Bioaerosols Management Plan

Issue 04

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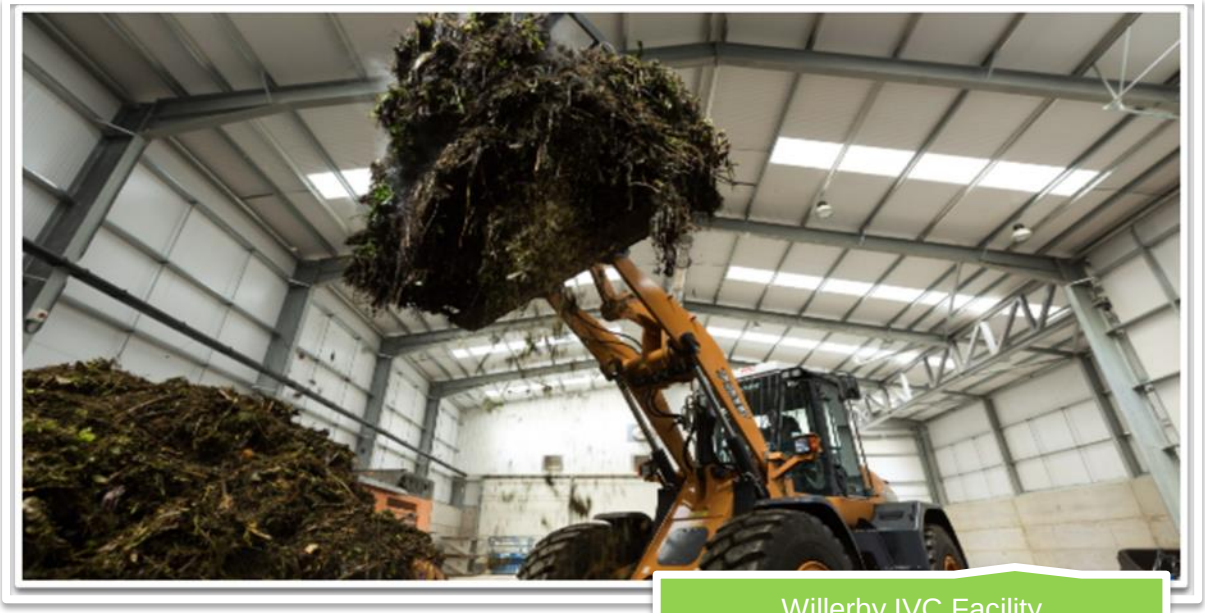

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Version No.	Date	Description of change
01	07/07/2017	Initial management plan
02	05/03/2019	Amended following review of sensitive receptors
03	12/11/2019	Amended following management review
04	03/11/2020	Reviewed for submission of permit variation to increase capacity

CONTENTS

1.0 INTRODUCTION

This Bioaerosols Management plan has been developed to identify likely causes of bioaerosols emission on site at the Biowise facility and to provide mitigation strategies designed to reduce bioaerosols levels.

1.1 Scope of Document

The Bioaerosols Management Plan has been developed to:

1. Detail typical site composting process
2. Identify likely sources of bioaerosols emissions
3. Establish procedures to enable Biowise to mitigate bioaerosols emissions

1.2 Sensitive Receptors

There are two sensitive receptors within 250m of the IVC site[1]. Table 1 below shows the sensitive receptors and their distances to the nearest site boundary:

Table 1 - Nearest Sensitive Receptors to operational boundary

Ref:	General Wind Direction (To)	Occurrence (%)	Nearest Sensitive Receptor	Approximate Distance From Site (m)	Grid Reference
SR01	N	16	Eppleworth Wood Farm	150 (IVC)	500365, 432137
SR05	SE	6	Albion Mill	260 (OC)	501779, 430941
SR08	SW-W	47	Hessle Golf Course	210 (IVC)	500165, 431539

There are no sensitive receptors within 250m of the ASP/OWC site, however, Biowise chooses to conduct bioaerosols monitoring at this site in order to provide a greater understanding of the bioaerosols emissions resulting from the composting activity. Figure 1 displays the location of all sensitive receptors, the site boundary and the location of the IVC and ASP/OWC site.

1.3 Site Layout

The satellite image below identifies the site boundary and sensitive receptor locations. This satellite image was taken when Biowise operated an Open Windrow Compost (OWC) process where they now operate the ASP process. Therefore, the process visible in Figure 1 is OWC not ASP. This is the latest satellite imagery available.

[1]Wheeler P.A., Stewart I., Dumitrean P., Donovan B. (2001) 'Health Effects of Composting: A Study of Three Compost Sites and Review of Past Data' *Environment Agency R&D Technical Report P1-315/TR*

Figure 1 - Satellite imagery of the Biowise site with composting process location superimposed

2.0 BIOAEROSOLS

2.1 Definition

Bioaerosols are defined as:

"Aerosols are liquid or solid particles suspended in a gaseous medium with size ranges from 0.001 to 100µm. Bioaerosols consists of aerosols containing microorganisms (bacteria, fungi, viruses) or organic compounds derived from microorganisms (endotoxins, metabolites, toxins and other microbial fragments). Bioaerosols vary in size (20nm to 100µm) and composition depending on the source, aerosolisation mechanisms, and environmental conditions prevailing at the site"[2].

