



Air Quality and Odour Impact Assessment to Support a Substantial Variation Permit

Eco Verde Energy Ltd

**Eco Verde Energy Ltd Attleborough Anaerobic Digestion
facility, Ellingham Road, Attleborough, Norfolk, NR17
1AE**

Prepared by:

Christine McHugh, MA, PhD, MIAQM, MEnvSc, CSci

ETL573/2021

Earthcare Technical Ltd
Manor Farm
Chalton
Waterlooville
Hants PO8 0BG

Tel: 02392 290 488




christine@earthcaretechnical.co.uk

27 August 2021

QUALITY CONTROL

Document Title:	Air Quality and Odour Impact Assessment to Support a Substantial Variation Permit Application
Revision:	V1.0
Date:	27 August 2021
Document Reference:	ETL573/AQIA/Final/V1.0/Aug 2021
Prepared For:	Eco Verde Energy Ltd
Project Reference:	ETL573/2021
Copyright:	Earthcare Technical Ltd. © 2021

Quality control sign off

Document Author	C. McHugh	
Technical Reviewer	M. Fuhrmann	
Quality Reviewer	A. Becvar	

This report has been prepared by Earthcare Technical Ltd on behalf of the Client, taking into account the agreed scope of works. Unless otherwise agreed, this document and all other Intellectual Property Rights remain the property of Earthcare Technical Ltd.

In preparing this report, Earthcare Technical Ltd has exercised all reasonable skill and care, taking into account the objectives and the agreed scope of works and any contract between Earthcare Technical Ltd and the Client. Earthcare Technical Ltd does not accept any liability in negligence for any matters arising outside of the agreed scope of works. When issued in electronic format, Earthcare Technical Ltd does not accept any responsibility for any unauthorised changes made by others. This document may not be copied in whole or in part without the prior written consent of Earthcare Technical Limited.

Contents

ABBREVIATIONS.....	7
1. INTRODUCTION	9
1.1. Background	9
1.2 Site description	9
1.3 Scope of report	10
2. PROCESS DESCRIPTION	11
2.1 Overview	11
2.2 Crop-AD Process Description	11
2.3 Waste-AD Process Description	12
2.4 Summary of emissions to air.....	14
3. LEGISLATION AND GUIDANCE	16
3.1. Overview	16
3.2. Legislation	17
3.3. Guidance	18
4. ASSESSMENT METHODOLOGY.....	20
4.1 Introduction	20
4.2 Modelling of air quality impacts	20
5. ASSESSMENT CRITERIA	28
5.1 Air Quality Standards	28
5.2 AQS for human health.....	28
5.3 AQS for sensitive conservation sites.....	30
5.4 Odour benchmarks	31
6. BACKGROUND CONCENTRATIONS AND DEPOSITION FLUXES	32
6.1 Breckland District Council air quality monitoring	32
6.2 Defra modelled background	32
6.3 NH ₃ concentration at sensitive conservation sites	33
6.4 Deposition fluxes at sensitive conservation sites	34
7. IMPACT ASSESSMENT OF AIR QUALITY ON HUMAN HEALTH	35
8. IMPACT ASSESSMENT OF AIR QUALITY ON ECOLOGICAL RECEPTORS.....	37
9. IMPACT ASSESSMENT OF ODOUR.....	40
10. CONCLUSION	41
FIGURES.....	43

APPENDIX A SITE PLANS FROM PLANDESCIL	51
APPENDIX B PROCESS FLOW DIAGRAMS.....	52
APPENDIX C MODEL AND MODEL SET-UP	53
C.1 Meteorology and associated parameters.....	53
C.2 Buildings.....	54
C.3 Terrain.....	55
C.4 Receptors	55
C.5 Post-processing.....	57
APPENDIX D CHP.....	60
APPENDIX E CROP-AD PLANT FLARE	61
APPENDIX F WASTE-AD PLANT FLARE	62
APPENDIX G BOILER, INCLUDING MONITORING DATA FROM WARDLEY	63
APPENDIX H GUU, INCLUDING MONITORING DATA FROM SHEPPEY	64
APPENDIX I CENTRIAIR EXHAUST	65
APPENDIX J DIGESTATE ANALYSIS.....	66
APPENDIX K HUMAN RECEPTOR RESULTS	67
APPENDIX L ECOLOGICAL RECEPTOR RESULTS.....	76

LIST OF TABLES & FIGURES

Table 1 Sources of emissions to air to be assessed	15
Table 2 Summary of legislation, policy and guidance.....	16
Table 3 Results of the model sensitivity tests, maximum concentration of NH ₃ (µg/m ³)	22
Table 4 Crop-AD plant stack and emission parameters.....	23
Table 5 Waste-AD plant stack and emission parameters	24
Table 6 Digestate lagoon vents and tanker vents.....	25
Table 7 Vents – leachate tanks and dirty water lagoon.....	26
Table 8 Volume sources: clamps, solids feeders, separator, trailer	27
Table 9 Air Quality Standards for human health	28
Table 10 Environmental standards for protected conservation areas	30
Table 11 Nutrient nitrogen deposition critical loads	30
Table 12 Acidity deposition critical loads	31
Table 13 Annual mean background concentrations (µg/m ³).....	32
Table 14 Background NH ₃ concentrations at ecological receptors.....	33
Table 15 Background deposition fluxes	34

Table 16 Results, long-term AQS	35
Table 17 Results, short-term AQS.....	36
Table 18 Comparison of PC due to the application and former impact of the turkey shed, NH ₃ (µg/m ³).....	37
Table 19 Results at ecological receptors, long-term and short-term AQS, worst case impact	39
Table 20 Worst-case nutrient nitrogen deposition.....	39
Table 21 Worst-case acid deposition	39
Table 22 98 th percentile hour mean odour concentration (ou _E /m ³).....	40
Figure 1 Site location.....	44
Figure 2 Modelled point sources	45
Figure 3 Modelled volume sources.....	46
Figure 4 RAF Marham Windroses 2016-2020	47
Figure 5 Modelled buildings.....	48
Figure 6 Human receptors	49
Figure 7 Ecological receptors	50
Table 23 Meteorological station data and parameters	53
Table 24 ADMS 5 meteorological parameter values	54
Table 25 Meteorological site and wide Site met parameters.....	54
Table 26 Modelled buildings.....	55
Table 27 Human receptors.....	56
Table 28 Sensitive conservation sites	56
Table 29 Ecological receptors	57
Table 30 Dry deposition velocities	58
Table 31 Conversion factors for deposition of species N, S.....	59
Table 32 Conversion factors for deposition of species deposition to acid equivalent	59
Table 33 Long-term and short-term results NO ₂	67
Table 34 Long-term and short-term results, PM ₁₀	68
Table 35 Long-term results, PM _{2.5}	69
Table 36 Short-term results, 15-minute and 1-hour, SO ₂	70
Table 37 Short-term results, 24-hours, SO ₂	71
Table 38 Short-term results, CO	72
Table 39 Long-term and short-term results, NH ₃	73
Table 40 Long-term and short-term results, TVOC as 10% Benzene.....	74
Table 41 Long-term and short-term results from Biogas upgrade plant, H ₂ S	75

Table 42 Results: Ecological receptors, long-term AQS for NH ₃	76
Table 43 Results: Ecological receptors, long-term and short-term AQS for NO _x	77
Table 44 Results: Ecological receptors, long-term AQS for SO ₂	78
Table 45 Results: Ecological receptors, nutrient nitrogen deposition, nationally designated sites.	79
Table 46 Results: Ecological receptors, acid deposition, nationally designated sites	80

Abbreviations

AAD	Ambient Air Quality Directive (2008/50/EC)
AD	Anaerobic Digester
AQIA	Air Quality and Odour Impact Assessment
AQMA	Air Quality Management Area
AQS	Air quality standards
AQSR	Air Quality Standards Regulations 2010
BAT	Best Available Techniques
BLD	Boundary layer depth
CH ₄	Methane
CLe	Critical level (concentration)
CLo	Critical load (deposition)
CO ₂	Carbon dioxide
Defra	Department for the Environment, Food and Rural Affairs
EA	Environment Agency
EAL	Environmental Assessment Level
EC	European Commission
ELV	Emission limit value
EPR	Environmental Permitting Regulations
EU	European Union
EVE	Eco Verde Energy Ltd
GPU	Gas processing unit
GUU	Gas upgrading unit
H1	Environment Agency Horizontal Guidance Note H1
H ₂ S	Hydrogen sulphide
IED	Industrial Emissions Directive
LAQM	Local Air Quality Management
MCP	Medium Combustion Plant
n/a	Not applicable
N	Nitrogen
NGR	National Grid Reference
O ₂	Oxygen
PC	Process Contribution
PEC	Predicted environmental concentration
PRV	Pressure and vacuum relief valve
PST	Pre-storage tank
SAC	Special Area of Conservation
SEPA	Scottish Environment Protection Agency
SPA	Special Protection Area

SWIP	small waste incineration plant
TG	Technical Guidance
TPA	Tonnes per annum
TVOC	Total gaseous and vaporous organic substances, expressed as total organic carbon
VOC	Volatile organic compounds

1. Introduction

1.1. Background

Earthcare Technical Ltd (ETL) has been commissioned on behalf of the applicant, Eco Verde Energy Ltd (EVE), to prepare an Air Quality and Odour Impact Assessment (AQIA) to support an application for a substantial permit variation to the existing permit for Attleborough Anaerobic Digestion (AD) plant (previously referred to as Crows Hall AD plant) at Ellingham Road, Attleborough, Norfolk, NR17 1AE ('the Site'). The Site is operated by Eco Verde Energy Limited (EVE) ('the Operator') on behalf of Attleborough Eco Electric Limited. The application is also to transfer the permit holder from Attleborough Eco Electric Limited to EVE to reflect the change in operator.

The installation is permitted by the Environment Agency (EA) under the Environmental Permitting (England and Wales) Regulations 2018,¹ via a Standard Rule permit (Standard Rules 2012 No 9 – On-farm anaerobic digestion facility using farm wastes only, including use of the resultant biogas), permit reference EPR/BB3931RA.

The Site doesn't currently treat any waste feedstocks. It processes up to 30,000 tonnes per annum (TPA) of crops in the existing anaerobic digestion plant and will be referred to as the 'Crop-AD plant.' The permit variation is for some minor changes to the Crop-AD plant and for the construction of a second AD plant adjacent to the existing AD plant which will treat up to 91,000 TPA of liquid and solid waste feedstocks including food waste. This will be referred to as the 'Waste-AD plant.'

There is a 1,560kWe combined heat and power engine (CHP) which is classified as 'existing' under the Medium Combustion Plant (MCP) Directive as it came into operation prior to December 2018. It will be required to be permitted by January 2029 to comply with the permit conditions including the stipulated emission limit values by January 2030. It will provide heat and power for both AD plants.

The two AD plants will be separate in terms of feedstocks, gas and digestate. A description of the processes at each AD plant and the sources of emissions to air is given in Section 2.

Appendix A contains the site drawings: the site overview layout; site layout; and emission point plan.

1.2 Site description

The Site is located at approximate National Grid Reference (NGR) TM 03300 95600. It lies approximately 250m to the north-west of the A11 dual carriageway, immediately beyond which lies the town of Attleborough, Norfolk, as shown in Figure 1 (Site location). A tributary of the River Thet lies approximately 120m to the south of the Site.

Attleborough AD plant does not lie in or near to an Air Quality Management Area (AQMA).

The nearest property is the Crowshall Veterinary Services, 260m to the north-east of the centre of the site and 64m from the boundary. The nearest dwellings lie just beyond the Veterinary Services, 350m from the centre of the Site.

¹ The Environmental Permitting (England and Wales) (Amendment) Regulations 2018, Statutory Instrument 2018 No, 110, 29th January 2018

Swangey Fen, 2.7km to the south-west of the Site is the nearest site of Special Scientific Interest (SSSI) and is also a Special Area of Conservation (SAC); Breckland, 8.7km to the west is the nearest Special Protection Area (SPA).

Land surrounding the Site is relatively flat, land use is primarily agricultural. Field boundaries are trees or low hedges with trees.

1.3 Scope of report

This AQIA assesses the impact on human and ecological receptors of emissions to air from combustion, feedstock processing and storage on the Site. Combustion sources have been modelled at the specified Emissions Limit Values (ELVs) if ELVs exist for the sources and from monitoring data from the Site, or similar plant at other sites if there are no ELVs.

The ADMS 5 dispersion model has been used to calculate concentrations of the pollutants, from which dry deposition to sensitive conservation sites has been calculated.

While ELVs and the air quality standards for ecological receptors are specified for NO_x, standards for human health are for nitrogen dioxide (NO₂) which is emitted as a by-product of combustion and is formed (and consumed) in chemical reactions including NO_x and other species.

Predicted concentrations have been compared with relevant air quality standards (AQS) (limits, targets, objectives and assessment levels) in order to assess their significance, considering background concentration data where relevant. There are no AQS for TVOC but there is an AQS for benzene which is one of the volatile organic compounds (VOC) emitted. TVOC has been modelled as 10% benzene.²

The pollutants considered in this AQIA are, therefore:

- Oxides of nitrogen (NO_x)
- Nitrogen dioxide (NO₂)
- Sulphur dioxide (SO₂)
- Carbon monoxide (CO)
- Total Volatile Organic Compounds (TVOC)
- Benzene
- Hydrogen sulphide (H₂S)
- Ammonia (NH₃), and
- Odour.

Predicted depositions have been compared with critical loads for nutrient nitrogen deposition and acid deposition at sensitive concentration sites.

This report describes: processes on Site (Section 2); relevant legislation and guidance for industrial emissions, ambient air quality and modelling of emissions to air (Section 3); the assessment methodology used to model concentrations of pollutants and odour (Section 4); assessment criteria (Section 5); background concentrations (Section 6); and results of the dispersion modelling (Sections 7, 8 and 9) before Section 10 concludes.

² N R Passant (2002) Speciation of UK emissions of non-methane volatile organic compounds. Reference: AEAT/ENV/R/0545 Issue 1

2. Process description

2.1 Overview

ETL report ETL573/2021 ATT-OD-01³ is the Environmental Management System Manual for Attleborough AD plant. In section 5 it contains a description of the processes proposed for the Site and that detail is not repeated in this section. Here, the Crop-AD plant and Waste-AD plant are described in sections 2.2 and 2.3 respectively to the extent required to understand emissions to air of pollutants and odour. Appendix B shows the Process Flow Diagrams.

2.2 Crop-AD Process Description

The feedstocks for the Crop-AD plant are approximately 30,295 TPA of maize and rye from local farms, which are ensiled in the two CIP-based (concrete and asphalt mix) **silage clamps** and covered with impermeable material i.e. plastic. The working face of the clamp will be uncovered to enable the front loader to fill with silage which is then loaded into the solids feeders. The working face is then re-covered. The covered silage is assumed not to emit odour but a part of the working face of each clamp has been modelled as a source of odour. As a pessimistic assumption the working face has been assumed to emit odour continuously during working hours (12h/day).

Leachate from the clamps will drain to a set of four half-buried **leachate tanks**; run-off from the apron between the clamps and the feeder will drain to the **dirty water holding lagoon**, which has a capacity of 175m³ and will take overflow from the leachate tanks.

Twice a day a front loader will load silage from the clamps into the **two solids feeders**. The face of the clamp from which silage is taken will be a source of odour, and a representative location on each clamp has been used to represent the source. Similarly, the solids feeders will be a source of odour from the surface of exposed and agitated silage. It has been assumed odour will be emitted continuously from the solid feeders as a conservative assumption.

Dirty water from the covered dirty water lagoon will be added to the silage in the hoppers which will then be pumped to the two primary digesters.

The **primary digesters (DG01 and DG02)** and **secondary digester or fermenter (DG03)** each has a pressure and vacuum relief valve (PRV) to emit biogas or take in air if there is an over-pressure or under-pressure respectively. PRVs will not operate during normal operation, only as a contingency and so releases of biogas and the associated odour from the PRVs has been neglected as a source.

Whole digestate from DG03 will be pumped to a **separator buffer tank** (0.5m³ capacity) and from there to the screw press **separator**. Separated fibre digestate will fall via a covered chute into a **covered trailer** below the separator and from there it will be taken off-site to be stored in field heaps on a farm. Approximately 660 TPA is produced. The separator and covered trailer have been considered as sources of NH₃ and odour.

³ ATT-OD-01 V2 (2021) Attleborough AD, Environmental Management System Manual, Earthcare Technical Ltd, Aug 2021

Digestate liquor from the separator is pumped to the covered **Crop-AD plant digestate storage lagoon** (10,000m³ capacity). There are two vents in the cover from which biogas will be emitted and these have been considered as sources of odour and NH₃.

Tankers will be filled at a location at the south-east of the Crop-AD digestate lagoon. Filling will take about 20 minutes during which time odorous air from the empty tanker will be exhausted via a vent at the top of the tanker. Data for 2020 showed 1,158 vehicle movements during the period February to September inclusive, with the tankers removing on average 17.3m³ of liquor. Vehicle movements take place during working hours on Mondays to Fridays only. The tanker vents have been modelled as a source of NH₃ and odour emissions, assuming contact emissions equal to those that would occur during filling, through the working hours, on weekdays, between February and September.

Biogas is stored in the double-membrane storage domes above the three digesters in which desulphurisation nets and injection of low-level oxygen reduces H₂S levels. A **1,560kWe CHP** (MVM V16) burns the biogas and emits pollutants (SO₂, TVOC, NO_x and CO) from the 7m stack. Heat and power from the CHP will be used to provide heat and power to Crop-AD plant and Waste-AD plant with excess electricity exported to the national electricity grid.

A **Crop-AD plant emergency flare** will burn biogas under abnormal operating conditions such as extended maintenance or malfunction of the CHP. It can burn up to 1,000Nm³/hr of biogas which is above the maximum production capacity of 700Nm³/hr. The flare should operate for a limited number of hours per year as production of gas can be controlled by controlling the rate of feeding the digesters. It has been considered as a source of pollutants (TVOC, NO_x and CO) for its impact on short-term concentrations as operating continuously at full load; and for their impact on long-term concentrations it has been assumed, pessimistically, it will operate for 10% of the year.

2.3 Waste-AD Process Description

The Waste-AD plant will process approximately 90,950 TPA of liquid and solid waste: packaged food waste, kerbside collected food waste, liquid food waste, bakery waste and industrial waste waters.

Solid waste will be delivered by vehicle into the Reception Building where the loads are tipped onto the floor and from there is moved into one of two storage bays or directly into the pre-treatment equipment (the depackaging plant or feeder). Sludges or waste that does not require pre-treatment may be tipped directly into the mixing pit.

The depackaging plant inside the Reception Building will separate packaging from organic food wastes, the latter will then be fed into the main pre-storage tank (PST), or directly into the digesters. Packaging is put into a compactor and a skip or dolav (pallet box) inside the Reception Building for removal off-site.

Liquid waste is pumped from tankers inside the Reception Building to one of the **three small PSTs** in the bunded, secondary containment area (where the digesters are located). It is pumped from there to the main PST or directly into the digesters.

Waste in the main PST will be mixed and heated and pumped to one of the primary digesters. The main PST has a PRV; as it should only operate as a contingency it has been neglected as a source of odour.

There will be three **primary digesters (DG1 DG2 and DG3)** and a **Post fermenter (PF)**. Each digester and the fermenter will have a PRV to emit biogas or take in air if there is an over-pressure or under-pressure respectively. PRVs will not operate during normal operation, only as a contingency and so releases of biogas and the associated odour from the PRVs has been neglected as a source.

Digestate from the PF will be macerated, screen and pasteurised before being cooled and pumped to the **Waste-AD plant screw press separator** located in the Reception Building. Separated fibre will fall onto the concrete floor of the storage bay from where it will be removed to off-site. Approximately 7,913 TPA of fibre digestate is produced and 71,214 TPA of digestate liquor.

Digestate liquor from the separator is pumped to the covered **Waste-AD plant digestate storage lagoon** (10,000m³ capacity). There are twelve vents in the cover from which biogas will be emitted and these have been considered as sources of NH₃ and odour.

Tankers will be filled with liquor from the Waste-AD plant lagoon for removal off-site at a point adjacent to the lagoon. The tanker vents have been modelled as a point source of NH₃ and odour.

Biogas will be stored in the main PST, and above the digesters and PF in the double membrane gas storage domes all of which have desulphurisation nets and injection of low-level oxygen to reduce H₂S levels.

Biogas from the gas holders will pass through gas treatment (**gas processing unit, GPU**) in which it is washed, cooled and scrubber using sulphuric acid to remove NH₃. It is then compressed, passes through a carbon VOC filter and two active carbon filters to reduce H₂S levels before passing into the **Pentair gas upgrade unit (GUU)**.

Some biogas may be used in the **backup biogas boiler** to generate heat to the Crop-AD plant and Waste-AD plant when the CHP cannot provide heat. The boiler will be dual-fuelled, using red diesel during commissioning and thereafter biogas. Emissions to air of SO₂, NO_x and CO from the 10m boiler stack have been modelled for their impact on short-term concentrations operating continuously at full load; for their impact on long-term concentrations it has been assumed, pessimistically, it will operate for 10% of the year.

Biogas (60% CH₄ by volume) enters the GUU and biomethane (97% CH₄ by volume) leaves the GUU. CO₂ is vented to air with traces of CH₄, H₂S and TVOC. The **GUU CO₂ vent** has been modelled as a source of emissions to air.

After addition of an odorant and propane the biomethane will be injected into the local gas grid through the **grid entry unit (GEU)**. There are no emissions to air from the GEU.

Biogas may be burnt under abnormal operating conditions such as extended maintenance or malfunction of the GUU or biogas boiler by the **Waste-AD plant emergency flare**. Off-specification biomethane from the GEU may also be burnt in the flare but it can also be reinjected into the gas storage domes. The flare can burn 425 - 1,850Nm³/hr of biogas or 250 – 950Nm³/hr of biomethane which are above the maximum production capacities of 1,606Nm³/hr biogas and 923Nm³/hr biomethane respectively. The flare should operate for a limited number of hours per year as production of gas can be controlled by controlling the rate of feeding the digesters. It has been considered as a source of pollutants (TVOC, NO_x and CO) and their impact on short-term

concentrations operating continuously at full load; and for their impact on long-term concentrations it has been assumed, pessimistically, it will operate for 10% of the year.

An **emergency backup generator** (220kWe) will provide back-up power when the CHP is not operational and if power is not available from the grid. The generator has not been modelled as a source of emissions to air as it is anticipated to operate for a few hours per year under emergency conditions.

Surface water from the Waste-AD plant site will be held in the Surface water attenuation lagoon (936m³ capacity). It has been neglected as a source of odour.

Odour control of emission in the Reception Building

In the Reception Building waste is received, stored and handled, solid food waste depackaged, digestate separated and loaded into vehicles for removal off-site, while liquid waste is pumped to the PSTs and digestate liquor pumped to the storage lagoon. Odour emissions from the building are controlled using a Centriair air handling and odour abatement system and fast-acting roller shutters on the doors.

The odour abatement system will consist of two units: one main unit outside the building and one secondary 'DEO' catalyst unit, which is also supplemented by a sulphured™ (iron pellet) filter, installed inside the building. The DEO unit is designed for higher loadings of odours and is located in the Reception Building close to the most odorous sources: the mixing pit, screw separator and off-taking station. It exhausts via the main system combined exhaust (14m high on the south-west side of the building). The **Centriair odour abatement stack** has been modelled as a source of NH₃, H₂S, PM₁₀, PM_{2.5} and odour.

Louvres will be installed in the external wall of the reception hall for intake of ambient air which will create a slight negative pressure inside the reception hall at all times.

The combination of fast-acting roller doors, constant negative pressure and an odour abatement system will minimize fugitive odour emissions and fugitive emissions have been assumed to be negligible.

2.4 Summary of emissions to air

Table 1 lists the sources of emissions to air that have been considered in this impact assessment.

Table 1 Sources of emissions to air to be assessed

AD	Source	Emissions	Operation profile
Crop	Working face of the two clamps	Odour	Maximum working hours exposed, 12h/day
Crop	Two solids feeders	Odour	Continuous
Crop	Covered trailer	Odour, NH ₃	Continuous
Crop	Separator	Odour, NH ₃	Continuous
Crop	Digestate storage lagoon – two vents	Odour, NH ₃	Continuous
Crop	Tanker vent	Odour, NH ₃	06:00-22:00; 5 days/week; Feb-Sep
Crop	CHP	NOx, SO ₂ , TVOC, CO	Continuous
Crop	Crop-AD emergency flare	NOx, TVOC, CO	Emergency back-up ¹
Crop	4x leachate tanks each with a vent	Odour, NH ₃	Continuous
Crop	Dirty Water Lagoon	Odour, NH ₃	Continuous
Waste	Digestate storage lagoon – 12 vents	Odour, NH ₃	Continuous
Waste	Tanker vent	Odour, NH ₃	06:00-22:00; 5 days/week; all year
Waste	Back-up boiler	NOx, TVOC, CO	Emergency back-up ¹
Waste	Gas upgrading unit (GUU)	CO ₂ , TVOC, H ₂ S	Continuous
Waste	Centair odour abatement stack	NH ₃ , H ₂ S, PM ₁₀ , PM _{2.5} , Odour	Continuous
Waste	Waste-AD Flare	NOx, TVOC, CO	Emergency back-up ¹

Notes: ¹modelled as continuous operation at full load for comparison with short-term AQS; assumed to operate for 10% of the year for comparison with long-term AQS.

3. Legislation and guidance

3.1. Overview

This section describes the relevant legislation, policy and guidance relevant to this assessment which is summarised in Table 2 and described further in Sections 3.2 to 3.3. Section 4 summarises the air quality limit values, objectives and Environmental Assessment Levels.

Table 2 Summary of legislation, policy and guidance

Short name	Name	Body	Scope
Legislation			
1995 Act	Environment Act 1995 ⁴	UK Parliament	Establishes the framework for managing air quality to achieve compliance with air quality objectives
4 th Daughter Directive	Directive 2004/107/EC ⁵	European Commission, now EU	Sets limit values for arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air
AAD	Ambient Air Quality Directive 2008/50/EC ⁶	EU	Ambient air quality, sets limit and target values
IED	Industrial Emissions Directive, 2010/75/EU ⁷	EU	Industrial emissions
MCPD	Medium Combustion Plant Directive, EU/2015/2193 ⁸	EU	Emission limit values for pollutants from combustion plant greater than 1MWthi and less than 50MWthi
AQSR	Air Quality (Standards) Regulations 2010 ⁹ as amended in 2016 ¹⁰	UK Parliament	Ambient air quality, standards for pollutant concentrations. Transposed EU limit values defined in AAD into law in England and Wales
EPR	Environmental Permitting Regulations 2018 ¹	UK Parliament	Industrial emissions. Transposed IED into law in England and Wales
Guidance			
Defra permit guidance	Air emissions risk assessment for your environmental permit ¹¹	Department for Environment, Food & Rural Affairs and	How to undertake an air quality assessment for a permit

⁴ Environment Act 1995, 1995 Chapter 25, Part IV Air Quality

⁵ DIRECTIVE 2004/107/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL, of 15 December 2004, relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air

⁶ DIRECTIVE 2008/50/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 May 2008 on ambient air quality and cleaner air for Europe comment on amendment

⁷ DIRECTIVE 2010/75/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 24 November 2010 on industrial emissions (integrated pollution prevention and control)

⁸ DIRECTIVE (EU) 2015/2193 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 November 2015 on the limitation of emissions of certain pollutants into the air from medium combustion plants

⁹ Statutory Instrument: 2010 No. 1001, ENVIRONMENTAL PROTECTION, The Air Quality (Standards) Regulations 2010 comment on amendment

¹⁰ The Air Quality Standards (Amendment) Regulations 2016, Statutory Instrument 2016 No. 1184, Made 6th December 2016

Short name	Name	Body	Scope
		Environment Agency	
EA AD Technical Guidance	How to comply with your environmental permit. Additional guidance for: Anaerobic Digestion ¹²	Environment Agency	Sets out indicative Best Available Technique (BAT) or appropriate measures for the AD of organic materials
Waste Treatment BREF	BAT Reference Document Waste Treatment ¹³	European IPPC Bureau,	Indicative BAT for waste treatment including Associated Emission Levels
EA H4	Technical Guidance Note H4 – Odour Management ¹⁴	Environment Agency	Guidance on assessing odour impact, includes benchmark values
Defra SWIP	Specified generators: dispersion modelling assessment ¹⁵	Environment Agency and Natural Resources Wales	Includes reference for conversion of NO _x to NO ₂
AQTAG06	AQTAG06 Technical guidance on detailed modelling approach for an appropriate assessment for emissions to air ¹⁶	Air Quality Advisory Group	Guidance on calculating deposition
LAQM.TG16	Local Air Quality Management, Technical Guidance (TG16) ¹⁷	Department for Environment, Food & Rural Affairs and the Devolved Authorities	Includes general guidance on dispersion modelling

3.2. Legislation

Environment Act

The Environment Act, which established the Environment Agency for England and Wales with functions including the control of pollution. Part IV of the Environment Act 1995 establishes the framework for managing air quality to achieve compliance with air quality objectives and for local air quality management (LAQM). Under LAQM local authorities (district councils) are required to monitor, review, assess and improve air quality in their areas; if exceedances are monitored or predicted, they must consider establishing an AQMA. Part IV requires the Secretary of State to prepare a National Air Quality Strategy.

¹¹ Department for Environment, Food & Rural Affairs and Environment Agency, Air emissions risk assessment for your environmental permit <https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit> (accessed 9/9/2020)

¹² Environment Agency (2013) How to comply with your environmental permit. Additional guidance for: Anaerobic Digestion. AD Technical Guidance Note November 2013 Version 1.0.

¹³ Best Available Techniques (BAT) Reference Document for Waste Treatment, European IPPC Bureau, 2018

¹⁴ Environment Agency (March 2011) Technical Guidance Note H4 - Odour Management. How to comply with your environmental permit

¹⁵ Environment Agency and Natural Resources Wales, Specified generators: dispersion modelling assessment <https://www.gov.uk/guidance/specified-generators-dispersion-modelling-assessment#nosubxsub-to-nosub2sub-conversion-ratios-to-use> (accessed 9/9/2020)

¹⁶ Air Quality Advisory Group, 2014, AQTAG06 Technical guidance on detailed modelling approach for an appropriate assessment for emissions to air

¹⁷ Department for Environment, Food & Rural Affairs and the Devolved Authorities, Local Air Quality Management Technical Guidance (TG16), February 2018

Ambient Air Quality Directive and 4th Daughter Directive

The Ambient Air Quality Directive and 4th Daughter Directive contain **Limit Values** and **Target Values** with which the UK must comply. The Ambient Air Quality Directive also addresses: common methods and criteria; information on ambient air quality to help combat air pollution and nuisance, to monitor long-term trends; and making information and pollution alerts available to the public.

Air Quality Standards Regulations

The Air Quality (Standards) Regulations 2010 is the instrument by which the Ambient Air Quality Directive and the 4th Daughter Directive were transposed into English law.

Industrial Emissions Directive

The IED is the main EU instrument by which pollutant emissions from industrial installations are regulated. It consolidated seven earlier directives including, in particular, the Integrated Pollution Prevention and Control Directive and the Waste Incineration Directive. It defines emissions limit values (ELVs) for some process-fuel combinations but there are no ELVs relevant to the Biogas upgrading stack.

Environmental Permitting Regulations

The Environmental Permitting (England and Wales) (Amendment) Regulations 2018 is the latest consolidated version of instrument by which the IED was transposed into national legislation.

3.3. Guidance

Air emissions risk assessment for your environmental permit

The webpage provides Department for Environment, Food & Rural Affairs and Environment Agency guidance on how to carry an air emissions risk assessment. It replaced the Environment Agency, H1 Annex F – Air Emissions.¹⁸ It includes guidance on the ecological receptors to be assessed, tests on significance on results, relevant air quality Limit Values (from the Ambient Air Directory), objectives from the National Air Quality Strategy and it lists short-term (hourly) and long-term (annual mean) **Environmental Assessment Levels (EALs)** for human health.

Additional guidance for Anaerobic Digestion

The guidance sets out indicative Best Available Technique (BAT) or appropriate measures for the AD of organic materials and provides practical guidance on how and why odour emissions occur, as well as measures that can be employed to prevent or minimise release of emissions to air including odour.

BAT Reference Document Waste Treatment

This document is a reference document on indicative Best Available Techniques (BAT) for the waste treatment sector. This includes BAT for the anaerobic treatment of waste, the associated emission

¹⁸ Environment Agency, H1 Annex F – Air Emissions – now withdrawn. Version 2.2, December 2011

levels (and other environmental performance levels) and the associated monitoring for this sector according to Article 3(10) of, and Annex III to, the Directive 2010/75/EU.⁷Error! Bookmark not defined.

Technical Guidance Note H4 – Odour Management

The guidance from EA is intended for permit holders and applicants, to advise them on how to comply with odour conditions set by the permit. It covers: assessing odour pollution; measures to reduce pollution; control measures; and monitoring. It contains advice on odour thresholds or benchmarks for assessment.

Specified generators: dispersion modelling assessment

The webpage provides Defra and Environment Agency guidance on how to do detailed air quality modelling for specified generators. This includes the use environmental standards for air, the use of NO_x to NO₂ conversion ratios, and guidance on impact assessment.

Local Air Quality Management, Technical Guidance

This technical guidance (LAQM.TG16) is published to support local authorities in carrying out their duties under the Environment Act 1995, which established the LAQM process. It provides guidance on monitoring and assessing air quality, action planning and reporting. While aimed at local authorities the advice is used more widely by those working in the field, and not just for LAQM.

4. Assessment Methodology

4.1 Introduction

The methodology comprised three parts which are described in more detail in Sections 4 to 6:

1. Baseline conditions assessment at the Site and the surrounding area:
 - AQMAs and designated conservation areas; background concentration and deposition.
2. Modelling of impacts:
 - assessment of the likely changes in concentration and deposition due emissions from the sources listed in Table 1 and operation of the plant under normal operating conditions. The assessment was undertaken using the ADMS 5 dispersion model (section 4.2).
 - The modelling assessment included an assessment of the sensitivity of model results and hence, the impacts, to changes in model input.
 - Modelling of odour impacts due to odour emissions from the sources listed in Table 1.
3. Assessment of significance. Sections 5.2, 5.3 and 5.4 describe this.

If the impacts are significant then further investigation would be required.

4.2 Modelling of air quality impacts

Model

The dispersion model used to predict ambient concentrations due to the stack emissions was ADMS 5 (version 5.2.2.0). The model is termed a 'new generation' model and is commonly used in the UK for industrial permit applications to the Environment Agency.

It requires as input: data on the source of emissions and the mass emission rates of each pollutant (Table 4 to Table 8), meteorological data and associated parameters, buildings data, terrain data, and receptor locations. Full details of the meteorological, buildings and receptor data are described in Appendix C.

The outputs calculated by the model are the air concentrations of pollutants from the sources modelled for the relevant averaging times and statistics. The contribution from the modelled sources on the Site to air concentration and to deposition rate are referred to the Process Contribution (PC), which is then compared with the relevant AQS. When background concentration or deposition rate are added to the PC, the totals are referred to as Predicted Environmental Concentration (PEC) and Predicted Environmental Deposition Rate (PEDR) respectively, which are also compared with the relevant AQS.

From air concentration of NO₂ and NH₃ the deposition rate of nitrogen can be calculated and the acid deposition due to nitrogen; from the air concentration of SO₂ the contribution of sulphur to acid deposition.

Model options and scenarios

Two main emission scenarios have been modelled. The scenario for the calculation of short-term impacts assumed the continuous operation all year of all sources, at the maximum possible load if relevant. This is a pessimistic approach as it means the sources which do not operate continuously have been modelled coinciding with worst case meteorological data. Moreover, the flares and back-up boiler are unlikely to be operated simultaneously with the CHP engine, so this represents further a pessimistic assumption. For calculation of long-term impacts, the contribution of the flares and back-up boiler were modelled at 10% of the maximum output, to represent a pessimistic assumption that they would be operated for 10% of the year.

For sources which will have emission limit values (ELVs) set in the permit, emissions have been modelled at the ELVs. In the absence of ELVs monitoring data from comparable plant at other sites or manufacturer specified values have been used. Assuming the continuous operation of these sources provides a pessimistic prediction of impacts as no account has been taken of planned outages for maintenance.

The model was run for each of the five years of meteorological data (2016-2020) for two combinations of model option scenarios:

- Flat terrain: no buildings and no terrain (hills)
- Flat terrain: with buildings and no terrain (hills)

Results at the receptors were calculated as the maximum value at each receptor from these 10 model runs and are therefore worst-case values across all five years and considering flat terrain or buildings.

The effect of terrain was not modelled as the terrain gradients in the modelled domain are well below the 1:10 threshold usually applied.

Model options and sensitivity

The impact of buildings, meteorological data year and choice of surface roughness value at the dispersion site (z0d) and at the meteorological data site (z0m) were assessed and the results are shown in Table 3. It shows the maximum predicted at a human and at an ecological receptor due to the annual mean concentration and the maximum hourly concentration. NH₃ has been used as a pollutant with both long-term and short-term AQS (for human receptors) for the sensitivity assessment.

Table 3 Results of the model sensitivity tests, maximum concentration of NH₃ (µg/m³)

Buildings/Flat terrain	Year	z0d	z0m	Human receptors		Ecological receptors*
				Annual mean (µg/m ³)	Maximum hourly (µg/m ³)	Annual mean (µg/m ³)
Buildings	2016	0.2	0.1	18.1	270.8	0.070
Flat terrain	2016	0.1	0.1	18.4	275.9	0.071
Flat terrain	2016	0.3	0.2	16.7	264.7	0.065
Flat terrain	2016	0.2	0.1	18.1	270.8	0.071
Flat terrain	2017	0.2	0.1	17.6	270.8	0.041
Flat terrain	2018	0.2	0.1	15.2	270.8	0.060
Flat terrain	2019	0.2	0.1	17.3	270.8	0.061
Flat terrain	2020	0.2	0.1	16.2	270.8	0.052

Notes: *nationally designated sites, receptors E1-E9

The variation in maximum annual mean concentrations according to the yearly meteorological data (18% at human receptors, 73% for ecological receptors) was greater than the variation between buildings and flat terrain, or changing the surface roughness values. Modelling buildings did not have a significant effect. The variation in maximum hourly concentration at the human receptors is 4%.

The modelling has been carried out using z0d=0.2m and z0m=0.1m as these values gave the highest concentration.

Sources and emissions

The source geometry, parameters, ELVs, design emission limits and calculated emissions are given in Table 4 for point sources (CHP, Crop-AD plant flare, Waste-AD plant flare), Table 5 for point sources (Back-up boiler, GUU, Centriair odour abatement exhaust stack).

Table 6 and Table 7 detail the emission parameters for the lagoon and tanker vents.-The emission rates for non-point sources (Working face of the clamps, solid feeders, fibre digestate trailer) are included in Table 8. The source locations are shown in Figure 2 and Figure 3.

Monitoring data for the CHP show that SO₂ emissions are well below the ELV for existing engines of 162mg/Nm³ that is to be met by the end of 2029 and therefore that ELV has been used in the modelling.

Monitoring reports and manufacturer data sheets used are in Appendix D to Appendix I.

The Waste-AD plant flare is dual-fuelled, it can use biogas or biomethane. Modelling has used emission parameters based on the maximum volume in of biogas as the most pessimistic scenario as it is the scenario with the highest mass emission rate of pollutants.

Table 4 Crop-AD plant stack and emission parameters

Parameter	Units	CHP ¹	Crop-AD plant flare ²	Waste-AD plant flare ³
Location	NGR (X,Y) m	603277, 295623	603393, 295585	603292, 295601
Stack height	m	7	5.6	7.67
Internal diameter at stack exit	m	0.58	1.3	2.5
Volume flow rate (dry)	Nm ³ /s	1.38	4.46	3.81
Volume flow rate (wet)	Am ³ /s	2.96	23	43.6
Velocity	m/s	11.2	17.3	8.9
Temperature	°C	180	700	1,000
Exit concentration SO ₂	mg/Nm ³	162 (ELV, 5% O ₂)	-	-
Exit concentration TVOC	mg/Nm ³	1,000 (ELV, 5% O ₂)	10 (3% O ₂)	10 (3% O ₂)
Exit concentration NO _x	mg/Nm ³	500 (ELV, 5% O ₂)	150 (3% O ₂)	150 (3% O ₂)
Exit concentration CO	mg/Nm ³	1,400 (ELV, 5% O ₂)	50 (3% O ₂)	50 (3% O ₂)
Emission rate SO ₂	g/s	0.223	-	-
Emission rate TVOC	g/s	1.379	0.045	0.038
Emission rate NO _x	g/s	0.690	0.670	0.571
Emission rate CO	g/s	1.931	0.223	0.190
Notes: ¹ CHP, MVM V16, 1,560kWe, fuelled by biogas (Appendix D). ELVs are the MCP Directive values for new plant (Annex II, Part 2, Table 2), which the CHP meets currently. Mass flow rate of wet exhaust was taken from the manufacturer's datasheet. ² Crop-AD plant flare data, VAR Close Stationary Torch Installation (Appendix E). ELVs are assumed to be the same as those of the Waste-AD plant flare. Biogas capacity and exhaust volume flow rate were supplied by HOST Bio-energy Installations. ³ Waste-AD plant flare, Uniflare UF10-1850 High Temperature Enclosed Flare Stack (Appendix F). Data on ELVs, temperature and volume flow rate were supplied by the manufacturer, Uniflare. Height and diameter supplied by BioConstruct				

The back-up boiler is dual-fuelled, able to use red diesel or biogas. It will only use red diesel during the commissioning phase and therefore the modelling has used emission parameters based on use of biogas.

There are no ELVs for the GUU CO₂ vent stack. Emission rates have been calculated from monitoring data at a comparable AD facility.

Table 5 Waste-AD plant stack and emission parameters

Parameter	Units	Boiler ¹	GUU CO ₂ vent ²	Centriair odour abatement stack ³
Location	NGR (X,Y) m	603321, 295588	603314, 295580	603333, 295561
Stack height	m	10	10.7	14
Internal diameter at stack exit	m	0.4	0.25	1.2
Volume flow rate (dry)	Nm ³ /s	0.142	0.160	15.22
Volume flow rate (wet)	Am ³ /s	0.283	0.183	16.48
Velocity	m/s	2.3	3.7	14.6
Temperature	°C	154	38	10-35, modelled as 'Ambient'
Exit concentration SO ₂	mg/Nm ³	100 (ELV, 3% O ₂)	-	-
Exit concentration TVOC	mg/Nm ³	-	2,054 (wet, stack O ₂)	-
Exit concentration NO _x	mg/Nm ³	200 (ELV, 3% O ₂)	-	-
Exit concentration CO	mg/Nm ³	4.4 (Monitored, 3% O ₂)	-	-
Exit concentration H ₂ S	mg/Nm ³	-	1.99 (wet, stack O ₂)	0.140 (0.1 ppm)
Exit concentration NH ₃	mg/Nm ³	-	--	1.402 (2 ppm)
Exit concentration PM ₁₀	mg/Nm ³	-	-	5
Exit concentration PM _{2.5}	mg/Nm ³	-	-	5
Exit concentration Odour	mg/Nm ³	-	-	1,000
Emission rate SO ₂	g/s	0.014	-	-
Emission rate TVOC	g/s	-	0.329	-
Emission rate NO _x	g/s	0.028	-	-
Emission rate CO	g/s	0.001	-	-
Emission rate H ₂ S	g/s	-	0.0003	0.002
Emission rate NH ₃	g/s	-	-	0.021
Emission rate PM ₁₀	g/s	-	-	0.076
Emission rate PM _{2.5}	g/s	-	-	0.076
Emission rate Odour	ouE/s	-	-	15,221
Notes: ¹ Boiler, 560kW, Veissmann Vitoplex 200, Weishaupt Burner WM - G(L)10/3-A, Dual fuel: biogas/red diesel (Appendix G) ELVs for SO ₂ and NO _x are the MCP Directive values for new plant (Annex II, Part 2, Table 1). CO exit concentration and volume flow rate were taken from monitoring data from the same boiler and burner at Wardley Biogas AD Facility, West Bolton (16 November 2020). ² GUU, Pentair Biogas Upgrading Facility for 1,500Nm ³ /h and SE Solution (Appendix H). Manufacturer's datasheet from Pentair. Calculation sheet from BioConstruct. Emission concentrations from monitoring undertaken at a similar plant at Sheppey Energy Ltd, Sheerness (19 May 2021). ³ CentriAir odour abatement system and Deo system (Appendix I). Data on exit concentrations, flow rate and temperature from Centriair data sheet.				

