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Wessex Water Services Ltd.

Bioaerosol Risk Assessment:

Avonmouth Wastewater Treatment Works, Avonmouth, Bristol, BS11 0YS

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Produced by Crestwood Environmental Ltd.

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CONTENTS

LIST OF TABLES:

1 INTRODUCTION

1.1 BACKGROUND

1.1.1 Crestwood Environmental Ltd, a firm of environmental consultants based in Wolverhampton, has been commissioned by Wessex Water Services Ltd. ('the Client') to undertake a Bioaerosol Risk Assessment in relation sludge and food waste treatment activities within permitted areas of Avonmouth Wastewater Treatment Works (WwTW) ('the Site') in Avonmouth, BS11 0YS.

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

1.1.3 The purpose of this Bioaerosol Risk Assessment is to:

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

1.2 SITE LOCATION AND CONTEXT

1.2.1 Avonmouth WwTW is located on land off Kings Weston Lane, Avonmouth, at approximate National Grid Reference (NGR): 353355, 179395. Reference should be made to Figure 1 for a map of the Site and surrounding area.

1.2.2 The WwTW includes Avonmouth Renewable Energy Park (REP) and Avonmouth Bioresources Centre (BC).

1.2.3 Avonmouth REP receives food wastes which are delivered to the Site in Heavy Goods Vehicles (HGVs) and road tankers. The materials are then processed within an Anaerobic Digestion (AD) plant to produce biogas which is combusted using a Combined Heat and Power (CHP) unit in order to generate electricity and heat for use on site. A proportion of the biogas is also upgraded for injection into the national grid.

1.2.4 Avonmouth BC treats indigenous sewage sludges arising from processes at the WwTW, as well as materials untreated sewage sludges generated by smaller Wessex Water 'satellite' works. Operations include reception and screening of sludges following by processing within an AD plant in order to generate biogas for combustion within a CHP unit upgrade prior to injection into the national grid.

1.2.5 The operation of Avonmouth REP and BC may result in bioaerosol emissions from a number of activities. Operations from both sites have the potential to cause impacts at sensitive locations within the vicinity of the Site and have therefore been assessed within this report.

1.2.6 Because the activities of the Avonmouth REP and BC are so closely aligned with each other, a single assessment has been completed to support both activities. The bioaerosol risk assessment presented as Section 6 of this report does however present individual risk assessments for both the Avonmouth REP and BC, and the bioaerosol sources from each are also considered separately in Section 4.

2 PROCESS DESCRIPTION

2.1 INTRODUCTION

2.1.1 A summary of operations undertaken at Avonmouth REP and BC is provided in the following Sections. Reference should be made to Figure 2 and Figure 3 for layout plans of both facilities.

2.2 AVONMOUTH RENEWABLE ENERGY SITE

2.2.1 A summary of operations at Avonmouth REP is provided in the following Sections:

WASTE RECEPTION AND SEPARATION

2.2.2 Waste is delivered to facility using a variety of vehicles. On arrival these are weighed, logged and then directed to the biowaste reception hall. Access to the building is provided by fast acting doors which are activated by the hall operator in response to signals from delivery drivers.

2.2.3 Delivery vehicles reverse into the building. The fast-acting doors then close to contain the reception area. Once contained, the drivers tip the loads onto the reception hall floor, wash the vehicle wheels and surrounding areas, and then exit via the fast-acting doors.

2.2.4 Delivered waste is pushed by the reception area operator using a dedicated front-end loader into a pile using 'push walls'. The waste is then loaded into a fixed shredder within the reception area where it is macerated.

2.2.5 Liquid generated by wet materials within the reception area and shredder drains via enclosed conduits into a sump and is then pumped to the buffer tank feed sump via the rotary drum screen, which is located within the separation area and provides contaminant removal. The liquid is then pumped to the hydrolysis tank. Wash down water generated by clean down operations within the reception hall is collected in the same manner.

2.2.6 Plastics/ contaminants removed by the screen are transferred back to the reception area where they drop directly into a hopper which feeds to a hammer mill to provide further organics recovery. The organics are contained in a thick slurry which is conveyed by gravity to the sump to join the other liquid stream prior to transfer to the hydrolysis buffer tank.

2.2.7 The plastics and other contaminants separated by the hammer mill are squeezed in a press to recover more liquid which is captured. The residual contaminants are then loaded into a skip for removal from the Site and subsequent energy recovery at other facilities.

2.2.8 Air is extracted from the reception building using mechanical ventilation and transferred to an Odour Control Unit (OCU) for treatment prior to discharge to atmosphere. The reception area is partitioned from the separation area by a dividing wall. This allows general extraction from the reception area at a rate equivalent to 2 air changes per hour (ac/hr) for improved emission control.

WASTE MIXING

2.2.9 The waste mixing area contains process equipment designed to mix organic material prior to AD and to dilute it to level suitable for discharge to the screening step. Packaging, contaminants and oversize materials are screened out and discharged to the hammer mill in the waste reception area, as described above. The liquors are discharged into the foul drainage system and then transferred to the internal pumping station prior to return to the head of the WwTW for treatment.

2.2.10 Material from the reception area is fed into a fixed shredder where it is reduced in size to <50mm. Shredded material is then transferred to a surge hopper with sufficient storage capacity for a turbo-dissolver mix batch. The discharge from the hopper feeds to a double shaft-less screw conveyor and from this point on, all processing equipment is enclosed with only manual inspection hatches within the separation area.

2.2.11 Shredded material is conveyed to 2 number turbo-dissolver mixers which operate on a batch system. The dissolvers liquefy the organic material reducing particle size, whilst leaving packaging, hard inorganic particles and root vegetables unaffected. Each dissolver has a working capacity of $8m^3$ and a nominal hydraulic retention time of 20-minutes.

2.2.12 Material delivered to the waste reception hall has a typical dry matter content of 20% - 40% dry solids, whilst the anaerobic digesters operate with a feed solids concentration of 12%. To achieve this, liquid food waste, potable water and centrate (limited to a maximum of 50% of volume required) is added to the dissolvers and mixed with the raw material. Addition of feed dry solids and liquids is controlled by a Programmable Logic Controller (PLC) via a configurable menu.

2.2.13 The mixture of solid/liquid biowaste and final effluent is blended for 10 to 20-minutes and then discharged via actuated valves to a rotary drum screen. This removes contamination larger than 10mm which is then de-watered using a screw compactor.

2.2.14 The remaining contaminants are discharged back to the hammer mill within the reception area which reprocesses the material to recover further organic material through a screen. Following hammer mill treatment, the remaining contaminants are compacted and then loaded into skips for removal from the Site and disposal at an energy recovery facility.

2.2.15 The organic slurry from the dissolvers flows from the fine rotary drum screen via gravity to the buffer tank feed sump within the separation hall and is joined by the recovered slurry from the hammer mill. From here it is pumped to the hydrolysis buffer tank.

FOOD WASTE LIQUID TANK

2.2.16 Liquid wastes are delivered by tanker into an above ground storage tank. The tank is made from epoxy coated steel with a Glass Reinforced Plastic (GRP) roof and is vented to atmosphere. Material within the tank is mixed using a chopper-pump system to maintain solids in suspension.

2.2.17 Slurry is pumped from the reception tank to the turbo dissolvers using a positive displacement system. Addition of slurry to the system is controlled by the PLC via a configurable menu.

HYDROLYSIS BUFFER TANK

2.2.18 Slurry from the separation building is transferred to the hydrolysis buffer tank via duty/standby pumps. The tank has a working volume of $800m^3$ and acts as a buffer between the intermittently working reception and separation halls and the continuously operating AD plant. Material within the vessel is mixed continuously using an external pump recirculation system in order to reduce settlement of solids. Air is extracted from the hydrolysis tank and transferred to the OCU for treatment prior to discharge to atmosphere.

2.2.19 Condensate from the biogas pipework (connected to the pasteurisers) is collected in a vessel at the lowest point by gravity and then returned to the hydrolysis buffer tank using a positive displacement pump.

PASTEURISATION SYSTEM

2.2.20 Slurry is transferred from the hydrolysis buffer tank to the pasteurisation plant at a rate of approximately $10m^3$/hr. The material is initially pumped via a heat exchanger which raises the temperature from 30°C to 50°C through recovery from the hot pasteurised sludge. Pasteurisation then takes place in 3 parallel tanks each with a maximum working volume of $15m^3$. At any one time, one tank is filling and being heated to 70°C, one tank is holding at 70°C to ensure pathogen kill and one tank is emptying. This approach allows a continuous feed in and a continuous feed out whilst providing the 1-hour batch hold time required by the Animal By-Products Regulations for Category 3 material.

2.2.21 Hot pasteurised sludge is pumped from the plant via a heat recovery exchanger where the temperature is reduced from 70°C to 50°C and then transferred to the AD plant. Heat exchange is via a sludge/water/sludge unit with detachable bends on the slurry side for ease of cleaning.

2.2.22 The pasteurisation tanks are externally mixed and incorporate at least 3 temperature transmitters and a level transducer per vessel. Each batch treated is logged for time and temperature to monitor Hazard Analysis Critical Control Point (HACCP) compliance.

2.2.23 The biogas pipework connected to the pasteurisers is fitted with a relief valve to protect the vessels and biogas train against excessively high or low pressures, which could occur under abnormal fault conditions. This is a safety device and should not operate under normal working scenarios. However, under abnormal conditions the valve is designed to release biogas to atmosphere.

ANAEROBIC DIGESTION

2.2.24 Pasteurised slurry is pumped in turn to one of two anaerobic digesters via the heat recovery exchanger and discharged through a limpet-box weir arrangement.

2.2.25 The anaerobic digesters convert organic material to biogas, which comprises methane (CH_4) and carbon dioxide (CO_2), through the fermentation of organic material in the absence of oxygen. The minimum retention time of the digesters is over 18-days and biogas is collected within the roof spaces of the vessels which are connected to the gas line.

2.2.26 Digested slurry is displaced by gravity overflow from the digesters via the existing weir on the limpet-box which acts as a siphon break in the event of a down-stream pipe fracture. The slurry is then transferred via duty/standby pumps to the post digestion storage tank.

DEWATERING

2.2.27 Digested slurry is pumped from the post digestion tank to the dewatering centrifuge where polymer is added, and solids are reduced to approximately 25% dry solids. The centrifuges are located indoors within the processing building and digested solid material falls by gravity into the cake storage bay where it is captured in open skips. The storage area is designed to hold 1-days' worth of digested cake and is connected to the odour control system to allow direct extraction and treatment of air prior to discharge to atmosphere.

2.2.28 Liquor from the dewatering process gravitates from the centrate tank overflow to the head of the WwTW for further treatment.

GAS HOLDER

2.2.29 There are two double membrane gas holders at the Site and these act as storage for the biogas produced by the REP and BC.