The biological agents that have been examined in relation to bioaerosol exposures associated with waste handling and treatment processes include pathogenic and non-pathogenic spores, live (viable) or dead (non-viable) bacteria, fungi, viruses, bacterial endotoxins, mycotoxins, and peptidoglycans. Although other types of biological component may also be present as airborne particles such as algal fragments, protozoa and nematodes, these have not been considered in studies of bioaerosols emitted by the waste industry to date[3].

2.2 Causes of Bioaerosols Emission

The potential for particulates to be liberated from organic waste treatment sites does exist. Airborne dusts and so bioaerosols are likely to be aerosolised by the handling of the waste materials accepted on site, their storage and movement and by meteorological conditions (presence or absence of precipitation, wind, etc.). Bioaerosols are aerosolised as clumps, aggregates and attached to larger mineral particles in the TSP size range4. Hence, they generally settle fairly rapidly, i.e. within a minute or two and within 250m of the point of generation.

Weather conditions can also affect generation and aerosolisation. Viability can deteriorate according to temperature, humidity and sunlight. Die off is generally exponential, although non-viable (dead) microorganisms may still be able to cause health effects (allergenic/toxic effects in sufficient concentrations). However, the standard protocol for England and Wales4 and the majority of data at present utilises counts of viable micro-organisms.

It is important to note other activities and environments can affect local concentrations of bioaerosols. In terms of published scientific literature, a range of authors report natural concentrations of bacteria and fungi routinely range from 1,000 to 100,000 (103 to 105) cfu/m^3 air5. An investigation of an open windrow site reported high measurements of fungi off-site in wet woodland comparable to on-site. Additionally, it was reported that mowing a nearby meadow also significantly affected results of viable fungi and bacteria (160 and 480 respectively prior to mowing, 15.0 x 103 cfu/m^3 and 17.6 x 103 cfu/m^3 after)6.

[2] Mandal, J and Brandl, H. (2011) 'Bioaerosols in Indoor Environment – A review with special reference to residential and occupational locations. *The Open Environmental & Biological Monitoring Journal.* P83:4.

[3] Defra (2009) *Exposure response relationships for bioaerosol emissions from waste treatment processes WR0606*.

[4] Wheeler P.A., Stewart I., Dumitrean P., Donovan B. (2001) *Health Effects of Composting: A Study of Three Compost Sites and Review of Past Data*. Environment Agency R&D Technical Report P1-315/TR.

[5] Cox C.S., Wathes C. M. ed. (1995) 'The Bioaerosols Handbook' Lewis Publications Ltd

[6] Frederickson, J.; Boardman, C. P.; Gladding, T. L.; Simpson, A. E.; Howell, G. and Sgouridis, F. (2013). Evidence: Biofilter performance and operation as related to commercial composting. Environment Agency, Bristol.

3.0 SITE PROCESS

This section provides a basic overview of the composting process from waste reception to production of final graded compost product. The process involves two stages, the first stage (sanitisation) taking place in enclosed tunnels (IVC) and the second stage (stabilisation) taking place in open air aerated static piles. The sanitisation of segregated green wastes can be performed using the ASP if necessary. A full summary of the site process is available in the site's Management System.

3.1 Composting Techniques

The facility deploys three different composting techniques which can be utilised in parallel or series depending upon operational requirements. The flow diagram below outlines the different process routes depending upon material treated and technique employed.

The facility deploys three different composting techniques which can be utilised in parallel or series depending upon operational requirements. The flow diagram below outlines the different process routes depending upon material treated and technique employed. The primary treatment technology for external processing will be ASP composting as maturation for post IVC sanitised materials and for sanitisation and stabilisation of green only materials (highlighted in red below). The use of open windrow composting will be as a back up to the ASP system for any down time during routine or abnormal outage.

