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Gravesend Sludge Treatment Centre Environmental Permit Application

Bioaerosol risk assessment
790101_ERA_BioaRA_GRA

February 2024

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1 Introduction

1.1 Overview

Southern Water is applying for a new environmental permit to operate its sludge treatment facility at the Gravesend Wastewater Treatment Works (WTW) and Sludge Treatment Centre (STC) ('the Site'). Sludge treatment activity is covered by the Environmental Permitting Regulations (EPR) 2016, which incorporates the application of the Industrial Emissions Directive (IED). The Site currently operates under a T21 exemption and has one environmental permit for Combined Heat and Power (CHP) activities (MCP/SG Permit, Ref: EPR/QP3337QC).

Regulatory Position Statement 209[1], issued 23 January 2018 by the Environment Agency, states that all sites that have a permit for the treatment of biological waste within 250 metres of a sensitive receptor (a place where people live or work for more than 6 hours at a time) must carry out a site-specific bioaerosol risk assessment. As sensitive receptors are found close the boundary of the Site, the closest of which is approximately 60m from the nearest potential source of bioaerosols at the Site, a bioaerosol risk assessment has been undertaken to accompany the permit application for this Site.

This bioaerosol risk assessment has assessed the magnitude of risk from potential emissions of bioaerosols from the Site at nearby sensitive human health receptors. The assessment has been undertaken in accordance with the methods and principles outlined in Environment Agency's "*Guidance on the evaluation of bioaerosol risk assessments for composting facilities*" [2].

1.2 Site location

The Site is situated in the northeast of the town of Gravesend, Kent. The layout of the Site is shown in 790101_MSD_SiteLayoutPlan_GRA_February 2024.

[1] Environment Agency (2018) Bioaerosol monitoring at regulated facilities - use of M9: RPS 209. Available online at: https://www.gov.uk/government/publications/bioaerosol-monitoring-at-regulated-facilities-use-of-m9-rps-209/bioaerosol-monitoring-at-regulated-facilities-use-of-m9-rps-209

[2] Drew, G.H., Deacon, L.J., Pankhurst, L., Pollard, S.J.T. and Tyrrel, S.F. (2009). Guidance on the evaluation of bioaerosol risk assessments for composting facilities. Environment Agency.

2 Methodology

2.1 Overview

Bioaerosols are naturally present in the air, but they are also associated with composting, anaerobic digestion (AD) and mechanical biological treatment, which are the main processes used to treat organic waste in the UK.

Bioaerosols are micro-organisms which are suspended in the air; these can include bacteria, fungi and viruses, or parts of living organisms, such as spores and plant pollen. Bioaerosols range in size from 0.02-100µm but are generally smaller than 10µm in diameter so can easily be breathed into the human respiratory system where they can cause adverse health impacts such as respiratory and gastrointestinal illnesses. Especially relevant to waste treatment facilities are infections of the respiratory system caused by *Aspergillus fumigatus*, which can be fatal, especially for at-risk and immuno-compromised patients. Bioaerosols can also cause eye irritation and dermatitis if they come into contact with the eyes and skin.[3]

2.2 Guidance

There is minimal regulatory guidance available for assessing bioaerosol emissions from AD facilities. Regulatory Position Statement (RPS) 031[4] states that bioaerosol concerns would normally be associated with composting activities, which are defined as: *'biological decomposition of biodegradable waste under conditions that are predominantly aerobic and that allow the development of thermophilic temperatures as a result of biologically produced heat'*.

This RPS also defines operations which are *'likely to result in the uncontrolled release of high levels of bioaerosols'* as including '*the shredding of waste and the turning of waste in the sanitisation, stabilisation and maturation stages of composting where these operations are not contained or are not subject to exhaust ventilation and scrubbing/filtering'*.

These activities do not occur at the Site as the biological decomposition of waste occurs under controlled, anaerobic conditions. Therefore, the Site is unlikely to be a high-risk site for bioaerosol emissions. This is supported by a 2012 Environment Agency guidance note[5] which states that the Environment Agency do not consider bioaerosols from anaerobic digestion to be of serious concern (provided composting activities are not undertaken at the facility).

Nonetheless, current Environment Agency guidance[6] requires any facility which could release bioaerosols to provide a site-specific bioaerosol risk assessment if there are sensitive receptors within 250m of activities. For new permits there is also a requirement to monitor bioaerosols if the site is within 250m of a sensitive receptor[7].

[3] Drew, G.H., Deacon, L.J., Pankhurst, L., Pollard, S.J.T. and Tyrrel, S.F. (2009). Guidance on the evaluation of bioaerosol risk assessments for composting facilities. Environment Agency.

[4] Environment Agency. 2011. Composting and potential health effects from bioaerosols: our interim guidance for permit applicants. Regulatory Position Statement 031.

[5] Environment Agency. 2012. Guidance for developments requiring planning permission and environmental permits' (England)

[6] Environment Agency (2018) Bioaerosol monitoring at regulated facilities - use of M9: RPS 209. Available online at: https://www.gov.uk/government/publications/bioaerosol-monitoring-at-regulated-facilities-use-of-m9-rps-209/bioaerosol-monitoring-at-regulated-facilities-use-of-m9-rps-209

[7] *"Sensitive receptor – any building, other structure or installation, in which at least one person normally lives or works, other than a building, structure or installation within the same ownership or control as the operator/owner of the composting facility."* Taken from 'Guidance on the evaluation of bioaerosol risk assessments for composting facilities.'

However, following a Schedule 5 notice from the Environment Agency for another similar STC, a conservative approach has been undertaken and human receptors within 500m of the Site have been considered instead of the 250m specified in the Environment Agency guidance[8].

2.3 Methodology

The method used for this bioaerosol risk assessment is adapted from the Environment Agency's '*Guidance on the evaluation of bioaerosol risk assessments for composting facilities*'[9], which recommends using a Source-Pathway-Receptor model to help determine the magnitude of the risk associated with bioaerosol emissions from a facility.

The magnitude of risk is a function of both the probability of exposure and the consequences of the hazard. The probability of exposure to bioaerosols can be described as:

- 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
- Very low – exposure very unlikely, effective and multiple barriers

The consequence of the hazard considers the nature of the source, the hazard and receptor. These consequences can be described as:

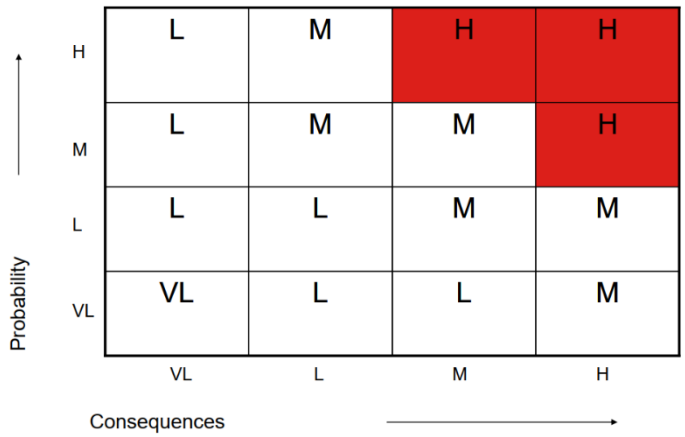
- High – severe consequences, evidence that exposure may result in serious damage
- Medium – significant consequences, evidence that exposure may result in damage that is not severe and is reversible
- Low – minor consequences, damage not apparent, reversible adverse changes possible
- Very low – negligible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

The probability of exposure and consequence of the hazards are then combined to determine the overall magnitude of the risk, as demonstrated in Figure 2.1.

[8] Environment Agency (2018) Bioaerosol monitoring at regulated facilities - use of M9: RPS 209. Available online at: https://www.gov.uk/government/publications/bioaerosol-monitoring-at-regulated-facilities-use-of-m9-rps-209/bioaerosol-monitoring-at-regulated-facilities-use-of-m9-rps-209

[9] Drew, G.H., Deacon, L.J., Pankhurst, L., Pollard, S.J.T. and Tyrrel, S.F. (2009). Guidance on the evaluation of bioaerosol risk assessments for composting facilities. Environment Agency.

Figure 2.1: Magnitude of risk matrices



Source: Environment Agency, 2009

For this bioaerosol risk assessment, a Source-Pathway-Receptor model has been used to help assess the probability of exposure associated with different processes at the Site (Section 3). Existing control measures have also been identified to help inform the probability of exposure (Section 4). This has then been combined with the consequence of the hazard in Section 5 to determine the overall magnitude of risk associated with the different sources of bioaerosols at the Site, using the risk matrix above.

