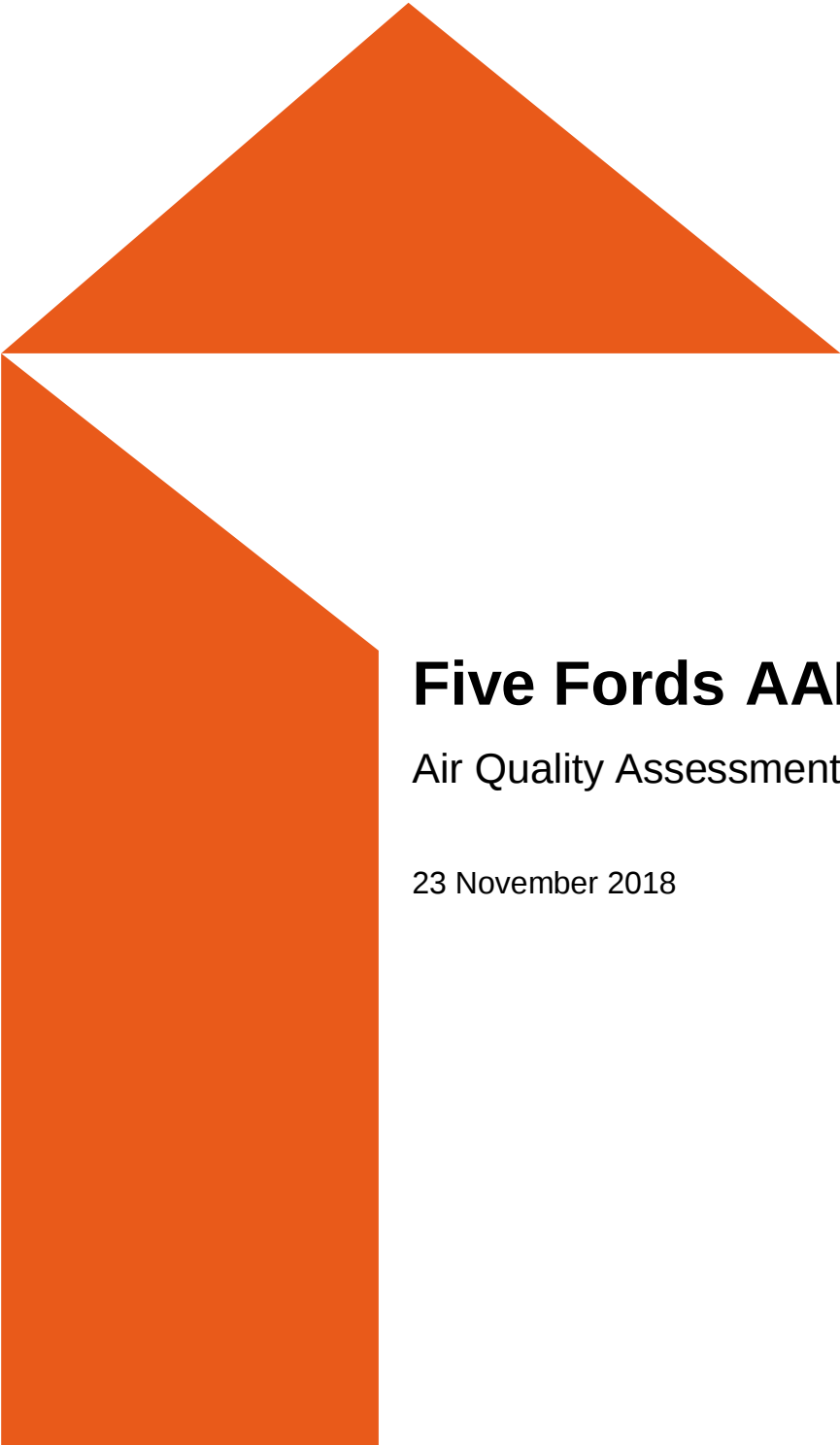




Five Fords AAD

Air Quality Assessment

23 November 2018

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1 Introduction

1.1 Overview

This document has been prepared to support the application to vary the existing bespoke Environmental Permit (hereafter referred to as 'the EP') EPR/AP3139FT for the Five Fords Advanced Anaerobic Digestion (AAD) ('the Plant') on behalf of Dŵr Cymru Welsh Water (DCWW) ('the Operator'). In order to satisfy the requirements of the Environmental Permitting Regulations (EPR) 2016, the Operator must apply to the Natural Resource Wales (NRW) for a change (variation) to an Existing Permit.

The existing EP includes the continuous operation of two Combined Heat and Power (CHP) engines which utilise biogas produced by the Anaerobic Digestion (AD) process one dual fuel (natural gas and biogas) standby boiler. This air quality assessment which supports the EP permit variation assesses two new proposed 1.6 MWth dual fuel steam boilers and changes to the operation of the existing CHP and standby boiler.

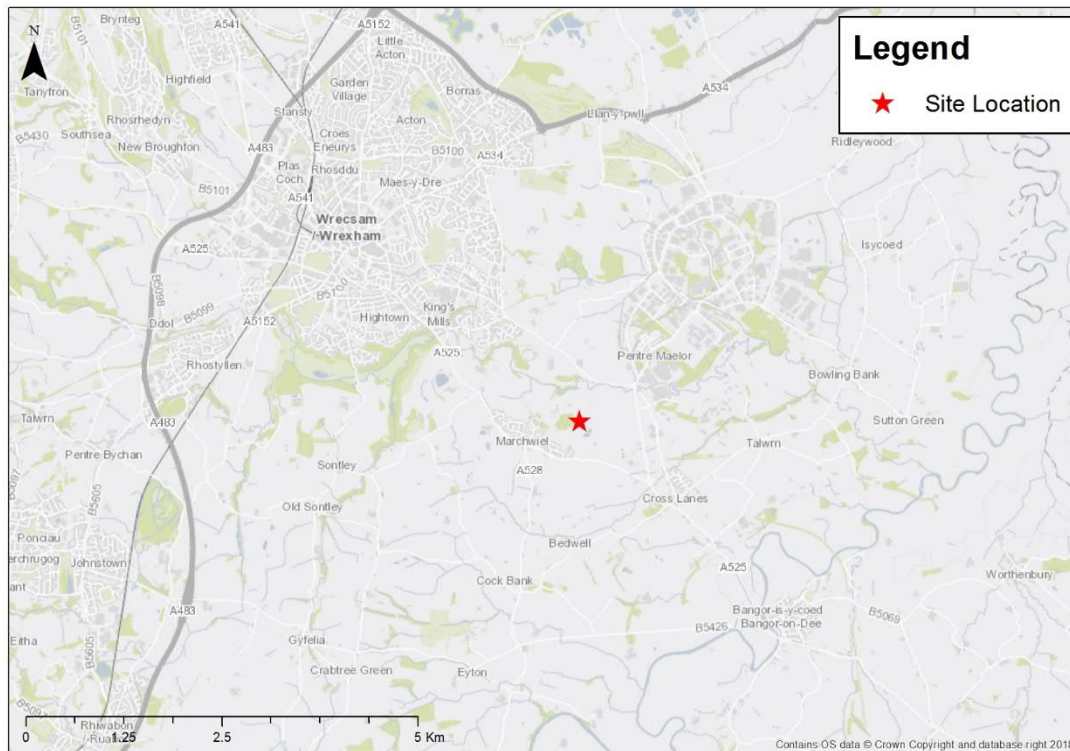
This report provides an assessment of potentially significant point source emissions to air, and subsequent air quality effects, associated with the operation of the existing and proposed plant using a detailed dispersion model.

A description of the plant process is presented in the main application document.

1.2 Site Location

The proposed plant is located within the existing Five Fords AAD, which is situated approximately 3.5km south east Wrexham Town Centre. Figure 1 shows the location of the site and the extent of the study area.

Figure 1: Site Location



1.3 Summary of key pollutants

This assessment considers emissions of oxides of nitrogen (NO_x), sulphur dioxide (SO_2) and carbon monoxide (CO). These are the key pollutants of potential concern, given the fuels used. The following sub-sections present a brief description of the key pollutants referred to above and their behaviour in the atmosphere.

1.3.1 Oxides of nitrogen

Oxides of nitrogen is a term used to describe a mixture of NO and NO_2 , referred to collectively as NO_x . These are primarily formed from atmospheric and fuel nitrogen as a result of high temperature combustion. The most important sources in the UK are road traffic and power generation.

During the process of combustion, atmospheric and fuel nitrogen is partially oxidised via a series of complex reactions to NO . The process is dependent on the temperature, pressure, oxygen concentration and residence time of the combustion gases in the combustion zone. Most NO_x exhausting from a combustion process is in the form of NO , which is a colourless and tasteless gas. It is readily oxidised to NO_2 , a more harmful form of NO_x , by chemical reaction with ozone and other chemicals in the atmosphere. NO_2 is a yellowish-orange to reddish-brown gas with a pungent, irritating odour and is a strong oxidant.

