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Consulting Engineers Limited

Northacre Facility

Northacre Renewable Energy Limited

Odour, Bioaerosol and Taint Assessment

ENGINEERING + CONSULTING

Document approval

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Management Summary

Fichtner Consulting Engineers Ltd ("Fichtner") has been engaged to undertake an Odour, Bioaerosol and Taint Assessment to support the development of the Northacre Renewable Energy Facility (the Facility) in order to provide details on the likely impact of odour and bioaerosols on adjacent premises.

Activities at the neighbouring Westbury Dairy (the Dairy), owned by Arla, include the production of powdered milk which requires the introduction of air, which is brought in through air intake vents on the eastern side of the Dairy, facing the Facility. Arla is concerned that emissions from the Facility could contaminate the powdered milk, causing "taint". Therefore, these air intake vents are the receptors of concern for Arla and the transport of volatile organic compounds (VOCs) to these vents has been modelled to determine the likely risk of taint of Arla's product.

A similar assessment was carried out to support the planning application for the adjacent Northacre Resource Recovery Centre (the NRRC). The assessment for the NRRC explains that the methodology was refined between SLR and the Dairy and their representatives. In carrying out this assessment, the methodology agreed for the NRRC has been drawn upon and the Applicant is not aware of any changes to operations at the Dairy since the NRRC application was submitted.

During normal operation of the Facility, the potentially odorous air will be drawn from the waste reception areas and used as combustion air within the combustion process. This will destroy the potentially odour compounds. However, VOCs resulting from combustion will be released from the stack and some of these VOCs have the potential to affect the products from the Dairy. Therefore, this impact has been assessed.

When the Facility is not operational, air from the waste reception areas will be drawn through an odour extraction system which include dust filters and a carbon filter system. A carbon filter system, with dust filter, is considered to represent the Best Available Technique (BAT) for the abatement of odours, bioaerosols, and VOCs for this type of waste treatment process. Emissions from the odour extraction system will vent to atmosphere via a stack situated on the top of the bunker parapet which will reach 43 m above the surrounding ground level.

Dispersion modelling of odour, bioaerosols and VOCs from the odour extraction system and VOCs from the main stack has been carried out using the ADMS dispersion model. The model uses weather data from the local area to predict the spread and movement of the emissions from the odour extraction system for each hour over a five-year period. The model takes account of wind speed, wind direction, temperature, humidity and the amount of cloud cover, as all of these factors influence the dispersion of emissions. The model also takes account of the effects of buildings and terrain on the movement of air. To set up the model, it has been assumed that the odour extraction system operates for the whole year, where this would only operate when demand for process air drops below the air flow required to maintain negative pressure of the main building. The model was used to predict the concentrations of odour across the local area and the concentrations of bioaerosols and VOCs at the air intakes for the Dairy. When calculating the release rates, conservative assumptions have been applied.

The impact of odour has been compared to the Environment Agency's (EA's) assessment criterion. The analysis has concluded that the impact would be well below the EA Odour Guidance benchmark below which there would be no reasonable cause for annoyance for highly offensive odour even for a hypersensitive population, and even assuming that the odour extraction system operates during the worst-case weather conditions for dispersion.

The impact of bioaerosols has been compared to the background levels. There is predicted to be a slight change from the background levels for short periods. However, this is not considered to lead to a significant risk of blocking the air filtration system at the Dairy.

The impact of VOCs has been compared to the published taint thresholds for product (health, taste and odour). The predicted increase in VOC levels in product is well below the taint threshold values. Therefore, the levels of VOCs expected at the air intakes for the Dairy is not expected to lead to any taint of product (either health, taste or odour) of the Dairy.

Contents

1 Introduction

Northacre Renewable Energy Limited (NREL) has applied to the Environment Agency (EA) for an Environmental Permit (EP) to operate the Northacre Renewable Energy Facility (the Facility) on land off Stephenson Road, Westbury, Wiltshire.

This report has been developed to quantity the potential impacts of odour and bioaerosols from the Facility upon adjacent premises, during both normal and non-standard operating scenarios.

In addition, it is noted that Arla Foods (referred to as Arla) has raised concerns regarding the potential for emissions from the Facility to affect the quality of the products which it manufactures at its adjacent Westbury Dairy. Therefore, while not specifically requested by the EA, this report has also considered the potential for emissions from the Facility to lead to "taint" Arla's products.

1.1 Background to Taint Assessment

The Facility is located adjacent to the Westbury Dairy (the Dairy). Air is pulled from the outside environment, via air intakes, to provide air for the production of powdered milk. The air intakes are fitted with a filtration system to remove particulates (which would include bioaerosols) from the air which is used within the manufacturing process. The air is then heated and used within the process to evaporate the water content of the milk to produce the powdered milk.

Increased levels of volatile organic compounds (VOCs) at the air intakes could result in transfer to the product therefore presenting the risk of taint of the powdered milk. Increased levels of bioaerosols could result in an increase in the rate of fouling of the filters on the air intakes. Therefore, this assessment has considered the potential for increased fouling of Arla's filtration system fitted to the air intakes and the likely risk of taint of product from the release of VOC's from the Facility.

The Northacre Resource Recovery Centre (the NRRC) is a Mechanical Biological Treatment (MBT) facility located adjacent to the Facility on land of Stephenson Road.

The NRRC was granted planning permission (Ref: W/07/09004/WCM) in March 2009. The planning application for the NRRC included an assessment of the potential risk of the NRRC upon the Dairy. The assessment was undertaken by SLR (herein referred to as the 2008 SLR Report). The 2008 SLR Report explains that the methodology was refined and agreed between SLR and the representatives of the Dairy. NREL has attempted to engage with representatives of the Dairy and Arla to review and agree a methodology for the same type of assessment for the Facility; however, unfortunately, the Dairy and Arla (and its representatives) are not currently prepared to engage with NREL to agree a suitable assessment methodology to determine the impact of the Facility upon the operation of the Dairy. Therefore, for the assessment of taint impacts within this report, NREL has replicated the assessment methodology agreed with SLR and the representatives of the Dairy for the NRRC.

2 Dust and odour abatement systems

BAT 21 of the Waste Incineration Best Available Techniques (BAT) Reference document (herein referred to as the Waste Incineration BREF), which states:

> *In order to prevent or reduce diffuse emissions from the incineration plant, including odour emissions, BAT is to:*

- *store solid and bulk pasty wastes that are odorous and/or prone to releasing volatile substances in enclosed buildings under controlled sub-atmospheric pressure and use the extracted air as combustion air for incineration or send it to another suitable abatement system in the case of a risk of explosion;*
- *store liquid wastes in tanks under appropriate controlled pressure and duct the tank vents to the combustion air feed or to another suitable abatement system;*
- *control the risk of odour during complete shutdown periods when no incineration capacity is available, e.g. by:*
  - *sending the vented or extracted air to an alternative abatement system, e.g. a wet scrubber, a fixed adsorption bed;*
  - *minimising the amount of waste in storage, e.g. by interrupting, reducing or transferring waste deliveries, as a part of waste stream management (see BAT 9);*
  - *storing waste in properly sealed bales.*

As detailed within the EP Application Pack, and also within the Air Emissions Management Plan submitted to the Environment Agency in support of the response to the Schedule 5 Request, dated 30 July 2021, the Facility will be designed and operated in accordance with the requirements of BAT21.

The operation of the dust and dour abatement systems may change dependant on the different operating scenarios for the Facility, as follows:

1. Normal operations;
2. Abnormal operations;
3. Offline periods (including start-up and shutdown); and
4. Significant events.

The Air Emissions Management Plan sets out all of the controls to be implemented at the Facility to minimise the impact of emission from the Facility during all of the above scenarios. However, they are summarised in sections 2.1 to 2.4.

2.1 Normal operations

During normal operations, the waste reception areas (which will include the waste tipping hall handling and storage areas as well as the unloading of waste deliveries) will be maintained under negative pressure, to ensure that no odours are able to escape the building. The negative pressure will be created by drawing potentially odorous air from the waste reception areas and using it as combustion air within the combustion process. Therefore, the only point source odour or dust emissions from the Facility will be from the main stack.

The Industrial Emissions Directive (IED) requires that any combustion gases passing through a waste incineration plant must experience a temperature of 850°C or more for at least two seconds. Due to the high temperatures associated with the combustion process, it will destroy the odorous compounds within the combustion process. However, there is an emission limit (ELV) for VOCs, and the compounds considered for the taint assessment for the Arla products are VOCs.

There is no risk of the release of bioaerosol from the main stack because they will have been destroyed within the combustion process prior to release from the stack.

The building management system will manage door and louvre opening such that only 1 roller shutter door (including delivery doors and maintenance and access roller shutter doors) can open at a time, and when no roller shutter doors are open, ventilation louvres in the same wall as the delivery doors will open to maintain the directional flow of air from the area of the inlet doors, across the waste reception area, bunker and waste handling area, to the combustion air extraction system.

2.2 Abnormal operations

The EA defines abnormal operation within the EP which it grants as:

> *"any technically unavoidable stoppages, disturbances, or failures of the abatement plant or the measurement devices, during which the emissions into the air and the discharges of waste water may exceed the prescribed emission limit values for the pollutant(s) affected."*

Abnormal operation will occur when the Facility is in full operation. Therefore, during this time, the odour and dust abatement systems will be the same as those during normal operations (i.e. the potentially odorous air from the waste reception areas will be used as combustion air). Furthermore, the impact of VOC's (referred to as Total Organic Carbon) as explained within the Abnormal Emissions Assessment submitted within Appendix E of the EP Application, will be the same as during normal operations as the ELV for VOC's during abnormal operation is no different to the ELV which would apply during normal operation.

2.3 Offline periods (including start-up and shutdown)

During periods of planned or unplanned shutdown, including the periods when the Facility is in start-up and shutdown, the waste reception areas area will be maintained under negative pressure by a standby air extraction system controlled by the building management system. As assumed in the EP application, the Facility will operate for 7,860 hours per annum. Therefore, the odour abatement system will need to operate for approximately 10% of the year.

The building management system will ensure that the odour abatement system starts-up immediately in the event that the Facility enters shutdown and/or during periods when the Facility is offline. Due to the design of the odour abatement system, it will provide effective abatement of odours as soon as it starts-up.

The odour extraction system has been designed to provide 3 air changes per hour from waste receptions areas during periods when the Facility is offline. During periods when the Facility is offline, all doors and louvres to the waste reception areas will be maintained closed to minimise uncontrolled fugitive emission of dust and odour from the Facility. Therefore, any escape of dust and odour from the building will be minimal given the containment of the waste storage areas and the odour extraction system.