3 Source – Pathway – Receptor model

3.1 Overview

This section provides a summary of the sources of bioaerosols at the Site and the potential pathways that the bioaerosols could travel to sensitive human health receptors.

3.2 Sources

3.2.1 Overview

The Site includes the following assets which could release bioaerosols:

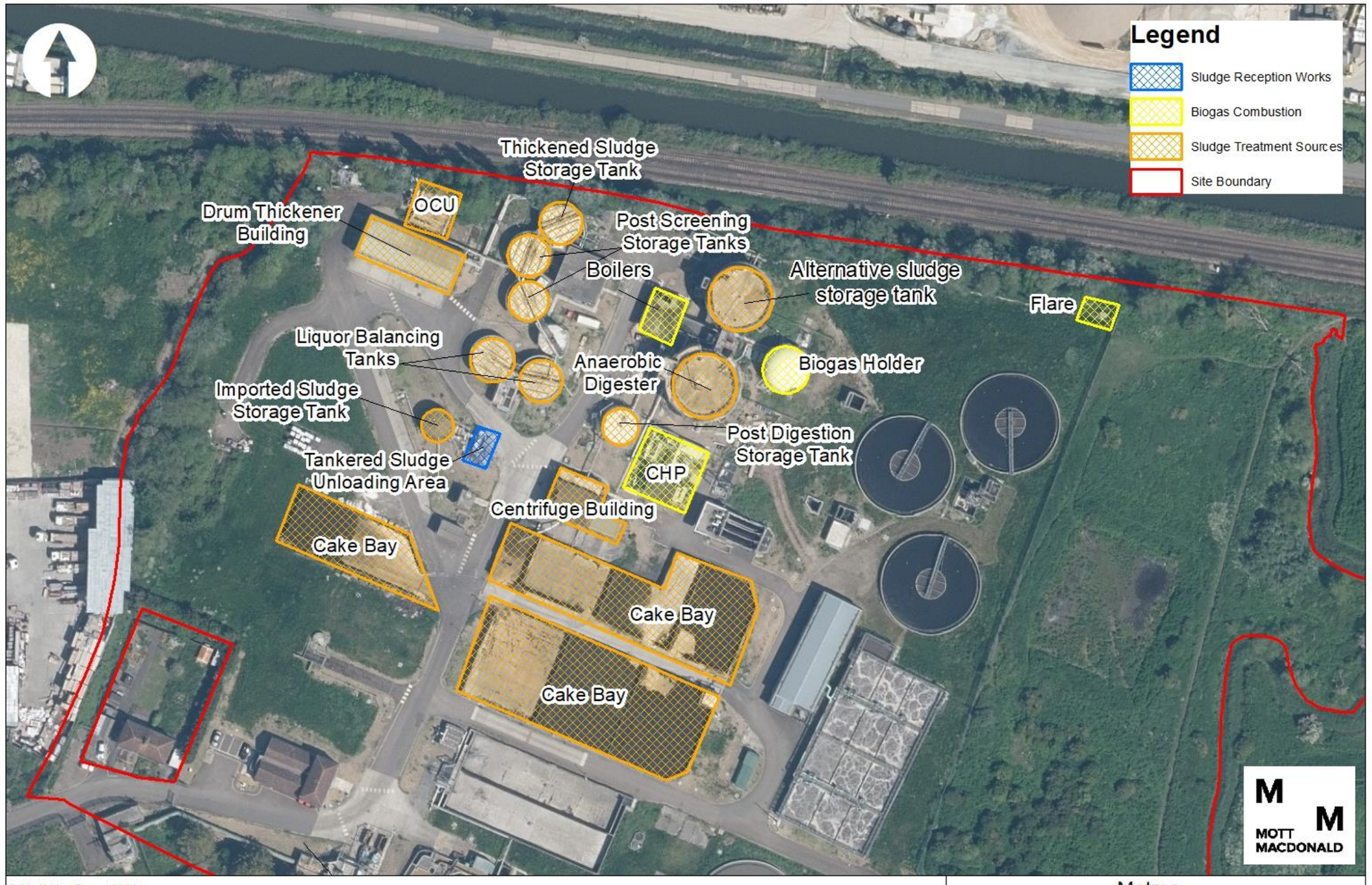
- Tankered sludge unloading area
- Sludge holding tank
- Imported sludge storage tank
- Drum thickener building
- Thickened sludge storage tank
- Two liquor balancing tanks
- One anaerobic digester
- Post digestion storage tank
- One alternative sludge storage tank
- Centrifuge building
- Seven cake bays
- Odour control unit (OCU)
- Biogas holder
- One Combined Heat and Power (CHP) unit
- Two dual fuelled boilers
- One flare

The following processes undertaken at the Site involving these assets, therefore, have the potential to release bioaerosols:

- Sludge reception and distribution
- Sludge treatment (sludge storage, thickening, digester, centrifuge and cake bays)
- Biogas combustion

Figure 3.1 shows the locations of these different processes and assets across the Site. A summary of the activities which occur at the Site involving these assets is then presented in the subsequent sections below.

Figure 3.1: Potential sources of bioaerosols at the Site



Metres
0 25 50 100

3.2.2 Sludge reception and distribution

Currently the Site accepts indigenous sludge and imported liquid sludge. Sludge is mainly imported from Northfleet, as well as from Oxted, Tonbridge, Whitewall Creek and Stoke and Grain. On average the Site accepts four tankers per day of liquid sludge imports. This Site does not accept tankered trade waste from third-party producers.

3.2.3 Sludge treatment

The Site treats indigenous sludge (from the primary and secondary wastewater treatment processes) as well as imported sludge. Imported sludge and indigenous sludge are screened by two strain presses before passing to a sludge holding tank. The sludge is then pumped through to two drum thickeners for thickening before being stored within a thickened sludge storage tank.

The thickened sludge is then fed into the anaerobic digester. The anaerobic digestion process provides a controlled environment where micro-organisms, including bacteria and fungi, can grow, multiply and break-down organic material to form water, carbon dioxide and methane (biogas). After digestion, the sludge is stored in the post digestion storage tank and dewatered by a centrifuge. The cake produced from the post digestion storage tank is transferred to a trailer and transported across the Site to be stored in the cake bays. The cake is stored in the cake bays for a few days to allow it to mature before it is collected by trucks for agricultural use. All vehicles entering and leaving the Site are covered to minimise potential odours.

Sludge liquors from the drum thickeners and centrifuge are collected at pumping stations and pumped upstream or downstream of primary treatment.

3.2.3.1 Odour control

There are two OCUs on Site. The first of these is connected to the inlet pumping station and inlet screens which are part of the wastewater treatment process.

The second OCU is located next to the sludge thickening building and serves the drum thickeners, liquor balancing tanks, sludge reception tank, sludge storage tank and combined thickened sludge storage tank. This OCU comprises of a biofilter only and releases treated air to the atmosphere.

3.2.4 Biogas combustion

Biogas produced during anaerobic digestion is transferred to the biogas holder and then to the CHP and back-up boilers where it is combusted to generate heat and electricity for use on-site, to assist with the wastewater and sludge treatment processes. When the amount of biogas produced on-site exceeds that can be combusted within the CHP and there is insufficient space in the gas bag holder to store surplus biogas, excess biogas is sent to the flare to be burned. The flare is not regularly required and only operates when the CHP is offline, including during CHP downtime (which lasts for approximately 4 weeks per year).

3.3 Pathways

Bioaerosols are very small and light in weight so can easily be transport by the wind from their source to a receptor. The 2019-2023 wind rose for the nearest meteorological site, London City Airport (located approximately 24.8km northwest of the Site), is shown in Figure 3.2. The London City meteorological site experiences frequent winds from the southwest. This suggests that sensitive receptors located to the northeast of the Site would be at the greatest risk from

bioaerosol emissions from the Site as they would be downwind of the prevailing wind direction. As the meteorological site is located, 24.8km away, a wind Vortex model has also been employed.

The Vortex model uses historic ERA5 data from the European Centre for Medium-Range Weather Forecasts (ECMWF) and works by combining past meteorological data with current weather models. This allows meteorological parameters, such as wind speed and direction, to be predicted at any location for any time period from the past 40 years, accounting for some localised effects. The data from this model is a popular dataset for climate modellers and is used by the World Meteorological Organization for their annual State of the Climate report.

Figure 3.3 presents the wind rose generated for the Site from the Vortex model for the period from 2019-2023. The wind rose demonstrates that historically this location experiences strong prevailing winds from the southwest. This suggests that sensitive receptors located to the northeast of the Site would be at the greatest risk from bioaerosol emissions from the Site as they would be downwind of the prevailing wind direction.

