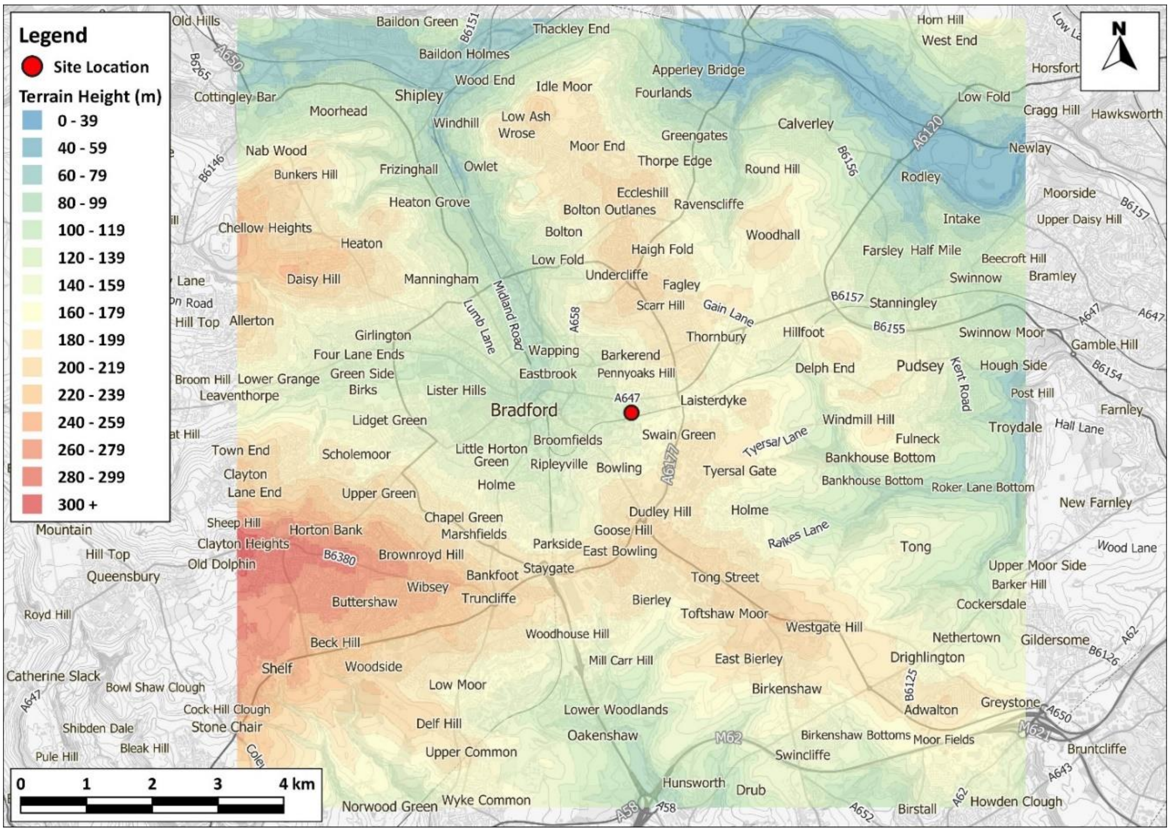

Figure 3: Terrain across Modelled Area

3 Description of Process

Overview of New Plant Requiring Permit Variation

3.1 The proposed biogas-fired CHP plant has a net thermal input capacity of 1,320 kW (1,464.7 kW gross thermal input). The combustion gases from the proposed CHP unit will be exhausted from a vertical flue terminating 10 m above ground level.

3.2 Figure 4 shows the site and existing and proposed flue locations. Basic plant details for the proposed CHP are given in Table 4 and Table 5.

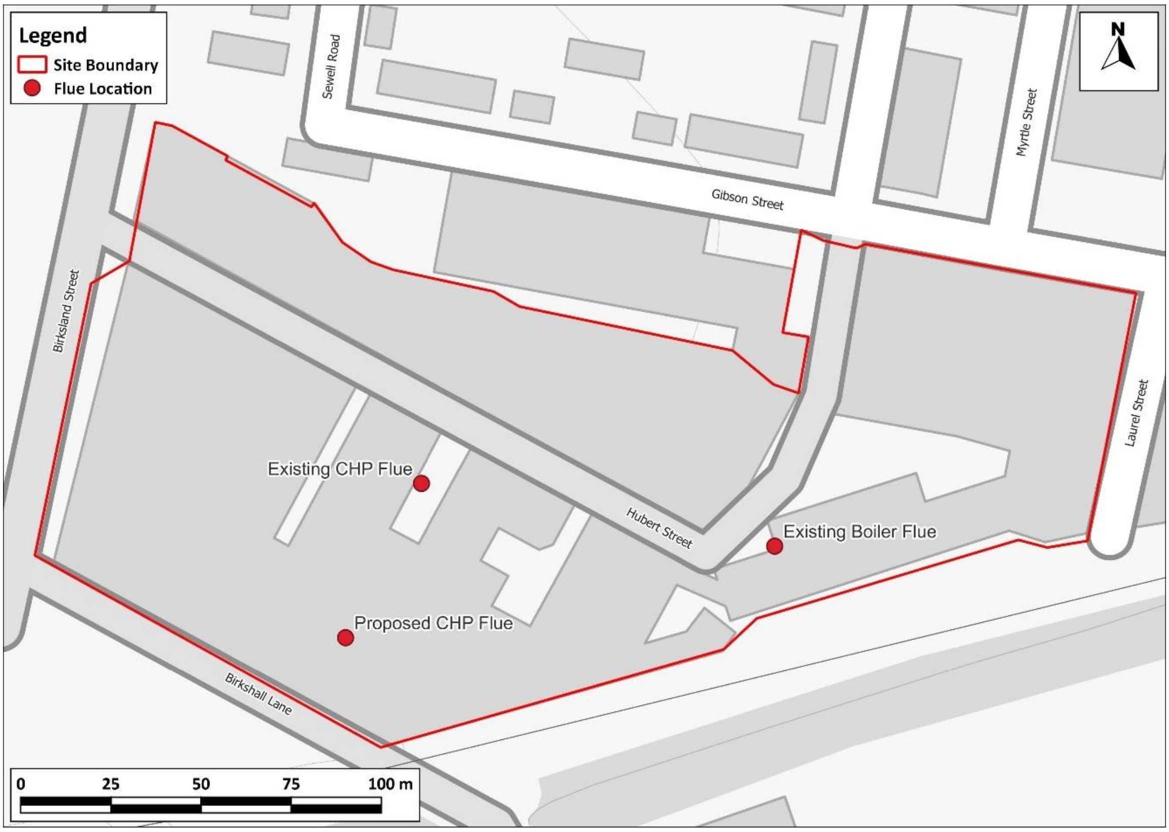

Figure 4: Site Layout

Table 4: Plant Information – Proposed CHP

Parameter	Value
Specified generator usage type category	CHP
Mixed Tranche A and B Specified Generator site?	Yes

Specified generators aggregated rated thermal input	1320 kW
Operational hours per year	5,360
If 'Peaking' or 'Balancing', is rolling average flexibility required?	No
Existing or new medium combustion plant generators?	New
Do the generators have secondary abatement fitted?	No
Emission Limit Value (273 K, dry and 15% O_2)	190 mg/Nm^3

Table 5: Stack and Building Information

Parameter	Value
Stack height above ground	10 m
Internal flue diameter at point of release	250 mm
Is there one or more buildings within 5L and with heights more than 40% of the stack height?	Yes
Height of tallest building within 5L	33 m
Length of tallest building within 5L	6 m
Width of tallest building within 5L	6 m

Additional Details

3.3 The facility currently comprises a gas-fired boiler which is controlled through an existing permit. This boiler has an approximate net thermal input capacity of ~2,909 kWth (~3,222 kWth gross thermal input)[2]. The boiler is used to generate hot water and steam for both the wash and rinse bowls of the scouring process and the drying oven to dry the cleaned wool fibre as well as facilitate the effluent treatment plant on-site. Emissions from the boiler are vented through a 20 m high stack.

3.4 The facility also includes a natural gas-fired CHP unit which is also controlled through the existing permit. The existing CHP unit has an approximate net thermal input capacity of 3,557 kWth (3,940 kWth gross thermal input). The CHP plant is used to provide electricity for the process and provide hot water and steam for the industrial washing water boiler. Emissions from the boiler are vented through a 34 m high stack.

3.5 Full details of existing plant are included in the modelling methodology section of this report (Section 6).

[2] The exact specification for the boiler is not known. Therefore, the emission and physical parameters have been calculated based on a number of conservative assumptions detailed in Section 6.

4 Environmental Standards for Air

4.1 The relevant Air Quality Standards (AQS) for human health impacts are set out in Table 6 (EA, 2023a).

Table 6: AQS for Human Health

Pollutant	Averaging Period	AQS (µg/m³)	Acceptable Exceedance Criteria
NO_2	Annual Mean	40	Zero exceedances
	1-hour	200	Not to be exceeded more than 18 times a year

4.2 The AQS for NO_2 are defined as UK objectives within the Air Quality (England) Regulations (2000) and the Air Quality (England) (Amendment) Regulations (2002). The same numerical values are also set as European Limit values (The European Parliament and the Council of the European Union, 2008).

4.3 The objectives apply at locations where members of the public are likely to be regularly present and are likely to be exposed over the averaging period of the objective. Defra explains where these objectives will apply in its Local Air Quality Management Technical Guidance (Defra, 2022) . The annual mean objectives are considered to apply at the façades of residential properties, schools, hospitals etc.; they do not apply at hotels. The 1-hour mean objective for nitrogen dioxide applies wherever members of the public might regularly spend 1-hour or more, including outdoor eating locations and pavements of busy shopping streets. In the UK, only monitoring and modelling carried out by UK Central Government meets the specification required to assess compliance with the limit values and specific monitor and receptor siting requirements apply. Neither the objectives nor limit values apply in places of work where members of the public have no free access and where relevant provisions concerning health and safety at work apply (AQC, 2016).

5 Baseline Conditions

Human Health

5.1 Figure 5 sets out the background annual mean NO_2 concentrations in the study area taken from Defra's published maps for 2024 (Defra, 2021). Figure 6: Measured Annual Mean NO2 Concentrations (µg/m3)Figure 6 shows the annual mean NO_2 concentrations in the study area as measured by City of Bradford Metropolitan District Council (BMDC) in 2022, which is the most recent year for which the Council has published its measurements. Measurements made by BMDC are also tabulated in Table 7.

5.2 Monitored concentrations at DT209A/B/C have been considered to be suitably representative of concentrations at roadside locations around the site. Higher roadside concentrations have been measured elsewhere in the model domain, but not close to locations where significant effects are possible. Specifically, monitoring sites CM6 and DT12A/B/C recorded higher concentrations than DT209A/B/C in recent years; however these are located in the Airedale Road AQMA, 900 m away from the site, and are not representative of concentrations at receptors nearer to the site, outside the AQMA. Concentrations from DT209A/B/C have therefore informed the roadside baseline concentrations in this assessment. The most recent year of monitoring data (2022) shows annual mean NO_2 concentrations at the DT209A/B/C was 31.3 µg/m^3.