2.2.30 Firstly, the gas holders are a safety device acting as a volume buffer to the digester and pasteuriser tanks. When liquid is pumped out of one of the tanks, the gas holders supply biogas to replace the lost volume hence maintaining system pressure. Similarly, when biogas is produced within the digesters the gas holders act as a storage volume preventing an increase in pressure.

2.2.31 Secondly the gas holders act as a buffer for biogas production and use. The CHP plant uses biogas at a fixed rate of approximately 500m^3/hr per engine. However, production within the digesters can vary widely. The gas holders act as a buffer to allow the CHP plant to operate at a constant rate with varying gas production.

2.2.32 The gas holders also act as the pressure regulating device in the system. Air is blown into an outside bag which surrounds the inner membrane. The outlet is restricted by a valve to create a constant air pressure in the outer bag, typically 20 – 25mbarg, and this in turn regulates the gas to the same pressure. By maintaining the gas at a positive pressure at all times, the risk of oxygen being drawn into the gas system from a leak or relief valve is eliminated and hence the potential for an explosive mixture of methane and air forming within the plant is reduced.

2.2.33 The gas holders are fitted with pressure and vacuum relief valves that protect the units against excessively high or low pressures which could occur under abnormal fault conditions. These are safety devices and do not operate under normal working conditions. However, under abnormal operating scenarios, the valves are designed to release biogas to atmosphere.

COMBINED HEAT AND POWER PLANT

2.2.34 The CHP units are generators which convert biogas into heat and power. Electricity is generated from the combustion of biogas with air and heat is recovered from the cooling jacket, oil lubrication system and flue gas into a common hot and cold header. The CHP supplies heat to all digesters on site: 2 AD digesters for Avonmouth REP and the 8 digesters and 6 acid phase digesters for the Avonmouth BC. This supplies heat to 8 number AD tanks and the acid phase digestion system which feeds into 8 of the 10 digesters. Hot water for the pasteurisation system is taken from the circuit in such a way that the existing plant on site is not disrupted or starved of heat.

2.2.35 The steam plant and drier on site are not in use and are disconnected from all treatment processes at Avonmouth.

GAS TO GRID

2.2.36 The Gas to Grid plant is connected to the digestion systems on site at the digester stages which allows gas to flow to the holders or to the Malmberg upgrading plant. The volume of biogas that enters the plant is controlled by one of two blowers that operate as duty/assist. These units increase the pressure to 0.78bar. Moisture is then removed, and the gas cooled.

2.2.37 The biogas is compressed using one of four dedicated units causing the temperature to rise to 78°C. The gas is then cooled to 8.4°C and fed into the absorption column which is held at 6.10bar pressure and filled with plastic media in order to allow water to flow from the top to the bottom at a rate of 0.16m^3/m^3bio-gas/hr. The gas is introduced at the bottom, so it has an opposing flow to the water. The water 'scrubs' the gas of all undesirable compounds such as hydrogen sulphide (H_2S) and CO_2, leaving a high concentration bio-methane.

2.2.38 The bio-methane is vented at the top of the column for further treatment. The contaminated water passes through a column where the pressure is reduced to 1.14bar which causes any trapped CH_4 to be 'flashed' out as a gas and returned to the top for further treatment.

2.2.39 The final process is the desorption column which is maintained at atmospheric pressure and used to remove all remaining undesirable compounds from the contaminated water so it can be recycled. The water flows from the top over plastic media and collects at the bottom ready for reuse. As the water falls, an opposing air flow is forced up from the bottom causing the release of CO_2, H_2S and any other contaminants. The waste gas is vented to atmosphere via an abatement system.

2.2.40 Bio-methane vented from the top of the absorption and flash columns is combined and transferred through two carbon filters which can be set to run in series, parallel or as singular modules.

2.2.41 In line with national grid injection regulations, the calorific value (CV) of the gas must be increased from 36.09Mj/m to 39.0Mj/m. This is achieved by injecting propane into the bio-methane stream. Once the gas has reached the correct CV, an odourant is added and it is injected to the grid through a fiscal meter.

2.3 AVONMOUTH BIORESOURCES CENTRE

2.3.1 Sludge from the primary sedimentation tanks located at the wider WwTW flows from an internal pumping station into the raw strain press feed sump. It is then processed through the primary sludge strain presses which remove any residual rags.

2.3.2 The strained sludge is delivered to two pumping stations. At present both sumps are connected together by a penstock between them.

2.3.3 Imported sludges from satellite sites across the Wessex Water area are transported by road tanker and discharged into a reception tank. The sludge is then transferred to the strain presses and subsequently to the internal pumping station. This includes 2 sets of pumps that are used to send the strained sludge for further treatment within the installation area.

2.3.4 Should the raw strain press feed sump go into high level, there is a bypass arrangement that allows sludge from the primary tanks to flow into the strained sump. The purpose of this is to prevent build-up of solids in the primary tanks and prevent deterioration in the performance of the WwTW.

2.3.5 The strained sludge pumping station delivers material at approximately 1.5% dry solids content to the Acid Phase Digestion (APD) Gravity Belt Thickeners (GBTs) 1, 2 and 3. The sludge is then thickened to around 5-6% dry solids and pumped to the APD feed tank where it is mixed with thickened Surplus Activated Sludge (SAS) from the Sequencing Batch Reactor (SBR) wastewater process.

2.3.6 The strained sludge pumping station can also deliver material with a dry solids content of approximately 1.5% dry solids to the two Avonmouth consolidation tanks. These are used to thicken the sludge to around 2.5% dry solids prior to transfer to the Bellmer feed tank. The material is then pumped to the Bellmer GBTs which further thicken the sludge to around 5-6% dry solids before transfer to the APD feed tank.

2.3.7 Sludge from the feed tank is heated to 33.5°C using a hot water/sludge heat exchanger and then batch fed through a series of 6 insulated stainless steel covered tanks which forming the APD process. The sludge is mixed and sequentially transferred between the tanks using compressors.

2.3.8 The APD sludge is sent to 8 concrete Mesophilic Anaerobic Digestion (MAD) tanks which include dedicated mixing pumps. All digesters feature fixed roofs, a sludge fill & spill withdrawal system, a heating/recirculation system, biogas mixing compressors, pressure/vacuum relief valves, gas flow meters and biogas pipework.

2.3.9 Biogas from the digesters can either be used as fuel for the CHP units or upgraded for injection into the national grid depending on site requirements. The primary source of biogas consumption is the gas to grid process.

2.3.10 Digested sludge is transferred to the Secondary Sludge Storage Tanks (SSSTs). These provide 1-day retention of material prior to dewatering. Compliant digested sludge from the SSSTs is transferred to the centrifuge feed sludge tank where it is dewatered producing a sludge cake at 25% dry solids content. The cake is discharged by conveyor into trailers and transported to lorry skips for removal off site.

2.3.11 Due to the loss of embedded dewatering equipment at the Site, three temporary dewatering rigs have been hired on site to allow processing at the required capacity. Sludge cake generated is initially added to trailers on site and is transported and transferred to lorry skips. The liquors are discharged into the foul drainage system and transferred to the internal pumping station prior to return to the head of the WwTW for treatment.

2.3.12 All other liquors from the various thickening/dewatering processes are returned to the internal pumping station via the site foul water drainage network and transferred back to the head of the works.

3 BIOAEROSOL BACKGROUND

3.1 BIOAEROSOL DEFINITION

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

3.1.2 Although bioaerosols are ubiquitous, operations involving organic materials provide environments conducive to their growth. Bioaerosols are therefore likely to be associated with sludge and liquor treatment activities, in particular, operations which result in the agitation of materials and the associated release of microorganisms into the air.

3.2 HEALTH RISKS FROM BIOAEROSOLS

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

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

3.3 BIOAEROSOL EMISSIONS FROM WASTE MANAGEMENT OPERATIONS

3.3.1 Most scientific research on bioaerosol emissions from waste management operations focusses on open windrow and In-Vessel Composting (IVC) systems. It is recognised that there are fundamental differences between composting and food waste/sludge treatment processes. However, the research has been used to the inform regulatory requirements for biological waste treatment facilities and therefore a review of relevant literature has been undertaken in order to inform the assessment. The findings are detailed in the following Section.

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

3.3.3 The ADAS report 'Bioaerosol Monitoring and Dispersal from Composting Sites'[3] provides a summary of the findings from measurement work undertaken at three composting sites. Sampling for bioaerosols was undertaken downwind of a wide range of composting activities including

1 Guidance on the evaluation of bioaerosol risk assessments for composting facilities, EA, undated.
2 Health Effects of Composting - A Study of Three Compost Sites and Review of Past Data, EA, 2001.
3 Bioaerosol Monitoring and Dispersal from Composting Sites, ADAS, 2005.

shredding, turning, loading, unloading and screening. The results indicated that 91% of all micro-organisms sampled across all three sites were below 1,000cfu/m^3 at a downwind distance of 125m.

3.3.4 The Scotland and Northern Ireland Forum for Environmental Research (SNIFFER) report 'Measurement and Modelling of Emissions from Three Composting Sites'[4] provides a summary of the findings from monitoring work undertaken at three composting sites, which included two IVC facilities and one open windrow system. The findings indicated that there is the potential for seasonal variation in ambient concentrations of the mould of Aspergillus fumigatus, with concentrations being the highest in the autumn. In most cases, levels of all bioaerosols assessed were at or below background equivalent concentrations within 250m of the sources assessed.

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

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

3.4 BIOAEROSOL EMISSIONS FROM WASTEWATER TREATMENT PROCESSES

3.4.1 A review of relevant scientific research and industry guidance on bioaerosol emissions from wastewater treatment operations has also been undertaken in order to inform the assessment. The findings are detailed in the following Section.

3.4.2 The Indian Institute of Science report 'Gaseous and bioaerosol emissions from municipal wastewater treatment plants'[6] concludes that WwTW are identified as potential emission sources of bioaerosols, and the most significant releases are likely to occur as a result of Activated Sludge Processes (ASPs).

3.4.3 The research report 'Microorganisms in bioaerosol emissions from wastewater treatment plants during summer at a Mediterranean site'[7] provides a summary of the findings of measurement work undertaken in the vicinity of a WwTW in order to assess ambient bioaerosol concentrations under intensive solar radiation. Air samples were taken at various stages of the ASPs carried out at the site. Cultivation of viable mesophilic bacteria and fungi colonies collected onto the samples was then undertaken. The findings indicated that the highest concentrations of airborne microorganisms were observed at the aerated grit removal stage of the process. A gradual decrease in bioaerosol emissions was observed during the advanced stages of treatment.