All the lagoon vents are of the 'top-hat' style which will reduce the emission velocity, however, the calculated velocities are relatively low and therefore they have not been further reduced. There are 12 vents on the Waste-AD plant lagoon and two vents on the Crop-AD plant lagoon.

Digestate liquor in the two lagoons will generate biogas due to the anaerobic biochemical conversion of any residual organic matter. An analysis of the digestate liquor from the Crop-AD plant (Appendix J) shows 4% dry matter (DM). The rate of biogas production has been calculated by

applying the PAS110 maximum permitted rate of 0.45 litres biogas/g DM. It has been assumed that the flow rate from the vents is due to the biogas generated.

The NH₃ emission rate has been calculated using the value from SCAIL for pig slurry in a lagoon with a floating cover as a surrogate. Pig slurry is often used as a surrogate for crop-based digestate as the dry matter (DM), Total Kjeldahl Nitrogen (TKN) and Total Ammoniacal Nitrogen (TAN) of pig slurry (4%, 3.6% and 2.5% respectively)¹⁹ are similar to the values arising from crop-based digestate analysis.

The same odour concentration and NH₃ emission rate as used for the lagoon vents has been used to calculate emissions from the vent at the top of the tankers that remove liquid digestate from the lagoons to off-site. Data from 2019 showed a total of 1,158 tanker movements, with an average capacity removed of 17.3m³. A filling time of 20 minutes has been assumed during which time the air in the tanker would vent. It has been assumed that the odour concentration in the tanker is 10,000 ou_E/m³ and the NH₃ emission rate has been assumed to be that of the digestate lagoons. A time varying file has been used so that the tanker vents emit only during the hours/days of the week/months when vehicles are permitted.

Table 6 Digestate lagoon vents and tanker vents

Parameter	Units	Crop-AD plant lagoon	Waste-AD plant lagoon	Tanker vent
Number of vents exhausting to air	-	2	12	1 per tanker
Lagoon/tanker surface area (emitting area)	m ²	2,706	3,955	15
Location of vent(s)	NGR (X,Y) m	See Figure 2	See Figure 2	See Figure 2
Vent release height	m	3.5	0	3
Internal diameter at stack exit	m	0.45	0.10	0.15
Volume flow rate	Am ³ /s	0.004 (biogas, per vent) ¹	0.002 (biogas, total) ¹	0.014 ⁴
Velocity	m/s	0.02 (per vent)	0.28	0.8
Temperature	°C	Modelled as 'Ambient'	Modelled as 'Ambient'	Modelled as 'Ambient'
Area emission rate NH ₃	g/m ² /h	0.16 ³	0.16 ³	0.16 ³
Exit concentration Odour	ou _E /m ³	10,000 ²	10,000 ²	10,000 ²
Emission rate NH ₃	g/s	0.024 (per vent)	0.006 (per vent)	2.94x10 ⁻⁵ ⁵
Emission rate Odour	ou _E /s	39.4 (per vent)	22.2 (per vent)	144.4 ⁵
Notes: ¹ Biogas emission rate calculated assuming 4% DM (Digestate analysis, Appendix J) and the PAS110 Annex A, maximum allowed rated of biogas generation: ² Value taken from: Smith S. (2017) A Dispersion Modelling Study of the Impact of Odour from the Proposed Biofertilizer Storage Lagoon at land west of Hangman Stone Lane, near High Melton in South Yorkshire, AS Modelling & Data Ltd, 19 September 2017 ³ SCAIL, pig slurry lagoon with capacity 10,000m ³ and a floating cover ⁴ Calculated from the tanker volume of 17.3m ³ and a filling time of 20 minutes				

¹⁹ ADAS, MANNER-NPK Available at: <http://www.planet4farmers.co.uk/Manner.aspx> [Accessed 12 August 2021]

⁵Emission rate during filling. The total ou_E/yr and NH₃ g/yr have been kept constant and assumed to be even spread across the hours when emissions can occur:

- Crop-AD Tanker: 16 h/day, 5 days/week, 8 months/yr, giving emission rates of 18.8ou_E/s and 3.82x10⁻⁶ g/s of NH₃
- Waste-AD Tanker: 16 h/day, 5 days/week, 12 months/yr, giving emission rates of 13.4ou_E/s and 2.72x10⁻⁶ g/s of NH₃

Silage effluent will be held in four, 5.8m³ tanks, each with a vent to air, that will be half-buried adjacent to the dirty water lagoon. The effluent may over-run into the dirty water lagoon which will be covered. The contents of the dirty water lagoon will be pumped back into the process.

Emission from the leachate tank vents and dirty water lagoon vent have been modelled as point source emissions with no plume rise, with odour and NH₃ emitted from the maximum possible surface within the tank (if the tank were half full). This is a pessimistic assumption. While silage effluent is not the same as digestate, in the absence of other values for comparison, an emission rate has been calculated using pig slurry as a precautionary surrogate. Emissions from the dirty water lagoon have, similarly, used pig slurry as a surrogate, assuming a lagoon with a rigid cover and a 50% dilution (reduction in emission) as the lagoon's primary purpose is to hold dirty water.

Table 7 Vents – leachate tanks and dirty water lagoon

Parameter	Units	Leachate tank (each tank)	Dirty water lagoon
Number of vents exhausting to air	-	1	1
Maximum surface area (emitting area)	m ²	6.2 ¹	100 ²
Vent release height	m	0.76	0.5
Internal diameter at stack exit	m	0.11	0.1
Volume flow rate	Am ³ /h	0 (no plume rise)	0 (no plume rise)
Velocity	m/s	0 (no plume rise)	0 (no plume rise)
Temperature	°C	Modelled as 'Ambient'	Modelled as 'Ambient'
Area emission rate NH ₃	kg/m ² /yr	0.84 ³	0.28 ⁴
Exit concentration Odour	ou _E /m ² /yr	63,072 ³	63,072 ⁵
Emission rate NH ₃	g/s	0.0002	0.00044 ⁶
Emission rate Odour	Ou _E /s	0.0124	0.1 ⁶
Notes: ¹ Estimated based on a length of 4.3m and diameter of 1.45m ² Estimated based on a capacity of 175m ³ and depth of 2m ³ Value taken from: Smith S. (2017) A Dispersion Modelling Study of the Impact of Odour from the Proposed Biofertilizer Storage Lagoon at land west of Hangman Stone Lane, near High Melton in South Yorkshire, AS Modelling & Data Ltd, 19 September 2017 ⁴ SCAIL value for emissions from a lagoon with floating cover ⁵ SCAIL value for emissions from a lagoon with rigid cover (same as for floating cover) ⁶ Emission rate reduced by 50% to account for dilution with surface water run-off			

The working face of the clamp will be uncovered to enable the loader to remove silage which is then transferred to the solids feeders. The working face will then be recovered. It has been assumed it

will potentially be uncovered for 12h per day, which is a pessimistic assumption. A time varying file has been used so that the working face of the clamps is modelled as an emission source for 12h/day.

The solids feeders are filled twice a day but they have been assumed to emit odour continuously as some silage may remain in feeders even when they are not operating. Similarly, the screw press separator and trailer have been assumed to emit odour and NH₃ continuously.

The separator has been modelled as an elevated volume source and the trailer has been modelled as a volume source. Emission rates of odour and NH₃ from the trailer have been halved as the trailer will be covered.

Table 8 Volume sources: clamps, solids feeders, separator, trailer

Parameter	Units	Working face of each clamp	Solids feeders (per feeder)	Separator	Trailer
Depth, width, length	Each in m	3, 7.5, 2 (each clamp)	0.5, 9.8, 2.9 ²	1, 2, 1	0.5, 7.5, 2.5
Emitting surface area	m ²	22.5	14.2	2	18.75
Emission mid-height	m	1.5	4	5	2.5
Area emission rate NH ₃	µg/m ² /s	n/a	n/a	24.0 ³	12.0 ^{3,5}
Exit concentration Odour	ou _E /m ² /s	50 ¹	50 ¹	2.8 ⁴	1.4 ^{4,5}
Emission rate NH ₃	g/m ³ /s	n/a	n/a	1.2x10 ⁻⁵	2.4x10 ⁻⁵
Emission rate Odour	ou _E /m ³ /s	25	100	2.8	2.8
Notes: ¹ Odour Impact Assessment for a proposed Crop CHP Plant at Stoke Bardolph, Nottinghamshire, Odournet UK Ltd. Value of 20ou _E /m ² /s undisturbed, increased to 50ou _E /m ² /s for disturbed ² Data sheet for 20 tonne feeder, Biogastechnik Süd, EBT-FA-AM, Feeding system 40 - 76 m ³ ³ Bell, M. W., Tang, Y. S., Dragosits, U., Flechard, C. R., Ward, P. and Braban, C. F. 92016) Ammonia emissions from an anaerobic digestion plant estimated using atmospheric measurements and dispersion modelling, Waste Management 56 (2016) pp113-124, value for NH ₃ emissions from the digestate store ⁴ Value taken from: Smith S. (2017) A Dispersion Modelling Study of the Impact of Odour from the Proposed Biofertilizer Storage Lagoon at land west of Hangman Stone Lane, near High Melton in South Yorkshire, AS Modelling & Data Ltd, 19 September 2017 ⁵ Emission rate reduced by 50% as the trailer is covered					

5. Assessment criteria

5.1 Air Quality Standards

European and national legislation, policy and guidance, as described in Section 3.2 to Section 3.3, set various limit values, target values, objectives and environmental assessment levels (EALs) that may apply to human or ecological receptors. These will be collectively referred to throughout this report as air quality standards (AQS).

The AQS are defined with respect to an averaging time and a statistic. Annual mean AQS are an example of a long-term AQS, which is defined over a long period of time as the effects of the pollutant on human health or the environment are chronic, that is, due to long-term exposure. Pollutants may also have acute impacts, that is, the effects become apparent after short period of exposure to high values. For these pollutants short-term AQS are defined, for instance the 1-hour limits for benzene and H₂S are maximum hourly average that must not be exceeded.

5.2 AQS for human health

Table 9 sets out the AQS for human health for the pollutants relevant to this assessment. The standards which apply at human receptor locations apply where people will be exposed to a pollutant for a period relevant to the standard such as at residential locations, hospitals and schools for annual mean values.

Emissions are specified for TVOC for which there are no AQS. There is an AQS for benzene, one component of TVOC. An AEA Technology report on the Speciation of UK emissions of non-methane volatile organic compounds (2002)² reported on a series of VOC species profiles available for stationary combustion sources, covering a range of both fuel types and scale of combustion. The benzene fraction in industrial and commercial combustion of natural gas was reported to be less than 10%, therefore the TVOC concentrations at receptors has been modelled as 10% benzene.

Table 9 Air Quality Standards for human health

Substance	Emission period	Limit (average)	Standard	Exceedances ¹
Ammonia	1 hour	2,500µg/m ³	EAL	None
Ammonia	Annual	180µg/m ³	EAL	None
Benzene	1 hour	195µg/m ³	EAL	None
Benzene	Annual	5µg/m ³	AAD Limit Value and AQS Objective	None
Carbon monoxide	8 hour running average across a 24-hour period	10,000µg/m ³	AAD Limit Value	None
Hydrogen sulphide	1 hour	150µg/m ³	EAL	None
Hydrogen sulphide	Annual	140µg/m ³	EAL	None
Nitrogen dioxide	1 hour	200µg/m ³	AAD Limit Value	Up to 18 1-hour periods

Substance	Emission period	Limit (average)	Standard	Exceedances ¹
Nitrogen dioxide	Annual	40µg/m ³	AAD Limit Value	None
Particulates (PM ₁₀)	24 hour	50µg/m ³	AAD Limit Value	Up to 35 times a year
Particulates (PM ₁₀)	Annual	40µg/m ³	AAD Limit Value	None
Particulates (PM _{2.5})	Annual	25µg/m ³	AAD Limit Value	None
Sulphur dioxide	15 minutes	266µg/m ³	UK AQS Objective	Up to 35 15-minute periods
Sulphur dioxide	1 hour	350µg/m ³	AAD Limit Value	Up to 24 1-hour periods
Sulphur dioxide	24 hour	125µg/m ³	AAD Limit Value	Up to 3 24-hour periods

Notes: from <https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit>

¹number of times a year that you can exceed the limit

Significance of results

The Defra permit guidance addresses when impacts can be considered insignificant. The guidance considers initial screening and then detailed modelling.

At the initial screening stage, a PC can be screened out from further assessment if:

- the short-term PC is less than 10% of the short-term environmental standard, and
- the long-term PC is less than 1% of the long-term environmental standard

The second stage of screening considers the background concentration as well as the PC. The Predicted Environmental Concentration (PEC) is the sum of the PC and background concentration. A further assessment is not needed if:

- the short-term PC is less than 20% of the short-term environmental standards minus twice the long-term background concentration, and
- the long-term PEC is less than 70% of the long-term environmental standards

If the PC cannot be screened out on that basis, following detailed modelling, two tests are applied:

- the proposed emissions must comply with BAT associated emission levels (AELs) or the equivalent requirements where there is no BAT AEL
- the resulting PECs will not exceed environmental standards

If those tests are not satisfied it is necessary to consider whether: the PCs could cause the PEC to exceed an AQS; the PEC already exceeds an AQS; or the activity on site is not covered by a BAT reference document. Ultimately a cost-benefit analysis may be required.

5.3 AQS for sensitive conservation sites

Table 10 sets out the AQS for the pollutants relevant to this assessment for designated ecological site receptors. The AQS for which there are numerical values in Table 10 are critical levels as they are values for concentrations of pollutants in air.

Lichens and bryophytes are not present at Breckland SPA and therefore the higher AQS for NH₃, 3µg/m³, applies at that site; the lower threshold applies at all other sites.

The critical loads (CL) for deposition of nutrient nitrogen and acid deposition vary spatially and with habitat. Values of the critical loads for the most sensitive species/habitat are given in Table 11 and Table 12.

Table 10 Environmental standards for protected conservation areas

Substance	Target	Emission period
Ammonia	1µg/m ³ where lichens or bryophytes (including mosses, landworts and hornworts) are present 3µg/m ³ where they are not present	Annual
Sulphur dioxide ¹	10µg/m ³ where lichens or bryophytes are present 20µg/m ³ where they are not present	Annual
Nitrogen oxide (expressed as nitrogen dioxide) ²	30µg/m ³	Annual
Nitrogen oxide (expressed as nitrogen dioxide)	75µg/m ³	Daily
Nutrient nitrogen deposition	Depends on location, use www.apis.ac.uk ²⁰ to check it, see Table 11	Annual
Acidity deposition	Depends on location, use www.apis.ac.uk to check it, see Table 12	Annual

Notes: from <https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit>

¹20µg/m³ is an AAD Limit Value if you have nature or conservation sites in the area;

²30µg/m³ is an AAD Limit Value

Table 11 Nutrient nitrogen deposition critical loads

Site	Most sensitive habitat	Critical load (kgN/ha/yr)
Swangey Fen (SSSI, SAC)	Broadleaved, mixed and yew woodland	10-20
Norfolk Valley Fen (SAC)	Northern wet heath	10-20
Breckland (SPA)	Caprimulgus europaeus: Coniferous woodland	5-15
Attleborough Wood (AW, CWS)	Broadleaved, mixed and yew woodland	10-20

Notes: Values from www.apis.ac.uk

²⁰ UK Air Pollution Information System (APIS) <http://www.apis.ac.uk/>

Table 12 Acidity deposition critical loads

Site	Most sensitive habitat	Critical load (keq/ha/yr)
Swangey Fen (SSSI, SAC)	Broadleaved, mixed and yew woodland	MinCLminN: 0.142 MaxCLminN: 0.357 MinCLMaxS: 0.853 MaxCLMaxS: 10.779 MinCLMaxN: 1.209 MaxCLMaxN: 10.921
Norfolk Valley Fen (SAC)	Molinia meadows on calcareous, peaty or clayey-silt-laden soils: acid grassland	MinCLminN: 0.223 MaxCLminN: 0.438 MinCLMaxS: 0.23 MaxCLMaxS: 4.16 MinCLMaxN: 0.606 MaxCLMaxN: 4.383
Breckland (SPA)	Caprimulgus europaeus: Coniferous woodland	MinCLminN: 0.142 MaxCLminN: 0.357 MinCLMaxS: 0.251 MaxCLMaxS: 10.868 MinCLMaxN: 0.536 MaxCLMaxN: 11.01
Attleborough Wood (AW, CWS)	Broadleaved, mixed and yew woodland	CLminN: 0.357 CLmaxS: 2.384 CLmaxN: 2.741

Notes: Values from www.apis.ac.uk

Significance of results

For nationally designated sites same tests on significance are the same as for human receptors (as given in section 5.2). For locally designated sites (AW, CWS), impacts can be screened out as insignificant if the short-term and long-term PCs are less than 100% of the relevant AQS.

5.4 Odour benchmarks

Most odours arise from mixtures of pollutants and the odour threshold is judged subjectively.

Environment Agency H4 Odour Management guidance¹⁴ sets out benchmark odour criteria based on the 98th percentile of hourly mean concentrations of odour modelled over a year at a site boundary, that is the benchmarks are odour concentrations that may be exceeded during 2% of hours.

The benchmarks, to which predicted odour impacts have been compared are:

- 1.5ou_E/m³ for “most offensive” odours e.g. processes involving septic effluent or sludge, processes involving decaying animal or fish remains, biological landfill odours.
- 3.0 ou_E/m³ for “moderately offensive” odours e.g. intensive livestock rearing, well-aerated green composting, sugar beet processing. Odours from poultry rearing and Wastewater Treatment Works operating normally i.e. non-septic conditions, are usually placed in the “moderately offensive” category.
- 6.0 ou_E/m³ for “less offensive” odours e.g. brewery, bakery, coffee roasting.

Odours from the normal operation of the plant are considered to fall within the “moderately offensive” category.

6. Background concentrations and deposition fluxes

6.1 Breckland District Council air quality monitoring

BDC carries out monitoring of NO₂ across its district using 30 passive diffusion tubes and two automatic monitoring locations.²¹ There is one AQMA, at Swaffham, over 25km from the Site. There are two monitoring sites in Attleborough: an urban centre monitoring site on the High Street and an urban background site on Croft Green. In 2019, the latest year for which data have been reported, the concentration at the High Street site was 24.6µg/m³ and that at Croft Green was 10.4 µg/m³.

6.2 Defra modelled background

Defra provides maps of background concentration that include concentrations of benzene (based on a reference year of 2001) projected forward to 2010. Factors are provided to project the concentrations to 2025.²² The maps and factors have been used to determine background concentrations at each of the receptors which are shown in Table 13. Background concentrations of NH₃ are not part of the Defra maps but have been obtained from APIS.²³

Background NO₂ concentrations broadly agree with the value monitored at Croft Green urban background site (10.4 µg/m³). As rural values they are lower, so the Defra spatially varying background concentrations have been used in this assessment.

Table 13 Annual mean background concentrations (µg/m³)

ID	Annual mean concentration (µg/m ³)							
	NO _x	NO ₂	PM ₁₀	PM _{2.5}	SO ₂	Benzene	CO	NH ₃
H1	8.41	6.60	13.69	8.55	1.96	0.19	255	12.2
H2	8.41	6.60	13.69	8.55	1.96	0.19	255	12.2
H3	8.41	6.60	13.69	8.55	1.96	0.19	255	12.2
H4	8.43	6.62	13.67	8.53	1.91	0.19	253	12.2
H5	8.43	6.62	13.67	8.53	1.91	0.19	253	12.2
H6	8.43	6.62	13.67	8.53	1.91	0.19	253	12.2
H7	8.43	6.62	13.67	8.53	1.91	0.19	253	12.2
H8	7.53	5.94	12.61	8.30	1.80	0.18	249	12.2
H9	7.62	6.01	12.81	8.38	1.90	0.18	250	12.2
H10	7.62	6.01	12.81	8.38	1.90	0.18	250	12.2
H11	7.62	6.01	12.81	8.38	1.90	0.18	250	12.2
H12	8.03	6.31	13.23	8.42	2.09	0.19	256	6.9
H13	8.03	6.31	13.23	8.42	2.09	0.19	256	6.9
H14	8.41	6.60	13.69	8.55	1.96	0.19	255	12.2
H15	8.41	6.60	13.69	8.55	1.96	0.19	255	12.2
H16	8.41	6.60	13.69	8.55	1.96	0.19	255	12.2
H17	8.22	6.45	16.39	9.12	2.75	0.20	258	12.2
H18	8.43	6.62	13.67	8.53	1.91	0.19	253	12.2

²¹ Breckland Council, 2020 Air Quality Annual Status Report (ASR), August 2020

²² Defra, Background Maps, <https://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html> (accessed 9/9/2020)

²³ www.apis.ac.uk [Accessed 13 August 2021]

6.3 NH₃ concentration at sensitive conservation sites

Background concentrations at the ecological receptors have been obtained from APIS designated site-specific values for SSSIs, SACs and SPA, and the APIS location-specific values for the AW and CWS; they are an average for the years 2017-2019. This AQIA assesses the impact of NH₃ concentrations from the proposed Crop-AD and Waste-AD plants. The Crop-AD plant emissions will largely be unchanged in this proposed variation and therefore the Crop-AD contribution to background to concentration is already accounted for in the background. In addition, the construction of the Waste-AD plant will involve the removal of a turkey shed; in fact the turkeys were removed in March 2021. These two factors mean the prediction of impact on NH₃ concentrations is pessimistic.

The former impact of the turkey shed on NH₃ concentrations at each of the ecological receptors has been calculated using the SCAIL Agriculture screening model²⁴ and is shown in Table 14 where a modified background, removing the contribution due to the turkey shed, has been calculated. The input data to SCAIL were:

- Location: (603339, 295583)
- Source type: Housing, turkey (male)
- Livestock number: 2,844 (Numbers decrease from 5,000 in mid-October to 1,500 in August)
- Housing floor area: 2,720m²
- Building height: 5m
- Fan location: roof

The calculated emission of NH₃ was 1,280kg/yr.

The unmodified background has been used in this assessment, but the PC due to the removed turkey shed has been compared to the PC due to the Crop-AD and Waste-AD plants.

Table 14 Background NH₃ concentrations at ecological receptors

ID	Receptors	Background (µg/m ³)	PC due to removed turkey shed (µg/m ³)	Modified background (µg/m ³)
E1	Swangey Fens 1	3.44	0.031	3.41
E2	Swangey Fens 2	3.44	0.024	3.42
E3	Swangey Fens 3	3.44	0.028	3.41
E4	Norfolk Valley Fen	2.77	0.005	2.77
E5	Breckland 1	3.39	0.005	3.38
E6	Breckland 2	3.39	0.004	3.39
E7	Breckland 3	3.43	0.004	3.43
E8	Attleborough Wood 1	6.10	0.063	6.05
E9	Attleborough Wood 2	6.10	0.058	6.04
E10	Attleborough Wood	6.10	0.051	6.05

²⁴ SCAIL-Agriculture, CEH, Available at: <http://www.scail.ceh.ac.uk/cgi-bin/agriculture/input.pl> [Accessed 25 August 2021]

6.4 Deposition fluxes at sensitive conservation sites

Background deposition fluxes for nutrient nitrogen deposition (NDep) and acid deposition due to nitrogen (NAcidDep) and sulphur (SAcidDep) are given in Table 15. They were obtained from the APIS website. Values for the nationally designated sites are specific to the designated site and those for locally designated sites, in this case Attleborough Wood, are not specific to the designation.

Table 15 Background deposition fluxes

Name	NDep (kgN/ha/yr)	NAcidDep (keqN/ha/yr)	SAcidDep (keqS/ha/yr)
Swangey Fen	3.33	3.3	0.2
Norfolk Valley Fen	23.1	1.7	0.2
Breckland	3.32	1.4	0.1
Attleborough Wood	69.98	5.0	0.22

7. Impact assessment of air quality on human health

Predicted impacts of each pollutant at each human receptor are given in Appendix K. In this section the highest results are presented, that is, the impacts at the worst-case receptor. Table 16 shows the maximum annual mean (long-term) concentration and Table 17 shows the comparison of predicted short-term impacts, from 15 minutes to 24 hours. The predicted concentrations, with and without background concentrations, have been compared with the AQS. Long-term AQS are not applicable at the closest receptor, H1, the veterinary surgery as it is a workplace and members of the public will not spend sufficient hours at the premises.

The maximum long-term concentrations for each AQS, across all receptors and all meteorological years, and the worst of with and without buildings, are given in Table 16. Maximum long-term impacts for all pollutants are predicted at the nearest residential receptor, H2, Stuart House.

PCs of PM₁₀, PM_{2.5} and H₂S do not exceed 1% of the AQS. PCs of NO₂, Benzene and NH₃ exceed 1% (4%, 12%, 4% respectively) but the PECs for these pollutants do not exceed the AQS; the maximum PEC is 21% for NO₂.

The long-term impacts at all receptors can therefore be screened out as not significant and there is no need for further assessment.

Table 16 Results, long-term AQS

Pollutant	AQS (µg/m ³)	PC (µg/m ³)	PC/AQS (%)	PEC (µg/m ³)	PEC/AQS (%)	Receptor
NO ₂	40	1.6	4	8.2	21	H2
PM ₁₀	40	0.2	0.4	13.9	35	H2
PM _{2.5}	40	0.2	1	8.7	44	H2
Benzene	5	0.6	12	0.8	16	H2
NH ₃	180	7.7	4	13.8	8	H2
H ₂ S	140	<0.1	<0.1	<0.1	<0.1	H2

Notes: bold font indicates an exceedance of the screening threshold

Data on each row is for one receptor, the receptor at which the percentage of PC/AQS is greatest

The maximum short-term concentrations for each AQS, across all receptors and all meteorological years, and the worst of with and without buildings, are given in Table 17. Maximum short-term impacts are predicted at the nearest receptor, H1, Crowshall Veterinary Services for NO₂, PM₁₀, SO₂ (1h and 24h) and NH₃; at R9, Shrugge's Lane, to the north-west of the Site for SO₂ (15min); at H15, Carver's Lane, Attleborough, for Benzene; and H3, Houses at Cakes Hill, for H₂S.

Only one PC exceeds the screening threshold of 10%: the short-term PC of NH₃ is 11% of the AQS. Comparing the PCs with calculated headroom, all values are less than 20% of the headroom; the maximum is for NH₃ for which the PC is 11% of the headroom.

The short-term impacts at all receptors can therefore be screened out as not significant and there is no need for further assessment.

Table 17 Results, short-term AQS

Pollutant	Statistic	AQS ($\mu\text{g}/\text{m}^3$)	PC ($\mu\text{g}/\text{m}^3$)	PC/AQS (%)	Headroom ($\mu\text{g}/\text{m}^3$)	PC/ Headroom (%)	Receptor
NO ₂	99.79 th 1h	200	14.5	7	186.8	8	H1
PM ₁₀	90.41 st 24h	50	1.0	2	22.6	4	H1
SO ₂	99.9 th 15min	266	12.2	5	262.1	5	H9
SO ₂	99.73 rd 1h	350	10.3	3	346.1	3	H1
SO ₂	99.18 th 24h	125	5.3	4	121.1	4	H1
CO	Max daily 8h*	10,000	81	1	9,490	1	H1
Benzene	Max 1h	195	9.5	5	195	5	H15
NH ₃	Max 1h	2,500	271	11	2,488	11	H1
H ₂ S	Max 1h	150	0.2	0.1	150	0.1	H3

Notes: Maximum daily 8h running

Bold font indicates an exceedance of the screening threshold

Data on each row is for one receptor, the receptor at which the percentage of PC/AQS is greatest

8. Impact assessment of air quality on ecological receptors

Predicted impacts of each pollutant at each human receptor are given in Appendix L. In this section the highest results are presented, that is, the impacts at the worst-case receptor across all meteorological years, and the worst of with and without buildings.

The highest concentrations and deposition rates are predicted at those receptors closest to the Site: E10, Attleborough Wood and E1, Swangey Fen SSSI. E10 lies 1.5km to the north-east of the Site; Swangey Fen lies 2.66km from the Site to the south-west. (At E10 Attleborough Wood is a CWS but is not designated as AW; at E10 and E11 it is both a CWS and AW.)

The PCs for NO_x and SO₂ do not exceed 1% of the AQS so no further investigation is required. For NH₃, Table 19 shows the maximum concentrations, with and without background concentrations, compared to the AQS. Predicted PCs do not exceed the threshold screening values at the locally designated Sites (E8-E10), Breckland SPA where the relevant critical level is 3µg/m³, and at Norfolk Valley Fens (E6) where the relevant critical level is 1µg/m³. The 1% threshold is exceeded at both SSSIs (E1-E5) with a maximum impact of 7% (Table 42, Appendix K). At each site the background concentrations exceed the relevant critical level; the PEC values are up to 351% of the AQS.

At Attleborough Wood the predicted NH₃ impact is 25% of the AQS. Defra's guidance suggests no further action is required for AW/CWS.

Taking into account the impact on NH₃ concentrations of the removal of the turkey shed (section 6.3), the maximum net impact at a nationally designated site is 4% of the AQS.

Table 18 Comparison of PC due to the application and former impact of the turkey shed, NH₃ (µg/m³)

ID	Receptors	PC due to the application (µg/m ³)	PC/AQS (%)	PC due to removed turkey shed (µg/m ³)	Net PC (µg/m ³)	Net PC/AQS (%)
E1	Swangey Fens 1	0.071	7%	0.031	0.039	4%
E2	Swangey Fens 2	0.051	5%	0.024	0.027	3%
E3	Swangey Fens 3	0.064	6%	0.028	0.036	4%
E4	Norfolk Valley Fen	0.010	1%	0.005	0.005	1%
E5	Breckland 1	0.011	0%	0.005	0.006	0%
E6	Breckland 2	0.009	0%	0.004	0.004	0%
E7	Breckland 3	0.008	0%	0.004	0.004	0%
E8	Attleborough Wood 1	0.224	22%	0.063	0.161	16%
E9	Attleborough Wood 2	0.191	19%	0.058	0.132	13%
E10	Attleborough Wood	0.253	25%	0.051	0.203	20%

Table 20, predicted nutrient nitrogen deposition due to NO₂ and NH₃ is compared with the minimum and maximum CLoS. The PC exceeds 1% of CL_{omin} and CL_{omax} just at Swangey Fen E1-E3 (maximum 6% of CL_{omin}, 3% of CL_{omax}). Notwithstanding this, the PEDR for sites E1-E3 do not exceed the minimum environmental benchmark (maximum 39% of CL_{omin}, 19% of CL_{omax}).

Predicted nitrogen deposition does not exceed 100% at the local sites (maximum 10% at E10).

It is considered that no further investigation is required for nutrient nitrogen deposition.

In Table 21 predicted contributions to acid deposition, due to NO₂, NH₃ and SO₂, are compared with the CLomin and CLomax. Results have been obtained using the APIS critical load function tool.²⁵ At the nationally designated sites the PC exceeds 1% of CLomin (maximum 3.3% at E1) and the background acid deposition exceeds CLomin (289.5%); however the PC does not exceed 1% of CLomax (maximum 0.4% at E1 and E3).

At Attleborough Wood (CWS, AW) the predicted impact is up to 5.5% of the AQS. Defra's guidance suggests no further action is required for AW/CWS.

The PC for NH₃ exceeds 1% of the AQS at the SSSIs, but not at the SACs and SPA. The maximum impact is 7%. At each site the background concentrations exceed the relevant critical level; the PEC values are up to 351% of the AQS. Taking into account the removal of the turkey shed the maximum net impact at a nationally designated site is reduced to 4% of the AQS.

While the PEC for NH₃ concentration and CLomin for acid deposition are exceeded at all the ecological receptors, the exceedances are due to existing high background levels and would not be due to the proposal which will comply with BAT. It is not proposed to enclose the Crop-AD separator in a building with extraction/treatment; emissions of NH₃ from the separator are small. A BAT assessment has been submitted as part of this application. Therefore, no further assessment has been carried out.

²⁵ Air Pollution Information System, Critical Load Function Tool, Available at: <http://www.apis.ac.uk/critical-load-function-tool> [Accessed 21 August 2021]

Table 19 Results at ecological receptors, long-term and short-term AQS, worst case impact

Pollutant	AQS (µg/m³)	Averaging time	Statistic	LT or ST AQS*	PC (µg/m³)	PC/AQS (%)	PEC (µg/m³)	PEC/AQS (%)	Receptor
NOx	30	Annual	mean	LT	0.2	1	8.2	27	E10 (CWS)
SO ₂	20	Annual	mean	LT	<0.1	<1	1.9	9	E10 (CWS)
SO ₂	10	Annual	mean	LT	0.1	1	1.9	19	E10 (CWS)
NH ₃	3	Annual (SSSI, SAC, SPA)	mean	LT	<0.1	<1	3.4	113	E7 (SAC)
NH ₃	1	Annual (AW, CWS)	mean	LT	0.25	25	6.35	635	E10 (CWS)
NH ₃	1	Annual (SSSI, SAC, SPA)	mean	LT	0.1	7	3.5	351	E1 (SSSI)
Pollutant	AQS (µg/m³)	Averaging time	Statistic	LT or ST AQS*	PC (µg/m³)	PC/AQS (%)	PEC (µg/m³)	PEC/AQS (%)	Receptor
NOx	75	24-hour	100 th percentile	ST	2.4	3	18.4	24%	E10 (CWS)

Notes: *LT= long-term, ST = short-term; Bold font indicates an exceedance of the screening threshold

Data on each row is for one receptor, the receptor at which the percentage of PC/AQS is greatest

Table 20 Worst-case nutrient nitrogen deposition

Pollutant	PC (kg/ha/y)	CLomin (ka/ha/y)	CLomax (ka/ha/y)	PC/CLomin (%)	PC/CLomax (%)	PEDR/CLomin (%)	PEDR/CLomax (%)	Receptor
CWS	2.02	10	20	20	10	719	359	E10 (CWS)
SSSI, SPA, SAC	0.56	10	20	5.6	2.8	39	19	E1 (SSSI)

Notes: Bold font indicates an exceedance of the screening threshold; data on each row is for one receptor, the receptor at which the percentage of PC/CLmin is greatest

Table 21 Worst-case acid deposition

Pollutant	PC/CLo (%)	Background/CLo (%)	PEDR/CLo (%)	Receptor
CWS with respect to CLmin	5.8	190.1	195.9	E10 (CWS)
SSSI, SPA, SAC with respect to CLmin	3.3	289.5	292.8	E1 (SSSI)
CWS with respect to CLmax	n/a	n/a	n/a	n/a
SSSI, SPA, SAC with respect to CLmax	0.4	32	32.4	E1, E3 (SSSI, SAC)

Notes: Bold font indicates an exceedance of the screening threshold; data on each row is for one receptor, the receptor at which the percentage of PC/CL is greatest

9. Impact assessment of odour

Table 22 shows the predicted 98th percentile of 1-hour mean odour concentrations at the modelled discrete receptor locations. The values given are the worst case for each year (with or without buildings) and the final column gives the worst case across all five years. The maximum predicted, 1.27ou_E/m³, is at the nearest receptor, H1, Crowshall Veterinary Services. H2, Stuart House, is the residential receptor at which the maximum odour impact is predicted.

The maximum odour impact is below even the lowest threshold of 1.5ou_E/m³ for the “most offensive” odours and therefore the Site operation is not likely to be an odour nuisance at human receptors.

Table 22 98th percentile hour mean odour concentration (ou_E/m³)

ID	2016	2017	2018	2019	2021	Worst case
H1	1.13	1.27	0.97	1.00	1.00	1.27
H2	0.84	0.87	0.73	0.74	0.74	0.87
H3	0.86	0.85	0.66	0.75	0.71	0.86
H4	0.73	0.76	0.59	0.68	0.58	0.76
H5	0.59	0.57	0.49	0.51	0.50	0.59
H6	0.61	0.55	0.45	0.50	0.51	0.61
H7	0.59	0.50	0.48	0.50	0.53	0.59
H8	0.46	0.39	0.41	0.41	0.42	0.46
H9	0.40	0.31	0.40	0.37	0.40	0.40
H10	0.22	0.11	0.16	0.16	0.16	0.22
H11	0.37	0.22	0.29	0.35	0.25	0.37
H12	0.27	0.12	0.21	0.16	0.20	0.27
H13	0.23	0.15	0.20	0.18	0.16	0.23
H14	0.31	0.26	0.24	0.27	0.24	0.31
H15	0.35	0.35	0.26	0.32	0.29	0.35
H16	0.26	0.26	0.20	0.23	0.23	0.26
H17	0.18	0.26	0.16	0.17	0.19	0.26
H18	0.21	0.20	0.17	0.18	0.18	0.21

10. Conclusion

This AQIA has been prepared to support an application for a substantial variation to the existing permit for Attleborough Anaerobic Digestion (AD) plant (previously referred to as Crows Hall AD plant) at Ellingham Road, Attleborough, Norfolk, NR17 1AE ('the Site'). The Site is operated by Eco Verde Energy Limited (EVE) ('the Operator') on behalf of Attleborough Eco Electric Limited.

It is currently permitted by the Environment Agency (EA) under the Environmental Permitting (England and Wales) regulations 2018,²⁶ via a Standard Rule permit (Standard Rules 2012 No 9 – On-farm anaerobic digestion facility using farm wastes only, including use of the resultant biogas), permit reference EPR/BB3931RA.

The permit variation is for some minor changes to the Crop-AD plant and for the construction of a second Waste-AD plant adjacent to the existing AD plant which will treat up to 91,000 TPA of liquid and solid waste feedstocks including food waste.

Baseline conditions of sensitive receptors, current background concentrations and deposition rates have been established. The Site is in a rural area, 250m to the north-west of the A11 dual carriageway, immediately beyond which lies the town of Attleborough, Norfolk. It is not in an AQMA, the nearest of which is at Swaffham, over 25km away. The nearest property is the Crowshall Veterinary Services, 260m to the north-east of the centre of the site and 64m from the boundary. The nearest dwellings lie just beyond the Veterinary Services, 350m from the centre of the Site.

Swangey Fen, 2.7km to the south-west of the Site is the nearest site of Special Scientific Interest (SSSI) and is also a Special Area of Conservation (SAC); Breckland, 8.7km to the west is the nearest Special Protection Area (SPA).

Detailed modelling has been carried out using the ADMS 5 dispersion model and meteorological data from RAF Marham. Pessimistic assumptions have been made in respect of:

- Assuming emission at ELV levels, the maximum permitted
- Assuming the CHP, GUU and Centriair stack operate continuously all year, whereas there will be maintenance periods
- Assuming the back-up sources, the boiler and two flares, operate for 10% of hours and coincidentally with the CHP
- Assuming the Waste-AD flare combusts biogas rather than biomethane
- Assuming the leachate tanks are always half full and therefore the surface area for emission is maximised
- Assuming the working face of the clamp is exposed 12h/day
- That the contribution to background concentration and deposition due to emissions from the Crop-AD plant are already accounted for in the background values; as part of the proposal changes to the Crop-AD plant emissions will be minimal, and
- Plume depletion due to deposition has not been modelled so predicted concentrations and deposition fluxes are pessimistic.

²⁶ The Environmental Permitting (England and Wales) (Amendment) Regulations 2018, Statutory Instrument 2018 No, 110, 29th January 2018

Human receptors

Maximum predicted long-term PCs of PM₁₀, PM_{2.5} and H₂S do not exceed 1% of the AQS. PCs of NO₂, Benzene and NH₃ exceed 1% (4%, 11%, 4% respectively) but the PECs do not exceed the AQS; the maximum PEC is 21% of the AQS for NO₂.

The long-term impacts at all receptors can therefore be regarded as not significant.

Only one maximum short-term PC exceeds the screening threshold of 10%: the short-term PC of NH₃ is 11% of the AQS. Comparing the PCs with calculated headroom, all values are less than 20% of the headroom; the maximum is for NH₃ for which the PC is 11% of the headroom.

The short-term impacts at all receptors can therefore be regarded as not significant.

Ecological receptors

Predicted PCs do not exceed the threshold screening values at the locally designated Sites (E8-E10), Breckland SPA where the relevant critical level is 3µg/m³, and at Norfolk Valley Fens (E6) where the relevant critical level is 1µg/m³.

The 1% threshold is exceeded at both SSSIs (E1-E5) with a maximum impact of 7%. At each receptor the background concentrations exceed the relevant critical level; the PEC values are up to 351% of the AQS. Taking into account the removal of the turkey shed, the maximum net impact at a nationally designated site is reduced to 4% of the AQS.

Predicted nutrient nitrogen deposition is predicted to exceed 1% of CLomin and CLomax just at Swangey Fen E1-E3 (maximum 6% of CLomin, 3% of CLomax). Notwithstanding this, the PEDR for sites E1-E3 do not exceed the minimum environmental benchmark (maximum 39% of CLomin, 19% of CLomax). Predicted nitrogen deposition does not exceed 100% at the local sites (maximum 10% at E10). It is considered that no further investigation is required for nutrient nitrogen deposition.

Predicted contributions to acid deposition at the nationally designated sites the PC exceeds 1% of CLomin (maximum 3.3% at E1) and the background acid deposition exceeds CLomin (289.5%); however the PC does not exceed 1% of CLomax (maximum 0.4% at E1 and E3).

The acid deposition PC is <100% at Attleborough Wood (CWS, AW); the predicted impact is 5.1% of the AQS. Defra's guidance suggests no further action is required for AW/CWS.

While the PEC for NH₃ concentration and CLomin for acid deposition are exceeded at all the ecological receptors, the exceedances are due to existing high background levels and would not be due to the proposal which will comply with BAT. A BAT assessment has been submitted as part of this application. Therefore, no further assessment has been carried out.

Odour

The total odour impact was predicted to be 1.27ou_E/m³, predicted at the nearest receptor, H1, Crowshall Veterinary Services. The predicted impact is below the strictest odour benchmark of 1.5ou_E/m³. There is, therefore, not likely to be an odour nuisance due to the Site operation.

