Odour Impact Assessment

Poultry Processing Facility at the Maelor Foods Plant, Pickhill Lane, Wrexham

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Submitted to:

Mulkh Mehta

Maelor Foods Limited

Prepared by:

RSK ADAS Ltd

Pendeford House

Pendeford Business Park

Wolverhampton

WV9 5AP

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Quality Assurance

Authors:	Checked by:	Issued by:
Laura Donnelly BSc, MSc	Steve Peirson BSc, CEng, CEnv, MIAgrE	Steve Peirson BSc, CEng, CEnv, MIAgrE

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Executive Summary

ADAS has been instructed by Mr Mulkh Mehta of Maelor Foods Ltd to produce a preliminary, odour impact assessment for a consented poultry processing facility at Pickhill Lane, Wrexham, LL13 0UE. Planning permission was granted for change of use of the Maelor Creamery site to a poultry processing facility on 2nd March 2015 (Ref; SES P/2014/0781).

Odours from a small number of sources on site have some potential to cause increases in ground level odour concentrations. An Odour Impact Assessment was therefore commissioned to consider potential odour impacts as a result of the proposed scheme. The modelling assessment inputs and assumptions are set out in the following report.

Process conditions of the proposed facility were used to quantify potential odour impacts at sensitive receptor locations around the proposed plant using dispersion modelling. The results were subsequently compared with appropriate odour benchmark levels to determine the potential for adverse effects in the vicinity of the site.

The results set out in Table 8 show that predicted odour impacts, assuming a 16m stack discharging air from a chemical scrubber, at all receptors are all well below a precautionary impact benchmark of 3.0 ou_E/m^3. Results suggest that the predominant odour source(s) will be from the effluent treatment plant.

The significance of the predicted odour impact is therefore assessed to be '**negligible**' at all receptor locations using the IAQM assessment criterion.

Based on the assessment results, it is anticipated that odour impacts at receptor locations as a result of operation of the proposed poultry processing plant would be negligible. As such, the potential for adverse odour impacts in the vicinity of the site is considered to be low and would not result in loss of local amenity value.

1 Introduction & Plant Description

1.1 Background

ADAS has been instructed by Mr Mulkh Mehta of Maelor Foods Ltd to produce a preliminary, odour impact assessment for a consented poultry processing facility at Pickhill Lane, Wrexham, LL13 0UE. Planning permission was granted for change of use of the Maelor Creamery site to a poultry processing facility on 2nd March 2015 (Ref; SES P/2014/0781).

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1.2 Site Location and Context

The consented poultry processing facility is to be developed on the site of the disused Maelor Creamery, Pickhill Lane, approximately 1 km to the north-north-west of the village of Bangor-on-Dee and approximately 700m to the south-east of the residential area of Cross Lanes. The map at Appendix 1 shows the locations of potentially sensitive receptors around the plant.

There are small numbers of potentially sensitive residential properties located off Pickhill Lane, to the west of the proposed main poultry processing building, and also isolated residences to the north of the plant at Pickhill Old Hall and Whitegate Cottage. The close proximity of sensitive receptors on Pickhill Lane is such that there are risks of off-site odours being caused, and therefore means that high standards of odour management are required.

1.3 Proposed Site Activities

Overview

The plant is concerned with the slaughter and processing of broiler chickens to produce chicken meat and chicken meat products for the food and retail markets. The follow paragraphs describe the key activities in each area of the plant, the odour risks in each area and the key control measures which will be used to reduce odour emissions and/or disrupt the pathways for odours to potential receptors. The odour risk of each area has been assessed based on experience gained at other UK poultry processing plants.

Lairage / Intake

Live chickens from broiler production farms will arrive at the plant in modules on HGV trailers. The HGV trailers will enter a lairage area, before moving to the intake area where the modules will be unloaded. Birds will be transferred from the intake area to the preliminary processing area where the modules will be loaded onto the intake line.