3.4.4 The research report 'Emissions of bacteria and fungi in the air from wastewater treatment plants - a review'[8], confirms that the principal mechanism for transfer of microorganisms from wastewater to the atmosphere is through the entrainment of water droplets. The potential for this process to occur is increased by the movement of materials between treatment areas and agitation as part of forced aeration and sludge thickening. The report indicates that viability of bioaerosols once entrained into the atmosphere is largely governed by meteorological and climatic conditions which can contribute to desiccation and annihilation of microorganisms.

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

4 Measurement and Modelling of Emissions from Three Composting Sites, SNIFFER, 2007.
5 Bioaerosols and odour emissions from composting facilities, DEFRA, 2013.
6 Gaseous and bioaerosol emissions from municipal wastewater treatment plants, Department of Civil Engineering, Indian Institute of Science, 2013.
7 Microorganisms in bioaerosol emissions from wastewater treatment plants during summer at a Mediterranean site, Karra et al, Water Research Volume 41 Issue 6, 2007.
8 Emissions of bacteria and fungi in the air from wastewater treatment plants - a review, Korzeniewska.E, 2011.

3.5 BIOAEROSOL LEGISLATIVE CONTROL

3.5.1 Atmospheric emissions from industry are controlled in the UK through the Environmental Permitting (England and Wales) Regulations (2016) and subsequent amendments. The operation of Avonmouth REP and BC is included within the Regulations. As such, the sites are required to operate in accordance with Environmental Permits issued by the EA.

3.6 ENVIRONMENT AGENCY POLICY

3.6.1 The EA Regulatory Position Statement (RPS) 'Bioaerosol monitoring at regulated facilities - use of M9: RPS 209'[9] outlines the conditions that apply to biological waste treatment facilities in relation to bioaerosol emissions.

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

- Monitor bioaerosols in accordance with EA guidance 'M9: environmental monitoring of bioaerosols at regulated facilities'[10]; and,
- Undertake a site specific Bioaerosol Risk Assessment.

3.6.3 The RPS indicates that existing permit holders have until 31st March 2019 to meet these requirements. Environmental Permits issued after 1st April 2017 must demonstrate compliance with the requirements from the date on the permit.

3.6.4 The conditions outlined within the RPS have been considered as appropriate throughout the assessment.

3.7 BENCHMARK LEVELS

3.7.1 The EA have adopted a precautionary risk-based approach in determining guidance levels for bioaerosols. The EA position statement 'Composting and potential health effects from bioaerosols: our interim guidance for permit applicants'[11] specifies the following criteria for acceptable concentrations of Aspergillus fumigatus and total bacteria at sensitive receptor locations:

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

3.8 BEST PRACTICE GUIDANCE

3.8.1 The EA guidance 'How to comply with your environmental permit. Additional technical guidance for: Anaerobic Digestion'[12] sets out indicative Best Available Technique (BAT) or appropriate measures for the AD of organic materials. The document provides practical guidance on how and why bioaerosol emissions occur, as well as measures that can be employed to prevent or minimise release. The requirements of the guidance have been considered throughout the assessment.

9 Bioaerosol monitoring at regulated facilities - use of M9: RPS 209, EA, 2018.
10 M9: environmental monitoring of bioaerosols at regulated facilities, EA, 2017.
11 Composting and potential health effects from bioaerosols: our interim guidance for permit applicants, EA, 2010.
12 How to comply with your environmental permit. Additional technical guidance for: Anaerobic Digestion, EA, 2013.

4 PROBLEM DEFINITION

4.1 INTRODUCTION

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

4.1.2 The EA document 'Guidance on the evaluation of bioaerosol risk assessments for composting facilities'[13] indicates that the problem definition should state any limitations, uncertainties and assumptions in order to justify any potential gaps in the appraisal approach. The principal elements for consideration with respect to this assessment are as follows:

- Uncertainties in dispersal due to particle size and aggregation which can affect how far downwind bioaerosols can travel;
- Uncertainties in the bioaerosol emission potential of different sources at the site;
- Uncertainties in bioaerosol dose response relationships; and,
- Variation in sampling procedures and the affect that this has on ambient concentrations measured as part of monitoring campaigns.

4.1.3 The stated elements have been considered and addressed as follows in order to ensure a robust assessment and limit the number of gaps associated with the appraisal:

- Uncertainties in dispersal - The assessment considered the results of Bioaerosol Monitoring undertaken by Crestwood Environmental at Avonmouth WwTW, as shown in Section 4.6. The monitoring was undertaken in order to provide site-specific assessment of baseline conditions and potential impacts at the Nearest Sensitive Receptor (NSR) as a result of emissions from the facility. As such, use of the data is considered to reduce uncertainties associated with bioaerosol dispersal at the site;
- Uncertainties in bioaerosol emission potential - Worst-case assumptions were utilised as appropriate throughout the assessment with respect to the emission potential for different sources at the facility in order to ensure a precautionary appraisal of impact;
- Uncertainties in bioaerosol dose response relationships - A 'medium' harm classification was utilised as part of the assessment. This is considered to represent a worst-case approach as it assumes that there is the potential for significant consequences as a result of emissions from all sources at the site;
- Variation in sampling procedures - The Bioaerosol Monitoring undertaken by Crestwood Environmental was completed in accordance with approved methods specified in EA guidance 'M9: environmental monitoring of bioaerosols at regulated facilities'[14] in order to limit uncertainties associated with sampling techniques.

4.1.4 It is considered that use of the stated measures and worst-case assumptions where necessary has resulted in an assessment accuracy of an acceptable level.

4.2 CONCEPTUAL MODEL

4.2.1 Potential hazards from bioaerosol are summarised in the conceptual model presented in Table 1.

13 Guidance on the evaluation of bioaerosol risk assessments for composting facilities, EA, undated.
14 M9: environmental monitoring of bioaerosols at regulated facilities, EA, 2017.

Table 1   Conceptual Model

Criteria	Comment
Source	Sludges and liquors on the site as outlined in Section 4.3
Hazard	Potential adverse health impacts as outlined in Section 3.2
Transport Mechanism	Airborne
Medium of Exposure	Inhalation, ingestion, absorption, injection
Receptor	Human receptors as outlined in Section 4.4

4.3 SOURCES

4.3.1 A review of operations at Avonmouth REP and BC was undertaken in order identify potential bioaerosol emission sources which required further consideration as part of the assessment.

AVONMOUTH BC

4.3.2 A summary of the relevant sources at Avonmouth BC is provided in Table 2. Reference should be made to Figure 4 for a map of the source locations.

Table 2   Avonmouth BC Bioaerosol Emission Sources

Source	Source Type	Emission Potential and Characteristics
Import sludge tank	Raw sludge imports	The sludge tank is covered. However, there may be the potential for bioaerosol emissions from the vent serving the vessel which expels headspace air to atmosphere during filling
Import strain press (x2) Primary strain press (x3)	Raw sludge	The strain presses are covered. This is likely to contribute to effective containment of bioaerosols. However, there may be the potential for fugitive emissions from the plant
Sludge screening skips	Screenings	The sludge screening skips are open to atmosphere. As such, there may be the potential for diffuse emissions from the surface of materials within the vessels
Internal pumping station	Raw sludge/ sludge liquors	The pumping station is covered. This is likely to contribute to effective containment of bioaerosols. However, there may be the potential for fugitive emissions
SAS GBT (x3)	Secondary aerated sludge	The SAS GBTs are covered and housed within a building. This is likely to contribute to effective containment of bioaerosols. Air is extracted from the building and exhausted to atmosphere via a vent on the side of the structure. This represents a potential bioaerosol emission point source and has therefore been considered further as part of the assessment.
SAS tank (x2)	Secondary aerated sludge	The SAS tanks are covered. However, there may be the potential for bioaerosol emissions from the vents serving the vessels which expel headspace air to atmosphere during filling
Avonmouth consolidation tanks (x 2) (PFT2)	Raw sludge	The tanks are open to atmosphere. As such, there may be the potential for diffuse emissions from the surface of material within the vessel
Bellmer feed tank	Raw sludge	The tank is open to atmosphere. As such, there may be the potential for diffuse emissions from the surface of material within the vessel.

Source	Source Type	Emission Potential and Characteristics
Bellmer GBT (x2)	Raw sludge	The Bellmer GBTs are covered. This is likely to contribute to effective containment of bioaerosols. However, there may be the potential for fugitive emissions
Bellmer thickened sludge tank	Raw sludge	The tank is covered. However, there may be the potential for bioaerosol emissions from the vent serving the vessel which expels headspace air to atmosphere during filling
APD feed tank	Raw sludge	The APD feed tank is covered. However, there may be the potential for bioaerosol emissions from the vent serving the vessel which expels headspace air to atmosphere during filling
Secondary sludge storage tanks (x2)	Digested sludge	The sludge storage tanks are open to atmosphere. As such, there may be the potential for diffuse emissions from the surfaces of materials within the vessels
Raw sludge feed tank to APD GBTs 1, 2 and 3	Raw sludge	The tank is covered. However, there may be the potential for bioaerosol emissions from the vent serving the vessel which expels headspace air to atmosphere during filling
APD GBTs 1, 2 and 3	Raw sludge	The APD GBTs are covered. This is likely to contribute to effective containment of bioaerosols. However, there may be the potential fugitive emissions
Centrifuge feed sludge tank for centrifuge 7 & 8 (can also feed 5&6)	Digested sludge	The centrifuge feed sludge tank is open to atmosphere. As such, there may be the potential for diffuse emissions from the surface of material within the vessel
Centrifuge 7&8	Digested sludge	The centrifuges are contained within acontainer. This is likely to contribute to effective containment of bioaerosols. However, there may be the potential fugitive emissions
Centrifuge No5-No 6 Raw feed	Raw sludge	The tanks are open to atmosphere. As such, there may be the potential for diffuse emissions from the surfaces of material within the vessels
Centrifuge 5 and 6	Raw	The centrifuges are contained within a container. This is likely to contribute to effective containment of bioaerosols. However, there may be the potential fugitive emissions

4.3.1 It should be noted that the APD tanks, digesters and gas holders at the BC are completely enclosed and during normal operation, biogas produced by the AD processes is transferred to the CHPs for combustion or to the upgrade plant to allow injection into the national grid. The BC and biogas system have a backup biogas flare and the REP has a backup biomethane flare; both burn biogas in a controlled manner if the CHP units or upgrade plant stop temporarily e.g. during periods of on-site maintenance.

4.3.2 Should the flares fail for any reason the APD tanks, digesters and gas holders are fitted with emergency release valves to avoid over pressure. These are a necessary safety feature to avoid any possibility of explosion or other damage to the plant.

4.3.3 Any gases released from the pressure release valves are likely to contain bioaerosols due to the nature of housed materials and as a result of the digestion processes. However, releases from these sources are expected to be extremely infrequent and short-term as they would only occur in an emergency. As such, the risk of impact from these emissions is not considered to be significant and releases from the pressure release valves serving the primary digesters or gas holders have not been evaluated further as part of the assessment.

