Bioaerosol Risk Assessment

Somerset Farm, Murrow

Client: Murrow AD Plant Ltd

Reference: 5500-3r3

Date: 15th February 2024

Report Issue

Report Title: Bioaerosol Risk Assessment - Somerset Farm, Murrow

Report Reference: 5500-3

Field	Report Version			
	1	2	3	4
Prepared by	Ger Parry	Ger Parry	Ger Parry	
Position	Director	Director	Director	
Reviewed by	Lauren Casey	Lauren Casey	Jethro Redmore	
Position	Senior Air Quality Consultant	Senior Air Quality Consultant	Director	
Date of Issue	6th February 2023	28th February 2023	15th February 2024	
Comments	Draft for comment	Updated draft	-	

Serendipity Labs, Building 7, Exchange Quay, Salford, M5 3EP

info@red-env.co.uk | 0161 706 0075 | www.red-env.co.uk

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1.0 INTRODUCTION

1.1 Background

1.1.1 Redmore Environmental Ltd was commissioned by Murrow AD Plant Ltd to undertake a Bioaerosol Risk Assessment in support of an Environmental Permit Variation Application for Murrow Anaerobic Digestion (AD) facility at Somerset Farm, Murrow.

1.1.2 During the operation of the facility there is the potential for bioaerosol emissions and associated impacts at sensitive receptor locations in the vicinity of the site. A Risk Assessment has therefore been undertaken to identify potential emission sources and evaluate effects in the local area.

1.1.3 The purpose of this Bioaerosol Risk Assessment is to:

- Establish the likely sources of bioaerosols arising from existing and proposed operations at the site;
- Assess the potential for significant risk of impact at sensitive locations due to emissions from the identified sources; and,
- Identify any additional mitigation required to control potential effects.

1.2 Site Location and Context

1.2.1 Murrow AD plant is located at Somerset Farm, Murrow, at National Grid Reference (NGR): 537342, 304756. Reference should be made to Figure 1 for a map of the site and surrounding area.

1.2.2 The plant is currently authorised to operate as an AD facility using farm wastes only, including the use of the resultant biogas, under a Standard Rules Environmental Permit (SR2021 No.8) issued by the Environment Agency (EA) (Permit No: EPR/FB3133AW/V005).

1.2.3 An Environmental Permit Variation Application is currently being made to the EA in order to authorise a number of changes to operations. These include an increase in processing capacity to 125,000 tonnes per annum (tpa). This exceeds the threshold for regulation of the site under the existing SR2021 No.8 Environmental Permit. As such, there is a requirement for the Operator to obtain a Bespoke Part A Environmental Permit.

1.2.4 The site operations incorporating the changes proposed under the Environmental Permit Variation can be summarised as follows:

- The facility processes purpose grown crops (principally maize), crop residues and animal manures/slurries within five primary and one secondary AD tank to produce biogas and digestate;
- Solid farm-based feedstocks are stored on a concrete pad area or within a clamp on the northern section of the facility prior to processing;
- Crops within the clamp are compacted and covered using protective plastic sheeting in order to preserve the feedstock and minimise emissions. The cover remains slightly open at one end to allow access to the feedstock for removal and transportation to the AD plant feed hoppers;
- Farm-based feedstocks with higher odour potential such as poultry manures are accepted on a 'just in time' basis according to the procedures outlined in the site Odour Management Plan (OMP) and remain covered within the concrete pad area or clamp prior to transfer to the feed hoppers;
- Vegetables are delivered to site and deposited within the concrete pad area or clamp. The vegetables within the clamp remain covered during storage in order to minimise emissions;
- Cattle manure is stored within the concrete pad area and then shredded using a mobile unit prior to introduction to the AD process;
- Liquid animal slurries are received into a covered reception tank which includes an atmospheric vent;
- All solid feedstocks are introduced into the process via feeding units which are top loaded using a telehandler;
- Biogas produced in the AD process is stored in the roof head spaces of the digesters. The biogas is combusted within two 250kW combined heat and power (CHP) units. These provide both heat and power for site operations, as do a further two 500kW CHP units which are run on imported liquified natural gas (LNG). All four engines were commissioned after December 2018;
- The remaining biogas produced at the site is upgraded to produce biomethane and injected directly to the high-pressure National Gas Transmission (NTS) system via 1km of pipework and a block valve connection. The biomethane does not need to be blended to a distribution specification because it is injected to a high-pressure network and blended therein. As no odorant is needed, no associated chemicals are handled at the site;