Lairage/intake areas typically generate relatively low levels of odour emissions from the birds themselves and from their droppings. Ventilation is required to maintain good working conditions and particularly to provide comfort for the birds held in this area prior to slaughter. Building air will be extracted to atmosphere through roof mounted vertical discharge fans which will disperse emissions vertically at high level.

There will also be fans which blow air into, and re-circulate air within the building and around the module cages to provide enhanced cooling for the birds in warmer weather. This cooling air will be extracted from the building through roof mounted extraction fans. This is a LOW odour risk area of the plant.

Preliminary Processing Area

Birds will be transferred from the intake area to the preliminary processing area. The module cages will be loaded onto the intake line and the birds will be gas stunned, then removed from the modules and hung-on to the "shackles" of an overhead conveyor line and transferred to a bleeding area. In the bleeding area the birds' heads are removed and blood will drain into, and be collected in, a trough and pumped away at frequent intervals during the day to an enclosed and odour extracted blood storage tank in the offal collection bay. Blood will therefore be removed from the bleeding area before there is any odorous decay and this area will be thoroughly washed and sanitised at the end of each processing day, and this will alleviate the risk of odours from the decay of residues.

The empty modules (crates/cages) will be transferred to the "module washing" area and then transferred to the "box return" service area where they will be loaded onto empty HGV trailers for subsequent re-use in the collection of birds from farms.

Low intensity odour emissions will arise from handling the modules and the birds as they are hung on to the conveying system but emissions are limited because: a) there will only be small numbers of birds in the stunning and hang-on areas at any one time, and b) there will be no significant changes to the state or composition of the chickens within these areas. It is also noted that fresh blood has no significant odour. However, low odour intensity building headspace air from the preliminary processing area will be extracted and dispersed through the roof mounted, vertical discharge, extraction fans. Floors and walls of the kill and bleed area are washed down and sanitised during night shifts and at weekends.

The bird hang-on area will have a specific extraction system with extracted air being treated/filtered through a dust filtration system to remove dust and feathers from the extracted air prior to high level vertical discharge and dispersion through a roof mounted stack.

AeroScalder & De-feather

The birds will be slaughtered mechanically as they move around the conveying system. After bleeding the birds will be conveyed in to a de-feather room where they will be scalded by a saturated hot air system. The birds will be conveyed through the scalding unit to loosen their feathers to facilitate mechanical plucking in the de-feather area. This new technology provides a non-immersion scalding method that minimises water and energy use and has much lower odour emissions as it avoids the large volumes of water containing decaying organic matter that are normally involved in wet "tank"scalding.

AeroScalder is entirely enclosed and consists of two chambers; an air conditioning chamber where the moisturised hot air is prepared and, next to it, the scalding chamber itself through which birds are conveyed and into which the scalding air is blown. Moisturised hot air is blown forcefully onto the most critical parts of the broiler, preventing over scalding of fragile parts. It penetrates and separates the feather pack, transferring heat effectively to the feather follicle. Air temperature depends on whether products are to be hard, medium or soft scalded.

Scald vapours are enclosed inside the unit but any escape of odorous air will be extracted directly into a chemical scrubber for abatement before dispersion to atmosphere through a tall stack.

The spent scald water within the air scalder is filtered and recirculated in the system. Separated waste and overflow water may have a high organic content but the volume flow for discharge to the effluent treatment plant is low so it that the effluent treatment system has a lower flow, and this will minimise balance tank.

Scalding has normally been a high risk odour area of the plant as residual blood, and organic matter from the chicken's feet and feathers progressively decay in the warm water in conventional scald tanks during each production day. Odour emissions are much lower with the Aeroscalder technology, but as a precautionary measure provision is made to extract air from this area of the plant at high rates directly to a **chemical scrubber** odour abatement system. Chemical scrubbers have been used in a number of other UK poultry processing plants to treat higher intensity odour streams.

There will also be fresh air inlets to provide "cooling" air, which will in turn be extracted to the chemical scrubbing abatement system.