Figures

Figure 1 Site location

Figure 2 Modelled point sources

Figure 3 Modelled volume sources

Figure 4 RAF Marham Windroses 2016-2020

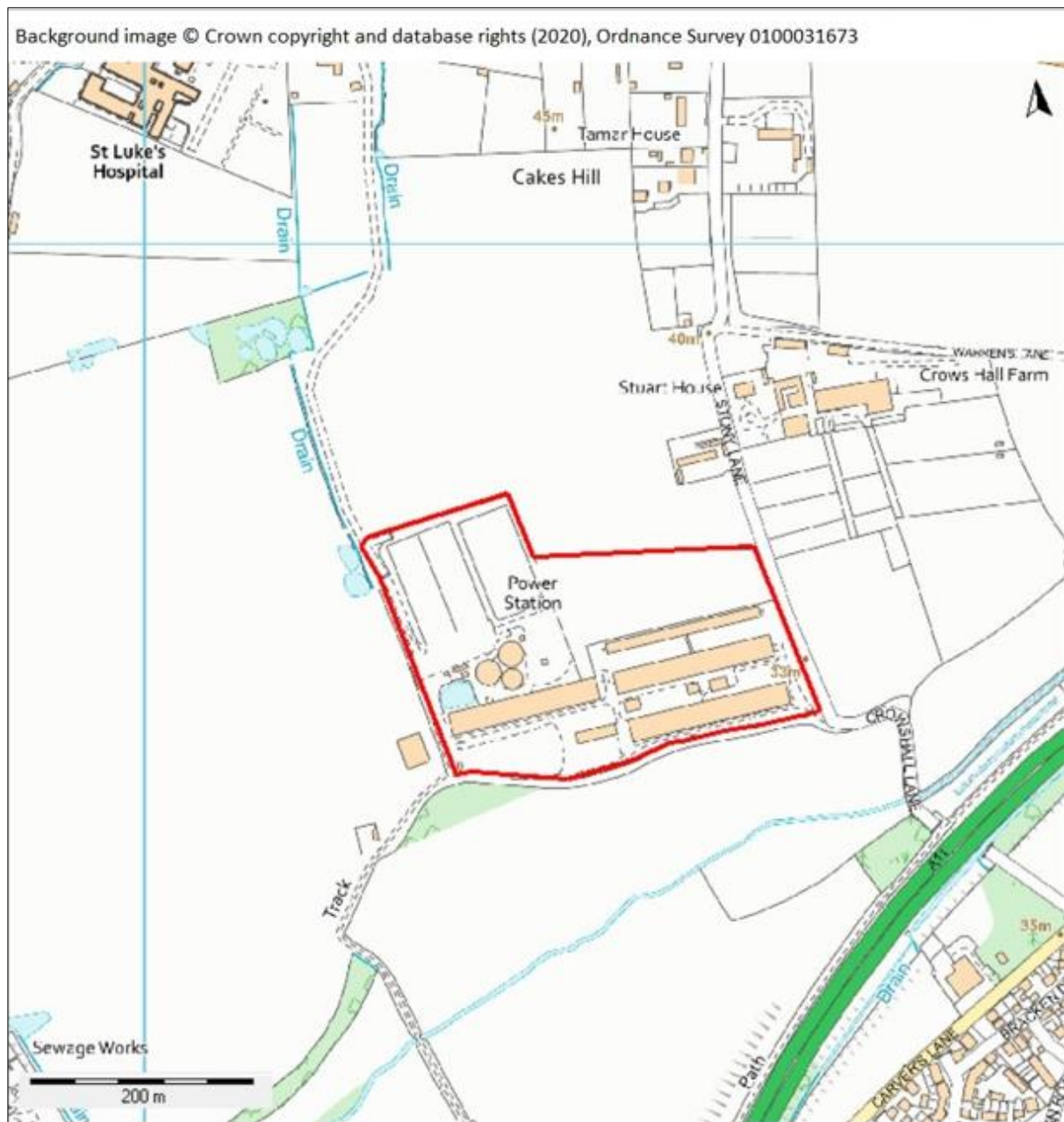
Figure 5 Modelled buildings

Figure 6 Human receptors

Figure 7 Ecological receptors

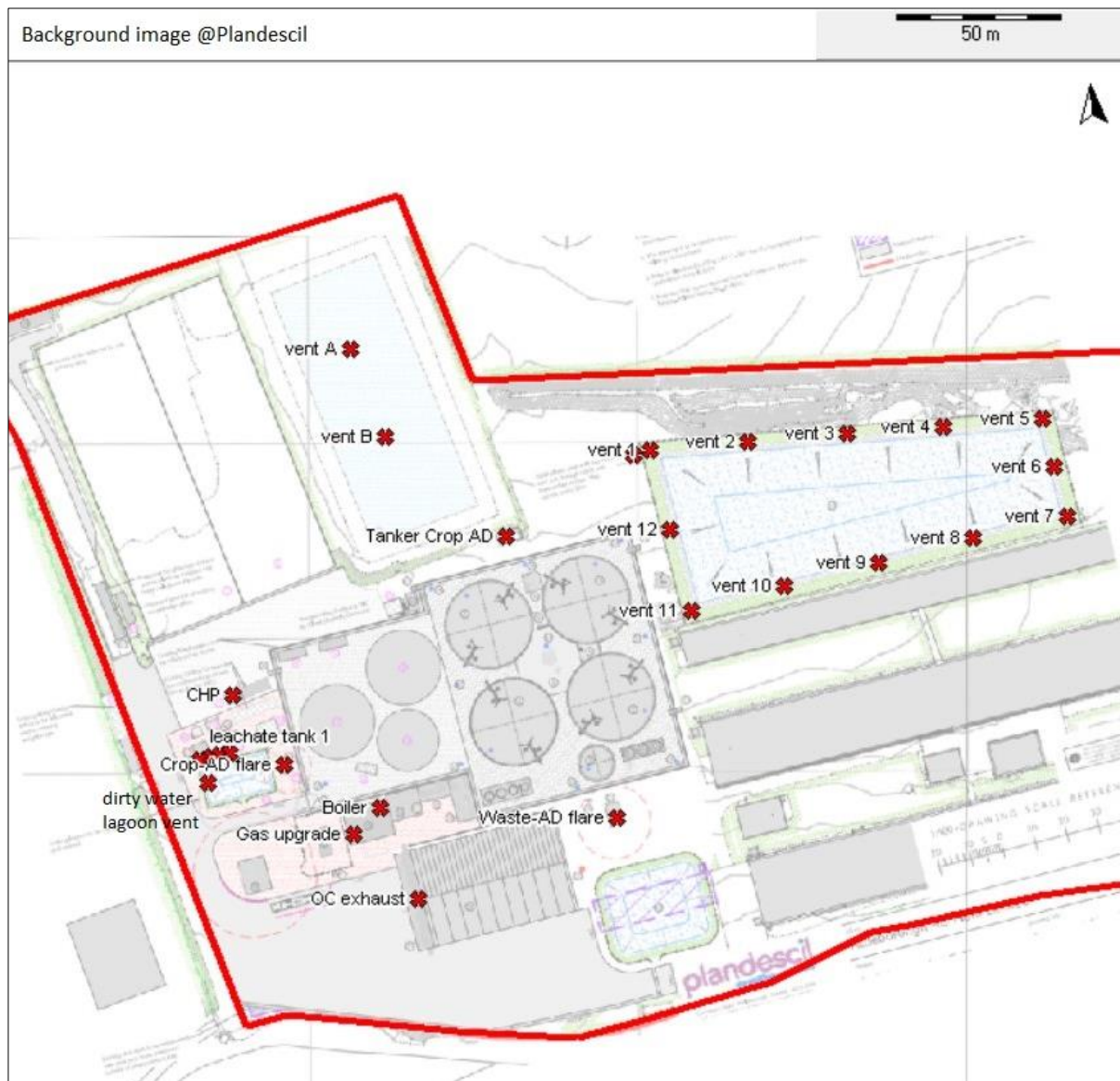
Attleborough AD Facility, Norfolk

Figure 1 Site location



Note: red line shows the planning application boundary

Figure 2 Modelled point sources

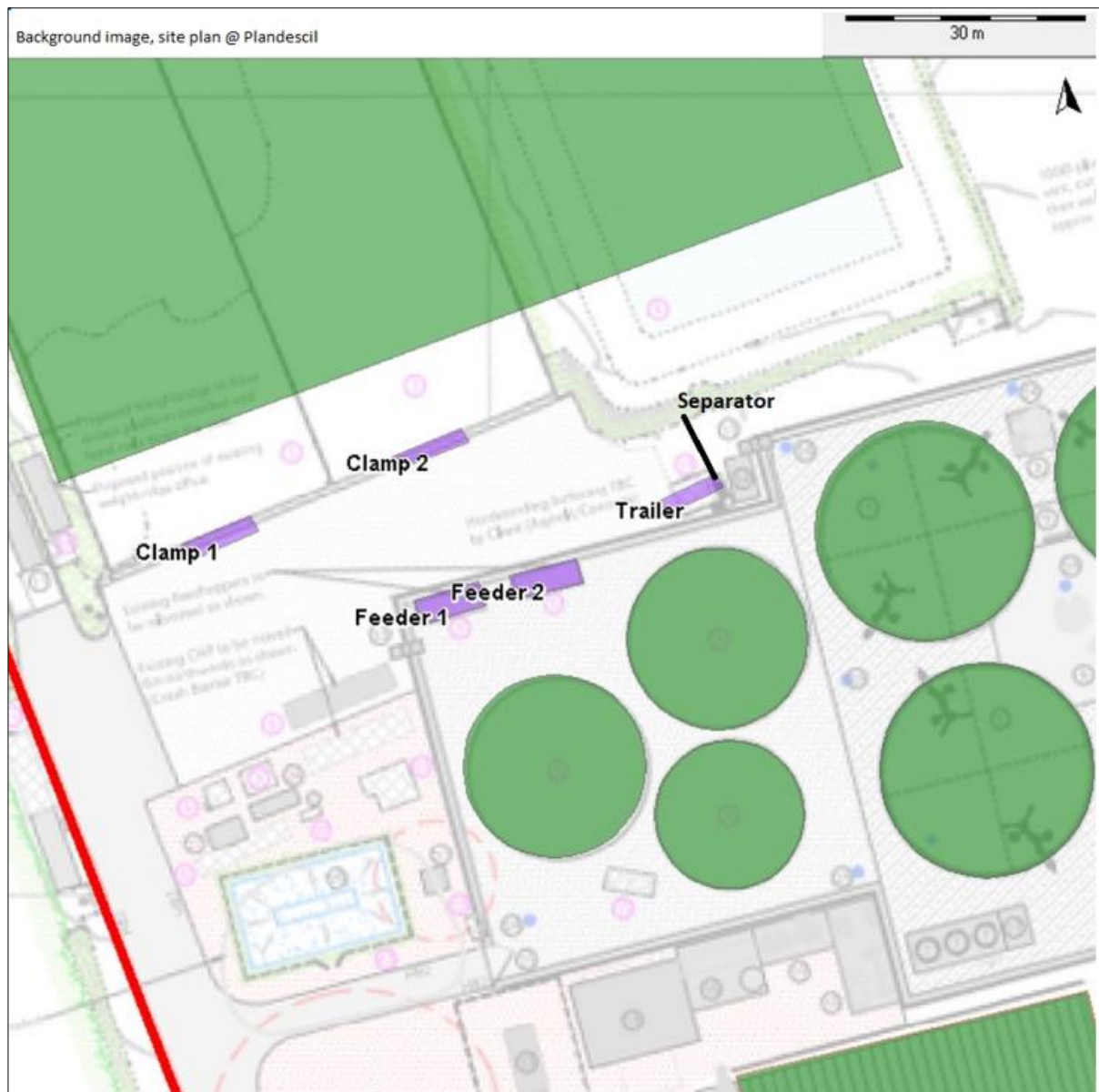


Note: red line shows the planning application boundary

Legend

- ☐ ☒ Site boundary
- ☐ ☒ Point sources (27)
- ☐ ☒ Buildings (9)

Figure 3 Modelled volume sources



Legend

- ☐ ☒ Site boundary
- ☐ ☒ Volume sources (6)
- ☐ ☒ Buildings (9)

Figure 4 RAF Marham Windroses 2016-2020

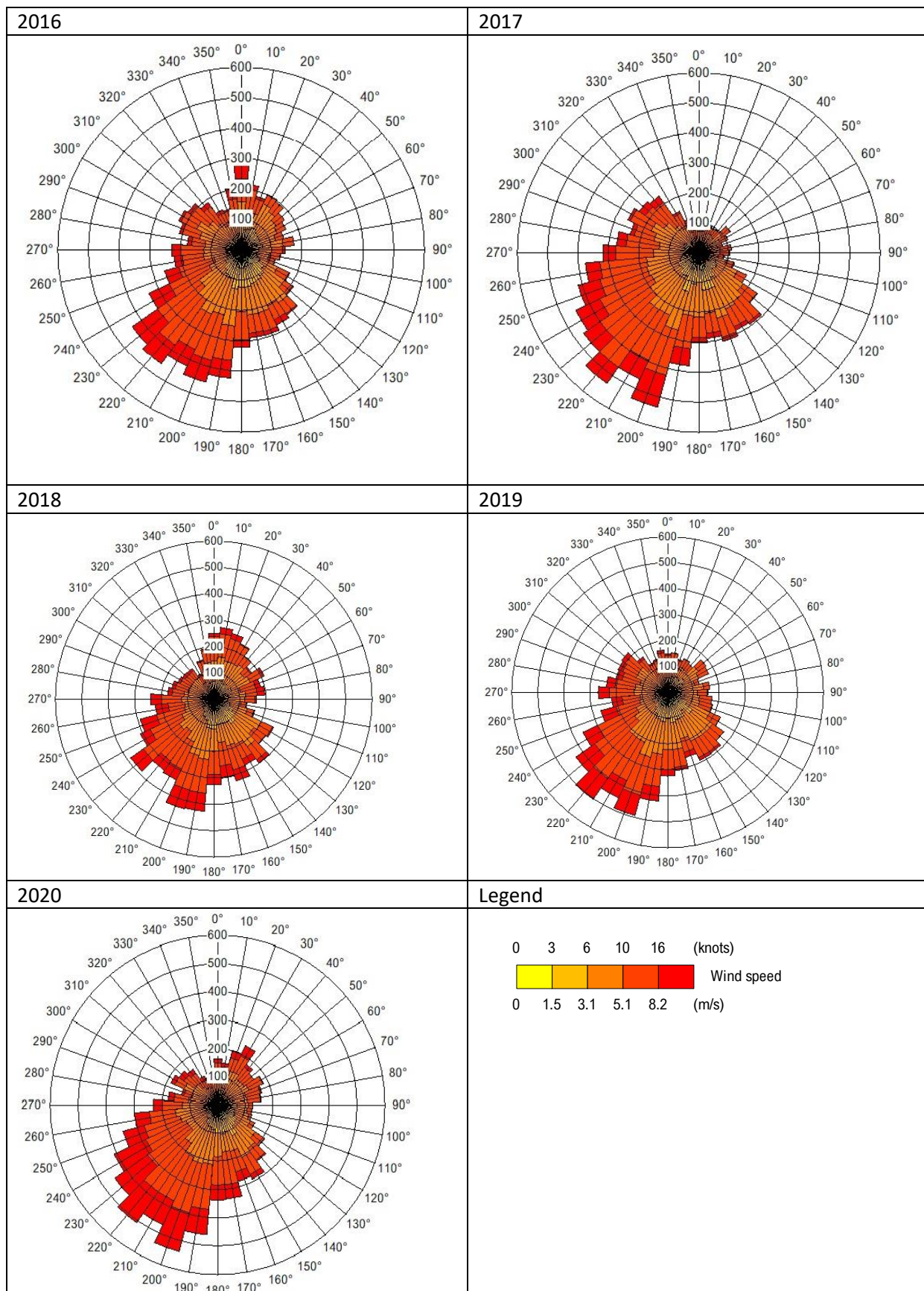
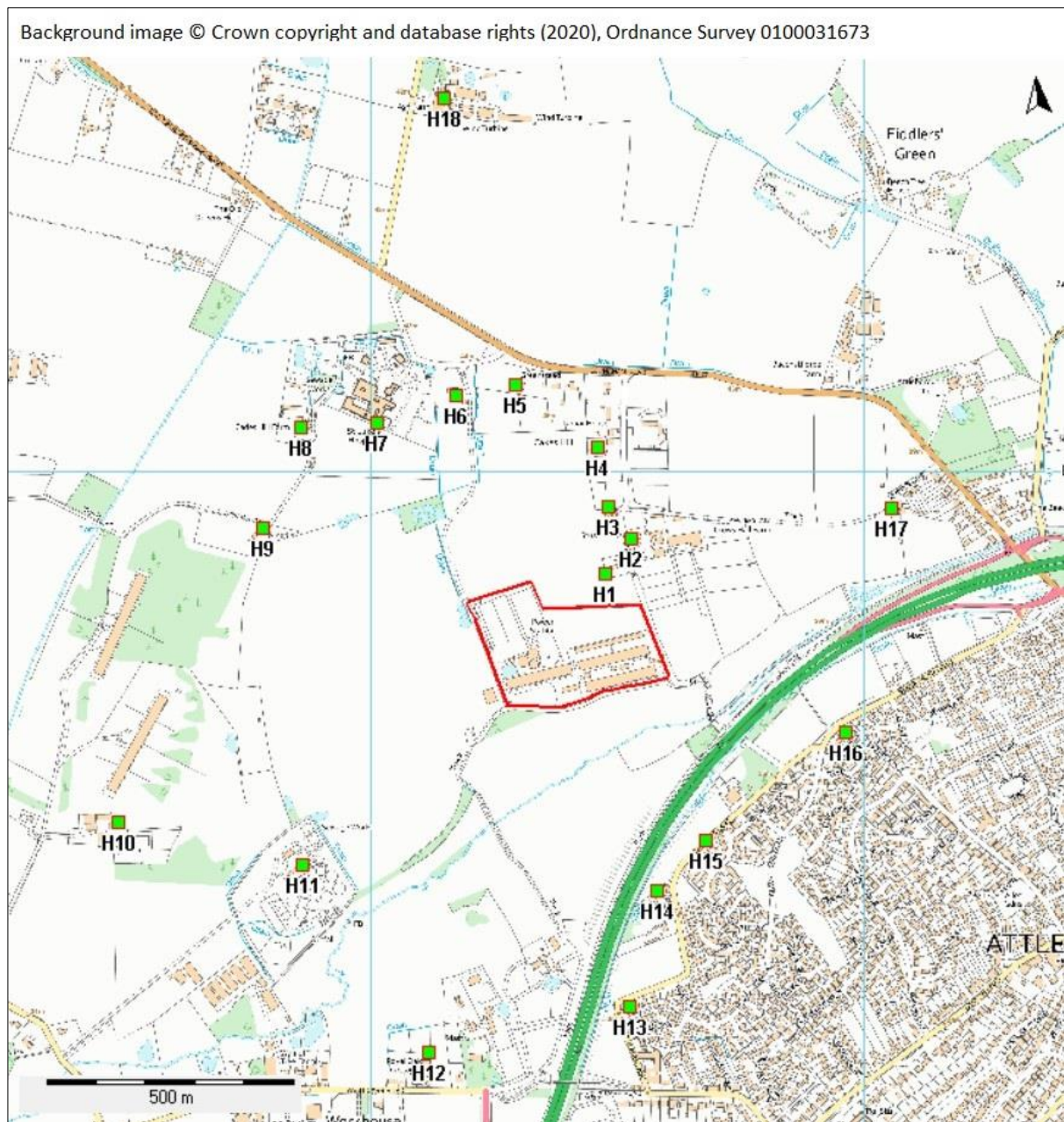


Figure 5 Modelled buildings



Note: red line shows the planning application boundary

Figure 6 Human receptors



Note: red line shows the planning application boundary

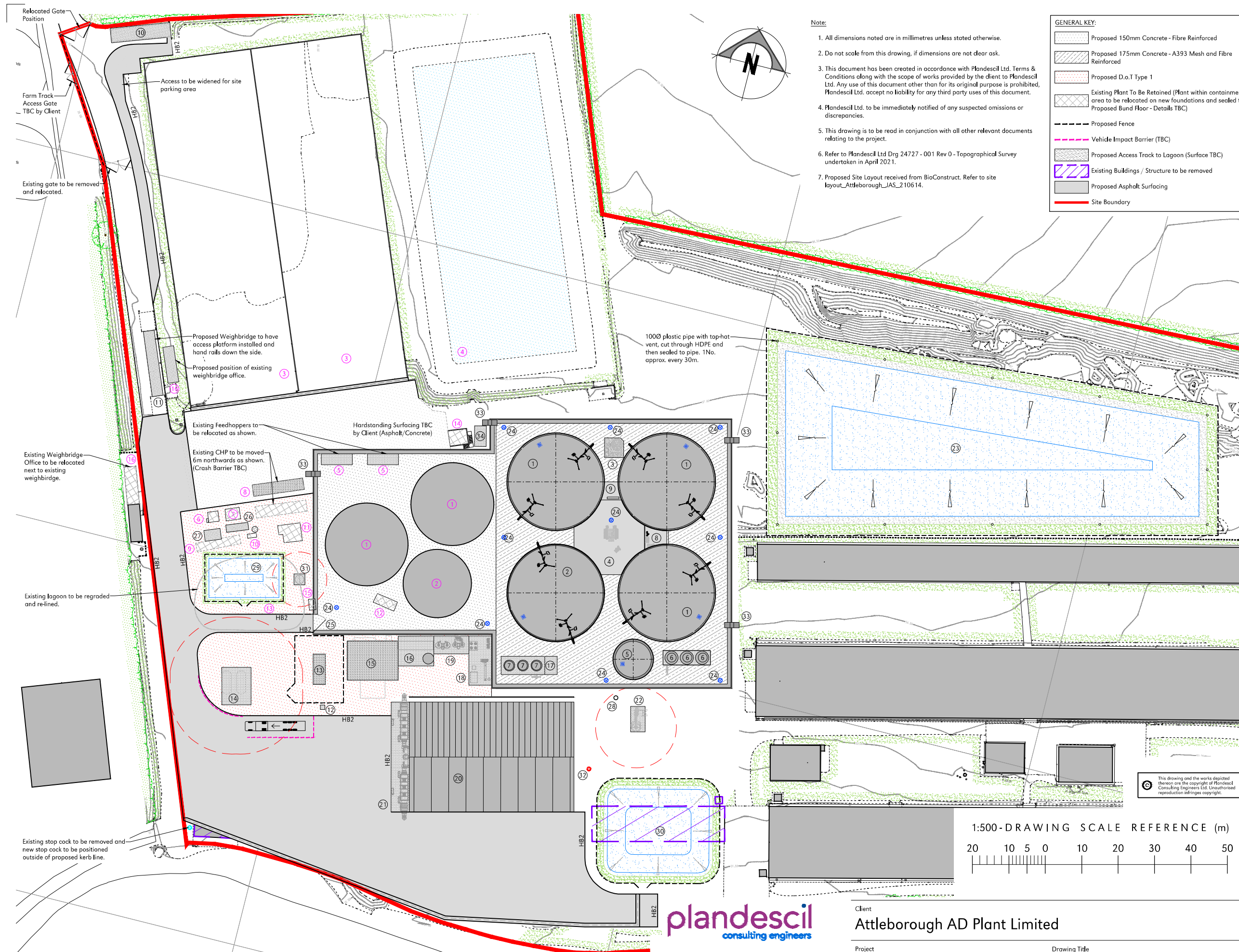
Legend

- ☐ ☒ Site
- ☐ ☒ Human receptors

Appendix A Site Plans from Plandescil

All figures in this appendix are shown as A3 which is not the original drawing size:

- Proposed Site Layout, overview
- Proposed Site layout
- Emission points



- Note:**
1. All dimensions noted are in millimetres unless stated otherwise.
 2. Do not scale from this drawing, if dimensions are not clear ask.
 3. This document has been created in accordance with Plandescil Ltd. Terms & Conditions along with the scope of works provided by the client to Plandescil Ltd. Any use of this document other than for its original purpose is prohibited, Plandescil Ltd. accept no liability for any third party uses of this document.
 4. Plandescil Ltd. to be immediately notified of any suspected omissions or discrepancies.
 5. This drawing is to be read in conjunction with all other relevant documents relating to the project.
 6. Refer to Plandescil Ltd Drg 24727 - 001 Rev 0 - Topographical Survey undertaken in April 2021.
 7. Proposed Site Layout received from BioConstruct. Refer to site layout_Attleborough_JAS_210614.

GENERAL KEY:

- Proposed 150mm Concrete - Fibre Reinforced
- Proposed 175mm Concrete - A393 Mesh and Fibre Reinforced
- Proposed D.o.T Type 1
- Existing Plant To Be Retained (Plant within containment area to be relocated on new foundations and sealed to Proposed Bund Floor - Details TBC)
- Proposed Fence
- Vehicle Impact Barrier (TBC)
- Proposed Access Track to Lagoon (Surface TBC)
- Existing Buildings / Structure to be removed
- Proposed Asphalt Surfacing
- Site Boundary

- EXISTING PLANT KEY:**
- 1 Digester (2No.) (23mØ)
 - 2 Fermenter (19mØ)
 - 3 Silage Clamp (2No.) (30m x 95m)
 - 4 Covered Lagoon
 - 5 Feedhopper (2No.) - To Be Relocated
 - 6 Substation
 - 7 Transformer
 - 8 CHP Engine - To Be Relocated
 - 9 Storage Container - To Be Relocated
 - 10 Chiller & Oil Container
 - 11 Technical Container
 - 12 Boiler
 - 13 Dirty Water Holding Lagoon - To Be Regraded/Relined
 - 14 Separator
 - 15 Flare - To Be Removed
 - 16 Welfare Facility / Site Office - To Be Relocated

- PROPOSED PLANT KEY:**
- 1 BioConstruct Fermenter (3No. @ 26.00mØ)
 - 2 BioConstruct Post-Fermenter (26.00mØ)
 - 3 Reception Tank
 - 4 Technical Building
 - 5 Pre-Storage Tank (10.00mØ)
 - 6 Pre-Storage Tank (3No. @ 3.50mØ)
 - 7 Pasteurisation Tank (3No.)
 - 8 Oxygen Generator
 - 9 Switchboard Room
 - 10 Site Office
 - 11 Weighbridge
 - 12 VSAT
 - 13 Grid Entry Unit
 - 14 Propane Tanks
 - 15 Gas Upgrading Unit
 - 16 Boiler, Heating Buffer Tank
 - 17 Switchboard Container
 - 18 Gas Processing Unit
 - 19 Active Carbon Tanks (2No.)
 - 20 Reception Building (30.20m x 45.20m)
 - 21 Odour Control Filter (1No.)
 - 22 Flare - BioConstruct (10.00m Exclusion Zone)
 - 23 Digestate Storage Lagoon (10,000m³ Storage)
 - 24 Containment Sump (8No.) - TBC
 - 25 Bund Gate (1No.)
 - 26 LV Switchboard
 - 27 Emergency Generator
 - 28 Condensate Pit
 - 29 Dirty Water Holding Lagoon (175m³ Storage)
 - 30 Surface Water Attenuation Lagoon (936m³ Storage)
 - 31 Flare - EVE (7.50m Exclusion Zone TBC By Client)
 - 32 Borehole - Position TBC
 - 33 Stair Access (4No.)
 - 34 Leachate Tank (20,000l - Capacity TBC)

APPROVAL & COMMENT				
H	22-07-21	JHB	OAJ	Amendments Following Comments
G	23-06-21	JHB	OAJ	Amendments Following Comments
F	16-06-21	JHB	OAJ	Amendments Following Comments
E	11-06-21	JHB	OAJ	Amendments Following Comments
D	03-06-21	JHB	OAJ	Amendments Following Comments
C	30-04-21	JHB	OAJ	Amendments Following Comments
B	20-04-21	JHB	OAJ	Amendments Following Comments
A	13-09-19	JHB	OAJ	Amendments Following Comments
O	09-09-19	JHB	OAJ	First Issue
Rev	Date	Rev By	Chkd	Description

plandescil
consulting engineers

Connaught Road Attleborough Norfolk NR17 2BW
Telephone: (01953) 452001 Fax: (01953) 456955
E-mail: pdcl@plandescil.co.uk www.plandescil.co.uk

civil / structural / environmental / surveying

Client
Attleborough AD Plant Limited

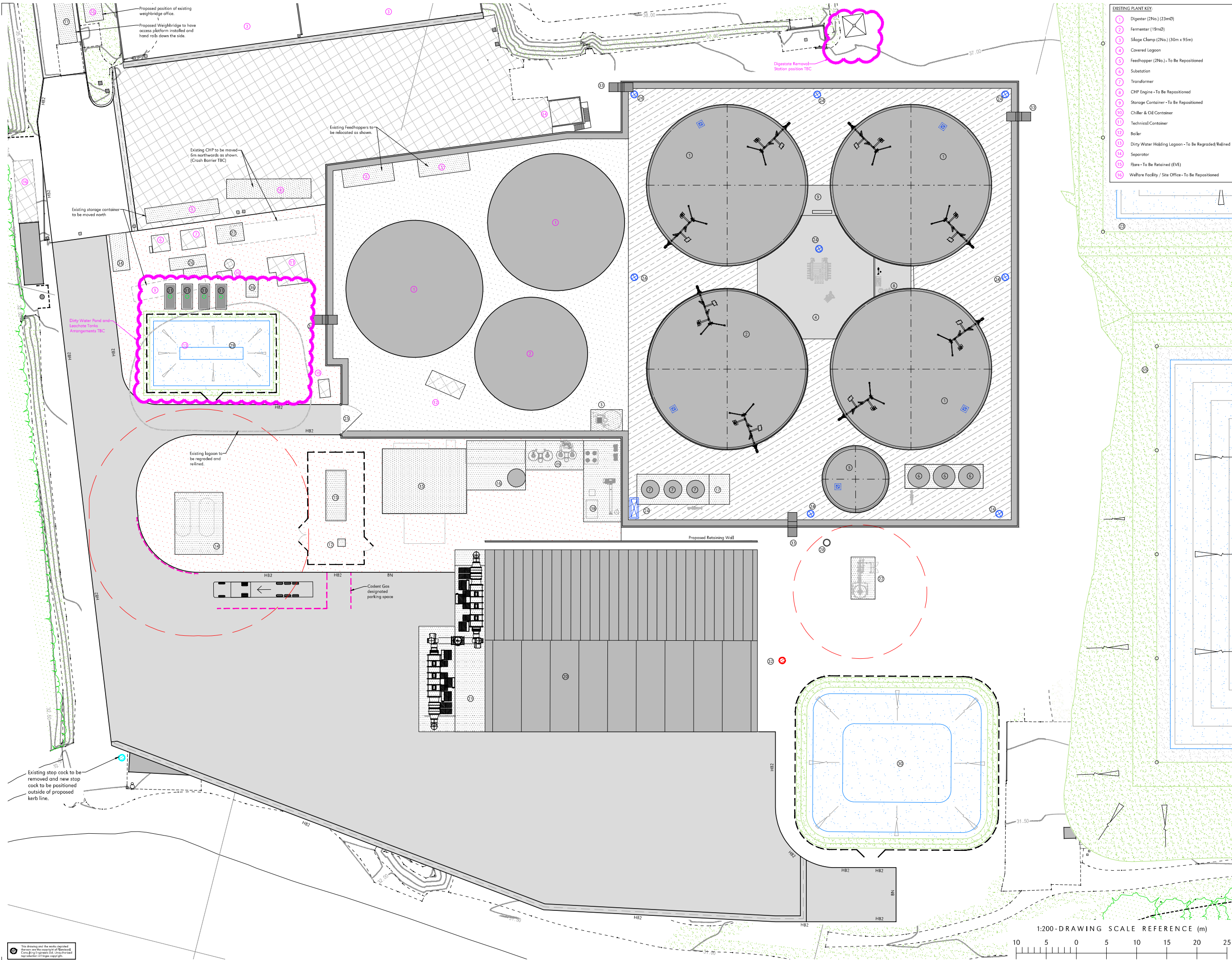
Project
Attleborough AD Plant, Attleborough, NR17 1AE

Drawing Title
Proposed Site Overview Layout

Scale U.N.O. Date September 2019 Drawn By JHB

1:500 (A1)

Drawing No. 24727/010 Rev H



- EXISTING PLANT KEY:**
- 1 Digester (2No.) (23mØ)
 - 2 Fermenter (19mØ)
 - 3 Silage Clamp (2No.) (30m x 95m)
 - 4 Covered Lagoon
 - 5 Feedhopper (2No.) - To Be Repositioned
 - 6 Substation
 - 7 Transformer
 - 8 CHP Engine - To Be Repositioned
 - 9 Storage Container - To Be Repositioned
 - 10 Chiller & Oil Container
 - 11 Technical Container
 - 12 Boiler
 - 13 Dirty Water Holding Lagoon - To Be Regraded/Relined
 - 14 Separator
 - 15 Flare - To Be Retained (EVE)
 - 16 Welfare Facility / Site Office - To Be Repositioned

- PROPOSED PLANT KEY:**
- 1 BioConstruct Fermenter (3No. @ 26.00mØ)
 - 2 BioConstruct Post-Fermenter (26.00mØ)
 - 3 Ferric Chloride Tank
 - 4 Technical Building
 - 5 Pre-Storage Tank (10.00mØ)
 - 6 Pre-Storage Tank (3No. @ 3.50mØ)
 - 7 Pasteurisation Tank (3No.)
 - 8 Oxygen Generator
 - 9 Switchboard Room
 - 10 Site Office
 - 11 Weighbridge
 - 12 VSAT
 - 13 Grid Entry Unit
 - 14 Propane Tanks
 - 15 Gas Upgrading Unit
 - 16 Boiler, Heating Buffer Tank
 - 17 Switchboard Container
 - 18 Gas Processing Unit
 - 19 Active Carbon Tanks (2No.)
 - 20 Reception Building (30.20m x 45.20m)
 - 21 Odour Control Filter (1No.)
 - 22 Flare - BioConstruct (10.00m Exclusion Zone)
 - 23 Digestate Storage Lagoon (10,000m³ Storage)
 - 24 Containment Sump (8No.) - TBC
 - 25 Bund Gate (1No.)
 - 26 LV Switchboard
 - 27 Emergency Generator
 - 28 Condensate Pit
 - 29 Dirty Water Holding Lagoon (175m³ Storage)
 - 30 Surface Water Attenuation Lagoon (936m³ Storage)
 - 31 Leachate Tank (4No.) (4,800L)
 - 32 Borehole
 - 33 Stair Access (4No.)
 - 34 BioConstruct Container
 - 35 Digestate Storage Lagoon (25,000m³)
 - 36 Leachate Pump

- GENERAL KEY:**
- Proposed 150mm Concrete - Fibre Reinforced
 - Proposed 175mm Concrete - A393 Mesh and Fibre Reinforced
 - Proposed D.O.T Type 1
 - Existing Concrete Aggregates and Ancillary Equipment Plant Foundations to be Retained / Reinstated (TBC)
 - Proposed Fence
 - Vehicle Impact Barrier (TBC)
 - Proposed Access Track to Lagoon (Surface TBC)
 - Proposed Asphalt Surfacing

APPROVAL & COMMENT				
K	20-08-21	TOH	OAJ	Minor Amendments
J	02-08-21	JHB	OAJ	Minor Amendments
H	22-07-21	JHB	OAJ	Minor Amendments
G	23-06-21	JHB	OAJ	Minor Amendments
E	11-06-21	JHB	OAJ	Minor Amendments
D	03-06-21	TOH	OAJ	Minor Amendments
C	10-12-20	MJP	OAJ	Minor Amendments
B	16-03-20	MJP	OAJ	Planning Issue Amendments
A	13-01-20	MJP	OAJ	Client Name Amended
O	10-01-20	-	OAJ	First Issue
Rev	Date	Rev By	Chkd	Description

plandescil
consulting engineers

Comaught Road, Attleborough, Norfolk, NR17 2BW
Telephone: (01533) 432001 Fax: (01533) 436035
Email: pdon@plandescil.co.uk www.plandescil.co.uk

civil / structural / environmental / surveying

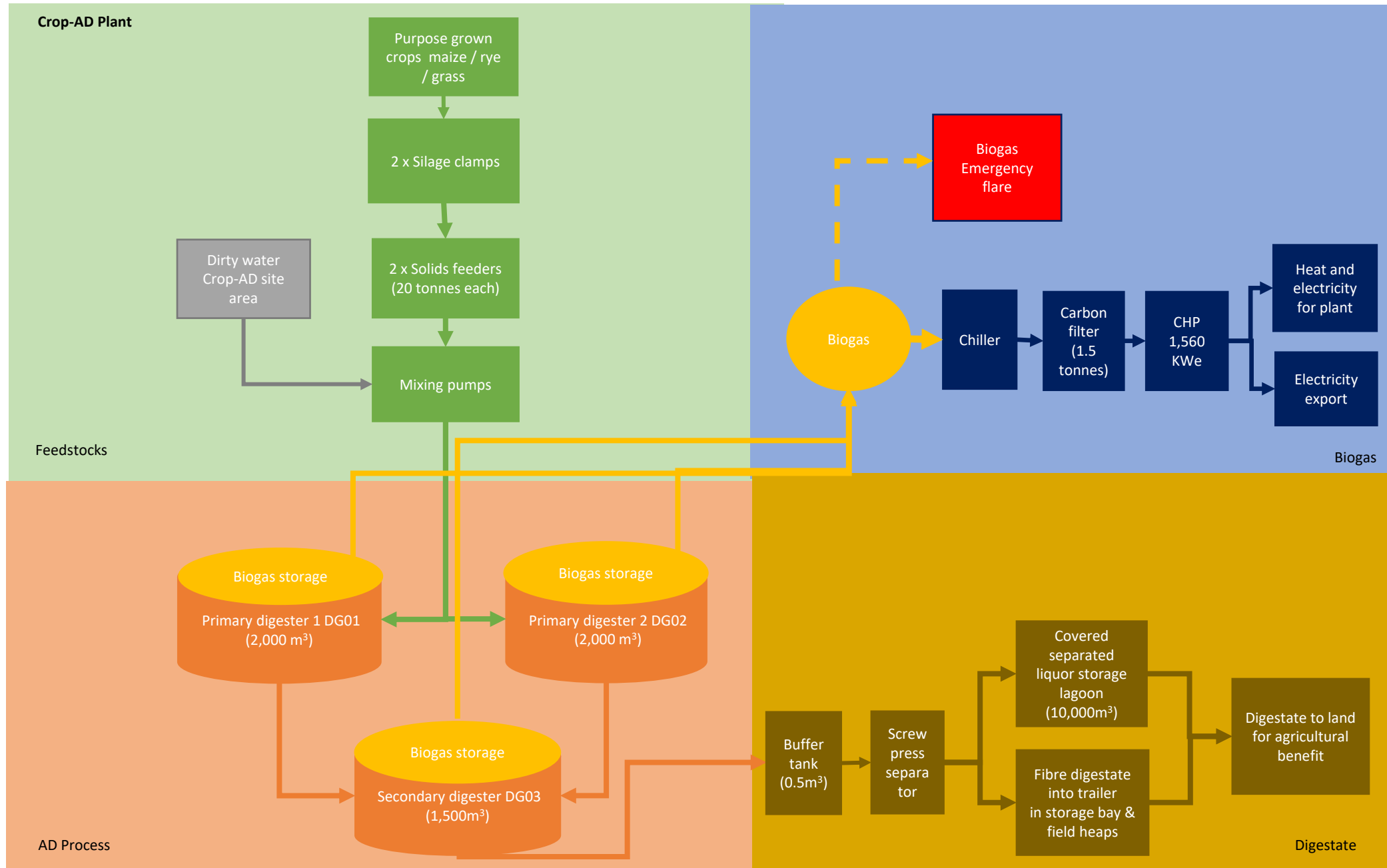
Client:
Attleborough AD Plant Limited

Project:
**Attleborough AD Plant,
Attleborough, Norfolk,
NR17 1AE**

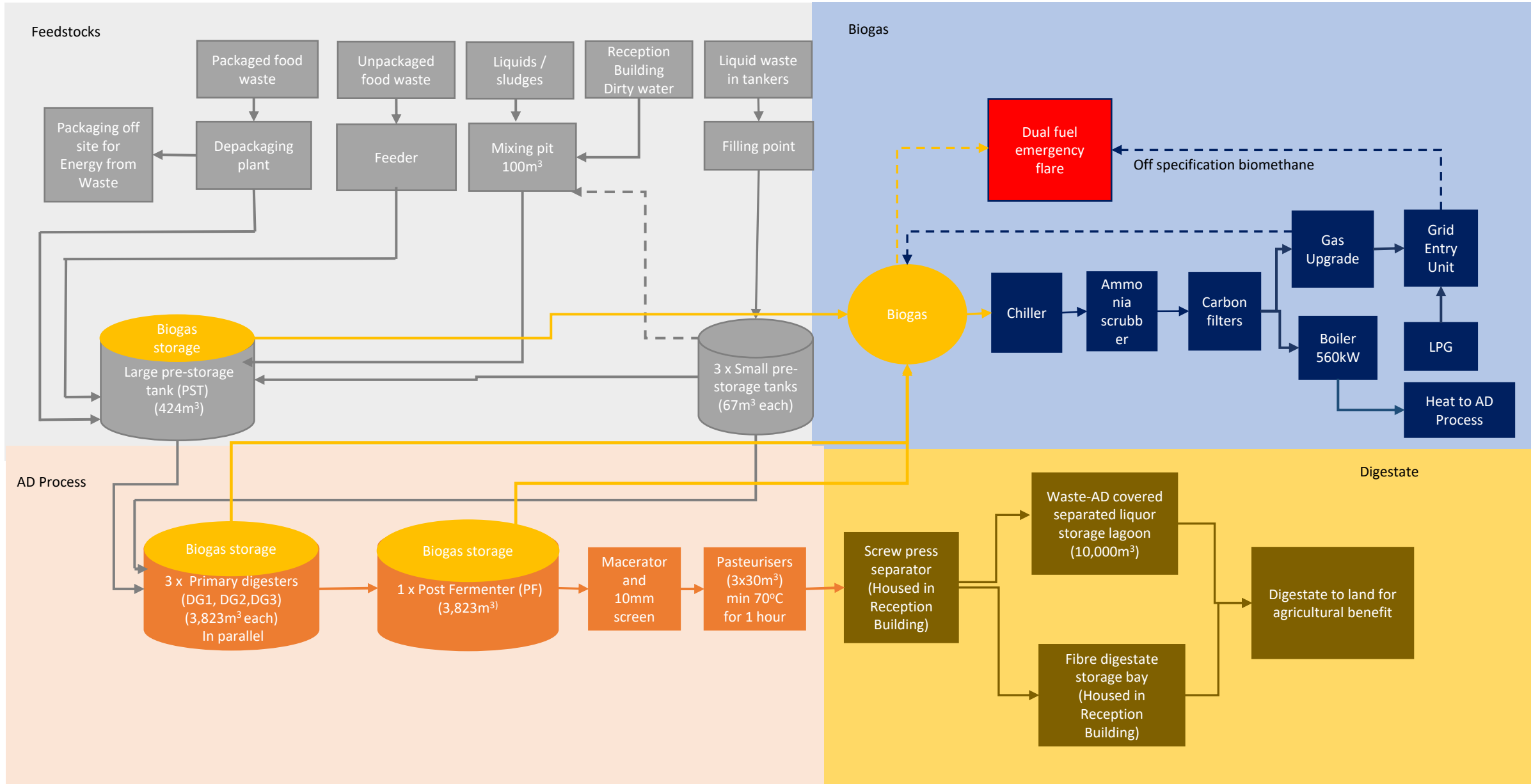
Drawing Title:
Proposed Site Layout

Scale: U.N.O.	Date: January 2020	Drawn By: TOH
Drawing No: 24727/005	Rev: K	

Appendix B Process Flow Diagrams



Waste-AD Plant



Appendix C Model and Model Set-up

C.1 Meteorology and associated parameters

Hourly meteorological data

The model uses hourly data of surface meteorology parameters that are typically measured at a synoptic station or are generated by a numerical model. In this assessment, five years' of data were obtained for the nearest synoptic station, RAF Marham,²⁷ 33km to the north-west of the Site. It is a flat, rural site and airfield.

Table 23 shows the location of the meteorological station and Figure 4 shows windroses for each year of data. The prevailing wind directions are west south-west and south-west. The data were used with the ADMS 5 calms option. Table 23 shows the number of lines of usable data each year with and without calms option. Without the calms options the lowest percentage of usable lines was 97.0% and with the calms option 99.5%.

Defra's LAQM TG16¹⁷ contains cautionary guidance on use of data with less than 85% usable data in calculating for comparison with short-term AQS. The minimum value of usable data were far above this threshold.

Table 23 Meteorological station data and parameters

Parameter	Value	
Meteorological station name	RAF Marham	
Station location	TF 736090	
Year of data	Number of hours not used	Hours not used (%)
2015	8,520	8,784
2016	8,559	8,760
2017	8,534	8,718
2018	8,542	8,748
2019	8,532	8,784

Notes:

¹Parameters are: wind speed, wind direction, near-ground air temperature, cloud cover

Meteorological parameters

The ADMS model uses various meteorological parameters to represent the area at the meteorological station and the site of the Site. The key parameters that have been defined are the surface roughness and minimum Monin-Obuhkov length which are defined at the site of the meteorological data measurement (RAF Marham) and the dispersion site (the Wider Site).

- Surface roughness: this is related to land-use and the height of obstacles on the ground which give rise to mechanically-generated turbulence; and

²⁷ Air Pollution Services Ltd

- Minimum Monin-Obuhkov length: this is used to model the extent to which the urban heat island effect limits the most stable atmospheric conditions. Heat released from the urban area prevents the atmospheric boundary layer becoming very stable.

Table 24 shows the values of the parameters that can be selected in the model from a drop-down menu. Other, intermediate, values can be entered directly. The values selected for the meteorological data site and the Wider Site are given Table 25.