- During the biogas upgrading process, carbon dioxide (CO_2) is removed from the biogas and vented to atmosphere. The site undertakes an additional step to recover the CO_2 which might otherwise be vented to atmosphere. This is processed in a dedicated recovery facility that removes any final trace impurities and transforms the CO_2 into a liquid state. The recovered liquid CO_2 is then stored in a tank as a final product that reaches end of waste status and is fit for use in the food and drink manufacturing and supply industry;
- Final digestate arising from the process is passed through a separator to produce a liquid and solid fraction. The separated solid fraction drops into a bunker and is routinely taken off site for interim storage in satellite field heaps prior to use as an agricultural fertiliser or soil conditioner;
- The separated liquid digestate is piped to one of two earth bank stores/lagoons which are not located within the permit boundary proposed under the variation;
- Condensate arising from the gas line, CHP engines and upgrading unit is collected in a dedicated system and pumped back through the process;
- The site also includes an emergency flare for management of excess gas during engine or upgrading unit downtime. This is capable of burning all biogas produced at the site in an emergency situation should the need arise. The site is also equipped with an emergency backup diesel generator which provides sufficient power to operate key functions during power outage in order to maintain safe operations until normal processes resume; and,
- The whole facility is operated in accordance with an Environmental Management System (EMS) and technical competence requirements are met by inhouse staff who hold the relevant AD WAMITAB qualification.

1.2.5 The operation of the plant may result in bioaerosol emissions from a number of activities. These have the potential to cause impacts at sensitive locations within the vicinity of the site and have therefore been assessed within this report.

2.0 BIOAEROSOL BACKGROUND

2.1 Bioaerosol Definition

2.1.1 Bioaerosol is a general term for microorganisms suspended in the air. These microorganisms include fungi and bacteria, as well as their components such as mycotoxins, endotoxins and glucans. Bioaerosols are generally less than 100µm in size and are not filtered out by hairs and specialised cells that line the nose. Due to their airborne nature and small size, many bioaerosols can penetrate the human respiratory system, resulting in inflammatory and allergic responses.

2.1.2 Although bioaerosols are ubiquitous, operations involving organic materials provide environments that are conducive to their growth. Bioaerosols are therefore likely to be associated with AD feedstocks and output materials, and in particular, organic material handling activities, which may release microorganisms into the air.

2.2 Health Risks from Bioaerosols

2.2.1 Exposure to bioaerosols has been associated with human health effects, symptoms can include inflammation of the respiratory system, coughs and fever. Inhalation of bioaerosols may also cause or exacerbate respiratory diseases[1]. They have been known to cause gastrointestinal illness, eye irritation and dermatitis.

2.2.2 Possible links have also been made between exposure to bioaerosols and organic dust toxic syndrome. This is an acute disease that causes symptoms resembling those of influenza, such as shivering, an increase in body temperature, dry cough and muscle and joint pains. Of particular relevance to waste management facilities are infections caused by Aspergillus fumigatus. Invasive aspergillosis is a particularly severe infection, which may be fatal and is primarily a concern with at risk and immuno-suppressed patients.

2.2.3 Although some data is available, one of the major knowledge gaps for bioaerosols is their associated dose-response relationships. It is not currently possible to state with any certainty that a given concentration will result in a particular health impact. This is due to

[1] Guidance on the evaluation of bioaerosol risk assessments for composting facilities, Environment Agency, undated.

the number of bioaerosols that are naturally present within the environment as well as the complexities associated with human responses to different microorganisms.

2.3 Bioaerosol Emissions from Waste Management Operations

2.3.1 Most scientific research on bioaerosol emissions from waste management operations focusses on open windrow and In-Vessel Composting (IVC) systems. Although it is recognised that there are fundamental differences between composting and food waste processing actives, there are similarities between the types of feedstocks, handling activities and infrastructure utilised. As such, a review of relevant research has been undertaken in order to inform the assessment. The findings are detailed in the following Section.

2.3.2 The EA document 'Health Effects of Composting - A Study of Three Compost Sites and Review of Past Data'[2] summarises the findings of emissions measurement work undertaken at three composting facilities, including two open air turned windrow sites and one IVC plant. The results from the work indicated a well-defined decline in concentrations of bioaerosols with increased distance from source. In most cases, measured concentrations were at or below background levels within 250m of the sources assessed.

2.3.3 The ADAS report 'Bioaerosol Monitoring and Dispersal from Composting Sites'[3] provides a summary of the findings from measurement work undertaken at three composting sites. Sampling for bioaerosols was undertaken downwind of a wide range of composting activities including shredding, turning, loading, unloading and screening. The results indicated that 91% of all micro-organisms sampled across all three sites were below 1,000cfu/m^3 at a downwind distance of 125m.

2.3.4 The Scotland and Northern Ireland Forum for Environmental Research (SNIFFER) report 'Measurement and Modelling of Emissions from Three Composting Sites'[4] provides a summary of the findings from monitoring work undertaken at three composting sites, which included two IVC facilities and one open windrow system. The findings indicated that there is the potential for seasonal variation in ambient concentrations of the mould

[2] Health Effects of Composting - A Study of Three Compost Sites and Review of Past Data, EA, 2001.

[3] Bioaerosol Monitoring and Dispersal from Composting Sites, ADAS, 2005.

[4] Measurement and Modelling of Emissions from Three Composting Sites, SNIFFER, 2007.

of Aspergillus fumigatus, with concentrations being the highest in the autumn. In most cases, levels of all bioaerosols assessed were at or below background equivalent concentrations within 250m of the sources assessed.