5.3 Monitored concentrations at DT201 have been considered suitably representative of concentrations at urban background locations around the site. Whilst DT201 is a roadside monitor, it is not located on a busy main road and is considered more representative of the non-roadside receptors near to the site than BMDC urban background monitoring locations which are over 3.9 km from the site. The most recent year of monitoring data (2022) for DT201 measured an annual mean NO_2 concentration of 28.0 µg/m^3. This compares with the Defra mapped concentration of 16.3 µg/m^3 at the same location and thus the measured concentration at DT201 is considered to be more conservative.

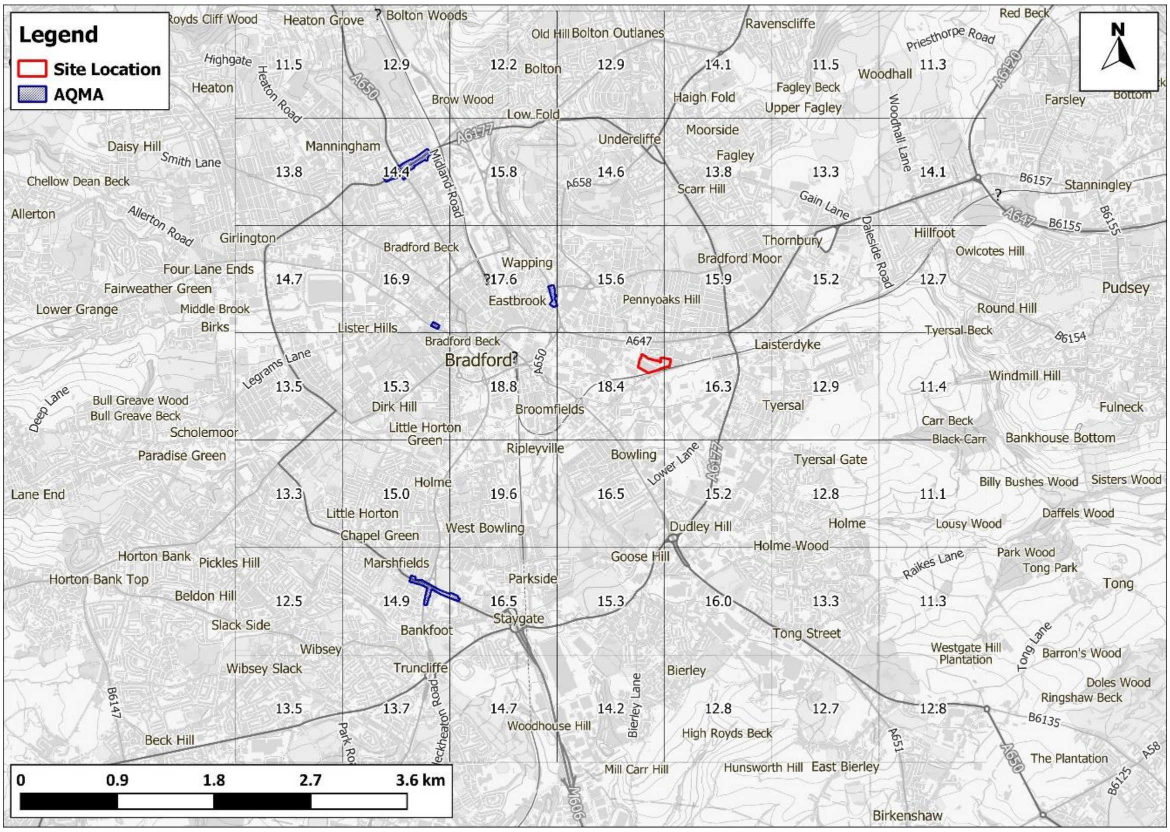

Figure 5: Defra's Predicted NO_2 Background Concentrations in the Area Surrounding the Site (μg/m^3)

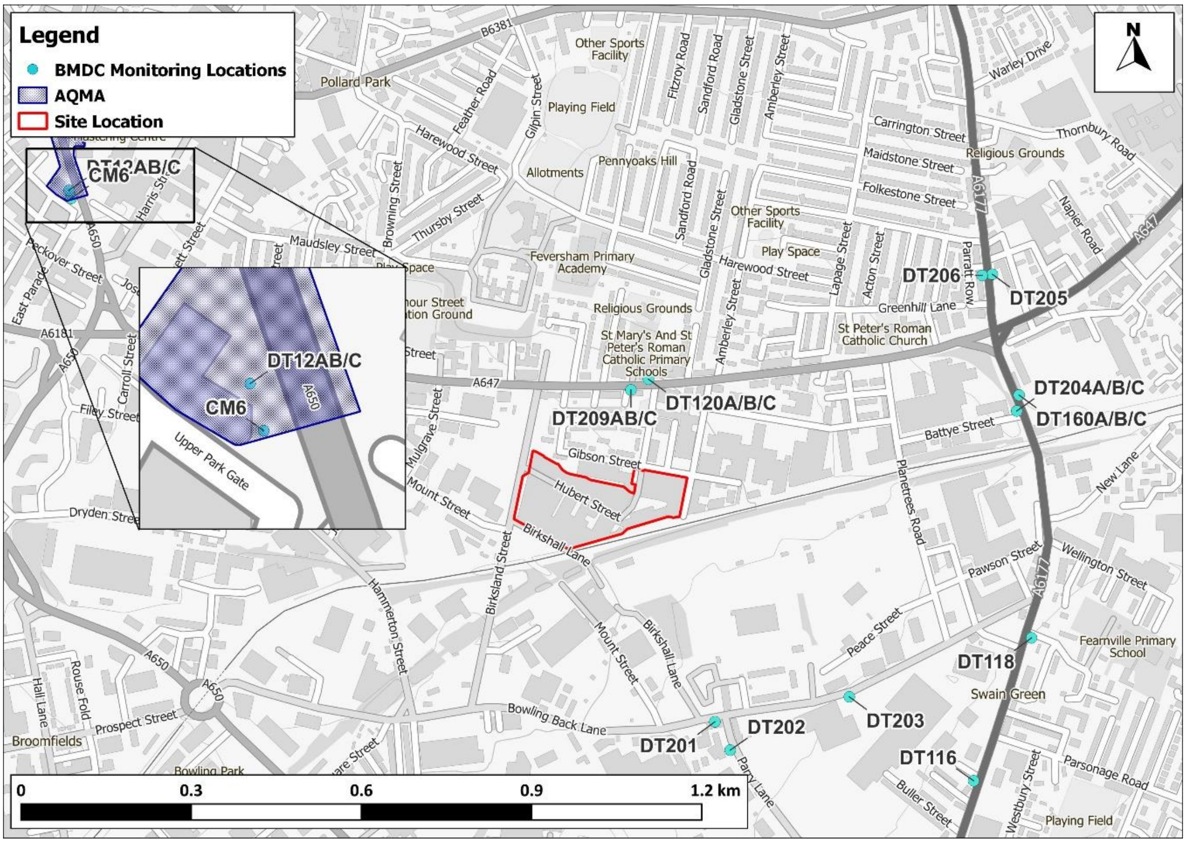

Figure 6: Measured Annual Mean NO_2 Concentrations (μg/m^3)

Table 7: Summary of NO_2 Monitoring (2018-2022) [a]

Site No.	Site Type	Location	2018	2019	2020	2021	2022
Automatic Monitor - Annual Mean (µg/m³)							
CM6	Roadside	Shipley Airedale Road	**48**	**46**	38	**41**	37
Objective			**40**				
Automatic Monitor - No. of Hours > 200 µg/m³ [b]							
CM6	Roadside	Shipley Airedale Road	0	0	0	0 (99.7)	0
Objective			**18 (200)**				
Diffusion Tubes - Annual Mean (µg/m³) [c]							
DT116	Roadside	Sticker Lane lp41	27	24	18.9	20.6	22.6
DT118	Roadside	Fearnville Drive lp1	27	27	20.5	22.1	24.1
DT201	Roadside	Bowling Back Lane / Parry Lane	-	-	-	30	28
DT202	Roadside	Parry Lane LP2	-	-	-	22	21.2
DT203	Roadside	LP 43 Bowling Back Lane opposite entrance to recycling Centre	-	-	-	23.6	25.6
DT160A/ B/C	Roadside	Laisterdyke	-	-	22.9	24.4	23.8
DT204 A/B/C	Roadside	Laisterdyke LP9 opp DT119	-	-	-	19.2	20.6
DT120A/ B/C	Roadside	Leeds Rd St Marys School	35	31	27.1	30.6	30.5
DT209A/ B/C	Roadside	LP57 Leeds Road opposite Steadman Terrace and 120	-	-	-	33.1	31.3
DT205	Roadside	LP6 Killinghall Road across from House no. 17	-	-	-	24.4	26
DT206	Roadside	LP5 Killinghall Road outside house no. 17 opp DT205	-	-	-	29.4	30.9
DT12A/B /C	Roadside	Treadwell Mills - Shipley Airedale Rd	**55**	**52**	**45.8**	**50.6**	**49.3**
Objective			**40**				

[a] Data from the BMDC Annual Status Report (City of Bradford Metropolitan District Council, 2023)

[b] Values in brackets are 99.79th percentiles, which are presented where data capture is <75%.

[c] Diffusion tubes prepared and analysed by Gradko (using the 50% TEA in acetone method) and adjusted for bias by the Council.

[d] Exceedances of the objectives are shown in bold.

Summary of Baseline NO_2 Concentrations

5.4 Table 8 sets out the baseline NO_2 concentrations used in this assessment.

Table 8: Baseline NO_2 Concentrations Used in Assessment

Location	Value ($\mu g/m^3$)	Derivation
Annual Mean Concentrations		
All Receptors Close to A-Roads	31.3	Highest concentration across all of the roadside measurements (excluding within AQMAs) and all of the roadside Pollution Climate Modelling (PCM) predictions in the nearby study area
All Receptors Away from A-Roads	28.0	Highest concentration across all of the measurements at monitoring sites away from the A-road network and all of the mapped Defra background concentrations in the study area
1-hour Mean Concentrations		
All Receptors Close to A-Roads	62.6	2 x the annual mean
All Receptors Away from A-Roads	56	

[a] PCM provide gridded 1x1 km maps of background pollutant concentrations.

6 Modelling Methodology

6.1 Modelling has been carried out in line with EA documents:

- Air emissions risk assessment for your environmental permit (EA, 2023a) ;
- Environmental permitting: air dispersion modelling reports (EA, 2024); and
- Emissions from specified generators. Guidance on dispersion modelling for oxides of nitrogen assessment from specified generators Version 1 (EA, 2023b).

Dispersion Model

6.2 There are two primary dispersion models which are used extensively throughout the UK for assessments of this nature and accepted as appropriate air quality modelling tools by the Regulators and local planning authorities alike:

- The ADMS model, developed in the UK by Cambridge Environmental Research Consultants (CERC) in collaboration with the Met Office, National Power and the University of Surrey; and
- The AERMOD model, developed in the United States by the American Meteorological Society (AMS)/United States Environmental Protection Agency (EPA) Regulatory Model Improvement Committee (AERMIC).