Table 24 ADMS 5 meteorological parameter values

Surface roughness		Minimum Monin-Obuhkov length	
Descriptor	Value (m)	Descriptor	Value (m)
Large urban areas	1.5	Large conurbations >1million	100m
Cities, woodland	1.0	Cities and large towns	30m
Parkland, open suburbia	0.5	Mixed urban/industrial	30m
Agricultural areas (max)	0.3	Rural areas (max) ¹	20m
Agricultural areas (min)	0.2	Small towns < 50,000	10m
Root crops	0.1	Rural areas (min) ¹	2m
Open grassland	0.02		
Short grass	0.005		
Sea	0.0001		

Notes: ¹ Not available from the ADMS drop-down menu

Table 25 Meteorological site and wide Site met parameters

Parameter	Meteorological data site	Wider Site
Surface roughness	0.2m	0.3m
Minimum Monin-Obuhkov length	2m	2m

C.2 Buildings

The presence of buildings close to an emission point can affect the dispersion from a source, bringing the plume centreline down towards the ground in the lee of a building and entraining pollutant into the cavity (or, recirculation) region in the lee of a building. In the cavity, concentrations are assumed to be uniform and it may be a region of high concentrations depending on the amount of pollutant entrained. The presence of buildings may increase or decrease concentrations at a location compared with the no buildings scenario.

ADMS allows up to 25 buildings to be included as input and the model combines the relevant input buildings into one effective building; the effective building is calculated for each line of meteorological data. Buildings can only be circular or rectangular in cross-section so the buildings entered are simplified geometries. Buildings less than one third of the height of the stack will be ignored by the ADMS 5 model. Smaller Site structures such as the CHP container, have been neglected as their effect outside the Site will be limited compared with the larger digester structures, clamps and Crop-AD plant lagoon and Reception Building.

Table 26 shows the (simplified) parameters of the 11 buildings on site used as input to the model; they are shown in Figure 5.

In ADMS, for each stack a 'main' building must be specified; for each source the nearest building was specified as the main buildings. The sensitivity analysis did not show a significant impact of buildings on model predictions.

Table 26 Modelled buildings

Building name	Building centre X	Building centre Y	Height (m)	Length/ Diameter (m)	Width (m)	Orientation (°)
Reception Building	603357	295568	11.4	30.3	45.3	166.5
Clamps-lagoon	603285	295709	3	113	79.6	69.6
DG01	603329	295632	7.7	22.7	-	-
DG02	603308	295616	7.7	22.9	-	-
DG03	603330	295610	7.7	18.7	-	-
DG1	603355	295645	10.2	27.5	-	-
DG2	603385	295653	10.2	27.1	-	-
DG3	603392	295623	10.2	26.2	-	-
PF	603363	295615	10.2	26.9	-	-
DG3	603392	295623	10.2	26.2	-	-
PF	603363	295615	10.2	26.9	-	-

Notes:

Buildings with circular cross-section, such as the digesters, do not have a width and orientation specified

C.3 Terrain

The effect of complex terrain (hills) on dispersion has not been modelled as within +/-10km of the Site the terrain elevation varies by just 65m and the gradients around the Site are well below the 1:10 gradient used as a rule of thumb for trigger terrain modelling.

C.4 Receptors

The impact of stack emissions at relevant human and ecological receptors has been modelled. A relevant receptor is defined in Defra's LAQM TG16¹⁷ as:

'A location representative of human (or ecological) exposure to a pollutant, over a time period relevant to the objective that is being assessed against, where the Air Quality Strategy objectives are considered to apply.'

Human receptors

For long-term AQS the relevant receptors are residences (including care homes), schools and hospitals. For short-term AQS additional receptors may also need to be considered: outdoor spaces such as balconies, gardens, leisure sites and public space where human populations may spend the relevant time period. As most short-term AQS allow for a number of exceedances per annum, the human exposure may need to be repeated in order to be relevant. Workplaces are usually excluded from consideration as air quality in workplaces is covered by Health and Safety legislation.²⁸

²⁸ Health and Safety Executive EH40/2005 Workplace Exposure Limits (Fourth Edition 2020)

Table 27 shows the locations of the receptors selected to be representative of the relevant human receptors. H1 is a commercial premises, not residential, and therefore long-term AQS do not apply there.. All the receptors have been modelled at a height of 1.5m, representative of inhalation height (nose level) at ground level. Their locations are shown in Figure 6.

Table 27 Human receptors

ID	Location	NGR X	NGR Y	Distance from Site boundary (m)	Direction from Site
H1	Crowshall Veterinary Services	603479	295790	64	NE
H2	Stuart House	603530	295863	135	NE
H3	Houses at Cakes Hill	603486	295927	200	NE
H4	Crowshall Lane	603463	296047	320	NE
H5	Ellingham Road	603296	296176	399	N
H6	Suggit Farm Serv	603174	296152	402	N
H7	St Lukes Hospital	603013	296096	408	N
H8	Cades Hill Farm	602860	296089	492	NW
H9	Shrugg's Lane	602783	295883	440	NW
H10	Lyng Farm	602487	295286	830	SW
H11	WwTW	602861	295200	527	SW
H12	Houses along West Carr Road, Workhouse Common	603119	294819	720	SW
H13	Carver's Lane, Attleborough 1	603528	294910	623	S
H14	Carver's Lane, Attleborough 2	603583	295146	416	S
H15	Carver's Lane, Attleborough 3	603683	295248	343	S
H16	Chapel Road, Attleborough	603966	295468	375	SE
H17	Houses in Baconsthorpe	604061	295923	550	E
H18	Ash Farm	603151	296756	994	N

Notes: All modelled at a height of 1.5m.

Ecological receptors

Ecological receptors were placed in the designated areas at the nearest locations to the Site. Table 28 shows conservation sites identified within the specified distance²⁹ (2km for SSSIs, AW, CWS and 10km for SPAs, SACs, Ramsar) and their distance and direction from the Site. Table 29 lists the ecological receptors modelled which are illustrated in Figure 7.

Table 28 Sensitive conservation sites

Name	Designation	Distance from Site boundary (km)	Direction from Site
Swangey Fen	SSSI, SAC	2.66	SW
Norfolk Valley Fen	SAC	2.67	SW
Breckland	SPA	8.73	SW
Attleborough Wood	AW, CWS	1.59	NE
Attleborough Wood	CWS	1.50	NE

Table 29 Ecological receptors

ID	Site name	NGR X	NGR Y	Height (m)	Distance from boundary (km)	Direction from boundary
E1	Swangey Fens 1	601545	293505	1.5	2.677	SW
E2	Swangey Fens 2	600855	293505	1.5	3.144	SW
E3	Swangey Fens 3	601828	293007	1.5	2.906	SW
E4	Norfolk Valley Fen	594111	295955	1.5	9.124	SW
E5	Breckland 1	594881	293336	1.5	8.663	SW
E6	Breckland 2	594449	291765	1.5	9.603	SW
E7	Breckland 3	594799	288793	1.5	10.796	SW
E8	Attleborough Wood 1	604161	297193	1.5	1.585	NE
E9	Attleborough Wood 2	604217	297364	1.5	1.757	NE
E10	Attleborough Wood	604064	297135	1.5	1.499	NE

C.5 Post-processing

Use of background data

Considering long-term AQS, it is a straightforward matter to add the annual mean contribution from the source, (annual mean PC) to the annual mean background concentration to predict the total concentration (annual mean PEC).

For comparison with short-term AQS the addition of background is not so straightforward. The ADMS model allows for the calculation of percentiles from hourly background and process concentrations but hourly background concentrations are not commonly available, and not for all pollutants. The approach used was that described in the Defra permit guidance:¹¹

‘When you calculate background concentration, you can assume that the short-term background concentration of a substance is twice its long-term concentration.’

This has been used for all for short-term AQS for averaging times for 15 minutes to 24 hours.

Conversion of NO_x to NO₂

The ADMS model includes a NO_x chemistry model, but the conversion of primary NO_x emissions to NO₂ is usually undertaken as a post-processing step for industrial permitting applications. For primary NO₂ to NO_x ratios of 10% or less, which is likely to be the case for the stack emissions, the Environment Agency and Natural Resources Wales³⁰ recommend use of the following conversion ratios:

- 35% for short term assessment
- 70% for long term assessment.

³⁰ <https://www.gov.uk/guidance/specified-generators-dispersion-modelling-assessment#nosubxsub-to-nosub2sub-conversion-ratios-to-use>

These ratios have been used in this assessment.

Conversion of TVOC to benzene

Emissions are specified as TVOC for which there are no AQS. There is an AQS for benzene, one component of TVOC. An AEA Technology report on the Speciation of UK emissions of non-methane volatile organic compounds (2002)² reported on a series of VOC species profiles available for stationary combustion sources, covering a range of both fuel types and scale of combustion. The benzene fraction in industrial and commercial combustion of natural gas was reported to be less than 10%, therefore the TVOC concentrations at receptors has been modelled as 10% benzene.

Deposition to ecological receptors

The ADMS model includes the ability to calculate the deposition flux rate (deposition) of pollutants, but the Environment Agency recommends deposition be calculated as a post-processing step in order to give conservative estimates of both ground level concentration and deposition, by assuming no loss of pollutant from air concentration to ground deposition.

Deposition may be 'dry' or 'wet'. Dry deposition of gases occurs due to diffusive motions and removal at surfaces, primarily the ground. It is characterised by a deposition velocity that depends on the pollutant and the nature of the surface.

Table 30 gives the deposition velocities for grassland and forest for the pollutants included in this assessment which are the values recommended by AQTAG 06.¹⁶ The values for grassland, which are lower than those for forest, have been used to represent deposition at all receptors.

Wet deposition occurs when precipitation washes pollutants out of the air. Some pollutants have a low solubility, and in addition, wet deposition is considered to be of limited importance close to the source. Wet deposition has been neglected.

Table 30 Dry deposition velocities

Pollutant	Deposition velocity (m/s)	
	Grassland	Forest
NO ₂	0.0015	0.003
SO ₂	0.012	0.024
NH ₃	0.020	0.030

Deposition ($\mu\text{g}/\text{m}^2/\text{s}$) is calculated by multiplying the near ground air concentration ($\mu\text{g}/\text{m}^3$) by deposition velocity.

Ecological receptors are sensitive to deposition of nitrogen (nutrient nitrogen) and to deposition of acid species including nitrogen (N), sulphur (S) and HCl. To convert from deposition of a pollutant to deposition of a species, the conversion factors given in Table 31 were used.

Nutrient nitrogen deposition is calculated as the total deposition of N in kg/ha/year, due to NO₂ and NH₃.

Table 31 Conversion factors for deposition of species N, S

Pollutant	Species deposited	Conversion factor from deposition of pollutant ($\mu\text{g}/\text{m}^2/\text{s}$) to deposition of species ($\text{kg}/\text{ha}/\text{year}$)
NO ₂	N	96
SO ₂	S	157.7
NH ₃	N	259.7

To convert from deposition of N or S deposited to equivalent acidification units, a measure of how acidifying the chemical species can be, ($\text{keq}/\text{ha}/\text{year}$), the conversion factors given in Table 32 were used.

Table 32 Conversion factors for deposition of species deposition to acid equivalent

Species	Conversion factor from deposition of species ($\text{kg}/\text{ha}/\text{year}$) to deposition of equivalent acidification units ($\text{keq}/\text{ha}/\text{year}$)
N	0.071428
S	0.0625

Acid deposition is calculated taking into account the acidifying nitrogen and sulphur deposition, both expressed as $\text{keq}/\text{ha}/\text{year}$.

Appendix D CHP

Technical data**1560 kWel; 400 V, 50 Hz; Bio gas****Design conditions**

Comb. air temperature / rel. Humidity:	[°C] / [%]	25 / 60
Altitude:	[m]	100
Exhaust temp. after heat exchanger:	[°C]	180
NO _x Emission (tolerance - 8%):	[mg/Nm ³ @5%O ₂]	500

Genset:

Engine:	TCG2020V16	
Speed:	[1/min]	1500
Configuration / number of cylinders:	[-]	V / 16
Bore / Stroke / Displacement:	[mm]/[mm]/[dm ³]	170 / 195 / 71
Compression ratio:	[-]	13,5
Mean piston speed:	[m/s]	9,8
Mean lube oil consumption at full load:	[g/kWh]	0,2
Engine-management-system:	[-]	TEM EVO

Generator:	Marelli MJB 500 MD4	
Voltage / voltage range / cos Phi:	[V] / [%] / [-]	400 / ±5 / 1
Speed / frequency:	[1/min] / [Hz]	1500 / 50

Fuel gas data: ²⁾

Methane number:	[-]	149
Lower calorific value:	[kWh/Nm ³]	4,986
Gas density:	[kg/Nm ³]	1,35
Standard gas: Bio gas		
Analysis: CO ₂	[Vol%]	50
N ₂	[Vol%]	0
O ₂	[Vol%]	0
H ₂	[Vol%]	0
CO	[Vol%]	0
CH ₄	[Vol%]	50
C ₂ H ₆	[Vol%]	0
C ₃ H ₈	[Vol%]	0
C ₄ H ₁₀	[Vol%]	0
C _x H _y	[Vol%]	0
H ₂ S	[Vol%]	0

Energy balance

Load:	[%]	100	75	50
Electrical power COP acc. ISO 8528-1:	[kW]	1560	1170	780
Engine jacket water heat:	[kW ±8%]	838	627	446
Intercooler LT heat:	[kW ±8%]	129	88	55
Lube oil heat:	[kW ±8%]			
Exhaust heat with temp. after heat exchanger:	[kW ±8%]	790	647	488
Exhaust temperature:	[°C]	485	509	539
Exhaust mass flow, wet:	[kg/h]	8304	6263	4322
Combustion mass air flow:	[kg/h]	7281	5479	3771
Radiation heat engine / generator:	[kW ±8%]	53 / 45	52 / 35	45 / 28
Fuel consumption:	[kW+5%]	3787	2900	2037
Electrical / thermal efficiency:	[%]	41,2 / 43,0	40,3 / 43,9	38,3 / 45,8
Total efficiency:	[%]	84,2	84,3	84,1

System parameters ¹⁾

Ventilation air flow (comb. air incl.) with ΔT = 15K	[kg/h]	39300
Combustion air temperature minimum / design:	[°C]	20 / 25
Exhaust back pressure from / to:	[mbar]	30 / 50
Maximum pressure loss in front of air cleaner:	[mbar]	5
Zero-pressure gas control unit selectable from / to: ²⁾	[mbar]	20 / 200
Pre-pressure gas control unit selectable from / to: ²⁾	[bar]	0,5 / 10
Starter battery 24V, capacity required:	[Ah]	430
Starter motor:	[kWel.] / [VDC]	15 / 24,0
Lube oil content engine / base frame:	[dm ³]	265 / -
Dry weight engine / genset:	[kg]	6090 / 12600

Cooling system

Glycol content engine jacket water / intercooler:	[% Vol.]	35 / 35
Water volume engine jacket / intercooler:	[dm ³]	151 / 20
KVS / Cv value engine jacket water / intercooler:	[m ³ /h]	46 / 30
Jacket water coolant temperature in / out:	[°C]	80 / 93
Intercooler coolant temperature in / out:	[°C]	50 / 54
Engine jacket water flow rate from / to:	[m ³ /h]	50 / 65
Water flow rate engine jacket water / intercooler:	[m ³ /h]	59 / 35
Water pressure loss engine jacket water / intercooler:	[bar]	1,7 / 1,4

1) See also "Layout of power plants":

2) See also Techn. Circular 0199-99-3017

Engine noise level	Octave band centre frequency								Sum level (distance 1 meter)
	63	125	250	500	1000	2000	4000	8000	
Exhaust noise [dB(lin)]	117	127	118	116	113	112	110	103	120 dB(A) (±2,5 dB(A))
Air-borne noise [dB(lin)]	94	96	99	100	102	100	107	104	111 dB(A) (±1,0 dB(A))

Report for the Periodic Monitoring of Emissions to Air from the MWM Engine Stack Located at Crows Hall AD Site, Attleborough

Part 1: Executive Summary

Permit Number: BB3931RA

Operator: Attleborough Eco Electric Ltd

Installation: MWM CHP Engine



4251

Monitoring dates: 12th March 2021

Job Number: **R21120**

Version: 1

Client Address: **Attleborough Eco Electric Ltd**

Ellingham Road

Attleborough

Norfolk, NR17 1AE

Monitoring Organisation: **EnviroDat Ltd**

Address: Cutbush Commercial

Cutbush Lane East

Reading, RG2 9AF

Date of Report: 6th April 2021

Report Approved By: David Littlewood

MCERTS Registration Number: MM06 772 Level II (TE1, 2, 3 & 4)

Function: Operations Manager (Team Leader)



Signed:

CONTENTS

Page No.

PART 1: EXECUTIVE SUMMARY

1.1 Monitoring Objectives	3
1.2 Monitoring Results	4
1.3 Operating Information	5
1.4 Monitoring Deviations	5

PART 2: SUPPORTING INFORMATION

2.1 Appendix I: General Information	6
2.2 Appendix II: Emission Point Reference Data & Results	8
2.3 Appendix III: Uncertainty Calculations	13
2.4 Appendix IV: Moisture Calculations	15
2.5 Appendix V: Acid Gas Calculations	16

Notes to Report.

- a). EnviroDat Ltd, Report Template V12.
- b). This report should not be reproduced except in full, without written approval of Envirodat Ltd.
- c). Opinions and Interpretations herein are outside the scope of UKAS/MCerts Accreditation.

PART 1: EXECUTIVE SUMMARY

1.1 Monitoring Objectives

Attleborough Eco Electric Ltd operate a CHP Engine at its anaerobic digestion facility located at Attleborough. This combustion plant has the potential to pollute the atmosphere. These processes are subject to regulation under the environmental permitting regulations and periodic environmental monitoring is necessary for compliance.

Biogas is piped to a spark ignition engine plant (MWM engine). This plant combusts the gas and produces electricity which is then sold onto the National Grid. There is a gas flare that is used as a stand-by to burn off excess gas or for use during engine breakdown or maintenance.

EnviroDat Ltd was commissioned to monitor the pollutants within the engine emissions - as prescribed in the operational permit - in order to establish the sites environmental compliance.

The pollutants monitored, as required under BB3931RA, are summarised below:

Substances to be monitored	Emission Point Identification
	MWM CHP Engine
Oxides of Nitrogen (NO _x as NO ₂)	✓
Carbon Monoxide (CO)	✓
Total Volatile Organic Compounds (VOCs)	✓
Sulphur Dioxide (SO ₂)	✓
Moisture (for correction)	✓
Oxygen (for correction)	✓
Special requirements	None requested

1.2 Monitoring Results

Emission Point Reference	Substance to be Monitored	Emission Limit Value	Periodic Monitoring Result	Estimate of Uncertainty (2σ at 95% confidence)	Units	Reference Conditions	Date of Sampling	Start and End Times	Monitoring Method Reference	Accreditation for use of Method (see note below)	Operating Status
MWM CHP Engine	Oxides of Nitrogen (as NO ₂)	500	457	±12	mg(N)m ⁻³	101.3 kPa, 273K, dry gas, 5% O ₂	12/03/2021	10:45-11:45	BS EN 14792	A	At 87% capacity
	Carbon Monoxide	1400	674	±20	mg(N)m ⁻³				BS EN 15058	A	
	Volatile Organic Compounds (VOCs as carbon)	1000	472	±11	mg(N)m ⁻³				BS EN 12619	A	
	Sulphur Dioxide (SO ₂)	350	15.0	±1.0	mg(N)m ⁻³				BS EN 14791	B	
	Moisture	-	11.2	n/a	%	101.3 kPa, 273K, dry gas			BS EN 14790	A	
	Oxygen	-	7.06	±0.34	%				BS EN 14789	A	

NOTE:

- A. EnviroDat Ltd MCerts/UKAS Accredited for sampling and analysis.
- B. EnviroDat Ltd MCerts/UKAS Accredited for sampling only, UKAS Accredited analysis conducted by sub-contract laboratory.

1.3 Operating Information

Emission Point Reference	Date	Process Type	Process Duration	Fuel	Feedstock	Abatement	Load*	Comparison of Operator CEMS and Periodic Monitoring Results			
								Substance	CEMS Results	Periodic Monitoring Results	Units
MWM CHP Engine	12/03/21	Combustion	Continuous	Biogas	N/A	None	Producing 1361kW _e (87% MCR)	N/A	N/A	N/A	N/A

*obtained from client

1.4 Monitoring Deviations

Emission Point Reference	Substance Deviations	Monitoring Deviations	Other Relevant Issues
MWM CHP Engine	None	None	None

PART 2: SUPPORTING INFORMATION

2.1 Appendix I: General Information

2.1.1 Monitoring organisation staff details

Monitoring at Crows Hall AD Site was conducted by the following EnviroDat Engineers:

Team Leader, Daniel Taylor - Mcerts Level II (TE1, 2, 3 & 4) MM 16 1363

2.1.2 Monitoring method details

Parameter	Standard Reference Method/Alternative	EnviroDat Procedure	MCerts Accreditation
Oxides of Nitrogen (as NO ₂)	BS EN 14792	SP14792	MCerts
Carbon Monoxide (CO)	BS EN 15058	SP15058	MCerts
Volatile Organic Compounds (VOCs)	BS EN 12619	SP12619	MCerts
Sulphur Dioxide (SO ₂)	BS EN 14791	SP14791	MCerts
Moisture (H ₂ O)	BS EN 14790	SP14790	MCerts
Oxygen (O ₂)	BS EN 14789	SP14789	MCerts

2.1.3 Monitoring organisation equipment and gas check list references

EQUIPMENT – LJ62 GHV			
Item	Reference	Calibration Due	PAT Due
Portable Gas Analyser	PGA#04	27-Aug-21	Nov-21
Flame Ionisation Detector Analyser	FID#06	21-May-21	Nov-21
Gas Conditioner	COND#07	04-Mar-22	Nov-21
Data Logger	DL#02	26-Nov-21	Nov-21

Item	Reference	Calibration Due	PAT Due
Digital Barometer	DB#25	27-Aug-21	-
NOx Converter	CONV#07	23-Jul-21	Nov-21
Balance	BAL#03	30-Mar-21	-
Heated Line	HL#03B	03-May-21	Nov-21
Heated Line Controller	HLC#05	03-May-21	Nov-21
Heated Filter Holder	HFH#05	05-Jan-22	Nov-21
Method 5 Console	APEX#05	See each item	Nov-21
Dry Gas Meter (APEX#05)	DGM#13	27-Aug-21	-
Thermocouple Reader (APEX#05)	TCR#21	19-Aug-21	-
Thermocouple Reader (APEX#05)	TCR#22	19-Aug-21	-
Thermocouple Reader (APEX#05)	TCR#23	19-Aug-21	-
Thermocouple Reader	TCR#19	17-Dec-21	-
Manometer (APEX#05 Yellow)	MAN#11	29-Aug-21	-
Manometer (APEX#05 Red)	MAN#10	29-Aug-21	-
Timepiece (APEX#05)	TP#19	29-Aug-21	-
Timepiece	TP#07	26-Nov-21	-
Thermocouple (APEX#05 Dogleg Exit)	TC#21	26-Jul-21	-
Thermocouple (APEX#05 Dry Gas Meter)	TC#47	29-Aug-21	-

GAS CYLINDERS – LJ62 GHV			
Item	Certificate No.	Level (ppm)	Validity
Nitrogen Zero Gas (%)	VC7661226	99.999%	-
Carbon Monoxide Span Gas	VC5872	1199	06-Dec-21
Nitric Oxide Span Gas	VC5872	262.0	06-Dec-21
Oxygen Span Gas (%)	VCDY0097	8.22%	06-Jul-21
VOC Span Gas	VCDY0097	618	06-Jul-21

2.2 Appendix II: Emission Point Reference Data & Results

2.2.1 Photograph of Sampling Location on MWM CHP Engine



Stack sampled from a 20mm port located on engine container roof. Stack of circular cross-section and 0.58m in diameter. Access to container roof via hooped ladder.

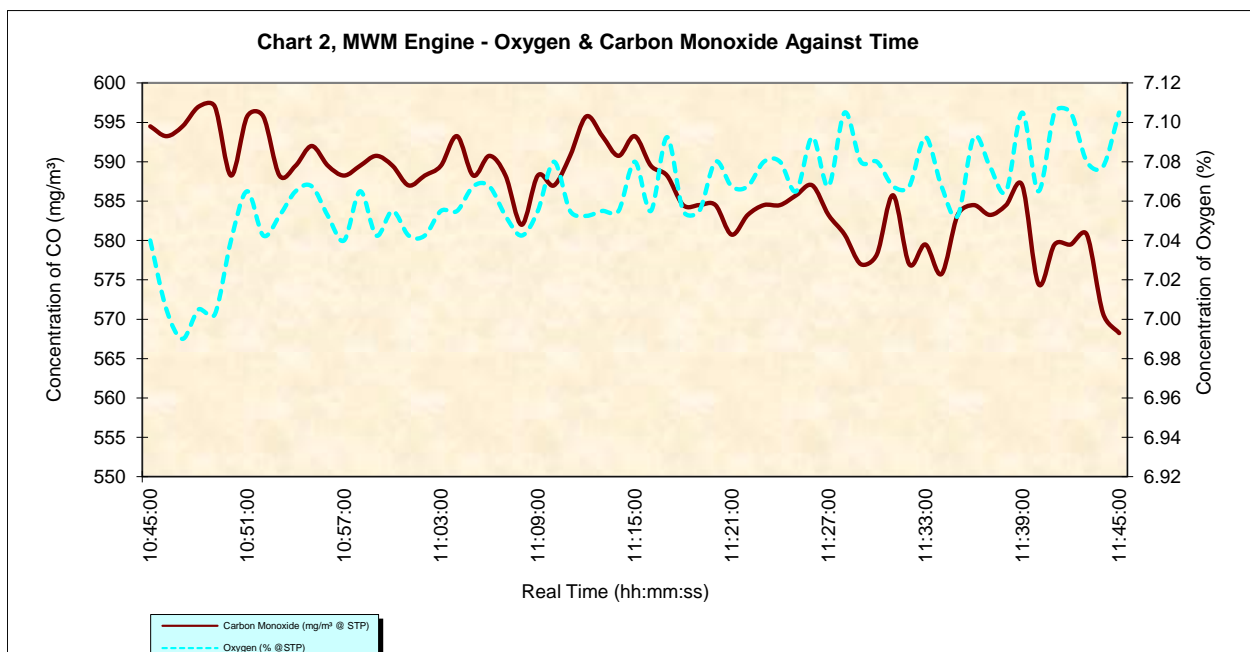
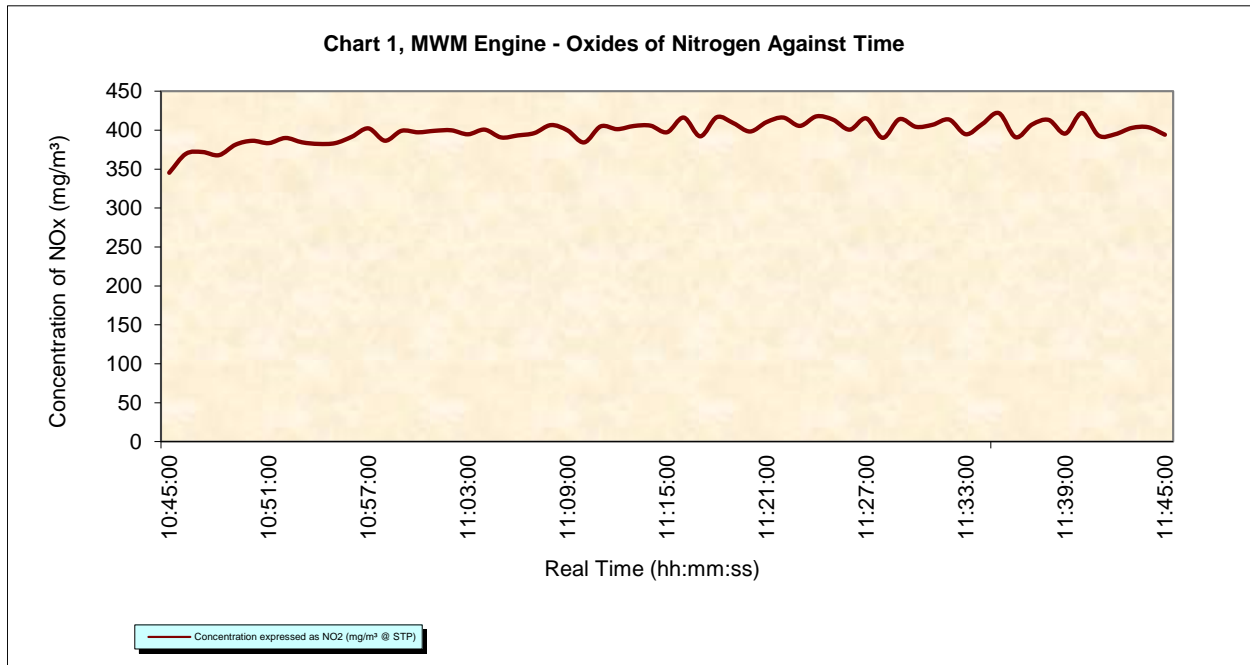
2.2.2 Homogeneity testing

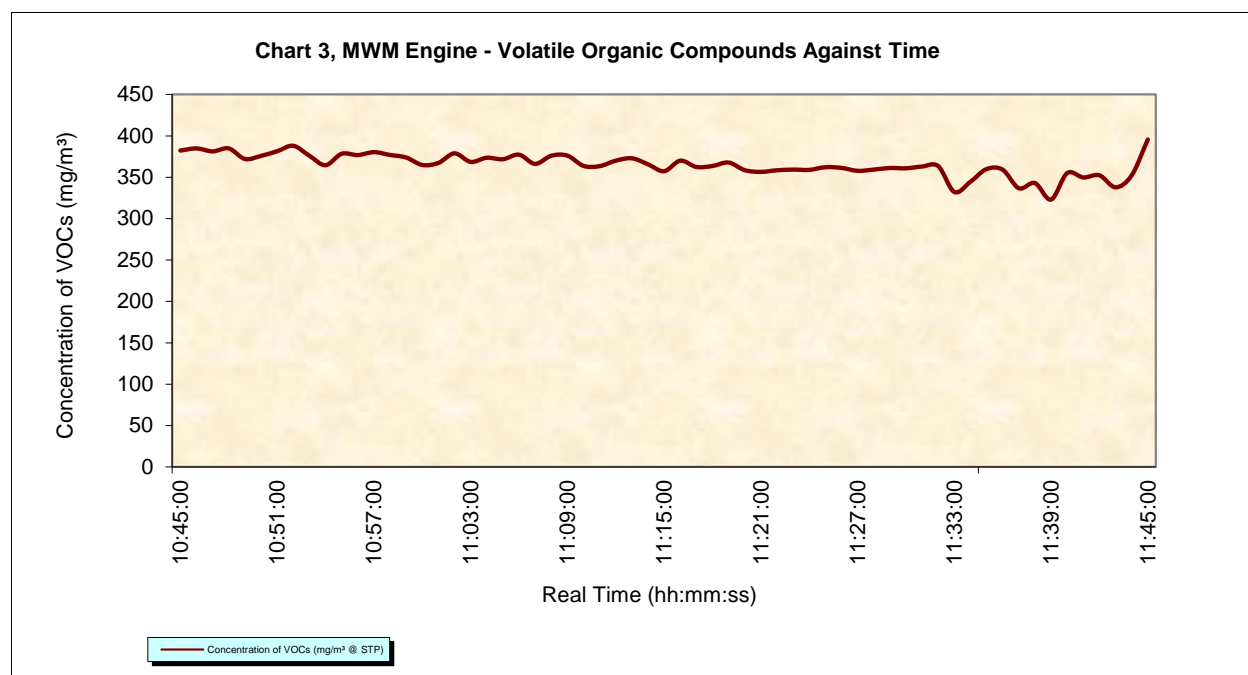
BS EN 15259 stipulates that the exhaust gases emitted from combustion processes are tested to ensure homogeneity and that a representative sample is obtained during the monitoring, subject to a number of caveats as elucidated in Environment Agency guidance MID15259. The details of the testing at each emission point are summarised below:

Stack	Result of Homogeneity Testing
MWM CHP Engine	N/A – homogeneity testing only required on stacks exceeding 1.13 m diameter, as specified in MID 15259. Homogeneity assumed & single point sampling acceptable.

2.2.3 Gas analyser site measurements and calibrations

The data in the following Charts 1 - 3 and in Table 2 are expressed in mgm^{-3} @ STP and is uncorrected for O_2 . In addition, VOC results are expressed as carbon equivalent. This data was subsequently converted to reference oxygen concentrations (Section 1.2) with the addition of moisture correction for VOCs. Calibration data is shown in Table 1.



**Table 1 – MWM CHP Engine, Calibration Data**

ANALYSER CALIBRATION DATA					
Pre Sampling Check					
		NO (ppm)	CO (ppm)	O ₂ (%)	VOC's (ppm)
Range		500	2000	25	1000
Zero Gas	Cylinder No.	VC7661226			Scrubbed Air
Span Gas	Cylinder No.	VC5872	VC5872	VCDY0097	VCDY0097
	Certified Value	262	1199	8.22	618
Zero Check	Value	0.2	1	0.01	0
	Within 2% of span	YES	YES	YES	YES
Down Line Zero & Span Check					
Zero Gas	Value	0.4	2	0.11	1
	<2% of span	YES	YES	YES	YES
Span Gas	Value	261.1	1195	8.29	615
	Within 2% of span	YES	YES	YES	YES
Post Sampling Drift Check					
Zero Gas	Value	0.2	1	0.04	1
	Drift (%)	0.1	0.1	0.5	0.0
	Validation	No Correction Required	No Correction Required	No Correction Required	No Correction Required
Span Gas	Value	263.2	1205	8.23	616
	Drift (%)	0.4	0.4	0.4	0.2
	Validation	No Correction Required	No Correction Required	No Correction Required	No Correction Required

Table 2 – MWM CHP Engine, Raw Data

Time	Oxygen (%)	VOC (mgC/m ³)	CO (mg/m ³)	NO _x (mg/m ³)	Comment
10:45:00	7.0	382.2	594.5	345.4	
10:46:00	7.0	384.8	593.3	369.6	
10:47:00	7.0	381.2	594.5	372.0	
10:48:00	7.0	384.8	597.0	368.0	
10:49:00	7.0	372.1	597.0	381.5	
10:50:00	7.0	375.8	588.3	386.4	
10:51:00	7.1	381.4	595.8	383.4	
10:52:00	7.0	388.0	595.8	390.0	
10:53:00	7.1	375.9	588.3	384.4	
10:54:00	7.1	364.5	589.5	382.4	
10:55:00	7.1	378.3	592.0	383.4	
10:56:00	7.1	376.7	589.5	391.5	
10:57:00	7.0	380.3	588.3	402.3	
10:58:00	7.1	376.9	589.5	386.5	
10:59:00	7.0	373.8	590.8	399.2	
11:00:00	7.1	364.8	589.5	397.3	
11:01:00	7.0	367.2	587.0	399.2	
11:02:00	7.0	378.8	588.3	399.8	
11:03:00	7.1	368.5	589.5	394.7	
11:04:00	7.1	373.5	593.3	400.7	
11:05:00	7.1	371.7	588.3	390.7	
11:06:00	7.1	377.2	590.8	393.3	
11:07:00	7.1	366.1	588.3	396.2	
11:08:00	7.0	375.9	582.0	406.5	
11:09:00	7.1	376.1	588.3	399.7	
11:10:00	7.1	363.7	587.0	384.3	
11:11:00	7.1	363.4	590.8	404.9	
11:12:00	7.1	370.0	595.8	401.3	
11:13:00	7.1	372.9	593.3	405.4	
11:14:00	7.1	365.6	590.8	405.8	
11:15:00	7.1	357.3	593.3	397.4	
11:16:00	7.1	370.0	589.5	416.2	
11:17:00	7.1	362.4	588.3	392.1	
11:18:00	7.1	363.5	584.5	416.7	
11:19:00	7.1	367.7	584.5	409.0	
11:20:00	7.1	358.6	584.5	398.3	
11:21:00	7.1	356.5	580.8	410.4	
11:22:00	7.1	358.4	583.3	416.2	
11:23:00	7.1	359.2	584.5	405.5	
11:24:00	7.1	358.9	584.5	417.7	
11:25:00	7.1	362.1	585.8	413.5	

Time	Oxygen (%)	VOC (mgC/m ³)	CO (mg/m ³)	NO _x (mg/m ³)	Comment
11:26:00	7.1	361.3	587.0	400.7	
11:27:00	7.1	357.8	583.3	415.1	
11:28:00	7.1	359.2	580.8	390.2	
11:29:00	7.1	361.1	577.0	414.1	
11:30:00	7.1	360.8	578.3	404.2	
11:31:00	7.1	362.9	585.8	406.9	
11:32:00	7.1	363.4	577.0	413.6	
11:33:00	7.1	332.2	579.5	394.8	
11:34:00	7.1	344.6	575.8	407.9	
11:35:00	7.1	359.8	583.3	421.8	
11:36:00	7.1	359.0	584.5	391.0	
11:37:00	7.1	336.7	583.3	407.3	
11:38:00	7.1	343.0	584.5	413.1	
11:39:00	7.1	323.0	587.0	395.6	
11:40:00	7.1	355.0	574.5	421.9	
11:41:00	7.1	349.7	579.5	393.2	
11:42:00	7.1	352.3	579.5	394.8	
11:43:00	7.1	337.8	580.8	402.8	
11:44:00	7.1	352.3	570.8	403.7	

2.3 Appendix III: Uncertainty Calculations

2.3.1 MWM CHP Engine, Uncertainty Calculations

NOx - Measurement performance related to stationary conditions		
Performance characteristic	Uncertainty	Value of uncertainty quantity
Standard deviation of repeatability at zero	U_{r0}	0.80
Standard deviation of repeatability at span level	U_{rs}	0.10
Lack of fit	U_{rlt}	2.37
Drift	U_{odr}	0.70
volume or pressure flow dependence	U_{spres}	0.06
atmospheric pressure dependence	U_{apres}	1.18
ambient temperature dependence	U_{temp}	0.17
NH ₃ (20 mg/m ³)	U_{interf}	0.14
CO ₂ (15%)	-	0.02
H ₂ O (30%)	-	0.01
Error in logger voltage	-	0.50
Dependence on voltage	U_{volt}	0.03
Converter efficiency	U_{ceff}	1.84
losses in the line (leak)	U_{leak}	1.38
Uncertainty of calibration gas	U_{calib}	4.60

NOx Measurement uncertainty		Result	
Combined uncertainty		5.85	mg/m ³
Expanded uncertainty	k = 2	11.70	mg/m ³
Uncertainty corrected to std conds		11.70	mg.m-3 (corrected)
Expanded uncertainty expressed with a level of confidence of 95%		2.34 % ELV	
Expanded uncertainty expressed with a level of confidence of 95%		11.70 mg.m⁻³ of result	

CO - Measurement performance related to stationary conditions		
Performance characteristic	Uncertainty	Value of uncertainty quantity
Standard deviation of repeatability at zero	U_{r0}	0.80
Standard deviation of repeatability at span level	U_{rs}	0.10
Lack of fit	U_{rlt}	5.77
Drift	U_{odr}	1.57
volume or pressure flow dependence	U_{spres}	0.00
atmospheric pressure dependence	U_{apres}	2.31
ambient temperature dependence	U_{temp}	0.00
CO ₂ (15%)	U_{interf}	0.00
N ₂ O (40mgm ³)	-	0.00
CH ₄ (57mgm ³)	-	0.00
H ₂ O (1%)	-	0.00
Dependence on voltage	U_{volt}	0.03
Error in Logger reading	-	2.00
losses in the line (leak)	U_{leak}	2.03
Uncertainty of calibration gas	U_{calib}	6.77

CO Measurement uncertainty		Result	
Combined uncertainty		586.68	mg/m ³
Expanded uncertainty	k = 2	9.76	mg/m ³
Uncertainty corrected to std conds		19.51	mg/m ³
Expanded uncertainty expressed with a level of confidence of 95%		1.39 % ELV	
Expanded uncertainty expressed with a level of confidence of 95%		19.51 mg.m⁻³ of result	

VOC - Measurement performance related to stationary conditions		
Performance characteristic	Uncertainty	Value of uncertainty quantity
Standard deviation of repeatability at zero	U_{r0}	0.80
Standard deviation of repeatability at span level	U_{rs}	0.10
Lack of fit	U_{rf}	3.74
Drift	U_{odr}	0.21
volume or pressure flow dependence	U_{spres}	0.00
atmospheric pressure dependence	U_{apres}	1.50
ambient temperature dependence	U_{temp}	0.00
NH ₃ (20 mg/m ³)	U_{interf}	0.00
CO ₂ (15%)	-	0.00
H ₂ O (30%)	-	0.00
Error on Logger voltage	-	1.00
Dependence on voltage	U_{volt}	0.03
losses in the line (leak)	U_{leak}	1.26
Uncertainty of calibration gas	U_{calib}	3.45

VOC Measurement uncertainty		Result	
Combined uncertainty		364.62	mg/m ³
Expanded uncertainty		5.55	mg/m ³
Expanded uncertainty	k = 2	11.10	mg/m ³
Uncertainty corrected to std conds		11.10	mg.m-3 (corrected)
Expanded uncertainty expressed with a level of confidence of 95%		1.11 % ELV	
Expanded uncertainty expressed with a level of confidence of 95%		11.10 mg.m ³ of result	

Oxygen - Measurement performance related to stationary conditions		
Performance characteristic	Uncertainty	Value of uncertainty quantity
Standard deviation of repeatability at zero	U_{r0}	0.20
Standard deviation of repeatability at span level	U_{rs}	0.03
Lack of fit	U_{rf}	0.08
Drift	U_{odr}	0.11
volume or pressure flow dependence	U_{spres}	0.00
atmospheric pressure dependence	U_{apres}	0.01
ambient temperature dependence	U_{temp}	0.03
CO ₂ (15%)	-	0.00
NO ₂ (300)	-	0.06
NO ₂ (30)	-	0.00
dependence on voltage	U_{volt}	0.02
losses in the line (leak)	U_{leak}	0.02
Error in Logger voltage	-	0.03
Uncertainty of calibration gas	U_{calib}	0.07

O ₂ Measurement uncertainty		Result	
Combined uncertainty		7.06	%vol
Expanded uncertainty		0.17	%vol
% of value		2.44	%
Expanded uncertainty expressed with a level of confidence of 95%		4.88 % of value	
Expanded uncertainty expressed with a level of confidence of 95%		0.34 % vol	

Parameter	Value	Units	Sensitivity coeff	Uncertainty contribution	Uncertainty as %
Corrected Volume (standard conditic	V	0.45 m ³	28.99	0.16 mg.m ⁻³	1.19 %
Mass	m	9.55 mg	1.37	0.43 mg.m ⁻³	3.29 %
Factor for O2 Correction	fc	1.15	11.39	0.16 mg.m ⁻³	1.24 %
Leak	L	0.15 mg.m ⁻³	1.00	0.15 mg.m ⁻³	1.15 %
Combined uncertainty				0.51 mg.m ⁻³	
Expanded uncertainty as percentage of measured value		7.78 % measured of value		expressed with a level of confidence of 95% (Using a coverage factor k=2)	
Expanded uncertainty in units of measurement		1.02 mg.m ⁻³			
Expanded uncertainty as percentqge of limit value		0.29 % ELV			

2.4 Appendix IV: Moisture Calculations

2.4.1 MWM CHP Engine, Moisture Calculation

Test No	T2
Date	12-3-21
pbar (mbar)	993
pbar (mmHg)	745
Nozzle Diameter (mm)	n/a
Temp of Meter (in)/(out) °C	17
DH _{ave} (mmH ₂ O)	10.0
DGM Cal Factor (Y)	1.0239

Site	Attleborough Eco Electric Crows Hall AD Site
Stack	MWM Engine
Job Number:	R21120
Site Team:	DT
Data Entered By:	DT

Start Volume Reading	679.3530	m³
End Volume Reading	679.8700	m³
Volume Sampled	0.5294	m³