4.3.4 Combustion gases do not contain bioaerosols. As such, releases from CHP units and flare at the Site have not been considered further in the assessment.

AVONMOUTH REP

4.3.5 A summary of the relevant sources at Avonmouth REP is provided in Table 3. Reference should be made to Figure 5 for a map of the source locations.

4.3.6 It should be noted all processes and infrastructure at the Site are contained and served by the Odour Control Unit (OCU) with the exception of the post digestion storage tank and strain presses.

Table 3 Avonmouth REP Bioaerosol Emission Sources

Source	Source Type	Emission Potential and Characteristics
Post digestion storage tank	Digested sludge	The post digestion storage tank is open to atmosphere. As such, there may be the potential for diffuse emissions from the surface of material within the vessel
Strain-presses	Digested sludge	The strain presses are covered. This is likely to contribute to effective containment of bioaerosols. However, there may be the potential fugitive emissions from the plant
OCU serving the waste building which contains the food waste reception hall, food liquid waste tank, food waste pre-treatment, de-packaging and screening skips, hydrolysis buffer tank, pasteurisation tanks, centrifuges, digestate cake skips and centrate tank	Treated air from OCU outlet	Air is extracted from the food waste building and associated plant/ infrastructure contained within the building. The air is air is extracted to a pumice and coir biofilter and the air is vented via a stack. The stated arrangements are likely to contribute to effective containment and control of bioaerosol emissions. However, there may be the potential for residual emissions from the OCU outlet
OCU serving the gas to grid plant	Treated air from OCU outlet	Air is extracted from the gas to grid facility and vented through a biofilter with a polishing granular activated carbon (GAC) unit and air is vented via the stack. The stated arrangements are likely to contribute to effective containment and control of bioaerosol emissions. Due to the presence of the GAC unit, there is very limited potential for residual emissions from this OCU outlet.

4.3.7 Similar to the BC, all digesters and gas holders at the REP are completely enclosed and during normal operation, biogas produced by the AD processes is transferred to the CHPs for combustion or to the upgrade plant to allow injection into the national grid. As stated previously, the BC and biogas system have a backup biogas flare and the REP has a backup biomethane flare; both burn biogas in a controlled manner if the CHP units or upgrade plant stop temporarily e.g., during periods of on-site maintenance.

4.3.8 Should the flares fail for any reason the digesters and gas holders are fitted with emergency release valves to avoid over pressure. These are a necessary safety feature to avoid any possibility of explosion or other damage to the plant.

4.3.9 Any gases released from the pressure release valves are likely to contain bioaerosols due to the nature of housed materials and as a result of the digestion processes. However, releases from these sources are expected to be extremely infrequent and short-term as they would only occur in an emergency situation. As such, the risk of impact from these emissions is not considered to be significant and releases from the pressure release valves serving the digesters or gas holders have not been evaluated further as part of the assessment.

4.3.10 Combustion gases do not contain bioaerosols. As such, releases from CHP units and flare at the Site have not been considered further in the assessment.

4.4 RECEPTORS

4.4.1 EA guidance 'M9: environmental monitoring of bioaerosols at regulated facilities'[15] defines the NSR as follows:

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

4.4.2 A desk-top study was undertaken in order to identify any sensitive locations in the vicinity of the site that required specific consideration during the assessment. In accordance with the EA EPS[16], this focussed on locations within 250m of the facility boundary where people may be present for more than 6-hours at one time. The identified receptors are summarised in Table 4.

Table 4 Sensitive Receptor Locations

Receptor		NGR (m)		Direction from Closest Source	Approximate Distance from Closest Source (m)
		X	Y		
R1	Commercial - TJ Transport	352948.7	179435.6	West	165
R2	Industrial - Avonmouth Household Reuse and Recycling Centre	353342.4	179779.0	North-east	170
R3	Commercial - Culina Chilled Ltd/ Amazon Warehouse	353687.4	179584.9	North-east	210
R4	Commercial - Holleys Fine Foods Ltd	353470.1	179864.6	North-east	300
R5	Commercial - Macfarlane Packaging Bristol	353537.2	179837.3	North-east	320
R6	Commercial - Kuehne & Nagel	353601.4	179787.9	North-east	330
R7	Commercial - Yankee Candle Official	353449.8	179922.5	North-east	350

4.4.3 Reference should be made to Figure 6 for a visual representation of the identified receptors.

4.5 METEOROLOGICAL CONDITIONS

4.5.1 The potential for bioaerosol emissions to impact at sensitive locations depends significantly on the meteorology, particularly wind direction, during release. In order to consider prevailing conditions at the site review of historical weather data was undertaken. Bristol Lulsgate Meteorological Station is located at NGR: 349996, 164986, which is approximately 14km south-west of the site. It is considered that conditions are likely to be reasonably similar over a distance of this magnitude and the information is a suitable source of data for an assessment of this nature.

4.5.2 Meteorological data was obtained from Bristol Lulsgate Meteorological Station over the period 1st January 2017 to 31st December 2021 (inclusive). The frequency of wind from the twelve sectors which best describe the directions which may cause impacts in the vicinity of the site is shown in Table 5. Reference should be made to Figure 7 for a wind rose of the meteorological data.

15 M9: environmental monitoring of bioaerosols at regulated facilities, EA, 2017.190
16 Bioaerosol monitoring at regulated facilities - use of M9: RPS 209, EA, 2018.

Table 5 Wind Frequency Data

Wind Direction (°)	**Frequency of Wind (%)**
345 - 15	3.41
15 - 45	6.87
45 - 75	8.05
75 - 105	6.00
105 - 135	4.94
135 - 165	4.59
165 - 195	8.50
195 - 225	13.13
225 - 255	16.71
255 - 285	18.42
285 - 315	5.00
315 - 345	3.12
Sub-Total	98.73
Calms	0.41
Missing/Incomplete	0.86

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

4.5.4 As shown in Table 5, the prevailing wind direction at the Site is from the south-west. Winds from the north and east are relatively infrequent, which is indicative of conditions throughout the majority of the UK.

4.6 BIOAEROSOL MONITORING DATA

4.6.1 In accordance with the requirements of the EA RPS[17], a programme of Bioaerosol Monitoring has been undertaken at Avonmouth WwTW in order to determine baseline levels and quantity potential impacts at the NSR to the Site as a result of emissions from the REP and BC.

4.6.2 The monitoring was completed by Crestwood Environmental Ltd on 18th September 2022 and included quantification of Aspergillus fumigatus and mesophilic bacteria concentrations at the following locations in accordance with the methods specified in EA guidance 'M9: environmental monitoring of bioaerosols at regulated facilities'[18]:

- Upwind of the facility approximately 120m from the centre of the active operational area; and,
- At three separate downwind locations which were positioned at equivalent or comparable separation distances from the centre of the active operational area to the nearest sensitive receptor and in a fan shape arrangement to account for variation in the emission plume as a result of meteorological conditions throughout the monitoring period.

17 Bioaerosol monitoring at regulated facilities - use of M9: RPS 209, EA, 2018.
18 M9: environmental monitoring of bioaerosols at regulated facilities, EA, 2017.

4.6.3 A summary of the monitoring results is provided in Table 6.

Table 6 Bioaerosol Monitoring Results

Monitoring Location	Distance from Centre of Operational Area (m)	Median Bioaerosol Concentration (cfu/m^3)	
		Aspergillus fumigatus	Mesophilic bacteria
Upwind	120	0	0
Downwind 1	260	0	139
Downwind 2	320	0	0
Downwind 3	310	0	0

4.6.4 As shown in Table 6, median concentrations of Aspergillus fumigatus and mesophilic bacteria were below the respective EA guidance levels of 500cfu/m^3 and 1,000cfu/m^3 at all monitoring locations. This indicates that there is limited potential for emissions from Avonmouth REP, BC, the wider WwTW and other background sources in the immediate vicinity of the Site to contribute to ambient bioaerosol concentrations at sensitive locations.

4.6.5 The results of the monitoring have been considered as appropriate throughout the assessment.

5 RISK ASSESSMENT METHODOLOGY

5.1 OVERVIEW

5.1.1 The Bioaerosol Risk Assessment has been undertaken in accordance with the general principles of EA document 'Guidance on the evaluation of bioaerosol risk assessments for composting facilities'[19]. This included consideration of the following:

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

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

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

5.2 RECEPTOR

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

5.3 PROBABILITY OF EXPOSURE

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

- Distance between source and receptor;
- Dispersion potential of emission;
- Duration of emission; and,
- Frequency of emission.

5.3.2 Probability was categorised in accordance with the following criteria:

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

19 Guidance on the evaluation of bioaerosol risk assessments for composting facilities, EA, undated.

5.4 HARM

5.4.1 The severity of harm from a risk depends on:

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

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

5.4.3 Harm can be described as follows:

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

5.5 MAGNITUDE OF RISK

5.5.1 The level of risk is a combination of:

- How likely a problem is to occur; and,
- How serious the harm might be.

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

5.5.3 Risk was defined based on the interaction between the probability of exposure and potential harm, as outlined in Table 7.

Table 7 Magnitude of Risk

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

5.6 FURTHER REQUIREMENTS

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

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

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

6 RISK ASSESSMENT

6.1.1 The Bioaerosol Risk Assessment for sources at Avonmouth BC is shown in Table 8.

Table 8 Avonmouth BC Risk Assessment

Source	Probability of Exposure	Harm	Magnitude of Risk	Control Measures	Residual Risk	Justification for Residual Risk
Import sludge tank	**Very Low** at all receptors due to the enclosed nature of the source and associated containment of emissions, the wet nature of materials which is likely to limit release potential, the distance between the source and receptors, as well as the frequency of winds towards the locations.	**Medium**	**Low**	The tank is covered in order to provide containment of emissions. Regular inspection of the tank is undertaken by site operatives in order to ensure that it is providing effective containment of materials and emissions. Inspection hatches are kept closed unless in use.	**Very Low**	Full implementation of the stated control measures is considered to result in a **very low** risk of impact occurring
Import strain press (x2) Primary strain press (x3)	**Very Low** at all receptors due to the enclosed nature of the sources and associated containment of emissions, the wet nature of materials processed which is likely to limit release potential, the distance between the sources and receptors, as well as the frequency of winds towards the locations.	**Medium**	**Low**	The strain presses are covered in order to provide containment of emissions. Inspection hatches are kept closed unless in use. Regular inspection of the plant is undertaken by site operatives in order to ensure correct performance and that there is effective containment of materials and emissions.	**Very Low**	Full implementation of the stated control measures is considered to result in a **very low** risk of impact occurring of impact occurring
Sludge screening skips	**Low** at all receptors due to frequent replacement of the skips which limits storage or significant quantities of screenings, the distance between the skips and receptors, as well as the frequency of winds towards the locations.	**Medium**	**Medium**	Regular inspection of the skips is undertaken by site operatives in order to ensure that they are providing effective containment of materials. No excess screenings are stored on site. The skips are replaced when full	**Low**	Full implementation of the stated control measures is considered to result in a **low** risk of impact occurring