6.3 Both models are termed 'new generation' Gaussian plume models, parameterising stability and turbulence in the planetary boundary layer (PBL) by the Monin-Obukhov length and the boundary layer depth. This approach allows the vertical structure of the PBL to be more accurately defined than by the stability classification methods of earlier dispersion models. Like these earlier models, ADMS and AERMOD adopt a symmetrical Gaussian profile of the concentration distribution in the vertical and crosswind directions in neutral and stable conditions. However, unlike earlier models, the ADMS and AERMOD vertical concentration profile in convective conditions adopts a skewed Gaussian distribution to take account of the heterogeneous nature of the vertical velocity distribution in the Convective Boundary Layer (CBL).

6.4 Numerous model inter-comparison studies have demonstrated little difference between the output of ADMS and AERMOD, except in certain scenarios, such as in areas of complex terrain (Carruthers et al., 2011). For the purposes of this particular study, the use of the ADMS model (version 6.0) is adopted. ADMS is widely used for assessments of this type and has been extensively validated (CERC, 2024). Consequently, it is considered suitable for the current assessment.

Emission Parameters

6.5 Operational parameters for the proposed CHP unit for net fuel consumption, exhaust mass flow rate and pollutant emission rate have been determined from the generator product specification datasheet (see Appendix A1). The stack diameter and exhaust temperature have been provided by

2G Energy Ltd (the engine manufacturers). These parameters have been used as the basis for the combustion, exhaust and pollutant emission calculations. The pollutant emission rate taken from the generator specification datasheet is below the relevant emission limit value from the Medium Combustion Plant Directive (The European Parliament and the Council of the European Union, 2015). The proposed stack height has been modelled at 10 m.

6.6 The combustion parameters have been calculated for biogas, with a composition as defined in Table 9. The composition is representative of raw biogas, although it is assumed that an biogas used at the site will be sulfurized (i.e. been through a process of sulphur removal thus eliminating SO_2 emissions). Using this raw biogas composition is conservative as it results in a higher mass NOx emissions rate than using a fuel composition with a higher proportion of methane and lower proportion of carbon dioxide. If such as biogas were to be used (i.e. closer to natural gas) then the pollutant emission rate would be lower. The specified parameters are based on the complete combustion of the fuel used. The volume of combustion air has been calculated to ensure the exhaust gas mass flow rate (kg/h) of the combustion products matches the amount stated in the technical data sheet in Appendix A1 when operating at full load.

Table 9: Biogas Gas Composition

Parameter	Value
Methane	50%
Carbon Dioxide	50%

6.7 Based on this fuel, and assuming complete combustion, the plant parameters are shown in Table 10. Orange highlighted cells contain the values entered into the model, for ease of reference.

6.8 Emission parameters for the existing plant have been taken from the detailed air quality assessment undertaken prior to the installation of the existing CHP (Air Quality Consultants, 2023).

Table 10: Plant Specifications, Emissions and Release Conditions (per flue)

Parameter	Value		
	Proposed CHP	Existing CHP	Existing Boiler
Electrical Power Output (kW_{out})	550	1521	N/A
Net Input Fuel Rate (kW_{in})	1320	3557	2909
Gross Input Fuel Rate (kW_{in})	1464.7	3939	3222
Gross Fuel Consumption (kg/hr)	355.6	275	302
Combustion Air_{in} (kg/h dry)	2688.76	7819	4203
Excess Air (%)	64.2	77	17
Exhaust Mass Flow (kg/h) for Actual Flow	3060.1	8140	4210

Parameter	Value		
	Proposed CHP	Existing CHP	Existing Boiler
Molar Flow Rate (mol/s) for Actual Flow	29.32	80	40
Molecular Mass (g/mol) for Actual Flow	28.99	28	29
Exhaust Flow (Am^3/s) [a, b] for Actual Flow	0.946	2.59	1.63
Flue Internal Diameter (m)	0.25	0.394	0.3
Exhaust Velocity (Am/s) for Actual Flow	19.27	21.2	23.1
Exhaust Temperature (ºC)	120	120	217
Actual Exhaust O_2 Content (%)	7.2	8.6	3.0
Actual Exhaust H_2O Content (%)	12	11.7	9.2
Molar Flow Rate (mol/s) for Normalised Flow	20.63	50	36
Exhaust Flow (Nm^3/s) [c,d] for Normalised Flow	0.462 [d]	1.12 [d]	0.81 [e]
NOx Emission Concentration (mg/Nm^3) [d]	500 [d]	250 [d]	174 [e]
NOx Emission Rate (g/s)	0.23117	0.27996	0.14160

a Actual flow conditions in the exhaust at the stated exhaust O_2 and H_2O contents.

b Calculated from molar flow rate x 8.3145 x (T+273.13) / 101,325, where T is the temperature in ºC.

c Calculated from normalised molar flow rate x 8.3145 x (273.13) / 101325.

d At 0 ºC, 101.325 kPa, 5% oxygen, dry.

e At 0 ºC, 101.325 kPa, 3% oxygen, dry.

6.9 The physical parameters for the sources included in the modelling are outlined in Table 11. The stacks have been modelled as three individual point sources.

Table 11: Modelled Physical Release Emission Parameters for the Facility

Parameter	Modelled Release Emission Parameters		
	Stack 1 (Proposed CHP)	Stack 2 (Existing CHP)	Stack 3 (Existing Boiler)
Source Type	Point		
X-Coordinate	417840	417861	417959
Y-Coordinate	432657	432700	432682
Height above ground (m)	10	34	20

Receptors and Study Area

Receptor Grid

6.10 Human health impacts have been predicted over a 10 km x 10 km model domain, with the proposed CHP plant at the centre. Concentrations have been predicted over this area using nested Cartesian grids (see Figure 7). These grids have a spacing of 5 m x 5 m within 200 m of the facility, 25 m x 25 m within 400 m of the facility, 50 m x 50 m within 1,000 m of the facility, 250 m x 250 m within 2,000 m of the facility and 500 m x 500 m within 5,000 m of the facility. This grid is considered to provide a sufficiently high resolution to enable the identification of worst-case impacts throughout the study area. The receptor grid has been modelled at a height of 1.5 m above ground level.

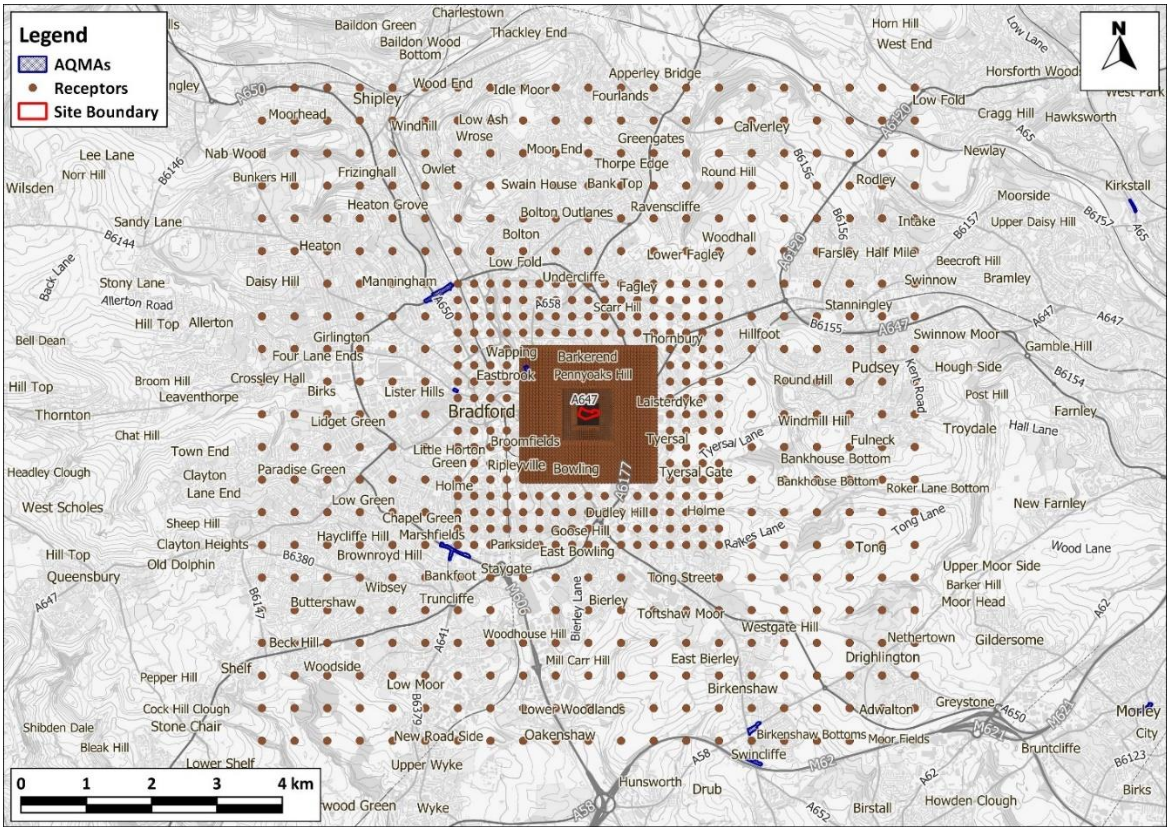

Figure 7: Modelled Receptors (Nested Grid)

Specific Human Health Receptors

6.11 Specific receptors have also been selected to determine impacts at locations where the AQS apply (i.e. relevant exposure) and at locations where air quality conditions may be worst-case. In some cases, these may have been determined based on initial results across the nested Cartesian grids. The specific receptors identified are detailed in Table 12 and shown in Figure 8.

Table 12: Specific Human Health Receptor Coordinates

Receptor ID	Description	X Coordinate	Y Coordinate	Height (m)
1	Residential (garden)	417824.3	432806.2	1.5
2	Residential (garden)	417797.4	432811.2	1.5
3	Residential	417801.8	432816.3	1.5
4	Residential	417822.8	432812.7	1.5
5	Residential	417848.7	432807.8	1.5
6	Residential	417891.1	432800.3	1.5

Receptor ID	Description	X Coordinate	Y Coordinate	Height (m)
7	Residential	417924.9	432794.4	1.5
8	Residential	417965.3	432787.2	1.5
9	Residential (garden)	417842.6	432803.1	1.5
10	Residential (garden)	417890.0	432794.5	1.5
11	Residential (garden)	417924.0	432788.5	1.5
12	Residential (garden)	417969.3	432780.2	1.5
13	Retail	417699.6	432652.6	1.5
14	Retail	417638.8	432687.4	1.5
15	Residential	418103.2	432321.0	1.5
16	Residential	418142.4	432328.2	1.5
17	Community Centre	418003.3	432833.5	1.5
18	Cafe	418080.6	432899.1	1.5
19	Retail	418130.0	432876.8	1.5
20	Residential	418102.7	432905.9	1.5
21	Recreation Centre	418253.7	432861.0	1.5
22	Retail	418396.8	432837.3	1.5
23	Retail	418347.1	432837.5	1.5
24	Residential	418336.1	432848.9	1.5
25	Reso	418302.3	432902.7	1.5
26	Residential	418253.4	432908.4	1.5
27	Residential	418487.5	432613.2	1.5
28	Gym	418565.5	432517.7	1.5
29	Residential	418648.4	432386.3	4.0
30	Retail	418546.6	432434.0	1.5
31	Residential	418405.2	432222.6	1.5
32	Residential	417566.5	432316.6	1.5
33	Residential	416969.8	432418.4	1.5
34	Restaurant/Retail	417641.2	432911.8	1.5
35	Restaurant/Retail	417603.7	432847.6	1.5
36	Residential	417492.5	432948.3	4.0
37	Residential	417371.2	432909.7	1.5
38	Residential	418080.6	432899.1	4.5
39	Residential	418170.0	432912.5	1.5