1.3.2 Sulphur dioxide

SO_2 is a colourless, non-flammable gas with a penetrating odour that can irritate the eyes and air passages. It reacts on the surface of a variety of airborne solid particles, is soluble in water

and can be oxidised within airborne water droplets. The most common sources of SO₂ include fossil fuel combustion, smelting, manufacture of sulphuric acid, conversion of wood pulp to paper, incineration of waste and production of elemental sulphur. Coal burning is the single largest man-made source of sulphur dioxide accounting for about 50% of annual global emissions, with oil burning accounting for a further 25-30%. The most common natural source of SO₂ is volcanoes.

1.3.3 Carbon monoxide

CO is a colourless, odourless gas produced by the incomplete combustion of carbon-based fuels and by biological and industrial processes. The major source of CO is traffic, particularly in urban areas. CO is produced under conditions of inefficient combustion, is rapidly dispersed away from the source and is relatively inert over the timescales relevant for its dispersion.

2 Legislative Context

2.1 European Union

Various EU Air Quality Directives and UK Air Quality Regulations are relevant to the operation of the CHP and Boiler Plant. The following section provides a summary of the relevant legal framework.

Directive 2008/50/EC¹ on ambient air quality and cleaner air for Europe was adopted in May 2008 and sets out a range of mandatory Limit Values (LV) for different pollutants including NO₂, SO₂ and CO. The directive consolidated previous air quality directives (apart from the Fourth Daughter Directive), setting Limit Values or Target Values for the concentrations of specific air pollutants and providing a new regulatory framework for particulate matter smaller than 2.5µm in diameter (PM_{2.5}). It also allows Member States to apply to postpone attainment deadlines.

The Air Quality Standards Regulations 2010² came into force in June 2010; they implement the EU's Directive 2008/50/EC on ambient air quality.

The Air Quality (England) Regulations 2000³ and Air Quality (England) (Amendment) Regulations 2002⁴ include air quality objectives that have different compliance target dates but which, in most cases, are numerically synonymous with the limit values. The air quality objectives are for specific use by local authorities in undertaking their local air quality management duties pursuant to Part IV of the Environment Act 1995. Relevant air quality objectives are also referenced for information in this assessment in absence of any limit values.

The Environment Act 1995 requires the UK Government to produce a national 'Air Quality Strategy' (AQS). The AQS establishes the UK framework for air quality improvements. Measures agreed at the national and international level are the foundations on which the strategy is based. The first Air Quality Strategy was adopted in 1997 and replaced by the Air Quality Strategy for England, Scotland, Wales and Northern Ireland published in January 2000. The 2000 Strategy has subsequently been replaced by the Air Quality Strategy for England, Scotland, Wales and Northern Ireland 2007⁵.

The air quality objectives in the AQS are a statement of policy intentions or policy targets. As such, there is no legal requirement to meet these objectives except in as far as they mirror any equivalent legally binding limit values in EU Directives and English Regulations.

The Environment Act 1995 requires that Natural Resource Wales has regard to the AQS in exercising their pollution control functions. Local Authorities are also required to work towards the Strategy's objectives prescribed in regulations for that purpose.

¹ European Union. (April 2008), 'Directive on Ambient Air Quality and cleaner Air for Europe', Directive 2008/50/EC Official Journal, vol. 152, pp. 0001-0044.

² Statutory Instrument. (2010), 'The Environmental Permitting (England and Wales) Regulations', Queen's Printer of Acts of Parliament.

³ Statutory Instrument. (2000), 'Air Quality (England) Regulations', No. 97. Queen's Printer of Acts of Parliament.

⁴ Statutory Instrument. (2002), 'Air Quality (England) (Amendment) Regulations', No. 297. Queen's Printer of Acts of Parliament.

⁵ Department for Environment Food and Rural Affairs. (July 2007), 'The Air Quality Strategy for England, Scotland, Wales and Northern Ireland', Cm 7169, Department for Environment Food and Rural Affairs.

2.2 Permitting Requirements and Associated Guidance

2.2.1 Assessment criteria

The following section presents the relevant air quality standards that are applicable to the AAD plant and are collectively described as the environmental quality standards (EQS).

Natural Resource Wales have adopted the guidance issued by the Environment Agency. Environment Agency's Horizontal Guidance Note H1 (EA's H1) was replaced in February 2016 by the "air emissions risk assessment for your environmental permit"⁶ which provides guidelines for the air dispersion modelling report and environmental standards for air and Environmental Assessment Levels (EALs) for emissions to air and has been applied to this assessment.

Further criteria for which to assess potential impact on nutrient deposition and acid deposition at designated sites are available from the Air Pollution Information System (APIS). For clarity, these are presented in Section 5. The use of APIS in this way is recommended by the EA guidance⁷.

2.2.2 Air quality limit values and objectives

Table 1 summarises the air quality objectives and limit values for the pollutants relevant to this assessment.

Table 1: Summary of relevant air quality objectives and limit values

Pollutant	Averaging period	Objective / limit value ($\mu\text{g}/\text{m}^3$)	Allowance
For the protection of human health			
Nitrogen dioxide (NO_2)	1 hour	200	18 times pcy
	Annual	40	–
Sulphur dioxide (SO_2)	15 minute	266	35 times pcy
	1 hour	350	24 times pcy
	24 hour	125	3 times pcy
Carbon monoxide (CO)	8 hour	10,000	Maximum daily running 8 hour mean
For the Protection of Vegetation and ecosystems			
Nitrogen oxides (NO_x)	Annual	30	–
	Daily	75	–
Sulphur dioxide (SO_2)	Annual	20	–

Notes: 'pcy' = per calendar year

Directive 2008/50/EC¹ sets out that the Limit Values apply everywhere with the exception of:

- any locations situated within areas where members of the public do not have access and there is no fixed habitation;
- in accordance with Article 2(1), on factory premises or at industrial installations to which all relevant provisions concerning health and safety at work apply;
- on the carriageway of roads; and
- on the central reservations of roads except where there is normally pedestrian access to the central reservation.

⁶ Environment Agency. (2016) 'Air Emissions Risk Assessment for your Environmental Permit'.

⁷ UK Air Pollution Information System (APIS) www.apis.ac.uk [last accessed 12/11/2018]

Table 2 presents the locations where the Air Quality Objectives apply for the protection of human health.

Table 2: Locations where air quality objectives apply

Averaging period	Objectives should apply at:	Objectives should not apply at:
Annual	All locations where members of the public might be regularly exposed. Building façades of residential properties, schools, hospitals, care homes etc.	Building façades of offices or other places of work where members of the public do not have regular access. Hotels, unless people live there as their permanent residence. Gardens of residential properties. Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short term.
24 Hour	All locations where the annual mean objective would apply, together with hotels. Gardens of residential properties.	Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short term.
1 Hour	All locations where the annual mean and 24 and 8-hour mean objectives apply. Kerbside sites (for example, pavements of busy shopping streets). Those parts of car parks, bus stations and railway stations etc which are not fully enclosed, where members of the public might reasonably be expected to spend one hour or more. Any outdoor locations where members of the public might reasonably be expected to spend one hour or longer.	Kerbside sites where the public would not be expected to have regular access.

The areas where the Air Quality Standards Regulations annual limit for the protection of vegetation applies are as follows:

- More than 20 kilometres from an agglomeration (i.e. an area with a population of more than 250,000);
- More than 5 kilometres away from industrial sources regulated under Part A of the Environment Act 1990 (and/or Part A1 sites under the Environmental Permitting regulations);
- More than 5 kilometres away from motorways or major roads with traffic counts of more than 50,000 vehicles per day; and
- More than 5 kilometres away from built up areas of more than 5,000 people.

Therefore, designated ecological sites within these areas do not have the benefit of protection from statutory air quality limit values. However, the regulatory agencies have agreed with the countryside agencies that these critical levels should be applied on a precautionary basis.

2.2.3 Environmental assessment levels

The Environment Agency Risk Assessment Guidance provides further assessment criteria in the form of Environmental Assessment Levels (EALs). The only additional applicable EAL to this assessment is a short term (1 hour) EAL for CO, at 30,000 µg/m³.

3 Methodology

3.1 Overview

The approach to the air quality assessment has involved the following key elements:

- Establishing the Ambient Concentration (AC) from consideration of the Department for Environment Food and Rural Affairs (Defra) Air Quality Information Resource (UK-AIR)⁸ background predictions in the vicinity of the site;
- Quantitative assessment of the operational effects on local air quality, utilising a new generation dispersion model– ADMS and presenting results as Process Contributions (PC) and where required the Predicted Environmental Concentrations (PEC) in the context of relevant standards.