The potentially odorous extracted air from waste reception areas will be treated in an odour abatement system. The odour abatement system will include an initial dust filter with the 'filtered' air being passed through a carbon filter to abate potentially odorous emissions. From discussions with recognised suppliers of carbon filter systems, such as that proposed for the Facility, it is understood that the carbon filters will have a typical efficiency of between 95% and 99% for the abatement of odour and VOC's.

The abated air will be released to atmosphere via a dedicated odour stack, with the top of the stack being 43 m above the surrounding ground level – protruding 11 m above the bunker parapet. The dedicated odour stack will assist with the dispersion of emissions from the odour abatement system. The odour abatement system will include for a second odour extraction ID fan, to provide redundancy, in the unlikely event of breakdown of the primary odour extraction ID fan.

Carbon filter systems, such as those proposed can experience problems with saturation of the filters which will reduce their efficiency over time. During normal operation, when the abatement system is not operational, the carbon filters will be isolated to prevent the carbon from being unnecessarily exposed to ambient air. This will retain the quality of the carbon filters between periods of shutdown. It will be planned to replace any saturated carbon media when the abatement system is not operational, but the carbon filter system will be designed with redundant vessels to allow replacement of the saturated carbon media with fresh media during operation if necessary.

In the event that the Facility were to lose its connection to the grid requiring an emergency to take place, the emergency diesel generators are sized to provide power to the odour abatement system during shutdown, as well as to maintain the operation of the odour abatement system until the connection to the grid is restored and the Facility can be restarted.

2.4 Significant events

As explained within the EP application, the Facility has been designed to minimise the risk of pollution events and document management systems will be implemented to control the operation and maintenance of the pollution prevention measures proposed to be incorporated into the design of the Facility. These include those set out in the Environmental Risk Assessment (Appendix D of the EP application), as well as the Fire Prevention Plan (Appendix I of the EP application).

In the event of a significant pollution incident or a fire, where practicable the operation of all of the odour abatement systems would be maintained. However, in the event that a significant pollution event or a fire meant that the odour abatement systems are not able to be operated, NREL would notify all relevant stakeholders, including regulatory authorities and adjacent premises, of the incident.

3 Westbury Dairy

When raising its concerns to the planning application for the Facility, through the planning consultation process, Arla provided design information relating to its operations at the Dairy (Ref: 202021046 Planning Technical Briefing Notes). Arla also provided information to inform the 2008 SLR report. Both sets of information have been used to inform this assessment.

3.1 Operations at the Westbury Dairy

Arla's manufacturing process at the Dairy include the production of powdered milk and butter. The production of powdered milk involves a spray drier which is used to remove moisture from milk concentrate. Air and heat are the essential inputs in the drying process, with air used as the medium to deliver the heat energy required to remove moisture from the milk concentrate. The air which is used in the spray drier is extracted from outside the building via air intake ducts. Therefore, any pollutants which are within the area of influence of the intake vent have the potential to be transferred into the powdered milk.

For the purposes of this assessment, the air intake vents have been considered as the receptors of concern. However, due to the suction effect of the vents, it is not appropriate to use the exact location of the vents as receptors as they will draw in air from the surrounding area. Therefore, the area of influence of the intake vent has been calculated and the edge of the vent closest to the Facility has been used as the receptor locations. This has been calculated to be 7.79 m from the dairy building, rounded up to 8 m for the purpose of this assessment. To ensure the entire potential area of influence from the vents is covered, 5 receptors have been modelled at 3 different heights; ground level, 5 m (the height of the vents), and 13 m (the height of the vents plus 8 m potential air capture distance). The receptor locations which have been assessed are listed in Table 1.

Table 1: Air Intake Receptor Locations

Receptor	Elevations (m above ground level)	X (m)	Y (m)
R1	0, 5, 13	385609	152092
R2	0, 5, 13	385598	152084
R3	0, 5, 13	385611	152098
R4	0, 5, 13	385605	152090
R5	0, 5, 13	385603	152086

The air intake vents are fitted with an air filtration system to remove airborne particles. The abatement of particulates within the Dairy air filtration system has not been allowed for within the assessment; therefore, the results are considered to be conservative.

For the 2008 SLR report, Arla provided the following information.

- The intake flow rate = 165,000 m^3/hr per line.
- The milk production rate = 5500 kg/hr per line.
- The transfer rate to product = 90%

In Arla's Planning Technical Briefing Note, some slightly different information is provided.

- The air intake is stated to be 138,000 kg/hr per line at a density of 1.22 kg/m^3, giving an intake flow rate of 113,114 m^3/hr per line.
- The powder production lines are stated to have a capacity of 5 t/hr, or 5,000 kg/hr.

- The total production rate is stated to be 55,000 tonnes of milk powder per year, which implies an average production rate of 3,140 kg/hr.

For this assessment, the same values as provided for the 2008 SLR report have been used it is assumed that these are the peak design values. It is possible that the latest figures from Arla reflect optimised performance, such that the drier plant can now operate with less air. This means that this assessment is conservative.

4 Odour Impact Assessment

4.1 Background

As explained in section 2.1 during normal operations, waste reception, handling and storage areas will be maintained under negative pressure, to ensure that no odours are able to escape the building. The extracted air will be used as combustion air within the combustion process. The high temperatures within the combustion process will destroy the odorous compounds, and the flue gases from the combustion process will be released from the main stack. Therefore, the likelihood of potentially odorous emissions being released from the Facility during normal operation is considered to be very low.

During periods when the Facility is off-line, referred to in section 2.3, a carbon filter system, will be used to abate the potentially odorous air. Therefore, this analysis has only focussed on the impact of the operation of the odour abatement system on the operations at the Dairy. For the purpose of modelling this scenario, it has been assumed that the odour abatement system is continually operating as this will ensure that the modelling includes for the operation of the odour abatement system during the worst-case atmospheric conditions for dispersion. However, as explained in section 2.3, it will only actually operate for approximately 10% of the year.

Detailed dispersion modelling has been carried out using ADMS 5.2. The modelling has used the same dispersion model which supported the EP application, and the planning application. Full details of the model assumptions are set out in Appendix A.

The results of the modelling have been assessed in accordance with the EA Guidance, titled 'H4 Odour Management', referred to as the EA Odour Guidance. The EA Odour Guidance recommends some indicative odour exposure criteria for ground level concentrations of mixtures of odorant, below which there would be "*no reasonable cause for annoyance*". For "*highly offensive odours*", including those from activities involving putrescible waste, the criterion is 1.5 OU_E/m^3 as the 98th percentile of hourly averages. This has been used as the evaluation criterion for the odour assessment. It is noted that the EA Odour Guidance also states that it may be prudent to "*reduce the benchmark by … 0.5* OU_E/m^3*, where a local population has already become sensitised*". Therefore, the benchmark would be reduced to 1 OU_E/m^3 for a hypersensitive population. To ensure that this assessment is suitably conservative, it has been assumed that the receptor locations are already sensitive to odour.

4.2 Approach

There are no UK guidelines relating specifically to the types of waste to be processed at the Facility. Therefore, the calculation of odour emissions has been derived from the Netherlands Emission Guidelines. This approach has been considered appropriate for recent permit applications and has been accepted by UK regulatory authorities.

It is reasonable to assume that the more odorous materials found within the feedstock waste will be similar in make-up to household organic waste. Therefore, the odour calculations for the Facility have used the 'Key Odour Emission Factor' for 'Receipt of household organic waste: Storage' ($5x10^5$ $OU_E/m^2/h$). The footnote in the guidance confirms that this factor describes the number of odour units per m^2 of stored household organic waste per hour. The depth of waste is not included as a factor, but the empirical nature of the 'Key Odour Emission Factor' suggests that while the odour arising may be from the bulk of the material, the emission is assumed to be from the surface of the waste pile for the purposes of the calculation.

The 'Key Odour Emission Factor' is based on household organic waste. The Facility will process a mixture of wastes from domestic municipal solid waste (MSW), Commercial and Industrial Wastes (C&I) and Solid Residual Fuel (SRF) from the MBT plant. Whilst it is reasonable to assume that the more odorous materials found within these wastes will be similar in make-up to household organic waste, it is not reasonable to assume the entirety of waste received for processing at the Facility will be household organic waste. Therefore, an analysis of the waste composition has been conducted to determine the likely putrescible waste content of the feedstock.

The three fractions of waste which would be expected to produce odours are '*organic putrescible*', '*absorbent hygiene products*' and '*fines*'. The percentages of these fractions found in MSW and C&I waste have been summed, using data from *Environment Agency Wales/SLR: "Determination of the Biodegradability of Mixed Industrial and Commercial Waste Landfilled in Wales", 2007* and *"DEFRA EV0801 National compositional estimates for local authority collected waste and recycling in England, 2010/11", 2013.* The percentages of putrescible waste found in each waste type are displayed in Table 2. As a conservative assumption, it is assumed that the SRF from the MBT is odorous and so this percentage has been set to 100%.

Table 2: Percentages of putrescible waste in feedstock wastes

Waste	Fines	Organics	Adsorbent hygiene products	TOTAL
MSW	2.31%	40.23%	6.95%	49.49%
C&I	6.77%	5.65%	0.00%	12.42%
SRF from MBT	-	-	-	100%

Feedstock from the MBT is expected to be approximately 20% of the total feedstock. Feedstocks of MSW and C&I are not yet fully defined, and are subject to change. In a worst-case scenario, in terms of the amount of putrescible waste, assuming a feedstock of 20% MBT and 80% MSW would result in 60% of waste being considered putrescible. Therefore, this assessment has used a putrescible content factor of 0.6. This is very much a worst case and conservative value; in reality, it is likely that the putrescible content will be much lower than this.

At this stage of design of the Facility, a detailed 3D model of the waste within the bunker is not available, but it is expected to be developed by the technology provider as part of the detailed design of the bunker. However, the concept design, which has been developed to support the EP application, includes indicative bunker dimensions to determine the maximum waste storage capacity. From these calculations the following assumptions have been used:

- Bunker length: 45 m
- Exposed width at top of pile: 4.6 m
- Exposed width at tipping hall level: 5 m
- Height of the waste pile: 18 m

Using the above data, the exposed surface area of the waste in the bunker has been calculated as 1,367.67 m^2. This conservatively assumes that bunker is full to its maximum capacity. However, in the event of a planned shutdown the waste in the bunker would be run-down and in the event of a prolonged emergency shutdown there are measures in place to enable backloading of waste from the bunker and transfer off-site to an alternative waste management facility.