Evisceration

After de-feather/plucking, the birds will be mechanically eviscerated in an evisceration area. This involves removal of the birds' intestines and other internal organs (heart, lungs, gizzards, livers etc.). Evisceration does not generate significant emissions of odours because the intestines are not broken and the other organs are not odorous.

Building headspace air in the evisceration areas of the factory will be extracted directly to roof mounted extraction/dispersion fans for mitigation by high level dispersion.

Inedible offal removed during the evisceration process will be transferred by vacuum lines to the animal by-products trailer in the offal collection bay where it will be collected on a daily basis for off-site processing.

Edible offal will be transported away from the evisceration area for chilling and onward dispatch to customers. No offal is therefore allowed to accumulate in the evisceration area, minimising its potential as an odour source

This is a low odour risk area of the plant as the chicken offal is fresh and there is no decay. The building air will be extracted and discharged by roof mounted fans.

Offal Bays – Loading & Removal Building

Feathers will be transferred in a water flume to the offal bay building where they will be separated from the flume water (which is recirculated) and the flume water will be drained down to the effluent treatment plant at the end of each day. The pressed feathers will be loaded into bulk trailers for transport off-site to a rendering plant. Feathers will be removed from the site on a daily basis.

Offal which is not fit for human consumption will also be transferred to the offal bay building where it will also be loaded into to trailers and transported off-site to a rendering plant on a daily basis.

The offal bay waste removal building will be fully enclosed and building headspace air will be extracted directly to the **chemical scrubber and stack** odour mitigation systems.

This is a medium odour risk area of the plant. Although the feather and offal material will be removed from site on a daily basis, before odorous decay becomes established, experience from other sites is that even small traces of animal protein residues on equipment and trailers do result in the generation of some odours.

Blood Storage Tanks

Blood from the bleeding area will be pump/transferred to a blood tank located inside the building housing the feather separation pit which has internal drains to the effluent treatment plant. Poultry blood is not sold on for further processing into foodstuffs for human consumption or pharmaceutical applications so the blood tank will not be refrigerated.

The blood tank will be sealed and fitted with a high level interlocked alarm to prevent overfill. It will have capacity to hold at least 110% of the maximum kill capacity of blood to cover contingencies such as transport delays.

The blood tank will be fully emptied at least daily and regularly cleaned to prevent build-up of odorous residues. There is potential for very high intensity odour emissions from the storage of blood if the blood decays in warmer weather, although this decay is limited in larger processing plants, such as this plant, by the frequent collection and removal of blood from the site. Use of a hopper bottomed tank means that all blood will be removed each time the tank is emptied, and therefore that there are no odorous residues in the tank. The blood storage tank will be connected directly to extraction ducting to the chemical scrubbing odour treatment system.

Air displaced from HGV road tankers collecting blood from the storage tank will be ducted directly into the odour extraction system. This will be achieved by tanker drivers connecting the outlet/exhaust of their tanker vacuum pumps to a flexible hose which will in turn be directly connected to the chemical scrubber abatement system extraction ducting.

This is a high odour risk area of the plant and the building area will be fully enclosed and extracted directly at a rate of at least 3 air changes per hour to the chemical scrubber and stack odour mitigation systems.

Offal Cold Store

Offal material which is fit for human consumption will be transferred to chillers and cold storage areas, where it will be stored before transport off-site. The cold storage buildings will be kept refrigerated to prevent decay, and will be largely “sealed” by means of a cold-store type door.

These are negligible odour risk areas of the plant.

Module Washing

Module cages used to transport chickens to site will be washed in the “box washing” area. Low intensity odour emissions will arise from handling of the empty modules, and building air in the box washing area of the plant will be extracted directly by roof mounted extraction fans for high level dispersion.

This is a low odour risk area of the plant

Truck Washing

Unloaded HGV trailers will move from the intake area to the “truck washing” area where they will be completely washed down before moving to the “box return” area. Low intensity odour emissions may arise from truck washing operations, and air will be extracted directly by roof mounted extraction fans for high level dispersion. This is a low odour risk area of the plant.