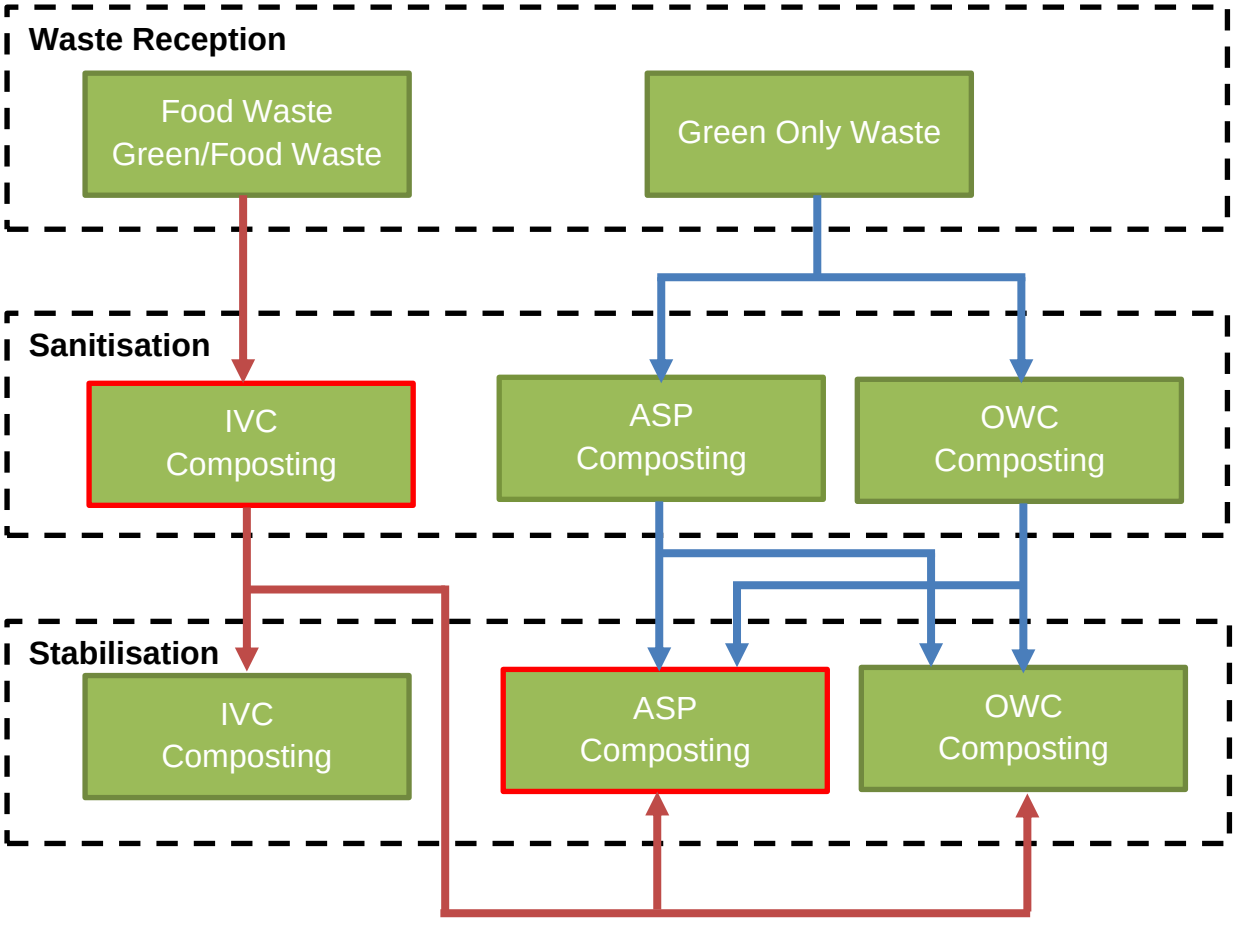

Figure 2 – Process Technique Material Flow Diagram

3.2 In Vessel Sanitisation

Following receipt of conforming waste at the IVC reception hall each accepted load shall be assessed for size, material must be less than 150mm in one plane only, prior to the waste being loaded into the IVC tunnel. For example, a branch may be 300mm long, but if it is less than 150mm thick it will meet the required standard. This can be achieved in one of two ways: through shredding; or through the removal of non-conforming oversized materials. Site operatives in the IVC inspect the waste on receipt and remove any non-conforming waste into the receptacles provided for further processing (i.e. liberating waste in black bin liners or shredding any oversized items). Post shredded materials are then transferred to the composting tunnels for processing.

A loading shovel is used to deposit the blended feedstock into the enclosed tunnels. The tunnels are loaded to a maximum of 315 tonnes. Throughout the sanitisation phase tunnels are actively monitored for temperature and moisture content using an automated data logging system integrated within the GICOM IVC system. The ABP sanitisation process will last a minimum of 2 days, and the total time within the IVC tunnels will typically be between 7 and 10 days. Prior to exit, the material will be flushed with air through the air handling forced aeration system to stabilise the material. After a minimum of 2 days at 60^{o}C in the IVC the material will be transferred to the open windrow composting pad for maturation.

3.3 Open Windrow Sanitisation

Following waste acceptance, the green waste will be shredded to <400mm and formed into batches in open windrows. The dimensions of each windrow shall be approximately 4 metres high, 8 metres wide and 40 metres long. Gaps of suitable width to enable turning/monitoring and litter picking will be left between the windrows.

Throughout the sanitisation phase windrows are actively monitored for temperature and moisture content using a hand held temperature probe and squeeze test on a daily basis. The sanitisation process will last a minimum of 7 days during which period the critical limits must be met, but typically lasts for 2 weeks. During this period a minimum of 1 turn is made to fully incorporate the compost by loading shovel. After meeting the requirements of the sanitisation phase, material will be further treated through the maturation phase.