2.3.5 The Department for Environment Food and Rural Affairs (DEFRA) research report 'Bioaerosols and odour emissions from composting facilities'[5] focusses on the comparability of different sampling methodologies and the influence of spatial and temporal variation on ambient bioaerosol concentrations. Measurements were undertaken at four different composting facilities in England, which represent a range of system types. The results of the study corroborate existing research and suggest that concentrations of bioaerosols generally return to background levels within 250m of the source.

2.3.6 The findings of the review have been considered as appropriate throughout the assessment.

2.4 Legislative Control

2.4.1 Atmospheric emissions from industry are controlled in the UK through the Environmental Permitting (England and Wales) Regulations (2016) and subsequent amendments. Activities at the site are included within the Regulations. As such, the facility is required to operate in accordance with an Environmental Permit issued by the EA.

2.5 Environment Agency Policy and Guidance

2.5.1 The EA Regulatory Position Statement (RPS) 'Bioaerosol monitoring at regulated facilities - use of M9: RPS 209'[6] outlines the conditions that apply to facilities in relation to bioaerosol emissions.

2.5.2 The RPS states that if a regulated facility is located within 250m of a sensitive receptor (a place where people live of work for more than 6-hours at a time), the operator must:

5 Bioaerosols and odour emissions from composting facilities, DEFRA, 2013.

6 Bioaerosol monitoring at regulated facilities - use of M9: RPS 209, EA, 2018.

- Monitor bioaerosols in accordance with EA guidance 'M9: environmental monitoring of bioaerosols at regulated facilities'[7]; and,
- Undertake a site specific Bioaerosol Risk Assessment.

2.5.3 The stated conditions are also specified in the EA document 'Biological waste treatment: appropriate measures for permitted facilities'[8] which represents the most up to date guidance published by the regulator on the standards that are relevant to biowaste sites, including criteria for emissions control. The requirements of the RPS and the stated EA guidance have been considered throughout the assessment.

2.6 Benchmark Levels

2.6.1 In the absence of dose-response data, the EA have adopted a precautionary risk-based approach in determining guidance levels for bioaerosols. The EA position statement 'Composting and potential health effects from bioaerosols: our interim guidance for permit applicants'[9] specifies the following criteria for acceptable concentrations of Aspergillus fumigatus and total bacteria at sensitive receptor locations:

- Aspergillus fumigatus - 500cfu/m^3; and,
- Total bacteria - 1,000cfu/m^3.

2.6.2 The relevant benchmark levels have been considered as appropriate throughout the assessment.

7 M9: environmental monitoring of bioaerosols at regulated facilities, EA, 2017.

8 Biological waste treatment: appropriate measures for permitted facilities, EA, 2022.

9 Composting and potential health effects from bioaerosols: our interim guidance for permit applicants, EA, 2010.

3.0 PROBLEM DEFINITION

3.1 Introduction

3.1.1 The first stage of any risk assessment is to clearly set out the problem, including what will be addressed and what will not. This determines the scope, level of detail and focus. In particular, the temporal and spatial scales, contaminants to be assessed, persons at risk and the endpoint are identified. These factors are considered in the following Sections.

3.2 Conceptual Model

3.2.1 Potential hazards from bioaerosols are summarised in the conceptual model in Table 1.

Table 1 Conceptual Model

Criteria	Comment
Source	Feedstocks and output materials on the site as outlined in Section 3.3
Hazard	Potential adverse health impacts as outlined in Section 2.2
Transport Mechanism	Airborne
Medium of Exposure	Inhalation, ingestion, absorption, injection
Receptor	Human receptors at the proposed development site as outlined in Section 3.4

3.3 Sources

3.3.1 The operation of the facility may result in bioaerosol emissions from a number of activities. Potential odour sources associated with the site were identified from information provided by Murrow AD Plant Ltd. These are summarised in Table 2.

Table 2 Bioaerosol Sources

Source		Emission Characteristics
1	Exposed materials within the concrete pad storage area	Diffuse emissions from exposed materials
2	Exposed and covered materials within the clamp storage area	Diffuse emissions from exposed and covered materials

Source		Emission Characteristics
3	Poultry manure within covered trailers on the concrete pad prior to input to the plant	Fugitive emissions from the covered trailer
4	Exposed cattle manure within the shredder	Diffuse emissions from exposed materials
5	Exposed material within the feed hoppers	Diffuse bioaerosol emissions from exposed materials
6	Covered slurry tank	The tank will be covered in order to provide containment of emissions. Air displaced from the tank during filling will discharge to atmosphere via a vent
7	Exposed solid digestate within the separator bunker	Diffuse bioaerosol emissions from the surface of exposed material

3.3.2 It should be noted that the actual AD process itself is sealed and therefore does not form a source of bioaerosols under normal operation. The digesters feature release valves to avoid over pressure and any gases released from these are likely to contain bioaerosols as a result of the digestion processes. However, releases from the sources are expected to be extremely infrequent and short-term as they would only occur in an emergency situation. As such, the risk of impact from emissions is not considered to be significant and they have not been evaluated further in the context of this assessment.