Module Return Area

Washed and sanitised module cages will be returned to the “box return” area where they will loaded onto clean HGV trailers. Insignificant odour emissions will arise from box loading operations as both the vehicles and the modules have been washed at this stage. Air will be extracted directly by roof mounted extraction fans for high level dispersion. This is a very low odour risk area of the plant

Effluent Treatment Plant (ETP)

Effluent will be generated predominantly as contaminated wash water from the abattoir and specifically from the de-feather areas and the feather flume system.

The ETP is located downhill beyond the factory buildings, well away from any potential receptors on Pickhill Lane.

Raw effluent will drain to a raw effluent pump sump and from there will be pumped through an enclosed rotary drum screen on top of the balance tank to screen out larger solids from the effluent before treatment. The primary screenings will fall into a skip and full skips will either be covered to minimise odour and keep rainwater out or else be stored inside. The screenings will be transferred into the ABP's trailer in the offal bays.

The balance tank has a retention time at peak flow of 12 hours. This will allow waste streams of high and low organic loading to be combined so the effluent plant will be presented with more even or "average" and more consistent pollutant load flows and not peak or more "concentrated" flows such as occur at the time of discharge of entire scald tanks contents at the end of each production day. There is also a diversion tank which may be used occasionally to segregate effluent in abnormal events such as spillages or to recycle out of specification treated effluent. It is not envisaged that the balance tank will be used other than very occasionally as a contingency because of low volumes of effluent produced by the Aeroscalder system.

The balance and diversion tanks will be agitated by two venturi mixers to mix and aerate their contents and to maintain aerobic conditions and prevent them from going septic and becoming odorous.

The balance and diversion tanks are existing tanks from the former First Milk effluent treatment plant installation. As these tanks are open topped we have assessed the likelihood of odours from them contributing to offsite odours.

From the balance tank effluent will be transferred to a Dissolved Air Flotation (DAF) system to flocculate and separate/remove suspended solids, fats, oils and greases, from where the separated solids will be pumped to a covered sludge storage tank.

DAF plants can generate small volumes of quite intense and offensive odours, so that in this case the DAF plant will be fitted with a stainless steel cover with removable inspection hatches and the headspace will be vented directly to a passive carbon filter for odour removal.

The separated liquid from the DAF plant will be transferred to an activated sludge system tank for aerobic (activated sludge) treatment, prior to final settlement and discharge to river.

The odour from activated sludge tanks is much less offensive than from DAF plants and sludge facilities, and odours are not usually attributable to them unless the system has been overloaded and this has adversely affected the treatment.

In this case the activated sludge plant will consist of an anoxic vessel followed by an aeration tank where the conditioned mixed liquor will be injected with air via fine bubble air diffusion manifolds.

A final settling clarifier tank will remove the remaining suspended solids from the effluent backed up by a rotary disc ultrafilter to guarantee the final effluent quality.

Given the controls in place, the features of the ETP design and its relatively isolated location, there is a low odour risk from this area

ETP Sludge Storage Tanks

A sludge holding tank will store the combined DAF and waste or surplus activated sludge prior to transfer off-site for land spreading or injection by contractors. The sludge tank will be covered and a mixer will be used to keep the sludge mixed. The off gas from the tank headspace will be vented through a passive activated carbon filter.

Air displaced from HGV road tankers collecting sludge from the storage tank will be ducted into a portable, passive activated carbon filter system. This will be achieved by tanker drivers connecting the outlet/exhaust of their tank or tanker vacuum pumps to a flexible hose which will in turn be directly connected to the carbon filter. Odorous air will thus pass through the filters for treatment prior to release into the atmosphere.

Displaced air from the road tanker during sludge transfers will be fed into a portable passive carbon filter to abate odours.