Overall, the two datasets show general agreement with the modelled data indicating the predominant wind originating from a south westerly direction.

Figure 3.2: Average wind rose for London City meteorological site 2019- 2023

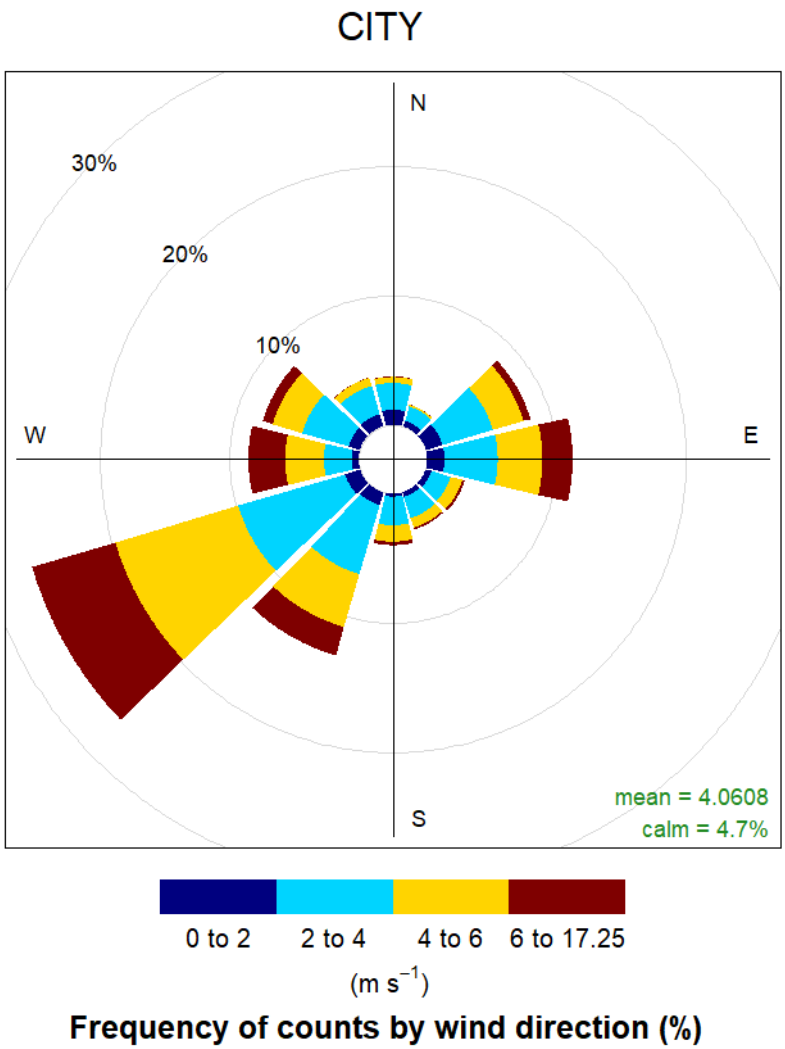
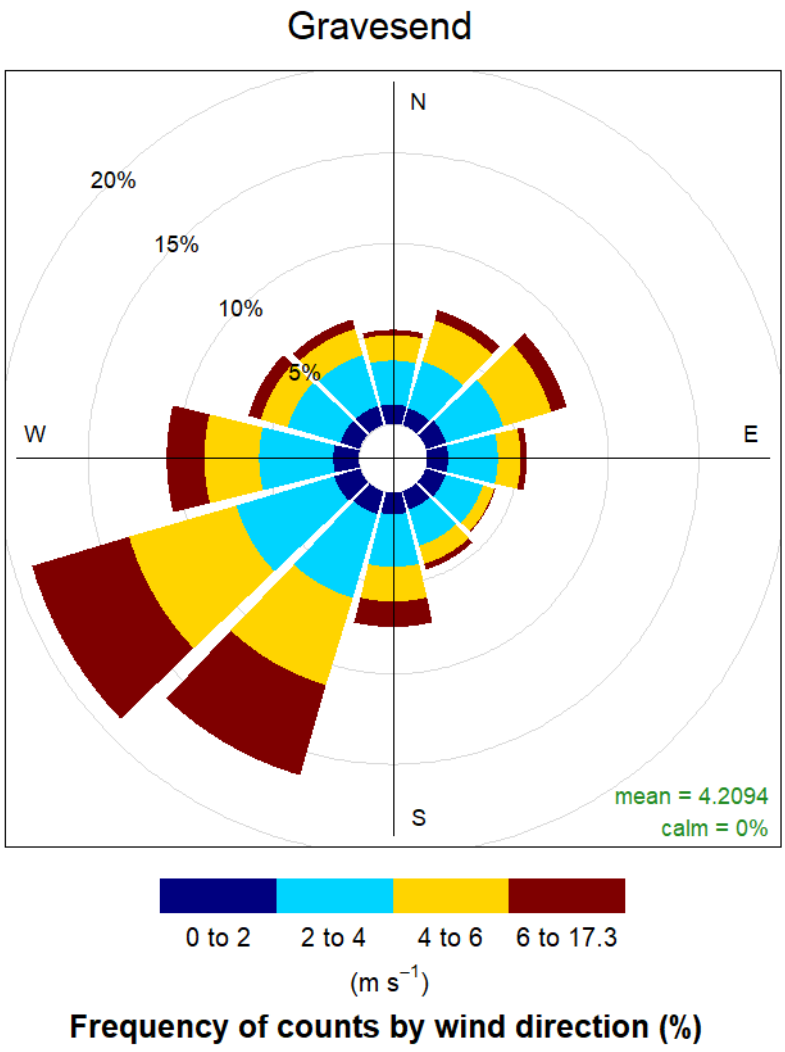


Figure 3.3: Average wind rose for the Site from the Vortex model, 2019 - 2023



Concentrations of bioaerosols decline rapidly within the first 100m from a source and generally decrease to background concentrations within 250m[10,11]. The local terrain surrounding the Site (and within a 250m area) is relatively flat. Much of the Site is screened by trees and heavy vegetation. This could present a natural barrier to the transportation of bioaerosols by the wind. However, this would be dependent on the release height of bioaerosols on Site.

[10] Environment Agency. 2011. Composting and potential health effects from bioaerosols: our interim guidance for permit applicants. Regulatory Position Statement 031.

[11] Health and Safety Executive, 2010. Bioaerosol emissions from waste composting and the potential for workers' exposure.

3.4 Receptors

Although Environment Agency guidance[12] recommends a screening distance of 250m from bioaerosol emission sources to static receptor locations, a screening distance of 500m has been used as a conservative approach. Sensitive receptors are defined as:

"*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*."

There are nine areas of sensitive receptors found within 500m of potential bioaerosol emission sources at the Site. As demonstrated in Figure 3.4, areas of industrial land use are found to the north, northeast, southeast, south, southwest and northwest of the Site, whilst residential properties are located to the southeast and southwest.

For each area of sensitive receptors, the distance and direction from each potential bioaerosol emission source to the receptor has been identified below in Table 3.1. Where multiple assets exist for the same process, such as digesters, only the closest asset has been presented.

The receptor closest to a potential emission source is an industrial estate, which is located approximately 60m southwest of the cake bays.

[12] Environment Agency (2018) Technical Guidance Note (Monitoring) M9 – Environmental monitoring of bioaerosols at regulated facilities. Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/730226/M9_Environmental_monitoring_of_bioaerosols_at_regulated_facilities.pdf

Table 3.1: Closest receptors within 500m of potential emission sources at the Site