Start time	10:45	hr:min
End time	11:45	hr:min
Total time	01:00	hr:min

IMPINGER	1	2	3	4	Initials of Analyst
Absorber Solution (Type):	H ₂ O	H ₂ O	KO IMP	SILICA	
Sample No:	T2A		T2B	n/a	
Analysis Required:	Sulphate			n/a	
Initial Weight of Impingers plus absorber (g)	822.4	821.2	829.2	870.2	DT
Final Weight of Impingers plus absorber (g)	863.0	825.1	829.4	875.1	DT
Weight Gain (g)	40.6	3.9	0.2	4.9	

Total Weight Gain (1+2+3+4) (g)	49.6
---------------------------------	------

Gas Volume of water at 0°C and 101.3kPa (l)	61.75
Gas Meter volume at 0°C and 101.3kPa (l)	488.97

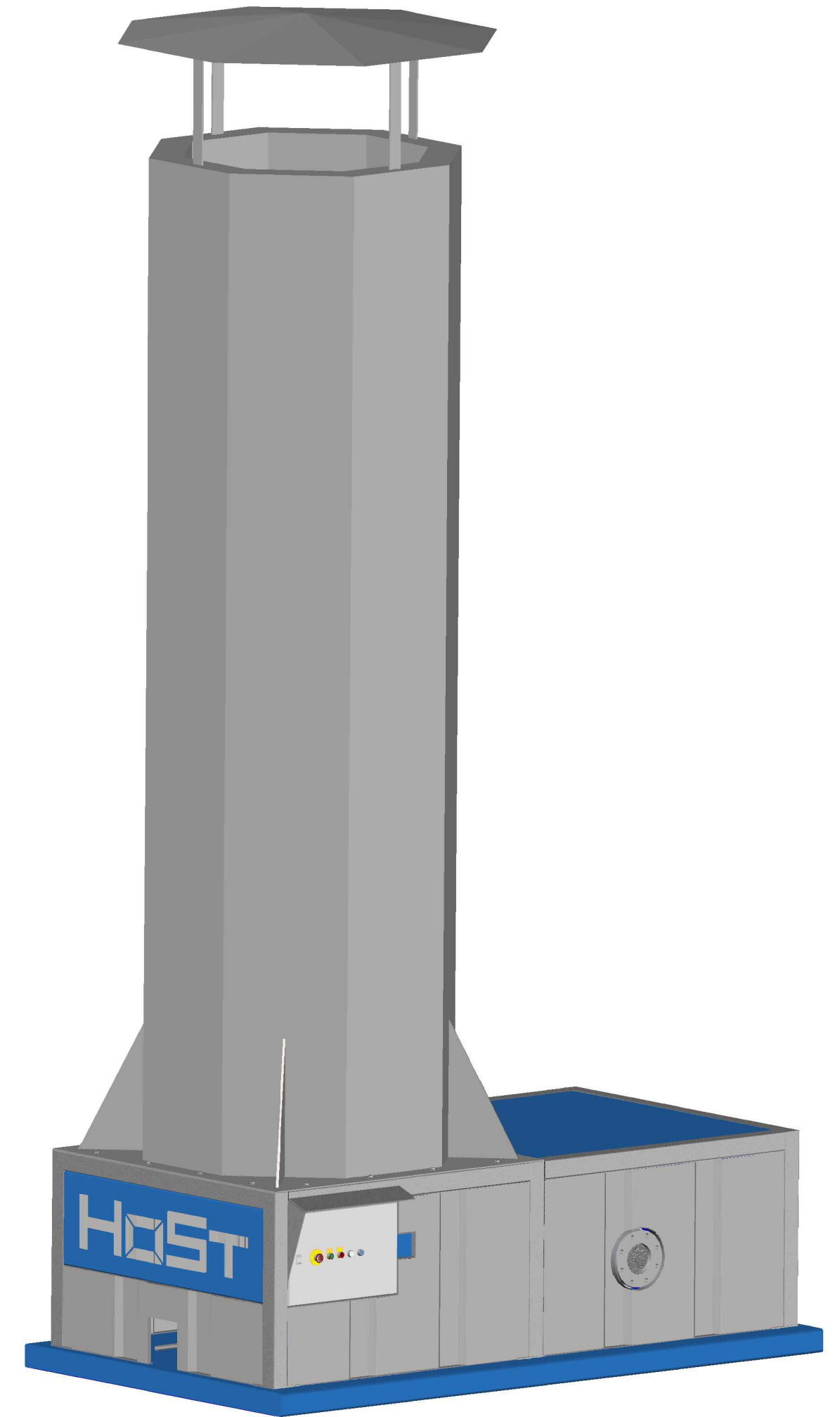
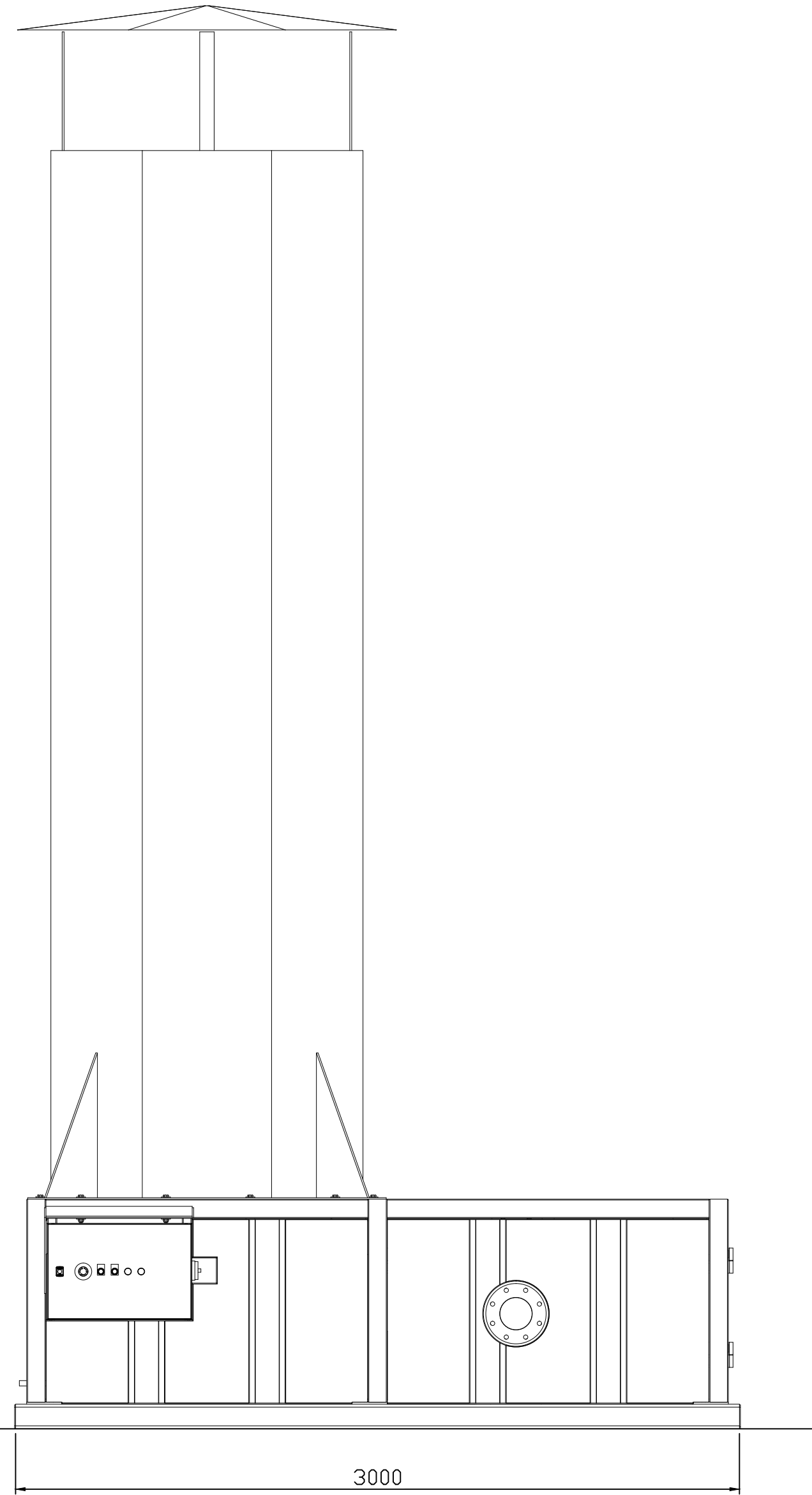
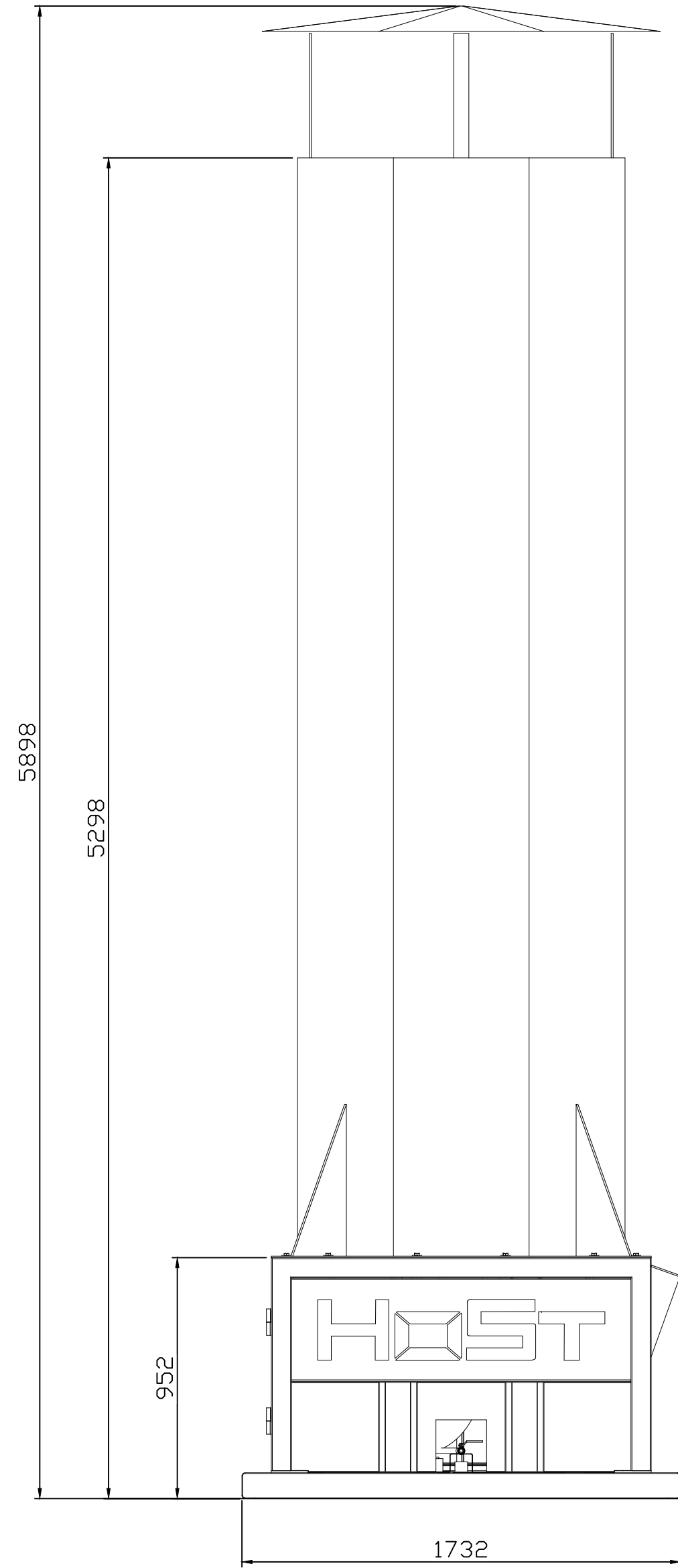
Moisture content of Gases (%)	11.2
-------------------------------	------


2.5 Appendix V: Acid Gas Calculations

2.5.1 MWM CHP Engine, Sulphur Dioxide Calculations

SUMMARY OF ACID GAS IMPINGEMENT SAMPLING			
Stack ID		MWM Engine	
Stack Dimensions (m)		0.58	
Date of Test		12-Mar-21	12-Mar-21
TEST NUMBER		T1	T2
	Applied Standard	BS EN 14791	
Start Time (hh:mm)		10:15	10:45
Stop Time (hh:mm)		10:21	11:45
Duration (minutes)		5	60
Sampled Gas Volume (m ³)		Field Blank	0.5170
Mean Temperature DGM (°C)			17.00
Mean Sample Pressure (mmH ₂ O)			10.00
Corrected Sampled Gas Vol. (Sm ³ @20°C)			0.5250
Corrected Sampled Gas Vol. (Nm ³ @STP)			0.4892
Average Flowrate (l/min @STP)			8.15
Required Pollutant (eg:HCl, HF or SO ₂)		SO ₂	
Molecular Weight Pollutant		64	64
Determinant Species		Sulphate	
Molecular Weight Determinand		96	96
	Analysing Laboratory UKAS No.	0605	
Measured concentration(Front) (ug/ml)		0.2	25.8
Solution Sample Volume (ml)		290.0	370.0
Measured concentration(Back) (ug/ml)		0.2	0.4
Solution Sample Volume (ml)		145.0	150.0
	Efficiency of Capture (%)	N/A	99.42%
Total Determinand Mass (mg)		0.103	9.602
Moles of Determinand (mol)		0.001	0.100
Mass of Pollutant (mg)		0.07	6.40
Concentration (@ STP, Dry) (mg/m ³)		0.14	13.08
Stack Moisture (%)v/v		11.20	11.20
Moisture Correction dim'less		1.13	1.13
Stack Oxygen (%)v/v		7.06	7.06
Oxygen Correction Factor dim'less		1.15	1.15
	Net Correction Factor dim'less	1.15	1.15
Concentration @ Ref (mg/(N)m ³)		0.16	15.03
Sample as a percentage of ELV (%)		0.05%	4.29%
Blank Value (mg/(N)m ³)		0.16	
Is Blank value < 10% of ELV		Yes	

Appendix E Crop-AD plant flare



Project: Gesloten stationaire fakkel 1000m³		Status: AS BUILT
Sectie:		Projectnummer:
		Tekeningnummer: 12.5.1.3.43A
 Postbus 184 7380 AD TWELLO T : 065-301.8300 F : 065-301.8350 E : info@var.nl W : www.var.nl		Afmeting: A2
		Getekend: DS
		Gezien:
		Schaal: NVT
alle rechten voorbehouden		Datum: 05-11-2012
alle Rechte vorbehalten		tous droits de reproduction reserves
copyright reserved		

Component:	Biogas flare				
Zone class:	2	Temperatuur groep:	T1	Explosie groep:	IIA
Zone dimension:	A spherical zone 2 with radius 5,6 meter from the outlet opening of the safety. The outlet opening is installed on the side of the digester.				

Process description:

* Normal operation situation:

The produced biogas is used in the CHP-installation.

By means of gas buffers on the primary digester(s) and the secondary digester, peaks in the gas production are levelled.

* Situation using the flare

The entire or a part of the biogas production is used by the flare.

Dependent of the operation, a situation can occur in which no or almost no biogas is used by the CHP.

For example at maintenance or repair activities a part or all of the biogas has to be burned off.

A zone is present at the top of the flare in the situation that the fan is in operation and the gas isn't ignited.

This will occur however for a very short periode (a few seconds), because at insufficient temperature that a temperature transmitter detects, the gas valve will be shut and the gas supply be shut off.

* Calamities

The flare is equipped with a ignition burner. If the flare doesn't ignite the gas supply to the main burner will be shut. The biogas will not be transported through the flare unburned.

As a result the gas buffer will be filled to it's maximum resulting in a raise of the gas pressure to 3,5 cmWK.

At this pressure the biogas will be emitted through the overpressure safety.

In the situation that for a longer period biogas needs to be burned off, the feed to the digester will be minimised.

After minimisation of the feed, the biogas installation will produced biogas for several time.

At a voltage cutoff, the burner valves of the flare will be closed and the biogas will be emitted through the overpressure safety. The flare is not connected to a separate voltage source.

Start-up procedure flae

The flare is started and controlled by an electric control unit. When the installation is started, the automatic shut-off valve opens and the ignition and ventilator are started. The ignition is continuously and will ignite the gas when it passes. The flare will started until the thermocouple is sufficiently heated by the flame.

The installation goes to automatic operation after sufficient heating of the thermocouple

When there is loss of flame the thermocouple cools down and the automatic shut-off valve (gas supply) will be closed. The cooling down of the thermocouple takes about 20 seconds.

Gas/vapour composition:	CH ₄	53%			
	CO ₂	46%			
	N ₂	1%			
	H ₂ S (ppm)	< 200			
Relative gas density:	1,05	LEL: (vol%)	5,3	UEL: (vol%)	15,0

FOUNDATIONS:

Component:	Biogas flare	
Category of the danger source:	Primary	
Argumentation:		
The following sources of release are identified:		
- Flange connection to the biogas supply	Release of gas during normal operation is not expected	Secondary grade of release
- Flanges automatic shut-off valve	Release of gas during normal operation is not expected	Secondary grade of release
- Flanges ventilator	Release of gas during normal operation is not expected	Secondary grade of release
- Ventilator seals	Release of gas during normal operation is not expected	Secondary grade of release
- Flanges manual valve	Release of gas during normal operation is not expected	Secondary grade of release
- Flange connection between upper and lower part of the flare	Release of gas during normal operation is not expected	Secondary grade of release
- Exit flare	Release of gas during normal start-up of the installation and during flame failure (20 s)	Primary grade of release
Ventilation circumstances	Open air circumstances	
Argumentation:		
The flare is placed in the open air.		
Flow of the danger zone:	smaller than	360 gram/second
Argumentation:		
The capacity of the flare is	1000 m3/h	
Average mole weight biogas [M]	29,05 g/mol	
1 nm3 =	44,61 mol	(= 1/ 22,4 x 1000)
1 nm3 =	1.296 gram	(= 44,64 x mole weight biogas)
Biogas production	1.296.063 gram/hour	(=gram biogas x biogas flow)
Biogas production	360 gram/sec	(= gram/hour / 3.600)
Argumentation zone classification:		
<i>The zone class is equal to the danger source</i>		
A zone in which the presence of an explosive atmosphere is unlikely at normal operation and in which such a gaseous atmosphere, if present, occurs rarely and during a short period is classified as zone 2.		
Argumentation zone dimension:		
Factor f for the open air is 1	f =	1
Safety factor	k =	0,25
LELm = 0,416 x 10-3 x M x LELv	LELm =	0,064
This results in a flow of	23 m3/s (including the safety factor).	
The corresponding zone has a volume of	750,5 m3.	
This results in a radius of	5,6 m.	
A danger source with a flow smaller than	360 gram/s in "open air circumstances" gives	
a spherical shape danger zone with the danger zone as centre		
The spherical danger zone has a radius of	5,6 meter	

Appendix F Waste-AD plant flare

UF10 1850 Emissions Page EA Compliant Stand Alone Flare Stack

Customer	BIOCONSTRUCT GmbH			
Our Reference No.	Attleborough			
Machine type	UF10-1850 High Temperature Enclosed Flare Stack			
Turndown Ratio	5:1			
Design Flow – Biogas	425 - 1850	Nm3hr (Variable)		
Design Flow – Biomethane	250 - 950	Nm3hr		
Combined Flow	925Nm3hr Biogas & 475Nm3hr Biomethane			
Pilot System	Uniflare Fire Blaster Propane ZAI ionisation pilot			
Use environment	Site in open air with restricted access.			
Hazardous area classification in compliance with ATEX requirements.	Zone 2 in sphere 200 mm radius around all positive gas pipe connections and 100 mm radius around all negative pressure gas pipe connections			
Maximum design emissions Normalised at 0°C, 101.3 k Pa and 3% O2:	Carbon monoxide (CO)	50 mg Nm-3		
	Oxides of nitrogen (NOx)	150 mg Nm-3		
	Total volatile organic carbon as carbon	10 mg Nm-3		
	Non-methane volatile organic carbon	5 mg Nm-3		
Operation	Unattended Intermittent use			
Design Media	52 - 97%	Methane CH ⁴		
Design Burner Pressure	Minimum Burner inlet Pressure		80	mbarg
Thermal Rating	11.07	MW		
Design Destruction Efficiency	>99.7%			
Design Combustion temperature	Combustion >1000°C Fully refractory line with automated combustion control			
Minimum retention time	> 0.3 seconds			
Control system	PLC controlled with Hardwired interface. Remote Start Stop. Status and Information available for Remote and site SCADA system.			
Safety systems	CE marked equipment Piltz PNOZ monitoring e-stop circuit Gas pressure protection IS barriers Local Isolators Flash back protected Flame arrestor Pressure and Temperature monitoring DSEAR and ATEX compliant			

UF10 1850 Emissions Page EA Compliant Stand Alone Flare Stack

Design Calculation Page

UF10-1850 High Temperature Flare @ 60%CH₄

CALCULATION OF RETENTION TIME					
CALCULATION OF COMPOSITION OF COMBUSTION PRODUCTS BS 5854					
per one volume of fuel @ 15° C and 1013 mbar					
Constituent	Percentage	rel den	rel den fuel		
	in fuel		to air		
CH ₄	60%	0.554	0.3324		
CO ₂	40%	1.5198	0.60792		
	1	OK	0.94032		
STOICHIOMETRIC AIR PER UNIT VOLUME OF METHANE IS 9.55					
	biogas flow rate	1850	m ³ h ⁻¹ >	1110	m ³ h ⁻¹ CH ₄
	min air required	10600.5	m ³ h ⁻¹		
	excess air	200%			
	specific volume of air	0.819	m ³ kg ⁻¹		
	mass flow rate of air	38830	kg h ⁻¹		
	mass flow rate of biogas	2124	kg h ⁻¹		
	total mass flow rate	40954	kg h ⁻¹		
fuel gases above their dew point have a specific volume similar to air at the relevant temperature					
	the volume of 1 kg of				
	flue gases at	1000 ° C is			
		4	m ³ kg ⁻¹		
	therefore the volume flow rate	156402	m ³ h ⁻¹		
		43	m ³ s ⁻¹		
	hot face diameter	2.193	m		
	area	3.78	m ²		
	velocity	11.5	m s ⁻¹		
	height above flame	5.5	m		
	retention time	0.48	s		
	Retention time at sample port	0.39	s	Port 1m down from top	
	Heat release turn down ratio	5 :1			
	Combustion heat release full load	11.07	MW		
	Minimum heat release	2.21	MW	Created	RPB
EA Guidance on Landfill Gas Flaring 4.8.7 Page 24				Checked	MIJ

UF10 1850 Emissions Page EA Compliant Stand Alone Flare Stack

UF10-950 High Temperature Flare @ 97%CH₄

CALCULATION OF RETENTION TIME			
CALCULATION OF COMPOSITION OF COMBUSTION PRODUCTS BS 5854			
per one volume of fuel @ 15° C and 1013 mbar			
Constituent	Percentage	rel den	rel den fuel
	in fuel		to air
CH ₄	97%	0.554	0.53738
CO ₂	3%	1.5198	0.045594
	1	OK	0.582974
STOICHIOMETRIC AIR PER UNIT VOLUME OF METHANE IS 9.55			
biogas flow rate	950	m ³ h ⁻¹ >	921.5 m ³ h ⁻¹ CH ₄
min air required	8800.325	m ³ h ⁻¹	
excess air	200%		
specific volume of air	0.819	m ³ kg ⁻¹	
mass flow rate of air	32236	kg h ⁻¹	
mass flow rate of biogas	676	kg h ⁻¹	
total mass flow rate	32912	kg h ⁻¹	
fuel gases above their dew point have a specific volume similar to air at the relevant temperature			
the volume of 1 kg of			
flue gases at	1000 ° C is		
	4	m ³ kg ⁻¹	
therefore the volume flow rate	125690	m ³ h ⁻¹	
	35	m ³ s ⁻¹	
hot face diameter	1.966	m	
area	3.04	m ²	
velocity	11.5	m s ⁻¹	
height above flame	5.5	m	
retention time	0.48	s	
Retention time at sample port	0.39	s	Port 1m down from top
Heat release turn down ratio	5 :1		
Combustion heat release full load	9.19	MW	
Minimum heat release	1.84	MW	Created RPB
EA Guidance on Landfill Gas Flaring 4.8.7 Page 24			Checked MIJ

Please see below the calculation of the O₂ and H₂O that we missed from the data table

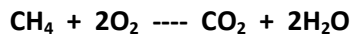
Attleborough (Evercreech will be the same percentages)

From the flare calculation sheet, when burning biogas at 60% methane

Inputs (including 200% excess air)

Methane	= 60% x 1850	= 1,110 m ³ /hr
Carbon Dioxide	= 40% x 1850	= 740 m ³ /hr
Oxygen	= 20.9% x 3 x 10,600.5	= 6,646.5 m ³ /hr
Nitrogen	= 79.1% x 3 x 10,600.5	= 25,155 m ³ /hr
Total		= 33,651.5 m ³ /hr

Equation for the combustion of methane



Outputs

Carbon Dioxide (in biogas)		= 740 m ³ /hr
Carbon Dioxide (combustion)		= 1,110 m ³ /hr
Nitrogen		= 25,155 m ³ /hr
Oxygen (remaining)	= (6,646.5 – 2,220)	= 4,426.5 m ³ /hr
Water vapour		= 2,220 m ³ /hr
Total		= 33,651.5 m ³ /hr

So,

Oxygen content of exhaust gas = 4,426.5/33,651.5 = 13.15% by vol

Water content of exhaust gas = 2,220/33,651.5 = 6.6 % by vol

Appendix G Boiler

Datasheet

Part no. and prices: See pricelist



VITOPLEX 200 Type SX2A

Low temperature oil/gas boiler

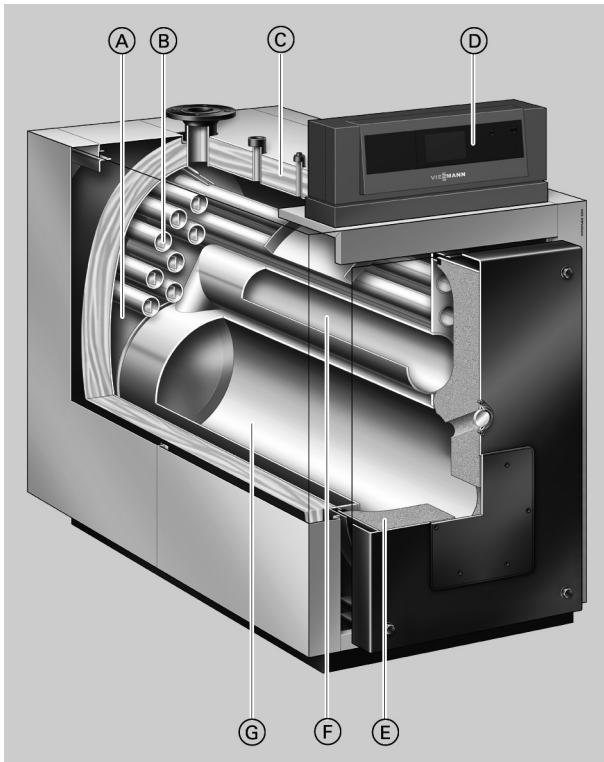
- Three-pass boiler
- For operation with modulating boiler water temperature
- With Vitotrans 300 as condensing unit

Information for type SX2A, 90 to 350 kW:

In accordance with the Ecodesign Directive for Heating Appliances and Water Heaters (Dir. 2009/125/EC), Implementing Regulation (EU) No. 813/2013 and (EU) No. 814/2013, these boilers may not be sold and used within the EU for the purpose of generating space heating and domestic hot water. A sale is subject to the proviso of exclusive use for purposes not included in the regulations stated above.

Benefits at a glance

- Economical and environmentally responsible thanks to modulating boiler water temperature
- Standard seasonal efficiency [to DIN] for operation with fuel oil: 89 % (H_s) [gross cv]
- Optional stainless steel flue gas/water heat exchanger for higher standard seasonal efficiency [to DIN], utilising the condensing effect
- Three-pass boiler with low combustion chamber loading, resulting in clean combustion with low emissions
- Wide water galleries and large water content provide excellent natural circulation and reliable heat transfer.
- Integral Therm-Control start-up system for easy hydraulic connection – no shunt pump or return temperature raising facility are required.
- Boilers up to 300 kW do not require a low water indicator
- Compact design for easy transportation into boiler rooms and economical use of space – important for modernisation projects
- Fastfix installation system for control unit and thermal insulation
- Easy to use Vitotronic control unit with colour touchscreen
- Integral WiFi for service interface
- Economical and safe operation of the heating system through the Vitotronic control system with communication capability which, in conjunction with Vitogate 300 (accessories), enables integration into building management systems.



- (A) Wide water galleries and large water content ensure excellent natural circulation and easy hydraulic connection
- (B) Third hot gas flue
- (C) Highly effective thermal insulation
- (D) Vitotronic control unit with colour touchscreen
- (E) Thermal insulation on boiler door
- (F) Hot gas flue (second pass)
- (G) Combustion chamber

Boiler specification

Specification

Rated heating output	kW	90	120	150	200	270	350	440	560
Rated heat input	kW	98	130	163	217	293	380	478	609
CE designation		CE-0085BQ0020						—	—
– According to Efficiency Directive		CE-0085BQ0020							
– According to Gas Appliances Directive									
Permiss. flow temperature (= safety temperature)	°C	110 (up to 120 °C on request)							
Permiss. operating temperature	°C	95							
Permiss. operating pressure	bar	4							
	kPa	400							
Pressure drop on the hot gas side	Pa	60	80	100	200	180	310	280	400
	mbar	0.6	0.8	1.0	2.0	1.8	3.1	2.8	4.0
Boiler body dimensions									
Length (dim. q) ^{*1}	mm	1195	1400	1385	1580	1600	1800	1825	1970
Width (dim. d)	mm	575	575	650	650	730	730	865	865
Height (incl. connectors) (dim. t)	mm	1145	1145	1180	1180	1285	1285	1455	1455
Total dimensions									
Total length (dim. r)	mm	1260	1460	1445	1640	1660	1860	1885	2030
Total length incl. burner and hood, depending on burner make (dim. s)	mm	1660	1860	1865	2060	2085	—	—	—
Total width (dim. e)	mm	755	755	825	825	905	905	1040	1040
Total height (dim. b)	mm	1315	1315	1350	1350	1460	1460	1625	1625
Service height (control unit) (dim. a)	mm	1485	1485	1520	1520	1630	1630	1795	1795
Height									
– Adjustable anti-vibration feet	mm	28	28	28	28	28	28	28	28
– Anti-vibration boiler supports (under load)	mm	—	—	—	—	—	37	37	37
Foundation									
Length	mm	1000	1200	1200	1400	1400	1650	1650	1800
Width	mm	760	760	830	830	900	900	1040	1040
Combustion chamber diameter	mm	380	380	400	400	480	480	570	570
Combustion chamber length	mm	800	1000	1000	1200	1200	1400	1400	1550
Weight boiler body	kg	315	365	415	460	585	700	895	1100
Total weight	kg	360	410	465	510	635	760	960	1170
Boiler incl. thermal insulation and boiler control unit									
Total weight	kg	390	440	495	540	665	—	—	—
Boiler incl. thermal insulation, burner and boiler control unit									
Capacity boiler water	litres	180	210	255	300	400	445	600	635
Boiler connections									
Boiler flow and return	PN 6 DN	65	65	65	65	65	80	100	100
Safety connection (safety valve) (male thread)	R	1¼	1¼	1¼	1¼	1¼	1¼	1½	1½
Drain (male thread)	R	1¼							
Flue gas parameters ^{*2}									
Temperature (at 60 °C boiler water temperature)									
– At rated heating output	°C				180				
– At partial load	°C				125				
Temperature (at 80 °C boiler water temperature)	°C				195				
Flue gas mass flow rate									
– For natural gas	kg/h	1.5225 x combustion output in kW							
– For fuel oil EL	kg/h	1.5 x combustion output in kW							
Required draught	Pa/mbar	0							
Flue gas connection	Ø mm	180	180	200	200	200	200	250	250
Standard seasonal efficiency [to DIN]	%	89 (H _s) [gross cv]							
(for operation with fuel oil)									
For heating system temperature 75/60 °C									

*1 Boiler door removed.

*2 Values for calculating the size of the flue system to EN 13384, relative to 13.2 % CO₂ for fuel oil EL and 10 % CO₂ for natural gas.

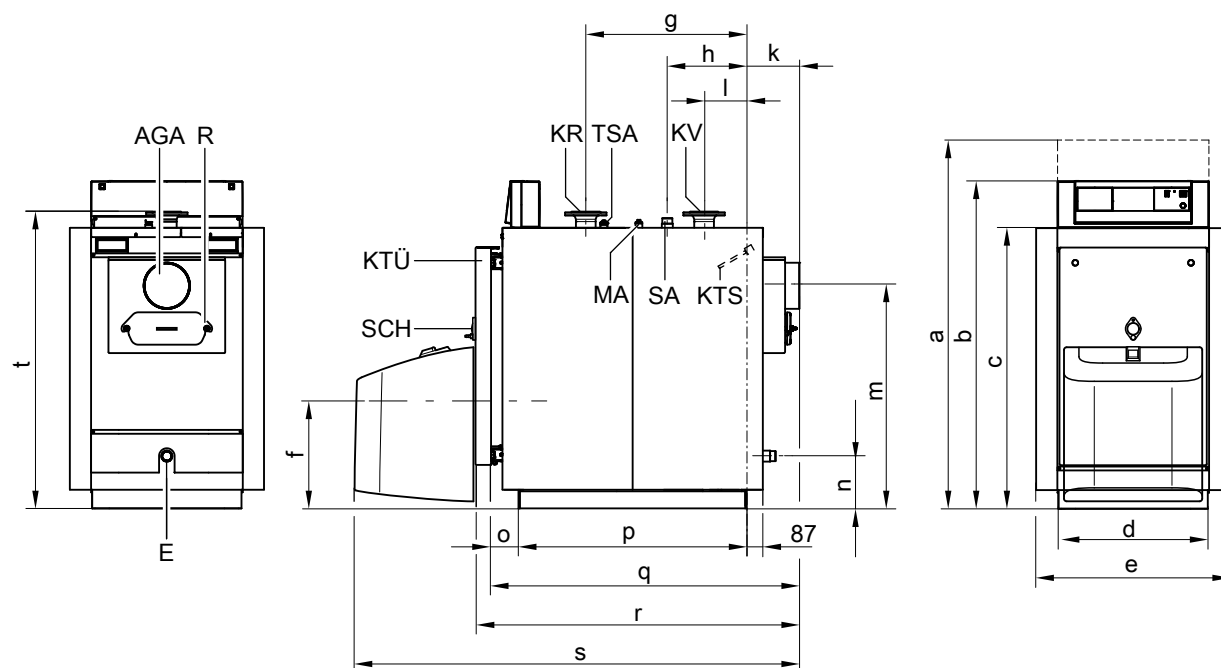
Flue gas temperatures as actual gross values at 20 °C combustion air temperature.

The details for partial load refer to an output of 60 % of rated heating output. If the partial load differs (depending on operating mode), calculate the flue gas mass flow rate accordingly.

Boiler specification (cont.)

Rated heating output		kW	90	120	150	200	270	350	440	560
Standby loss $q_{B,70}$		%	0.40	0.35	0.30	0.30	0.25	0.25	0.22	0.20
Sound pressure level*3 1 m in front of the boiler (1st/2nd stage)		dB(A)	<68/<69					–		
In the flue pipe (1st/2nd stage)		dB(A)	<96/<103					–		
Matching Vitotrans 300										
– Gas operation		Part no.	Z010326		Z010327		Z010328		Z010329	
– Oil operation		Part no.	Z010330		Z010331		Z010332		Z010333	
Rated heating output										
Boiler with Vitotrans 300										
– Gas operation		kW	98.7	131.4	164.3	219.0	295.6	383.3	478.7	608.9
– Oil operation		kW	95.8	127.8	159.8	213.0	287.5	372.7	466.4	593.5
CE designation			CE-0085BS0287							
Vitotrans 300 in conjunction with boiler as a condensing unit										
Pressure drop on the hot gas side		Pa	125	145	185	285	280	410	385	505
Boiler with Vitotrans 300		mbar	1.25	1.45	1.85	2.85	2.80	4.10	3.85	5.05
Total length		mm	1990		2290		2570		2950	
Boiler with Vitotrans 300 excl. burner										

Dimensions

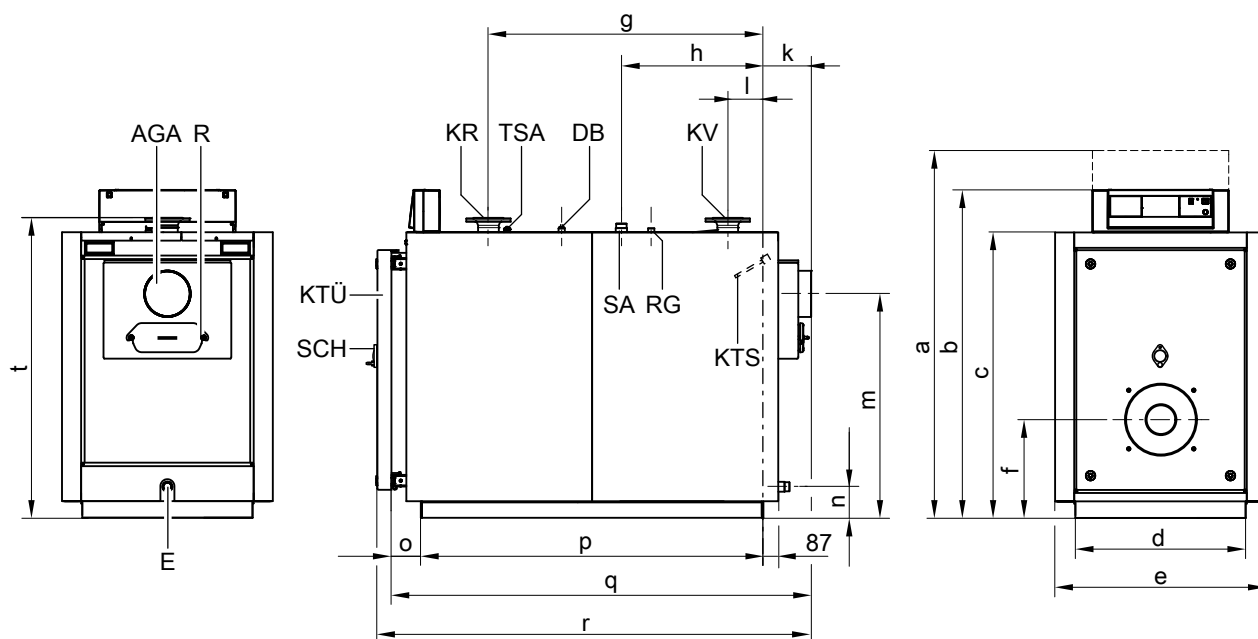


90 to 270 kW

AGA	Flue outlet	MA	Female connection R ½ (male thread) for pressure gauge
E	Drain	R	Cleaning aperture
KR	Boiler return	SA	Safety connection (safety valve)
KTS	Boiler water temperature sensor	SCH	Inspection port
KTÜ	Boiler door	TSA	Female connection R ½ (male thread) for Therm-Control temperature sensor
KV	Boiler flow		

^{*3} Standard values resulting from sound pressure level testing cannot be guaranteed, as sound pressure level tests are always dependent on the specific system. The data provided here refers to Viessmann Vitoflame 100 pressure-jet oil/gas burners.

Boiler specification (cont.)



350 to 560 kW

AGA	Flue outlet	KV	Boiler flow
DB	Female connection R ½ (male thread) for maximum pressure limiter	R	Cleaning aperture
E	Drain	RG	Female connection R ½ (male thread) for additional control equipment
KR	Boiler return	SA	Safety connection (safety valve)
KTS	Boiler water temperature sensor	SCH	Inspection port
KTÜ	Boiler door	TSA	Female connection R ½ (male thread) for Therm-Control temperature sensor

Dimensions

Rated heating output	kW	90	120	150	200	270	350	440	560
a	mm	1485	1485	1520	1520	1630	1630	1795	1795
b	mm	1315	1315	1350	1350	1460	1460	1625	1625
c	mm	1085	1085	1115	1115	1225	1225	1395	1395
d	mm	575	575	650	650	730	730	865	865
e	mm	755	755	825	825	905	905	1040	1040
f	mm	440	440	440	440	420	420	470	470
g	mm	622	825	811	1009	979	1179	1146	1292
h	mm	307	395	324	423	409	609	710	783
k	mm	203	203	203	203	203	203	224	224
l	mm	165	165	151	151	153	153	166	166
m	mm	860	860	885	885	960	960	1110	1110
n	mm	200	200	190	190	135	135	135	135
o	mm	110	110	110	110	130	130	130	130
p (length of base rails)	mm	882	1085	1071	1268	1269	1469	1471	1617
q (transport dimension)	mm	1195	1400	1385	1580	1600	1800	1825	1970
r	mm	1260	1460	1445	1640	1660	1860	1885	2030
s (depending on burner make)	mm	1670	1875	1880	2075	2095	—	—	—
t	mm	1145	1145	1180	1180	1285	1285	1455	1455

Where access to the boiler room is difficult the boiler door can be removed.

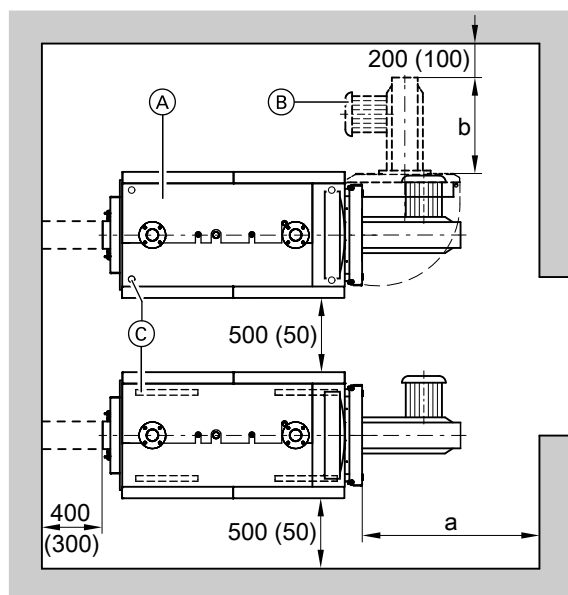
Dim. f: Observe the installed burner height.

Dim. q: With boiler door removed

Boiler specification (cont.)

Siting

Minimum clearances



Observe the stated dimensions to ensure easy installation and maintenance. Where space is tight, only the minimum clearances (dimensions in brackets) need to be maintained. In the delivered condition, the boiler door is fitted so it opens to the left. The hinge pins can be repositioned so the door opens to the right.

- (A) Boiler
- (B) Burner
- (C) Adjustable anti-vibration feet (90 to 560 kW) or anti-vibration boiler supports (350 to 560 kW)

Rated heating output	kW	90	120	150	200	270	350	440	560
a	mm	1100			1400		1600		

Dim. a: Maintain this space in front of the boiler to enable removal of the turbulators and cleaning of the hot gas flues.

Dim. b: Observe the installed burner length.

Siting conditions

- Prevent air contamination by halogenated hydrocarbons (e.g. as contained in sprays, paints, solvents and cleaning agents)
- Prevent very dusty conditions
- Prevent high levels of humidity
- Prevent frost and ensure good ventilation

Otherwise the system may suffer faults and damage.

In rooms where air contamination through **halogenated hydrocarbons** may occur, install the boiler only if adequate measures can be taken to provide a supply of uncontaminated combustion air.

Burner installation

Boilers up to 120 kW:

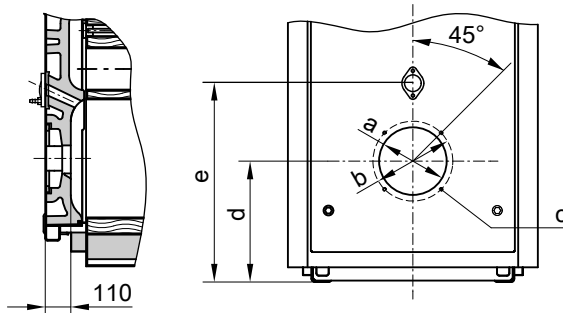
The burner fixing hole circle, burner fixing holes and flame tube aperture comply with EN 226.