Receptor ID	Description	X Coordinate	Y Coordinate	Height (m)
40	Residential	418223.6	432913.2	1.5
41	Retail	418554.8	432472.4	1.5
42	Residential	418554.8	432472.4	4.0

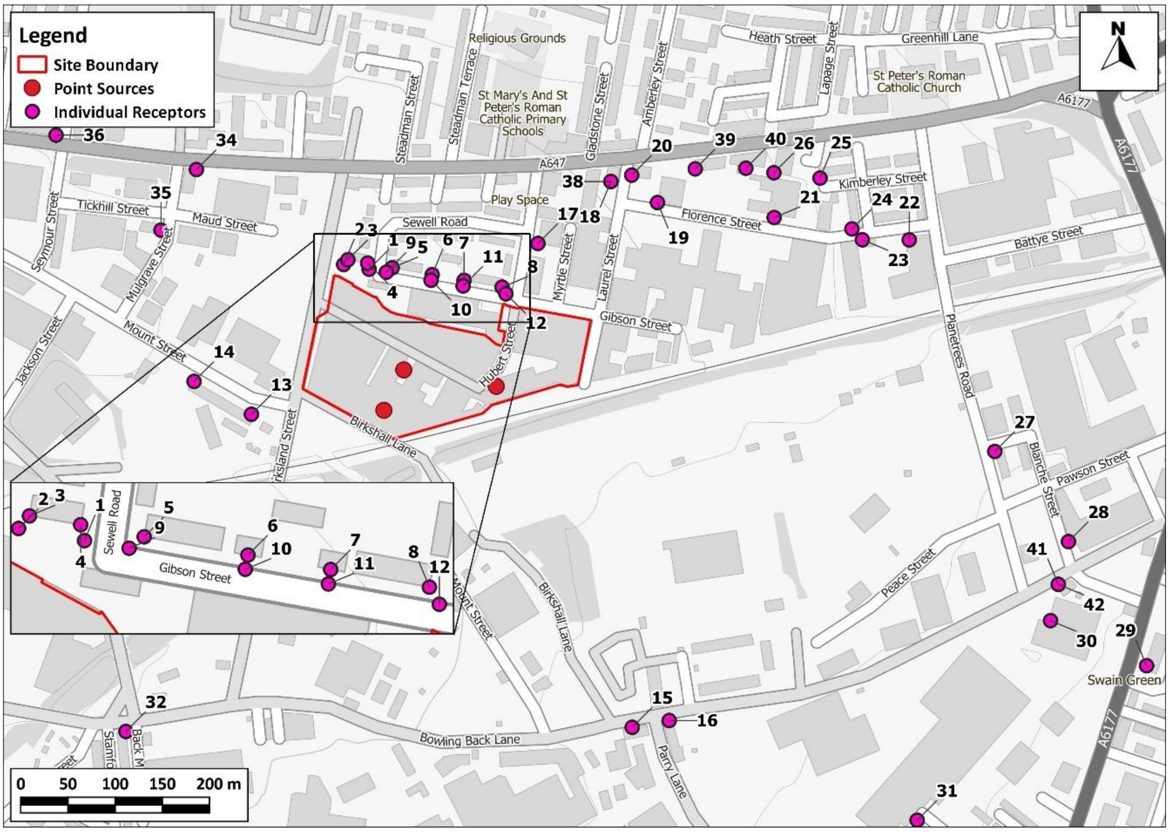

Figure 8: Modelled Receptors (Discrete)

Meteorological Data

6.12 In order to allow for uncertainties in local and future-year conditions, the dispersion model has been run five times, with each run using a different full year of hour-by-hour meteorological data from the nearest appropriate meteorological site. For each individual receptor point on the nested Cartesian grids, the maximum predicted concentration across any of the five meteorological datasets has then been determined. It is these maxima which are presented.

6.13 Hourly sequential meteorological data from Bingley have been used for the years 2018-2022 inclusive. The Bingley meteorological monitoring station is located approximately 9.5 km to the northeast of the site. The topography at Bingley is similar to that in the study area and measured data from Bingley are considered to provide the most robust available estimates of meteorological conditions within the study area. The Bingley meteorological station is operated by the UK Meteorological Office. Raw data were provided by the Met Office and processed by AQC for use in ADMS.

6.14 The meteorological parameters entered into the model are shown in Table 13. Wind roses for each year are presented in Appendix A2.

Table 13: Meteorological Parameters Entered into the ADMS Model

Parameter	Modelled Receptors (including Cartesian Grids)	Meteorological Site
Surface Roughness	Variable Surface Roughness File	0.3 m
Minimum MO length	30 m	30 m
Surface Albedo	0.23[a]	0.23[a]
Priestly-Taylor Parameter	1[a]	1[a]

[a] Model default value

Variable Surface Roughness File

6.15 The study area encompasses a range of land types. A variable surface roughness file has been used to represent the spatial variation of the surface roughness over each land type as shown in Figure 9. The following parameters have been used regarding surface roughness and land type:

- forest – 1 m;
- built-up area – 0.5 m;
- grassland – 0.2 m; and
- water – 0.0001 m.

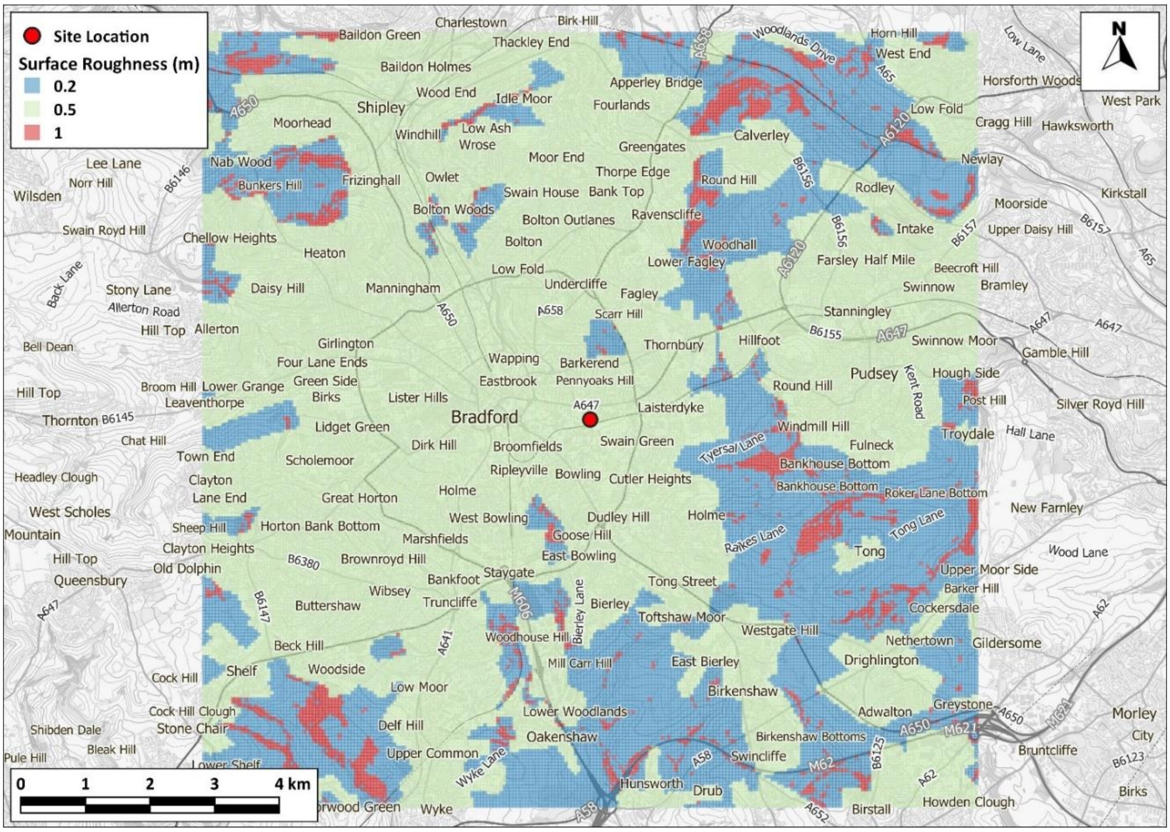

Figure 9: **Surface Roughness across Modelled Area**

Buildings

6.16 Where buildings are a significant height relative to the stack height, building downwash effects may occur. The downwash effects should be accounted for within modelling where the stack is less than 2.5 times the height of the buildings within a distance which is five times the minimum of the stack height and the maximum projected width of the building.

6.17 The model has been run once with the adjacent buildings included, and once without, for each meteorological year. The maximum predicted concentrations from either buildings scenario, and any meteorological year, have then been determined and presented. Modelled buildings are shown in Figure 10, and the dimensions of all buildings are given in Table 14.

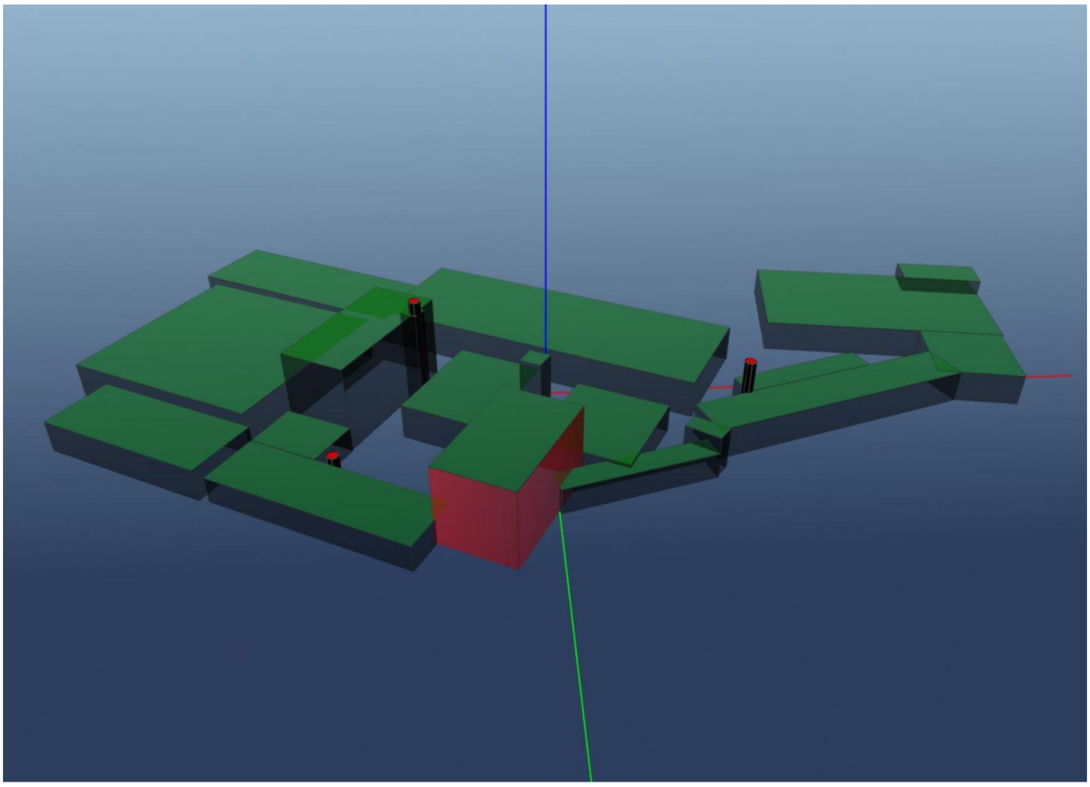

Figure 10: Buildings Included in the Model (Green-topped Objects) and Modelled Flues (Red-topped Cylinders)