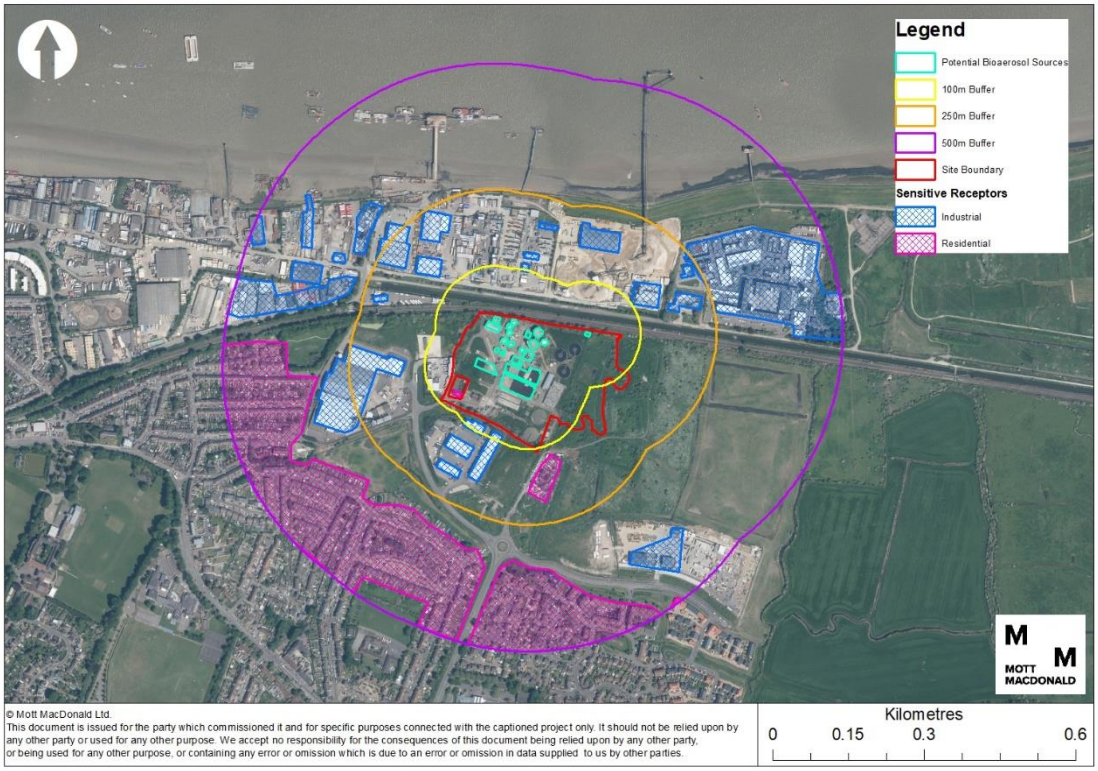
Nearest potential emission source to receptor	Process	Distance (m) and direction of different receptors[a] from nearest potential emission source [b]								
		Industrial land use north of the Site (m)	Industrial land use northeast of the Site (m)	Industrial land use southeast of the Site (m)	Industrial land use south of the Site (m)	Industrial land use southwest of the Site (m)	Industrial land use northwest of the Site (m)	Residential properties southeast of the Site (m)	Residential properties southwest of the Site (m)	Residential properties southwest of the Site (m)
Tankered sludge unloading area	Sludge reception and distribution	160, north	265, northeast	460, southeast	140, south	190, southwest	190, northwest	220, southeast	**110**, southwest	350, southwest
Post screening storage tanks	Sludge treatment	**110**, north	240, northeast	490, southeast	180, southwest	210, southwest	170, northwest	250, southeast	145, southwest	390, southwest
Imported sludge storage tank	Sludge treatment	160, northeast	275, northeast	475, southeast	140, southwest	180, southwest	180, northwest	230, southeast	**105**, southwest	350, southwest
Drum thickener building	Sludge treatment	**115**, northeast	260, northeast	510, southeast	180, southwest	175, southwest	130, northwest	265, southeast	140, southwest	385, southwest
Thickened sludge storage tank	Sludge treatment	**95**, north	230, northeast	505, southeast	205, southwest	225, southwest	165, northwest	270, southeast	170, southwest	415, southwest
Liquor balancing tanks	Sludge treatment	135, northeast	245, northeast	470, southeast	160, southwest	195, southwest	175, northwest	225, southeast	**130**, southwest	380, southwest
Anaerobic digester	Sludge treatment	**135**, northwest	200, northeast	445, southeast	180, southwest	250, southwest	225, northwest	215, southeast	165, southwest	390, southwest
Post digestion storage tank	Sludge treatment	150, north	230, northeast	460, southeast	160, southwest	230, southwest	215, northwest	210, southeast	**140**, southwest	375, southwest
Alternative sludge storage tank	Sludge treatment	**110**, northwest	185, northeast	460, southeast	205, southwest	260, southwest	215, northwest	235, southeast	185, southwest	420, southwest
Centrifuge building	Sludge treatment	170, north	245, northeast	440, southeast	140, southwest	210, west	215, northwest	185, southeast	**115**, southwest	350, southwest

Nearest potential emission source to receptor	Process	Distance (m) and direction of different receptors[a] from nearest potential emission source [b]								
		Industrial land use north of the Site (m)	Industrial land use northeast of the Site (m)	Industrial land use southeast of the Site (m)	Industrial land use south of the Site (m)	Industrial land use southwest of the Site (m)	Industrial land use northwest of the Site (m)	Residential properties southeast of the Site (m)	Residential properties southwest of the Site (m)	Residential properties southwest of the Site (m)
Cake bays	Sludge treatment	190, north	225, northeast	380, southeast	85, southwest	140, west	180, northwest	120, southeast	**60**, southwest	300, southwest
Biogas holder	Biogas combustion	**135**, northwest	180, northeast	440, southeast	200, southwest	270, southwest	240, northwest	220, southeast	185, southwest	395, southwest
Boilers	Biogas combustion	**120**, northwest	205, northeast	470, southeast	200, southwest	240, southwest	205, northwest	235, southeast	170, southwest	410, southwest
Flare	Biogas combustion	165, north	**100**, northeast	415, southeast	260, southwest	360, southwest	310, northwest	245, southeast	270, southwest	475, southwest
CHP	Biogas combustion	155, northwest	215, northeast	435, southeast	150, southwest	230, west	225, northwest	190, southeast	**140**, southwest	370, southwest

Source: (a) Number refers to the receptor number presented within Figure 3.4.
(b) Distance from source to receptor is rounded to the nearest 5m and is measured from the closest receptor building

Value in **bold** represents the nearest potential emission source for each process which is closest to a sensitive receptor

Figure 3.4: Sensitive receptors within 500m



3.5 Summary

Table 3.2 below summarises the potential sources of bioaerosol emissions at the Site, the sensitive receptors most at risk and the pathways through which the bioaerosols could travel from source to receptor.

Table 3.2: Source-Pathway-Receptor model

Source process	Potential emission source	Pathway	Nearest receptor
Sludge reception and distribution	Tankered sludge unloading area	Air transport then: • Inhalation (through nose or mouth) • Ingestion (eating or swallowing) • Absorption/contact (through skin or eyes) • Injection (by high pressure equipment/contaminated sharp objects)	Residential area (southwest of Site) – 110m southwest
Sludge treatment	Post screening storage tanks		Industrial estate (north of Site) – 110m north
	Imported sludge storage tank		Residential area (southwest of Site) – 105m southwest
	Drum thickener building		Industrial estate (north of Site) – 115m northeast
	Thickened sludge storage tank		Industrial estate (north of Site) – 95m north
	Liquor balancing tanks		Residential area (southwest of Site) – 130m southwest
	Anaerobic digester		Industrial estate (north of Site) – 135m northwest
	Post digestion storage tank		Residential area (southwest of Site) – 140m southwest

Source process	Potential emission source	Pathway	Nearest receptor
	Alternative sludge storage tank		Industrial estate (north of Site) – 110m northwest
	Centrifuge building		Residential area (southwest of Site) – 115m southwest
	Cake bays		Residential area (southwest of Site) – 60m southwest
Biogas combustion	Biogas holder		Industrial estate (north of Site) – 135m northwest
	Boilers		Industrial estate (north of Site) – 120m northwest
	Flare		Industrial estate (northeast of Site) – 100m northeast
	CHP		Residential area (southwest of Site) – 140m southwest

4 Control measures

4.1 Overview

The three primary ways to mitigate emissions of bioaerosols[13] is to:

- Reduce emissions
- Contain emissions
- Enhance dispersion

The sections below outline the different control measures in place at the Site for sludge reception cake and distribution, sludge treatment and biogas combustion processes. These control measures aim to reduce and contain emissions of bioaerosols to prevent the source-pathway-receptor link associated with each of the potential emission sources identified in Section 3.5.

4.2 Control measures

4.2.1 Sludge reception and distribution

The transfer of liquid sludge from the tankers has a short duration and, on average only takes place seven/eight times a day, so the potential for release of bioaerosols is minimal. Tankers are unloading via hose into the imported sludge storage tank. Imported processed sludge cake arriving to Site is unloaded to the cake bays by tipper truck where it then may be moved and stacked within the cake bay.

If a spillage of sludge/cake occurs, operators will carry out clean up as soon as possible (using disinfectant where necessary). If the spillage is caused by a lorry or tanker, the driver is responsible for cleaning up the spill before leaving the Site. If a lorry or tanker left a spillage behind, operators will log and report any incident observed and the driver or company involved will be asked to return to the Site immediately to clean up. Significant spillage incidents will be recorded in the Site diary.