3.3.3 The CHP units and flare only emit products of combustion when in use which do not contain bioaerosols. As such, they have not been considered further in this report.

3.3.4 In the future, a proportion of the biogas produced from the AD process may be upgraded for injection into the gas grid. This process will involve transfer of biogas through an activated carbon filter to remove specific compounds before CO_2 is stripped through selective membranes and vented to atmosphere through a dedicated flue. The system is likely to provide beneficial reductions in bioaerosol concentrations between inlet and vented air due to the impaction of microorganisms onto the carbon media during operation. As such, emissions from the potential future upgrade process are not considered to be significant and they have not been evaluated further in the context of this assessment.

3.3.5 The potential for bioaerosol emissions from each remaining source is considered further in the following Sections. Reference should be made to Figure 2 for visual representation of the source locations.

Exposed Feedstocks on the Concrete Pad

3.3.6 Solid feedstocks including crops, vegetables and cattle manure are delivered to the facility throughout the year using a tractor and trailer. The feedstocks are deposited onto a concrete pad on the north-eastern section of the site where they are stored prior to processing within the AD plant or transfer off-site.

3.3.7 Disturbance of the feedstocks during delivery may result in bioaerosol release. As such, the drop height is minimised as far as practicable during unloading in order to limit agitation and the associated potential for emissions. In addition, where practicable, feedstocks are tipped as bulk loads to reduce material separation and the overall emitting surface area that is exposed to atmosphere.

3.3.8 The feedstocks remain uncovered during storage. As such, there is the potential for passive emissions from the materials, as well as wind stripping of bioaerosols from the surfaces of the stockpiles. All feedstocks remain static unless transfer is required in order to limit the disturbance of materials and the associated potential for bioaerosol emissions.

Feedstocks within the Clamp Area

3.3.9 Crop feedstocks are also delivered to the facility and deposited within the clamp area on the northern section of the site. Disturbance of the material during delivery may cause bioaerosol release. However, the seasonal nature of deliveries and short amount of time required to deposit loads is likely to minimise potential exposure durations.

3.3.10 During delivery, the drop height of material is minimised as far as practicable in order to limit agitation and the associated potential for emissions. In addition, where practicable, crops are tipped as bulk loads to reduce material separation and the overall emitting surface area that is exposed to atmosphere.

3.3.11 Following delivery, the crops are compacted and covered with protective sheeting. This helps to minimise bioaerosol release during storage.

3.3.12 The cover on the crops is slightly open at one end in order to allow access to the feedstock for removal and transportation to the AD plant feed hoppers. The area of uncovered material during transfer to the hopper is kept to a minimum at all times in order to limit the potential for surface wind stripping of microorganisms.

3.3.13 Vegetables and poultry manure are delivered to the site and deposited within the clamp. Both materials are sheeted following delivery and remain covered during storage except for when transfer to the feed hoppers is required. This helps to minimise the potential for bioaerosol emissions.

3.3.14 The clamp is inspected on a daily basis to ensure the sheeting is intact and providing effective coverage of the feedstock materials.

Poultry Manure in Trailers

3.3.15 Poultry manure is also accepted in trailer loads on a 'just in time' basis. All trailers remain fully sheeted whilst on site and are only uncovered to allow transfer of manure to one of the feed hoppers. This arrangement helps to ensure containment of the material and therefore reduce the potential for bioaerosol emissions.

Exposed Cattle Manure During Shredding

3.3.16 Cattle manure is macerated using a mobile shredding unit prior to incorporation into the AD plant via the feed hoppers. Disturbance of the manure during loading into the shredder may result in bioaerosol release. As such, the drop height is minimised as far as practicable in order to limit agitation and the associated potential for emissions.

3.3.17 Maceration of material within the shredder may also result in bioaerosol release. As such, operation of the unit is limited to approximately 2-hours per day in order to minimise potential emission periods and associated exposure durations at sensitive locations.

3.3.18 Full training has been provided to all relevant staff on use and maintenance of the shredder. In addition, visual inspection of the unit is undertaken daily in order to identify any mechanical issues which need to be resolved or operating conditions which have the potential to result in an increased potential for bioaerosol emissions. In the event there

is evidence of increased emission potential, operations are reviewed and if required suspended until appropriate measures have been identified to restore control.

Feed Hoppers

3.3.19 The facility includes four separate feed hoppers which are used to macerate and blend materials prior to processing within the AD plant. Bioaerosol emissions may occur during loading of the feed hoppers. As such, the drop height of feedstocks is minimised as far as practicable in order to limit agitation and the associated potential for bioaerosol release.

3.3.20 There is also the potential bioaerosol emissions from materials as they are macerated within the hoppers. Full training has been provided to all relevant staff on use and maintenance of the feed hoppers. In addition, visual inspection of the hoppers is undertaken daily in order to identify any mechanical issues which need to be resolved or operating conditions which may result in an increased potential for bioaerosol emissions. In the event there is evidence of increased emission potential, operations are reviewed and if required suspended until appropriate measures have been identified to restore control.