Source	Probability of Exposure	Harm	Magnitude of Risk	Control Measures	Residual Risk	Justification for Residual Risk
Internal pumping station	**Very Low** at all receptors due to the enclosed nature of the source and associated containment of emissions, the wet nature of materials which is likely to limit release potential, the distance between the source and receptors, as well as the frequency of winds towards the locations.	**Medium**	**Low**	The pumping station is covered in order to provide containment of emissions. Regular inspection of the plant is undertaken by site operatives in order to ensure correct performance and that there is effective containment of materials and emissions.	**Very Low**	Full implementation of the stated control measures is considered to result in a **very low** risk of impact occurring
SAS GBT (x3)	**Low** at all receptors due to the distance between the building extract vent and the frequency of winds towards the locations.	**Medium**	**Medium**	The SAS GBTs are covered and housed within a building. This is likely to contribute to effective containment of bioaerosols. Air is extracted from the building and exhausted to atmosphere via a vent on the side of the structure. Regular inspection of the plant is undertaken by site operatives in order to ensure correct performance and that there is effective containment of materials and emissions.	**Low**	Full implementation of the stated control measures is considered to result in a **low** risk of impact occurring
SAS tank (x2)	**Very Low** at all receptors due to the enclosed nature of the source and associated containment of emissions, the wet nature of materials which is likely to limit release potential, the distance between the source and receptors, as well as the frequency of winds towards the locations.	**Medium**	**Low**	The SAS tanks are covered and housed within a building to provide containment of emissions. Inspection hatches are kept closed unless in use. Regular inspection of the tank is undertaken by site operatives in order to ensure correct performance and that there is effective containment of materials and emissions.	**Very Low**	Full implementation of the stated control measures is considered to result in a **very low** risk of impact occurring

Source	Probability of Exposure	Harm	Magnitude of Risk	Control Measures	Residual Risk	Justification for Residual Risk
Avonmouth consolidation tanks (x 2) (PFTs)	**Medium** at all receptors due to distance between the source and receptors, the wet nature of materials stored which is likely to limit release potential and the frequency of winds towards the locations.	**Medium**	**Medium**	Regular inspection of the tank is undertaken by site operatives in order to ensure that it is providing effective containment of materials.	**Low**	Full implementation of the stated control measures is considered to result in a **low** risk of impact occurring
Bellmer feed tank	**Medium** at all receptors due to distance between the source and receptors, the wet nature of materials stored which is likely to limit release potential and the frequency of winds towards the locations.	**Medium**	**Medium**	Regular inspection of the tank is undertaken by site operatives in order to ensure that it is providing effective containment of materials.	**Low**	Full implementation of the stated control measures is considered to result in a **low** risk of impact occurring
Bellmer GBT (x2)	**Very Low** at all receptors due to the enclosed nature of the source and associated containment of emissions, the wet nature of materials which is likely to limit release potential, the distance between the source and receptors, as well as the frequency of winds towards the locations.	**Medium**	**Low**	The Bellmer GBTs are covered in order to provide containment of emissions. Inspection hatches are kept closed unless in use. Regular inspection of the plant is undertaken by site operatives in order to ensure correct performance and that there is effective containment of materials and emissions.	**Very Low**	Full implementation of the stated control measures is considered to result in a **very low** risk of impact occurring
Bellmer thickened sludge tank	**Very Low** at all receptors due to the enclosed nature of the source and associated containment of emissions, the wet nature of materials which is likely to limit release potential, the distance between the source and receptors, as well as the frequency of winds towards the locations.	**Medium**	**Low**	The tank is covered in order to provide containment of emissions. Regular inspection of the tank is undertaken by site operatives in order to ensure correct performance and that there is effective containment of materials and emissions.	**Very Low**	Full implementation of the stated control measures is considered to result in a **very low** risk of impact occurring

Source	Probability of Exposure	Harm	Magnitude of Risk	Control Measures	Residual Risk	Justification for Residual Risk
APD feed tank	**Very Low** at all receptors due to the enclosed nature of the source and associated containment of emissions, the wet nature of materials which is likely to limit release potential, the distance between the source and receptors, as well as the frequency of winds towards the locations.	**Medium**	**Low**	The tank is covered in order to provide containment of emissions. Inspection hatches are kept closed unless in use. Regular inspection of the plant is undertaken by site operatives in order to ensure correct performance and that there is effective containment of materials and emissions.	**Very Low**	Full implementation of the stated control measures is considered to result in a **very low** risk of impact occurring
Secondary sludge storage tanks (x2)	**Medium** at all receptors due to distance between the sources and receptors, the wet nature of materials stored which is likely to limit release potential and the frequency of winds towards the locations.	**Medium**	**Medium**	Regular inspection of the tanks is undertaken by site operatives in order to ensure that it is providing effective containment of materials.	**Low**	Full implementation of the stated control measures is considered to result in a **low** risk of impact occurring
Raw sludge feed tank to APD GBT 1-2-3	**Very Low** at all receptors due to the enclosed nature of the source and associated containment of emissions, the wet nature of materials which is likely to limit release potential, the distance between the source and receptors, as well as the frequency of winds towards the locations.	**Medium**	**Low**	The tank is covered in order to provide containment of emissions. Inspection hatches are kept closed unless in use. Regular inspection of the plant is undertaken by site operatives in order to ensure correct performance and that there is effective containment of materials and emissions.	**Very Low**	Full implementation of the stated control measures is considered to result in a **very low** risk of impact occurring
APD GBTs 1, 2 and 3	**Very Low** at all receptors due to the enclosed nature of the sources and associated containment of emissions, the wet nature of materials which is likely to limit release potential, the distance between the source and receptors, as well as the frequency of	**Medium**	**Low**	The APD GBTs are covered in order to provide containment of emissions. Regular inspection of the plant is undertaken by site operatives in order to ensure correct performance and that there is effective containment of materials and emissions.	**Very Low**	Full implementation of the stated control measures is considered to result in a **very low** risk of impact occurring

Source	Probability of Exposure	Harm	Magnitude of Risk	Control Measures	Residual Risk	Justification for Residual Risk
	winds towards the locations.					
Centrifuge feed sludge tank for centrifuge 7 & 8 (can also feed 5&6)	**Medium** at all receptors due to the distance between the source and receptors, as well as the frequency of winds towards the locations.	**Medium**	**Medium**	Regular inspection of the tanks is undertaken by site operatives in order to ensure that it is providing effective containment of materials.	**Low**	Full implementation of the stated control measures is considered to result in a **low** risk of impact occurring
Centrifuge 7&8	**Very Low** at all receptors due to the enclosed nature of the sources and associated containment of emissions, the distance between the source and receptors, as well as the frequency of winds towards the locations.	**Medium**	**Low**	The centrifuges are contained within a building which is likely to control emissions. Regular inspection of the plant is undertaken by site operatives in order to ensure correct performance and that there is effective containment of materials and emissions.	**Very Low**	Full implementation of the stated control measures is considered to result in a **very low** risk of impact occurring
Centrifuge No5-No 6 Raw feed tank	**Medium** at all receptors due to distance between the sources and receptors, the wet nature of materials stored which is likely to limit release potential and the frequency of winds towards the locations.	**Medium**	**Medium**	Regular inspection of the tanks is undertaken by site operatives in order to ensure correct performance and that there is effective containment of materials and emissions.	**Low**	Full implementation of the stated control measures is considered to result in a **low** risk of impact occurring
Centrifuge 5 and 6	**Very Low** at all receptors due to the enclosed nature of the sources and associated containment of emissions, the distance between the source and receptors, as well as the frequency of winds towards the locations.	**Medium**	**Low**	The centrifuges are contained within a building which is likely to control emissions. Regular inspection of the plant is undertaken by site operatives in order to ensure correct performance and that there is effective containment of materials and emissions	**Very Low**	Full implementation of the stated control measures is considered to result in a **very low** risk of impact occurring

6.1.1 The Bioaerosol Risk Assessment for sources at Avonmouth RES is shown in Table 9.

Table 9 Avonmouth REP Risk Assessment

Source	Probability of Exposure	Harm	Magnitude of Risk	Control Measures	Residual Risk	Justification for Residual Risk
Fugitive emissions from the building which houses the reception hall, pre-treatment plant, liquid food waste tank, de-packaging/ screening skips, centrifuges, digestate cake skips and centrate tank	**Very Low** at all receptors due to the building structure, which is expected to provide effective containment of emissions, mechanical extraction of air from the building which helps to promote negative pressure and limit the potential for fugitive release when doors are opened, the distance between the source and receptors, as well as the frequency of winds towards the locations.	**Medium**	**Low**	Air is extracted from the building and transferred to an OCU for treatment prior to discharge to atmosphere. This arrangement helps to promote negative pressure within the structure and limit the potential for fugitive emissions when the doors are opened to provide access. Regular inspection of the building structure is undertaken by site operatives in order to assess the condition and ensure that there is effective containment of materials and emissions.	**Very Low**	Full implementation of the stated control measures is considered to result in a **very low** risk of impact occurring
Post digestion storage tank	**Medium** at all receptors due to distance between the sources and receptors, the wet nature of materials stored which is likely to limit release potential and the frequency of winds towards the locations.	**Medium**	**Medium**	Regular inspection of the tank is undertaken by site operatives in order to ensure that it is providing effective containment of materials.	**Low**	Full implementation of the stated control measures is considered to result in a **low** risk of impact occurring
Strain-presses	**Very Low** at all receptors due to the enclosed nature of the source and associated containment of emissions, the wet nature of materials which is likely to limit release potential, the distance between the source and receptors, as well as the frequency of winds towards the locations.	**Medium**	**Low**	The strain presses are covered which will provide containment of emissions. Regular inspection of the plant is undertaken by site operatives in order to ensure correct performance and that there is effective containment of materials and emissions.	**Very Low**	Full implementation of the stated control measures is considered to result in a **very low** risk of impact occurring
OCU serving which contains the food waste reception hall, food liquid waste tank, food waste pre-	**Very Low** at all receptors due to the treated air which is vented via stack into the atmosphere. This is likely to limit the distance between the source and receptors, as well as	**Medium**	**Low**	Regular inspection of the OCU is undertaken by site operatives in order to ensure that it is providing effective containment of materials.	**Very Low**	Full implementation of the stated control measures is considered to result in a **very low** risk of impact occurring

Source	Probability of Exposure	Harm	Magnitude of Risk	Control Measures	Residual Risk	Justification for Residual Risk
treatment, de-packaging and screening skips, hydrolysis buffer tank, pasteurisation tanks, centrifuges, digestate cake skips and centrate tank	the frequency of winds towards the locations.					
OCU serving the gas to grid plant	**Very Low** at all receptors due to the treated air which is vented via stack into the atmosphere. This is likely to limit the distance between the source and receptors, as well as the frequency of winds towards the locations.	**Medium**	**Low**	Regular inspection of the OCU is undertaken by site operatives in order to ensure that it is providing effective containment of materials.	**Very Low**	Full implementation of the stated control measures is considered to result in a **very low** risk of impact occurring

6.1.2 As shown in Table 8 and Table 9, the results of the assessment indicated that the residual risk from all sources ranged between **low** and **very low**. This is supported by the results of the Bioaerosol Monitoring undertaken by Crestwood Ltd at the facility which indicated that concentrations of Aspergillus fumigatus and mesophilic bacteria were below the relevant EA criteria downwind of the Avonmouth WwTW at equivalent separation distances to the NSR.