There is a medium odour risk from this area of the plant

Odour Control & Mitigation Systems

Odorous emissions from those areas of the plant which generate the most intense odours, and in particular the scalding/de-feather, feathers/offal/waste removal areas, and the blood storage tanks will be extracted to a chemical scrubbing system to abate odour. The abatement system will be based on a scrubber (or scrubbers), comprising single stage chemical scrubbing with caustic soda and sodium hypochlorite scrubbing liquor and with a final mitigation stage of a tall scrubber dispersion stack to disperse residual odours. The main assessment has been based on a stack height of 16m, however the results of a stack height analysis exercise are displayed in Table 11 in the appendix.

The scrubbing system is a high odour risk area of the plant as it will be abating air extracted from the most odorous areas of the plant and therefore effective scrubber operation is critical to controlling off-site odour impacts.

The off-site impact of room extraction air from the less odorous areas of the plant (lairage, hang-on area, bleeding, evisceration, and the module and trailer washing areas) will be mitigated by dispersion of building headspace air at high level through roof mounted fans. Air extracted from the bird “hang-on” area will be pre-filtered to remove dust before being discharged to atmosphere. These airflows represent low odour risk areas of the plant because of the low odour concentrations associated with these activities and as such, have not been included in the odour impact assessment.

2 Legislation and Policy

2.1 Odour Legislation and Guidance

The following legislation and guidance has been used in this assessment:

- H4: Odour Management, Environment Agency (EA), 2011;
- Odour Guidance for Local Authorities, Department for Environment, Food and Rural Affairs (DEFRA), 2010;
- Environmental Permitting (England and Wales) Regulations (2010); and,
- Guidance on the Assessment of Odour for Planning, Institute of Air Quality Management (IAQM), 2014.

2.2 Odour Definition

DEFRA guidance[1] defines odour as:

"An odour is the organoleptic attribute perceptible by the olfactory organ on sniffing certain volatile substances. It is a property of odorous substances that make them perceptible to our sense of smell. The term odour refers to the stimuli from a chemical compound that is volatilised in air. Odour is our perception of that sensation and we interpret what the odour means. Odours may be perceived as pleasant or unpleasant. The main concern with odour is its ability to cause a response in individuals that is considered to be objectionable or offensive.

Odours have the potential to trigger strong reactions for good reason. Pleasant odours can provide enjoyment and prompt responses such as those associated with appetite. Equally, unpleasant odours can be useful indicators to protect us from harm such as the ingestion of rotten food. These protective mechanisms are learnt throughout our lives. Whilst there is often agreement about what constitutes pleasant and unpleasant odours, there is a wide variation between individuals as to what is deemed unacceptable and what affects our quality of life."

2.3 Odour Impacts

The magnitude of odour impact depends on a number of factors and the potential for adverse impacts varies due to the subjective nature of odour perception. The FIDOR acronym is a useful reminder of the factors that can be used to help determine the degree of odour pollution:

- **F**requency of detection - frequent odour incidents are more likely to result in adverse impacts;
- **I**ntensity as perceived - intense odour incidents are more likely to result in adverse impacts;
- **D**uration of exposure - prolonged exposure is more likely to result in adverse impacts;
- **O**ffensiveness - more offensive odours have a higher risk of resulting in adverse impacts; and,
- **R**eceptor sensitivity - sensitive areas are more likely to have a lower odour tolerance.

It is important to note that even infrequent emissions of odours may cause loss of amenity if odours are perceived to be particularly intense or offensive.

The FIDOR factors can be further considered to provide the following issues in regards to the potential for an odour emission to cause adverse impacts:

- The rate of emission of the compound(s);
- The duration and frequency of emissions;
- The time of the day that this emission occurs;
- The prevailing meteorology (wind direction, wind speeds etc.);

[1] Odour Guidance for Local Authorities, DEFRA, 2010.