3.2 Modelling approach

3.2.1 Modelled Scenarios

The emission sources which have been included within this assessment are:

- Two existing 2.8MWth output combined heat and power engines ('CHPs')
- One existing 1.5MWth output hot water standby boiler ('existing boiler')
- Two new 1.6 MWth output dual fuel steam raising boilers ('new boilers')

The existing operating conditions for the Plant consists of the two CHP engines operating at 100% load continuously all year (with the exception of planned shutdowns for maintenance etc). The existing boiler operates occasionally throughout the year when either one or both engines are not running, typically due to maintenance, to maintain temperature within the heated anaerobic digestion process.

The proposed operating conditions for the Plant consists of the two new boilers operating at 100% load continuously all year (with the exception of planned shutdowns for maintenance etc) and the two existing CHP engines being used for peak lopping, assumed to be 8 hours per month. The existing standby boiler would be decommissioned.

In order to undertake a comprehensive assessment, a number of scenarios have been included to capture the worst-case effects.

On the basis of the above, the following scenarios have been assessed:

- Scenario 1 – Two existing CHP engines operating on biogas at full load continuously throughout the year
- Scenario 2 – One existing CHP engine and one existing standby boiler operating on biogas at full load continuously throughout the year
- Scenario 3 – Two new boilers operating on natural gas at full load continuously throughout the year
- Scenario 4 - Two new boilers operating on biogas at full load continuously throughout the year

⁸ Defra Air Information Resource available at <https://uk-air.defra.gov.uk/> [last accessed 03/08/2018]

- Scenario 5 - Two new boilers and two existing CHPs operating on natural gas at full load continuously throughout the year.

It is expected that the gas to grid plant would have approximately 98% availability across a year and therefore Scenario 4 is highly unlikely as it would only occur when the gas to grid plant was unavailable. Nevertheless, this scenario has been included for completeness to present worst case impacts.

Scenario 5 represents a hypothetical operating condition as it assumes that the two new boilers and the two existing engines will operate continuously, all year at full load. The scenarios are hypothetical as the plant would not be operated in this way. However, this scenario has been undertaken for the purpose of this assessment for comparison with the short term EQS to ensure any operation of the plant coincides with worst case meteorological conditions.

The existing CHPs and new boilers will not operate simultaneously on biogas and therefore a scenario covering this operation has not been considered further.

3.2.2 Model selection

A number of commercially available dispersion models are able to predict ground level concentrations arising from emissions to atmosphere from elevated point sources.

Atmospheric Dispersion Modelling System (ADMS) is a practical dispersion model, developed by Cambridge Environmental Research Consultants (CERC), which models a wide range of buoyant and passive releases to atmosphere either individually or in combination. ADMS brings together the results of recent research on dispersion modelling. The model calculates the mean concentration over flat terrain and also allows for the effect of plume rise, complex terrain, buildings, radioactive decay and deposition. The model has been subject to extensive validation. ADMS comprises a number of individual modules each representing one of the processes contributing to dispersion or an aspect of data input and output. The latest version of the model, ADMS 5.2, has been used in this assessment.

3.2.3 Buildings

The movement of air over and around buildings generates areas of flow circulation, which can lead to increased ground level concentrations in the building wakes. Where building heights are greater than about 30 - 40% of the stack height, downwash effects can be significant. ADMS includes a building effects module (as described above) used to calculate the dispersion of pollution from sources near large structures. The buildings likely to have a dominant effect (i.e. with the greatest dimensions likely to promote turbulence) are listed in Table 3 and illustrated in Figure 2 and have been included within the model.

Table 3: Building dimensions used within the assessment

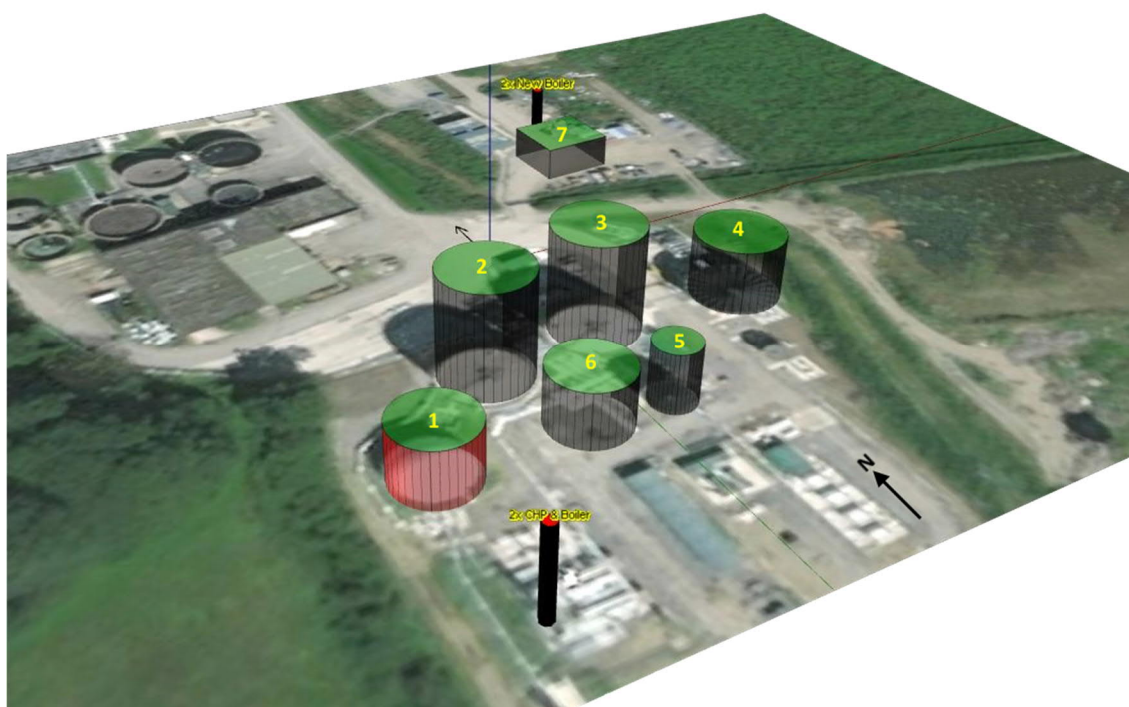
ID	Building	Shape	National grid reference		Height (m)	Length/diameter (m)	Width (m)	Angle (°)
			X	Y				
1	Gas Holder	Circular	336403	347923	11	15	-	-
2	Digester	Circular	336422	347943	21	17	-	-
3	Digester	Circular	336446	347947	21	17	-	-
4	Sludge Tank	Circular	336476	347945	12.8	17	-	-
5	Sludge Tank	Circular	336445	347923	11.7	8.5	-	-
6	New Gas Holder	Circular	336430	347924	11	15	-	-

ID	Building	Shape	National grid reference		Height (m)	Length/diameter (m)	Width (m)	Angle (°)
			X	Y				
7	New Boiler House	Rectangle	336476	348010	7	15	14	87

Note: OS Grid Reference for centre of buildings.

Angle relates to the orientation of the buildings within the ADMS model

Figure 2: Building layout used within the dispersion model



3.2.4 Meteorology

The most important meteorological parameters governing the atmospheric dispersion of pollutants are wind direction, wind speed and atmospheric stability as described below:

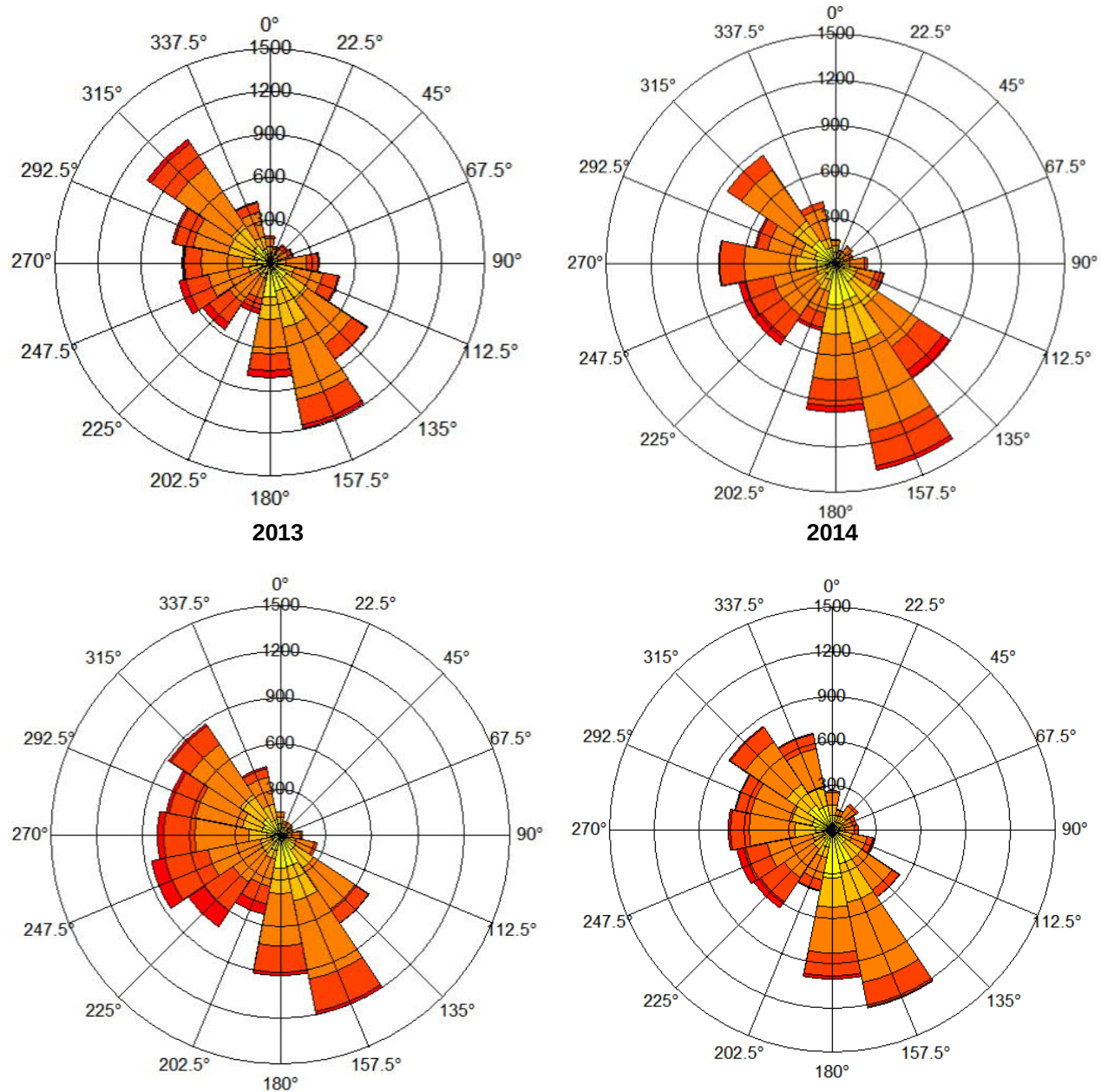
- Wind direction determines the sector of the compass into which the plume is dispersed.
- Wind speed affects the distance the plume travels over time and can affect plume dispersion by increasing the initial dilution of pollutants and inhibiting plume rise.
- Atmospheric stability is a measure of the turbulence of the air, and particularly of its vertical motion. It therefore affects the spread of the plume as it travels away from the source. ADMS uses a parameter known as the Monin-Obukhov length that, together with the wind speed, describes the stability of the atmosphere.

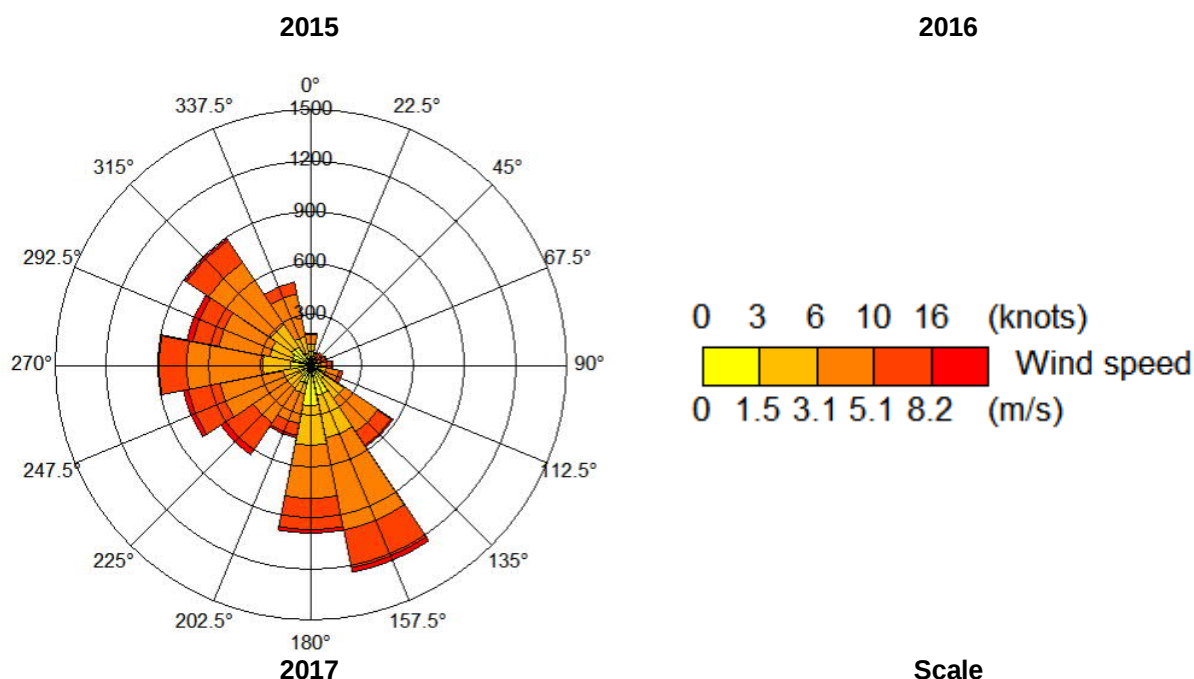
For meteorological data to be suitable for dispersion modelling purposes, a number of meteorological parameters need to be measured on an hourly basis. These parameters include wind speed, wind direction, cloud cover and temperature. There are only a limited number of sites where the required meteorological measurements are made.

The year of meteorological data that is used for a modelling assessment can have a significant effect on source contribution concentrations. As recommended by the EA, dispersion model simulations were performed for emissions from the site using five years of data. Data from Harwarden meteorological station were used as this was the most representative of the site. Data from the last five years were used, comprising the years 2013 to 2017. This meteorological station is located approximately 17 kilometres to the north of the site.

Wind roses have been constructed for each of the five years of meteorological data used in this assessment. The wind roses presented in Figure 3 illustrate that in most years there is dominance in winds from the south-east with less frequent winds from the west, north west and south west.

Figure 3: Wind roses for Harwarden (2013 – 2017)





3.2.5 Terrain

The presence of elevated terrain can significantly affect (usually increase) ground level concentrations of pollutants emitted from elevated sources such as stacks by reducing the distance between the plume centre line and ground level and increasing turbulence and, hence, plume mixing.

Terrain in the region of the site is generally flat and has slopes with gradient less than a one metre gain in height for 10 metres travelled, and therefore no terrain data has been included in the dispersion model.

3.2.6 Surface roughness

The roughness of the terrain over which a plume passes can have a significant effect on dispersion by altering the velocity profile with height, and the degree of atmospheric turbulence. This is accounted for by a parameter called the surface roughness length. Land use surrounding the site can largely be characterised as agricultural, therefore, a surface roughness length of 0.3 metres has been assigned.

3.2.7 Emissions data

Emissions for all individual combustion sources have been based on an annual average plant load of 100%. It has been assumed that exhaust gases will contain the maximum concentrations of pollutants presented and Plant will run at 100% load all year round. This approach is considered to result in a conservative assessment as, in practice, annual average plant loads of the boilers are likely to be below 100% (due to maintenance, downtime etc.) and the CHP engines will only operate intermittently, in addition pollutant concentrations will likely be below those proposed.

The two new boiler emissions have been calculated from data provided by the supplier. Where information was not available emission parameters have been calculated. The equations used in the flue gas calculations are presented below:

- Correcting for water content:
Dry value = Measured value x 100 / (100 – H₂O measured concentrations [%]).
- Correcting for oxygen content:
Corrected value = Measured value x (21 – O₂ Reference value [%] / 21 – O₂ Measured Value [%]).
- Correcting for temperature:
Corrected value = Measured value x (Temperature of measured value [K] / 273 [K]).

Table 4 presents the emission data which was used in the dispersion modelling for all scenarios. Emissions from the proposed plant are compliant with the requirements of the Medium Combustion Plant Directive.