6.1.3 Based on the findings, it is concluded that no further control measures, other than those specified, are required in order reduce the potential for impacts at sensitive locations in the vicinity of the site.

7 CONCLUSION

7.1.1 Crestwood Environmental was commissioned by Wessex Water Services Ltd to undertake a Bioaerosol Risk Assessment in relation sludge and food waste treatment activities at Avonmouth RES and BC, Avonmouth WwTW, BS11 0YS.

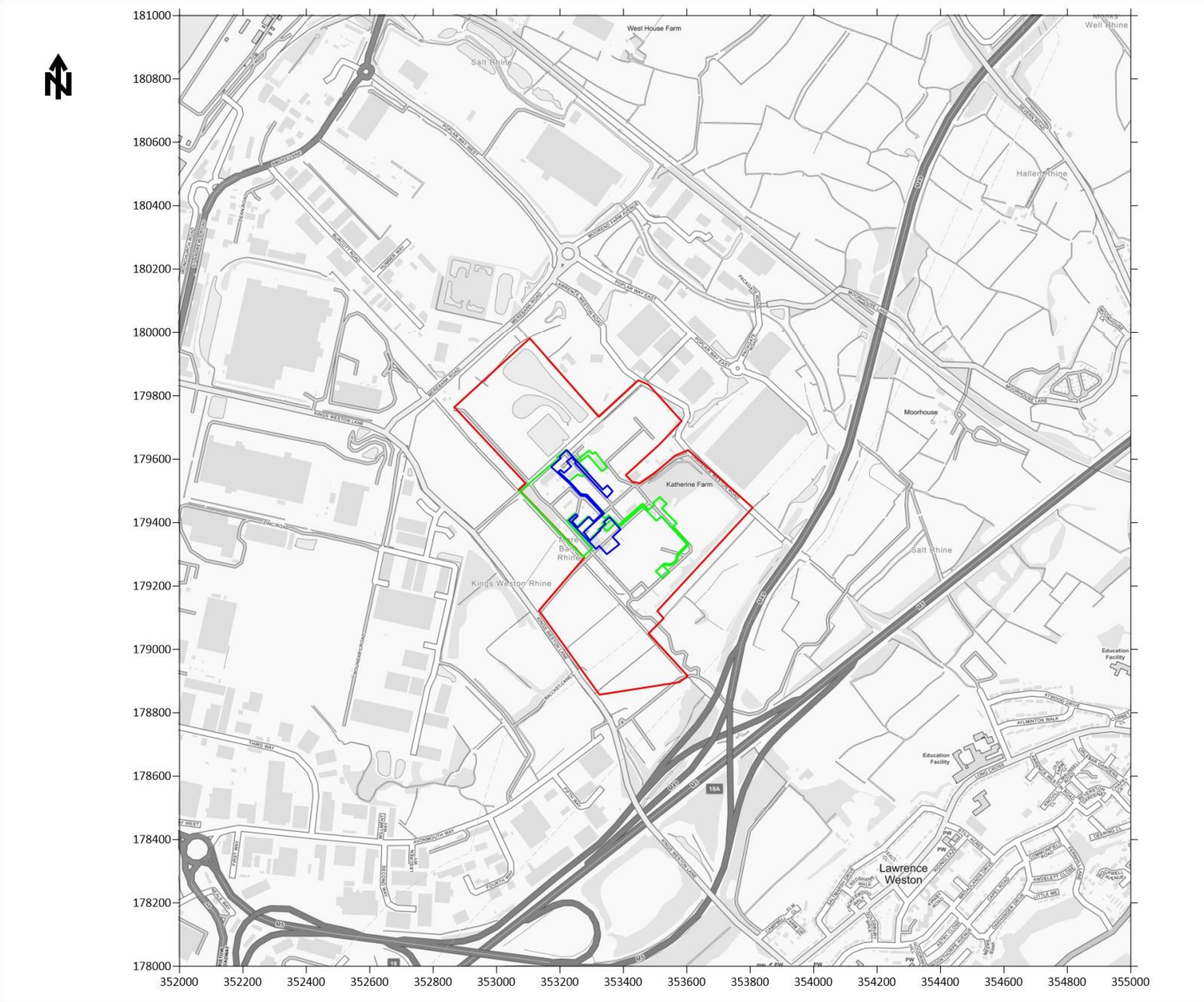
7.1.2 During the operation of the facilities, there is the potential for bioaerosol emissions and associated impacts at sensitive receptor locations in the vicinity of the Site. A Risk Assessment was therefore undertaken to identify potential emissions sources and evaluate effects in the local area.

7.1.3 A review of operations at Avonmouth REP and BC was undertaken in order to identify relevant bioaerosol emissions sources.

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

7.1.5 The results of the assessment indicated residual risk from all sources was either **very low** or **low**. This is supported by the results of the Bioaerosol Monitoring undertaken by Crestwood Ltd at the Site which indicated that concentrations of Aspergillus fumigatus and mesophilic bacteria were below the relevant EA criteria downwind of the Avonmouth WwTW at equivalent separation distances to the NSR.

7.1.6 Based on the findings, it is concluded that no further control measures, other than those detailed in the assessment, are required in order reduce the potential for impacts at sensitive locations in the vicinity of the Site.

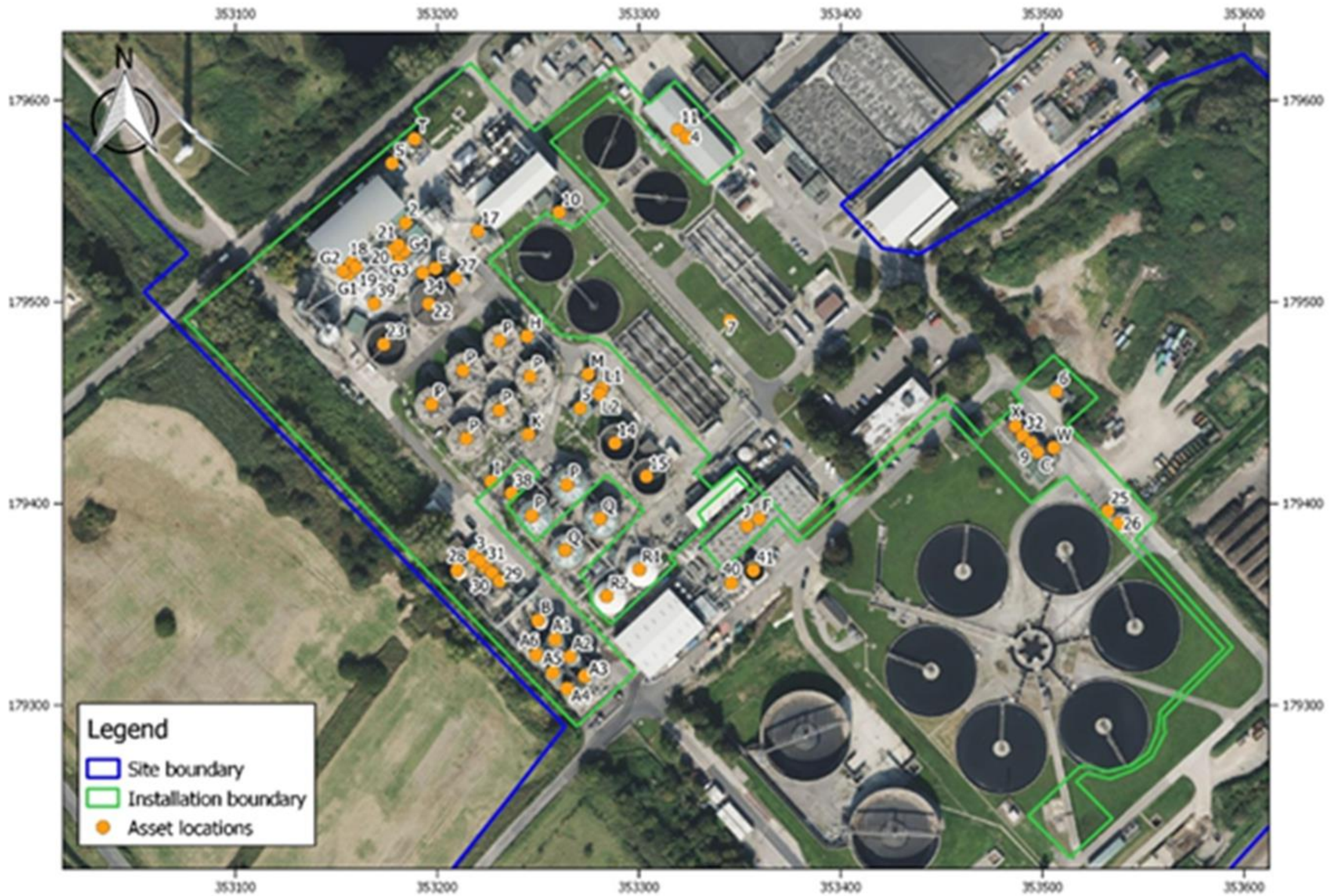


Title

Figure 1 - Site Location Plan

Project

Bioaerosol Risk Assessment
Avonmouth Wastewater Treatment Works



Legend

Name	Letter
Import sludge tank	26
Strain presses (x3 PSTS, x2 imported sludge tanks)	W/6
Sludge screening skips	W/6
Internal pumping station	X
SAS GBT	11 SAS GBTs 1,2 and 3
SAS tank	12
Avonmouth consolidation tank 2 (PFT2)	22 & 23
Bellmer feed tank	M
Bellmer GBT	L1/L2
Bellmer thickened sludge tank	K
APD feed tank	B
APD GBT 1,2,3	29,30,31
Secondary sludge storage tank Nr 2	14 &15
Raw sludge feed to APD GBT 1-2-3	28
Centrifuge feed sludge tank for centrifuge 7&8 (can also feed 5&6)	E
Centrifuge 7&8	G3 & G4
Centrifuge 5 and 6	G1 &G4
Sludge conveyor belts	18, 19, 20, 21