Figure 11: Buildings Included in the Model (Green) and Modelled Flues (Red)

Imagery ©2024 Maxar Technologies, Map data ©2024

Table 14: Modelled Building Dimensions

Building	Height (m)	Length / Diameter (m)	Width (m)	Rotation (°)
1	14	64	62	298
2	10	54	22	298
3	9	29	32	299
4	33	6	6	298
5	9	79	27	299
6	10	14	85	342
7	10	8	43	342
8	11	27	36	299
9	10	26	26	281
10	10	76	43	280
11	15	26	12	281
12	8	21	16	298
13	12	110	39	299
14	27	21	48	298
15	13	11	6	309
16	30	5	5	298
17	8	64	19	298
18	24	24	40	298
19	8	8	46	344

Terrain Effects

6.18 The area immediately surrounding the site is generally less than 1 in 10 in gradient, such that the base of the stack from which the plant exhausts is a similar elevation as the base of the on-site building and nearest human health receptors, with gradual gradient change across the modelled area (see Figure 3). A sensitivity test was conducted to run the model both with and without OS Terrain 50 data which determined the higher maximum PCs were predicted without the terrain data and therefore terrain data was not included within the final model setup.

NO_X to NO_2 conversion

6.19 NOx emissions will be in the form of nitric oxide (NO) and primary NO_2. Primary NO_2 from gas-fuelled generators is likely to be in the region of 5-12% of the total NOx. Over time, the NO emissions will react with available ozone (O_3) to form NO_2. In close proximity to the source, the ratio will be similar to the primary NO_2 proportion; with increasing distance from the source the ratio will increase, depending on the availability of O_3.

6.20 The EA (EA, 2023a) recommends that, as a conservative / worst-case approach:

- 70% of the NOx emitted from the plant converts to NO_2 for the annual mean average concentrations; and
- 35% of the 1-hour mean NOx emitted from the plant converts to NO_2 for the 1-hour mean average concentrations.

6.21 The EA guidance on dispersion modelling from specified generators (EA, 2023b) states: "For primary NO_2 to NOx ratios of 10% or less, you can use worst case NOx to NO_2 conversion ratios of: 35% for short term assessment; 70% for long term assessment".

6.22 Given the size of the CHP plant and its fuel, it is likely that the primary NO_2:NOx ratio will be 10% or less; therefore, the 70% (long-term) and 35% (short-term) conversion ratios used represent a conservative approach.

Model Post-Processing

Annual Mean PCs

6.23 The model has been run assuming constant operation. Annual mean Process Contributions (PCs) have then been reduced to account for the fact that the plant will not operate for more than 5,360 hours per year. This has been done by multiplying the annual mean model outputs by 0.612 (i.e. 5,360 / 8,760).

Short-term PCs

6.24 The AQS for 1-hour mean NO_2 is based on the number of hours (18) that a threshold concentration (200 µg/m^3) can be exceeded in a year. The 1-hour mean AQS has been assessed by assuming constant operation, and considering the 99.79th percentile of 1-hour mean concentrations, which represents the 19th highest hour from a full year (8,760 hours). This provides a worst-case assessment.

Uncertainty

6.25 The point source dispersion model used in the assessment is dependent upon emission rates, flow rates, exhaust temperatures and other parameters for each source, all of which are both variable and uncertain. There are then additional uncertainties, as models are required to simplify real-world conditions into a series of algorithms. These uncertainties cannot be easily quantified and it is not possible to verify the point-source model outputs. Where these parameters have been estimated the approach has been to use reasonable worst-case assumptions.

6.26 On balance, when taking into account the assumed number of operating hours; the approach taken to meteorological conditions and the sensitivity testing for building downwash, the assessment can be expected to over-predict the impacts of the facility. The approach has been designed to provide a robust and conservative assessment.

7 Assessment Approach

7.1 The Environment Agency's *air emissions risk assessment for your environmental permit* (previously Horizontal Guidance Note H1) provides methods for quantifying the environmental impacts of emissions to air. This compares predicted process contributions (PC) and predicted environmental concentrations (PEC, i.e., PC in addition to background) to both long- and short-term environmental standards. These standards primarily include guideline EALs and statutory AQS.

7.2 Air emission risk assessments for environmental permits require a three-tiered approach to assessing the significance of emissions to atmosphere. The first stage is to 'screen out' insignificant emissions to air using the H1 screening tool; these are emissions which are emitted in such small quantities that they are unlikely to cause a significant impact on ground level concentrations. The Environment Agency's guidance suggests that emissions are insignificant where PCs are less than:

- 1% of a long-term environmental standard; or
- 10% of a short-term environmental standard

7.3 This is the case regardless of the total concentration or deposition flux (i.e. the PC + the local baseline, or the Predicted Environmental Concentration 'PEC').

7.4 For those emissions that cannot be screened out as insignificant, the guidance indicates that further modelling of emissions may be appropriate for long term effects where the PEC is greater than 70% of the long-term environmental benchmark. For short-term effects, further modelling of emissions is required where the PC is more than 20% of the difference between twice the (long term) background concentration and the relevant short term environmental benchmark (i.e., more than 20% of the model 'headroom').

7.5 In any resultant modelling assessment, the EA guidance explains no further action is required where the assessment shows that both of the following apply:

- Emissions comply with Best Available Technique Associated Emission Levels (BAT-AELs) or the equivalent requirements where there is no BAT-AEL; and
- The resulting PECs will not exceed environmental standards.

7.6 For human health receptors considered in this assessment, the approach has been to provide contour plots which highlight the area within which PCs cannot be considered insignificant using the criteria outlined in Paragraph 7.2. Consideration is also given to the maximum PCs at locations with relevant exposure to the AQS, and to the PECs. A judgement of significance has then reached based on the potential for the facility to cause an exceedance of the AQS.

8 Results

8.1 The PCs presented here include the modelled contribution from the proposed CHP unit. The PECs include the modelled contributions from the proposed CHP unit, the existing CHP unit, and the existing boiler, plus the monitored background concentrations (Table 8). Some contribution from the existing boiler and to a lesser extent the existing CHP unit, is expected to be included in the monitored background concentrations, but the contribution may be greater at some relevant receptors than it is at the monitoring locations; therefore, they have been included to ensure the assessment is worst-case, accepting a degree of double-counting. The installation wide PC (i.e. modelled contributions for the existing boiler, existing CHP unit and proposed CHP unit) have also been presented in Table 15 for completeness.

8.2 Figure 12 presents the area where the annual mean PC for the proposed CHP is greater than 1%. The 1% contour (i.e. an increase of up to 0.4 µg/m^3) covers an area which extends up to approximately 480 m from the proposed CHP unit exhaust flue.

8.3 Figure 13 presents the area where the PC to the 99.79th percentile of 1-hour mean NO_2 concentrations is greater than 5 µg/m^3 and 10 µg/m^3.

8.4 Figure 12 and Figure 13 also show the locations where the maximum PCs for the proposed CHP unit are predicted (whole instillation PC contours are presented in Appendix A4):

- anywhere on the nested Cartesian grids;
- at any location with relevant exposure to each AQS[3]; and
- at any busy roadside location with relevant exposure to each AQS. This is important because, as shown in Table 8, baseline concentrations are higher at the roadside, meaning that a smaller PC may give rise to an exceedance of the AQS.

8.5 The predicted PCs and PECs at these worst-case locations are set out in Table 15. Predicted PCs and PECs at the specific receptors identified in Figure 8 and Table 12 are set out in Table 16.

3 See Paragraph 4.3.

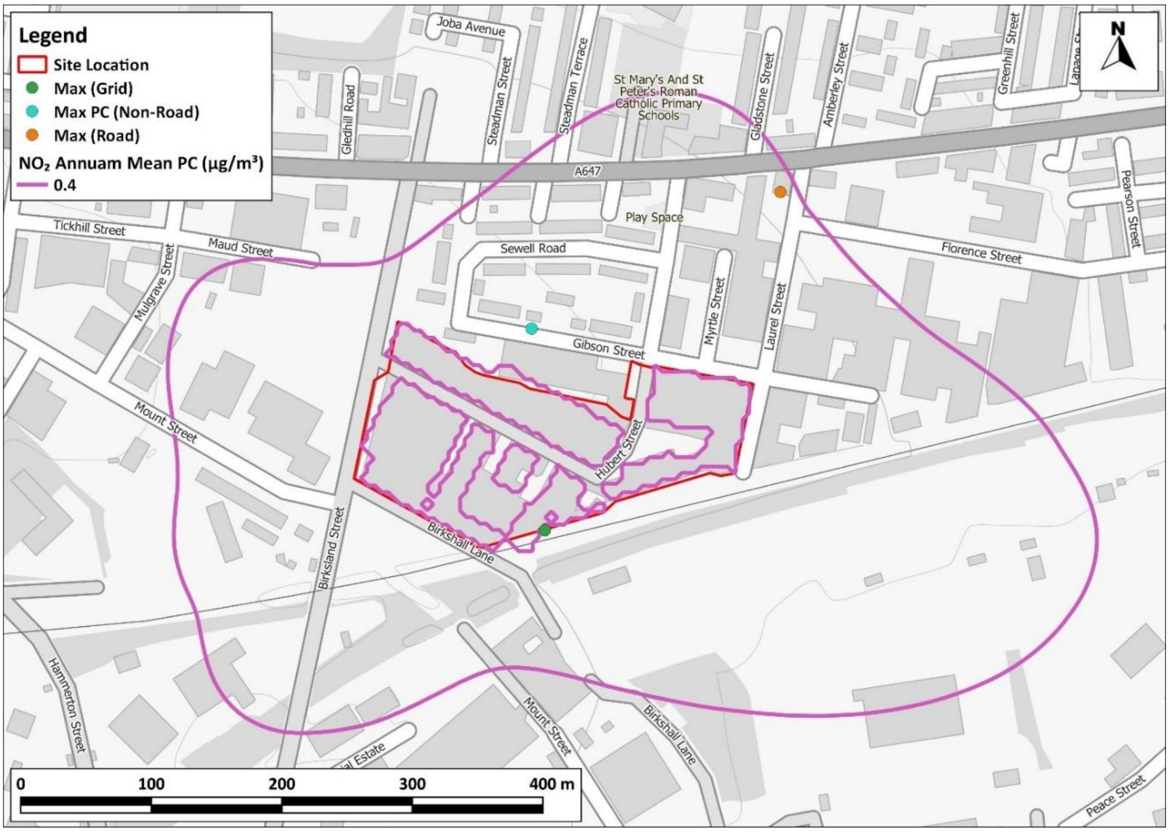

Figure 12: Contour Plot of Annual Mean NO_2 PCs and Locations of Maxima on Entire Grid, at a Relevant Receptor and at a Relevant Roadside Receptor