3.4 Open Windrow Maturation/Stabilisation

Once sanitisation is achieved the compost is then further processed to mature to the required finished product quality as prescribed by PAS100/QP. This additional processing incudes OWC, ASP and IVC sanitised material. All material streams are matured on the external composting pad through OWC processes. No mixing of the waste streams will take place, materials are held in discrete batches.

Post sanitised batches are formed into windrows approximately 4 metres high, 8 metres wide and 40 metres long. Gaps of suitable width to enable turning/monitoring and litter picking will be left between the windrows. During this period a minimum of 2 turns are made to fully incorporate the compost by loading shovel.

The Batch formation during the open windrow stage will be based on a maximum available batch size of 400 tonnes. Temperature logging is recorded weekly across the minimum 6 week maturation period.

3.5 ASP Sanitisation

Following waste acceptance, the green waste will be shredded to <400mm and formed into batches in static piles within an ASP bay. The dimensions of each pile shall be approximately 4 metres high, 30 metres wide and 20 metres long.

Throughout the sanitisation phase the piles are actively monitored for temperature and moisture content using an automated temperature probe and squeeze test on a daily basis. In addition, oxygen levels are monitored within the pile using the automated oxygen sensor within the ASP bay. The sanitisation process will last a minimum of 7 days during which period the critical limits must be met, but typically lasts for 2 weeks. After meeting the requirements of the sanitisation phase, material will be further treated through the maturation phase.

3.6 ASP Maturation/Stabilisation

Once sanitisation is achieved the compost is then further processed to mature to the required finished product quality as prescribed by PAS100/QP. This additional processing incudes material previously sanitised by either ASP, OWC or IVC. These material streams are matured on the ASP bays. No mixing of the waste streams will take place, materials are held in discrete batches.

Post sanitised batches are formed into piles approximately 4 metres high, 30 metres wide and 20 metres long. The batch formation will be based on a maximum available batch size of 1,560 tonnes to progress through to the maturation stage of the process. Temperature logging is recorded continuously across the minimum 4 week maturation period.

3.7 Screening

Following the actively managed composting phase, each batch will be screened to the required particle size grade; such as 0-10mm or 0-25mm or 25mm-80mm. Any oversize material (e.g. >80mm) will be cleaned up, re-shredded and added to a subsequent batch.

If the oversize material is too heavily contaminated for re-composting, it will be used for on-site restoration works or disposed of to a suitably licensed facility.

The screened compost will be transferred to the appropriate storage area where it will be stored in separate batches for up to 12 months prior to blending, bagging and/or dispatching to end markets. The composting system complies with PAS100 and the Quality Protocol for the production and use of quality compost from source-segregated biodegradable waste. This allows certification of compost produced on site, which can then be deemed a product, and not a waste.

4.0 LIKELY SOURCES OF BIOAEROSOLS EMISSION

This section identifies the potential sources of bioaerosols generation, including risk factors and typical duration of activity.

Table 2 - Emissions Classification for Site Activities

Emission Class	Site Activities	Comments	Hours/Week
Low	Vehicle movements	Constant activities but low level of material agitation.	60
	Site maintenance		
	Waste Movement	Trailers are filled below maximum capacity and adhere to speed limit to prevent spilling. Movement does not occur during strong winds.	60
	Shredding	Shredding at the external pad takes place more than 250m away from a sensitive receptor.	40
Low to Medium	Waste reception	Activities take place within an enclosed building with negative air pressure handling system.	40
	Shredding		
	Screening		
	Bay Loading	Loading takes places when the material is cool and damp, so less bioaerosols formed.	16
	Stabilisation	The material has been sanitised, so emissions are lower. Also, the static nature of the ASP process reduces the movement of material and mitigates the formation of bioaerosol emissions.	Continuous
Medium	Tunnel Loading	Material movements within enclosed building.	16
	Sanitisation	Low release from undisturbed enclosed tunnels with forced aeration treatment system.	Continuous
High	Tunnel Unloading	High instantaneous release of bioaerosols in immediacy of activities, which are actively agitating materials.	12
Very High	Accidents leading to elevated release events.	Rare due to management systems and processes.	<1

Table 2 presents site activities which are likely sources of bioaerosols emission and ranks them based on likelihood. The identified emission sources are addressed in Table 17, which presents mitigation strategies for these sources.

4.1 Dispersion Factors

Meteorological conditions affect the level of bioaerosols emission and cannot be controlled. Variables such as; temperature, humidity, precipitation and wind speed all influence the emission of bioaerosols.