Appropriate wash up facilities are also provided for drivers to clean the vehicles after loading or unloading in sludge storage bays and loading points. Lorry and tanker drivers are required to hose down any spillage after each loading or unloading and clean contaminated wheels before leaving the Site.

4.2.2 Sludge treatment

4.2.2.1 Containment of emissions

To contain emissions of bioaerosols and odour during sludge treatment, doors, covers and hatches to the buildings housing the sludge thickening activities and the centrifuge building are kept closed at all times except when access is required. When access is required for operation and maintenance, the doors and hatches to these treatment facilities will only be opened for minimum periods. If access is required for an extended period of time, such as for maintenance

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

activities, additional mitigation measures are implemented to minimise the impact associated with bioaerosols.

To further contain bioaerosol emissions, sludge thickening works are within process buildings. All sludge tanks and process units are covered, in addition to the digester and post digestion storage tank.

4.2.2.2 Reduce emissions

Throughout the sludge treatment process, biological material which could give rise to emissions of bioaerosols is broken down. This primarily occurs during anaerobic digestion, with subsequent processes such as liming being undertaken to further remove microorganisms by raising the pH and temperature. Therefore, at each stage of the sludge treatment process, the quantity of bioaerosols decreases, reducing the risk of exposure; the concentration of bioaerosols that could potentially be emitted from the cake (at the end of the sludge treatment process) is much lower than that from the sludge prior to anaerobic digestion.

While the cake bays are all uncovered, these areas all contain digested sludge products which are near the end of the sludge treatment process so the bioaerosol content and associated risk of exposure is reduced. Once the cake is deposited within the bays, it is not handled (apart from occasional liming) further until it is loaded into trucks to be transported off-site for agricultural use. This reduces the risk of bioaerosol emissions as agitation of cake could facilitate the resuspension of any remaining bioaerosols into the air. Cake is removed from Site on average every two months. It takes two days to empty the cake bays.

To further reduce potential bioaerosol emissions associated with sludge treatment, sludge produced on-site is processed immediately. This prevents processing of old sludge which is more odorous and difficult to process. Liquid sludge arriving on-site is also processed immediately to help minimise bioaerosol emissions.

To prevent emissions from sludge treatment activities, processes with the greatest potential to release bioaerosols such as sludge thickening are covered and odour controlled. The odorous air is treated within the OCU to remove odour and bioaerosols before it is released to the atmosphere.

4.2.3 Biogas combustion

Biogas produced during anaerobic digestion is stored within the biogas holder before being combusted at high temperatures within the CHP or flare. The biogas holder stores the biogas within an air-tight container which prevents the release of bioaerosol emissions. During combustion, any bioaerosols present within the biogas would be destroyed. Therefore, emissions of bioaerosols associated with biogas combustion would be de minimis.

4.3 Maintenance of control measures

Daily checks, measurements and sampling are conducted of the treatment processes on-site to ensure the equipment is working correctly. The parameters measured include: sludge blanket thickness, dissolved oxygen content, turbidity, temperature, pH and alkalinity (full list of parameters monitored are found within the operating plan for the WTW). Where desired operating parameters are not meant, various corrective actions and operating procedures are in place to rectify the problem. Performance issues and equipment problems are also reported promptly to Process Scientists, M&E technicians, ICA technicians or Specialist Contractors as appropriate.

Daily, weekly and monthly maintenance tasks/servicing are also performed on key equipment across the Site by Southern Water staff and specialist contractors. Southern Water has also issued generic maintenance task manuals for use across all their sites which include protocols for the maintenance of equipment such as absorbers, biofilters, odour extraction, fresh air supply ducting, wet scrubber (cleaning, pre-winter service, pH probe calibration, redox probe calibration), direct driven fan, belt driven fan and dryer exhaust ducting.

Currently bioaerosols are not directly monitored, however, future monitoring will be accordance with Environment Agency's Technical Guidance Note (TGN) M9[14] requirements to monitor effectiveness of control measures, where appropriate. Alternatively, the Odour Management Plan requires routine sniff tests and mitigation to odours, and therefore the Plan will indirectly aid the prevention and monitoring of bioaerosol.

Odour from the drum thickeners, liquor balancing tanks, sludge reception tank, sludge storage tank and combined thickened sludge storage tank, is controlled via one OCU. Filtered odour streams are discharged into the environment through an OCU stack as shown by A05 in 790101_MSD_SiteLayoutPlan_GRA_February 2024 and are monitored hourly to ensure the absence of odorous compounds.

The OCU is maintained in accordance with manufacturer's requirements to ensure treatment of bioaerosols and odours are effective.

All of the Site operations are fully enclosed or covered with the exception of the alternative cake bay which is uncovered. Diffuse emissions from the alternative cake bay are minimised by:

- Sludge cake is not handled once in the cake bay, (unless liming is required, however this requires minimal handling) until it is being removed from the Site;
- All sludge cake being exported is transported in covered lorries.

To minimise odour nuisance, it is important to ensure that the Gravesend WTW and STC is operating as designed. Covers and hatches are replaced to maintain the integrity of enclosures provided to collect odorous air.

The effectiveness of measures to prevent and limit bioaerosols, as well as odour, is undertaken by reviewing the Supervisory Control and Data Acquisition (SCADA) system to identify out of specification operation of assets. Whereby alerts are raised the measures within the Odour Management Plan will be followed to bring the operations in line with normal conditions.

Stocks of chemicals on-site are also carefully managed to ensure there are sufficient stocks of chemicals on-site so that the necessary treatment processes, control measures and maintenance activities can be undertaken when required.

4.4 Emergency procedures

In the event of plant failures or emergency situations, an alarm would be raised on the Site SCADA or telemetry systems, which will be reacted to by on-site or regional control room operators and Duty Managers.

Depending upon the nature of the fault or emergency, a mechanical or electrical technician, both of whom are on-call 24-hours, would be contacted and would attend the Site as soon as practicable if required. Where the on-call technicians are already engaged upon other response

[14] Environment Agency (2018) Technical Guidance Note (Monitoring) M9 - Environmental monitoring of bioaerosols at regulated facilities. Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/730226/M9_Environmental_monitoring_of_bioaerosols_at_regulated_facilities.pdf

work, there is the facility to access staff from other Southern Water geographic divisions, coordinated by the Duty Manager.

All faults, break-downs and emergencies are logged electronically together with records of the action taken and the solutions reached.

One such emergency event would be failure of the flare stack and/or CHP. Which would result in releases of biogas from the Whessoe Valves located on the roofs of the digesters, biogas holder and post digestion storage tank, which would release bioaerosols. Such biogas releases prevent over pressurisation of the digesters and gas systems. In the event of a problem, biogas generation is reduced by reducing or inhibiting the digester feed while the problem is rectified.

4.5 Monitoring

4.5.1 Overview

Bioaerosol emissions associated with the operation of the Site will be monitored in line with the Environment Agency Technical Guidance Note (TGN) M9[15] requirements to monitor effectiveness of control measures.

Sampling of bioaerosols using either impaction, filtration or impingement samplers will be undertaken by an MCERTS accredited organisation. The final approach would be determined prior to appointment in accordance with the requirements of TGN M9.

4.5.2 Monitoring Locations

As detailed in Section 3.3 **Error! Reference source not found.**, the prevailing wind direction at the Site is from the southwest, therefore, in accordance with TGN M9, three samplers will be positioned to the northeast of the Site to capture downwind bioaerosol concentrations and one sampler will be located upwind, to the southwest of the Site.