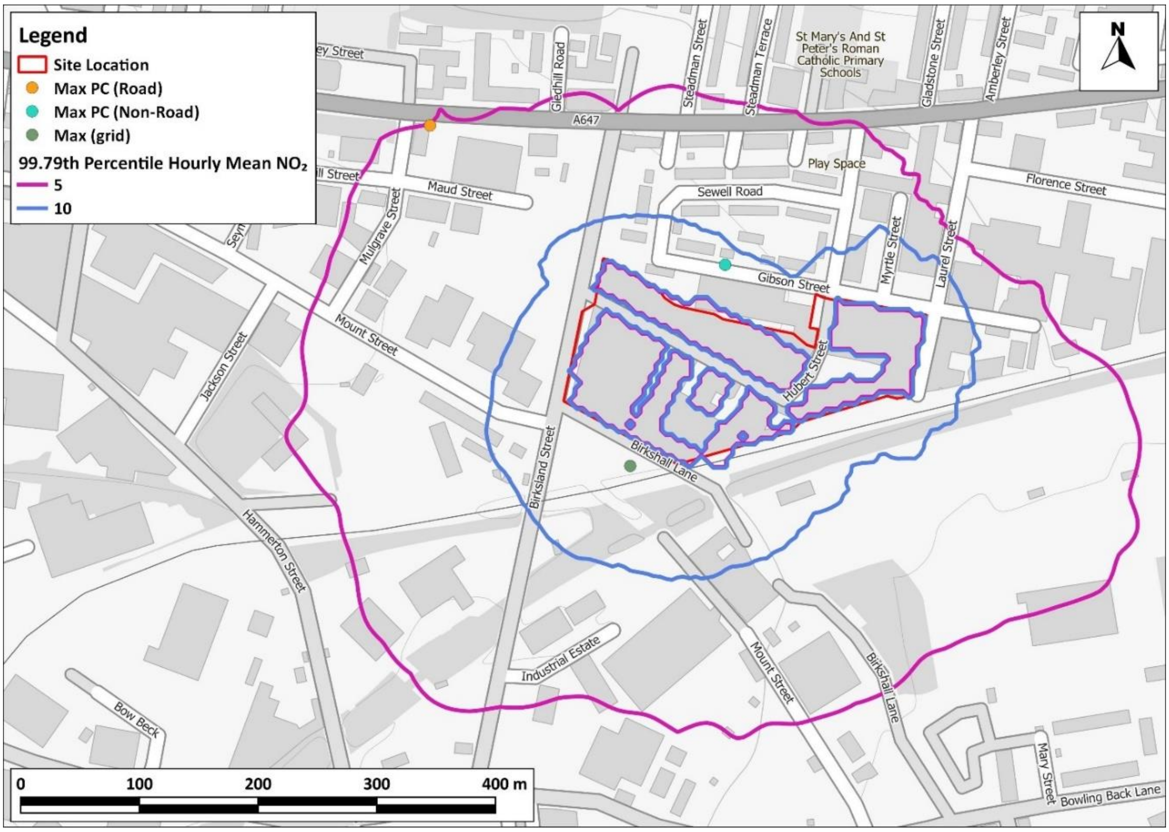

Figure 13: Contour Plot of the 99.79th Percentile of 1-hour Mean NO_2 PCs and Locations of Maxima on Entire Grid, at a Relevant Receptor and at a Relevant Roadside Receptor

Table 15: Maximum PCs and PECs Relevant for Human Health

	ID	X Coordinate	Y Coordinate	Whole Installation		Proposed CHP unit only		PEC (µg/m³) [b]	PEC (% of AQS)
				PC (µg/m³)	PC (% of AQS) [a]	PC (µg/m³)	PC (% of AQS) [a]		
Annual Mean NO_2 AQS (40 µg/m³)									
Max on Grid [c]	-	417900	432640	4.9	12.3	4.2	10.5	32.9	82
Max at Relevant[3] Receptor	12	417969	432780	2.2	5.0	[redacted]		30.1	75
Max at Relevant[3] Receptor	10	417890	432794.5	[redacted]		1.5	4.0	30.0	75
Max at Relevant[3] Roadside Receptor	18	418081	432899	0.9	2.0	0.4	1.0	32.2	81
1-hour Mean AQS (200 µg/m³) [d]									
Max on Grid [c]	-	417880	432620	49.5	24.8	[redacted]		105.6	53
Max on Grid [c]	-	417810	432625	[redacted]		37.7	18.9	93.7	47
Max at Relevant[3] Receptor	10	417890	432795	15.7	8.0	6.2	3.0	71.7	36
Max at Relevant[3] Roadside Receptor	38	418081	432899	8.7	4.0	[redacted]		71.3	36
Max at Relevant[3] Roadside Receptor	34	417641	432912	[redacted]		4.9	4.0	71.0	35

[a] Based on unrounded numbers.

[b] After adding the relevant baseline concentrations from Table 8.

[c] This row has been greyed out as the AQS do not apply at this location.

[d] 99.79th percentile of 1-hour means. PCs for the 100th percentile of 1-hour mean concentrations are provided in Appendix A3.

Table 16: PCs and PECs at Specific Receptors

Receptor ID	Annual Mean NO_2 AQS (40 µg/m^3)				1-hour Mean AQS (200 µg/m^3) [a]			
	Proposed CHP unit PC		PEC [b]		Proposed CHP unit PC		PEC [b]	
	µg/m^3	% AQS [c]	µg/m^3	% AQS [c]	µg/m^3	% AQS [c]	µg/m^3	% AQS [c]
1	0.7	1.8	29.1	73	17.9	9	81.3	41
2	0.6	1.4	28.9	72	17.1	9	80.6	40
3	0.6	1.6	29.0	72	17.3	9	80.6	40
4	0.7	1.8	29.1	73	17.7	9	81.1	41
5	1.0	2.4	29.3	73	18.4	9	82.2	41
6	1.4	3.4	29.8	75	15.6	8	80.2	40
7	1.4	3.5	30.0	75	10.6	5	74.7	37
8	1.2	2.9	29.9	75	18.1	9	82.3	41
9	0.8	2.1	29.2	73	18.0	9	81.7	41
10	1.5	3.9	30.0	75	19.1	10	83.8	42
11	1.5	3.8	30.1	75	12.2	6	76.5	38
12	1.3	3.3	30.1	75	20.5	10	85.2	43
13	0.8	1.9	29.2	73	11.1	6	72.8	36
14	0.5	1.2	28.8	72	7.3	4	68.1	34
15	0.1	0.2	28.2	70	3.2	2	62.4	31
16	0.1	0.3	28.2	70	3.3	2	62.4	31
17	0.7	1.8	29.4	74	6.0	3	68.0	34
18	0.4	1.1	32.2	81	4.4	2	71.2	36
19	0.4	0.9	28.9	72	4.0	2	64.6	32
20	0.4	1.0	32.2	80	4.1	2	70.9	35
21	0.3	0.7	28.6	72	3.6	2	63.7	32
22	0.2	0.5	28.5	71	2.7	1	61.9	31
23	0.2	0.6	28.5	71	3.0	2	62.5	31
24	0.2	0.6	28.5	71	3.1	2	62.6	31
25	0.2	0.5	28.5	71	3.0	1	62.4	31
26	0.2	0.6	31.8	80	3.4	2	69.6	35
27	0.3	0.6	28.6	71	2.7	1	61.6	31
28	0.2	0.5	28.4	71	2.3	1	60.9	30
29	0.1	0.3	28.3	71	1.8	1	60.0	30
30	0.2	0.4	28.4	71	2.3	1	60.7	30
31	0.1	0.2	28.2	70	1.9	1	60.0	30
32	0.1	0.4	28.3	71	3.5	2	61.5	31
33	0.0	0.1	28.1	70	1.3	1	58.8	29
34	0.3	0.7	31.8	80	4.9	2	71.0	35

Receptor ID	Annual Mean NO_2 AQS (40 µg/m³)				1-hour Mean AQS (200 µg/m³) [a]			
	Proposed CHP unit PC		PEC [b]		Proposed CHP unit PC		PEC [b]	
	µg/m³	% AQS [c]	µg/m³	% AQS [c]	µg/m³	% AQS [c]	µg/m³	% AQS [c]
35	0.3	0.8	28.6	71	5.4	3	64.7	32
36	0.2	0.5	31.7	79	3.6	2	68.8	34
37	0.1	0.4	28.3	71	2.9	1	61.2	31
38	0.4	1.1	32.2	81	4.4	2	71.3	36
39	0.3	0.7	32.0	80	3.6	2	70.1	35
40	0.3	0.6	31.9	80	3.3	2	69.6	35
41	0.2	0.5	28.4	71	2.3	1	60.8	30
42	0.2	0.5	28.4	71	2.3	1	60.8	30

[a] 99.79th percentile of 1-hour means

[b] After adding the relevant baseline concentrations from Table 8.

[c] Based on unrounded numbers.

[d] The annual mean AQS do not apply at these locations.

9 Discussion

Human Health Receptors

Annual Mean AQS

9.1 Table 16 shows that the PC from the proposed CHP unit only exceeds 1% of the long-term AQS at seventeen of the modelled specific receptors. The PC from the instillation wide units exceeds 1% of the long-term AQS at thirty-one of the modelled specific receptors The greatest PEC is 32.2 µg/m^3 or 81% of the AQS. At all modelled specific receptors, the maximum predicted PEC is below the AQS. The value of the AQS at the worst-case location on the grid (outside the site boundary) is below the AQS. There is thus no risk that the AQS will be exceeded as a result of emissions from the facility.

1-hour Mean AQS

9.2 Table 15 shows that the PC does not exceed 10% of the short-term AQS at any of the modelled specific receptors. The PEC exceeds 40% of the AQS at seven modelled receptors. The maximum predicted 1-hour mean PEC is 85.2 µg/m^3 or 43% of the AQS, which is below the AQS. Thus, there is no risk that the AQS will be exceeded as a result of the facility.

10 Conclusions

10.1 There is no risk that the annual mean NO_2 AQS will be exceeded as a result of the facility. On this basis, the impacts are judged to be not significant.

10.2 There is no risk that the 1-hour mean NO_2 AQS will be exceeded as a result of the facility. On this basis, the impacts are judged to be not significant.

10.3 The assessment is based on operation of the proposed CHP for 5,360 hours per year and includes a number of conservative assumptions. It also takes account of the maximum predicted impacts across several sensitivity tests. In particular:

- the results presented are the maxima from modelling with five separate years of meteorological data;
- the results presented are the maxima from modelling both with and without including surrounding buildings within the dispersion model;
- depletion has not been included in the model. This will cause a tendency for impacts to be over-predicted;
- the assessment of 1-hour mean concentrations has assumed the plant will operate continuously when they will be limited to operate for no more than 5,360 hours per year; and
- a conservative approach has been taken to calculating NO_2 concentrations from modelled NOx concentrations.

10.4 It is thus concluded that the proposed stack height of 10 m is sufficient and that air quality impacts of the proposed facility will be not significant.