Boilers from 150 kW:

The burner fixing hole circle, burner fixing holes and flame tube aperture are as detailed in the table below.

The burner may be mounted directly on the hinged boiler door. If the burner dimensions deviate from those stated in the table below, use the burner plate included in the standard delivery.

Burner tiles can be prepared at the factory on request (chargeable option). If this is required, state the burner make and type when ordering. The flame tube must protrude from the thermal insulation of the boiler door.

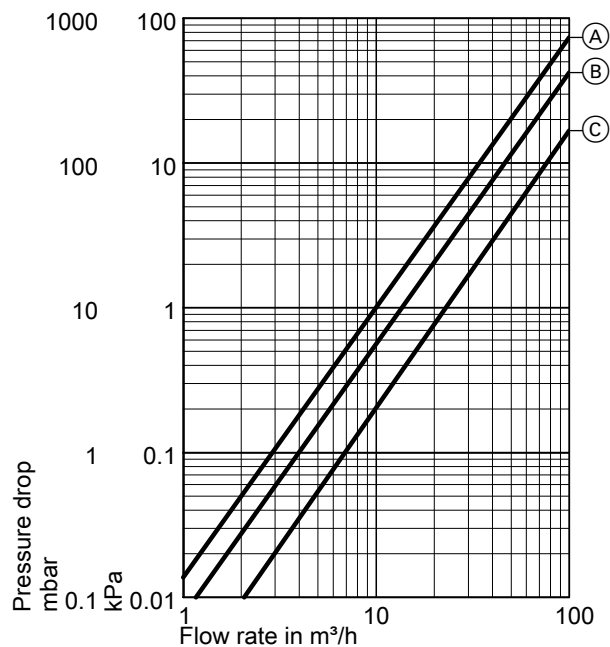


Rated heating output	kW	90	120	150	200	270	350	440	560
a	Ø mm	135	135	240	240	240	240	290	290
b	Ø mm	170	170	270	270	270	270	330	330
c	Number/thread	4/M 8	4/M 8	4/M 10	4/M 10	4/M 10	4/M 10	4/M 12	4/M 12

Boiler specification (cont.)

Rated heating output	kW	90	120	150	200	270	350	440	560
d	mm	440	440	440	440	420	420	470	470
e	mm	650	650	650	650	670	670	780	780

Pressure drop on the heating water side



The Vitoplex 200 is only suitable for fully pumped hot water heating systems.

- Ⓐ Rated heating output 90 to 270 kW
- Ⓑ Rated heating output 350 kW
- Ⓒ Rated heating output 440 and 560 kW

Vitotrans 300 specification

Specification

Vitotrans 300		Z010326	Z010327	Z010328	Z010329
– Gas operation	Part no.	Z010330	Z010331	Z010332	Z010333
– Oil operation	Part no.				
Rated boiler heating output	kW	90-125	140-200	230-350	380-560
Rated heating output range of the Vitotrans 300 for					
– Gas operation	from kW	8.7	12.7	21.8	33.3
	to kW	11.9	19.0	33.3	48.9
– Oil operation	from kW	5.8	8.8	14.9	22.9
	to kW	8.1	13.0	22.7	33.5
Permiss. operating pressure	bar	4	4	4	6
	MPa	0.4	0.4	0.4	0.6
Permiss. flow temperature (= safety temperature)	°C	110	110	110	110
Pressure drop on the hot gas side	mbar	0.65	0.85	1.00	1.05
	Pa	65	85	100	105
Flue gas temperature					
– Gas operation	°C	65	65	65	65
– Oil operation	°C	70	70	70	70
Flue gas mass flow rate	from kg/h	136	213	383	546
	to kg/h	213	341	596	954
Total dimensions					
Total length (dim. h) incl. mating flanges	mm	666	777	856	967
Total width (dim. b)	mm	714	760	837	928
Total height (dim. c)	mm	1037	1152	1167	1350
Transport dimensions					
Length excl. mating flanges	mm	648	760	837	928
Width (dim. a)	mm	618	636	706	839
Height (dim. d)	mm	1081	1098	1172	1296
Heat exchanger weight	kg	94	119	144	234
Total weight	kg	125	150	188	284
Heat exchanger incl. thermal insulation					
Capacity					
Heating water	litres	70	97	134	181
Flue gas	m ³	0.055	0.096	0.133	0.223
Connections					
Heating water flow and return	DN	40	50	50	65
Condensate drain (male thread)	R	½	½	½	½
Flue gas connection					
– To the boiler	DN	180	200	200	250
– To the flue system	DN	150	200	200	250

Rated heating output range of the Vitotrans 300 and flue gas temperature

Heating output of the Vitotrans 300 with flue gas cooling of 200/65 °C for gas operation and 200/70 °C for oil operation, with a heating water temperature rise in the Vitotrans 300 from 40 °C to 42.5 °C.

For conversion to other temperatures, see chapter "Output data".

Pressure drop on the hot gas side

Pressure drop on the hot gas side at rated heating output. The burner must overcome the hot gas pressure drop of the boiler, the Vitotrans 300 and the flue pipe.

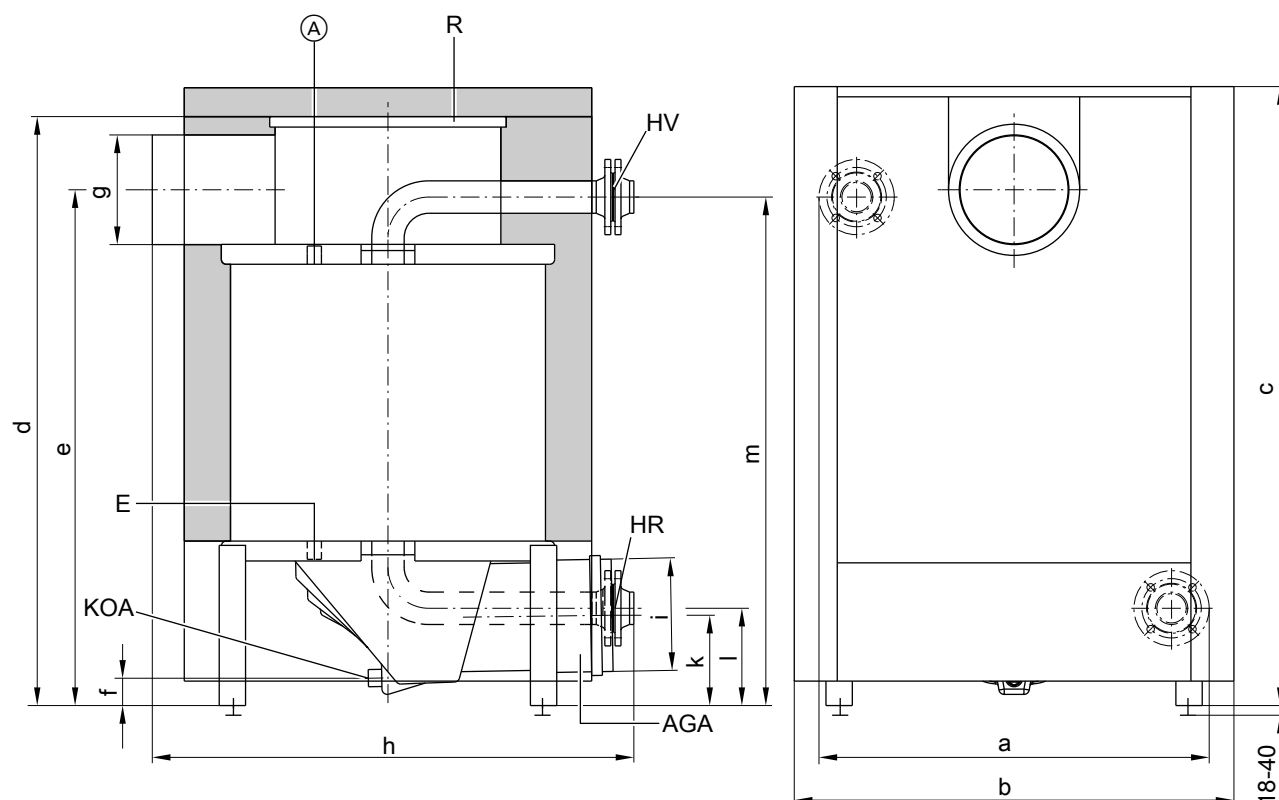
Tested quality



CE designation according to current EC Directives at a permissible flow temperature (safety temperature) of up to 110 °C to EN 12828.

Vitotrans 300 specification (cont.)

Dimensions



- (A) Additional female connection R ½ (male thread)
 AGA Flue outlet
 E Drain R ½ (male thread)

- HR Heating water return (inlet)
 HV Heating water flow (outlet)
 KOA Condensate drain Ø 32
 R Cleaning aperture

Dimensions

Part no.		Z010326 Z010330	Z010327 Z010331	Z010328 Z010332	Z010329 Z010333
a	mm	628	656	726	839
b	mm	714	746	818	912
c	mm	1022	1098	1151	1308
d	mm	965	1043	1096	1245
e	mm	851	907	960	1080
f	mm	73	53	51	88
g (internal)	Ø mm	181	201	201	251
h	mm	707	818	896	1015
i (internal)	Ø mm	151	201	201	251
k	mm	165	170	168	230
l	mm	170	172	181	232
m	mm	851	899	946	1075

Delivered condition

Heat exchanger body with fitted flue gas collector. Mating flanges are fitted to all connectors

1 box with thermal insulation

Connection on the flue gas side

Connect the boiler flue outlet and offset flue adaptor of the flue gas/ water heat exchanger through a connection collar (accessories) (do not weld).

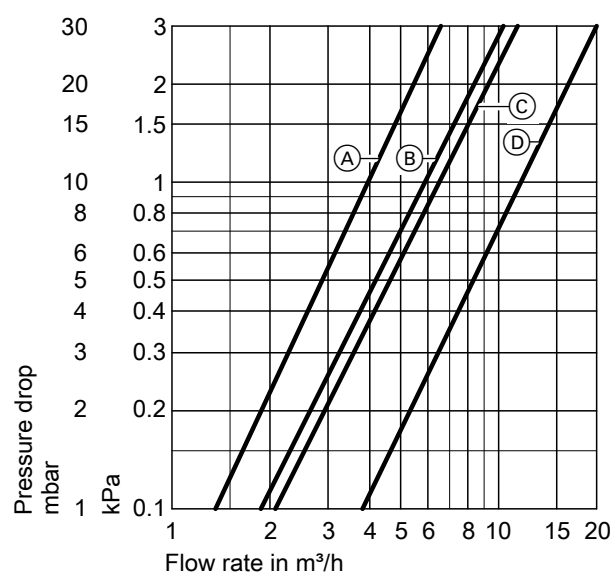
Height compensation:

- Vitoplex boiler through adjusting screws
- Vitorond boiler through on-site adaptor

Vitotrans 300 specification (cont.)

Pressure drop on the heating water side

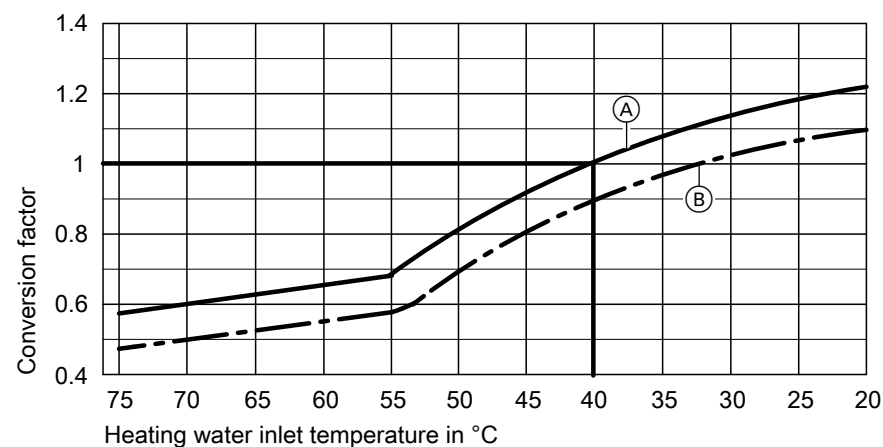
Part no. Z010326 to Z010333



Part no.	Curve
Z010326	(A)
Z010330	(A)
Z010327	(B)
Z010331	(B)
Z010328	(C)
Z010332	(C)
Z010329	(D)
Z010333	(D)

Output data

Vitotrans 300 for gas operation



- (A) Flue gas inlet temperature 200 °C
- (B) Flue gas inlet temperature 180 °C

Conversion of the output data

The heating output data of the Vitotrans 300 flue gas/water heat exchanger refers to a flue gas inlet temperature of 200 °C and a heating water inlet temperature into the heat exchanger of 40 °C.

For different conditions the heating output can be calculated by multiplying the specified rated heating output by the conversion factor established from the diagram.

Delivered condition of the boiler

Boiler body with fitted boiler door and cleaning cover.
Mating flanges are fitted to all connectors.
The adjusting screws are supplied in the combustion chamber.
Cleaning equipment can be found on top of the boiler.

- 2 boxes with thermal insulation
- 1 box with boiler control unit and 1 bag with technical documentation
- 1 Therm-Control
- 1 coding card and technical documentation for Vitoplex 200
- 1 burner plate (from 150 kW)

Control unit versions

For a single boiler system

■ Vitotronic 100, type CC1E

For the control unit with a constant boiler water temperature.

For weather-compensated or room temperature-dependent operation in conjunction with an external control unit.

■ Vitotronic 200, type CO1E

For weather-compensated operation and mixer control for up to 2 heating circuits with mixer. For the 2 heating circuits with mixer, the accessory "Extension for heating circuits 2 and 3" is required.

Control panel

- Vitocontrol control panel with e.g. Vitotronic 200-H, type HK1B or HK3B for 1 or up to 3 heating circuits with mixer on request.

For a multi boiler system (up to 8 boilers)

■ Vitotronic 300, type CM1E

For weather-compensated operation of a multi boiler system. This Vitotronic control unit also regulates the boiler water temperature of one boiler in this multi boiler system.

Vitotronic 100, type CC1E and LON communication module

To control the boiler water temperature for each additional boiler in the multi boiler system.

■ Vitocontrol 200-M multi mode system controller

For weather-compensated cascade control of boilers with a Vitotronic 100 control unit and a Vitobloc 200 CHP unit or other heat generators on request.

Control panel

- Vitocontrol control panel with e.g. Vitotronic 200-H, type HK1B or HK3B for 1 or up to 3 heating circuits with mixer on request.

Boiler accessories

See pricelist.

Operating conditions for systems with Vitotronic boiler protection

Vitotronic boiler protection, e.g. Therm-Control.

	Requirements	
Operation with burner load	≥ 60 %	< 60 %
1. Heating water flow rate	None	
2. Boiler return temperature (minimum value)* ⁴	None* ⁵	
3. Lower boiler water temperature	– Oil operation 50 °C – Gas operation 60 °C	– Oil operation 60 °C – Gas operation 65 °C
4. Two-stage burner operation	Stage 1: 60 % of rated heating output	No minimum load required
5. Modulating burner operation	Between 60 and 100 % of rated heating output	No minimum load required
6. Reduced mode	Single boiler systems and the lead boiler in multi boiler systems – Operation with lower boiler water temperature Lag boilers in multi boiler systems – Can be shut down	
7. Weekend setback	As per reduced mode	

For water quality requirements see the technical guide to this boiler.

Operating conditions for systems with on-site boiler protection

	Requirements	
Operation with burner load	≥ 60 %	< 60 %
1. Heating water flow rate	None	
2. Boiler return temperature (minimum value)	– Oil operation 40 °C – Gas operation 53 °C	– Oil operation 53 °C – Gas operation 58 °C
3. Lower boiler water temperature	– Oil operation 50 °C – Gas operation 60 °C	– Oil operation 60 °C – Gas operation 65 °C
4. 2-stage burner operation	1st stage 60 % of rated heating output	No minimum load required
5. Modulating burner operation	Between 60 and 100 % of rated heating output	No minimum load required

*⁴ The technical guide "System examples" contains relevant sample systems for use of the Therm-Control start-up system.

*⁵ No requirements; only in conjunction with Therm-Control.

Operating conditions for systems with on-site boiler protection (cont.)

Operation with burner load	Requirements	
	≥ 60 %	< 60 %
6. Reduced mode	Single boiler systems and lead boiler in multi boiler systems – Operation with lower boiler water temperature Lag boilers in multi boiler systems – Can be shut down	
7. Weekend setback	As per reduced mode	

For water quality requirements see the technical guide to this boiler.

Design/engineering information

Mounting a suitable burner

The burner must be suitable for the relevant rated heating output and the pressure drop on the hot gas side of the boiler (see burner manufacturer's specification).

The material of the burner head must be suitable for operating temperatures of at least 500 °C.

Pressure-jet oil burner

The burner must be tested and designated to EN 267.

Pressure-jet gas burner

The burner must be tested to EN 676 and CE-designated in accordance with Directive 2009/142/EC.

Burner adjustment

Adjust the oil or gas throughput of the burner to suit the rated boiler heating output.

Low water indicator

If the standard boiler control unit is connected in accordance with the installation instructions, the Vitoplex 200 up to 300 kW (except in attic heating centres) does not require a low water indicator to EN 12828.

In the event of a water shortage due to a leak in the heating system and simultaneous burner operation, the control unit will automatically shut down the burner before the boiler and/or flue system reach impermissible high temperatures.

Permissible flow temperatures

Hot water boiler for permissible flow temperatures (= safety temperatures)

Up to 110 °C

■ CE designation:

CE-0085 (90 to 350 kW) compliant with Efficiency Directive and
CE-0085 compliant with the Gas Appliances Directive

Above 110 °C (up to 120 °C) (with individual test certification on request)

■ CE designation:

CE-0035 in compliance with the Pressure Equipment Directive
For operation with safety temperatures in excess of 110 °C additional safety equipment is required.

Boilers with a safety temperature **above 110 °C** require supervision, according to the Health & Safety at Work Act [Germany]. In accordance with the conformity assessment diagram no. 5 of the EU Pressure Equipment Directive, these boilers must be classed as category III.

The system must be tested prior to commissioning.

- Annually: External inspection, inspection of the safety equipment and water quality.
- Every 3 years: Internal inspection (or water pressure test as an alternative).
- Every 9 years: Water pressure test (for max. test pressure see type plate).

An approved inspection body (e.g. TÜV [in Germany]) must carry out the test.

Further information on design/engineering

See the technical guide to this boiler.

Tested quality



CE designation according to current EC Directives



Subject to technical modifications.

Viessmann Werke GmbH & Co. KG
D-35107 Allendorf
Telephone: +49 6452 70-0
Fax: +49 6452 70-2780
www.viessmann.com

Viessmann Limited
Hortonwood 30, Telford
Shropshire, TF1 7YP, GB
Telephone: +44 1952 675000
Fax: +44 1952 675040
E-mail: info-uk@viessmann.com

5797332

Report for the Periodic Monitoring of Emissions to Atmosphere

BioConstruct NewEnergy Ltd

A12 - Boiler Stack

Permit No: EPR/GP363QX
Installation: Wardley Biogas AD Facility
Monitoring Dates: 16th November 2020
Site Address: Wardley Biogas AD Facility, Follinsby Lane, West Bolton, NE10 8YL

Report Number:	ES-0279	Version:	1	Visit:	1 in 2020
Date of Report:	14th December 2020				
Report Author:	Stephen Dick				
MCERTS No:	MM 10 1061	MCERTS Level:	2 (TE1, TE2, TE3, TE4)		
Approved By:	Nicky Kane	Function:	Senior Team Leader		
MCERTS No:	MM 08 998	MCERTS Level:	2 (TE1, TE2, TE3, TE4)		

Signed: 

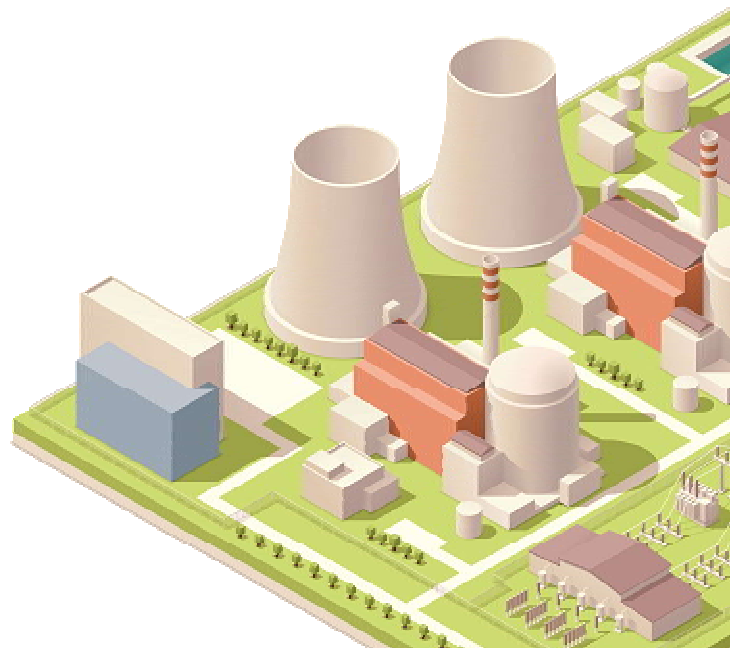
T: 01274 738668

E: sales@envirocare.org

Envirocare Technical Consultancy Ltd

Bradford Chamber Business Park, New Lane, Bradford, BD4 8BX

YOUR INDUSTRY EXPERTS



Contents

Executive Summary

Monitoring Objectives 3

Monitoring Results 4

Operating Information 4

Monitoring Deviations 4

Supporting Information

Appendix 1: General Information 5

Appendix 2: Results and Calculations 6 - 10

Executive Summary

Monitoring Objectives

Envirocare Technical Consultancy were contracted by BioConstruct NewEnergy Ltd to carry out emissions monitoring, to determine the compliance of A12 - Boiler Stack with the conditions specified in the operators permit (EPR/GP363QX) for emissions to atmosphere. The methodologies utilised and the results obtained form the basis of this report.

The substances requested for monitoring are listed below.

Emission Point Identification

Substances to be Monitored	A12 - Boiler Stack
Carbon Monoxide	✓
Oxides of Nitrogen (as NO ₂)	✓
Oxygen	✓
Volumetric Flow	✓
Sulphur Dioxide	✓
Water Vapour	✓

Special requirements: none.

Opinions and interpretations expressed within this report are outside the scope of Envirocare Technical Consultancy's MCERTS and UKAS accreditation. Envirocare accepts no responsibility for information in this report that was provided by the client, the client's representative or employees of the client. Where such information has been provided by external sources this is identified in footnotes of the respective tables.

Executive Summary

Monitoring Results

A12 - Boiler Stack

Substance	Emission Limit Value (mg/m³)	Periodic Monitoring Result (mg/m³)	Uncertainty % of Emission Concentration (95% confidence)	Reference Conditions	Date	Start and End Times	Monitoring Reference Method	Accreditation for Use of Method
Water Vapour	-	15.2%	-	273K, 101.3kPa	16/11/2020	14:45-15:45	BS EN 14790	MCERTS
Carbon Monoxide	-	4.4	85.3	273K, 101.3kPa, DRY, 3% O ₂	16/11/2020	15:40-16:40	BS EN 15058	MCERTS
Oxides of Nitrogen (as NO ₂)	-	54.6	10.0	273K, 101.3kPa, DRY, 3% O ₂	16/11/2020	15:40-16:40	BS EN 14792	MCERTS
Oxygen	N/A	4.3%	2.2	273K, 101.3kPa, DRY	16/11/2020	15:40-16:40	BS EN 14789	MCERTS
Volumetric Flow	N/A	651 m³/h	-	273K, 101.3kPa	16/11/2020	15:50-15:52	BS EN 16911-1	MCERTS
Sulphur Dioxide	-	2.9	23.3	273K, 101.3kPa, DRY 3% O ₂	16/11/2020	15:40-16:40	BS EN 14791	MCERTS

*Uncertainty expressed in terms of emission concentration.

Operating Information

A12 - Boiler Stack

Date	Process Type	Fuel	Feedstock	Abatement	Load	Operating Status
16/11/2020	Boiler Process	Biogas	N/A	None	Full Load	Normal

*information provided by Site

Monitoring Deviations

A12 - Boiler Stack

Substance Deviations	Monitoring Deviations	Other Relevant Issues
None	None	None

Supporting Information

Appendix 1: General Information

Monitoring Organisation Staff Details

Personnel	Function in Monitoring Campaign	MCERTS Level	MCERTS Number
Mr N Kane	Team Leader	2 (TE1, TE2, TE3, TE4)	MM 08 998
Mr S Dick	Team Leader	2 (TE1, TE2, TE3, TE4)	MM 10 1061

Monitoring Methods

Pollutant Species	Standard	Technique	ISO 17025 Analysis	Analysis Lab	Envirocare Internal Procedure
Volumetric Flow	BS EN ISO 16911-1	Pitot & Thermocouple	Yes	ENV	ETC-SE-24a
Sulphur Dioxide	BS EN 14791	IC	Yes	RPS	ETC-SE-14
Carbon Monoxide	BS EN 15058	NDIR	Yes	ENV	ETC-SE-10b
Oxides of Nitrogen	BS EN 14792	Chemiluminescence	Yes	ENV	ETC-SE-10b
Oxygen	BS EN 14789	Zirconium Cell	Yes	ENV	ETC-SE-10b
Water Vapour	BS EN 14790	Gravimetric	Yes	ENV	ETC-SE-11

Analysis Laboratories Accreditation Status

Envirocare (ENV)	ISO 17025 Accreditation Number: 2522
RPS Laboratories Ltd (RPS)	ISO 17025 Accreditation Number: 0605

Equipment Checklist

Equipment ID	Model Number	Purpose
ETC-S8.08	Millenium Console	Isokinetic Sampler
ETC-S04.11	0.5m Probe	Integrated Probe
4-3-20-2	S-Type Pitot	Duct Flow Measurement
BA8	Site Balance	Moisture Measurement
ETC-S12.08	Horiba PG 350	Multi-component Gas Analyser
ETC-S03.43b	M&C Gas Conditioner	Sample gas conditioner
ES-07.05	Heated Filter	Gas Sample Clean-up
ETC-S05.06	20m Winkler Heated line	PTFE cored heated sample line
TM16	3M Tape Measure	Duct dimension measurement
ETC-S10.08	Stopwatch	Sample duration measurement
ES-11.01 (BA11)	Barometer	Ambient pressure measurement
ETC-S24.01a	Micromanometer MPR 500	Differential pressure measurement
ETC-S24.01a-Temp	Micromanometer	Temperature measurement

Appendix 2: A12 - Boiler Stack Results and Calculations

Picture of the sampling location and positions



Water Vapour Measurements

Parameter	Value	Unit
Sampling Date	16/11/2020	-
Start Time	14:45	-
End Time	15:45	-
Barometric Pressure	1007	mbar

Parameter	Value	Unit
Stack Temperature	154.4	°C
Corrected Volume	580	L
Collected Mass	83.3	g
Stack Gas Water Vapour Content	15.2	% v/v

Flow Criteria Measurements

Duct Diameter (cm)	Cross Sectional Area (m²)	Barometric Pressure (mbar)	Ambient Temperature (°C)	Stack Gas Mr (g/mol)	Pitot Coefficient
25.0	0.049	1007	7.0	29.0	0.84

Sample Line	Traverse Point	Position (cm)	Differential Pressure Reading (cmH2O)				Stack Velocity (m/s)	Stack Temp (°C)	Angle of Swirl
			1	2	3	Average			
A	A1	12.5	0.20	0.20	0.20	0.20	5.8	154	-

Parameter	Mean Duct Velocity	Velocity Ratio (Max:Min)	Mean Stack Temperature	Mean Stack Temperature	Stack Gas Volume Flow	Corrected Stack Gas Volume Flow
Value	5.8	1.0:1	154	427	1025	651
Units	m/s	-	°C	K	m³/hr	Nm³/hr

Instrumental Gas Analyser Calibrations

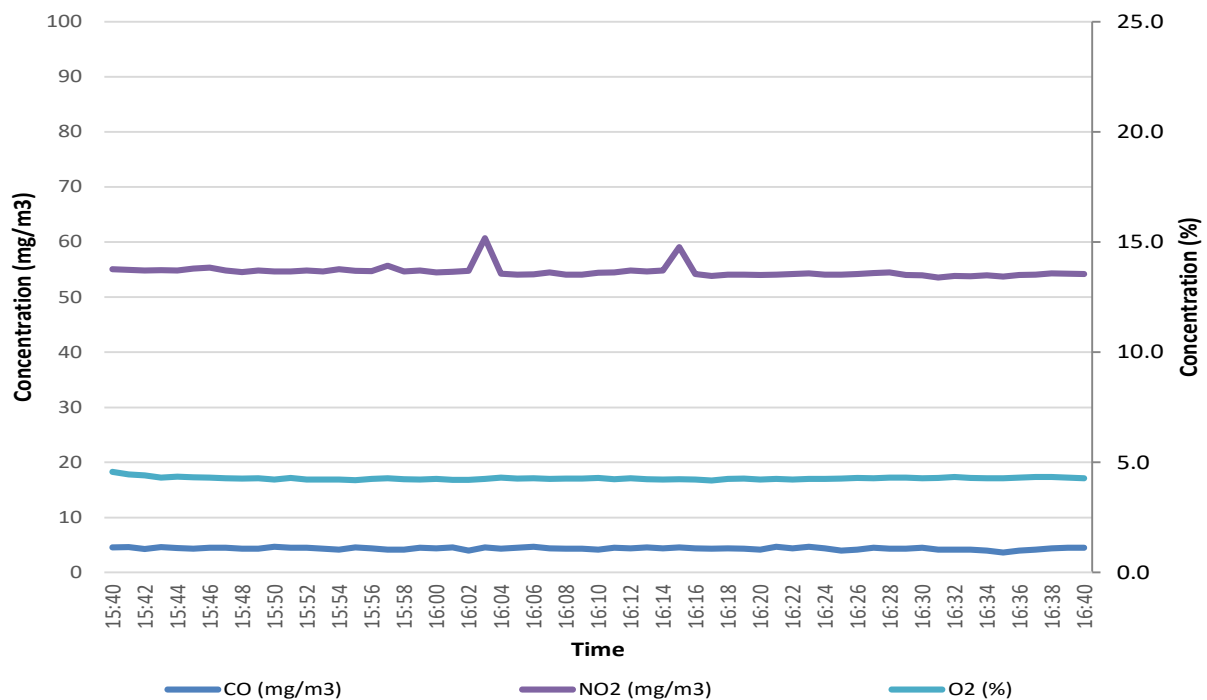
Date	Operators	Combustion Gas Analyser	Flame Ionisation Detector
16/11/2020	NK/SD	ETC-S12.08	-

Calibration Gas	Certified Concentration	T90 Time	Analyser Span	Pre-sample Cal		Post-sample Cal		Adjustment Required	Data Valid
				Zero	Span	Zero	Span		
Carbon Monoxide	162.2ppm	44	162.2	0.1	162.2	0.1	160.1	No	Yes
Nitric Oxide	198.24ppm	46	198.24	0.1	198.24	0.3	196.9	No	Yes
Oxygen	21.11%	44	21.11	0.02	21.11	0.1	21.07	No	Yes

Instrumental Gas Analyser Results

Substance	Run	Corrected Concentration			Units	Basis	O ₂ Correction
		Average	Max	Min			
Carbon Monoxide	1	4.4	4.7	3.6	mg/m ³	-	3%
Oxides of Nitrogen (as NO ₂)	1	54.6	60.7	53.5	mg/m ³	NO _x as NO ₂	3%
Oxygen	1	4.3	4.6	4.2	%	-	-

Instrumental Gas Analyser Chart - Run 1



Sulphur Dioxide - Run 1 Calculations

Sampling Details		
Meter Box Number	ETC-S8.08	-
Gas Meter Coefficient	0.971	-
Pitot Coefficient	0.840	-
Stack Gas Molecular Weight	29.0	g/mole
Static Pressure in Stack	0.10	cmH ₂ O

Analysis Details		
Collection Media	H2O2	
1st Collector Reference	ES-0279 Boiler R1 AB	
1st Collector Concentration	1551.42	µg
2nd Collector Reference	ES-0279 Boiler R1 C	
2nd Collector Concentration	20.104	µg
Blank Concentration	0.04	mg/Nm ³
Has breakthrough occurred?	No	-

Date	Operators
16/11/2020	NK

Parameter	Before	After	Unit
Barometric Pressure	1007	1007	mbar
Ambient Temperature	8.0	9.0	°C
Leak Check	0.06	0.06	L/min
Time	15:40	16:40	-

Emissions Calculations		
Total Sampling Time	60.0	min
Gas Meter Difference	616	L
Corrected Gas Meter Volume	598	L
Mean Sampling Rate	10.0	L/min
STP Dry Gas Meter Volume	580	NL
Mass of Water Vapour Collected	83.3	g
Volume of Water Vapour Collected	104	NL
Stack Gas Water Vapour Content	15.2	% v/v
Emission Limit Value	-	mg/Nm ³
Corrected SO₂ Emission	2.7	mg/Nm³
Corrected to 3% Oxygen	2.9	mg/Nm ³
Mass Emission Rate	0.001	kg/hr

Uncertainty

Uncertainty of Carbon Monoxide by Horiba Analyser

Parameter	Value	Unit
Emission Limit Value (ELV)	-	mg/m ³
Reading	3.5	ppm
Span Gas Certified Value	162.2	ppm
Range	200	ppm

Cal Gas
CO

Source of Uncertainty	Uncertainty Criteria	Probability Distribution	Divisor	Source Uncertainty u	Combined Uncertainty u ²
Zero Drift/Lower limit of detection (ppm)	0.10	Rectangular	1.7	0.06	0.003
Span Drift (ppm)	2.1	Rectangular	1.7	1.2	1.5
Linearity (% of value)	0.32	Rectangular	1.7	0.006	0.00004
Setting Gas Divider (% of value)	0.35	Normal	1.0	0.01	0.0001
Interference (% of value)	2.9	Rectangular	1.7	0.06	0.003
Standard deviation of repeatability at zero point (% of range)	0.20	Rectangular	-	0.40	0.16
Standard deviation of repeatability at span point (% of range)	0.41	Rectangular	-	0.82	0.67
Total					2.3
Combined Standard Uncertainty [(sum u²)^{0.5}]					1.5
Expanded Total Uncertainty (ppm) (95% confidence)					3.0
Expanded Total Uncertainty as a % of emission conc. (95% confidence)					85.3
Expanded Total Uncertainty (mg/m³) (95% confidence)					3.7
Expanded Total Uncertainty as a % of emission limit value (95% confidence)					-

Uncertainty of Oxides of Nitrogen by Horiba gas Analyser

Parameter	Value	Unit
Emission Limit Value (ELV)	-	mg/m ³
Reading	26.6	ppm
Span Gas Certified Value	198.2	ppm
Range	250	ppm

Cal Gas
NO

Source of Uncertainty	Uncertainty Criteria	Probability Distribution	Divisor	Source Uncertainty u	Combined Uncertainty u ²
Zero Drift/Lower limit of detection (ppm)	-0.20	Rectangular	1.7	-0.12	0.01
Span Drift (ppm)	1.3	Rectangular	1.7	0.77	0.60
Linearity (% of value)	0.84	Rectangular	1.7	0.13	0.02
Setting Gas Divider (% of value)	0.35	Normal	1.0	0.09	0.009
Interference (% of value)	1.2	Rectangular	1.7	0.18	0.03
Standard deviation of repeatability at zero point (% of range)	0.10	Rectangular	-	0.25	0.06
Standard deviation of repeatability at span point (% of range)	0.42	Rectangular	-	1.1	1.1
Total					1.8
Combined Standard Uncertainty [(sum u²)^{0.5}]					1.4
Expanded Total Uncertainty (ppm) (95% confidence)					2.7
Expanded Total Uncertainty as a % of emission conc. (95% confidence)					10.0
Expanded Total Uncertainty (mg/m³) (95% confidence)					5.5
Expanded Total Uncertainty as a % of emission limit value (95% confidence)					-

Uncertainty of Oxygen by Horiba Analyser

Parameter	Value	Unit
Reading	4.3	%
Span Gas Certified Value	21.11	%
Range	25	%

Cal Gas
O ₂

Source of Uncertainty	Uncertainty Criteria	Probability Distribution	Divisor	Source Uncertainty u	Combined Uncertainty u ²
Zero Drift/Lower limit of detection (%vol)	-0.05	Rectangular	1.7	-0.03	0.0008
Span Drift (%vol)	0.04	Rectangular	1.7	0.02	0.0005
Linearity (% of value)	0.79	Rectangular	1.7	0.02	0.0004
Setting Gas Divider (% of value)	0.35	Normal	1.0	0.01	0.0002
Interference (% of value)	0.56	Rectangular	1.7	0.01	0.0002
Standard deviation of repeatability at zero point (% of range)	0.00	Rectangular	-	0.00	0.00
Standard deviation of repeatability at span point (% of range)	0.03	Rectangular	-	0.008	0.00006
Total					0.002
Combined Standard Uncertainty [(sum u²)^{0.5}]					0.05
Expanded Total Uncertainty (%) (95% confidence)					0.09
Expanded Total Uncertainty as a % of emission conc. (95% confidence)					2.2

Uncertainty of Sulphur Dioxide - Run 1

Parameter	Value	Unit
Emission Limit Value (ELV)	-	mg/m ³
Mean Sampling Rate	10.0	L/min
Leak Rate	0.06	L/min
Barometric Pressure	1007	mbar
Average Stack Temperature	154	°C
Sampled Stack Gas Volume	598	L

Parameter	Value	Unit
Mean Emission Concentration	2.9	mg/m ³
Monitoring Duration	60	min
Console ID	ETC-S8.08	-
Temperature Uncertainty	0.24	°C
Gas Meter Uncertainty	0.37	%
Barometer Uncertainty	1.0	mbar

Source of Uncertainty	ASD*	BS EN 14791		Envirocare Certified Value	Units	% Actual Value	Source Uncertainty u	Combined Uncertainty u ²
		Uncertainty Criteria	Max. Value					
Analysis Procedure	Std	<2.5% of measured value	-	11.9	%	6.1	0.35	0.12
Leak Rate	Rect	<2% of sampling rate	0.20	0.06	L/min	0.60	0.01	0.0001
Time	Std	1sec in 1hour = 0.028%	2.0	1.0	sec	0.03	0.001	0.000001
Gasmeter Volume	Std	<2.5% volume of gas	15.0	2.2	L	0.37	0.01	0.0001
Temperature	Std	<1% absolute temperature	4.3	0.24	°C	0.06	0.002	0.000003
Pressure	Std	<1% absolute pressure	10.1	1.0	mbar	0.10	0.003	0.00001
Total								0.12
Combined Standard Uncertainty $[(\sum u^2)^{0.5}]$								0.35
Expanded Total Uncertainty as a % of emission conc. (95% confidence)								23.3
Expanded Total Uncertainty (mg/m³) (95% confidence)								0.68
Expanded Total Uncertainty as a % of emission limit value (95% confidence)								-

Appendix H GUU

Project: Attleborough (UK)

Specifications: Gas Upgrading Unit

Volumetric flow rate	1126,76 kg/h
Flow velocity	9 m/s
Temperature	38°C
Oxygen content	1,19 kg/h
Nitrogen content	0,15 kg/h
H2S content	0,00 kg/h
Ammonia content	0,00 kg/h
Moisture content	4,37 kg/h
Height / diameter vent	10.7m / 250mm

Report for the Periodic Monitoring of Emissions to Air from the Gas Engine and CO2 Vent Stacks Located at Sheppey Energy Ltd, Sheerness.**Part 1: Executive Summary**

Permit Number: CP3331YA

Operator: Sheppey Energy Ltd

Installation: AD Gas Engine Stack (A1) and CO2 Vent Stack (A6)



4279

Monitoring dates: 19th May 2021Job Number: **R21153**

Version: 1

Address: **Sheppey Energy Ltd**
New Hook Farm Cottages
Lower Road
Minster on Sea
Sheerness, ME12 3SUMonitoring Organisation: **Element Materials Technology Environmental UK Limited**Address: Cutbush Commercial
Cutbush Lane East
Reading, RG2 9AFDate of Report: 8th June 2021

Report Approved By: Bruce Kester

MCERTS Registration Number: MM03 190 Level II (TE1, 2, 3 & 4)

Function: Technical Specialist (Team Leader)

Signed:



CONTENTS

	Page No.
Part 1: Executive Summary	
1.1 Monitoring Objectives	3
1.2 Monitoring Results	4
1.3 Operating Information	6
1.4 Monitoring Deviations	7
 Part 2: Supporting Information	
2.1 Appendix I: General Information	8
2.2 Appendix II: Emission Point Reference Data & Results	10
2.3 Appendix III: Uncertainty Calculations	19
2.4 Appendix IV: Moisture Calculations	22
2.5 Appendix V: Acid Gas (SO₂) Calculations	23
2.6 Appendix VI: Hydrogen Sulphide Calculations	24

Notes to Report.

- a). Element Materials Technology Environmental UK Limited, Report Template V13.
- b). This report should not be reproduced except in full, without written approval of Element Materials Technology Environmental UK Limited.
- c). Opinions and Interpretations herein are outside the scope of UKAS/MCerts Accreditation.

PART 1: EXECUTIVE SUMMARY

1.1 Monitoring Objectives

Sheppey Energy Ltd. operate an anaerobic digestion plant at its facility located at New Hook Farm Cottages, Sheerness. This plant has the potential to pollute the atmosphere. Consequently, the processes involved are subject to regulation and periodic environmental monitoring is necessary under this regulation.

Biogas is piped to a spark ignition engine plant (2G engine). This plant combusts the gas and produces electricity which is then sold onto the National Grid. There is a gas flare that is used as a stand-by to burn off excess gas or for use during engine and boiler maintenance.

Element Ltd. was commissioned to monitor the engine and CO₂ vent stack for a suite of pollutants in order to provide data for environmental compliance.

The pollutants monitored are summarised below:

Substances to be monitored	Emission Point Identification	
	A1 2G Engine	A6 CO ₂ Vent Stack
Oxides of Nitrogen (NO _x as NO ₂)	✓	
Carbon Monoxide (CO)	✓	
Total Volatile Organic Compounds (VOCs)	✓	✓
Sulphur Dioxide (SO ₂)	✓	
Hydrogen Sulphide		✓
Moisture (for correction)	✓	✓
Oxygen (O ₂ - for correction)	✓	
Special requirements	None requested	

Job Number: R21153

Client Name: Sheppey Energy Ltd

1.2 Monitoring Results

Emission Point Reference	Substance to be Monitored	Emission Limit Value	Periodic Monitoring Result	Estimate of Uncertainty (2σ at 95% confidence)	Units	Reference Conditions	Date of Sampling	Start and End Times	Monitoring Method Reference	Accreditation for use of Method (see note below)	Operating Status
A1 2G Engine Stack	Oxides of Nitrogen (as NO ₂)	500	406	±19	mg(N)m ⁻³	101.3 kPa, 273K, dry gas, 5% O ₂	19/05/21	10:17-11:17	BS EN 14792	A	At 100% capacity
	Carbon Monoxide	1400	566	±39	mg(N)m ⁻³				BS EN 15058	A	
	Volatile Organic Compounds (VOCs as carbon)	1000	987	±35	mg(N)m ⁻³				BS EN 12619	A	
	Sulphur Dioxide	107	2.1	±0.1	mg(N)m ⁻³				BS EN 14791	B	
	Moisture	-	11.2	n/a	%	BS EN 14790			A		
	Oxygen	-	8.67	±0.46	%	BS EN 14789			A		

NOTE:

- A. Element Materials Technology Environmental UK Limited MCerts/UKAS Accredited for sampling and analysis.
- B. Element Materials Technology Environmental UK Limited MCerts/UKAS Accredited for sampling only, UKAS Accredited analysis conducted by sub-contract laboratory.
- C. Element Materials Technology Environmental UK Limited UKAS Accredited for sampling only (further clarification is given in section 1.4). Analysis of this component is not UKAS Accredited.
- D. The method for sampling and analysis is not UKAS or MCerts Accredited, method follows documented in-house procedure (further clarification is given in section 1.4).
- E. The method for sampling is not UKAS or MCerts Accredited, UKAS Accredited analysis conducted by sub-contract laboratory.