Table 4: Stack emission parameters

Property	Unit	2xCHP Multi-flue	1xCHP	Existing Boiler	2xNew Boiler Multi-flue	2xNew Boiler Multi-flue
Scenario (see Section 3.2.1)	-	1 and 5	2	2	3 and 5	4
Fuel	-	Biogas	Biogas	Biogas	Natural Gas	Biogas
Stack location (British National Grid)	x,y	336404, 347892	336404, 347892	336404, 347892	336476, 348020	336476, 348020
Stack height	m	17	17	17	14	14
Exit diameter	m	0.424	0.3	0.4	0.495	0.495
Exit temperature	°C	180	180	200	150	150
Efflux velocity (actual)	m/s	16.55	16.55	10.23	10.04	16.52
Volumetric flow rate (actual)	Am ³ /s	2.34	1.17	1.29	0.97	1.59
Actual O ₂	%	-	-	-	2.5	2.5
Actual H ₂ O	%	-	-	-	16.53	16.07
Volumetric flow rate (normalised)	Nm ³ /s	0.984	0.492	0.564	1.041	1.722
NO _x emission	mg/Nm ³	500	500	500	100 ^(a)	100 ^(a)
	g/s	0.492	0.246	0.282	0.104	0.172
SO ₂ emission	mg/Nm ³	-	-	-	-	100 ^{(a)(b)}
	g/s	0.44	0.22	0.25	0.0	0.172
CO emission	mg/Nm ³	1400	1400	1400	12.5	12.5
	g/s	0.04	0.02	0.03	0.013	0.022

Notes: Data from existing plant from previous assessment undertaken for Environmental Permit application

^(a) Normalised conditions = 3% O₂, 273.15 K, dry, 1 atm

^(b) The expected H₂S content of biogas is 46ppm and therefore concentrations in flue gas will be significantly below 100mg/Nm³ limit assumed in the assessment.

3.2.8 NO_x to NO₂ relationship

The NO_x emissions associated with combustion activities at the site will typically comprise approximately 90-95% nitrogen monoxide (NO) and 5-10% nitrogen dioxide (NO₂) at source. As described previously, the NO oxidises in the atmosphere in the presence of sunlight, ozone and volatile organic compounds to form NO₂, which is the principal concern in terms of environmental health effects.

There are various techniques available for estimating the portion of the NO_x that is converted to NO₂, which will increase with distance from the source. The Environment Agency's air emission risk assessment guidance⁶ identifies that a 100% conversion of NO_x to NO₂ can be used for calculation of annual average concentrations and a 50% conversion of NO_x to NO₂ is applicable for calculation of short term concentrations. For the purposes of this assessment, the EA's recommended conversion rates have been used.

3.2.9 Sensitive receptors

3.2.9.1 Human health

A number of discrete receptors representing the façades of the closest residential properties have been included within the model so that a comparison against the air quality objectives can be made. These receptors have been chosen as they are expected to experience the greatest change due to their close proximity to the proposed plant. Table 5 and Figure 4 show the locations of the discrete receptors considered within this assessment. These receptors are consistent with those used in the original EP application.

Table 5: Modelled human health receptors

Receptor Number	Receptor Description	National Grid Reference		Height of Receptor (m)
		X	Y	
R1	Farm approximately 850m north of the Site	336078	348678	1.5
R2	Residential approximately 540m west of the Site	335873	347936	1.5
R3	Residential approximately 410m southwest of the Site	336020	347752	1.5
R4	Farm approximately 615m northeast of the Site	336592	348480	1.5
R5	Farm approximately 410m northeast of the Site	336573	348262	1.5

This assessment has included modelling of pollutant concentrations across a Cartesian grid with a 50 metre receptor spacing up to a five kilometre radius around the site.

3.2.9.2 Ecological receptors

A review of ecological receptors has been carried out. Specific sites designated for their ecological importance need only be considered where they fall within set distances from the assessment site as specified in the EA Guidance:

- Special Protection Areas (SPAs), Special Areas of Conservation (SACs) or Ramsar sites within 10 kilometres of the installation; and,

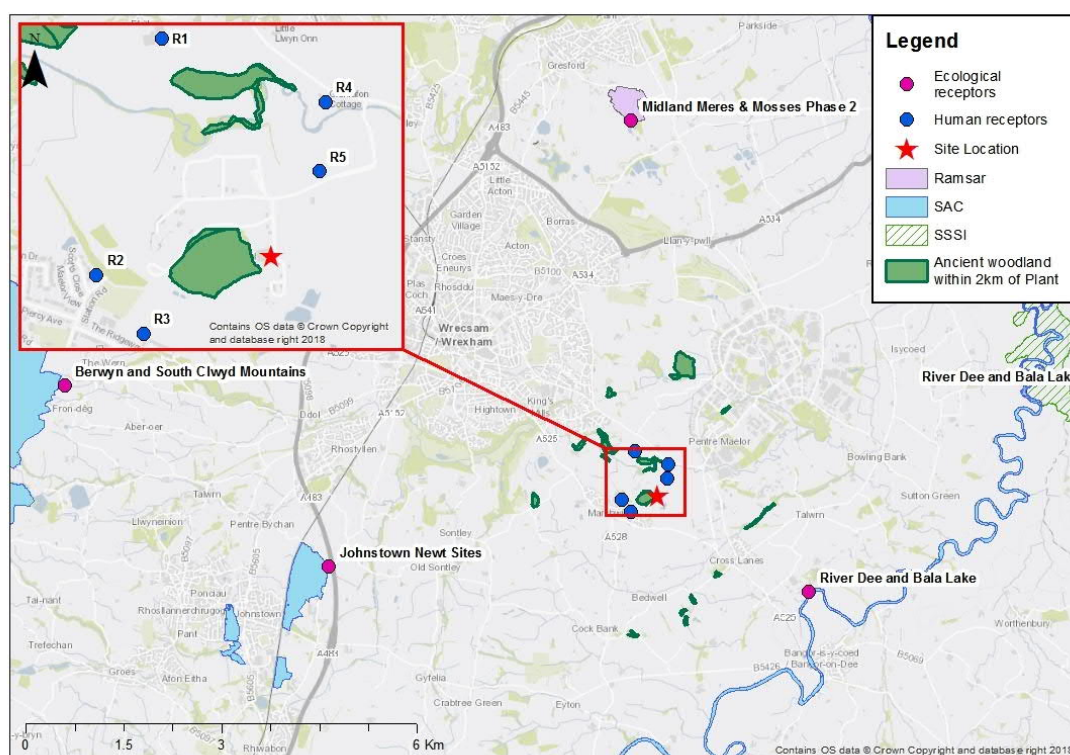
- Sites of Special Scientific Interest (SSSIs), National Nature Reserves (NNRs), Local Nature Reserves (LNRs), local wildlife sites and ancient woodlands (all known as local nature sites) within two kilometres of the location of the installation.

Discrete receptors representing the closest point of the ecological sites which meet the above criteria have been assessed. Table 6 and Figure 4 present the locations of the SACs and Ramsar ecological sites included in the modelling assessment. There are also local nature sites within two kilometres of the Plant. These include 24 ancient woodland sites and two local nature reserves known as Cefn Parc site and Marchwiell marsh.

Table 6: Ecological sites considered within the assessment

Site Name	Designation	Closest Modelled Location (x y)		Distance from Site (km)
Midland Meres & Mosses Phase 2	Ramsar	336024	353750	5.9
River Dee and Bala Lake	SAC	338742	346524	2.7
Johnstown Newt Sites	SAC	331384	346910	5.1
Berwyn and South Clwyd Mountains	SAC	327327	349688	9.3

Figure 4: Modelled Receptors



3.2.10 Effects on Vegetation and Ecosystems

3.2.10.1 Critical Levels

Critical levels for the protection of vegetation and ecosystems are specified within relevant European air quality directives and corresponding UK air quality regulations (see Table 1). PC and PEC of NO_x and SO₂ have been calculated for comparison against the identified critical levels.

3.2.10.2 Critical Loads

Critical loads are a quantitative estimate of exposure to deposition of one or more pollutants, below which significant harmful effects on sensitive elements of the environment do not occur, according to present knowledge.

Critical Loads – Acidification

Percentage contributions to acid deposition have been derived from dispersion modelling. Deposition rates were calculated using empirical methods recommended by EA guidance⁹ as follows:

- Calculate dry deposition flux (0.0015 m/s for NO_x) (0.012 m/s for SO₂)
- Dry deposition flux (µg/m²/s) = ground level concentration (µg/m³) x deposition velocity (m/s)
- Convert units from µg/m²/s to units of kg/ha/yr by multiplying the dry deposition flux by standard conversion factors (96 for NO_x) (157.7 for SO₂);
- Convert to units of equivalents (keq/ha/yr), which is a measure of how acidifying the chemical species can be, by multiplying the dry deposition flux (kg/ha/yr) by standard conversion factors (0.071428 for N) (0.0625 for S).
- Add predicted dry N and S deposition (keq/ha/year) to determine total acid deposition

Wet deposition in the near field is not significant compared with dry deposition and therefore for the purposes of this assessment, wet deposition has not been considered.

Predicted contributions to acid deposition have been calculated and compared with the relevant critical load function for the most sensitive habitat type associated with each designated site as derived from the APIS.

Critical Loads – Eutrophication

Percentage contributions to nutrient nitrogen deposition have been derived from dispersion modelling. Deposition rates were calculated using empirical methods recommended by EA guidance⁹, as follows:

- Calculate NO_x dry deposition flux (0.0015 m/s for NO_x assumed as deposition velocity):
 - Dry deposition flux (µg/m²/s) = ground level concentration (µg/m³) x deposition velocity (m/s)
- Convert units from µg/m²/s to units of kg/ha/yr by multiplying the dry deposition flux by a standard conversion factor (96 for NO_x).