Title

Figure 2 - Avonmouth BC Site Layout Plan

Project

Bioaerosol Risk Assessment Avonmouth Wastewater Treatment Works

N

Legend

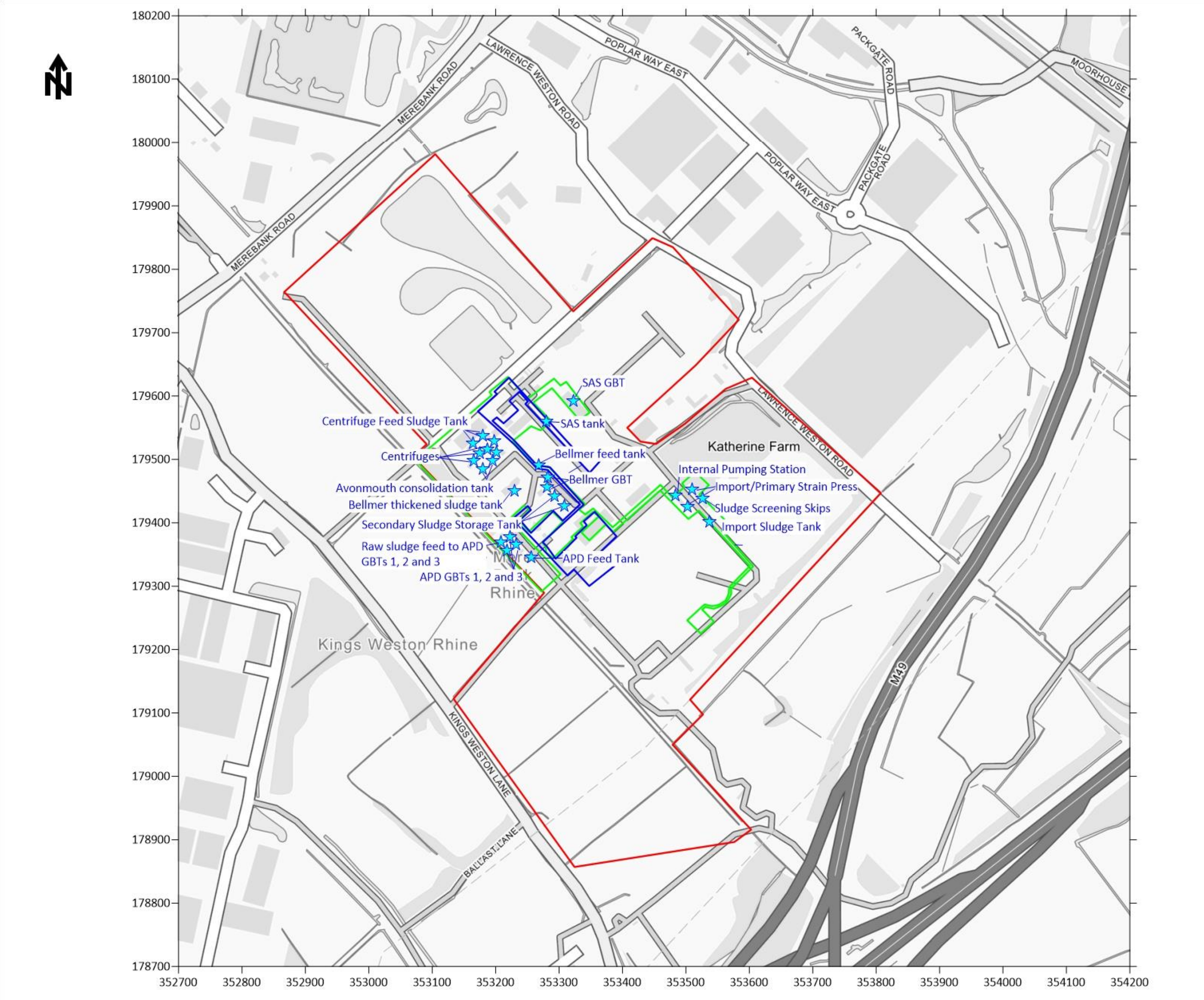
Name	Letter
Food Waste Reception Hall	A
Food Liquid Waste Tank	A (Contained within building)
Food waste pre treatment (including de-packing shredder, turbo dissolver, rotary drum screen 10mm and hammer mill).	A (Contained within building)
De-packaging and screening skips	B
Hydrolysis buffer tank	C
Pasteurisation tanks (x3)	D
Digester Nr1. and Nr3.	E/F
Biogas relief valves	E/F
Biogas holders (x2) (Shared assets with Avonmouth BC)	G/H
Waste gas burner/flare (Shared assets with Avonmouth BC)	I/J
Post digestion storage tank	K
Strain-presses	O/P
Centrifuge (x2)	A (Contained within building)
Digested sludge cake skip (x2)	A (Contained within building)
Centrate tank	A (Contained within building
Gas to grid plant (including siloxane plant)	J
Propane tank	Q