- The sensitivity of receptors to the emission i.e. whether the odorous compound is more likely to cause annoyance, such as the sick or elderly, who may be more sensitive;
- The odour detection capacity of individuals to the various compound(s) in odours; and,
- The individual perception of the odour (i.e. whether the odour is regarded as unpleasant). This is quite subjective, and may vary significantly from individual to individual. For example, some individuals may consider some odours as pleasant, such as petrol, paint and creosote, whilst others find them less tolerable.

2.4 Odour Measurement

The concentration at which an odour is just detectable to a human nose is referred to as the detection threshold. This concept of a threshold concentration is the basis of olfactometry in which a quantitative sensory measurement is used to define the concentration of an odour. Standardised methods for measuring and reporting the detectability or concentration of an odour sample have been defined by European standard BS:EN 13725:2003. The concentration at which an odour is just detectable by a panel of selected human odour assessors is defined as the detection threshold and has an odour concentration of 1 European odour unit per cubic metre (1 ou_E/m^3).

At the detection threshold, the concentration of an odour is so low that it is not recognisable as any specific odour at all, but the presence of some, very faint, odour can be sensed when the "sample" odour is compared to a clean, odour-free sample of air.

For a simple, single odorous compound (e.g. H_2S), the concentration of odour present in a sample of air can be expressed in terms of ppm, ppb or mg/m^3. More usually, odours are complex mixtures of many different compounds and the concentration of the mixture can be expressed in ou_E/m^3.

The concept of odour concentrations, expressed as ou_E/m^3, is based on a correlation between a physiological response when odour is detected by the nose and exposure to a particular sample at a specific concentration. The results of this assessment are expressed in terms of a single number. The odour sample assessed can be one of many individual odorous substances or a complex mixture of many substances, and so the odour unit or concentration will vary between test samples. A defined measurement standard for the odour unit is prescribed in the BS:EN standard on olfactometry using n-butanol. This gas is used to select and calibrate odour panel members.

An odour at a strength of 1 ou_E/m^3 is the concentration at which 50% of the population can just detect the odour and 50% cannot within the controlled environment of an odour laboratory[2]. As an odour becomes more concentrated, then it gradually becomes more apparent. Some guidance as to concentrations when this occurs can be derived from laboratory measurements of intensity. The following guideline values have been stated by DEFRA[3] to provide some context for discussion about exposure to typical odours:

- 1 ou_E/m^3 is the point of detection;
- 5 ou_E/m^3 is a faint odour; and,
- 10 ou_E/m^3 is a distinct odour.

It is important to note that these values are based on laboratory measurements and in the general environment other factors affect our sense of odour perception, such as:

- The population is continuously exposed to a wide range of background odours at a range of different concentrations, and usually people are unaware of there being any background odours at all due to normal habituation. Individuals can also develop a tolerance to background and other specific odours. In an odour laboratory the determination of detection threshold is undertaken

[2] Code of Practice on Odour Nuisance from Sewage Treatment Works, DEFRA, 2006.
[3] Odour Guidance for Local Authorities, DEFRA, 2010.

by comparison with non-odorous air, and in carefully controlled, odour-free, conditions. Normal background odours such as those from traffic, vegetation, grass mowings etc., can provide background odour concentrations from 5 to 60 ou_E/m^3 or more;
- The recognition threshold may be about 3 ou_E/m^3, although it might be less for offensive substances or perhaps more likely higher if the receptor is less familiar with the odour or distracted by other stimuli; and,
- An odour which fluctuates rapidly in concentration is often more noticeable than a steady odour at a low concentration.

2.5 Odour Benchmark Levels

Minimising waste and pollution is a key component of the National Planning Policy Framework (NPPF)[4]. There is no specific guidance for odour; however, odour is defined as pollution within the framework. It is stated in the framework that planning decisions must reflect and where appropriate promote relevant obligations and statutory requirements, for example, the Pollution Prevention and Control Act and Environmental Permitting (England and Wales) Regulations 2010 (as amended).