Table 3 - Wind Direction and Occurrence on Site during 2006 - 2014

Wind Direction (from)	N	NE	E	SE	S	SW	W	NW	Calm
% Occurrence	10	6	5	6	16	22	25	10	<1

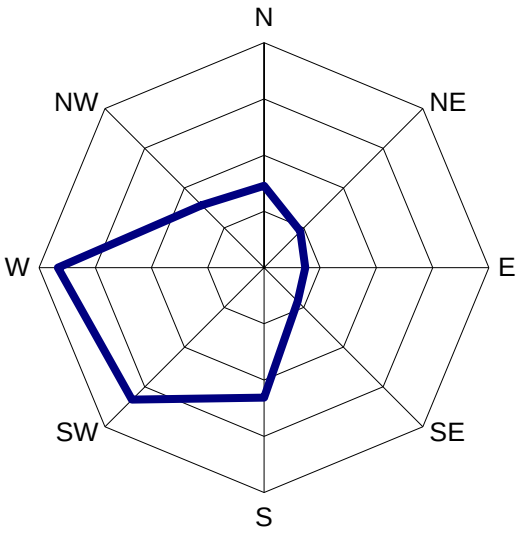

Figure 3 - Wind Direction Rose, January 2006 – September 2014

The predominant wind direction at site comes from either the West (25%) or South-west (22%) and blows towards the East or North-east. This predominant wind direction mitigates bioaerosols risk at the sensitive receptors, since the majority of the time the SRs will not be downwind of either the IVC site of the ASP/OWC site. Table 14 demonstrates that the SRs are only downwind of the IVC either 10% or 6% of the time. Table 15 demonstrates that the Albion Property Complex, which is greater than 250m away from the ASP/OWC site and not technically an SR, is only downwind of the ASP/OWC 10% of the time.

Table 4 - Frequency of wind directions blowing towards SR from IVC

Receptor	IVC site		Details
	Occurrence % (from)	Distance from site (m)	
Eppleworth Wood Farm (North of IVC)	10	150	Residential / Agricultural
Hessle Golf Club (South-west of IVC)	6	210	Golf course

Table 5 - Frequency of wind directions blowing towards SR from ASP/OWC

Receptor	ASP/OWC site		Details
	Occurrence % (from)	Distance from site (m)	
Albion Property complex (South-east of ASP/OWC)	10	>250	Residential

5.0 MANAGEMENT PLAN

Development of the Management Plan has been made in line with the requirements set in Section 2.8 of S5.06 (for accident management). This has been adopted to provide a robust assessment of risk levels and identification of appropriate strategies to mitigate such risks.

5.1 Risk Estimation

The Bioaerosols Management Plan has been developed with a risk assessment approach to each potential hazard by combining the probability and magnitude of the potential risk to give an estimation of the risk prior to any mitigation measures. The risk management measures, which are designed to reduce the likelihood of occurrence, are then detailed followed by an estimation of the actual risk post-mitigation (Residual Risk Rating).

The DEFRA guide to risk assessment[7] indicates the approach of subjectively classifying the magnitude of potential consequences into four categories depending upon the degree of the impact that the potential risk could have and the context in which the risk is being assessed. The classification is used as a guide in this Risk Assessment. The four categories are as follows:

- Severe: Possible health damage to vulnerable receptors, some short term impact on robust individuals. Bioaerosols concentrations above levels considered natural within the environment;
- Moderate: No significant effects on robust individual, vulnerable individual may experience short term effects. Bioaerosols levels above natural background concentrations;
- Mild: No observable effects on receptors with mid to high-range natural levels of bioaerosols;
- Negligible: The effects are negligible or at background levels within the natural environment.

The matrix shown below considers the probability of the potential risk against the magnitude of the potential impact, thereby giving an estimation of the resulting likelihood of the risk occurring.

Table 6 – Risk Estimation Matrix

Probability of Potential Risk	Magnitude of Potential Impact			
	Severe	Moderate	Mild	Negligible
High	High	High	Medium/Low	Negligible
Medium	High	Medium	Low	Negligible
Low	Medium	Medium	Low	Negligible
Negligible	Medium	Medium/Low	Low	Negligible

[7] DEFRA (1995) A Guide to Risk Assessment and the Risk Management for Environmental Protection.

The qualitative risk assessment for the Management Plan has been based on the matrix outlined above.

The final stage of the risk assessment is the judgement of the severity of the residual risk following implementation of the mitigation measures.