Table 17: EA Checklist for Dispersion Modelling Report for Installations

Item	Included	Comment
Location map	✓	See Figure 1 and Figure 2
Site plan	✓	See Figure 4
List of emissions modelled	✓	See Paragraph 1.3
Details of modelled scenarios	✓	Seea The coordinates refer to the centre of the site, not the point of release, as there are three release locations. Table 2 and Section 6
Details of relevant ambient concentrations used	✓	See Section 5
Model description and justification	✓	See Paragraph 6.2 to 6.4
Special model treatments used	✓	See Section 6
Table of emission parameters used	✓	See Table 11
Details of modelled domain receptors	✓	See Figure 2 and Paragraph 6.10
Details of meteorological data used (including origin) and justification	✓	See Paragraphs 6.12 to 6.14
Details of terrain treatment	✓	See Paragraph 6.18
Details of building treatment	✓	See Paragraphs 6.16 and 6.17
Sensitivity analysis	✓	See a The coordinates refer to the centre of the site, not the point of release, as there are three release locations. Table 2 and Section 6
Assessment of impacts	✓	See Sections 9 and 10
Model input files	✓	Sent electronically

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12 Appendices

A1 Engine Technical Data

1 Genset

1.1 General power data	50 %	75 %	100 %	Load	
Electrical power	275	413	550	kW	(5)
Recoverable thermal output	165	243	306	kW	(2)
Energy input	722	1023	1320	kW	(1)
Efficiencies electrical	38,1	40,3	41,7	%	(1)
Efficiencies thermal	22,9	23,7	23,2	%	(1), (2)
Efficiencies total (el. + th.)	60,9	64,1	64,8	%	(1), (2)
CHP coefficient	1,66	1,70	1,80		(1), (2)

1.2 Emissions exhaust * gas & sound

	with catalytic converter	w/o exhaust aftertreatment	
NOx	< 0,50	< 0,50	g/Nm³ (4), (6)
CO	< 0,50	< 1,0	g/Nm³ (4), (6)
HCHO	< 20	not specified	mg/Nm³ (4), (6)
THC (as total carbon)	< 1,3	< 1,3	g/Nm³ (4), (6)
Engine surface noise (without ** / with sound encapsulation (optional) **¹		112,4 / 70	dB(A) (7)
Exhaust outlet noise **		130	dB (7)

2 Mixture composition

2.1 Combustion air

Combustion air mass flow	2703	kg/h
Combustion air volume flow (25 °C, 1013 mbar)	2283	m³/h

2.2 Fuel

Fuel requirements in accordance with 'TA-004 Gas'

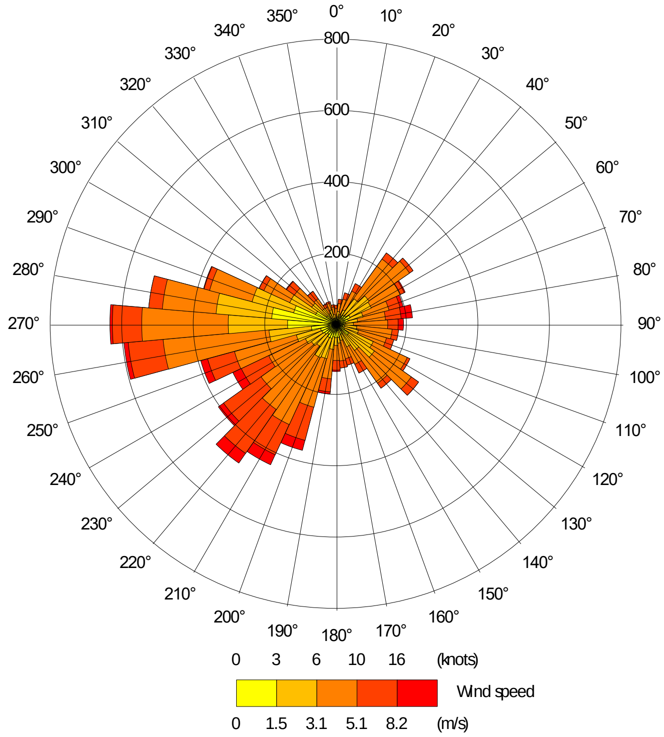
Reference methane number - minimum methane number	150 / 80	
Fuel mass flow	356,9	kg/h (1)
Fuel volume flow	264,9	Nm³/h (6), (1)
Min. gas pressure at nom. Output *	30	mbar
Max. gas pressure at nom. Output *	70	mbar
Gas regulation line safety pressure	500	mbar

4. Exhaust system

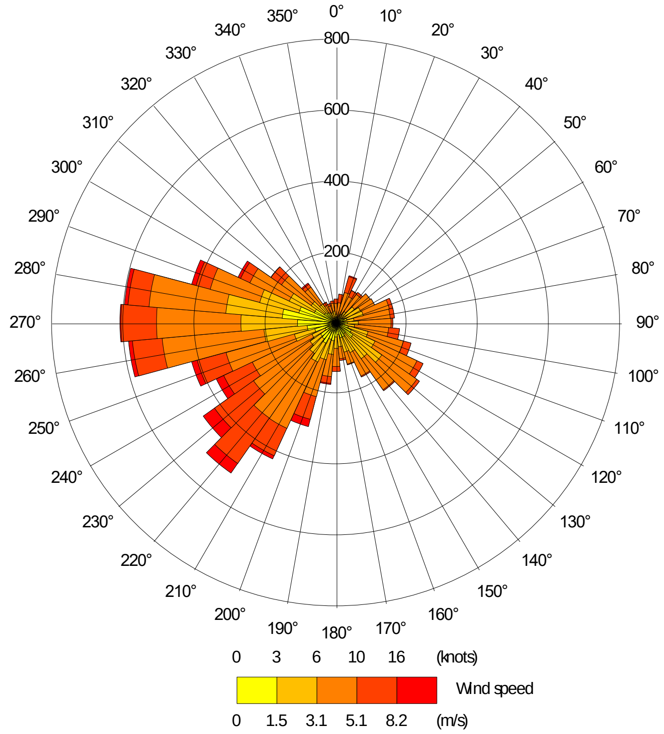
Exhaust gas temperature downstream of turbine	440	°C (3)
exhaust gas volume flow wet	2339	Nm³/h (6)
exhaust gas volume flow dry	2089	Nm³/h (6)
exhaust gas mass flow wet	3060	kg/h
exhaust gas mass flow dry	2846	kg/h
Exhaust back pressure downstream of turbine max.	60	mbar
Pressure reserve approx. (with catalytic converter) *	39 (32)	mbar

A2 Wind Roses for Bingley

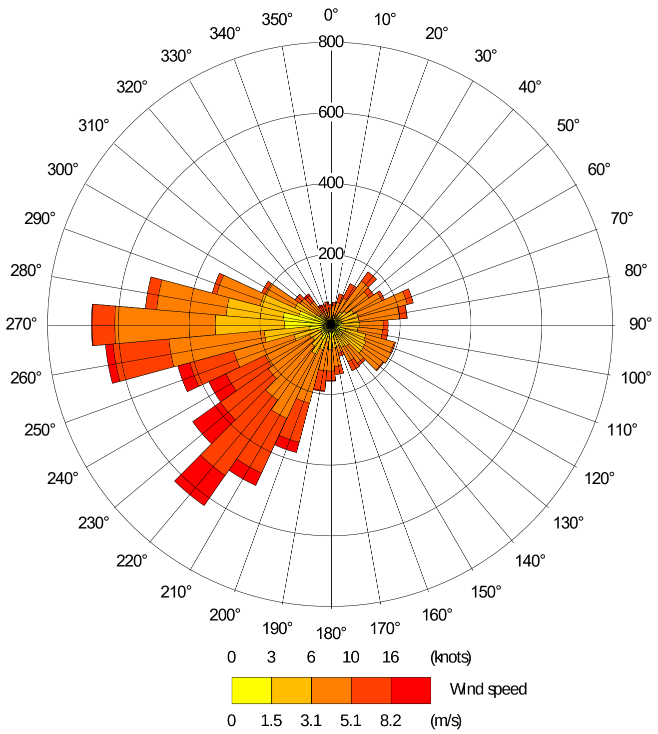
2018



2019



2020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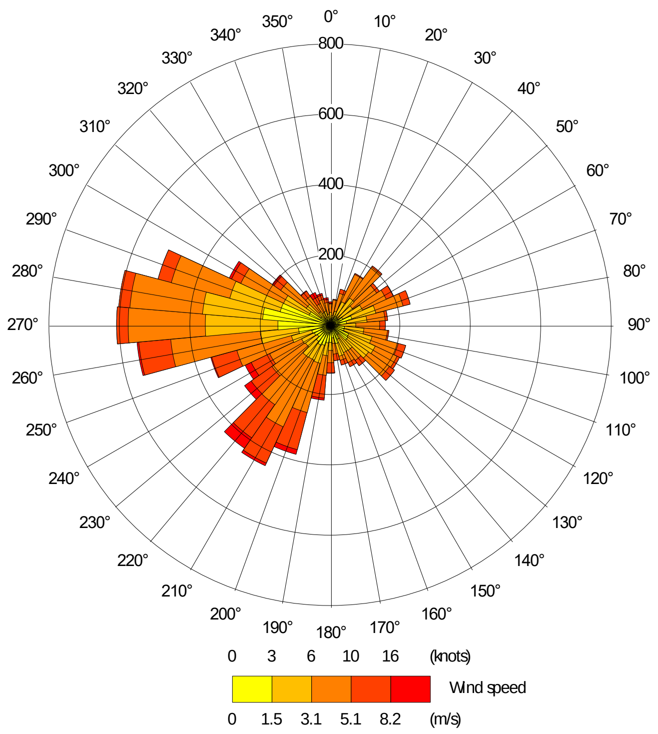
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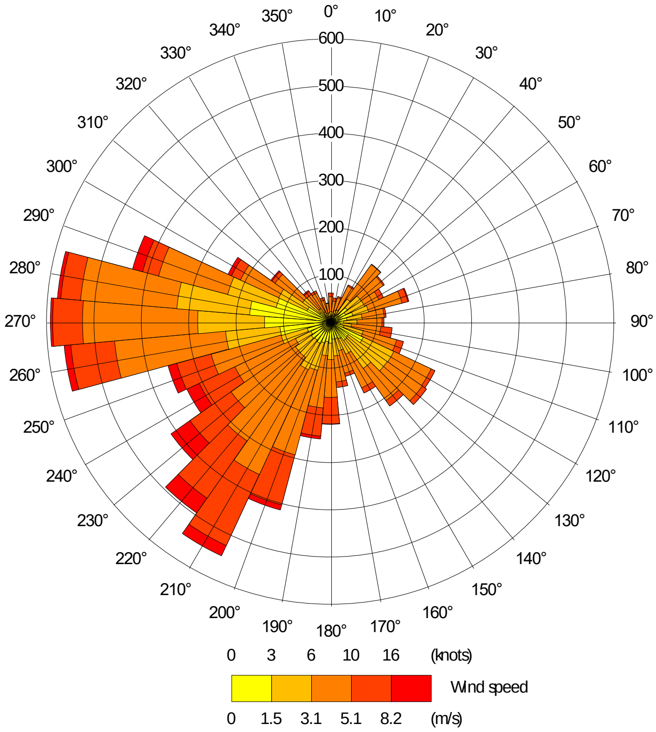
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A3 100th Percentile of 1-hour Mean PCs

A3.1 Table A3.1 presents the maximum 100th percentile of instillation wide 1-hour Mean NO_2 PCs at different receptors, while Figure A3.1 presents a contour plot of these PCs. The AQS for 1-hour mean NO_2 concentrations allows 18 exceedances of 200 µg/m³ in each calendar year. The 100th percentile of 1-hour means (i.e. the maximum in any hour of the year) is thus not directly comparable with the AQS. Results are provided here for information only.