Since the early 1990s the technique of odour dispersion modelling has become well established as a means of assessing the off-site odour impact of a very wide range of odorous activities and particularly sewage/wastewater and intensive livestock farming (poultry and pigs). Odour impact benchmark levels have been developed as a matter of "custom and practice", of which the best established is the so-called "Newbiggin" standard.

The widely accepted convention in the UK is that odour impacts are expressed as 98th percentile (%-ile) hourly means, and these standards have been based on "dose-response"relationships which take account of normal temporal and metrological variations in downwind/off-site odour impacts.

2.5.1 The Newbiggin Standard

This empirical standard, of 5.0 ou/m^3 at the 98th %-ile, has been widely used in the wastewater (sewage) sector in the UK and elsewhere, to assess the likelihood of community annoyance. This standard was derived from an early 1990s planning appeal decision relating to an appeal by Northumberland Water for the construction of a wastewater treatment facility at Newbiggin-by-the-Sea in Northumberland in which evidence on potential off-site odour impacts was presented using odour dispersion modelling. The decision in this appeal case was the origin of the now well-established "Newbiggin" criterion that has been used, and is still used to this day, for odour impact assessments.

2.5.2 UKWIR Research

In 2001 the UK Water industry Research (UKWIR) organisation undertook research into correlations between (dispersion) modelled odour impact and the distribution of odour complaints around wastewater (sewage) treatment works. The findings of this work were concisely summarised in a Chartered Institute of Water and Environmental Management (CIWEM) document[5]:

> *"The main source of research into odour impacts in the UK has been the wastewater industry and the most in-depth study published study in the UK of the correlation between of modelled odour impacts and human response (dose-effect) was published by UK Water industry Research (UKWIR) in 2001. This was based on a review of the correlation between reported odour complaints and modelled odour impacts in relation to 9 wastewater treatment works in the UK with ongoing odour complaints. The findings of this research (and subsequent UKWIR research) indicated the following:*

[4] National Planning Policy Framework, Department for Communities and Local Government, 2012.
[5] Policy Position Statement: Control of Odour. CIWEM, 2012.

- *At modelled exposures of below $C_{98,\ 1\text{-hour}}$ 5ou$_E$/m^3, complaints are relatively rare, at only 3% of the total registered;*
- *At modelled exposures between $C_{98,\ 1\text{-hour}}$ 5ou$_E$/m^3 and $C_{98,\ 1\text{-hour}}$ 10ou$_E$/m^3, a significant proportion of total registered complaints occur; 38% of the total;*
- *The majority of complaints occur in areas of modelled exposure greater than $C_{98,\ 1\text{-hour}}$ 10ou$_E$/m^3, 59% of the total."*

In effect these findings demonstrated that with appropriate modelling, potential odour impact and annoyance is effectively controlled at 98th%-ile hourly mean odour impacts of 5 ou$_E$/m^3 or less. These findings are consistent with the Newbiggin standard as well as with ADAS experience of correlating odour impacts/complaints (and the absence of complaints) with dispersion modelling results.

2.5.3 Environment Agency Criteria

The EA has published the H4 guidance on odour[6] in 2011 and it contains indicative benchmark levels for use in the assessment of potential impacts from facilities regulated under the Environmental Permitting (England and Wales) Regulations (2010) and subsequent amendments.

Benchmark levels are stated as the annual 98th perecntile (%-ile) hourly mean concentrations in ou$_E$/m^3 for odours of different offensiveness. In practice this is the 175th highest hourly average recorded in the year. This parameter reflects the previously described FIDOR factors, where an odour is likely to be noted on several occasions above a particular threshold concentration before an annoyance occurs. EA odour benchmark levels are summarised in Table 1.