Slurry Tank

3.3.21 Slurry is delivered to the site in tankers and transferred into a covered tank for storage prior to incorporation into the AD process. The tank cover is likely to provide effective containment of bioaerosol emissions. However, during filling, air may be displaced from the tank through the breather vent. The wet nature of material within the tank is likely to limit the bioaerosol emission potential of the source. However, any air released through the vent may contain microorganisms. As such, emissions have been considered further as part of the assessment.

Solid Digestate

3.3.22 Solid digestate produced during separation is stored within bunker prior to removal from the facility for use as an agricultural fertiliser or soil conditioner. Although the AD process

will reduce the quantities of some bioaerosols, particularly pathogens[10], there is the potential for emissions from this part of the process.

3.3.23 Solid digestate is removed from site as often as possible to avoid storage of significant amounts. This helps to reduce the exposed surface area of material within the bunker and limit the potential for surface wind stripping of microorganisms. Any material which is stored at the site remains static with minimal mechanical agitation in order to limit disturbance and the potential for bioaerosol release.

3.4 Receptors

3.4.1 EA guidance 'M9: environmental monitoring of bioaerosols at regulated facilities'[11] defines a sensitive receptor as follows:

> "Nearest sensitive receptor means the nearest place to the permitted activities where people are likely to be for prolonged periods. This term would therefore apply to dwellings (including any associated gardens) and to many types of workplaces. We would not normally regard a place where people are likely to be present for less than 6 hours at one time as being a sensitive receptor. The term does not apply to those controlling the permitted facility, their staff when they are at work or to visitors to the facility, as their health is covered by Health and Safety at Work legislation, but would apply to dwellings occupied by the family of those controlling the facility."

3.4.2 A desk-top study was undertaken in order to identify any sensitive receptor locations in the vicinity of the site that required specific consideration during the assessment. In accordance the requirements of the EA RPS[12], this focussed on locations within 250m of the facility boundary where people may be present for more than 6-hours at one time. The identified receptors are summarised in Table 3.

[10] Anaerobic digestion, storage, oligolysis, lime, heat and aerobic treatment of livestock manures, FEC Services Ltd, 2003.

[11] M9: environmental monitoring of bioaerosols at regulated facilities, EA, 2017.

[12] Bioaerosol monitoring at regulated facilities - use of M9: RPS 209, EA, 2018.

Table 3 Sensitive Receptors

Receptor		NGR (m)		Distance from Facility (m)	Direction from Facility
		X	Y		
R1	Residential - Poplar House	537342.8	304942.5	230	North
R2	Residential - Coronation Cottage	537456.6	304927.1	240	North-north-east

3.4.3 As shown in Table 3, the sensitive locations are located between approximately 230m and 240m from the site at their closest points. Reference should be made to Figure 3 for a visual representation of the identified receptors.

3.5 Prevailing Meteorological Conditions

3.5.1 The potential for bioaerosol emissions to impact at sensitive locations depends significantly on the meteorology, particularly wind direction, during release. In order to consider prevailing conditions at the site review of historical weather data was undertaken. Wittering observation station is located at NGR: 503490, 302412, which is approximately 32.9km west of the facility. It is anticipated that conditions would be reasonably similar over a distance of this magnitude. The data was therefore considered suitable for an assessment of this nature.

3.5.2 Meteorological data was obtained from Wittering observation station over the period 1st January 2017 to 31st December 2021 (inclusive). The frequency of wind from the eight sectors which best describe the directions which may cause impacts in the vicinity of the site is shown in Table 4. Reference should be made to Figure 4 for a wind rose of the meteorological data.

Table 4 Wind Frequency Data

Wind Direction (°)	Frequency of Wind (%)
337.5 - 22.5	9.1
22.5 - 67.5	9.5
67.5 - 112.5	5.2
112.5 - 157.5	5.8

Wind Direction (°)	Frequency of Wind (%)
157.5 - 202.5	15.2
202.5 - 247.5	20.0
247.5 - 292.5	21.3
292.5 - 337.5	8.8
Sub-Total	94.9
Calms	0.7
Missing/Incomplete	4.5

3.5.3 All meteorological data used in the assessment was provided by Atmospheric Dispersion Modelling Ltd, which is an established distributor of meteorological data within the UK.

3.5.4 As shown in Table 4, the prevailing wind direction at the AD plant is from the west, with significant frequencies from the south and south-west. Winds from the north and east are relatively infrequent, which is indicative of conditions throughout the majority of the UK.

3.6 Other Sources of Bioaerosols

3.6.1 The area surrounding the facility is predominantly rural, comprising agricultural land. Arable fields may form sources of bioaerosols if fertilised with animal manures or slurries, as well as during crop harvest periods. However, likely impacts associated with these releases are not considered to be significant and would be expected for any rural location within the UK.

3.6.2 The farm immediately to the north of the facility operates as a beef finishing unit. Activities at the site have the potential to result in bioaerosol emissions and therefore contribute to ambient concentrations locally. This has been considered as appropriate throughout the assessment.