Assuming the waste within the bunker has a putrescible content of 60%, the odour emissions have been calculated as:

$$Surface\ area\ of\ the\ waste\ in\ the\ bunker\ \times Key\ Odour\ Emission\ Factor\ \times 0.6$$

$$1{,}367.67\ m^2\ \times\ 5\ \times 10^5\ OU_E m^{-3} hr^{-1}\ \times 0.6 = 410{,}296{,}115\ OU_E hr^{-1}$$

In order to obtain the odour concentration in OU_E/m^3 this has been divided by the volumetric flow rate, assuming three air changes per hour:

$$\frac{410{,}296{,}115\ OU_E hr^{-1}}{132{,}000\ m^3 hr^{-1}} = \mathbf{3,108.3\ OU_E m^{-3}}$$

The volumetric flow rate has been calculated from the total air volume within the tipping hall, the bunker (from the height of the tipping hall floor to the level of the feed hopper), and the enclosed area within the bunker above the feed hopper level. The calculated volume is conservative because it does not consider the space that will be taken up by equipment and waste.

The value of 3,108.3 OU_E/m^3 has been calculated as the unabated odour release concentration from the waste within the bunker. This value has not considered the carbon filter odour abatement system, which will remove the majority of the odour. The Waste Treatment BREF reports the efficiency of carbon filters to be between 70% and 99%; however, this is considered to be conservative as technology providers of carbon abatement systems have advised that carbon abatement systems will typically abate 95-99% of VOCs, which covers many of the odorous compounds. Using the lower value stated in the Waste Treatment BREF (i.e. a 70% abatement efficiency), the abated odour release concentration from the waste within the bunker is 932.4 OU_E/m^3, which has been rounded up to be **1,000 OU_E/m^3.** This is considered to be very conservative as, using the lowest value stated by technology providers, the abated odour release concentration from the waste within the bunker would be only 155 OU_E/m^3.

4.3 Results

Figure 3 of Appendix B shows the distribution of odour impacts in the wider area at ground level assuming continual operation of the odour control system. As shown, the maximum 98th percentile of 1-hour odour concentrations is 0.5 OU_E/m^3. This occurs to the east of the Facility. This is well below the EA Odour Guidance benchmark below which there would be no reasonable cause for annoyance for highly offensive odour even for a hypersensitive population.

The maximum 98th percentile of the 1 hour odour concentrations at the air intake to the Dairy is even lower, as shown in the following table.

Table 3: Summary of Odour Impacts at Westbury Dairy Air Intakes

Parameter	Meteorological dataset				
	2015	2016	2017	2018	2019
98th percentile of 1-hour means	0.063	0.084	0.114	0.095	0.155

As explained in section 2.3, the odour control system will only need to operate when the Facility is offline, or during periods of start-up and shutdown, which, as explained in section 2.3, only covers approximately 10% of the year. As explained in section 2.1, during normal operations, potentially odorous air from waste reception areas will be used for combustion air with the odorous compounds being destroyed within the combustion process. Therefore, the likelihood of the worst-case weather conditions coinciding with periods when the Facility is offline is very low.

Furthermore, the results above are based on the conservative assumption that the odour abatement system runs at a 70% efficiency. This is the lower value of the expected 70-99% efficiency. Therefore, the results presented above are conservative and so there would be no reasonable cause for annoyance for highly offensive odour for a hypersensitive population.

Additional analysis has been carried out on the potential for odour taint of the product based on the likely VOC speciation and taint thresholds, and this is presented in section 6.

5 Bioaerosol Impact Assessment

5.1 Background

Bioaerosols are airborne particles which contain micro-organisms. They are found naturally in the environment and can include bacteria, fungi, viruses, pollen, spores, endotoxins and mycotoxins. The EA guidance titled, "*Guidance for developments requiring planning permission and environmental permits*" states that bioaerosols from anaerobic digestion plants are not considered to be a serious concern, although for some facilities it may be necessary to refer to the risk assessment guidance for composting facilities. The Facility is neither an anaerobic digestion plant or a composting facility, and it is not expected that there to be a significant quantify of bioaerosols released from the storage or handling of waste within the waste reception area.

However, Arla has raised its concerns over the potential for bioaerosols to blind (block) the air filtration systems at the Dairy. Therefore, a quantitative assessment of the potential for the release of bioaerosol levels from the Facility to impact upon the Dairy has been undertaken.

The Facility is a thermal treatment process and does not rely on micro-organisms to break down waste. However, the natural composting of the wastes delivered to the Facility and some composting within the waste bunker will have a small potential to produce emissions of bioaerosols before the waste is combusted.

As explained in section 2.1, during normal operations, waste reception areas will be maintained under negative pressure, to ensure that dusts are unable to escape the building. The extracted air will be used as combustion air within the combustion process. The high temperatures within the combustion process will destroy the bioaerosols, and the flue gases from the combustion process will be released from the main stack. Furthermore, the flue gas treatment systems include for bag filters. These are highly effective at abating emissions of particulates, and have an abatement efficiency of 99.9%, or higher depending on the size of the particle. Therefore, any residual bioaerosols which are not destroyed within the combustion process will be abated by the bag filters. On this basis, the likelihood of bioaerosols emissions being released from the Facility during normal operation is considered to be extremely low.

Therefore, the bioaerosol assessment has only considered periods when the Facility is off-line. As discussed in section 2.3, the odour extraction system, including a dust and carbon filter system, will be used to abate the extracted air from waste reception areas. As bioaerosols are particles, a large proportion of them will be abated in this system.

Detailed dispersion modelling has been carried out using ADMS 5.2. The modelling has used the same dispersion model which supported the EP application, and the planning application. Full details of the model assumptions are set out in Appendix A.

Although the odour extraction system will only operate for around 10% of the year, the impact has been modelled for the whole year as this will ensure that the modelling includes for the operation of the odour abatement system during the worst-case atmospheric conditions for dispersion.

5.2 Approach

The approach taken is similar to that used for other pollutants, i.e. comparing the bioaerosol contributions to background levels, to ensure that the process contribution (PC) from the Facility is not significant. A long-term increase of less than 1% is generally taken to be insignificant. The 2008 SLR Report, which was completed for the NRRC, indicated that an increase in levels of bioaerosols within 1 order of magnitude of existing background levels was broadly acceptable to Arla.

Ambient bioaerosol monitoring has been undertaken by Element at the NRRC, as a condition of its permit. The most recent monitoring report[1] at the time of writing reports bioaerosol concentrations of 125 colony forming units per cubic meter (cfu/m^3) upwind of the NRRC, and 250 cfu/m^3 downwind of the NRRC. This implies ambient background levels of 125 cfu/m^3 with an additional contribution of 125 cfu/m^3 from the NRRC.

The bioaerosol release value has been taken from a study by Gladding et al[2]. As part of this study bioaerosols release from residual household waste bins were measured. The aim was to assess the change in bioaerosol release of bins with an extended or missed collection cycle. The maximum recorded value of total bacteria from the waste within an 8-week period was given to be 34,700 cfu/m^3. The 8 week period is considered to be sufficient to cover the longest time that waste delivered to the Facility may have the potential to decompose and release bioaerosols (including collection time and time within the bunker) and the type of waste is considered representative of the majority of the waste to be received by the Facility. Therefore, this has been used as a conservative release rate for the modelling.

This concentration is based on bioaerosols released directly from waste and does not consider the abatement of bioaerosols by the dust or carbon filters within the odour abatement system. Although the filters will remove many of the bioaerosols, the removal efficiencies of these systems in relation to bioaerosols are not defined. Therefore, it has been conservatively assumed that no abatement of bioaerosols takes place and the use of a 34,700 cfu/m^3 release rate has been maintained, but this should be considered a very conservative value as actual levels are likely to be much lower.

5.3 Results

The impact of bioaerosols released from the Facility at the air intakes for the Dairy is presented in Table 4, including the relative impact compared to background levels. Results are the maximum predicted impact at all modelled receptors and using 5 years of weather data from 2015 to 2019.

Table 4: Bioaerosol analysis results at the Air Intake for the Westbury Dairy

Parameter	Maximum annual mean bioaerosols
Concentration (cfu/m^3)	0.38
As a percentage of ambient background levels (125 cfu/m^3)	0.30%

As shown, the modelling results at the air intakes at the Dairy show that the long term contribution of the Facility to bioaerosol levels is less than 1% of background levels, so the change in bioaerosol levels from background levels as a result of the operation of the odour extraction system at the Facility during non-standard operations is considered to be ‘insignificant’.

This is based on the odour extraction system operating for the whole year. However, as explained in section 2.3, it would only be used for approximately 10% of the year, in the event that the demand for process air drops below the air flow required to maintain negative pressure, such as when the Facility is offline. During normal operations, all air from within the bunker will be used for combustion air and all bioaerosols would be incinerated.

[1] Bioaerosol Monitoring, Hills Waste Solutions Limited, 9th March 2021, Element, March 2021

[2] Gladding et al (2017) - A study of the potential release of bioaerosols from containers as a result of reduced frequency residual waste collections

5.3.1 Sensitivity analysis

A sensitivity analysis has been undertaken to quantify the point at which the long term contribution from the Facility may no longer be considered 'insignificant'. For contributions of bioaerosols from the Facility to be 1% of the background levels at the air intakes for the Dairy, the emission concentration of bioaerosols from the waste would have to exceed 185,021 cfu/m^3. This emission value is approximately 5 times greater than the expected and modelled bioaerosols concentration.

According to the 1 order of magnitude approach as in the 2008 SLR Report for the MBT plant, bioaerosol concentration from the Facility would have to reach 1,250 cfu/m^3 before being considered significant. The modelled concentrations are well within this.

6 Taint Impact Assessment

6.1 Background

Engagement with the Dairy and its representatives in 2008 identified those VOC's which could potentially cause taint of the products manufactured at the Dairy, herein referred to as 'VOC's of concern'. An assessment impact of taint was undertaken within the planning application for the NRRC and presented in the 2008 SLR Report.

An assessment of taint on Arla's manufacturing process was also carried out in 2017/18, when NREL was developing a planning application for a waste gasification facility at the same site. At that time, Arla did not raise any objections to the assessment methodology that was applied to determine the impact of taint which was undertaken in support of the planning application; therefore, NREL considers the methodology, and associated assumptions, to be suitable to assess the potential impact of taint from the Facility upon the products manufactured at the Dairy.

In the 2008 SLR Report, the impact was compared to published taint thresholds (health, odour and taste) where available. The taint thresholds for odour and taste were derived from the values published by L.J. van Gemert[3], whilst the health thresholds were taken from a combination of food quality standards, UK drinking water standards and the USEPA national primary drinking water regulations.