Table A3.1: Maximum 100th Percentile of 1-hour Mean NO_2 PCs

	X Coordinate	Y Coordinate	PC (µg/m³)	PC (% of AQS)
Max on Grid	417870.0	432625.0	73.5	36.8
Max at Relevant [a] Receptor	417969.3	432780.2	39.4	19.7
Max at Relevant [a] Roadside Receptor	417641.3	432911.8	11.0	5.5

[a] See Paragraph 4.3.

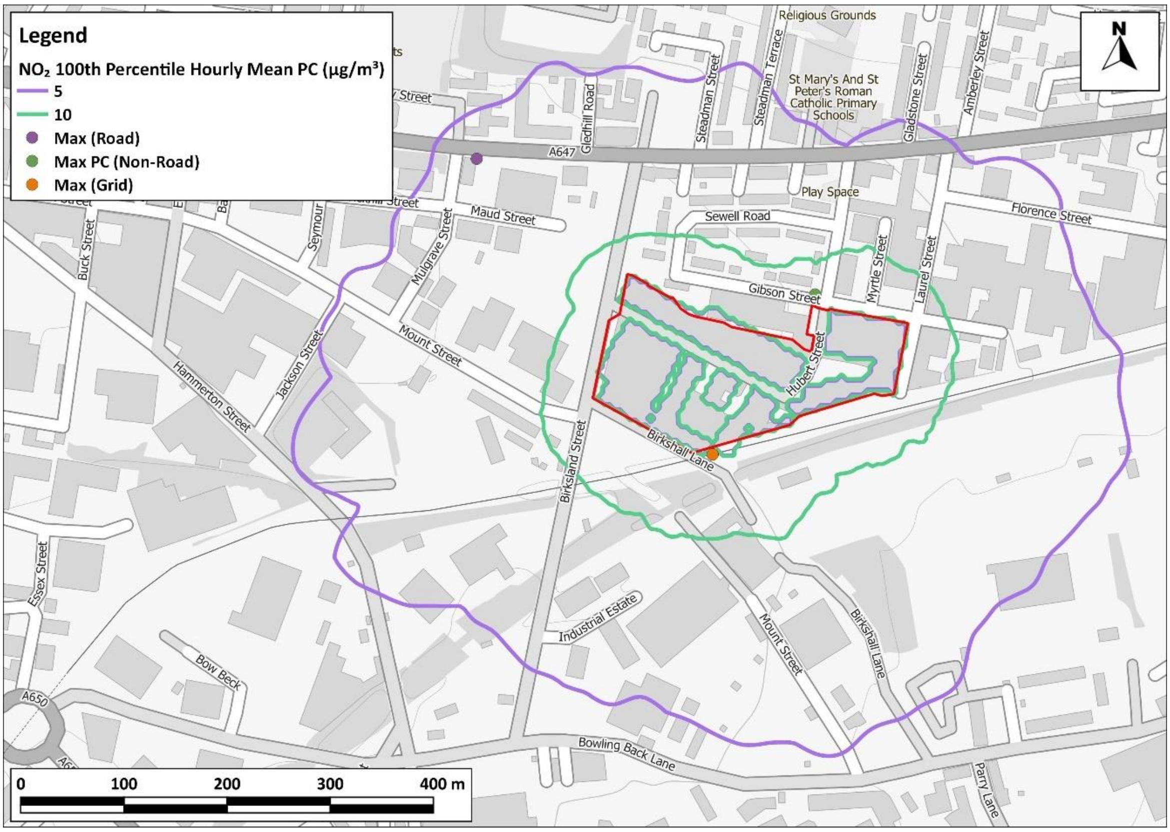

Figure A3.1: Contour Plot of the 100th Percentile of 1-hour Mean NO_2 PCs

A4 Instillation Wide PC's

A3.2 Figure A4.1 presents the area where the annual mean PC for the instillation wide boiler and CHP units is greater than 1%. The 1% contour (i.e. an increase of up to 0.4 µg/m³) covers an area which extends up to approximately 870 m from the proposed CHP unit exhaust flue.

A3.3 Figure A4.2 presents the area where the PC for the instillation wide boiler and CHP units to the 99.79th percentile of 1-hour mean NO_2 concentrations is greater than 10 µg/m³ and 20 µg/m³.

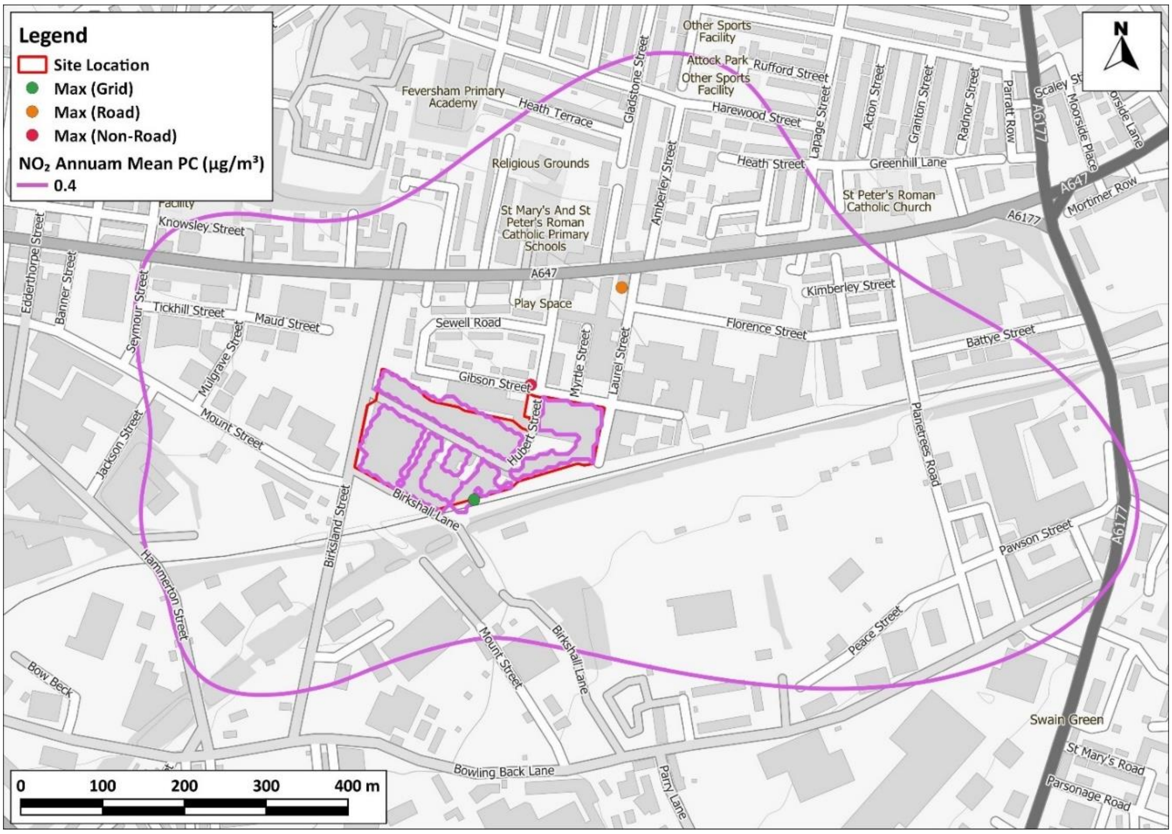

Figure A4.1: Contour Plot of Whole Installation Annual Mean NO_2 PCs

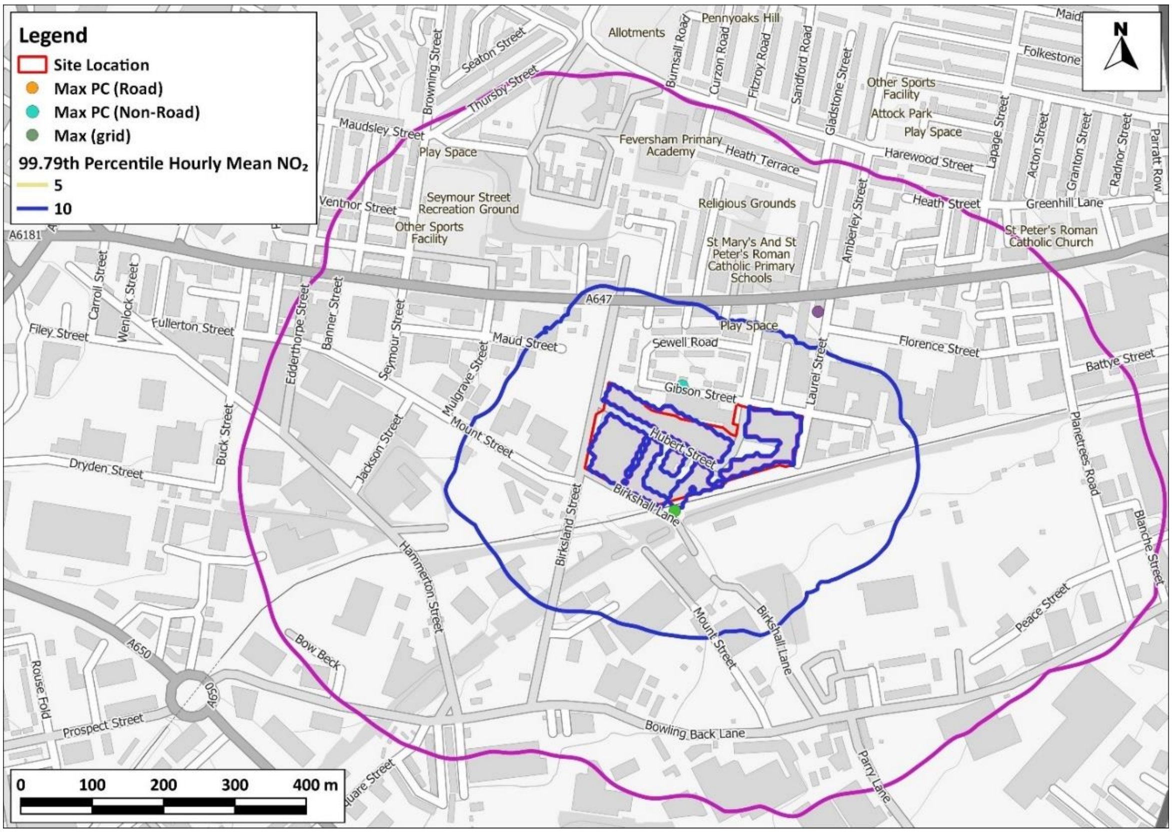

Figure A4.2: Contour Plot of Whole Installation 99.79th 1-hour Mean NO_2 PCs