4.0 RISK ASSESSMENT METHODOLOGY

4.1 Overview

4.1.1 The Bioaerosol Risk Assessment has been undertaken in accordance with the general principles of EA document 'Guidance on the evaluation of bioaerosol risk assessments for composting facilities'[13]. This included consideration of the following:

- Receptor - what is at risk? What do I wish to protect?
- Source - what is the agent or process with potential to cause harm?
- Harm - what are the harmful consequences if things go wrong?
- Pathway - how might the receptor come into contact with the source?
- Probability of exposure - how likely is this contact?
- Consequence - how severe will the consequences be if this occurs?
- Magnitude of risk - what is the overall magnitude of the risk? and,
- Justification for magnitude - on what did I base my judgement?

4.1.2 Based on the Bioaerosol Risk Assessment outcomes potential mitigation and control options were identified.

4.1.3 Further explanation for the key assessment areas is provided below.

4.2 Receptor

4.2.1 The first step was to consider how the activity could harm the environment. This involved identifying 'receptors' that may be affected and included people, property, and the natural and physical environment.

4.3 Probability of Exposure

4.3.1 The probability of exposure was defined based on the likelihood of exposure of the specific receptor to the identified sources. This depended on several factors, such as:

- Distance between source and receptor;

[13] Guidance on the evaluation of bioaerosol risk assessments for composting facilities, EA, undated.

- Dispersion potential of emission;
- Duration of emission; and,
- Frequency of emission.

4.3.2 Probability was categorised in accordance with the following criteria:

- High - exposure is probable, direct exposure likely with no/few barriers between source and receptor;
- Medium - exposure is fairly probable, barriers less controllable;
- Low - exposure unlikely, barriers exist to mitigate; or,
- Very low - exposure very unlikely, effective and multiple barriers.

4.4 Harm

4.4.1 The severity of harm from a risk depends on:

- How much a person or part of the environment is exposed; and,
- How sensitive a person or part of the environment is.

4.4.2 Some parts of the environment can be very sensitive. For example, serious health effects can occur if humans are exposed to certain chemicals for only short periods of time.

4.4.3 Harm can be described as follows:

- High - severe consequences, evidence that exposure may result in serious damage;
- Medium - significant consequences, evidence that exposure may result in damage that is not severe and is reversible;
- Low - minor consequences, damage not apparent, reversible adverse changes possible; and,
- Very low - negligible consequences, no evidence for adverse changes.

4.5 Magnitude of Risk

4.5.1 The level of risk is a combination of:

- How likely a problem is to occur; and,

- How serious the harm might be.

4.5.2 Risk is highest where both the likelihood of a problem is high and the potential harm is severe. Risk is lowest where a problem is unlikely to occur and the harm that might result is not serious.

4.5.3 Risk was defined based on the interaction between the probability of exposure and potential harm, as outlined in Table 5.

Table 5 Magnitude of Risk

Probability of Exposure	Potential Harm			
	Very Low	Low	Medium	High
High	Low	Medium	High	High
Medium	Low	Medium	Medium	High
Low	Low	Low	Medium	Medium
Very Low	Very Low	Low	Low	Medium

4.6 Further Requirements

4.6.1 Based on the outcomes of the risk assessment the EA document provides guidance on further requirements for different risks. These can be summarised as follows:

- High risks - additional assessment and active management;
- Medium risks - likely to require further assessment and may require either active management or monitoring; and,
- Low and very low risk - will only require periodic review.

4.6.2 Mitigation to reduce risk can also be applied to avoid the requirement for further assessment and/or monitoring.

5.0 RISK ASSESSMENT

5.1.1 The Bioaerosol Risk Assessment is shown in Table 6.

Table 6 Risk Assessment

Source	Probability of exposure	Harm	Magnitude of Risk	Control Measures	Residual Risk	Justification for Residual Risk
Exposed materials within the concrete pad storage area	**Low** due to the distance between the source and receptors and the prevailing meteorological conditions	**Medium**	**Medium**	The drop height of material is minimised as far as practicable during unloading in order to limit agitation and the associated potential for emissions Where practicable, materials are tipped as bulk loads to reduce separation and the overall emitting surface area that is exposed to atmosphere All feedstocks remain static unless transfer is required in order to limit the disturbance of materials and associated potential for bioaerosol emissions	**Low**	The distance between source and receptors, as well as and full implementation of the stated control measures, is considered to result in a **low** risk of impact occurring

Source	Probability of exposure	Harm	Magnitude of Risk	Control Measures	Residual Risk	Justification for Residual Risk
Exposed and covered materials within the clamp storage area	**Low** due to the distance between the source and receptors, the prevailing meteorological conditions and the containment of materials	**Medium**	**Medium**	The drop height of material is minimised as far as practicable during unloading in order to limit agitation and the associated potential for emissions Where practicable, materials are tipped as bulk loads to reduce material separation and the overall emitting surface area that is exposed to atmosphere Crops, vegetables and poultry manure are stored under sheeting following delivery in order to minimise the potential for emissions The area of uncovered crops is kept to a minimum during storage. This helps to limit the potential for surface wind stripping of microorganisms The clamp is inspected on a daily basis to ensure the sheeting is providing effective containment	**Low**	The distance between source and receptors, as well as and full implementation of the stated control measures, is considered to result in a **low** risk of impact occurring