6.2 Approach

As explained in section 2, there are two potential sources of VOCs from the Facility.

1. Under normal conditions, air from the waste reception areas will be used within the Facility as combustion air, so the vast majority of the VOCs would be destroyed through the combustion process. However, a small amount of VOCs will be released from the top of the stack.
2. As explained in section 2.3, during periods of both planned and unplanned shutdown of the Facility, the odour abatement system will operate. Air would be released into the atmosphere from the odour stack via the carbon filtration system.

Both of these cases have been considered within this assessment. As Arla's concerns relate to short term impacts on the product, both cases have been modelled for the entire year to ensure that the model captures operation during the worst-case atmospheric conditions for dispersion.

6.2.1 Odour Extraction System

As presented in the 2008 SLR Report, monitoring of VOCs was carried out at an Entsorga MBT Facility, Italy (herein referred to as the Entsorga Facility). The Entsorga Facility was taken as a surrogate for the NRRC, as it utilised a similar waste treatment process and included a biofilter within its design. The monitoring of VOCs was undertaken at both the inlet and the outlet from the biofilter.

Within the 2008 SLR Report, it was assumed that emissions of VOCs would follow the same profile as those monitored at the outlet of the biofilter at the Entsorga Facility. Where the VOC was not detected in the monitoring undertaken in Italy, appropriate library data was applied. If the VOC was

[3] L.J. van Germert, Flavour thresholds, Compilations of flavour threshold values in water and other media (Edition 2003)

not detected in the monitoring undertaken in Italy, or any of the reviewed library data, the threshold for the limit of detection of the monitoring technique was applied.

Whilst the NRRC processes 'similar' waste types to that proposed to be processed at the Facility, it is a very different waste treatment process as it is a biological process. Whilst the waste within the bunker at the Facility will be managed through regular rotation/turning of the waste, it is acknowledged that there will be some biological degradation of waste prior to delivery to the Facility and also within the bunker; however, the biological degradation of the waste will be significantly less than that within an MBT facility given that an MBT facility specifically includes biological degradation and the waste spends much longer in the MBT facility than in the bunker of an EfW facility. Therefore, the generation of VOC's from the degradation of the incoming waste is expected to be significantly less than that at an MBT facility

As the Facility does not include a biofilter, it is not appropriate to assume that the emissions of VOCs from the Facility will be the same as those from the outlet of a biofilter. Therefore, to ensure that this assessment is suitably conservative, it has been assumed that the profile of emissions of VOCs from the degradation of waste within the bunker will be the same as those monitored at the inlet of the biofilter at the Entsorga Facility. However, as the Facility includes a carbon filter, the abatement efficiency of the carbon filters has been taken into consideration in determining the predicted profile of VOC emissions from the odour extraction stack. As stated in section 2.3, recognised suppliers of carbon filter system have advised that the carbon filters would achieve an abatement efficiency of between 95% and 99% for VOCs. The lower end of the range of 95% abatement efficiency has been used in this assessment.

Detailed dispersion modelling has been carried out using ADMS 5.2. The modelling has used the same dispersion model which supported the EP application, and the planning application. Full details of the model assumptions are set out in Appendix A.

The impact was compared to published taint thresholds (health, odour and taste) where available. The taint thresholds for odour and taste were derived from the values published by L.J. van Gemert[4], whilst the health thresholds were taken from a combination of food quality standards, The Water Supply (Water Quality) Regulations 2016[5], and the USEPA national primary drinking water regulations. The taint thresholds (health, odour and taste) for each of the VOCs of concern are set out in Appendix B.

6.2.2 Main Stack

The emissions of total VOCs have already been modelled in the air quality assessment submitted with the EP and planning applications, assuming that the Facility operates at the emission limit of 10 mg/Nm^3. Therefore, this modelling has not been repeated within this assessment. However, the profile of VOC emissions has been considered as there is no reason for the profile of the VOC emissions from the main stack to be the same as the profile of VOC emissions from the odour extraction stack. This is because the VOCs produced by the degradation of waste would be combusted when air is extracted from the bunker and used as combustion air. The VOCs released from the stack would be the products of incomplete combustion.

There is limited information available on the profile of VOCs from the combustion of waste. The most complete analysis is included in a paper from Germany, Jay and Steiglitz (1995)[6]. The analysis

[4] L.J. van Germert, Flavour thresholds, Compilations of flavour threshold values in water and other media (Edition 2003)

[5] The Water Supply (Water Quality) Regulations 2016, Statutory Instrument 2016 No. 614

[6] Jay, K. and Stieglitz, L., Identification and quantification of volatile organic compounds in emissions of waste incineration plants, *Chemosphere* Vol30, No. 7, pp 1249-1260

for this paper noted that 58% of the measured VOC emissions consisted of "… *non-identified aliphatic hydrocarbons*", which are compounds such as methane and ethane, and also identified 250 compounds with measured concentrations of more than 50 ng/Nm^3 in a total measured concentration of 1.2 mg/Nm^3. This data has been used to determine the emission rates for the VOCs previously listed, as follows:

1. For compounds which were detected in the Jay and Steiglitz monitoring, the measured concentration was expressed as a percentage of the total VOC emissions.
2. For compounds which were not detected, it was assumed that they were present at a concentration of 50 ng/Nm^3 (i.e. the lowest reported measured concentration), which is 0.0042% of the measured VOC emissions.
3. For all compounds, these percentages were applied to the emission limit for VOCs from the main stack.

The emission concentrations are shown in Appendix A.

The impact was compared to published taint thresholds, as for the emissions from the odour extraction stack.

6.3 Results

6.3.1 Odour Extraction System

The impact of VOCs potentially released from the odour extraction system at the Facility on the air intakes at the Dairy is displayed in the following tables, including the relative impact compared to the health, taste and odour taint threshold. Results are the maximum predicted hourly average impact at all modelled receptors and using the 5 years of weather data from 2015 to 2019. The VOCs are shown in order of predicted impact, with the highest impacts first.

Table 5: VOC Analysis Results at Westbury Dairy Air Intake – Health Taint

Compound	Max Hourly Conc. at air intake (ng/m^3)	Conc. in product (mg/kg)	Taint threshold (mg/kg)	Taint to conc. ratio
Benzene	14.013	3.78E-04	0.001	0.378
Tetrachloroethylene	61.723	1.67E-03	0.005	0.333
1,2-Dichloropropane	5.338	1.44E-04	0.005	0.029
Dichloromethane	1.418	3.83E-05	0.005	0.008
Trichloroethylene	1.551	4.19E-05	0.005	0.008
1,2 Dichloroethane	0.601	1.62E-05	0.003	0.005
Acrylamide	0.017	4.50E-07	0.0001	0.005
p-Dichlorobenzene	4.838	1.31E-04	0.075	0.002
Toluene	63.391	1.71E-03	1	0.002
Vinyl chloride	0.017	4.50E-07	0.0005	0.001
Hexachlorobenzene	0.017	4.50E-07	0.001	<0.001
Carbon tetrachloride	0.017	4.50E-07	0.005	<0.001
1,1,2-Trichloroethane	0.017	4.50E-07	0.005	<0.001

Compound	Max Hourly Conc. at air intake (ng/m^3)	Conc. in product (mg/kg)	Taint threshold (mg/kg)	Taint to conc. ratio
1,1-Dichloroethylene	0.017	4.50E-07	0.007	<0.001

As shown in Table 5, the modelling results at the air intakes for the Dairy show that the health taint to concentration ratio is well below 1. The maximum impact would be in terms of benzene where the ratio is predicted to be 0.378, i.e. approximately a factor of 2.5 times lower than the health taint threshold.

Table 6: VOC Analysis Results at Air Intake at the Westbury Dairy – Taste Taint

Compound	Max Hourly Conc. at air intake (ng/m^3)	Conc. in product (mg/kg)	Taint threshold (mg/kg)	Taint to conc. ratio
d-Limonene	517.137	1.40E-02	0.1	0.140
Dimethyl sulphide	26.691	7.21E-04	0.006	0.120
2-Methybutanal	28.359	7.66E-04	0.0082	0.093
Butanal	16.348	4.41E-04	0.005	0.088
Styrene	15.514	4.19E-04	0.005	0.084
Heptanonic acid ethyl ester	12.011	3.24E-04	0.005	0.065
2,3 Butanedione	16.181	4.37E-04	0.007	0.062
Phenol	4.671	1.26E-04	0.01	0.013
Hexanal	7.507	2.03E-04	0.049	0.004
Toluene	63.391	1.71E-03	0.5	0.003
Heptanal	2.169	5.86E-05	0.02	0.003
Acetone	118.441	3.20E-03	1	0.003
Pentanal	11.844	3.20E-04	0.13	0.002
Tetrachloroethylene	61.723	1.67E-03	2.8	0.001
Acetaldehyde	2.002	5.40E-05	0.5	<0.001
Ethyl butanoate	0.017	4.50E-07	0.025	<0.001
Ethyl hexanoate	0.017	4.50E-07	0.005	<0.001
Benzaldehyde	6.172	1.67E-04	0.3	0.001
Decanal	0.167	4.50E-06	0.24	<0.001
Trichloroethylene	1.551	4.19E-05	2.6	<0.001

As shown in Table 6, the modelling results at the air intakes for the Dairy show that the taste taint to concentration ratio is well below 1. The maximum impact would be in terms of d-Limonene where the ratio is predicted to be 0.140, i.e. approximately a factor of 7 times lower than the taste taint threshold.

Table 7: VOC Analysis Results at Air Intake at the Westbury Dairy – Odour Taint

Compound	Max Hourly Conc. at air intake (ng/m³)	Conc. in product (mg/kg)	Taint threshold (mg/kg)	Taint to conc. ratio
2-Methybutanal	28.359	7.66E-04	0.0034	0.225
2,3 Butanedione	16.181	4.37E-04	0.0025	0.175
3-Methylbutanal	28.359	7.66E-04	0.0054	0.142
a-Pinene	200.182	5.40E-03	0.064	0.084
Heptanonic acid ethyl ester	12.011	3.24E-04	0.018	0.018
Butanal	16.348	4.41E-04	0.028	0.016
3-Methyl butanonic acid	11.344	3.06E-04	0.022	0.014
Acetaldehyde	2.002	5.40E-05	0.0079	0.007
Pentanoic acid	16.682	4.50E-04	0.061	0.007
Phenol	4.671	1.26E-04	0.026	0.005
Styrene	15.514	4.19E-04	0.1	0.004
Dimethyl sulphude	0.017	4.50E-07	0.0012	<0.001
Methanol	14.680	3.96E-04	25	<0.001
Formaldehyde	18.850	5.09E-04	25	<0.001
Benzaldehyde	6.172	1.67E-04	0.32	0.001
Ethyl butanoate	0.017	4.50E-07	0.028	<0.001
Ethyl hezanoate	0.017	4.50E-07	0.04	<0.001
Carbon disulphide	0.601	1.62E-05	1	<0.001
Toluene	63.391	1.71E-03	9	<0.001
1,2 Dichloroethane	0.601	1.62E-05	9.9	<0.001

As shown in Table 7, the modelling results at the air intakes at the Dairy show that the odour taint to concentration ratio is well below 1. The maximum impact would be in terms of 2-Methybutanal where the ratio is predicted to be 0.225, i.e. approximately a factor of 4 times lower than the odour taint threshold.