Wet deposition in the near field is not significant compared with dry deposition and therefore for the purposes of this assessment, wet deposition has not been considered.

Predicted contributions to nitrogen deposition have been calculated and compared with the relevant critical load range for the most sensitive habitat type associated with each designated site as derived from the APIS

⁹ Environment Agency (2006). Technical Guidance on detailed modelling approach for an appropriate assessment for emissions to air: Habitats Directive 2004 (AQTAG 06).

3.2.11 Significance Criteria

A number of approaches can be used to determine whether the potential air quality effects of a development are significant. However, there remains no universally recognised definition of what constitutes 'significance'.

Guidance is available from a range of regulatory authorities and advisory bodies on how best to determine and present the significance of effects within an air quality assessment. It is generally considered good practice that, where possible, an assessment should communicate effects both numerically and descriptively.

In order to ensure that the descriptions of effects used within this report are clear, consistent and in accordance with recent guidance, definitions have been adopted from the EA's Air Emissions Risk Assessment for your Environmental Permit Guidance⁶. Where impacts do not meet the EA's Air Emissions Risk Assessment description of 'insignificant', guidance from the Institute of Air Quality Management (IAQM) and Environmental Protection UK (EPUK)¹⁰ has been used. Table 7: provides a summary of criteria used to screen out insignificant emissions.

Table 7: Summary of assessment criteria

Parameter	Long Term Standards	Short Term Standards
Criteria for screening out insignificant emissions	Emissions can be seen as insignificant where: PC long term $\leq$ 1% of standard	Emissions can be seen as insignificant where: PC short term $\leq$ 10% of standard
Screen out insignificant PECs	PC long term + AC is less than 70% of standard	PC short term is less than 20% of standard minus twice the long term background concentration
Screening for SPAs, SACs, Ramsar and SSSIs	the long-term PC is less than 1% of the long-term environmental standard for protected conservation areas If your long-term PC is greater than 1% and your PEC is less than 70% of the long-term environmental standard, the emissions are insignificant	The short-term PC is less than 10% of the short-term environmental standard for protected conservation areas
Screening for local nature sites	If the long-term PC is less than 100% of the long-term environmental standard emissions are insignificant	If the short-term PC is less than 100% of the short-term environmental standard emissions are insignificant

Note: PC = Process Contribution; PEC = Predicted Environmental Concentration (PC + Ambient Concentration, AC);

EQS = Environmental Quality Standard; EAL = Environmental Assessment Level;

AQAP = Air Quality Action Plan:

3.2.12 Assessment of Compliance with EU Limit Values

Defra uses the Pollution Climate Mapping (PCM) model to report compliance with EU Directive 2008/50/EC. The PCM model calculates NO₂ concentrations at roadside locations where the EU limit values apply.

PCM projections are available for a modelled base year of 2015 and modelled projections for 2017 to 2030 with projected NO₂ concentrations declining year on year in response to anticipated improvements in air quality primarily as a result of future improvements in vehicle emissions.

¹⁰ Environmental Protection UK and Institute of Air Quality Management (May 2015), 'Land-Use Planning and Development Control: Planning for Air Quality' 2015.

2018 PCM data has been obtained from the Defra website. The closest PCM links included are located approximately 2.3km to the north west of the Plant. Concentrations in the PCM model within the modelled 5km radius are well below the EU limit values for NO₂.

4 Baseline Conditions

4.1 Introduction

Information on air quality in the UK can be obtained from a variety of sources including Local Authorities, national network monitoring sites and other published sources. For the purposes of this assessment, information has been obtained from Wrexham County Borough Council¹¹ (WCBC) and the Department for Environment, Food and Rural Affairs (Defra) Air Information Resource (AIR)⁸ website. Baseline conditions with respect to nutrient nitrogen deposition and acid deposition have been obtained from the Air Pollution Information System (APIS)⁷.

4.2 WCBC Review and Assessment

The North Wales Combined Authority fulfils the air quality review and assessment obligations, as specified in Part IV of the Environment Act 1995, for six local authorities including WCBC. The purpose of the review and assessment procedure is to determine areas that have an exceedance of or are at risk of exceeding the relevant air quality objectives. Where an area exceeds an air quality objective an Air Quality Management Area (AQMA) must be declared and an Air Quality Action Plan (AQAP) must be prepared to specify and implement measures to improve air quality.

Whilst WCBC undertake ambient monitoring, there are no background monitoring sites representative of the study area.

There are no AQMAs within the authority of WCBC suggesting that air quality is generally good. The closest AQMA is within Cheshire West and Chester Council and is approximately 18.5km north of the Plant and is outside of this assessments study area.

4.3 Defra Air Projected Background Concentrations

Defra provides estimates of pollution concentrations across the UK for each one kilometre grid square for future years up to 2030. Data has been collected for the nearest grid square (OS Grid Co-ordinates 574500, 207500) to the Plant. Table 8 presents data obtained from Defra for 2018 to represent current year background concentrations. These background concentrations have been added to the Plant process contribution (PC) to determine the predicted environmental concentrations (PEC). Short term background concentrations have been assumed to be twice the annual mean concentrations in line with EA Guidance⁶.

Table 8: Defra projected annual mean pollutant concentrations (µg/m³)

Pollutant	2018	
	Long Term	Short Term
NO _x	9.8	19.6
NO ₂	7.5	15
SO ₂ ^(a)	3.9	7.8
CO ^(a)	255	510

Notes: ^(a) 2001 concentration data assumed in the absence of more recent data and projection factors for future years.

¹¹ https://www.wrexham.gov.uk/english/environment/air_quality/ [last accessed 03/08/2018]

5 Results

5.1 Introduction

The results of modelling atmospheric emissions from the Plant at the discrete receptor locations are presented in tabular form in this section.

Additionally, contour plots for the worst-case meteorological year for each pollutant show the geographical distribution of pollutants.

5.2 Human Health Receptors

Table 9 presents the maximum Process Contribution (PC) of all relevant pollutants from Scenarios 1 to 6 across the modelled grid.

Scenario 1 and Scenario 2 present the results of the existing operating procedure of the two CHPs and boiler.

Scenario 3 and Scenario 4 present the results of the proposed operation of the two new dual fuel steam boilers; combusting natural gas and biogas respectively. Modelled short term PC's are below 10% and long term PCs are below 1% of the relevant EQS for all pollutants and therefore are considered to be insignificant in accordance with the EAs air emissions risk assessment guidance [8].

Scenario 5 presents the results of the proposed operation of the two new dual fuel steam boilers and the two existing CHPs. In Scenario 5 the two new boilers are combusting natural gas. All plant has been assumed to operate at full load continuously throughout the year. Long term (annual mean) concentrations have not been presented for this scenario as it is expected that the CHPs will only operate for 8 hours per month and therefore this limited operation would have negligible effect on annual mean concentrations. Although the predicted NO₂ short term PCs exceed the 10% criteria for screening out PCs, it is unlikely that they would always operate at a time that coincides with the worst meteorological conditions and are unlikely to be as high as those presented in Table 9. However, for completeness, Table 10 presents the predicted environmental concentrations (PECs) for Scenarios 1, 2 and 5 where the PCs exceed 10% of the short term EQS. Modelled short term PCs are less than 20% of the EQS minus the background concentration and the long term (annual mean) PECs are less than 70% of the EQS. Additionally, the PECs do not exceed the relevant EQS. Therefore, PC and PECs from Scenario 1, 2 and 5 are considered to be insignificant in accordance with the EAs air emissions risk assessment guidance [8].

A comparison of PCs from the existing plant in Scenario 1 and Scenario 2 against the proposed plant in Scenarios 3 and 4 shows that the proposed Plant will lead to an improvement in air quality compared to the existing situation.

A comparison of PCs from the existing plant in Scenario 1 and Scenario 2 against the proposed plant in Scenario 5 show that PCs are broadly similar, even with the highly conservative assumptions Included in Scenario 5.

Overall, the PCs from the new operating procedures in Scenarios 3- 5 are considered to be 'insignificant' with regards to human health.