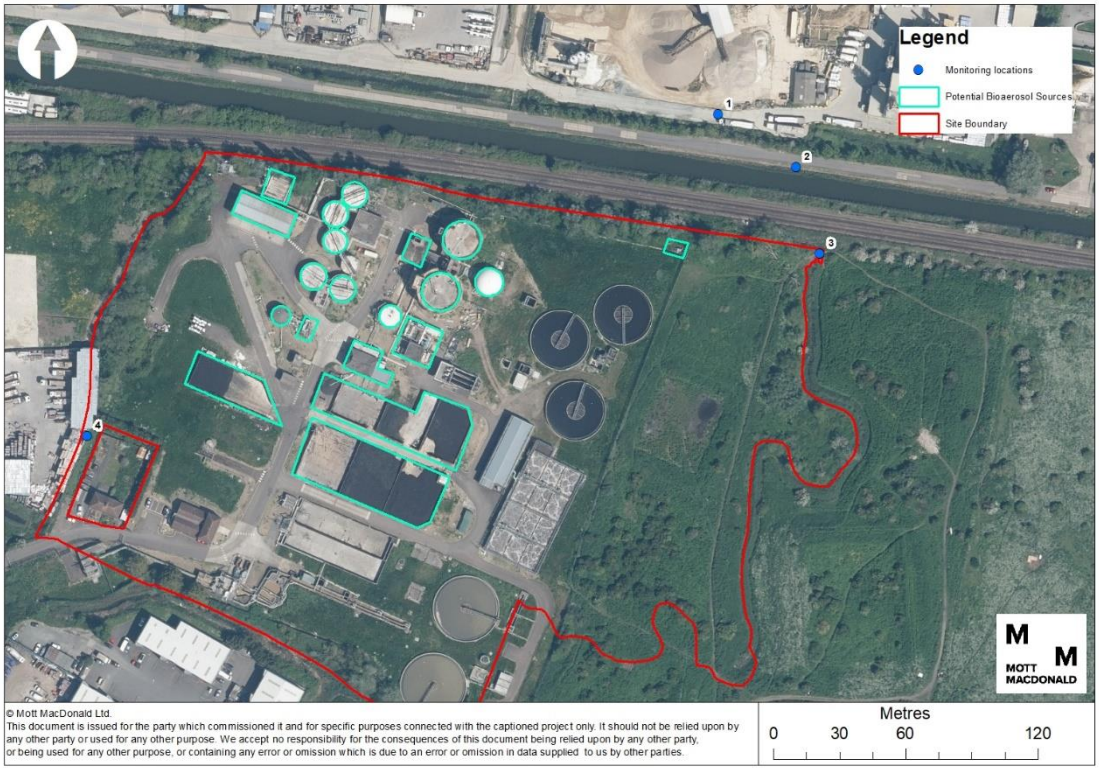
Figure 4.1 presents the indicative sampling locations identified for the Site. Locations 1, 2 and 3 represent the proposed locations for the three downwind samplers and are located at the same distance as the closest sensitive receptor (60m) from the nearest source of bioaerosols. The downwind samplers are arranged in a fan shape to ensure the maximum concentrations of bioaerosols are captured and variable wind directions will be accounted for.

The indicative monitoring location 4 represents the upwind sampler and is positioned approximately 50m from the nearest bioaerosol source. This location will provide a baseline concentration of bioaerosols, representative of background concentrations and any neighbouring sources of bioaerosols, such as agricultural activities, without contributions from the Site.

The exact sampling locations are dependent on the accessibility of each location and will be confirmed by the MCERTS accredited organisation that will conduct the sampling.

[15] Environment Agency (2018) Technical Guidance Note (Monitoring) M9 - Environmental monitoring of bioaerosols at regulated facilities. Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/730226/M9_Environmental_monitoring_of_bioaerosols_at_regulated_facilities.pdf

Figure 4.1: Indicative bioaerosol monitoring locations



4.5.3 Sampling methodology and frequency

Appropriate sampling of bioaerosols will be conducted by an MCERTS accredited organisation using procedures relevant to the sampler type, as described in TGN M9. Sampling at the upwind and downwind locations will be undertaken concurrently so that results can be compared. Monitoring will be undertaken on a quarterly basis for the first 12 months after permit issue and then six monthly thereafter. Where the bioaerosol action limit is exceeded, then quarterly monitoring will resume until such time that is it demonstrated that the site has adequate mitigation for a 12month period. Where it is confirmed that the risk is very low or low, Southern Water will make the decision as to whether further monitoring will be needed and under what circumstances it may need to be resumed, if at all.

Sampling will be undertaken during appropriate weather conditions such as avoiding rain, sleet and snow, depending on the sampling technique, and will consider the wind speed and direction at the time of sampling. Meteorological conditions including wind speed, wind direction, cloud cover, temperature, relative humidity, and atmospheric conditions will be recorded by an automatic weather station with an integral data logger during monitoring periods and this data will be recorded. The meteorological station will be positioned in a suitable location, away from anything which could influence measurements, such as at locations very close to buildings.

A minimum of three measurements of Aspergillus fumigatus and mesophilic bacteria will be taken from each sampler during each monitoring visit. Appropriate equipment and methodologies for each sampler type are described in TGN M9 and this guidance will be followed during the bioaerosol monitoring.

Following the measurements, samples will be stored and transported appropriately before being analysed in a laboratory.

Detailed and accurate records of the bioaerosol monitoring will be kept and the data will be recorded using the standard report forms provided in TGN M9 or an appropriate alternative.

4.6 Summary

As discussed above, there are a number of control measures in place at the Site to reduce and contain emissions of bioaerosols. These control measures are regularly maintained to sustain their efficacy and reduce the risk of equipment failure.

Across the Site, the potential for bioaerosol emissions, which could result in significant consequences is limited. The greatest risk of significant bioaerosol emissions from the Site is associated with emergency situations such as a failure of the flare or CHP/boilers, which could result in uncontrolled emissions of bioaerosols. However, such an emergency event would be unlikely, temporary, and infrequent due to the extensive monitoring and maintenance programmes undertaken at the Site, as well as the emergency procedures and warning systems in place.

5 Risk assessment

5.1 Overview

This section assesses the probability of exposure and consequence of the hazard associated with potential emissions of bioaerosols at the Site to determine the overall magnitude of risk. The descriptors used ('very low' to 'high') are based on the descriptors outlined in the Environment Agency guidance[16], as summarised in Section 2.3.

5.2 Probability of exposure

As described in Section 3, the main potential sources of bioaerosols at the Site are associated with:

- Sludge reception and distribution
- Sludge treatment (sludge storage, thickening, digester, centrifuge and cake bays)
- Biogas combustion

These processes have the potential to emit bioaerosols, which are transported through the air by the wind and could cause harm to nearby human health receptors. However, as discussed in Section 4, there are multiple control measures in place at the Site which restrict the Source-Pathway-Receptor link by reducing and containing emissions of bioaerosols from these processes. The overall probability of exposure of sensitive receptors to bioaerosols at the majority of sludge reception and distribution, sludge treatment and biogas combustion bioaerosol sources at the Site is therefore considered to be '**very low**' as exposure of the receptors to bioaerosols is "very unlikely" due to the "effective and multiple barriers" (control measures) in place.

The final probability of exposures to bioaerosols assessed for each emission source is presented below in Table 5.2.

Table 5.1: Probability of exposure to bioaerosols from different sources at the Site

Process	Potential source of bioaerosols	Probability of exposure	Justification
Sludge reception and distribution	Tankered sludge unloading area	Very low	Stringent loading and unloading procedures – uncontrolled release of bioaerosols very unlikely
Sludge treatment	Post screening storage tanks	Very low	Tanks covered, process monitored and regularly maintained – uncontrolled release of bioaerosols very unlikely
	Imported sludge storage tank	Very low	Tank covered, process monitored and regularly maintained – uncontrolled release of bioaerosols very unlikely
	Drum thickener building	Very low	All processes within the building are covered, process monitored and regularly maintained. Building connected to OCU and the air released from the unit has been treated to remove bioaerosols, process monitored and regularly

[16] Drew, G.H., Deacon, L.J., Pankhurst, L., Pollard, S.J.T. and Tyrrel, S.F. (2009). Guidance on the evaluation of bioaerosol risk assessments for composting facilities. Environment Agency.

Process	Potential source of bioaerosols	Probability of exposure	Justification
			maintained –uncontrolled release of bioaerosols very unlikely
	Thickened sludge storage tank	Very low	Tank covered, process monitored and regularly maintained – uncontrolled release of bioaerosols very unlikely
	Liquor balancing tanks	Very low	Tanks covered, process monitored and regularly maintained – uncontrolled release of bioaerosols very unlikely
	Anaerobic digester	Very low	Digester covered, odour controlled, process monitored and regularly maintained – uncontrolled release of bioaerosols very unlikely
	Post digestion storage tank	Very low	Tank covered, process monitored and regularly maintained – uncontrolled release of bioaerosols very unlikely
	Alternative sludge storage tank	Very low	Tank covered, regularly maintained and only used infrequently, during emergencies – uncontrolled release of bioaerosols very unlikely
	Centrifuge building	Very low	All processes within the building are covered, process monitored and regularly maintained – uncontrolled release of bioaerosols very unlikely
	Cake bays	Very low	While uncovered, cake within bays at the end of treatment process so bioaerosol concentrations would be very low/de minimis (any exposure would not result in “significant” consequences). Minimal disturbance of cake while in bays and, if required, restricted to non-windy days.
Biogas combustion	Biogas holder	Very low	Gas holder sealed to prevent uncontrolled release of bioaerosols – uncontrolled release of bioaerosols very unlikely
	Boilers	Very low	Combustion of biogas at very high temperatures which would destroy bioaerosols – uncontrolled release of bioaerosols very unlikely
	Flare	Very low	Combustion of biogas at very high temperatures which would destroy bioaerosols – uncontrolled release of bioaerosols very unlikely
	CHP	Very low	Combustion of biogas at very high temperatures which would destroy bioaerosols – uncontrolled release of bioaerosols very unlikely

5.3 Consequence of hazard

While the probability of exposure of receptors to bioaerosols is ‘very low’ as a result of the control measures in place or the nature of processes on Site, there is still a risk that nearby receptors could be exposed to bioaerosols, for example while cake was being loaded into lorries or if there was a failure of the control equipment. Should this occur, any exposure to bioaerosols would likely be temporary, any fault would be detected by the SCADA system and the emergency protocols would be undertaken to rectify the fault as soon as possible.