6.3.2 Sensitivity analysis

The above analysis has been based on a VOC removal efficiency of 95% which is the lower end of the range expected. As explained in section 2.3, the carbon filtration system will be subject to a robust preventative maintenance regime to ensure that the abatement efficiency remains high by ensuring that the activated carbon is replenished at suitable intervals. A sensitivity analysis has been carried out of the compound for which the greatest impact in relation to the taint threshold has been predicted to demonstrate what abatement efficiency is needed to have a taint to concentration ratio of less than 1, noting that this still conservatively assumes that:

- the transfer rate of product is 90%; and
- the odour extraction system operates during the worst-case weather conditions for dispersion.

This analysis has focussed on the impacts of benzene as this has the greatest taint to concentration ratio. To have a taint to concentration ratio of 1, the abatement efficiency would need to be 87%. This is well within the range achievable by the carbon filter odour abatement system.

6.3.3 Stack emissions

As noted above, the emissions of VOCs have already been modelled in the air quality assessment submitted with the EP and planning applications. The highest hourly ground level concentration of VOCs at any point, using the worst case weather conditions across five years of weather data and assuming that the Facility operates at the long term emission limit for VOCs, was predicted to be 2.13 µg/m^3. The highest hourly ground level concentration of VOCs at the air intake point is predicted to be 2.09 µg/m^3.

The impact of the specific VOCs which are a concern for Arla is displayed in the following tables, including the relative impact compared to the health, taste and odour taint threshold.

Table 8: VOC Analysis Results at Westbury Dairy Air Intake – Health Taint – Main Stack

Compound	Max Hourly Conc. at air intake (ng/m^3)	Conc. in product (mg/kg)	Taint threshold (mg/kg)	Taint to conc. ratio
Benzene	26.133	7.06E-04	0.001	0.706
Dichloromethane	34.843	9.41E-04	0.005	0.188
Acrylamide	0.087	2.35E-06	0.0001	0.024
Vinyl chloride	0.087	2.35E-06	0.0005	0.005
Hexachlorobenzene	0.192	5.17E-06	0.001	0.005
Tetrachloroethylene	0.279	7.53E-06	0.005	0.002
Toluene	59.234	1.60E-03	1	0.002
1,2 Dichloroethane	0.087	2.35E-06	0.003	0.001
1,2-Dichloropropane	0.087	2.35E-06	0.005	<0.001
Trichloroethylene	0.087	2.35E-06	0.005	<0.001
p-Dichlorobenzene	0.889	2.40E-05	0.075	<0.001
Carbon tetrachloride	0.087	2.35E-06	0.005	<0.001
1,1,2-Trichloroethane	0.087	2.35E-06	0.005	<0.001
1,1-Dichloroethylene	0.087	2.35E-06	0.007	<0.001

As shown in Table 8, the modelling results at the air intakes for the Dairy show that the health taint to concentration ratio is below 1. The maximum impact would be in terms of benzene where the ratio is predicted to be 0.706, but the next highest is dichloromethane where the ratio is predicted to be 0.140, i.e. approximately a factor of 5 times lower than the health taint threshold, and the other compounds are over 40 times lower than the threshold.

Table 9: VOC Analysis Results at Air Intake at the Westbury Dairy – Taste Taint – Main Stack

Compound	Max Hourly Conc. at air intake (ng/m³)	Conc. in product (mg/kg)	Taint threshold (mg/kg)	Taint to conc. ratio
Phenol	2.439	6.59E-05	0.01	0.007
Toluene	59.234	1.60E-03	0.5	0.003
Acetone	30.662	8.28E-04	1	0.001
Tetrachloroethylene	0.279	7.53E-06	2.8	<0.001
Acetaldehyde	0.087	2.35E-06	0.5	<0.001
Butanal	0.087	2.35E-06	0.005	<0.001
Ethyl butanoate	0.087	2.35E-06	0.025	<0.001
Styrene	0.087	2.35E-06	0.005	<0.001
Ethyl hexanoate	0.087	2.35E-06	0.005	<0.001
Heptanonic acid ethyl ester	0.087	2.35E-06	0.005	<0.001
Dimethyl sulphide	0.087	2.35E-06	0.006	<0.001
2,3 Butanedione	0.087	2.35E-06	0.007	<0.001
d-Limonene	0.087	2.35E-06	0.1	<0.001
2-Methybutanal	0.087	2.35E-06	0.0082	<0.001
Heptanal	0.087	2.35E-06	0.02	<0.001
Benzaldehyde	2.300	6.21E-05	0.3	<0.001
Decanal	0.087	2.35E-06	0.24	<0.001
Hexanal	0.087	2.35E-06	0.049	<0.001
Trichloroethylene	0.087	2.35E-06	2.6	<0.001
Pentanal	0.087	2.35E-06	0.13	<0.001

As shown in Table 9 , the modelling results at the air intakes for the Dairy show that the taste taint to concentration ratio is well below 1. The maximum impact would be for Phenol where the ratio is predicted to be 0.007, i.e. a factor of over 100 times lower than the taste taint threshold.

Table 10: VOC Analysis Results at Air Intake at the Westbury Dairy – Odour Taint - Main Stack

Compound	Max Hourly Conc. at air intake (ng/m³)	Conc. in product (mg/kg)	Taint threshold (mg/kg)	Taint to conc. ratio
Phenol	2.439	6.59E-05	0.026	0.003
Dimethyl sulphude	0.087	2.35E-06	0.0012	0.002
2,3 Butanedione	0.087	2.35E-06	0.0025	0.001
2-Methybutanal	0.087	2.35E-06	0.0034	0.001
Acetaldehyde	0.087	2.35E-06	0.0079	<0.001

Compound	Max Hourly Conc. at air intake (ng/m^3)	Conc. in product (mg/kg)	Taint threshold (mg/kg)	Taint to conc. ratio
Methanol	0.087	2.35E-06	25	<0.001
3-Methylbutanal	0.087	2.35E-06	0.0054	<0.001
3-Methyl butanonic acid	0.087	2.35E-06	0.022	<0.001
Heptanonic acid ethyl ester	0.087	2.35E-06	0.018	<0.001
Formaldehyde	0.087	2.35E-06	25	<0.001
Benzaldehyde	2.300	6.21E-05	0.32	<0.001
Butanal	0.087	2.35E-06	0.028	<0.001
Ethyl butanoate	0.087	2.35E-06	0.028	<0.001
Ethyl hezanoate	0.087	2.35E-06	0.04	<0.001
Carbon disulphide	0.087	2.35E-06	1	<0.001
Pentanoic acid	0.087	2.35E-06	0.061	<0.001
a-Pinene	0.087	2.35E-06	0.064	<0.001
Toluene	59.234	1.60E-03	9	<0.001
Styrene	0.087	2.35E-06	0.1	<0.001
1,2 Dichloroethane	0.087	2.35E-06	9.9	<0.001

As shown in Table 10, the modelling results at the air intakes at the Dairy show that the odour taint to concentration ratio is well below 1. The maximum impact would be for Phenol again, where the ratio is predicted to be 0.003, i.e. a factor of over 300 times lower than the odour taint threshold.

Across all of the VOCs considered, all except two compounds have predicted impacts which are more than 40 times lower than the threshold. The highest impact is for benzene, where the predicted concentration in the product is 0.0007 mg/kg compared to a threshold value of 0.001 mg/kg. However, this is very much a worst case.

1. UK EfW plants operate well below the emission limit for VOCs, with average emissions of around 0.5 mg/Nm^3 compared to an emission limit of 10 mg/Nm^3. This means that typical concentrations of benzene in the product would be around 20 times lower than assumed.
2. The highest 99.79th percentile hourly average concentration at the air intakes (i.e. the concentration which is only exceeded in 18 hours in a year) is 0.36 $\mu g/m^3$, which is 17% of the peak. Hence, the concentrations of benzene in the product would be at least 5 times lower than modelled for 99.8% of the year.
3. A transfer rate to the product of 90% has been assumed. However, this appears to be overly conservative.
    a. The background concentration of benzene, as reported in the air quality assessment, is 0.39 $\mu g/m^3$, or 390 ng/m^3. If 90% of this concentration were to transfer to the product, then the concentration of benzene in the product would be 0.0105 mg/kg, or around 10 times the heath-based taint threshold of 0.001 mg/kg. Since it is assumed that Arla's current product complies with the health-based taint threshold, the transfer rate to the product must be 10% or less.

b. Applying a transfer rate of 10%, the predicted concentration in the product would be reduced to 7.8% of the threshold for benzene.

Therefore, it is considered that the VOC emissions from the main stack will not lead to any taint of product.

7 Conclusions

This assessment has been produced to assess the impact of odour, bioaerosols and VOCs from the Facility at the Dairy air intakes and the likely risk of taint of Arla's product.

The primary conclusions of the assessment are summarised as follows.

1. The predicted levels of odour from the Facility are not considered to be significant for local people, or to the operations of the Dairy.
2. The change to baseline bioaerosol levels is not considered to lead to a significant risk of blocking the air filtration system at the Dairy.
3. The levels of VOCs expected at the air intakes for the Dairy is not expected to lead to any taint of product (either health, taste or odour), with predicted levels well below the relevant thresholds under normal operation and when the odour extraction system is operating.

Appendices

A ADMS Dispersion Modelling Assumptions

A.1 Selection of model

Detailed dispersion modelling was undertaken using the model ADMS 5.2, developed and supplied by Cambridge Environmental Research Consultants (CERC) This is a new generation dispersion model, which characterises the atmospheric boundary layer in terms of the atmospheric stability and the boundary layer height. In addition, the model uses a skewed Gaussian distribution for dispersion under convective conditions, to take into account the skewed nature of turbulence. The model also includes modules to take account of the effect of buildings and complex terrain.