Title

Figure 3 - Avonmouth REP Site Layout Plan

Project

Bioaerosol Risk Assessment Avonmouth Wastewater Treatment Works

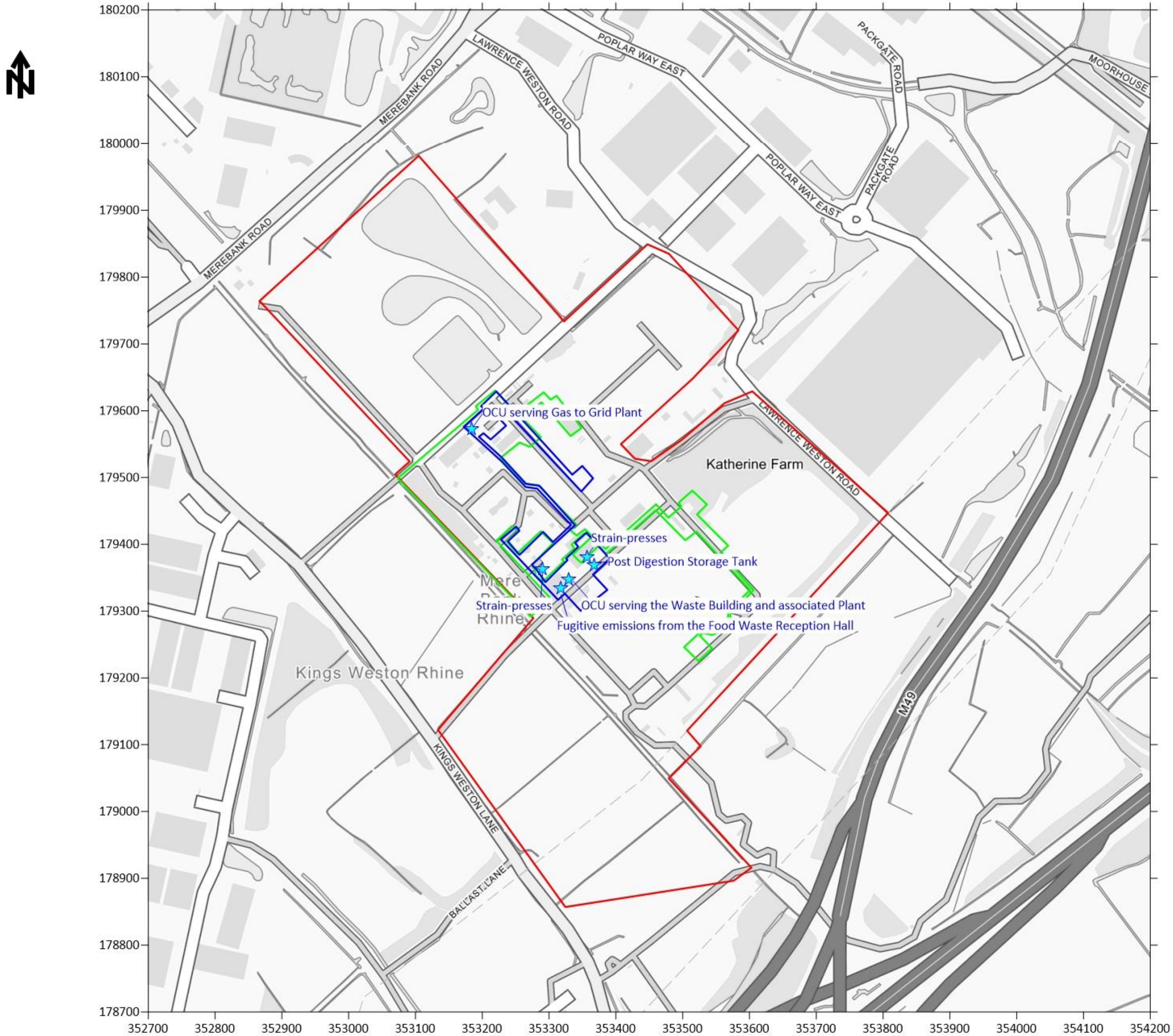


Title

Figure 4 - Avonmouth BC Bioaerosol Source Locations

Project

Bioaerosol Risk Assessment Avonmouth Wastewater Treatment Works



Legend

Avonmouth Site Boundary

Avonmouth BC Site Boundary

Avonmouth REP Site Boundary

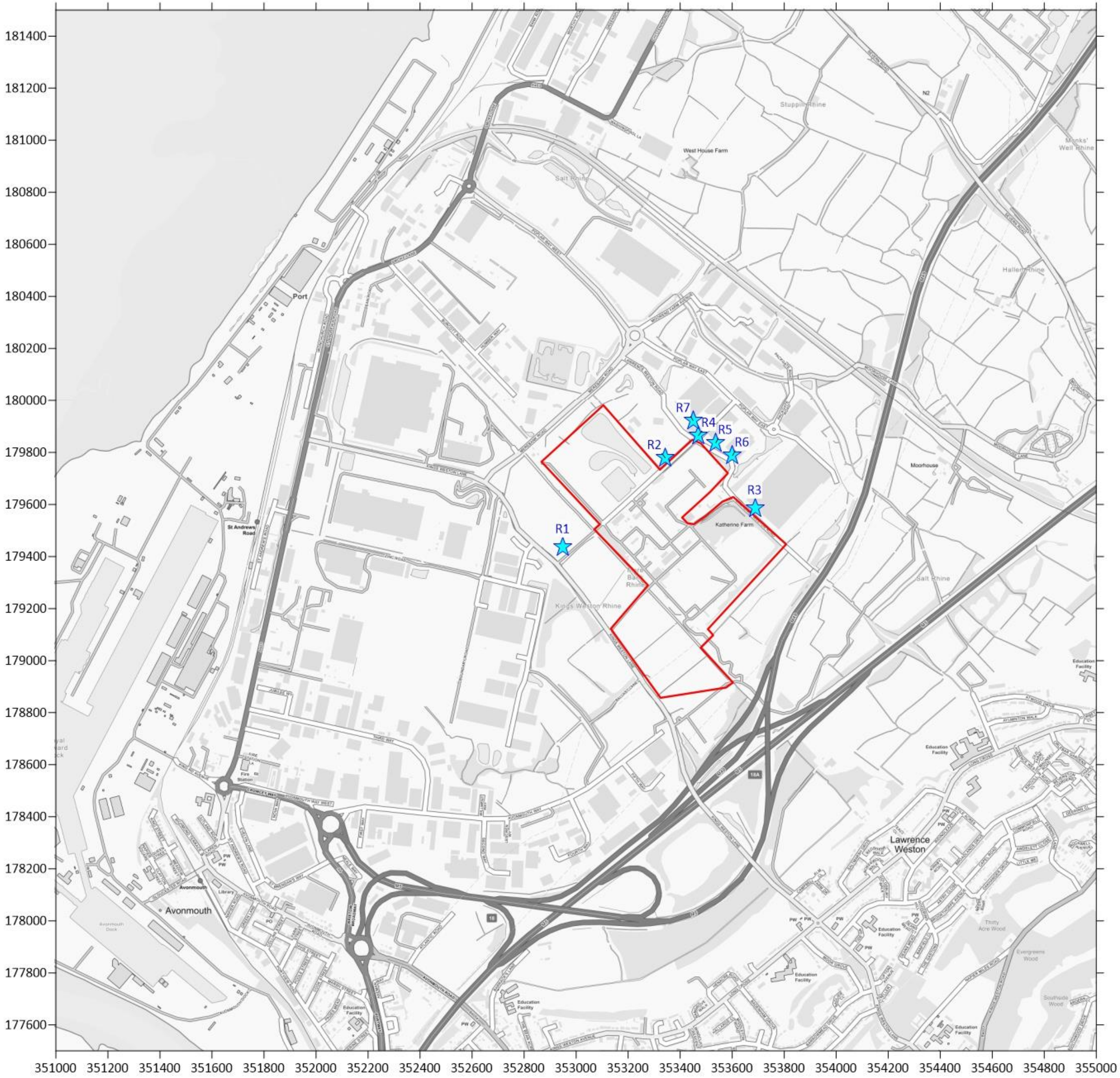
Bioaerosol Source

Title

Figure 5 - Avonmouth REP Bioaerosol Source Locations

Project

Bioaerosol Risk Assessment Avonmouth Wastewater Treatment Works



Legend

Avonmouth Site Boundary

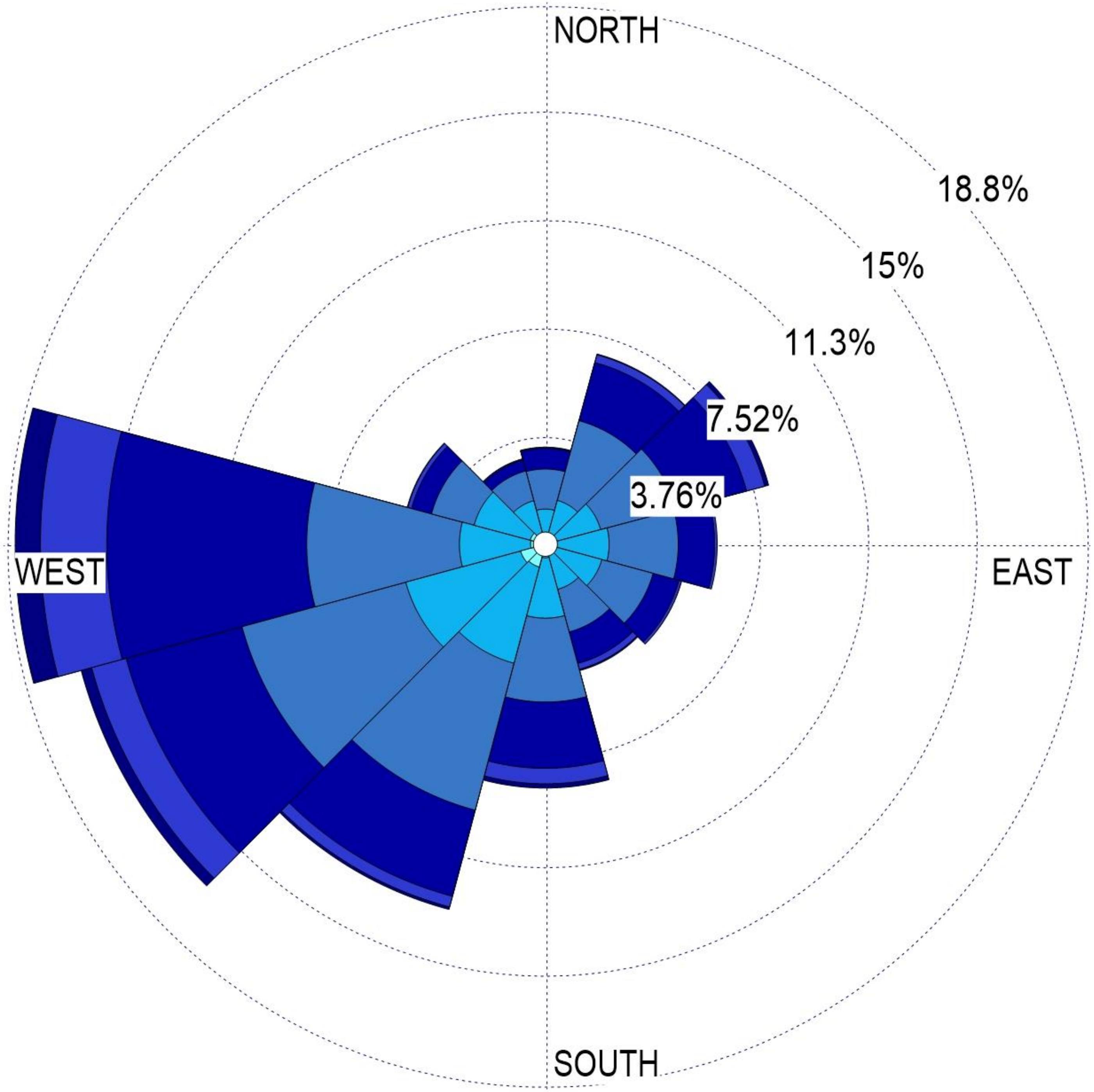
Sensitive Receptor Locations

Title

Figure 6 - Sensitive Receptor Locations

Project

Bioaerosol Risk Assessment
Avonmouth Wastewater
Treatment Works



Legend

WIND SPEED (m/s)

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

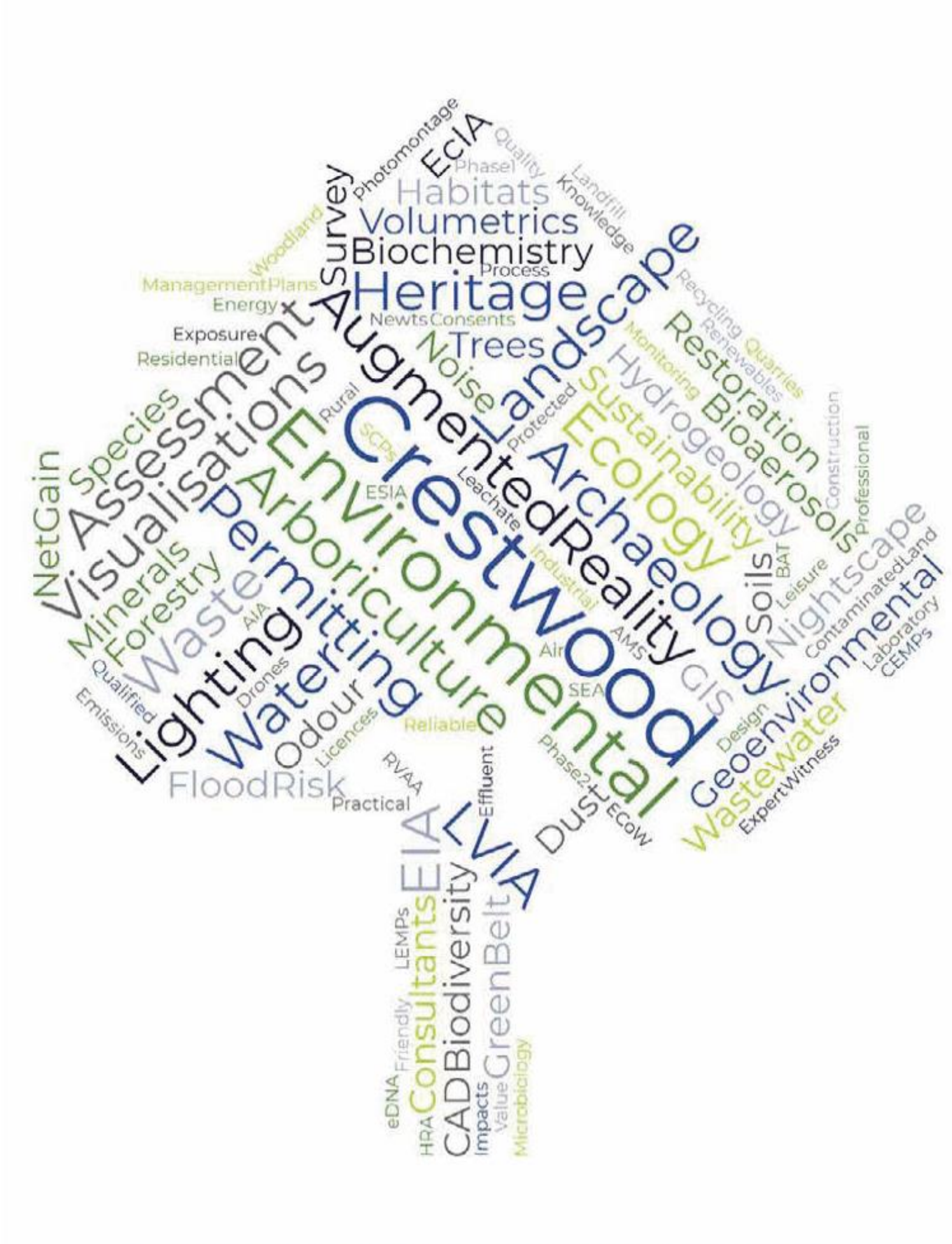
Calms: 0.41%

Title

Figure 7 - Wind Rose of 2017 to 2021 Bristol Lulsgate Meteorological Data

Project

Bioaerosol Risk Assessment Avonmouth Wastewater Treatment Works



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