However, if exposure to bioaerosols did occur, this could result in adverse health impacts at sensitive receptors. These impacts could include (but are not limited to):

- Respiratory infections and inflammation of the respiratory system
- Reduced lung function

- Allergic reactions
- Gastro-intestinal disorders
- Dermatitis
- Eye irritation

The consequence of the hazard at sensitive receptors (i.e. the severity of impacts on human health) is largely determined by the proximity of the receptor to the emission source; concentrations of bioaerosols decline rapidly within the first 50-100m from a source (and generally decrease to background concentrations within 250m) [17,18]. Therefore, receptors within 100m of bioaerosol emission sources will experience a greater hazard consequence than those more than 100m from the emission source.

For the purpose of this assessment, receptors within 50m of bioaerosol sources and downwind of the prevailing wind direction are considered to be '**high**' consequence of hazard. This is because within 50m of a source, consequences could be "severe", and "exposure may result in significant damage", being downwind of the prevailing wind direction also increases the likelihood of exposure. Receptors within 50m of bioaerosols that are upwind of the prevailing wind direction are considered to have a '**medium**' consequence of hazard, as though they are in close proximity to a bioaerosol source, they are less likely to be exposed due to the prevailing wind direction.

Sources of bioaerosols within 50-100m of receptors are considered to have a '**medium**' consequence of hazard. This is because within 50-100m of the source, concentrations of bioaerosols would reduce, so temporary exposure could result in "significant consequences" and potentially result in "damage that is not severe and is reversible". Beyond 100m, up to 250m, the consequence of the hazard is considered to be '**low**' as concentrations of bioaerosols would be lower so the consequence of the hazard would also be lower, resulting in "minor consequences" where damage is "not apparent, reversible adverse changes possible". Beyond 250m, the consequence is considered '**very low**' as concentrations of bioaerosols generally decrease to background concentrations at this distance so there would be "no evidence for adverse changes" at sensitive receptors at this distance. Beyond 500m, the consequence is not applicable (n/a).

The final consequence of hazard assessed for each emission source is presented below in Table 5.2. Across all potential bioaerosol emission sources at the Site, the consequence of hazard is '**low**' to '**medium**'.

Table 5.2: Consequence of hazard from bioaerosols at the Site

Source process	Potential source of bioaerosols	Nearest receptor	Consequence of hazard	Justification
Sludge reception and distribution	Tankered sludge unloading area	Residential area (southwest of Site) – 110m southwest	Low	Nearest receptor <250m from potential source, not downwind of the prevailing wind direction
Sludge treatment	Post screening storage tanks	Industrial estate (north of	Low	Nearest receptor <250m from potential source, not downwind

[17] Environment Agency. 2011. Composting and potential health effects from bioaerosols: our interim guidance for permit applicants. Regulatory Position Statement 031.

[18] Health and Safety Executive, 2010. Bioaerosol emissions from waste composting and the potential for workers' exposure.

Source process	Potential source of bioaerosols	Nearest receptor	Consequence of hazard	Justification
		Site) – 110m north		of the prevailing wind direction
	Imported sludge storage tank	Residential area (southwest of Site) – 105m southwest	Low	Nearest receptor <250m from potential source, not downwind of the prevailing wind direction
	Drum thickener building	Industrial estate (north of Site) – 115m northeast	Low	Nearest receptor <250m from potential source, not downwind of the prevailing wind direction
	Thickened sludge storage tank	Industrial estate (north of Site) – 95m north	Medium	Nearest receptor <100m from potential source, not downwind of the prevailing wind direction
	Liquor balancing tanks	Residential area (southwest of Site) – 130m southwest	Low	Nearest receptor <250m from potential source, not downwind of the prevailing wind direction
	Anaerobic digester	Industrial estate (north of Site) – 135m northwest	Low	Nearest receptor <250m from potential source, not downwind of the prevailing wind direction
	Post digestion storage tank	Residential area (southwest of Site) – 140m southwest	Low	Nearest receptor <250m from potential source, not downwind of the prevailing wind direction
	Alternative sludge storage tank	Industrial estate (north of Site) – 110m northwest	Low	Nearest receptor <250m from potential source, not downwind of the prevailing wind direction
	Centrifuge building	Residential area (southwest of Site) – 115m southwest	Low	Nearest receptor <250m from potential source, not downwind of the prevailing wind direction
	Cake bays	Residential area (southwest of Site) – 60m southwest	Medium	Nearest receptor <100m from potential source, not downwind of the prevailing wind direction
	Biogas holder	Industrial estate	Low	Nearest receptor <250m from potential

Source process	Potential source of bioaerosols	Nearest receptor	Consequence of hazard	Justification
Biogas combustion		(north of Site) – 135m northwest		source, not downwind of the prevailing wind direction
	Boilers	Industrial estate (north of Site) – 120m northwest	Low	Nearest receptor <250m from potential source, not downwind of the prevailing wind direction
	Flare	Industrial estate (northeast of Site) – 100m northeast	Medium	Nearest receptor <100m from potential source, downwind of the prevailing wind direction but screened by trees that could inhibit the pathway
	CHP	Residential area (southwest of Site) – 140m southwest	Low	Nearest receptor <250m from potential source, not downwind of the prevailing wind direction

5.4 Magnitude of risk

Table 5.3 below summarises the probability of exposure, consequence of hazard and resulting magnitude of risk for each potential bioaerosol emission source at the Site. Across all sources, there is a ‘very low’ probability of exposure due to the nature of the processes and control measures in place which would prevent uncontrolled releases of bioaerosols. The consequence of hazard is described as ‘low’ or ‘medium’ depending on the proximity of the potential emission source to a sensitive receptor.

In accordance with Environment Agency guidance[19], across all potential bioaerosol emission sources, the magnitude of risk is described as ‘**low**. Therefore, based on the maximum level of risk assessed, operation of the Site is unlikely to lead to significant impacts at nearby sensitive receptors from bioaerosol emissions.

Nonetheless, due to the proximity of the Site to sensitive receptors, monitoring of bioaerosols should be undertaken at the Site[20]. The requirements for bioaerosol monitoring at the Site will need to be agreed with the Environment Agency within the Environmental Permit issued for the Site.

[19] Drew, G.H., Deacon, L.J., Pankhurst, L., Pollard, S.J.T. and Tyrrel, S.F. (2009). Guidance on the evaluation of bioaerosol risk assessments for composting facilities. Environment Agency.

[20] Environment Agency (2018) Bioaerosol monitoring at regulated facilities - use of M9: RPS 209. Available online at: https://www.gov.uk/government/publications/bioaerosol-monitoring-at-regulated-facilities-use-of-m9-rps-209/bioaerosol-monitoring-at-regulated-facilities-use-of-m9-rps-209

Table 5.3: Magnitude of risk from bioaerosols at the Site

Process	Potential source of bioaerosols	Probability of exposure	Consequence of Hazard	Magnitude of risk	Justification
Sludge reception and distribution	Tankered sludge unloading area	Very low	Low	Low	Stringent loading and unloading procedures – uncontrolled release of bioaerosols very unlikely. Nearest receptor <250m from potential source, not downwind of the prevailing wind direction
Sludge treatment	Post screening storage tanks	Very low	Low	Low	Tanks covered, process monitored and regularly maintained – uncontrolled release of bioaerosols very unlikely. Nearest receptor <250m from potential source, not downwind of the prevailing wind direction
	Imported sludge storage tank	Very low	Low	Low	Tank covered, process monitored and regularly maintained – uncontrolled release of bioaerosols very unlikely. Nearest receptor <250m from potential source, not downwind of the prevailing wind direction
	Drum thickener building	Very low	Low	Low	All processes within the building are covered, process monitored and regularly maintained. Building connected to OCU and the air released from the unit has been treated to remove bioaerosols, process monitored and regularly maintained – uncontrolled