ADMS is routinely used for modelling of emissions for planning and Environmental Permitting purposes to the satisfaction of the EA and local authorities. The maximum predicted concentration for each pollutant and averaging period has been used to determine the significance of any potential impacts.

A.2 Source and emissions data

A.2.1 Odour Extraction Stack

The principal inputs to the model with respect to emissions from the odour extraction system are presented in the following tables. This data is based on achieving a volume of air equal to 3 times the volume of the tipping hall, the bunker (from the height of the tipping hall floor level to the feed hopper), and the enclosed area above the feed hopper – i.e. 44,000 m^3 x 3 = 132,000m^3/hr or 36.67 m^3/s.

Table 11: Odour Extraction Stack Source Data

Item	Unit	Value
Stack Data		
Height	m	43
Internal diameter	m	1.57
Location	m, m	385705 152021
Flue Gas Conditions		
Temperature	°C	15
Volume at actual conditions	m^3/s	36.67
Exit velocity	m/s	18.9
Odour concentration	OU_E/Nm^3	1,000
Odour release rate	OU_E/s	36,667
Bioaerosol concentration	cfu/m^3	34,700
Bioaerosol release rate	cfu/s	1,272,333

Table 12: Health Taint Compounds – Odour Extraction Stack Emissions

Compound	Emission Conc. Inlet[(1)] ($\mu g/m^3$)	Emission rate [(2)] (g/s)	Source
1,2 Dichloroethane	0.180	6.60E-06	Monitored
Vinyl chloride	0.005	1.83E-07	Lower limit of detection
Benzene	4.200	1.54E-04	Monitored
Tetrachloroethylene	18.500	6.78E-04	Monitored
Dichloromethane	0.425	1.56E-05	Monitored
1,2-Dichloropropane	1.600	5.87E-05	Monitored
Trichloroethylene	0.465	1.71E-05	Monitored
Acrylamide	0.005	1.83E-07	Lower limit of detection
Hexachlorobenzene	0.005	1.83E-07	Lower limit of detection
p-Dichlorobenzene	1.450	5.32E-05	Monitored
Carbon tetrachloride	0.005	1.83E-07	Lower limit of detection
1,1,2-Trichloroethane	0.005	1.83E-07	Lower limit of detection
1,1-Dichloroethylene	0.005	1.83E-07	Lower limit of detection
Toluene	19	6.97E-04	Monitored

Note:

[(1)] Emission concentration taken from 2008 SLR Report from the monitoring at the Entsorga MBT Facility biofilter inlet, and then reduced to allow for an abatement efficiency of 95%, which is the lower end of the range of efficiency for the proposed carbon filtration system .

[(2)] Calculated by multiplying by the volumetric flow rate assuming 3 air change per hour.

Table 13: Taste Taint Thresholds – Odour Extraction Stack Emissions

Compound	Emission Conc. Inlet(1) (µg/m³)	Emission rate (2) (g/s)	Source
Tetrachloroethylene	18.5	6.78E-04	Monitored
Toluene	19.0	6.97E-04	Monitored
Acetaldehyde	0.600	2.20E-05	Monitored
Butanal	4.9	1.80E-04	Monitored
Ethyl butanoate	0.005	1.83E-07	Lower limit of detection
Styrene	4.65	1.71E-04	Monitored
Ethyl hexanoate	0.005	1.83E-07	Lower limit of detection
Heptanonic acid ethyl ester	3.6	1.32E-04	Monitored
Dimethyl sulphide	8.0	2.93E-04	Monitored
2,3 Butanedione	3.350	1.78E-04	Monitored
d-Limonene	155	5.68E-03	Monitored
2-Methybutanal	8.500	3.12E-04	Monitored
Phenol	1.400	5.13E-05	Monitored
Heptanal	0.650	2.38E-05	Monitored
Benzaldehyde	1.850	6.78E-05	Monitored
Decanal	0.050	1.83E-06	Monitored
Acetone	35.5	1.30E-03	Monitored
Hexanal	2.25	8.25E-05	Monitored
Trichloroethylene	0.465	1.71E-05	Monitored
Pentanal	3.55	1.30E-04	Monitored

Note:

(1) Emission concentration taken from 2008 SLR Report from the monitoring at the Entsorga MBT Facility biofilter inlet, and then reduced to allow for an abatement efficiency of 95%, which is the lower end of the range of efficiency for the proposed carbon filtration system.

(2) Calculated by multiplying by the volumetric flow rate assuming 3 air change per hour.

Table 14: Odour Taint Thresholds – Odour Extraction Stack Emissions

Compound	Emission Conc. Inlet(1) ($\mu g/m^3$)	Emission rate (2) (g/s)	Source
Acetaldehyde	0.60	2.20E-05	Monitored
Dimethyl sulphide	0.005	1.83E-07	Monitored
2,3 Butanedione	3.35	1.78E-04	Monitored
2-Methybutanal	8.50	3.12E-04	Monitored
Methanol	4.40	1.61E-04	Monitored
3-Methylbutanal	8.50	3.12E-04	Monitored
3-Methyl butanonic acid	3.40	1.25E-04	Monitored
Heptanonic acid ethyl ester	3.60	1.32E-04	Monitored
Formaldehyde	0.570	2.07E-04	Monitored
Benzaldehyde	1.85	6.78E-05	Monitored
Phenol	1.40	5.13E-05	Monitored
Butanal	4.90	1.80E-04	Monitored
Ethyl butanoate	0.005	1.83E-07	Lower limit of detection
Ethyl hezanoate	0.005	1.83E-07	Lower limit of detection
Carbon disulphide	0.180	6.60E-06	Monitored
Pentanoic acid	5.0	1.83E-04	Monitored
a-Pinene	60.0	2.20E-03	Monitored
Toluene	19.0	6.97E-04	Monitored
Styrene	4.650	1.71E-04	Monitored
1,2 Dichloroethane	0.180	6.60E-06	Monitored

Note:
(1) Emission concentration taken from 2008 SLR Report from the monitoring at the Entsorga MBT Facility biofilter inlet, and then reduced to allow for an abatement efficiency of 95%, which is the lower end of the range of efficiency for the proposed carbon filtration system.
(2) Calculated by multiplying by the volumetric flow rate assuming 3 air change per hour.

For the purpose of dispersion modelling it has been assumed that the odour extraction system is in continuous operation. This ensures that the operation of the odour extraction system during the worst-case weather conditions is account for. However, as explained this system will be controlled automatically by the building management system and will operate automatically during periods of both planned and unplanned shutdown of the Facility, as required.

A.2.2 Main Stack

The source and emissions data for the Main Stack are set out in the air quality assessment included in the permit application. The specific emission rates for the VOCs considered are set out below.

Table 15: Health Taint Compounds – Main Stack Emissions

Compound	Emission Conc (μg/m^3)	Emission rate (g/s)	Source
1,2 Dichloroethane	0.42	2.14E-05	Lower limit of detection
Vinyl chloride	0.42	2.14E-05	Lower limit of detection
Benzene	125.00	6.41E-03	Monitored
Tetrachloroethylene	1.33	6.84E-05	Monitored
Dichloromethane	166.67	8.55E-03	Monitored
1,2-Dichloropropane	0.42	2.14E-05	Lower limit of detection
Trichloroethylene	0.42	2.14E-05	Lower limit of detection
Acrylamide	0.42	2.14E-05	Lower limit of detection
Hexachlorobenzene	0.92	4.70E-05	Monitored
p-Dichlorobenzene	4.25	2.18E-04	Monitored
Carbon tetrachloride	0.42	2.14E-05	Lower limit of detection
1,1,2-Trichloroethane	0.42	2.14E-05	Lower limit of detection
1,1-Dichloroethylene	0.42	2.14E-05	Lower limit of detection
Toluene	283.33	1.45E-02	Monitored

Table 16: Taste Taint Thresholds – Main Stack Emissions

Compound	Emission Conc (µg/m^3)	Emission rate (g/s)	Source
Tetrachloroethylene	1.33	6.84E-05	Monitored
Toluene	283.33	1.45E-02	Monitored
Acetaldehyde	0.42	2.14E-05	Lower limit of detection
Butanal	0.42	2.14E-05	Lower limit of detection
Ethyl butanoate	0.42	2.14E-05	Lower limit of detection
Styrene	0.42	2.14E-05	Lower limit of detection
Ethyl hexanoate	0.42	2.14E-05	Lower limit of detection
Heptanonic acid ethyl ester	0.42	2.14E-05	Lower limit of detection
Dimethyl sulphide	0.42	2.14E-05	Lower limit of detection
2,3 Butanedione	0.42	2.14E-05	Lower limit of detection
d-Limonene	0.42	2.14E-05	Lower limit of detection
2-Methybutanal	0.42	2.14E-05	Lower limit of detection
Phenol	11.67	5.99E-04	Monitored
Heptanal	0.42	2.14E-05	Lower limit of detection
Benzaldehyde	11.00	5.64E-04	Monitored
Decanal	0.42	2.14E-05	Lower limit of detection
Acetone	146.67	7.52E-03	Monitored
Hexanal	0.42	2.14E-05	Lower limit of detection
Trichloroethylene	0.42	2.14E-05	Lower limit of detection
Pentanal	0.42	2.14E-05	Lower limit of detection

Table 17: Odour Taint Thresholds – Main Stack Emissions

Compound	Emission Conc (µg/m^3)	Emission rate (g/s)	Source
Acetaldehyde	0.42	2.14E-05	Lower limit of detection
Dimethyl sulphide	0.42	2.14E-05	Lower limit of detection
2,3 Butanedione	0.42	2.14E-05	Lower limit of detection
2-Methybutanal	0.42	2.14E-05	Lower limit of detection
Methanol	0.42	2.14E-05	Lower limit of detection
3-Methylbutanal	0.42	2.14E-05	Lower limit of detection
3-Methyl butanonic acid	0.42	2.14E-05	Lower limit of detection
Heptanonic acid ethyl ester	0.42	2.14E-05	Lower limit of detection
Formaldehyde	0.42	2.14E-05	Lower limit of detection
Benzaldehyde	11.00	5.64E-04	Monitored
Phenol	11.67	5.99E-04	Monitored
Butanal	0.42	2.14E-05	Lower limit of detection
Ethyl butanoate	0.42	2.14E-05	Lower limit of detection
Ethyl hezanoate	0.42	2.14E-05	Lower limit of detection
Carbon disulphide	0.42	2.14E-05	Lower limit of detection
Pentanoic acid	0.42	2.14E-05	Lower limit of detection
a-Pinene	0.42	2.14E-05	Lower limit of detection
Toluene	283.33	1.45E-02	Monitored
Styrene	0.42	2.14E-05	Lower limit of detection
1,2 Dichloroethane	0.42	2.14E-05	Lower limit of detection

A.3 Other Inputs

A.3.1 Meteorological data and surface characteristics

The impact of meteorological data was taken into account by using weather data from the RAF Lyneham meteorological station for the years 2015 – 2019. Lyneham is approximately 30 km to the west of the Proposed Development and is the closest and most representative meteorological station available.