Table 9: Maximum Process Contributions (PCs) ($\mu\text{g}/\text{m}^3$)

Pollutant	Averaging period	Max PC					Max PC as % of EQS					EQS
		Sc1	Sc2	Sc3	Sc4	Sc5	Sc1	Sc2	Sc3	Sc4	Sc5	
NO ₂	99.79 %'ile of hourly averages	19.7	27.1	4.7	5.9	20.9	9.8	13.5	2.4	3.0	10.5	200
	Annual ^(a)	0.5	0.6	0.2	0.3	-	1.3	1.5	0.5	0.8	-	40
SO ₂	99.9 %'ile of 15 minute averages	39.8	54.5	0.0	12.6	39.8	15.0	20.5	0.0	6.2	15.0	266
	99.73 %'ile of hourly averages	33.6	47.4	0.0	11.7	33.6	9.6	13.5	0.0	4.4	9.6	350
	99.18 %'ile of 24 hourly averages	10.1	13.0	0.0	7.6	10.1	8.0	10.4	0.0	8.0	8.0	125
CO	Hourly Max	3.8	6.3	1.3	1.8	4.3	0.0	0.0	0.0	0.0	0.0	30,000
	Running 8 hour maximum	3.6	6.0	1.1	1.5	4.0	0.0	0.1	0.0	0.0	0.0	10,000

Note: PC = Process Contribution; EQS = Environmental Quality Standard

^(a) – Annual mean objective applies at long term receptors, such as residential, only. Results presented for annual means are at Receptor 5 which has the highest modelled PCs.

'-' means averaging period not applicable to Scenario

Bold text show PCs that exceed the screening criteria for long term (1%) and short term (10%) PCs.

Scenario 1 – Two existing engines operating on biogas at full load continuously throughout the year

Scenario 2 – One existing engine and one existing standby boiler operating on biogas at full load continuously throughout the year

Scenario 3 – Two new boilers operating on natural gas at full load continuously throughout the year

Scenario 4 – Two new boilers operating on biogas at full load continuously throughout the year

Scenario 5 – Two new boilers and two existing CHPs operating on natural gas at full load continuously throughout the year

Table 10: Maximum Predicted Environmental Concentrations (PECs) ($\mu\text{g}/\text{m}^3$)

Pollutant	Averaging period	Background Concentration ^(a)	Max PC			Max PEC			Max PC as % of EQS minus the Background Concentration for short term and Max PEC as % of EQS for long term (annual)			EQS
			Sc1	Sc2	Sc5	Sc1	Sc2	Sc5	Sc1	Sc2	Sc5	
NO ₂	99.79 %'ile of hourly averages	19.6	19.7	27.1	20.9	39.3	46.7	40.5	10.9	15.0	11.6	200
	Annual	9.8	0.5	0.6	-	10.3	10.4	-	30.0	31.8	-	40
SO ₂	99.9 %'ile of 15 minute averages	7.8	39.8	54.5	39.8	47.6	62.3	47.6	15.4	21.1	15.4	266
	99.73 %'ile of hourly averages	7.8	33.6	47.4	33.6	41.4	55.2	41.4	9.8	13.8	9.8	350
	99.18 %'ile of 24 hourly averages	7.8	10.1	13.0	10.1	17.9	20.8	17.9	8.6	11.1	8.6	125

Note: PC = Process Contribution; PEC = Predicted Environmental Concentration; EQS = Environmental Quality Standard

'-' means averaging period not applicable to Scenario

Bold text show PCs that exceed the screening criteria for long term (70%) and short term (20%) PECs.

- ^(a) Background concentrations for short term averaging periods are twice the long term background concentration (see Section 4.3)
- Scenario 1 – Two existing engines operating on biogas at full load continuously throughout the year
- Scenario 2 – One existing engine and one existing standby boiler operating on biogas at full load continuously throughout the year
- Scenario 5 - Two new boilers and two existing CHPs operating on natural gas at full load continuously throughout the year

5.3 Ecological Receptors

5.3.1 Overview

This section presents the PCs from Scenarios 1 to 5 on designated sites for comparison with the daily and annual EALs (critical levels) and the critical loads. Scenario 5 has only been presented for the daily averaging periods as this scenario is not representative of annual means given the likelihood of operation. The comparison of Scenario 5 against the daily averaging period is considered to be highly conservative as the CHPs would only operate 8 hours per month but the modelling assumes continuous operation all year round in the event that they operate for a period of 24 hours or more and this coincides with the worst case meteorological conditions.

5.3.2 Assessment of Critical Levels

Table 11 to Table 13 **Error! Reference source not found.** present the maximum predicted daily and annual PC of NO_x and annual SO₂. The results show that the highest predicted long term PCs are below 100% of the relevant EALs at the Local Nature Sites and below 1% of the relevant EALs at the Ramsar and SACs and therefore in accordance with EA guidance are considered to be insignificant.

5.3.3 Assessment of Critical Loads

Table 14 and Table 15 present the predicted nitrogen and acid deposition rates at the designated sites which have been calculated from the dispersion modelling results.

The results show that the highest predicted PCs are below 100% of the relevant EALs at the Local Nature Sites and below 1% of the relevant EALs at the Ramsar and SACs and therefore in accordance with EA guidance are considered to be insignificant.

5.3.4 Summary of Effects on Ecological Receptors

The PCs of NO_x, SO₂, nitrogen deposition and acid deposition from all scenarios do not exceed the screening criteria provided by EA guidance (see Table 7).

As discussed in Section 5.2, a comparison of PCs from the existing plant in Scenario 1 and Scenario 2 against the proposed plant in Scenarios 3 and 4 shows that the proposed Plant will lead to an improvement in air quality compared to the existing situation.

Overall, the PCs from the new operating procedures in Scenarios 3 and 4 are considered to be 'insignificant' with regards to ecological receptors.

Table 11: Critical Level Results – Annual Mean NO_x concentrations (µg/m³)

Site Name	Designation	Max PC				Max PC as % of EAL				EAL
		Sc1	Sc2	Sc3	Sc4	Sc1	Sc2	Sc3	Sc4	
Midland Meres & Mosses Phase 2	Ramsar	0.03	0.04	0.01	0.01	0.10	0.13	0.03	0.03	30
River Dee and Bala Lake	SAC	0.06	0.07	0.02	0.02	0.20	0.23	0.07	0.07	30
Johnstown Newt Sites	SAC	0.01	0.01	0.00	0.00	0.03	0.03	0.00	0.00	30
Berwyn and South Clwyd Mountains	SAC	0.00	0.01	0.00	0.00	0.00	0.03	0.00	0.00	30
Cefn Parc Site and Marchwiel Marsh	Local Nature Site	2.1	2.7	0.3	0.4	7.0	9.0	1.0	1.3	30

Note: PC = Process Contribution; EAL = Environmental Assessment Level; PC presented to two decimal places to demonstrate change and is not an indication of model accuracy. A PC of 0.00 means that PCs were smaller than two decimal places, not that the PC was zero.

Table 12: Critical Level Results – Daily NO_x concentrations (µg/m³)

Site Name	Designation	Max PC					Max PC as % of EAL					EAL
		Sc1	Sc2	Sc3	Sc4	Sc5	Sc1	Sc2	Sc3	Sc4	Sc5	
Midland Meres & Mosses Phase 2	Ramsar	0.27	0.45	0.09	0.10	0.36	0.36	0.60	0.12	0.13	0.48	75
River Dee and Bala Lake	SAC	0.49	0.61	0.15	0.18	0.61	0.65	0.81	0.20	0.24	0.81	75
Johnstown Newt Sites	SAC	0.13	0.17	0.03	0.05	0.17	0.17	0.23	0.04	0.07	0.23	75
Berwyn and South Clwyd Mountains	SAC	0.09	0.10	0.02	0.03	0.10	0.12	0.13	0.03	0.04	0.13	75
Cefn Parc Site and Marchwiel Marsh	Local Nature Site	12.3	14.6	4.1	5.4	12.3	16.4	19.5	5.5	7.2	16.4	75

Note: PC = Process Contribution; EAL = Environmental Assessment Level; PC presented to two decimal places to demonstrate change and is not an indication of model accuracy. The comparison of Scenario 5 and 6 against the daily averaging period is considered to be highly conservative as the CHPs would only operate 8 hours per month.

Table 13: Critical Level Results – Annual Mean SO₂ concentrations (µg/m³)

Site Name	Designation	Max PC			Max PC as % of EAL			EAL
		Sc1	Sc2	Sc4	Sc1	Sc2	Sc4	
Midland Meres & Mosses Phase 2	Ramsar	0.02	0.03	0.01	0.10	0.15	0.03	20
River Dee and Bala Lake	SAC	0.05	0.07	0.02	0.25	0.35	0.07	20
Johnstown Newt Sites	SAC	0.00	0.01	0.00	0.00	0.05	0.00	20
Berwyn and South Clwyd Mountains	SAC	0.00	0.00	0.00	0.00	0.00	0.00	20
Cefn Parc Site and Marchwiel Marsh	Local Nature Site	1.9	2.4	0.4	9.5	12.0	1.4	20

Note: PC = Process Contribution; EAL = Environmental Assessment Level; PC presented to two decimal places to demonstrate change and is not an indication of model accuracy; A PC of 0.00 means that PCs were smaller than two decimal places, not that the PC was zero.
There are no emissions of SO₂ from Scenario 3.