5.2 Management Plan and Risk Estimation

Table 7 - Bioaerosols Risk Estimation Matrix and Management Plan

Process Stage/Activity	Probability of Bioaerosol Emission	Magnitude of Potential Impact	Initial Risk Rating	Risk Management Techniques/Procedures	Residual Risk Rating
Waste Acceptance (IVC): The reception of feedstock materials by discharge from delivery vehicle.	**Medium:** The tipping of waste materials can generate bioaerosol release. Material received may be dry leading to additional emissions.	**Moderate:** Dry materials can release greater quantities of bioaerosols from wind action over the material surface and from material agitation. A sensitive receptor is located within 200m of the IVC facility.	**Medium**	• Powdered waste materials are not permitted at the composting facility. Strict pre-acceptance procedures are in place to prevent the receipt of such wastes. • Waste materials accepted at the IVC are deposited within the reception hall under negative pressure with >4$_{ae}$/hr. • The reception hall has fast action roller shutter doors which are closed during the tipping of any waste load. • Material is inspected during receipt and any dry material is wetted to meet the required moisture content as identified by grip test. • In line with ABP Regulations, all vehicles leaving the reception hall have their wheels washed to prevent loose debris from exiting the facility.	**Negligible**
Shredding (IVC): The size reduction of waste materials by mechanical process.	**High:** Material is disturbed at an elevated height in this process which is likely to lead to some aerolisation.	**Moderate:** Shredding activity readily disturbs the material generating dust and bioaerosols. A sensitive receptor is located within 200m of the IVC facility.	**High**	• Waste materials are shredded at the IVC within the reception hall under negative pressure with >4$_{ae}$/hr. • The reception hall has fast action roller shutter doors which are closed during the shredding of any waste load. • Prior to shredding, material is assessed for moisture content and wetted as appropriate to reduce emissions.	**Negligible**
Blending/Tunnel Loading (IVC): The blended of waste feedstocks and transfer into the process tunnels by loading shovel.	**Medium:** Material is disturbed in this process which is likely to lead to some aerolisation.	**Moderate:** Blending and loading activity readily disturbs the material generating dust and bioaerosols.	**Medium**	• Waste materials are blended and loaded into the tunnels at the IVC within the reception hall under negative pressure with >4$_{ae}$/hr. • The reception hall has fast action roller shutter doors which are closed during the blending and loading of waste materials into tunnels. • Tunnels are loading from inside the waste reception building so no material exists the enclosed environment.	**Negligible**

Process Stage/Activity	Probability of Bioaerosol Emission	Magnitude of Potential Impact	Initial Risk Rating	Risk Management Techniques/Procedures	Residual Risk Rating
		A sensitive receptor is located within 200m of the IVC facility.			
Sanitisation (IVC): The biological treatment of waste materials by composting in an enclosed vessel (composting).	**Low:** Material is static within the enclosed vessel with active forced aeration of piles.	**Mild:** Due to static process, levels of bioaerosols encountered at the sensitive receptor are predicted to be low from this activity. A sensitive receptor is located within 200m of the IVC facility.	**Low**	• The process tunnels are fully enclosed and waste piles are static throughout the sanitisation phase. • All processes in the IVC are controlled by a GICOM process computer. This control system enables parameters such as temperature, humidity and oxygen concentration to be set and controlled. This enables optimisation of the composting process, making the process more efficient and thus mitigating bioaerosols emissions. • 4 biofilters, each 15mx11m, are present in the IVC for the treatment of air. Each individual biofilter is controlled separately. If one biofilter fails or requires intensive maintenance, then the other biofilters can increase capacity to accommodate the temporary loss of one biofilter. Biofilters have been shown to mitigate bioaerosols emissions[8] • The site operates a strict maintenance regime, including the biofilters. This ensures that when a problem with the biofilters occurs, it is addressed ASAP to ensure that the biofiltration system is operational and at full capacity/efficiency.	**Negligible**
Tunnel Unloading (IVC): The unloading of the process tunnels by loading shovel into trailers for onward transportation.	**High:** Material is at target temperature and moisture prior to unloading. Physical agitation of material can emit bioaerosols.	**Moderate:** Active disturbance of material predicted to release bioaerosols. A sensitive receptor is located within 200m of the IVC facility.	**High**	• Tunnels are unloaded only once the composting process is fully complete, including the cool down cycle which ensures the material is cool and moist. • Dust suppression systems are implemented to help mitigate bioaerosols emission and are active during unloading. • Operatives moving material during unloading of tunnels are trained to limit drop-height of material to mitigate aerolisation.	**Low**

[8] Sykes, P., Jones, K., Wildsmith, J,D. (2007). 'Managing the potential public health risks from bioaerosol liberation at commercial composting sites in the UK: An analysis of the evidence base', *Resources, Conservation and Recycling*, 52, pp. 410-424.