The EA recommends that 5 years of data are used to take into account inter-annual fluctuations in weather conditions. Wind roses for each year are presented in Figure 1.

The minimum Monin-Obukhov length can be selected in ADMS for both the dispersion site and the meteorological site. This is a measure of the minimum stability of the atmosphere and can be adjusted to account for urban heat island effects which prevent the atmosphere in urban areas from ever becoming completely stable. The minimum Monin-Obukhov length has been set to 30 m (mixed urban and industrial) for the dispersion site. This is deemed most representative of the surrounding area of the site due to the large West Wilts Trading Estate to the north. The meteorological site uses a minimum Monin-Obukhov length of 1 m, appropriate for rural areas.

The surface roughness length can be selected in ADMS for both the dispersion site and the meteorological site. The surface roughness has been set to 0.5 m (parkland and open suburbia) for the dispersion site, which is deemed most appropriate for the mixed industrial and rural surroundings of the dispersion site. The surface roughness has been set to 0.3 m for the meteorological site as this best represents the open fields and rural surroundings of the meteorological site.

A.3.2 Buildings

The presence of adjacent buildings can significantly affect the dispersion of the atmospheric emissions in various ways:

- Wind blowing around a building distorts the flow and creates zones of turbulence. The increased turbulence can cause greater plume mixing.
- The rise and trajectory of the plume may be depressed slightly by the flow distortion. This downwash leads to higher ground level concentrations closer to the stack than those which would be present without the building.

The EA recommends that buildings should be included in the modelling if they are both:

- Within 5L of the stack (where L is the smaller of the building height and maximum projected width of the building); and
- Taller than 40% of the stack.

The ADMS 5.2 user guide also states that buildings less than one third of the stack height will not have any effect on dispersion.

A review of the site layout has been undertaken and the details of the applicable buildings are presented in Table 18. The buildings have been modelled at the height of the highest point of the structure. A site plan showing which buildings have been included in the model is presented in Figure 2. The main building has been selected as the boiler hall.

Table 18: Building Details

Buildings	Centre point X (m)	Centre point Y (m)	Height (m)	Width (m)	Length (m)	Angle (°)
Boiler Hall	385742	152022	40	54.8	28.8	148
ACC	385692	152052.5	23.6	33.9	24.3	148
FGT	385773.8	152052.7	29.7	31.6	28.6	148
Turbine Hall	385738	152048	23.3	33.6	20.3	148
Bunker Hall	385708	151997	32	29.8	52.9	148
Admin Block	385741	151995.6	28.1	24.6	15.1	148
Staircase	385753	152007	34.7	7.7	8.2	148
Tipping Hall and Bottom Ash Storage	385679.4	151996	16	28.4	68.6	148
CHP	385738.7	385738.7	9	8.8	7.6	148

Buildings	Centre point		Height (m)	Width (m)	Length (m)	Angle (°)
	X (m)	Y (m)				
Electrical Rooms	385716	152032	16	21.2	15.5	148

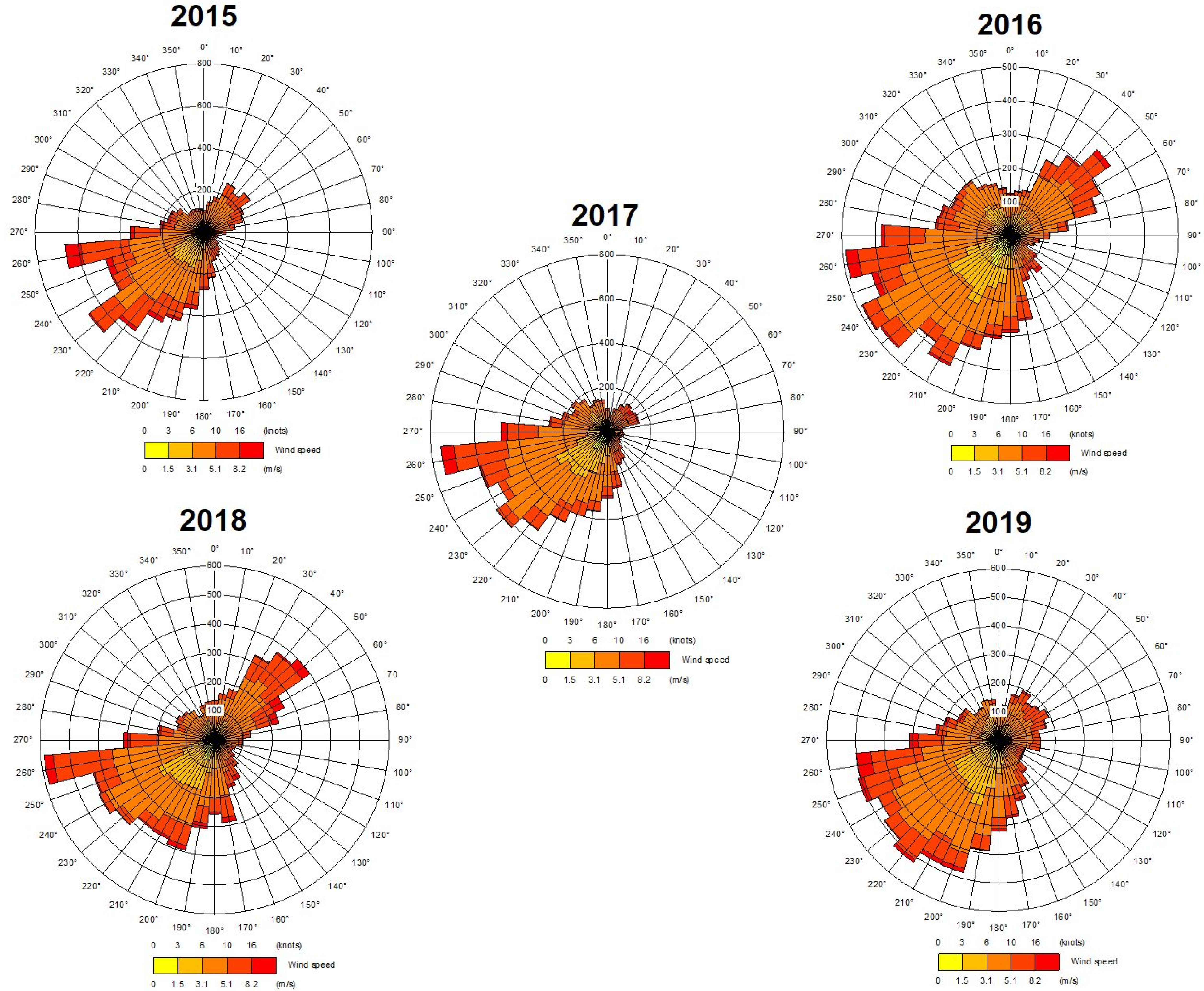
A.3.3 Terrain

It is recommended that, where gradients within 500 m of the modelling domain are greater than 1 in 10, the complex terrain module within ADMS (FLOWSTAR) should be used. A review of the local area has deemed that the effect of terrain should be taken into account in the modelling.

A terrain file large enough to cover the output grid of points was created using Ordnance Survey Terrain 50 data. The parameters of the terrain files used are presented in Table 19.

Table 19: Terrain File Parameters

Parameter	Value
Grid Start X	380750
Grid Finish X	390850
Grid Start Y	147050
Grid Finish Y	157150
Resolution	64 x 64



Client:	Northacre Renewable Energy Ltd
Site:	Northacre
Project:	2862
Title:	

Figure1 - Wind Roses

Drawn by: Rosalind Flavell | Date: 27/07/2021

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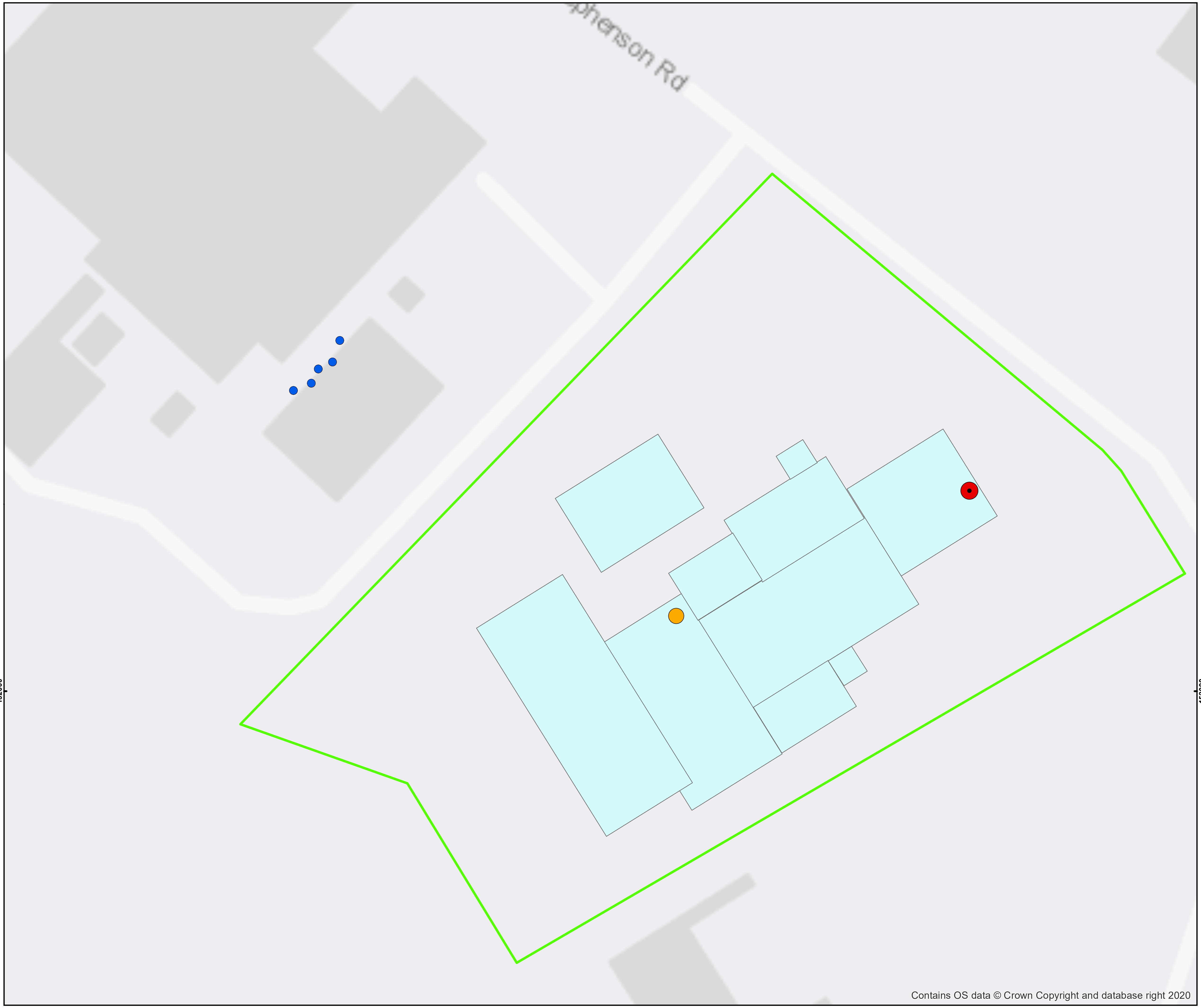
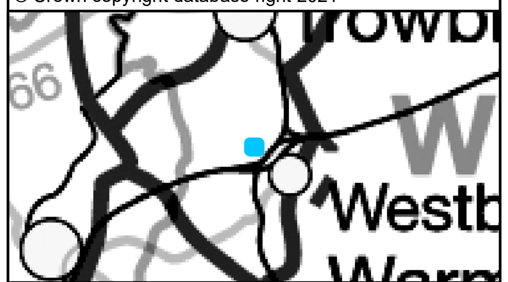
Kingsgate, Wellington Road North,
Stockport, Cheshire, SK4 1LW
Tel: 0161 476 0032
Fax: 0161 474 0618