Job Number: R21153

Client Name: Sheppey Energy Ltd

Emission Point Reference	Substance to be Monitored	Emission Limit Value	Periodic Monitoring Result	Estimate of Uncertainty (2σ at 95% confidence)	Units	Reference Conditions	Date of Sampling	Start and End Times	Monitoring Method Reference	Accreditation for use of Method (see note below)	Operating Status
A6 CO2 Vent Stack	Hydrogen Sulphide	-	0.18	±0.05	mg(N)m ⁻³	101.3 kPa, 273K, wet gas, Stack O ₂	19/05/21	10:03-11:03	BS EN 13649	C	At 80% capacity
	Volatile Organic Compounds (VOCs as carbon)	-	1732	±69	mg(N)m ⁻³			10:01-11:01	BS EN 12619	A	
	Velocity	-	11.31	±1.05	ms ⁻¹			11:12	BS EN16911	E	

NOTE:

- A. Element Materials Technology Environmental UK Limited MCerts/UKAS Accredited for sampling and analysis.
- B. Element Materials Technology Environmental UK Limited MCerts/UKAS Accredited for sampling only, UKAS Accredited analysis conducted by sub-contract laboratory.
- C. Element Materials Technology Environmental UK Limited UKAS Accredited for sampling only (further clarification is given in section 1.4). Analysis of this component is not UKAS Accredited.
- D. The method for sampling and analysis is not UKAS or MCerts Accredited, method follows documented in-house procedure (further clarification is given in section 1.4).
- E. The method for sampling is not UKAS or MCerts Accredited, UKAS Accredited analysis conducted by sub-contract laboratory.

Job Number: R21153

Client Name: Sheppey Energy Ltd

1.3 Operating Information

Emission Point Reference	Date	Process Type	Process Duration	Fuel	Feedstock	Abatement	Load	Comparison of Operator CEMS and Periodic Monitoring Results			
								Substance	CEMS Results	Periodic Monitoring Results	Units
Engine Stack	19/05/21	Combustion	Continuous	BioGas	N/A	N/A	500kWe (100% MCR)	N/A	N/A	N/A	N/A
A6 CO2 Vent Stack	19/05/21	CO2 removal	Batch/as demanded	BioGas	N/A	N/A	Pentair at 50% capacity	CH4 CO2 O2 H2S	N/A	0.5 97.0 0.4 0	% % % ppm

Bulk gases shown in the final four columns obtained from Element Mcerts Geotech 5000 calibrated gas analyser

1.4 Monitoring Deviations

Emission Point Reference	Substance Deviations	Monitoring Deviations	Other Relevant Issues
A1 Engine	None	None	Capture efficiency was 90%, ideally this should be over 95%, the reduced value is due to the low challenge of the pollutant offered to the impingement train
A6 CO2 Vent	None	The hydrogen sulphide value was also as registered at a similar concentration on the blank sample which was unexposed to the gas sample. These values are thought to be attributable to sulphur artefact on the sample tubes. The sample has been blank corrected	None

PART 2: SUPPORTING INFORMATION

2.1 Appendix I: General Information

2.1.1 Monitoring organisation staff details

Monitoring at Budds Farm WwTW was conducted by the following Element Ltd. engineers:

Team Leader, Bruce Kester - MCERTs Level II (TE1, 2, 3 & 4)	MM03 190
Technician, Niall Kester – MCERTS Trainee	MM19 1573

2.1.2 Monitoring method details

Parameter	Standard Reference Method/Alternative	Element Procedure	MCerts Accreditation
Oxides of Nitrogen (as NO ₂)	BS EN 14792	SP14792	MCerts
Carbon Monoxide (CO)	BS EN 15058	SP15058	MCerts
Volatile Organic Compounds (VOCs)	BS EN 12619	SP12619	MCerts
Sulphur Dioxide	BS EN 14791	SP14791	MCerts
Moisture (H ₂ O)	BS EN 14790	SP14790	MCerts
Oxygen (O ₂)	BS EN 14789	SP14789	MCerts

2.1.3 Monitoring organisation equipment and gas check list references

EQUIPMENT			
Item	Reference	Calibration Due	PAT Due
Portable Gas Analyser	PGA#03	17-Sep-21	Oct-21
Flame Ionisation Detector Analyser	FID#01	11-Oct-21	Oct-21
Gas Conditioner	COND#05	17-Aug-21	Oct-21

NOx Converter	CONV#04	5-Jan-22	Oct-21
Digital Barometer	DB#30	5-Apr-22	-
Balance	BAL#05	1-Apr-22	-
Heated Filter Head	HFH#04	5-Jan-22	Oct-21
Heated Line	HL#1, 2, 3	5-Jan-22	-
Timepiece	TP#13	5-Sep-21	-
Data logger	DL#01	5-Jan-22	-
'Apex' Kit	APEX#01	Various	Oct-21
Dry Gas Meter ('Apex')	DGM#13	19-Aug-21	-
Timepiece	TP#06	19-Aug-21	-
Thermocouple ('Apex')	TC#05	19-Aug-21	-
Thermocouple Reader ('Apex')	TCR#08	19-Aug-21	-
Manometer ('Apex' Red)	MAN#03	19-Aug-21	-
Thermocouple ('Apex' Dogleg Exit)	TC#08	19-Aug-21	-

GAS CYLINDERS

	Certificate No.	Level (ppm)	Validity
'Zero' Gas (%)	EQ70HEA	99.9995%	N/A
Oxygen Span Gas (%)	VC81D8934	7.52%	6-Jul-21
VOC Span Gas	VC81D8934	599	6-Jul-21
Carbon Monoxide Span Gas	VC109017	1204	15-Apr-22
Nitric Oxide Span Gas	VC109017	257.0	15-Apr-22

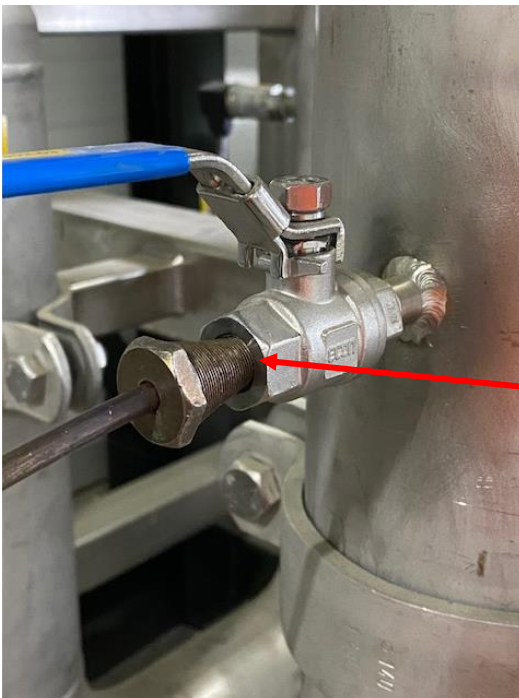
2.2 Appendix II: Emission Point Reference Data & Results

2.2.1 Photograph of Sampling Location on A1, Engine Stack



Sampling performed from turbo port located within engine container

2.2.2 Photograph of Sampling Location on A6, CO2 Vent Stack



Sampling performed from 1" port on CO2 exhaust line (A6). Stainless steel duct

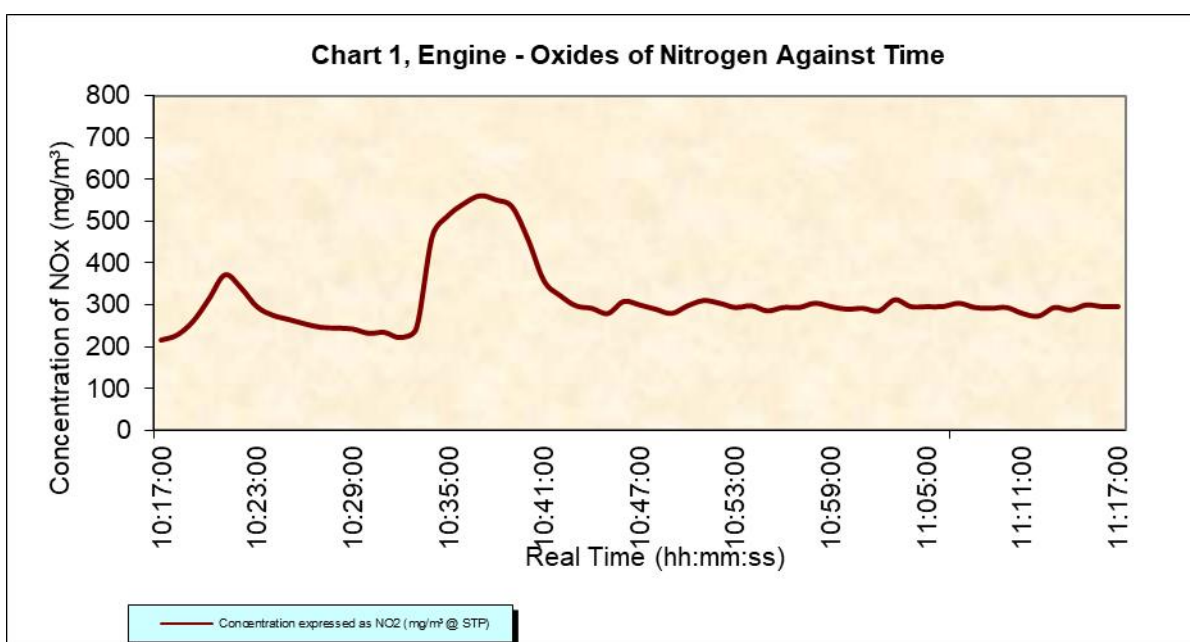
2.2.3 Homogeneity testing

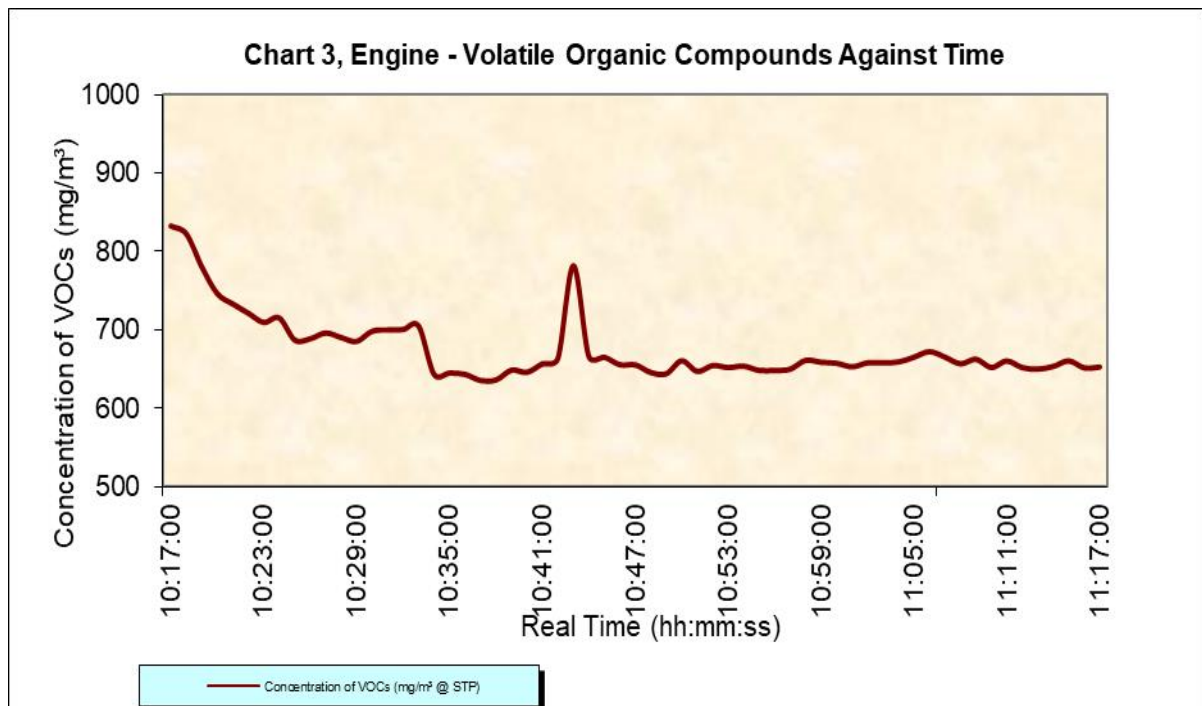
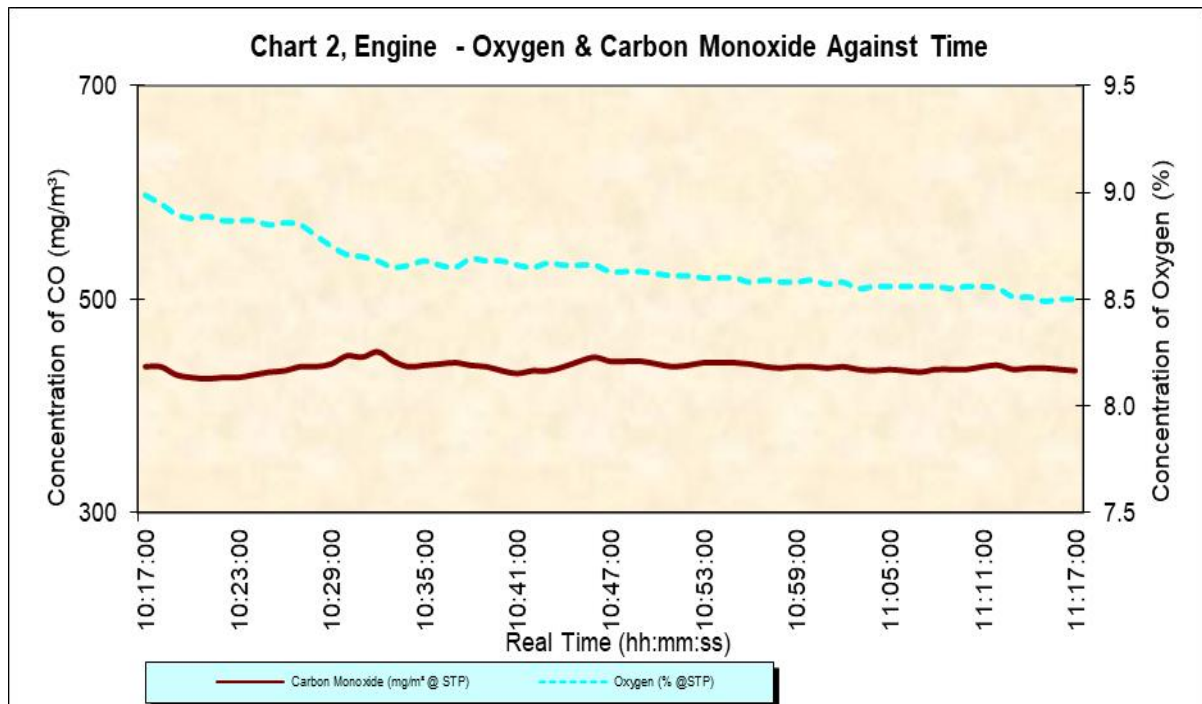
BS EN 15259 stipulates that the exhaust gases emitted from combustion processes are tested to ensure homogeneity and that a representative sample is obtained during the monitoring, subject to a number of caveats as elucidated in Environment Agency guidance MID15259. The details of the testing at each emission point are summarised below:

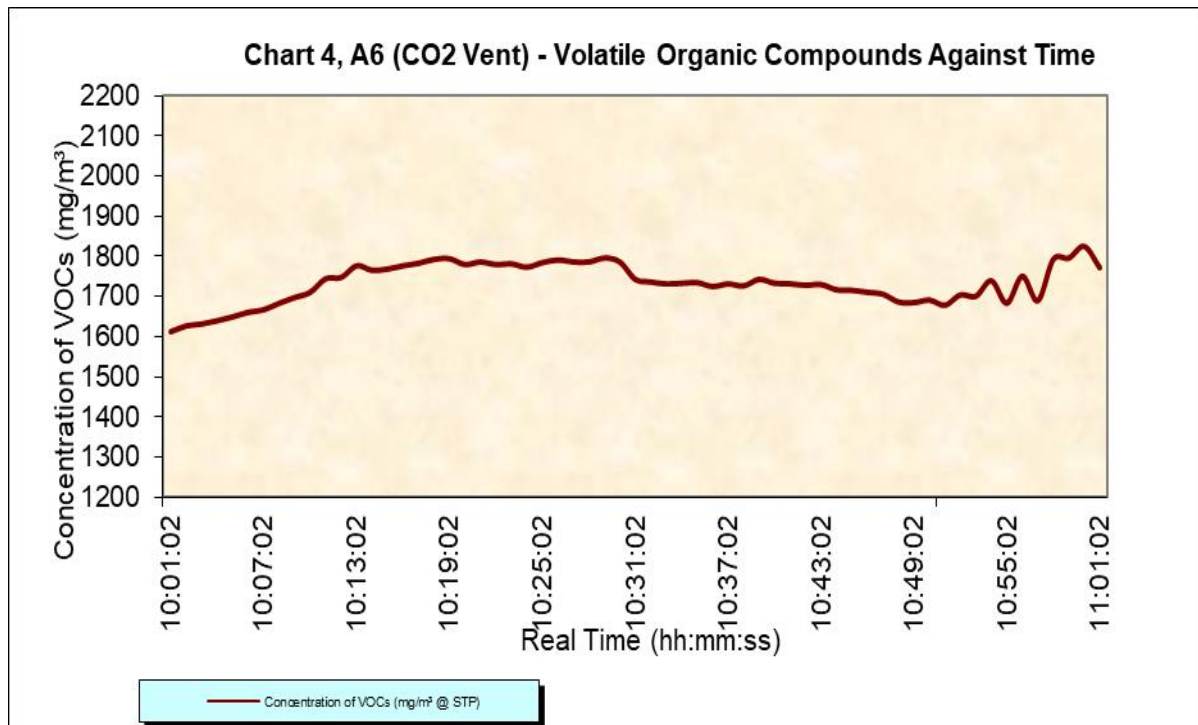
Stack	Result of Homogeneity Testing
Engine A1	N/A –homogeneity testing only required on stacks exceeding 1.13 m diameter, as specified in MID 15259. Homogeneity assumed & single point sampling acceptable.

2.2.4 Gas analyser site measurements and calibrations

The data in the following Charts 1 - 4 and Tables 1 & 2 are expressed in mgm^{-3} @ STP and is uncorrected for O_2 . In Addition, VOC results are expressed as carbon equivalent. This data was subsequently converted to reference oxygen concentrations (Section 1.2) with the addition of moisture correction for VOCs (engine A1). Calibration data is shown in Tables 3 & 4.





**Table 1 – Engine A1, Raw Data**

Time	Oxygen Dry Gas (%)	VOC Wet Gas (mgC/m ³)	CO Dry Gas (mg/m ³)	NO _x Dry Gas (mg/m ³)	Comment
10:17:00	9.0	831.7	436.3	215.6	
10:18:00	9.0	821.7	436.3	227.9	
10:19:00	8.9	779.6	428.8	260.8	
10:20:00	8.9	745.6	426.3	314.2	
10:21:00	8.9	732.4	425.0	371.7	
10:22:00	8.9	720.6	426.3	340.9	
10:23:00	8.9	708.8	426.3	295.7	
10:24:00	8.9	714.5	428.8	275.2	
10:25:00	8.9	686.3	431.3	264.9	
10:26:00	8.9	687.9	432.5	254.6	
10:27:00	8.9	695.3	436.3	246.4	
10:28:00	8.8	689.5	436.3	244.4	
10:29:00	8.8	684.6	438.8	242.3	
10:30:00	8.7	697.5	446.3	232.1	
10:31:00	8.7	699.1	445.0	234.1	
10:32:00	8.7	699.6	450.0	221.8	
10:33:00	8.7	704.3	441.3	244.4	

Time	Oxygen Dry Gas (%)	VOC Wet Gas (mgC/m ³)	CO Dry Gas (mg/m ³)	NO _x Dry Gas (mg/m ³)	Comment
10:34:00	8.7	642.5	436.3	464.1	
10:35:00	8.7	644.1	437.5	513.4	
10:36:00	8.7	642.5	438.8	542.1	
10:37:00	8.7	634.7	440.0	560.6	
10:38:00	8.7	635.3	437.5	550.4	
10:39:00	8.7	647.8	436.3	533.9	
10:40:00	8.7	645.1	432.5	455.9	
10:41:00	8.7	655.9	430.0	357.3	
10:42:00	8.7	662.8	432.5	322.4	
10:43:00	8.7	781.1	432.5	297.8	
10:44:00	8.7	665.2	436.3	291.6	
10:45:00	8.7	664.4	441.3	279.3	
10:46:00	8.7	654.8	445.0	308.0	
10:47:00	8.6	654.6	441.3	299.8	
10:48:00	8.6	644.9	441.3	289.6	
10:49:00	8.6	643.2	441.3	279.3	
10:50:00	8.6	659.9	438.8	297.8	
10:51:00	8.6	646.2	436.3	310.1	
10:52:00	8.6	653.8	437.5	303.9	
10:53:00	8.6	651.2	440.0	293.7	
10:54:00	8.6	653.0	440.0	297.8	
10:55:00	8.6	647.5	440.0	285.4	
10:56:00	8.6	647.5	438.8	293.7	
10:57:00	8.6	649.1	436.3	293.7	
10:58:00	8.6	660.4	435.0	303.9	
10:59:00	8.6	658.0	436.3	295.7	
11:00:00	8.6	656.7	436.3	289.6	
11:01:00	8.6	652.2	435.0	291.6	
11:02:00	8.6	657.2	436.3	285.4	
11:03:00	8.6	657.2	433.8	312.1	
11:04:00	8.6	658.3	432.5	295.7	
11:05:00	8.6	664.4	433.8	295.7	
11:06:00	8.6	671.5	432.5	295.7	
11:07:00	8.6	664.6	431.3	303.9	
11:08:00	8.6	656.0	433.8	293.7	
11:09:00	8.6	661.7	433.8	291.6	
11:10:00	8.6	651.4	433.8	293.7	
11:11:00	8.6	659.6	436.3	279.3	
11:12:00	8.6	651.1	437.5	273.1	
11:13:00	8.5	649.1	433.8	293.7	

Time	Oxygen Dry Gas (%)	VOC Wet Gas (mgC/m ³)	CO Dry Gas (mg/m ³)	NO _x Dry Gas (mg/m ³)	Comment
11:14:00	8.5	652.7	435.0	287.5	
11:15:00	8.5	659.7	435.0	299.8	
11:16:00	8.5	650.7	433.8	295.7	
11:17:00	8.5	651.9	432.5	295.7	

Table 2 – A6, CO2 Vent Stack, Raw Data

Time	VOC Wet Gas (mgC/m ³)	Comment
10:01:02	1612.0	
10:02:02	1626.4	
10:03:02	1631.3	
10:04:02	1639.3	
10:05:02	1648.9	
10:06:02	1660.2	
10:07:02	1666.6	
10:08:02	1682.7	
10:09:02	1697.1	
10:10:02	1710.0	
10:11:02	1743.8	
10:12:02	1747.0	
10:13:02	1775.9	
10:14:02	1764.6	
10:15:02	1767.9	
10:16:02	1775.9	
10:17:02	1782.3	
10:18:02	1792.0	
10:19:02	1793.6	
10:20:02	1779.1	
10:21:02	1785.5	
10:22:02	1779.1	
10:23:02	1780.7	
10:24:02	1772.7	
10:25:02	1783.9	
10:26:02	1790.4	
10:27:02	1785.5	
10:28:02	1785.5	
10:29:02	1795.2	
10:30:02	1785.5	
10:31:02	1742.1	

Time	VOC Wet Gas (mgC/m ³)	Comment
10:32:02	1735.7	
10:33:02	1730.9	
10:34:02	1732.5	
10:35:02	1734.1	
10:36:02	1724.5	
10:37:02	1730.9	
10:38:02	1726.1	
10:39:02	1742.1	
10:40:02	1732.5	
10:41:02	1730.9	
10:42:02	1727.7	
10:43:02	1729.3	
10:44:02	1716.4	
10:45:02	1714.8	
10:46:02	1710.0	
10:47:02	1705.2	
10:48:02	1685.9	
10:49:02	1684.3	
10:50:02	1690.7	
10:51:02	1677.9	
10:52:02	1703.6	
10:53:02	1700.4	
10:54:02	1738.9	
10:55:02	1682.7	
10:56:02	1750.2	
10:57:02	1689.1	
10:58:02	1792.0	
10:59:02	1795.2	
11:00:02	1824.1	
11:01:02	1771.1	

Table 3 – Calibration Data (A1)

ANALYSER CALIBRATION DATA					
Pre Sampling Check					
		NO (ppm)	CO (ppm)	O ₂ (%)	VOC's (ppm)
Range		500	2000	25	1000
Zero Gas	Cylinder No.	VC2686487			Scrubbed Air
Span Gas	Cylinder No.	VC109017	VC109017	VC81D8934	VC81D8934
	Certified Value	257	1204	7.52	599
Zero Check	Value	0.2	0	0.01	2
<2 x repeatability (Yes/No)		YES	YES	YES	YES
Down Line Zero & Span Check					
Zero Gas	Value	0.3	2	0.02	3
	<2% of span	YES	YES	YES	YES
Span Gas	Value	256	1193	7.53	592
	Within 2% of span	YES	YES	YES	YES
Post Sampling Drift Check					
Zero Gas	Value	0.4	2	0.02	-2
	Drift (%)	0.0	0.0	0.0	0.8
	Validation	No Correction Required	No Correction Required	No Correction Required	No Correction Required
Span Gas	Value	255.8	1191	7.54	589
	Drift (%)	0.1	0.2	0.1	0.3
	Validation	No Correction Required	No Correction Required	No Correction Required	No Correction Required

Table 4 – Calibration Data (A6)

ANALYSER CALIBRATION DATA					
Pre Sampling Check					
					VOC's (ppm)
Range					1000
Zero Gas	Cylinder No.				Scrubbed Air
Span Gas	Cylinder No.				5702977
	Certified Value				900
Zero Check	Value				2
<2 x repeatability (Yes/No)					YES
Down Line Zero & Span Check					
Zero Gas	Value				2
	<2% of span				YES
Span Gas	Value				891
	Within 2% of span				YES
Post Sampling Drift Check					
Zero Gas	Value				3
	Drift (%)				0.1
	Validation				No Correction Required
Span Gas	Value				887
	Drift (%)				0.6
	Validation				No Correction Required

2.3 Appendix III: Uncertainty Calculation

2.3.1 Uncertainty Calculations, A1 Engine

NOx - Measurement performance related to stationary conditions		
Performance characteristic	Uncertainty	Value of uncertainty quantity
Standard deviation of repeatability at zero	U_{r0}	0.80
Standard deviation of repeatability at span level	U_{rs}	0.10
Lack of fit	U_{rlt}	2.37
Drift	U_{odr}	7.73
volume or pressure flow dependence	U_{spres}	0.06
atmospheric pressure dependence	U_{apres}	0.59
ambient temperature dependence	U_{temp}	0.23
NH ₃ (20 mg/m ³)	U_{interf}	0.14
CO ₂ (15%)	-	0.02
H ₂ O (30%)	-	0.01
Error in logger voltage	-	0.50
Dependence on voltage	U_{volt}	0.03
Converter efficiency	U_{ceff}	1.45
losses in the line (leak)	U_{leak}	3.61
Uncertainty of calibration gas	U_{calib}	3.61

NOx Measurement uncertainty		Result	313.06	mg/m ³
Combined uncertainty			9.71	mg/m ³
Expanded uncertainty	k = 2		19.41	mg/m ³
Uncertainty corrected to std conds			19.41	mg.m-3 (corrected)
Expanded uncertainty		expressed with a level of confidence of 95%		
		3.88 % ELV		
Expanded uncertainty		expressed with a level of confidence of 95%		
		19.41 mg.m⁻³ of result		

CO - Measurement performance related to stationary conditions		
Performance characteristic	Uncertainty	Value of uncertainty quantity
Standard deviation of repeatability at zero	U_{r0}	0.80
Standard deviation of repeatability at span level	U_{rs}	0.10
Lack of fit	U_{rlt}	5.77
Drift	U_{odr}	16.95
volume or pressure flow dependence	U_{spres}	0.00
atmospheric pressure dependence	U_{apres}	1.15
ambient temperature dependence	U_{temp}	0.00
CO ₂ (15%)	U_{interf}	0.00
N ₂ O (40mgm ³)	-	0.00
CH ₄ (57mgm ³)	-	0.00
H ₂ O (1%)	-	0.00
Dependence on voltage	U_{volt}	0.03
Error in Logger reading	-	2.00
losses in the line (leak)	U_{leak}	5.03
Uncertainty of calibration gas	U_{calib}	5.03

CO Measurement uncertainty		Result	435.93	mg/m ³
Combined uncertainty			19.41	mg/m ³
Expanded uncertainty	k = 2		38.82	mg/m ³
Uncertainty corrected to std conds			38.82	mg.m-3 (corrected)
Expanded uncertainty		expressed with a level of confidence of 95%		
		2.77 % ELV		
Expanded uncertainty		expressed with a level of confidence of 95%		
		38.82 mg.m⁻³ of result		

Job Number: R21153

Client Name: Sheppey Energy Ltd

VOC - Measurement performance related to stationary conditions		
Performance characteristic	Uncertainty	Value of uncertainty quantity
Standard deviation of repeatability at zero	U_{r0}	0.80
Standard deviation of repeatability at span level	U_{rs}	0.10
Lack of fit	U_{rf}	3.74
Drift	U_{odr}	13.25
volume or pressure flow dependence	U_{spres}	0.00
atmospheric pressure dependence	U_{apres}	0.75
ambient temperature dependence	U_{temp}	0.00
NH ₃ (20 mg/m ³)	U_{interf}	0.00
CO ₂ (15%)	-	0.00
H ₂ O (30%)	-	0.00
Error on Logger voltage	-	1.00
Dependence on voltage	U_{volt}	0.03
losses in the line (leak)	U_{leak}	7.80
Uncertainty of calibration gas	U_{calib}	7.80

VOC Measurement uncertainty	Result	675.70	mg/m ³
Combined uncertainty		17.69	mg/m ³
Expanded uncertainty	k = 2	35.38	mg/m ³
Uncertainty corrected to std conds		35.38	mg.m-3 (corrected)
Expanded uncertainty	expressed with a level of confidence of 95%	3.54 % ELV	
Expanded uncertainty	expressed with a level of confidence of 95%	35.38 mg.m⁻³ of result	

Oxygen - Measurement performance related to stationary conditions		
Performance characteristic	Uncertainty	Value of uncertainty quantity
Standard deviation of repeatability at zero	U_{r0}	0.20
Standard deviation of repeatability at span level	U_{rs}	0.03
Lack of fit	U_{rf}	0.10
Drift	U_{odr}	0.12
volume or pressure flow dependence	U_{spres}	0.00
atmospheric pressure dependence	U_{apres}	0.01
ambient temperature dependence	U_{temp}	0.03
CO ₂ (15%)	-	0.00
NO ₂ (300)	-	0.06
NO ₂ (30)	-	0.00
dependence on voltage	U_{volt}	0.02
losses in the line (leak)	U_{leak}	0.10
Error in Logger voltage	-	0.03
Uncertainty of calibration gas	U_{calib}	0.10

O₂ Measurement uncertainty	Result	8.67	%vol
Combined uncertainty		0.23	%vol
% of value		2.64	%
Expanded uncertainty	expressed with a level of confidence of 95%	5.28 % of value	
Expanded uncertainty	expressed with a level of confidence of 95%	0.46 % vol	

Sulphur Dioxide

Parameter	Value	Units	Sensitivity coeff	Uncertainty contribution	Uncertainty as %
Corrected Volume (standard condit	V	0.51 m ³	3.12	0.02 mg.m ⁻³	1.19 %
Mass	m	1.17 mg	1.37	0.05 mg.m ⁻³	3.23 %
Factor for O ₂ Correction	fc	1.30	1.23	0.03 mg.m ⁻³	1.86 %
Leak	L	0.02 mg.m ⁻³	1.00	0.02 mg.m ⁻³	1.15 %
Combined uncertainty				0.07 mg.m⁻³	
Expanded uncertainty as percentage of measured value		8.16	% measured of value	expressed with a level of confidence of 95% (Using a coverage factor k=2)	
Expanded uncertainty in units of measurement		0.13	mg.m ⁻³		
Expanded uncertainty as percentage of limit value		0.12	% ELV		

2.3.2 Uncertainty Calculations, A2 CO2 Vent Stack

VOC - Measurement performance related to stationary conditions		
Performance characteristic	Uncertainty	Value of uncertainty quantity
Standard deviation of repeatability at zero	U_{r0}	0.80
Standard deviation of repeatability at span level	U_{rs}	0.10
Lack of fit	U_{lf}	3.74
Drift	U_{odr}	19.35
volume or pressure flow dependence	U_{spres}	0.00
atmospheric pressure dependence	U_{apres}	0.75
ambient temperature dependence	U_{temp}	0.00
NH3 (20 mg/m3)	U_{interf}	0.00
CO2 (15%)	-	0.00
H2O (30%)	-	0.00
Error on Logger voltage	-	1.00
Dependence on voltage	U_{volt}	0.03
losses in the line (leak)	U_{leak}	20.00
Uncertainty of calibration gas	U_{calib}	20.00

VOC Measurement uncertainty		Result	
Combined uncertainty		1732.02	mg/m ³
Expanded uncertainty		34.50	mg/m ³
Expanded uncertainty	k = 2	68.99	mg/m ³
Uncertainty corrected to std conds		68.99	mg.m-3 (corrected)
Expanded uncertainty	expressed with a level of confidence of 95%	n/a % ELV	
Expanded uncertainty	expressed with a level of confidence of 95%	68.99 mg.m ⁻³ of result	

H2S Uncertainty				
Parameter	Uncertainty Criteria	U (%)	U ²	Field Data
Timing Error	<1 second per hour	0.028	0.001	60
Pressure	1% of Pressure	1.012	1.024	101.2
Temperature	2.5K	0.853	0.728	293
Flow Rate	5% of flow	10.000	100.00	200
Lab Uncertainty contribution	All results	8.500	72.25	0.18
		SUM U ²	174.00	
		Total U	13.19	as %
		Total U	0.02	mgm ⁻³
		at 95% confidence	0.05	mgm ⁻³

2.4 Appendix IV: Moisture Calculations

Test No	T2
Date	19-5-21
pbar (mbar)	1016
pbar (mmHg)	762
Nozzle Diameter (mm)	n/a
Temp of Meter (in)/(out) °C	16
DH _{ave} (mmH ₂ O)	10.0
DGM Cal Factor (Y)	0.9927

Site	Sheppey AD Ltd Sheppey AD
Stack	Engine
Job Number:	R21153
Site Team:	BK & NK
Data Entered By:	BK

Enter Data into coloured cells only

Start Volume Reading	396.1600	m³
End Volume Reading	396.7328	m³
Volume Sampled	0.5686	m³

Start time	10:17	hr:min
End time	11:17	hr:min
Total time	01:00	hr:min

IMPINGER	1	2	3	4	Initials of Analyst
Absorber Solution (Type):	H2O2	H2O2	H2O2	SILICA	
Sample No:	n/a	n/a	n/a	n/a	
Analysis Required:	n/a	n/a	n/a	n/a	
Initial Weight of Impingers plus absorber (g)	830.1	832.1	815.4	861.8	NK
Final Weight of Impingers plus absorber (g)	871.0	836.4	815.7	870.7	NK
Weight Gain (g)	40.9	4.3	0.3	8.9	

Total Weight Gain (1+2+3+4) (g)	54.4
---------------------------------	------

Gas Volume of water at 0°C and 101.3kPa (l)	67.73
Gas Meter volume at 0°C and 101.3kPa (l)	539.25

Moisture content of Gases (%)	11.2
-------------------------------	------

2.5 Appendix V: Acid Gas Calculations

SUMMARY OF ACID GAS IMPINGEMENT SAMPLING			
Stack ID Stack Dimensions (m) Date of Test TEST NUMBER		Engine	
		0.20	
		19-May-21	19-May-21
		T1	T2
Applied Standard		BS EN 14791	
Start Time (hh:mm)	10:02	10:17	
Stop Time (hh:mm)	10:07	11:17	
Duration (minutes)	5	60	
Sampled Gas Volume (m³)	Field Blank	0.5728	
Mean Temperature DGM (°C)		16.00	
Mean Sample Pressure (mmH₂O)		10.00	
Mean Stack Temperature (°C)		392.00	
Corrected Sampled Gas Vol. (Sm³@20°C)		0.5790	
Corrected Sampled Gas Vol. (Nm³@STP)		0.5395	
Average Flowrate (l/min @STP)		8.99	
Required Pollutant (eg:HCl, HF or SO₂)		SO₂	
Molecular Weight Pollutant	64	64	
Determinant Species	Sulphate		
Molecular Weight Determinand	96	96	
Analysing Laboratory UKAS No.		2479	
Measured concentration(Front) (ug/ml)	0.1	2.8	
Solution Sample Volume (ml)	360.0	415.0	
Measured concentration(Back) (ug/ml)	0.1	0.8	
Solution Sample Volume (ml)	145.0	160.0	
Efficiency of Capture (%)		N/A	90.44%
Total Determinand Mass (mg)	0.025	1.289	
Moles of Determinand (mol)	0.000	0.013	
Mass of Pollutant (mg)	0.02	0.86	
Concentration (@ STP, Dry) (mg/m³)	0.03	1.59	
Stack Moisture (%)/v/v		11.14	
Moisture Correction dim'less	1.00	1.13	
Stack Oxygen (%)/v/v	8.67	8.67	
Oxygen Correction Factor dim'less	1.30	1.30	
Net Correction Factor dim'less		1.30	1.30
Concentration @ Ref (mg/(N)m³)	0.04	2.07	
Sample as a percentage of ELV (%)	0.04%	1.93%	
Blank Value (mg/(N)m³)	0.04		
Is Blank value < 10% of ELV	Yes		

2.6 Appendix VI: Hydrogen Sulphide Calculations

Test No	T1
Date	19/05/2021
Site	Sheppey AD
Stack	A6
Reference Conditions - Oxygen (%)	21
- Temperature (°C)	0
- Pressure (kPa)	101.3
Job Number	R21153
Site Team	BK & NK
Test Conducted By	BK
Data Entered By	BK

Test Start Time	10:03
Test End Time	11:03
Test Duration (min)	60
Flowmeter Rate at Start (ml/min)	200
Flowmeter Rate at End (ml/min)	200
Mean Flowmeter Rate (ml/min)	200
Uncorrected Volume Sampled (l)	12.00

Barometric Pressure (kPa)	101.2
Ambient Temperature (°C)	20
Flowmeter Calibration Factor (f)	0.9844
Stack Oxygen Level (%)	21
Volume Sampled @ Reference Conditions	10.99

Primary Tube Reference Identification Number	A61
Security Tube Reference Identification Number	A62
Blank Tube Reference Identification Number	A63
Mass of H ₂ S on Primary Tube (ug)	2
Mass of H ₂ S on Security Tube (ug)	0
Breakthrough (Reject if > 5%)	Pass
Total Mass of H ₂ S in Sample (ug)	2

H ₂ S Concentration (mg/m ³ @ STP and Ref O ₂)	0.18
--	------

Appendix I Centriair odour control system



Technical description: Odour removal–Attleborough

Centriair develops and offers technology leading solutions for abatement of industrial airborne emissions. We provide solutions with proven environmental and economic benefits. Our systems typically have higher performance and lower energy consumption than prevailing solutions. We help the industry solve a broad range of emission problems while increasing the productivity and reducing operations and maintenance costs.

These benefits are achieved through **higher performance, lower energy consumption** and by recovering energy from the process. We work across a broad range of industry sectors; however most of our customers are in the food processing and waste processing industries.

Concept:

- Mixing pit and tanker intake is now treated separately with our new system DEO, compact catalyst conversion of H₂S and other odour compounds. This unit combusts the air and feeds the treated air into the main duct to go out with the high concentration system. See separate document for description.
- Additionally a sulphured filter to give redundancy and extra capacity to the DEO system in achieving H₂S removal using oxidized iron pellet materials (dry solution) to capture sulphur compounds. This is also connected to the mixing pit and tanker intake sources.
- We have divided the main air sources in the building in two categories:



- Low contamination, this is air from the reception hall where trucks can enter (3,5 air changes).
- Medium contamination, this is air from rooms with processes that generate higher smells, mixing room, storage room. These air streams have a much higher dimensioning for the ColdOx® UV and Carbon Filter systems

This design uses all our experience from AD plants, where we have a number of tank systems (for food waste, slaughterhouse waste, manure, fish waste, etc.), process rooms (sludge dewatering, handling, depackaging, etc.) as well as large reception halls. Based on the typical odour loads we get from these different sources, we have tailored a solution that we strongly believe offers:

- High and reliable odour removal performance
- Attractive maintenance and energy consumption
- For the high volume of air to be treated a compact installation footprint

System emission parameters:

1. Release height (m), assuming optional stand-alone chimney – **14,0 meters**
2. Stack diameter (m), assuming optional stand-alone chimney – **1200 mm**
3. Emission concentration for odour, NH₃, H₂S, PM₁₀ (if relevant) the volume of release (m³/s) and the conditions these values are provided at:

Odour: < **1000 OU/m³**

NH₃: < **2 ppm**

H₂S: < **0,1 ppm**

PM₁₀: < **5 mg/m³**

4. Exit temperature (°C) - **10-35 °C**

5. Exit velocity (m/s) – **14 m/s**

Designed airflows for the facility

Please find below a table of the air flows from the different rooms in the facility with the air changes per hour for each part of the building.