Process Stage/Activity	Probability of Bioaerosol Emission	Magnitude of Potential Impact	Initial Risk Rating	Risk Management Techniques/Procedures	Residual Risk Rating
Biofilters (IVC): Biofilters in place to mitigate against odour and other emissions from the IVC	**Low:** Biofilters are designed to mitigate odour and other emissions from the IVC. However, if incorrectly managed biofilters can be a bioaerosols source	**Mild:** Additional emission of bioaerosols resulting from incorrect management of the biofilters	**Low**	• The biofilters are subject to a maintenance schedule • A daily visual inspection of the condition of the biofilter media of all biofilters shall be conducted by a trained operative, to identify areas of drying, weed growth, shrinkage of the bed, cracks and fissures, etc. The results will be recorded on the Biofilters Daily Inspection Form and any remedial action taken as necessary. There shall be regular monitoring of temperature and moisture levels of the biofilters. Results will be recorded electronically, and summarised on the Daily Biofilters Inspection Form. • As per the management system, when temperature in the biofilters exceeds 36^0C the system will ventilate the biofilters to cool them down.	**Negligible**
Waste Movement (IVC to ASP): After sanitisation in the IVC tunnels, material is moved to the ASP site. This done by loading a tractor trailer with a shovel loader, outside the IVC.	**Medium:** Material is transported in open trailers with the potential for wind action across the material surface to release bioaerosols.	**Mild:** Material is transported away from the direction of the sensitive receptors within 250m of the IVC.	**Low**	• Under normal circumstances when the prevailing wind direction blows towards an SR, transportation of material to the ASP site will not occur. • A 10mph speed limit is applied to the transportation of materials to mitigate the loss of materials from the trailer. • Trailers are filled below the maximum capacity so the risk of materials falling from the trailers is mitigated.	**Negligible**
Bay Loading (ASP): The unloading of material from the trailers to the ASP bays by loading shovel.	**High:** Movement of material from tractor trailer to ASP bays is likely to cause aerolisation of bioaerosols.	**Mild:** The nearest receptor to the ASP is over 250m away, therefore, levels of bioaerosols experienced at the property complex should be at background levels.	**Medium/Low**	• Material is transported straight from the IVC following cool down cycle so the material is cool and damp. • Drop heights of material from loading shovels to the bays/piles will are reduced as far as practicably possible.	**Low**

Process Stage/Activity	Probability of Bioaerosol Emission	Magnitude of Potential Impact	Initial Risk Rating	Risk Management Techniques/Procedures	Residual Risk Rating
Stabilisation (ASP): The biological treatment of waste in forced aerated static piles (composting).	**High:** The static nature of the process reduces movement of material and mitigates aerolisation. Outdoor forced aerated system more likely to generate bioaerosols.	**Mild:** The nearest receptor to the ASP is over 250m away, therefore, levels of bioaerosols experienced at the property complex should be at background levels.	**Medium/Low**	• The ASP process used on site reduces aerolisation of bioaerosols when compared to OWC processes. Turning of windrows in the OWC process can increase bioaerosols emission by x10[7] [9]. • ASP system allows oxygen levels in the piles to be continually monitored to maintain aerobic conditions providing optimum composting conditions and in turn mitigating bioaerosol emissions. • A demisting system is installed above the piles which can be utilised to dampen down the piles, thus mitigating the potential for dust and bioaerosol aerolisation.	**Low**
Screening (ASP): The physical grading of finished compost by star screen.	**High:** Screening is one of the most likely activities across the whole process to generate bioaerosols emissions.	**Mild:** The nearest SR to the ASP is over 250m away, therefore, levels of bioaerosols experienced at the property complex should be at background levels.	**Medium/Low**	• Screening only takes place once the composting process is complete and at target moisture content (40-65%). • If the material is too dry, then fresh water is sprayed onto the compost material whilst loading the screener to mitigate bioaerosol release.	**Low**
Shredding (OWC): The size reduction of waste materials by mechanical process.	**High:** Material is disturbed at an elevated height in this process which is likely to lead to some aerolisation.	**Mild:** The nearest SR to the ASP is over 250m away, therefore, levels of bioaerosols experienced at the property complex should be at background levels.	**Medium/Low**	• OWC is a backup option only to be used if the ASP is not functioning, thus negating a large amount of risk for all OWC activities.	**N/A**
Windrow Formation (OWC):	**High:** Movement of material with shovel loaders, including tipping is	**Mild:** The nearest SR to the ASP is over 250m away, therefore,	**Medium/Low**	• The OWC process is not the primary option for maturation. The ASP process is the primary option. The OWC is essentially a contingency process, to be used if there is an issue with the ASP. Since there is no turning in the ASP process, aerolisation risk is	**N/A**

[9] Taha, M.P.M, Drew, G.H., Longhurst, P.J., Smith, R., Pollard, S.J.T. (2006). 'Bioaerosol releases from compost facilities: Evaluating passive and active source terms at a green waste facility for improved risk assessments', *Atmospheric Environment*, 40, pp. 1159-1169.