Legend

- Dairy Intake Receptors
- Odour Stack
- Main Stack
- Buildings
- Installation boundary

Client:	Northacre Renewable Energy Ltd
Site:	Northacre
Project:	2862
Title:	Figure 2 - Dispersion Model Inputs
Drawn by: Rosalind Flavell	Date: 27/07/2021



0 0.01 0.02 0.04 km

Scale: 1:1,000

N

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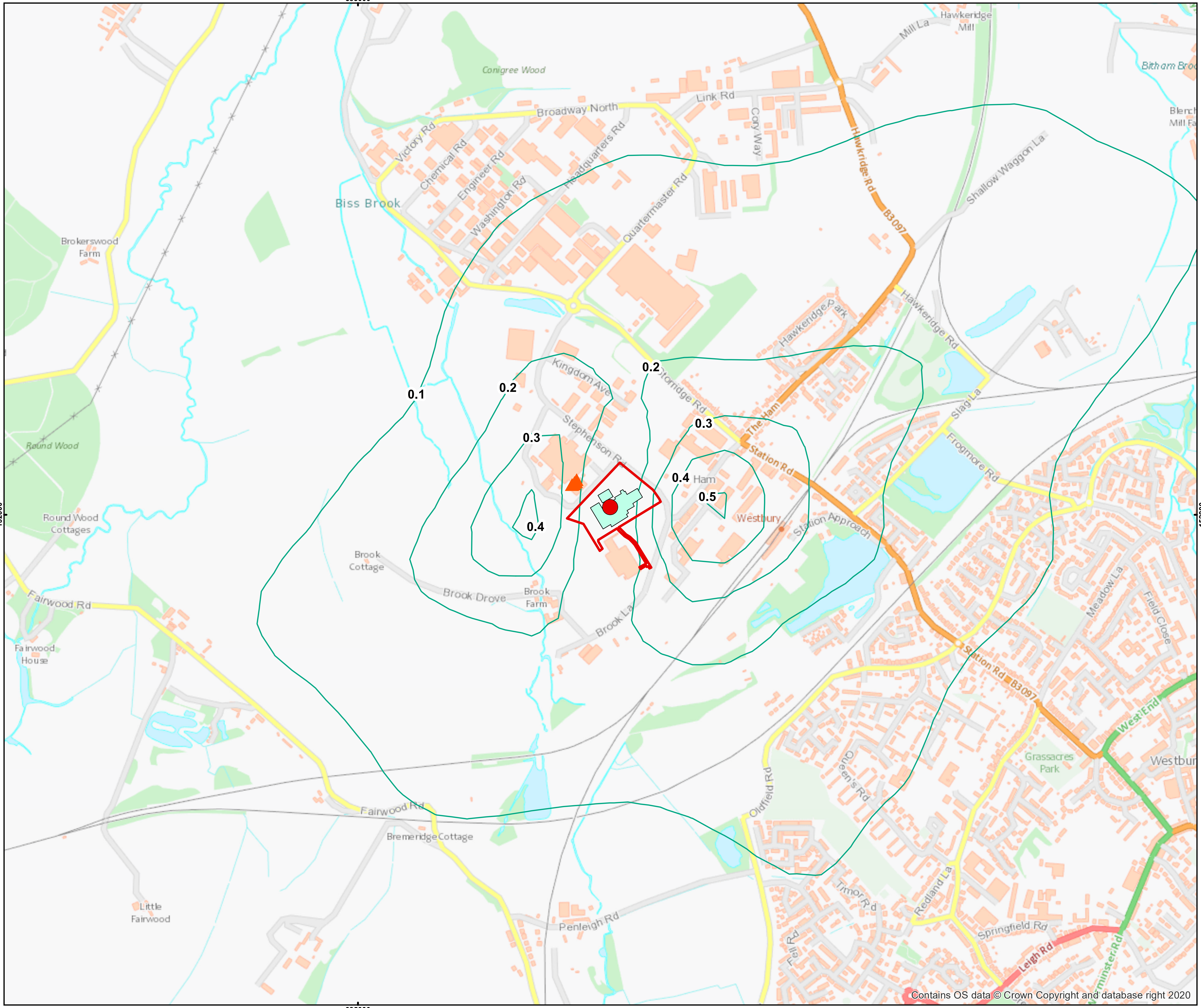
B Odour Impact Assessment Contours



Legend

- Receptors (8 m distance from vents, at 0, 5 and 13 m heights)
- Odour stack
- Northacre Facility building outline
- Northacre Facility Site boundary
- Odour emissions (OUe/m3)

Note: Odour emissions are using the 98th %ile of 1-hour means

Client:	Northacre Renewable Energy Ltd
Site:	Northacre ERF
Project:	2862
Title:	Figure 3 - Odour dispersion

Drawn by: Hannah Lederer | Date: 12/08/2021

Scale: 1:10,000

N

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C Taint Thresholds

Table 20: Health Taint Thresholds

Compound	Taint Limit (mg/l)	Source
1,2 Dichloroethane	0.003	The Water Supply (Water Quality) Regulations 2018
Vinyl chloride	0.0005	The Water Supply (Water Quality) Regulations 2018
Benzene	0.001	The Water Supply (Water Quality) Regulations 2018
Tetrachloroethylene	0.005	USEPA National Primary Drinking Water Regulations
Dichloromethane	0.005	USEPA National Primary Drinking Water Regulations
1,2-Dichloropropane	0.005	USEPA National Primary Drinking Water Regulations
Trichloroethylene	0.005	USEPA National Primary Drinking Water Regulations
Acrylamide	0.0001	The Water Supply (Water Quality) Regulations 2018
Hexachlorobenzene	0.001	USEPA National Primary Drinking Water Regulations
p-Dichlorobenzene	0.075	USEPA National Primary Drinking Water Regulations
Carbon tetrachloride	0.005	USEPA National Primary Drinking Water Regulations
1,1,2-Trichloroethane	0.005	USEPA National Primary Drinking Water Regulations
1,1-Dichloroethylene	0.007	USEPA National Primary Drinking Water Regulations
Toluene	1	USEPA National Primary Drinking Water Regulations

Table 21: Taste Taint Thresholds

Compound	Taint Limit (mg/l)	Source
Tetrachloroethylene	2.8	Alexander et al (1982)
Toluene	0.5	Jeon et al (1978)
Acetaldehyde	0.5	Harvey (1960)
Butanal	0.005	Hvolby (1961)
Ethyl butanoate	0.025	Honkanen et al. (1964)
Styrene	0.005	Milz et al (1980)
Ethyl hexanoate	0.005	Wellnitz-Ruen et al (1982)
Heptanonic acid ethyl ester	0.005	
Dimethyl sulphide	0.006	Golovja & Rothe (1980)
2,3 Butanedione	0.007	Rothe (1978)
d-Limonene	0.1	Harrison & Collins (1968)
2-Methybutanal	0.0082	Reiners & Grosch (1998)
Phenol	0.01	Urback et al (1970, 1972)
Heptanal	0.02	Hvolby (1961)

Compound	Taint Limit (mg/l)	Source
Benzaldehyde	0.3	Joen et al (1978)
Decanal	0.24	Lilart et al (1962), Day et al (1963)
Acetone	1	Harvey (1960)
Hexanal	0.049	Lilart et al (1962), Day et al (1963)
Trichloroethylene	2.6	
Pentanal	0.13	Lilart et al (1962), Day et al (1963)

Table 22: Taste Taint Thresholds

Compound	Taint Limit (mg/l)	Source
Acetaldehye	0.0079	Schnabel et al (1988)
Dimethyl sulphude	0.0012	Kubickova & Grosch (1988)
2,3 Butanedione	0.0025	Hermann & Abd El Salam (1980b)
2-Methybutanal	0.0034	Wagner & Grosch (1988)
Methanol	25	Middleton (1956)
3-Methylbutanal	0.0054	Preiniger & Grosch (1994)
3-Methyl butanonic acid	0.022	Reiners & Grosch (1988)
Heptanonic acid ethyl ester	0.018	Ferreia et al (1998)
Formaldehyde	25	
Benzaldehyde	0.32	Tilgner & Ziminska (1982)
Phenol	0.026	Funasaka et al (1967)
Butanal	0.028	Salo et al (1972)
Ethyl butanoate	0.028	Preiniger & Grosch (1994)
Ethyl hezanoate	0.04	Preiniger & Grosch (1994)
Carbon disulphide	1	Kleinschmidt (1983)
Pentanoic acid	0.061	Stephen & Steinhart (1999)
a-Pinene	0.064	Laska & Teubner
Toluene	9	Ruter (1992)
Styrene	0.1	Moiour & Berger (1977)
1,2 Dichloroethane	9.9	Rosen et al (1979)

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