Source	Probability of exposure	Harm	Magnitude of Risk	Control Measures	Residual Risk	Justification for Residual Risk
Poultry manure within trailers on the concrete pad prior to input to the plant	**Very Low** due to the distance between the source and receptors, the prevailing meteorological conditions and containment of manure for the majority of time	**Medium**	**Low**	Poultry manure is accepted in trailer loads on a 'just in time' basis All trailers remain fully sheeted whilst on site and are only uncovered to allow transfer of manure to one of the feed hoppers. This arrangement helps to ensure containment of the material and therefore reduce the potential for bioaerosol emissions All reasonable measures are taken to minimise disturbance of the material during loading into the feed hoppers	**Very Low**	The distance between source and receptors, as well as and full implementation of the stated control measures, is considered to result in a **very low** risk of impact occurring
Exposed cattle manure within the shredder	**Very Low** due to the distance between the source and receptors, the prevailing meteorological conditions and the short duration of the activity	**Medium**	**Low**	The drop height of material is minimised as far as practicable during loading of the shredder in order to limit agitation and the associated potential for emissions Operation of the unit is limited to approximately 2-hours per day in order to minimise potential emission periods and any associated exposure durations at sensitive locations Inspection of the shredding unit is undertaken daily in order to identify any mechanical issues which need to be resolved or operating conditions which have the potential to result in an increased potential for bioaerosol emissions	**Very Low**	The distance between source and receptors, as well as and full implementation of the stated control measures, is considered to result in a **very low** risk of impact occurring

Source	Probability of exposure	Harm	Magnitude of Risk	Control Measures	Residual Risk	Justification for Residual Risk
Exposed material within the feed hoppers	**Low** due to the distance between the source and receptors, the prevailing meteorological conditions and continuous nature of the operation	**Medium**	**Medium**	The drop height of material is minimised as far as practicable during loading of the hoppers in order to limit agitation and the associated potential for emissions Full training has been provided to all relevant staff on use and maintenance of the feed hoppers Visual inspection of the hoppers is undertaken daily in order to identify any mechanical issues which need to be resolved or operating conditions which have the potential to result in an increased potential for bioaerosol emissions	**Low**	The distance between source and receptors, as well as and full implementation of the stated control measures, is considered to result in a **low** risk of impact occurring
Covered slurry tank	**Very Low** due to the distance between the source and receptors, the prevailing meteorological conditions and the effectiveness of the tank cover in containing emissions	**Medium**	**Low**	The tank cover provides containment of materials and associated emissions The wet nature of slurry within the tank is likely to limit the bioaerosol release potential The tank is inspected regularly by site operatives in order to ensure that it is providing effective containment of emissions	**Very Low**	The distance between source and receptors, as well as and full implementation of the stated control measures, is considered to result in a **very low** risk of impact occurring
Exposed solid digestate within the separator bunker	**Very Low** due to the distance between the source and receptors, the prevailing meteorological	**Medium**	**Low**	Solid digestate is removed from site as often as possible to avoid storage of significant amounts. This helps to reduce the exposed surface area of material within the bunker and limit	**Very Low**	The distance between source and receptors, as well as and full implementation of the stated control measures, is

Source	Probability of exposure	Harm	Magnitude of Risk	Control Measures	Residual Risk	Justification for Residual Risk
	conditions and the limited quantities of digestate stored on site			the potential for surface wind stripping of microorganisms The material remains static during storage with minimal mechanical agitation All reasonable measures are taken to minimise disturbance of the material during loading		considered to result in a **very low** risk of impact occurring

5.1.2 As shown in Table 6, the residual risk of impact as a result of emissions from all sources was determined as **low** or **very low**. As such, it is concluded that no further control measures, other than those detailed in the assessment, are required in order to reduce the potential for impacts at sensitive locations in the vicinity of the site.

6.0 CONCLUSION

6.1.1 Redmore Environmental Ltd was commissioned by Murrow AD Plant Ltd to undertake an Bioaerosol Risk Assessment in support of an Environmental Permit Variation Application for Murrow AD facility at Somerset Farm, Murrow.

6.1.2 During the operation of the facility there is the potential for bioaerosol emissions and associated impacts at sensitive receptor locations in the vicinity of the site. A Risk Assessment was therefore undertaken to identify potential emission sources and evaluate effects in the local area.

6.1.3 The risk of significant bioaerosol impact at sensitive locations in the vicinity of the site was assessed using a source - pathway - receptor approach. This considered the nature of the potential emission, any barriers to dispersion and the severity of harm.

6.1.4 The results of the assessment indicated residual risk from all sources was determined as **low** or **very low**. As such, it is concluded that no further control measures, other than those detailed in the assessment, are required in order to reduce the potential for impacts at sensitive locations in the vicinity of the site.