Table 14: Critical Load Results – Nitrogen Deposition (kg/ha/year)

Site Name	Designation	APIS Habitat	Max PC				Max PC as % of Minimum Critical Load				Minimum Critical Load ^(a)
			Sc1	Sc2	Sc3	Sc4	Sc1	Sc2	Sc3	Sc4	
Midland Meres & Mosses Phase 2	Ramsar	Fen, Marsh and Swamp	0.0039	0.0053	0.0041	0.0014	0.0	0.1	0.0	0.0	10
River Dee and Bala Lake	SAC	Broadleaved, Mixed and Yew Woodland	0.0084	0.0105	0.0102	0.0032	0.1	0.1	0.1	0.0	10
Johnstown Newt Sites	SAC	Broadleaved, Mixed and Yew Woodland; Fen, Marsh and Swamp	0.0007	0.0009	0.0004	0.0002	0.0	0.0	0.0	0.0	10
Berwyn and South Clwyd Mountains	SAC	Fen, Marsh and Swamp	0.0007	0.0008	0.0003	0.0002	0.0	0.0	0.0	0.0	5
Cefn Parc Site and Marchwiell Marsh	Local Nature Site	Broadleaved, Mixed and Yew Woodland	0.3004	0.3912	0.0450	0.0600	3.0	3.9	0.4	0.6	10

Note: PC = Process Contribution; PC presented to four decimal places to demonstrate change and is not an indication of model accuracy

^(a) The lowest critical load has been applied where multiple habitats and vegetation types exist

Table 15: Critical Load Results – Acid Deposition (keq/ha/year)

Site Name	Designation	APIS Habitat	Max PC				Max PC as % of Critical Load Class				Critical Load Class
			Sc1	Sc2	Sc3	Sc4	Sc1	Sc2	Sc3	Sc4	
Midland Meres & Mosses Phase 2	Ramsar	Fen, Marsh and Swamp	0.0031	0.0042	0.0003	0.0012	-	-	-	-	Not sensitive to acid deposition
River Dee and Bala Lake	SAC	Broadleaved, Mixed and Yew Woodland	0.0067	0.0084	0.0007	0.0029	0.4	0.5	0.0	0.2	1.668
Johnstown Newt Sites	SAC	Broadleaved, Mixed and Yew Woodland; Fen, Marsh and Swamp	0.0006	0.0007	0.0000	0.0002	0.0	0.0	0.0	0.0	1.818
Berwyn and South Clwyd Mountains	SAC	Fen, Marsh and Swamp	0.0005	0.0006	0.0000	0.0002	0.1	0.1	0.0	0.0	0.673

Site Name	Designation	APIS Habitat	Max PC				Max PC as % of Critical Load Class				Critical Load Class
			Sc1	Sc2	Sc3	Sc4	Sc1	Sc2	Sc3	Sc4	
Cefn Parc Site and Marchwiel Marsh	Local Nature Site	Broadleaved, Mixed and Yew Woodland	0.2421	0.3140	0.0032	0.0535	13.7	17.8	0.2	3.0	1.764

Note: PC = Process Contribution; PC presented to four decimal places to demonstrate change and is not an indication of model accuracy

(a) The lowest critical load has been applied where multiple habitats and vegetation types exist

5.4 Contour Plots

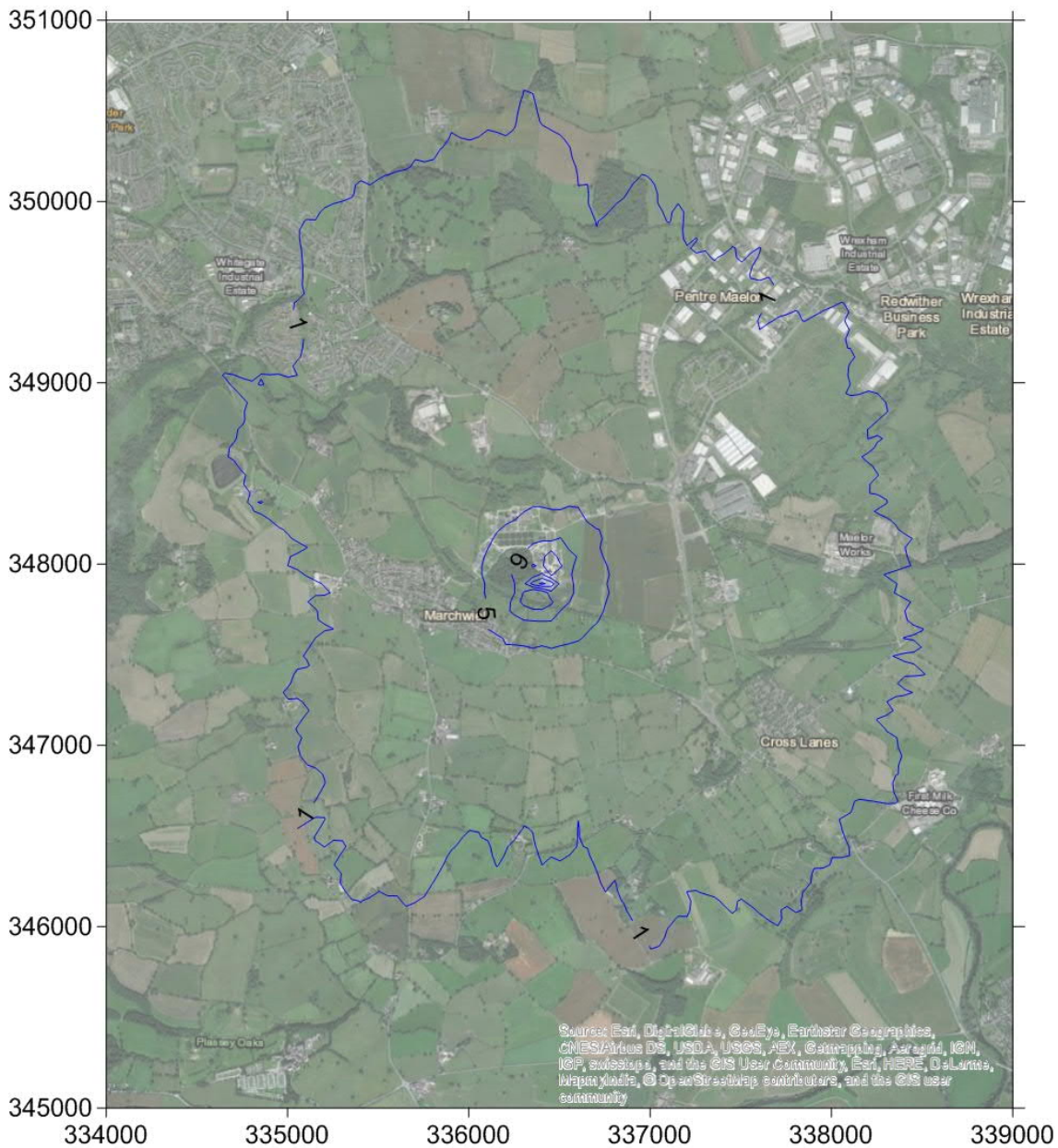
Figure 5 to Figure 8 present contour plots for long term and short term NO₂ PCs for Scenario 1 and Scenario 4. These contour plots have been presented to demonstrate the pattern of dispersion for long term and short-term averaging periods for the most common operating scenarios. The contour plots show that the maximum concentrations from the normal operation of the CHPs and boilers are very close to the Plant and that the proposed normal operation of the two new boilers has lower PCs and spatial spread than the existing operation of the CHPs.

Figure 5: Scenario 1 - Annual Mean NO₂ Contour Plot



Notes: Meteorological year: 2014; Minimum contour: 0.1µg/m³; Contour interval: 0.5µg/m³

Figure 6: Scenario 1 - 1 hour 99.79% NO₂ Contour Plot



Notes: Meteorological year: 2016; Minimum contour: 1 μ g/m³; Contour interval; 4 μ g/m³

Figure 7: Scenario 4 - Annual Mean NO₂ Contour Plot



Figure 8: Scenario 4 - 1 hour 99.79% NO₂ Contour Plot



6 Conclusions

An assessment has been undertaken to determine the effect on air quality associated with emissions from the site using advanced dispersion modelling. For potential human health effects the pollutant of key concern is NO₂, although emissions of SO₂ and CO have also been considered. Effects of atmospheric concentrations of NO_x and SO₂ and the effects of nitrogen and acid deposition have also been assessed with respect to sensitive ecological sites. The method of the assessment has taken a conservative approach by assuming worst case conditions for a number of aspects including emissions characteristics, operating scenarios, metrological conditions and critical loads.

The results indicate compliance with all relevant environmental quality standards for both the protection of human health and designated sites. Overall impacts of all pollutants are considered to be insignificant and the proposed Plant is predicted to lead to an improvement in air quality compared to the existing configuration.