Location	Air changes	Air Volume (m ³)	Treated Air (m ³ /h)	Description
Reception Hall	3,5	9 173	32 105	Trucks regularly enter this room and personnel at the plant are active here during the working days. NB, we have taken out the switch board room to reduce volumes that are not necessary to treat. Location with low concentrations.
Filling Station and Mixing pit air volume	3	1 895	5 686	General extraction from rooms
Switchboard room	1	236	236	Ventilation of electrical controls room
Taking Station room	4	1 685	6 739	Highly odourous sources in these rooms
Separation room	4	1 685	6 739	Highly odourous sources in these rooms
Small room with gully	4	316	1264	Highly odourous sources in these rooms
Mixing Pit	1	500	500	Extreme odour concentrations
Point extraction separation	1	500	500	Extreme odour concentrations

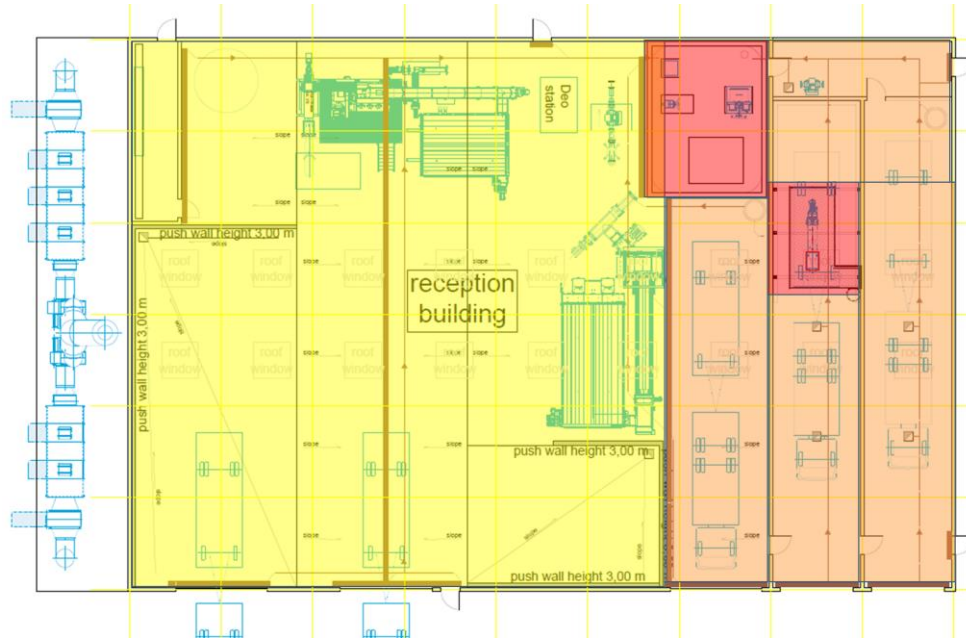
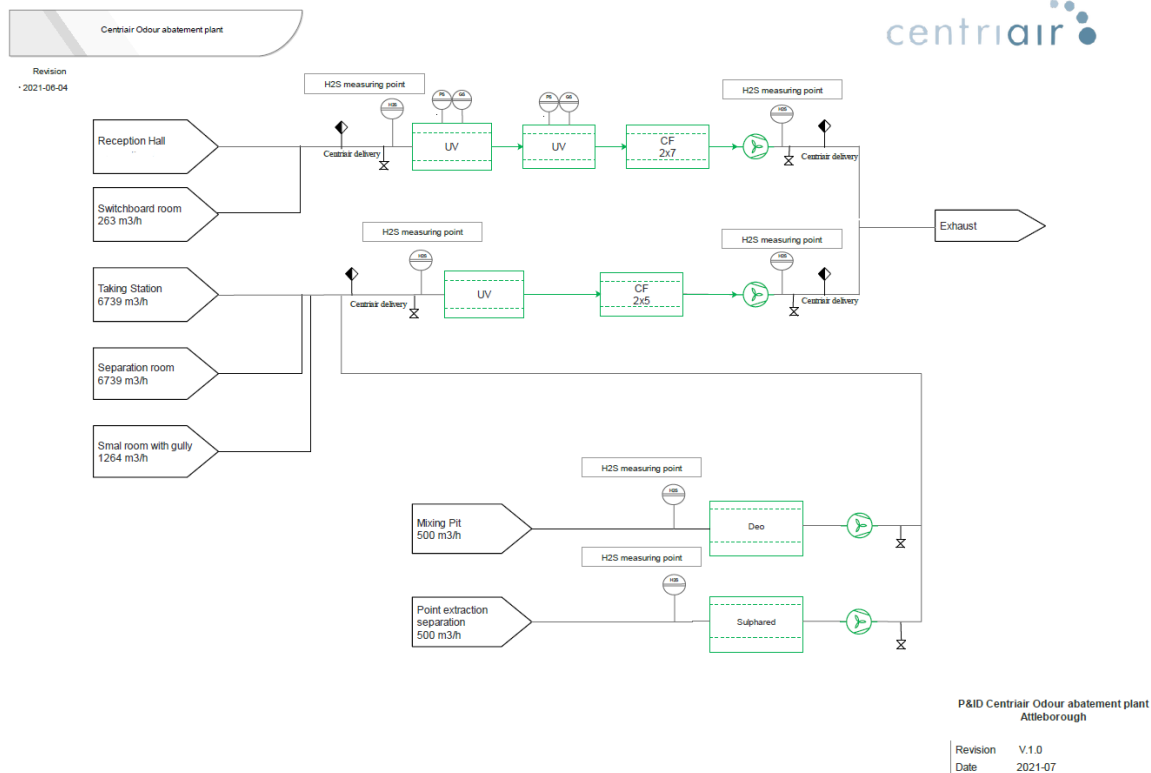


Illustration of the different odour source "zones" in the plant as specified in table above

REVISED					
ATTLEBOROUGH AIRFLOWS					
Building part	Measurements	Volume m3	Air Changes/hr	Air to be treated	Medium/low Concentration
Reception hall	28x11,7x28m	9 173	3,5	32 105	Low conc
Filling station & mixing pit air volume	27x11,7x6	1 895	3	5 686	Low conc
Switchboard room	9x11,7*2,5	263	1	263	Low conc
Taking Station 1	6x11,7x24	1 685	4	6 739	Medium Conc
Separation BioC	6x11,7x24	1 685	4	6 739	Medium Conc
Small Room with gully	9x11,7x3	316	4	1 264	Medium Conc
Extreme concentration after pre-treatment				1 000	Medium
			Sum	53 796	m3/h
SOURCES WITH "EXTREME" CONCENTRATIONS" - TREATED WITH SULPHARED AND DEO UNITS					
Point Extraction	Dimensions	Volume m3	Air Changes/hr	Air to be treated m3/h	
Mixing Pit	20 m3	500	1	500	Extreme Conc
Point extraction separation		500	1	500	Extreme Conc
					Not included
					0 Not included
			Sum	1 000	m3/h



Draft plant P&ID

The odour removal technique is based on the use of intense and energetic UV radiation to fragment the organic molecules and oxidize the odour compounds by the mechanism of ozonolysis and photolysis. The oxidized gases have a much lower odour threshold and activity.

A short/medium residence time carbon bed is installed after the UV reactor. This contains an adapted volume of carbon for Low and Medium Concentration sources in the plant. The active carbon has a long lifetime as the excess ozone generated by the UV lamps helps to destroy organic compounds captured on the carbon thus significantly extending the carbon life. The combination of these two technologies provides a high performance with competitive operational costs.

Specification of the equipment:

As described above the complete odours control solution consists of three separate stages:

1. Low concentrations – ColdOx system using UV and Active carbon

2. Medium concentrations – Higher dimensioned ColdOx system using UV and Active carbon
3. High/extreme concentrations – Catalytical conversion system taking H₂S, other Sulphur compounds as well as odour compounds. Alternatively Sulphared filter as an option.

For installation footprint, please see draft drawings of the units and possible installation layouts.

Overall system specification - Low Concentration:

ColdOx[®] system consisting of a ColdOx[®] UV reactor, Active carbon filter and a fan.

UV Specification:

Description :	<p>The UV reactor is the first treatment stage, built together with the active carbon filter.</p> <p>Basic control setup is start/stop signal from your system and running and error signal back to your system. Profinet connection included.</p> <p>Control and safety solution includes pressure guard for the UV as well as door switches. The unit comes with a pressure sensor to control the dust level in the system.</p> <p>Equipment prewired with “plug and play” to minimize site wiring. Automatic flushing system of lamps, CIP (Cleaning in Place). Drainage pipes come with heat tracing to avoid freezing in winter temperatures. Safety switches with alarm system in case of lamp failure. Operation and alarm to the external system via potential-free output.</p> <p>Flow switch starts / stops the UV system, and the ability to lock the fan. Solenoid valve included.</p>
Note:	The ballast panel should be positioned within 20 meter cable length from the UV reactor.
Electrical connection:	380-400 V/50 A three phase + Neutral 50 Hz
Operating power, UV:	17,5 kW
Materials:	Reactor, lamp frames, control panel casing stainless steel AISI 304.
Weight:	Total weight of one reactor including support and lamp frames is 350 kg.
Dimensions:	2120 x 1952 x 1012 mm (x2)
Process gas flow:	38 054 m ³ /h
Lamp life:	16 000 hours
Maximal operating temp:	70 °C
Control system:	PLC Siemens S7 1200 signal as Profinet



Image 1. Example of a Coldox® UV Reactor

Active Carbon Specification:

Description:	Active Carbon filter with medium residence time due to the initial treatment and combination effects from oxidation + carbon. Dual carbon beds to minimize pressure drop.
Carbon volume:	7,4 m ³
Pressure drop:	< 800 Pa
Dimensions:	2 000 x 7 000 x 2 650 mm
Material:	Stainless steel AISI 304
Disposal of Carbon	For the disposal of spent media, we recommend following the guidelines of the European Waste Catalogue EWC and use the waste code number 19 09 04 or 15 02 03 – non hazard waste. Numerous landfills containing household trash and building materials will accept the loaded gas purification product, which is totally harmless to the environment, after submitting a declaration of analysis.



Image 2. Example of a Carbon Filter

Fan Specification:

Description:	Industrial centrifugal fan (1) from stainless steel driven by frequency inverter in main panel. Expanded to allow a higher pressure-drop from future carbon bed. Fans come with VFD system to regulate the airflow changes. <i>The fan is designed with the pressure drop of 1 600 Pa. If the pressure drop increases, another fan needs to be suggested to overcome the pressure in the system and the ducting.</i>
Capacity:	38 054 m ³ /h
Electrical connection:	380-400 V
Installed Power:	17,5 kW (taken from another Rotodyne offer)
Operating Power:	12,7 kW (taken from another Rotodyne offer)
Noise Level	68,2 dB at 1 m distance

Overall system specification – Medium Concentration:

ColdOx® system consisting of a ColdOx® UV reactor, Active carbon filter and a fan.

UV Specification:

Description :	The UV reactor is the first treatment stage, built together with the active carbon filter. Basic control setup is start/stop signal from your
---------------	--

system and running and error signal back to your system. Profinet connection included.

Control and safety solution includes pressure guard for the UV as well as door switches. The unit comes with a pressure sensor to control the dust level in the system. Equipment prewired with “plug and play” to minimize site wiring. Automatic flushing system of lamps, CIP (Cleaning in Place). Drainage pipes come with heat tracing to avoid freezing in winter temperatures. Safety switches with alarm system in case of lamp failure. Operation and alarm to the external system via potential-free output. Flow switch starts / stops the UV system, and the ability to lock the fan. Solenoid valve included.

Note:	The ballast panel should be positioned within 20 meter cable length from the UV reactor.
Electrical connection:	380-400 V/50 A three phase + Neutral 50 Hz
Operating power, UV:	10,5 kW
Materials:	Reactor, lamp frames, control panel casing stainless steel AISI 304.
Weight:	Total weight of one reactor including support and lamp frames is 350 kg.
Dimensions:	2120 x 1952 x 1012 mm
Process gas flow:	14 742 m ³ /h
Lamp life:	16 000 hours
Maximal operating temp:	70 °C.
Control system:	PLC Siemens S7 1200 signal as Profinet

Active Carbon Specification:

Description:	Active Carbon filter with medium residence time due to the initial treatment and combination effects from oxidation + carbon. Dual carbon beds to minimize pressure drop.
Carbon volume:	7,37 m ³
Pressure drop:	< 200 Pa
Dimensions:	2 000 x 5 000 x 2 650 mm
Material:	Stainless steel AISI 304
Disposal of Carbon	For the disposal of spent media, we recommend following the guidelines of the European Waste

Catalogue EWC and use the waste code number 19 09 04 or 15 02 03 – non hazard waste. Numerous landfills containing household trash and building materials will accept the loaded gas purification product, which is totally harmless to the environment, after submitting a declaration of analysis.

Fan Specification:

Description:	Industrial centrifugal fan (1) from stainless steel driven by frequency inverter in main panel. Expanded to allow a higher pressure-drop from future carbon bed. Fans come with VFD system to regulate the airflow changes. <i>The fan is designed with the pressure drop of 1 200 Pa. If the pressure drop increases, another fan needs to be suggested to overcome the pressure in the system and the ducting.</i>
Capacity:	14 742 m ³ /h
Electrical connection:	380-400 V
Installed Power:	11 kW
Operating Power:	7,7 kW
Noise Level:	64 dB at 1 m distance

System specification – High Concentration

Sulphared™ pellets:

	Adsorption media active against Sulphur compounds in the form of pellets for increased surface area. The filter comes with bag filters for protection of the Sulphared media from unloading dust. Unit comes with booster fan incl. inverter to compensate for the pressure drop.
Media volume, total:	2,78 m3
Residence time:	10 sec
Pressure drop:	<500 Pa

Material containers: GRP



Image 3. Sulphared Media

Ducting specification

Ducting design and positioning needs to be reviewed once the odour equipment sizing and positioning has been finalized

Performance guarantee:

The quoted installation is dimensioned to give 90 % odour reduction level to reach below 1 000 OU/m³ at the chimney top. This also assumed that the waste handled is stored limited time on site in order not to let it degrade and create additional odours. Maximal storage time should be 48 hours.

Waste taken into the plant assumed to be fresh food waste collected without storage.

Scandinavian Centriair AB

www.centriair.com

Appendix J Digestate analysis



Purchase Order : BIO733ATT

ATTLEBOROUGH ECO ELECTRIC
LTD
CROWS HALL AD
ELLINGHAM RD
ATTLEBOROUGH
NORFOLK NR17 1AE

V767

Please quote above code for all enquiries

ATTLEBOROUGH ECO
ELECTRIC LTD
CROWS HALL AD
ELLINGHAM ROAD
ATTLEBOROUGH
NR17 1AE

DIGESTATE ANALYSIS RESULTS

Sample Reference :

LAGOON DIGESTATE -separated liquor

Sample Matrix : DIGESTATE

Laboratory References

Report Number	87818
Sample Number	92508

Date Received	14-FEB-2020
Date Reported	20-FEB-2020

The sample submitted was of adequate size to complete all analysis requested.

The sample will be kept under refrigeration for at least 3 weeks.

ANALYTICAL RESULTS *on 'as received' basis.*

Determinand	Value	Units
Oven Dry Solids	4.25	%
Total Kjeldahl Nitrogen	0.46	% w/w
Nitrate Nitrogen	<10	mg/kg
Ammonium Nitrogen	2678	mg/kg
Total Phosphorus (P)	317	mg/kg
Total Potassium (K)	4107	mg/kg
Total Magnesium (Mg)	146	mg/kg
Total Copper (Cu)	1.97	mg/kg
Total Zinc (Zn)	10.7	mg/kg
Total Sulphur (S)	235	mg/kg

Released by *Joe Cherrie*

Date *20/02/20*

NRM Coopers Bridge, Braziers Lane, Bracknell, Berkshire RG42 6NS
Tel: +44 (0) 1344 886338 Fax: +44 (0) 1344 890972 Email: enquiries@nrm.uk.com www.nrm.uk.com



SS AGRIPOWER LTD
CROWS HALL AD
ELLINGHAM RD
ATTLEBOROUGH
NORFOLK
NR17 1AE

V767

Please quote above code for all enquiries

SS AGRIPOWER LTD

DIGESTATE

DIGESTATE (Metric Units)

Sample Reference : SOLID DIGESTATE - Fibre digestate

Sample Matrix : DIGESTATE

The sample submitted was of adequate size to complete all analysis requested.

The sample will be kept as the dry ground sample for at least 1 month.

Laboratory References

Report Number 82604
Sample Number 108314

Date Received 08-JAN-2020

Date Reported 13-JAN-2020

ANALYTICAL RESULTS

Determinand on a DM basis unless otherwise indicated	Units	Result	Amount per fresh tonne	Amount applied at an equivalent total Nitrogen application of 250 kg N/ha	Units
pH 1:6 [Fresh]		9.16			
Oven Dry Matter	%	24.7	247.00	10684	kg DM
Total Nitrogen	% w/w	2.34	5.78	250	kg N
Ammonium Nitrogen	mg/kg	5675	1.40	60.63	kg NH4-N
Nitrate Nitrogen	mg/kg	<10	< 0.01		kg NO3-N
Total Phosphorus (P)	% w/w	0.390	2.21	95.42	kg P2O5
Total Potassium (K)	% w/w	1.58	4.68	202.56	kg K2O
Total Magnesium (Mg)	% w/w	0.271	1.11	48.06	kg MgO
Total Sulphur (S)	% w/w	0.249	1.54	66.51	kg SO3
Total Copper (Cu)	mg/kg	9.24	< 0.01		kg Cu
Total Zinc (Zn)	mg/kg	51.2	0.01	0.55	kg Zn
Total Sodium (Na)	% w/w	0.045	0.15	6.48	kg Na2O
Total Calcium (Ca)	mg/kg	20705	5.11	221.21	kg Ca
Equivalent field application rate		—	1.00	43.25	tonnes/ha

The above equivalent field application rate for total nitrogen of 250 kg/ha has been provided purely for guidance purposes only. Organic manures should be used in accordance with the Defra Code of Good Agricultural Practice and where required within the specific regulatory guidance for the spreading of that material to land. To get the most benefit from your organic manures it is recommended that you follow the principles as set out in Defra's Fertiliser Manual (RB209) or as directed by a FACTS qualified adviser.

Released by *Myles Nicholson*

Date *13/01/20*

NRM Coopers Bridge, Braziers Lane, Bracknell, Berkshire RG42 6NS
Tel: +44 (0) 1344 886338 Fax: +44 (0) 1344 890972 Email: enquiries@nrm.uk.com www.nrm.uk.com



Purchase Order : BIO733ATT

ATTLEBOROUGH ECO ELECTRIC
LTD
CROWS HALL AD
ELLINGHAM RD
ATTLEBOROUGH
NORFOLK NR17 1AE

V767

Please quote above code for all enquiries

ATTLEBOROUGH ECO
ELECTRIC LTD
CROWS HALL AD
ELLINGHAM ROAD
ATTLEBOROUGH
NR17 1AE

DIGESTATE ANALYSIS RESULTS

Sample Reference :

LAGOON DIGESTATE

Sample Matrix : DIGESTATE

Laboratory References

Report Number	87818
Sample Number	92508

Date Received	14-FEB-2020
Date Reported	20-FEB-2020

The sample submitted was of adequate size to complete all analysis requested.

The sample will be kept under refrigeration for at least 3 weeks.

ANALYTICAL RESULTS *on 'as received' basis.*

Determinand	Value	Units
Total Calcium (Ca)	1049	mg/kg
Total Sodium (Na)	139	mg/kg
pH 1:6 [Fresh]	8.24	

Released by *Joe Cherrie*

Date *20/02/20*

NRM Coopers Bridge, Braziers Lane, Bracknell, Berkshire RG42 6NS
Tel: +44 (0) 1344 886338 Fax: +44 (0) 1344 890972 Email: enquiries@nrm.uk.com www.nrm.uk.com



Purchase Order : BIO733ATT

ATTLEBOROUGH ECO ELECTRIC
LTD
CROWS HALL AD
ELLINGHAM RD
ATTLEBOROUGH
NORFOLK NR17 1AE

V767

Please quote above code for all enquiries

ATTLEBOROUGH ECO
ELECTRIC LTD
CROWS HALL AD
ELLINGHAM ROAD
ATTLEBOROUGH
NR17 1AE

DIGESTATE ANALYSIS RESULTS

Sample Reference :

AS DIGESTATE - Whole digestate

Sample Matrix : DIGESTATE

Laboratory References

Report Number	87818
Sample Number	92509

Date Received	14-FEB-2020
Date Reported	20-FEB-2020

The sample submitted was of adequate size to complete all analysis requested.

The sample will be kept under refrigeration for at least 3 weeks.

ANALYTICAL RESULTS *on 'as received' basis.*

Determinand	Value	Units
Oven Dry Solids	8.22	%
Total Kjeldahl Nitrogen	0.49	% w/w
Nitrate Nitrogen	<10	mg/kg
Ammonium Nitrogen	2453	mg/kg
Total Phosphorus (P)	627	mg/kg
Total Potassium (K)	3642	mg/kg
Total Magnesium (Mg)	477	mg/kg
Total Copper (Cu)	1.80	mg/kg
Total Zinc (Zn)	9.21	mg/kg
Total Sulphur (S)	282	mg/kg

Released by *Joe Cherrie*

Date *20/02/20*

NRM Coopers Bridge, Braziers Lane, Bracknell, Berkshire RG42 6NS
Tel: +44 (0) 1344 886338 Fax: +44 (0) 1344 890972 Email: enquiries@nrm.uk.com www.nrm.uk.com

Appendix K Human receptor results

Table 33 Long-term and short-term results NO₂

ID	Receptors	Comparison with annual mean AQS: 40µg/m ³				Comparison with 99.79 th percentile 1-hour threshold 200µg/m ³			
		PC (µg/m ³)	PC/AQS (%)	PEC (µg/m ³)	PEC/AQS (%)	PC (µg/m ³)	PC/AQS (%)	Headroom (µg/m ³)	PC/Headroom (%)
H1	Crowshall Veterinary Services	n/a	n/a	n/a	n/a	14.5	7%	186.8	8%
H2	Stuart House	1.6	4%	8.2	21%	10.5	5%	186.8	6%
H3	Houses at Cakes Hill	1.5	4%	8.1	20%	9.5	5%	186.8	5%
H4	Crowshall Lane	1.1	3%	7.7	19%	7.3	4%	186.8	4%
H5	Ellingham Road	0.6	2%	7.2	18%	6.1	3%	186.8	3%
H6	Suggit Farm Serv	0.5	1%	7.1	18%	6.1	3%	186.8	3%
H7	St Lukes Hospital	0.5	1%	7.1	18%	6.3	3%	186.8	3%
H8	Cades Hill Farm	0.4	1%	6.3	16%	6.1	3%	188.1	3%
H9	Shrugg's Lane	0.4	1%	6.4	16%	7.9	4%	188.0	4%
H10	Lyng Farm	0.2	0%	6.2	15%	4.0	2%	188.0	2%
H11	WwTW	0.3	1%	6.3	16%	5.5	3%	188.0	3%
H12	Houses along West Carr Road	0.2	1%	6.5	16%	3.8	2%	187.4	2%
H13	Carver's Lane, Attleborough 1	0.2	0%	6.5	16%	4.1	2%	187.4	2%
H14	Carver's Lane, Attleborough 2	0.3	1%	6.9	17%	5.5	3%	186.8	3%
H15	Carver's Lane, Attleborough 3	0.4	1%	7.0	18%	7.0	4%	186.8	4%
H16	Chapel Road, Attleborough	0.3	1%	6.9	17%	5.5	3%	186.8	3%
H17	Houses in Baconsthorpe	0.4	1%	6.8	17%	4.5	2%	187.1	2%
H18	Ash Farm	0.2	0%	6.8	17%	3.4	2%	186.8	2%

Attleborough AD Facility, Norfolk

Table 34 Long-term and short-term results, PM₁₀

ID	Receptors	Comparison with annual mean AQS: 40µg/m ³				Comparison with 90.41 st percentile 24-hour threshold: 50µg/m ³			
		PC (µg/m ³)	PC/AQS (%)	PEC (µg/m ³)	PEC/AQS (%)	PC (µg/m ³)	PC/AQS (%)	Headroom (µg/m ³)	PC/Headroom (%)
H1	Crowshall Veterinary Services	n/a	n/a	n/a	n/a	1.0	2%	22.6	4%
H2	Stuart House	0.2	0.6%	13.9	35%	0.7	1%	22.6	3%
H3	Houses at Cakes Hill	0.2	0.5%	13.9	35%	0.5	1%	22.6	2%
H4	Crowshall Lane	0.1	0.3%	13.8	35%	0.4	1%	22.7	2%
H5	Ellingham Road	0.1	0.2%	13.7	34%	0.2	<1%	22.7	1%
H6	Suggit Farm Serv	0.1	0.2%	13.7	34%	0.2	<1%	22.7	1%
H7	St Lukes Hospital	0.1	0.2%	13.7	34%	0.2	<1%	22.7	1%
H8	Cades Hill Farm	0.1	0.1%	12.7	32%	0.2	<1%	24.8	1%
H9	Shrugg's Lane	0.1	0.1%	12.9	32%	0.2	<1%	24.4	1%
H10	Lyng Farm	<0.1	0.1%	12.8	32%	0.1	<1%	24.4	<1%
H11	WwTW	0.1	0.1%	12.9	32%	0.2	<1%	24.4	1%
H12	Houses along West Carr Road	<0.1	0.1%	13.3	33%	0.2	<1%	23.5	1%
H13	Carver's Lane, Attleborough 1	<0.1	0.1%	13.3	33%	0.1	<1%	23.5	1%
H14	Carver's Lane, Attleborough 2	<0.1	0.1%	13.7	34%	0.2	<1%	22.6	1%
H15	Carver's Lane, Attleborough 3	0.1	0.2%	13.8	34%	0.3	1%	22.6	1%
H16	Chapel Road, Attleborough	0.1	0.1%	13.8	34%	0.2	<1%	22.6	1%
H17	Houses in Baconsthorpe	0.1	0.2%	16.5	41%	0.2	<1%	17.2	1%
H18	Ash Farm	<0.1	0.1%	13.7	34%	0.1	<1%	22.7	<1%

Attleborough AD Facility, Norfolk

Table 35 Long-term results, PM_{2.5}

ID	Receptors	Comparison with annual mean AQS: 20µg/m ³			
		PC (µg/m ³)	PC/AQS (%)	PEC (µg/m ³)	PEC/AQS (%)
H1	Crowshall Veterinary Services	n/a	n/a	n/a	n/a
H2	Stuart House	0.2	1%	8.8	44%
H3	Houses at Cakes Hill	0.2	1%	8.8	44%
H4	Crowshall Lane	0.1	1%	8.7	43%
H5	Ellingham Road	0.1	<1%	8.6	43%
H6	Suggit Farm Serv	0.1	<1%	8.6	43%
H7	St Lukes Hospital	0.1	<1%	8.6	43%
H8	Cades Hill Farm	0.1	<1%	8.4	42%
H9	Shrugg's Lane	0.1	<1%	8.4	42%
H10	Lyng Farm	<0.1	<1%	8.4	42%
H11	WwTW	0.1	<1%	8.4	42%
H12	Houses along West Carr Road	<0.1	<1%	8.5	42%
H13	Carver's Lane, Attleborough 1	<0.1	<1%	8.5	42%
H14	Carver's Lane, Attleborough 2	<0.1	<1%	8.6	43%
H15	Carver's Lane, Attleborough 3	0.1	<1%	8.6	43%
H16	Chapel Road, Attleborough	0.1	<1%	8.6	43%
H17	Houses in Baconsthorpe	0.1	<1%	9.2	46%
H18	Ash Farm	<0.1	<1%	8.6	43%

Attleborough AD Facility, Norfolk

Table 36 Short-term results, 15-minute and 1-hour, SO₂

ID	Receptors	Comparison with 99.9 th percentile 15-min threshold: 266µg/m ³				Comparison with 99.73 rd percentile 1-hour threshold: 350µg/m ³			
		PC (µg/m ³)	PC/AQS (%)	PEC (µg/m ³)	PEC/AQS (%)	PC (µg/m ³)	PC/AQS (%)	Headroom (µg/m ³)	PC/Headroom (%)
H1	Crowshall Veterinary Services	12.2	5%	262.1	5%	10.3	3%	346.1	3.0%
H2	Stuart House	9.4	4%	262.1	4%	7.4	2%	346.1	2.1%
H3	Houses at Cakes Hill	9.4	4%	262.1	4%	7.1	2%	346.1	2.1%
H4	Crowshall Lane	8.3	3%	262.2	3%	5.8	2%	346.2	1.7%
H5	Ellingham Road	8.1	3%	262.2	3%	5.2	1%	346.2	1.5%
H6	Suggit Farm Serv	7.8	3%	262.2	3%	5.0	1%	346.2	1.4%
H7	St Lukes Hospital	8.6	3%	262.2	3%	5.3	2%	346.2	1.5%
H8	Cades Hill Farm	7.6	3%	262.4	3%	4.8	1%	346.4	1.4%
H9	Shrugg's Lane	13.2	5%	262.2	5%	6.8	2%	346.2	2.0%
H10	Lyng Farm	6.3	2%	262.2	2%	3.3	1%	346.2	1.0%
H11	WwTW	7.4	3%	262.2	3%	4.3	1%	346.2	1.2%
H12	Houses along West Carr Road	6.2	2%	261.8	2%	3.4	1%	345.8	1.0%
H13	Carver's Lane, Attleborough 1	5.6	2%	261.8	2%	3.2	1%	345.8	0.9%
H14	Carver's Lane, Attleborough 2	6.2	2%	262.1	2%	4.0	1%	346.1	1.2%
H15	Carver's Lane, Attleborough 3	7.1	3%	262.1	3%	4.9	1%	346.1	1.4%
H16	Chapel Road, Attleborough	8.6	3%	262.1	3%	4.4	1%	346.1	1.3%
H17	Houses in Baconsthorpe	6.1	2%	260.5	2%	3.5	1%	344.5	1.0%
H18	Ash Farm	5.1	2%	262.2	2%	2.7	1%	346.2	0.8%

Attleborough AD Facility, Norfolk

Table 37 Short-term results, 24-hours, SO₂

ID	Receptors	Comparison with annual mean AQS: 5µg/m ³			
		PC (µg/m ³)	PC/AQS (%)	PEC (µg/m ³)	PEC/AQS (%)
H1	Crowshall Veterinary Services	5.3	4%	121.1	4%
H2	Stuart House	3.7	3%	121.1	3%
H3	Houses at Cakes Hill	3.8	3%	121.1	3%
H4	Crowshall Lane	2.4	2%	121.2	2%
H5	Ellingham Road	2.0	2%	121.2	2%
H6	Suggit Farm Serv	1.9	1%	121.2	2%
H7	St Lukes Hospital	1.9	1%	121.2	2%
H8	Cades Hill Farm	1.8	1%	121.4	1%
H9	Shrugg's Lane	2.1	2%	121.2	2%
H10	Lyng Farm	1.1	1%	121.2	1%
H11	WwTW	1.8	1%	121.2	1%
H12	Houses along West Carr Road	1.0	1%	120.8	1%
H13	Carver's Lane, Attleborough 1	0.9	1%	120.8	1%
H14	Carver's Lane, Attleborough 2	1.7	1%	121.1	1%
H15	Carver's Lane, Attleborough 3	1.8	1%	121.1	1%
H16	Chapel Road, Attleborough	1.2	1%	121.1	1%
H17	Houses in Baconsthorpe	0.9	1%	119.5	1%
H18	Ash Farm	0.6	1%	121.2	1%

Attleborough AD Facility, Norfolk

Table 38 Short-term results, CO

ID	Receptors	Comparison with maximum 8-hour running AQS: 10,000µg/m ³			
		PC (µg/m ³)	PC/AQS (%)	Headroom (µg/m ³)	PC/Headroom (%)
H1	Crowshall Veterinary Services	81	1%	9,490	1%
H2	Stuart House	58	1%	9,490	1%
H3	Houses at Cakes Hill	50	<1%	9,490	1%
H4	Crowshall Lane	40	<1%	9,494	<1%
H5	Ellingham Road	33	<1%	9,494	<1%
H6	Suggit Farm Serv	31	<1%	9,494	<1%
H7	St Lukes Hospital	32	<1%	9,494	<1%
H8	Cades Hill Farm	40	<1%	9,502	<1%
H9	Shrugg's Lane	35	<1%	9,500	<1%
H10	Lyng Farm	20	<1%	9,500	<1%
H11	WwTW	30	<1%	9,500	<1%
H12	Houses along West Carr Road	19	<1%	9,488	<1%
H13	Carver's Lane, Attleborough 1	22	<1%	9,488	<1%
H14	Carver's Lane, Attleborough 2	27	<1%	9,490	<1%
H15	Carver's Lane, Attleborough 3	32	<1%	9,490	<1%
H16	Chapel Road, Attleborough	29	<1%	9,490	<1%
H17	Houses in Baconsthorpe	20	<1%	9,484	<1%
H18	Ash Farm	16	<1%	9,494	<1%

Attleborough AD Facility, Norfolk

Table 39 Long-term and short-term results, NH₃

ID	Receptors	Comparison with annual mean AQS: 180µg/m ³				Comparison with maximum hourly AQS: 2,500µg/m ³			
		PC (µg/m ³)	PC/AQS (%)	PEC (µg/m ³)	PEC/AQS (%)	PC (µg/m ³)	PC/AQS (%)	Headroom (µg/m ³)	PC/Headroom (%)
H1	Crowshall Veterinary Services	n/a	n/a	n/a	n/a	271	11%	2,488	11%
H2	Stuart House	7.7	4%	13.8	8%	186	7%	2,488	7%
H3	Houses at Cakes Hill	6.0	3%	12.1	7%	138	6%	2,488	6%
H4	Crowshall Lane	3.5	2%	9.6	5%	94	4%	2,488	4%
H5	Ellingham Road	2.2	1%	8.3	5%	78	3%	2,488	3%
H6	Suggit Farm Serv	2.0	1%	8.1	4%	81	3%	2,488	3%
H7	St Lukes Hospital	1.6	1%	7.7	4%	80	3%	2,488	3%
H8	Cades Hill Farm	1.0	1%	7.1	4%	63	3%	2,488	3%
H9	Shrugg's Lane	0.9	<1%	7.0	4%	71	3%	2,488	3%
H10	Lyng Farm	0.4	<1%	6.5	4%	33	1%	2,488	1%
H11	WwTW	0.7	<1%	6.8	4%	51	2%	2,488	2%
H12	Houses along West Carr Road	0.5	<1%	3.9	2%	35	1%	2,493	1%
H13	Carver's Lane, Attleborough 1	0.5	<1%	4.0	2%	46	2%	2,493	2%
H14	Carver's Lane, Attleborough 2	0.8	<1%	6.9	4%	72	3%	2,488	3%
H15	Carver's Lane, Attleborough 3	0.9	1%	7.0	4%	83	3%	2,488	3%
H16	Chapel Road, Attleborough	0.8	<1%	6.9	4%	78	3%	2,488	3%
H17	Houses in Baconsthorpe	0.7	<1%	6.8	4%	61	2%	2,488	2%
H18	Ash Farm	0.6	<1%	6.7	4%	27	1%	2,488	1%

Attleborough AD Facility, Norfolk

Table 40 Long-term and short-term results, TVOC as 10% Benzene

ID	Receptors	Comparison with annual mean AQS: 5µg/m³				Comparison with maximum hourly AQS: 195µg/m³			
		PC (µg/m³)	PC/AQS (%)	PEC (µg/m³)	PEC/AQS (%)	PC (µg/m³)	PC/AQS (%)	Headroom (µg/m³)	PC/Headroom (%)
H1	Crowshall Veterinary Services	n/a	n/a	n/a	n/a	8.1	4%	195	4%
H2	Stuart House	0.6	12%	0.8	16%	6.2	3%	195	3%
H3	Houses at Cakes Hill	0.6	11%	0.8	15%	6.7	3%	195	3%
H4	Crowshall Lane	0.4	8%	0.6	12%	6.8	3%	195	3%
H5	Ellingham Road	0.2	5%	0.4	8%	5.1	3%	195	3%
H6	Suggit Farm Serv	0.2	4%	0.4	8%	5.3	3%	195	3%
H7	St Lukes Hospital	0.2	4%	0.4	8%	5.1	3%	195	3%
H8	Cades Hill Farm	0.2	3%	0.3	7%	4.7	2%	195	2%
H9	Shrugg's Lane	0.2	3%	0.4	7%	8.0	4%	195	4%
H10	Lyng Farm	0.1	1%	0.2	5%	4.0	2%	195	2%
H11	WwTW	0.1	2%	0.3	6%	5.1	3%	195	3%
H12	Houses along West Carr Road	0.1	2%	0.3	6%	3.9	2%	195	2%
H13	Carver's Lane, Attleborough 1	0.1	1%	0.3	5%	4.2	2%	195	2%
H14	Carver's Lane, Attleborough 2	0.1	2%	0.3	6%	5.5	3%	195	3%
H15	Carver's Lane, Attleborough 3	0.2	3%	0.4	7%	9.5	5%	195	5%
H16	Chapel Road, Attleborough	0.1	3%	0.3	7%	6.1	3%	195	3%
H17	Houses in Baconsthorpe	0.1	3%	0.3	7%	3.9	2%	195	2%
H18	Ash Farm	0.1	2%	0.3	5%	2.9	1%	195	1%

Attleborough AD Facility, Norfolk

Table 41 Long-term and short-term results from Biogas upgrade plant, H₂S

ID	Receptors	Comparison with annual mean AQS: 140µg/m ³				Comparison with maximum hourly AQS: 150µg/m ³			
		PC (µg/m ³)	PC/AQS (%)	PEC (µg/m ³)	PEC/AQS (%)	PC (µg/m ³)	PC/AQS (%)	Headroom (µg/m ³)	PC/Headroom (%)
H1	Crowshall Veterinary Services	n/a	n/a	n/a	n/a	0.1	0.1%	150	0.1%
H2	Stuart House	<0.1	<0.1%	<0.1	<0.1%	0.2	0.1%	150	0.1%
H3	Houses at Cakes Hill	<0.1	<0.1%	<0.1	<0.1%	0.2	0.1%	150	0.1%
H4	Crowshall Lane	<0.1	<0.1%	<0.1	<0.1%	0.1	0.1%	150	0.1%
H5	Ellingham Road	<0.1	<0.1%	<0.1	<0.1%	0.1	0.1%	150	0.1%
H6	Suggit Farm Serv	<0.1	<0.1%	<0.1	<0.1%	0.1	<0.1%	150	<0.1%
H7	St Lukes Hospital	<0.1	<0.1%	<0.1	<0.1%	0.1	<0.1%	150	<0.1%
H8	Cades Hill Farm	<0.1	<0.1%	<0.1	<0.1%	0.1	<0.1%	150	<0.1%
H9	Shrugg's Lane	<0.1	<0.1%	<0.1	<0.1%	0.1	0.1%	150	0.1%
H10	Lyng Farm	<0.1	<0.1%	<0.1	<0.1%	0.1	0.1%	150	0.1%
H11	WwTW	<0.1	<0.1%	<0.1	<0.1%	0.1	0.1%	150	0.1%
H12	Houses along West Carr Road	<0.1	<0.1%	<0.1	<0.1%	0.1	0.1%	150	0.1%
H13	Carver's Lane, Attleborough 1	<0.1	<0.1%	<0.1	<0.1%	0.1	0.0%	150	0.0%
H14	Carver's Lane, Attleborough 2	<0.1	<0.1%	<0.1	<0.1%	0.1	0.1%	150	0.1%
H15	Carver's Lane, Attleborough 3	<0.1	<0.1%	<0.1	<0.1%	0.1	0.1%	150	0.1%
H16	Chapel Road, Attleborough	<0.1	<0.1%	<0.1	<0.1%	0.1	0.1%	150	0.1%
H17	Houses in Baconsthorpe	<0.1	<0.1%	<0.1	<0.1%	0.1	0.1%	150	0.1%
H18	Ash Farm	<0.1	<0.1%	<0.1	<0.1%	<0.1	<0.1%	150	<0.1%

Appendix L Ecological receptor results

Table 42 Results: Ecological receptors, long-term AQS for NH₃

ID	Receptors	Comparison with annual mean AQS: 3µg/m ³				
		AQS (µg/m ³)	PC (µg/m ³)	PC/AQS (%)	Background (µg/m ³)	PEC/AQS (%)
E1	Swangey Fens 1	1	0.07	7%	3.51	351%
E2	Swangey Fens 2	1	0.05	5%	3.49	349%
E3	Swangey Fens 3	1	0.06	6%	3.50	350%
E4	Norfolk Valley Fen	1	0.01	1%	2.78	278%
E5	Breckland 1	3	0.01	0%	3.40	113%
E6	Breckland 2	3	0.01	0%	3.40	113%
E7	Breckland 3	3	0.01	0%	3.44	115%
E8	Attleborough Wood 1*	1	0.22	22%	6.32	632%
E9	Attleborough Wood 2*	1	0.19	19%	6.29	629%
E10	Attleborough Wood*	1	0.25	25%	6.35	635%

Notes: *No further analysis required if PC/AQS < 100%

Attleborough AD Facility, Norfolk

Table 43 Results: Ecological receptors, long-term and short-term AQS for NO_x

ID	Receptors	Comparison with annual mean AQS: 30µg/m ³				Comparison with maximum daily AQS: 75µg/m ³			
		PC (µg/m ³)	PC/AQS (%)	PC (µg/m ³)	PC/AQS (%)	PC (µg/m ³)	PC/AQS (%)	Headroom (µg/m ³)	PC/Headroom (%)
E1	Swangey Fens 1	0.05	<1%	8.6	29%	1.7	2%	57.9	3%
E2	Swangey Fens 2	0.04	<1%	7.8	26%	1.2	2%	59.4	2%
E3	Swangey Fens 3	0.05	<1%	8.6	29%	1.2	2%	57.9	2%
E4	Norfolk Valley Fen	0.01	<1%	9.2	31%	0.4	1%	56.7	1%
E5	Breckland 1	0.01	<1%	10.3	34%	0.5	1%	54.4	1%
E6	Breckland 2	0.01	<1%	8.1	27%	0.4	1%	58.8	1%
E7	Breckland 3	0.01	<1%	7.6	25%	0.3	<1%	59.9	<1%
E8	Attleborough Wood 1*	0.19	1%	8.2	27%	2.3	3%	59.1	4%
E9	Attleborough Wood 2*	0.17	1%	8.1	27%	2.0	3%	59.1	3%
E10	Attleborough Wood*	0.21	1%	8.2	27%	2.4	3%	59.1	4%

Notes: *No further analysis required if PC/AQS < 100%

Attleborough AD Facility, Norfolk

Table 44 Results: Ecological receptors, long-term AQS for SO₂

ID	Receptors	Comparison with annual mean AQS: 20µg/m ³				Comparison with annual mean AQS: 10µg/m ³			
		PC (µg/m ³)	PC/AQS (%)	Background (µg/m ³)	PEC/AQS (%)	PC (µg/m ³)	PC/AQS (%)	Background (µg/m ³)	PEC/AQS (%)
E1	Swangey Fens 1	<0.1	<1%	1.8	9%	<0.1	<1%	1.8	18%
E2	Swangey Fens 2	<0.1	<1%	1.8	9%	<0.1	<1%	1.8	18%
E3	Swangey Fens 3	<0.1	<1%	1.8	9%	<0.1	<1%	1.8	18%
E4	Norfolk Valley Fen	<0.1	<1%	1.7	8%	<0.1	<1%	1.7	17%
E5	Breckland 1	<0.1	<1%	1.7	8%	<0.1	<1%	1.7	17%
E6	Breckland 2	<0.1	<1%	1.7	9%	<0.1	<1%	1.7	17%
E7	Breckland 3	<0.1	<1%	1.7	9%	<0.1	<1%	1.7	17%
E8	Attleborough Wood 1*	0.1	<1%	1.9	9%	0.1	1%	1.9	19%
E9	Attleborough Wood 2*	0.1	<1%	1.9	9%	0.1	1%	1.9	19%
E10	Attleborough Wood*	0.1	<1%	1.9	9%	0.1	1%	1.9	19%

Notes: *No further analysis required if PC/AQS < 100%

Table 45 Results: Ecological receptors, nutrient nitrogen deposition, nationally designated sites

Receptors	Comparison with nutrient nitrogen critical loads								
	Deposition velocity type	PC (kgN/ha/yr)	CLmin (kgN/ha/yr)	CLmax (kgN/ha/yr)	PC/CLmin (%)	PC/CLmax (%)	Background (kgN/ha/yr)	PEDR/CLmin (%)	PEDR/CLmax (%)
E1	Forest	0.560	10	20	6%	3%	3.3	39%	19%
E2	Forest	0.405	10	20	4%	2%	3.3	37%	19%
E3	Forest	0.505	10	20	5%	3%	3.3	38%	19%
E4	Grass	0.054	10	20	1%	0%	1.7	232%	116%
E5	Forest	0.088	5	15	2%	1%	1.4	68%	23%
E6	Forest	0.071	5	15	1%	0%	1.4	68%	23%
E7	Forest	0.062	5	15	1%	0%	1.4	67%	22%
E8	Forest	1.783	10	20	18%	9%	5.0	716%	358%
E9	Forest	1.519	10	20	15%	8%	5.0	714%	357%
E10	Forest	2.017	10	20	20%	10%	5.0	719%	359%

Attleborough AD Facility, Norfolk

Table 46 Results: Ecological receptors, acid deposition, nationally designated sites

Receptors	PC (keqS/ha/yr)	PC (keqN/ha/yr)	Background (keqS/ha/yr)	Background (keqN/ha/yr)	Minimum critical loads			Maximum critical loads		
					PC (%)	Background (%)	PEC (%)	PC (%)	Background (%)	PEC (%)
E1	0.004	0.040	0.2	3.3	3.3	289.5	292.8	0.4	32	32.4
E2	0.003	0.029	0.2	3.3	2.5	289.5	292	0.3	32	32.3
E3	0.004	0.036	0.2	3.3	3.3	289.5	292.8	0.4	32	32.4
E4	0.000	0.004	0.2	1.7	0	313.5	313.5	0	43.3	43.3
E5	0.001	0.006	0.1	1.4	1.9	279.9	281.7	0.1	13.6	13.7
E6	0.001	0.005	0.1	1.4	1.9	279.9	281.7	0.1	13.6	13.7
E7	0.001	0.004	0.1	1.4	1.9	279.9	281.7	0.1	13.6	13.7
E8	0.014	0.127	0.22	4.99	5.1	190.1	195.2	-	-	-
E9	0.012	0.108	0.22	4.99	4.4	190.1	194.5	-	-	-
E10	0.015	0.144	0.22	4.99	5.8	190.1	195.9	-	-	-