7.0 ABBREVIATIONS

AD	Anaerobic Digestion
CH_4	Methane
CHP	Combined Heat and Power
CO_2	Carbon dioxide
BAT	Best Available Techniques
DEFRA	Department for Environment, Food and Rural Affairs
EA	Environment Agency
EMS	Environmental Management System
EC	European Commission
H_2S	Hydrogen sulphide
IVC	In-Vessel Composting
LNG	Liquified Natural Gas
NGR	National Grid Reference
RPS	Regulatory Position Statement
SNIFFER	Scotland and Northern Ireland Forum for Environmental Research

Figures

Legend

Site Boundary

Title
Figure 1 - Site Location Plan

Project
Bioaerosol Risk Assessment
Somerset Farm, Murrow

Project Reference
5500-3

Client
Murrow AD Plant Ltd

Redmore environmental
www.red-env.co.uk | 0161 7060075

Legend

Site Boundary

Emission Source

Building

Title
Figure 2 - Bioaerosol Sources

Project
Bioaerosol Risk Assessment
Somerset Farm, Murrow

Project Reference
5500-3

Client
Murrow AD Plant Ltd

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Legend

Site Boundary

Receptor

Title
Figure 3 - Sensitive Receptors

Project
Bioaerosol Risk Assessment
Somerset Farm, Murrow

Project Reference
5500-3

Client
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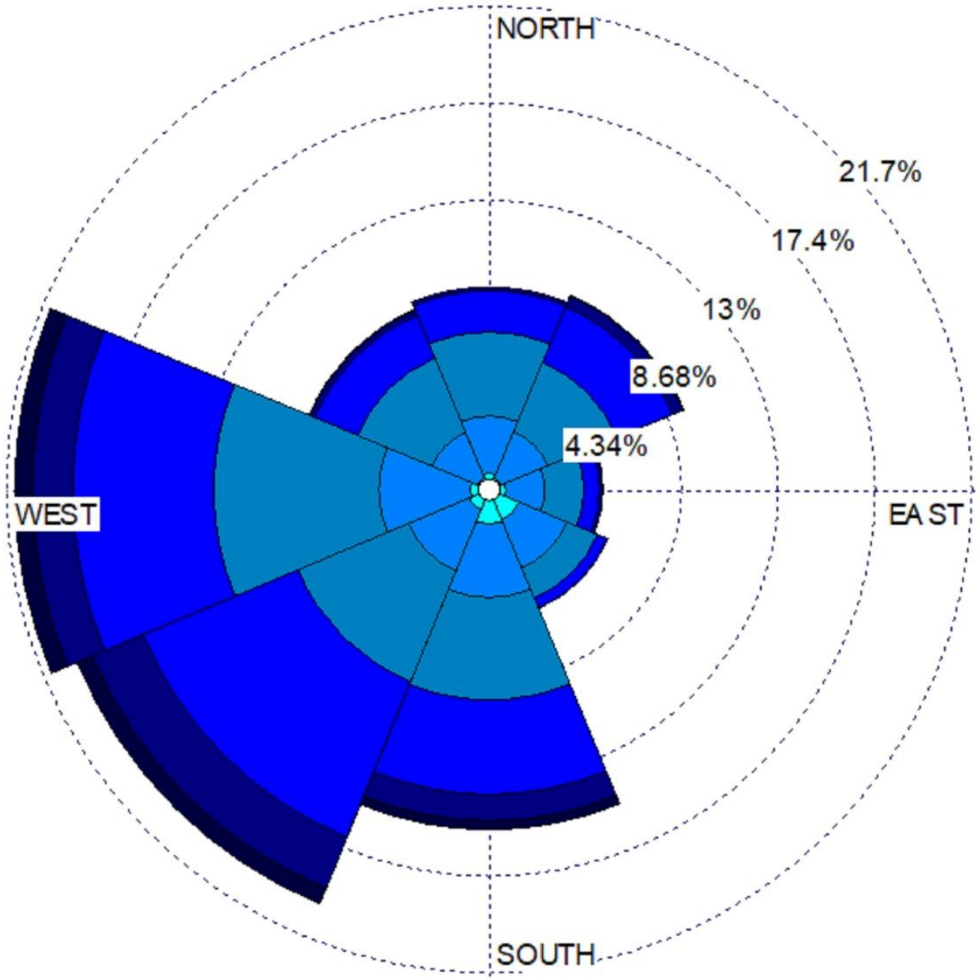

Legend

WIND SPEED (m/s)

- >= 11.10
- 8.80 - 11.10
- 5.70 - 8.80
- 3.60 - 5.70
- 2.10 - 3.60
- 0.50 - 2.10

Calms: 0.69%

Title
Figure 4 - Wind Rose of 2017 to 2021 Wittering Meteorological Station Data

Project
Bioaerosol Risk Assessment
Somerset Farm, Murrow

Project Reference
5500-3

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Murrow AD Plant LTD

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