Process	Potential source of bioaerosols	Probability of exposure	Consequence of Hazard	Magnitude of risk	Justification
					release of bioaerosols very unlikely. Nearest receptor <250m from potential source, not downwind of the prevailing wind direction
	Thickened sludge storage tank	Very low	Medium	Low	Tank covered, process monitored and regularly maintained – uncontrolled release of bioaerosols very unlikely. Nearest receptor <100m from potential source, not downwind of the prevailing wind direction
	Liquor balancing tanks	Very low	Low	Low	Tanks covered, process monitored and regularly maintained – uncontrolled release of bioaerosols very unlikely. Nearest receptor <250m from potential source, not downwind of the prevailing wind direction
	Anaerobic digester	Very low	Low	Low	Digester covered, odour controlled, process monitored and regularly maintained – uncontrolled release of bioaerosols very unlikely. Nearest receptor <250m from potential source, not downwind of the prevailing wind direction
	Post digestion storage tank	Very low	Low	Low	Tank covered, process monitored and regularly maintained – uncontrolled release of

Process	Potential source of bioaerosols	Probability of exposure	Consequence of Hazard	Magnitude of risk	Justification
					bioaerosols very unlikely. Nearest receptor <250m from potential source, not downwind of the prevailing wind direction
	Alternative sludge storage tank	Very low	Low	Low	Tank covered, process monitored and regularly maintained – uncontrolled release of bioaerosols very unlikely. Nearest receptor <250m from potential source, not downwind of the prevailing wind direction
	Centrifuge building	Very low	Low	Low	All processes within the building are covered, process monitored and regularly maintained.– uncontrolled release of bioaerosols very unlikely. Nearest receptor <250m from potential source, not downwind of the prevailing wind direction
	Cake bays	Very low	Medium	Low	While uncovered, cake within bays at the end of treatment process so bioaerosol concentrations would be very low/de minimis (any exposure would not result in “significant” consequences). Minimal disturbance of cake while in bays and, if required, restricted to non-windy days.. Nearest receptor <100m from potential source, not downwind of

Process	Potential source of bioaerosols	Probability of exposure	Consequence of Hazard	Magnitude of risk	Justification
					the prevailing wind direction
Biogas combustion	Biogas holder	Very low	Low	Low	Gas holder sealed to prevent uncontrolled release of bioaerosols – uncontrolled release of bioaerosols very unlikely. Nearest receptor <250m from potential source, not downwind of the prevailing wind direction
	Boilers	Very low	Low	Low	Combustion of biogas at very high temperatures which would destroy bioaerosols – uncontrolled release of bioaerosols very unlikely. Nearest receptor <250m from potential source, not downwind of the prevailing wind direction
	Flare	Very low	Medium	Low	Combustion of biogas at very high temperatures which would destroy bioaerosols – uncontrolled release of bioaerosols very unlikely. Nearest receptor <100m from potential source, downwind of the prevailing wind direction but screened by trees that could inhibit the pathway
	CHP	Very low	Low	Low	Combustion of biogas at very high temperatures which would destroy bioaerosols – uncontrolled release of bioaerosols very unlikely. Nearest

Process	Potential source of bioaerosols	Probability of exposure	Consequence of Hazard	Magnitude of risk	Justification
					receptor <100m from potential source, not downwind of the prevailing wind direction

6 Summary

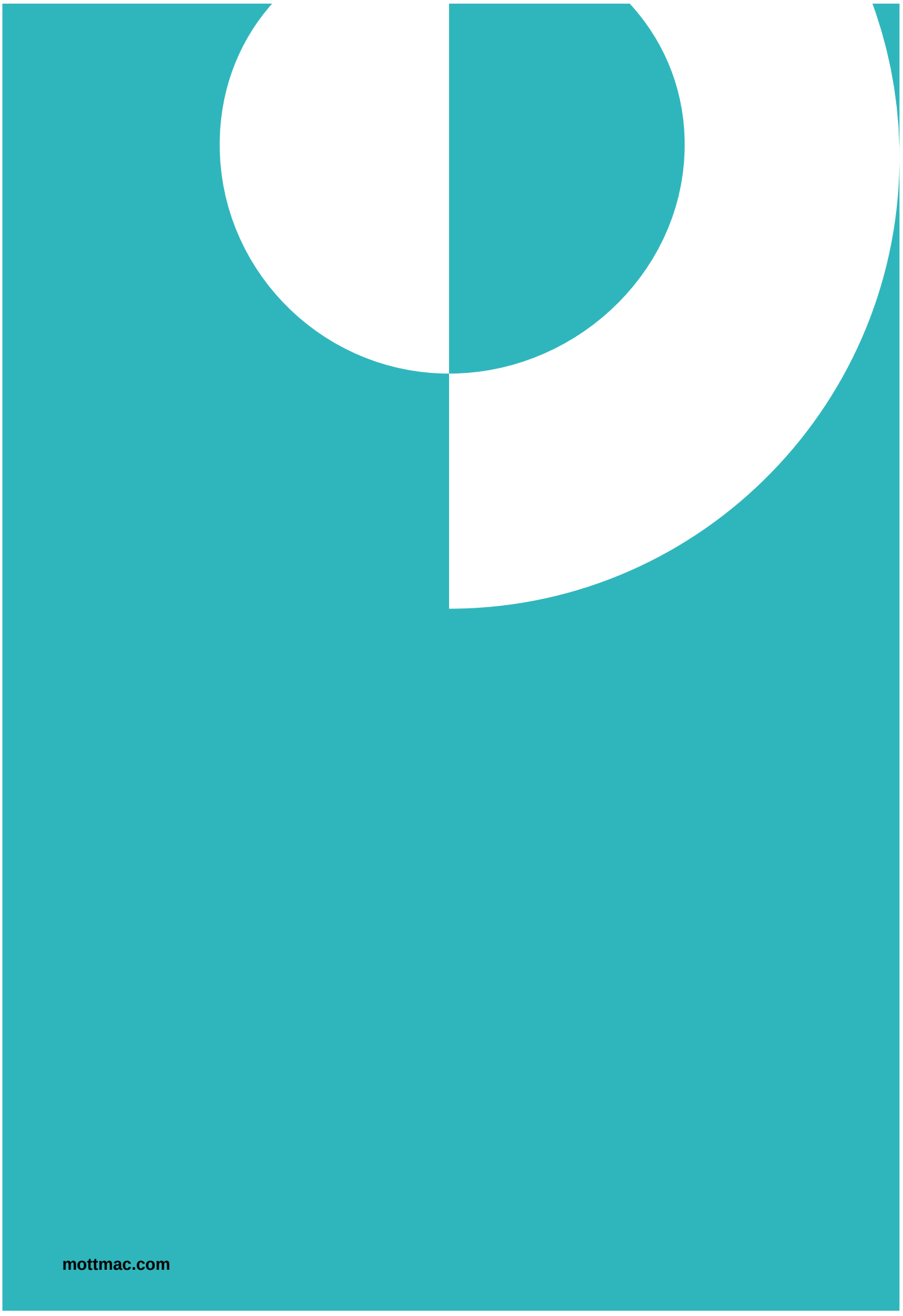
At the Site, there is the potential for bioaerosol emissions from:

- Sludge reception and distribution
- Sludge treatment (sludge storage, thickening, digester, centrifuge and cake bays)
- Biogas combustion

Bioaerosol emissions associated with these processes could be transported by the wind to nearby sensitive human health receptors bordering the Site, resulting in adverse health effects. As these sensitive human health receptors are within 250m of potential emission sources at the Site, a bioaerosol risk assessment has been undertaken in accordance with Environment Agency guidance. However, based on comments from the Environment Agency on a bioaerosol risk assessment undertaken for another similar STC, a conservative approach has been undertaken and human receptors within 500m of the Site have been considered instead of 250m in the bioaerosol risk assessment.

To inform the assessment, a Source-Pathway-Receptor model was developed and the control measures at the facility to reduce and contain bioaerosol emissions were reviewed. This was undertaken to determine the probability of exposure, consequence of hazard and overall magnitude of risk associated with different processes at the Site.

Based on the ‘very low’ probability of exposure and ‘low’ to ‘medium’ consequence of hazards associated with different processes at the Site, the overall magnitude of the risk associated with bioaerosols emissions from the Site is considered to be ‘low’. This is primarily due to the control measures in place at the Site which are considered to be effective at reducing and containing emissions of bioaerosols, inhibiting the pathway between source and receptor.



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