Process Stage/Activity	Probability of Bioaerosol Emission	Magnitude of Potential Impact	Initial Risk Rating	Risk Management Techniques/Procedures	Residual Risk Rating
The formation of trapezoidal windrows by loading shovel.	very likely to cause bioaerosol emission.	levels of bioaerosols experienced at the property complex should be at background levels.		lower. The transition from OWC to ASP is a major mitigation measure that Biowise have enacted. • OWC is a backup option only to be used if the ASP is not functioning, thus negating a large amount of risk for all OWC activities	
Stabilisation (OWC): The biological treatment of waste materials in open air windrows (composting).	**Low:** Period in which windrows are static and monitoring of composting conditions takes place.	**Mild:** The nearest SR to the OWC pad is over 250m away, therefore, levels of bioaerosols experienced at the property complex should be at background levels.	**Low**	• The OWC process is PAS100 certified. This means that composting conditions follow industry best practice and parameters such as moisture content and temperature are regularly monitored. This leads to optimum conditions, improving the efficiency of the process and reduces bioaerosols emissions. • OWC is a backup option only to be used if the ASP is not functioning, thus negating a large amount of risk for all OWC activities	**N/A**
Windrow turning (OWC): The physical movement of the compost windrows by loading shovel.	**High:** Windrow turning is one of the activities with the highest probability if bioaerosol emission as large quantities of material are disturbed, leading to aerolisation.	**Mild:** The nearest SR to the OWC pad is over 250m away, therefore, levels of bioaerosols experienced at the property complex should be at background levels.	**Medium/Low**	• Turning windrows creates the largest aerolisation and therefore, turning should be kept to a minimum, but in line with the management system. • OWC is a backup option only to be used if the ASP is not functioning, thus negating a large amount of risk for all OWC activities	**N/A**
Vehicle Movements (All Site): Movement of plant and HGVs/cars around site has the potential to lead to aerolisation.	**Medium:** Aerolisation potential, increased in dry/dusty conditions or where material is loose on roads/access routes.	**Moderate:** Depending on location of activity, could be within 250m of a SR, therefore, increasing magnitude of potential impact.	**Medium**	• Roadways are sprayed/dampened down during dry/dusty conditions mitigating potential impact. • To comply with ABPR vehicles leaving the IVC building have their wheels washed to prevent contamination. This measure will also mitigate bioaerosols emissions. • Vehicles are also cleaned before leaving site, preventing spread of bioaerosols outside of site.	**Low**

Process Stage/Activity	Probability of Bioaerosol Emission	Magnitude of Potential Impact	Initial Risk Rating	Risk Management Techniques/Procedures	Residual Risk Rating
Site Maintenance (All Site): The housekeeping and maintenance practices employed on site.	**Medium:** Potential for bioaerosols release from poor housekeeping due to loose material being disturbed around the site.	**Moderate:** Depending on location of activity, could be within 250m of an SR, therefore, increasing magnitude of potential impact.	**Medium**	• Maintenance is conducted in line with stringent controls established in the Management System which ensures that set procedures are followed. This uniform approach to maintenance ensures that maintenance is conducted in an efficient manner, mitigating the impact it has on site activities. • Core operational equipment that are identified within this plan for the mitigation of bioaerosols release are routinely inspected, with service contracts provided by technology suppliers, often with spare components stored on site. • Daily inspection checks ensure that the site is kept clean and tidy, reducing the risk from loose material. • A mobile water bowser is available for dampening road surfaces during dry/dusty weather periods.	**Negligible**
Storage of oversize and finished compost	**Medium:** Potential for bioaerosols release resulting from disturbance of the pile(s).	**Moderate:** Depending on location of activity, could be within 250m of an SR, therefore, increasing magnitude of potential impact.	**Medium**	• Material is to be stored in only designated areas, ensuring that there is a single point source for each oversize and finished compost • Effort should be made to ensure that the piles are disturbed as infrequently as possible. • Prior to any material movement it is grip tested for moisture content, if the material is too dry (<40%) then fresh water is sprayed onto the pile during movement to mitigate bioaerosol release.	**Low**

5.3 Improvement Measures

The risk estimation has identified one process stage that could be improved in order to reduce the overall risk from bioaerosol emission. In order to further reduce the risk from these activities, some suggested operational improvements are identified in Table 8 below. The following suggestions are to be considered in context of what is practicably possible.

Table 8 – Proposed Control Measures and Amended Risk Rating

Process Stage/Activity	Estimated Risk Rating	Proposed Improvement Measures	Amended Risk Rating (post adoption)	Proposed Timescale
Screening (ASP): The physical grading of finished compost by star screen.	**Medium/Low**	• A water misting system could be installed along the screening equipment to increase dust suppression. Dust suppression techniques have been shown to reduce bioaerosols emissions[10,11] • A hood system could be installed on the screening equipment against the predominant wind direction to shield screening activities.	**Low**	• Biowise are currently engaging technology suppliers to identify an appropriate enclosure/suppression system for the shredder and/or screen.

[10]Epstein, E. (1994). 'Composting and bioaerosols.', *BioCycle*, 35, pp. 51-59.
[11] Kummer, V., Thiel, W.R. (2008). 'Bioaerosols- Sources and Control Measures', *Int. J. Hyg. Environ.-Health,* 211, pp.299-307.

WRM Limited
18 Manor Square, Otley, LS21 3AY

Tel: 01943 468138

Email: info@wrm-ltd.co.uk Web: www.wrm-ltd.co.uk