Table 1 Odour Benchmark Levels

Relative Offensiveness of Odour	Benchmark Level as 98th%-ile 1-hour mean (ou$_E$/m^3)
Most offensive odours: • Processes involving decaying animal or fish • Processes involving septic effluent or sludge • Biological landfill odours	1.5
Moderately offensive odours: • Intensive livestock rearing • Fat frying (food processing) • Sugar beet processing • Well aerated green waste composting	3.0
Less offensive odours: • Brewery • Confectionery • Coffee roasting • Bakery	6.0

2.5.4 Conclusions on Odour Benchmarks

It should be noted that the prediction that any particular property lies above a particular 98th perecntile odour concentration level does not necessarily imply that a loss of residential amenity (or a nuisance) will follow. However, it is suggested that the probability of such an occurrence is increased in proportion to the exceedence.

[6] H4: Odour Management, EA, 2011.

ADAS has generally found that a range of odours are unlikely to cause adverse impacts with annual 98th percentile odour concentrations of less than 5.0 ou_E/m^3 over a five year period. However, once exposure exceeds 5.0 ou_E/m^3 at the annual 98th percentile, then there is an increasing risk of annoyance and complaints and above 10.0 ou_E/m^3 (as an hourly mean at the annual 98th percentile) some complaints would normally be expected.

Odours from the poultry rearing sources are commonly placed in the moderately offensive category and that would seem to be the most appropriate H4 benchmark in this case as odours from the processing activities are dominated by poultry type odours rather than by any septic or decaying components. The target suggested in H4 for moderately offensive odours is an hourly mean odour concentration of 3.0 ou_E/m^3 at the 98th percentile.

As a compromise between the various impact standards, and taking account of the range and types of odour emissions rates and odour "characters" an hourly mean odour concentrations of 3.0 ou_E/m^3 to 5.0 ou_E/m^3 at the 98th percentile are used in this study as a guideline to assess the range above which some loss of residential amenity may occur.

2.6 National Planning Policy

The NPPF[7] was published on 27th March 2012 and sets out the Government's core policies and principles with respect to land use planning, including air quality. The document includes the following considerations which are relevant to this assessment:

> *"The planning system should contribute to and enhance the natural and local environment by: […] Preventing both new and existing development from contributing to or being put at unacceptable risk from, or being adversely affected by unacceptable levels of soil, air, water or noise pollution or land instability"*

The implications of the NPPF have been considered during the production of this report.

2.7 Institute of Air Quality Management Guidance

The IAQM published the 'Guidance on the Assessment of Odour for Planning'[8] document on 20th May 2014. This guidance specifically deals with assessing odour impacts for planning purposes, namely potential effects on amenity. The assessment methodology outlined in the guidance has been utilised in this report to aid interpretation of the modelling results.

[7] National Planning Policy Framework, Department for Communities and Local Government, 2012.
[8] Guidance on the Assessment of Odour for Planning, IAQM, 2014.

3 Assessment Methodology

The proposed facility may result in odour emissions during normal operations. These were assessed in accordance with the following stages:

- Identification of odour sources;
- Identification of odour emission rates;
- Dispersion modelling of odour emissions; and,
- Comparison of modelling results with relevant criteria.

The following sections outline the methodology and inputs used for the assessment.

3.1 Odour Sources & Emission Rates

Odorous emissions from those areas of the plant which generate the most intense odours, and in particular the de-feather, feathers/offal/waste removal areas, and the blood storage tanks will be extracted to a chemical scrubbing system to abate odour. The abatement system will be based on one scrubber, comprising single stage chemical scrubbers with caustic soda and sodium hypochlorite scrubbing liquor and with a final mitigation stage of a tall scrubber dispersion stack to disperse residual odours.

The scrubbing system is a high odour risk area of the plant as it will be abating air extracted from the most odorous areas of the plant and therefore effective scrubber operation is critical to controlling off-site odour impacts.

The off-site impact of room extraction air from the less odorous areas of the plant (lairage, hang-on area, bleeding, evisceration, and the module and trailer washing areas) will be mitigated by dispersion of building headspace air at high level through roof mounted fans. Air extracted from the bird "hang-on" area will be pre-filtered to remove dust before being discharged to atmosphere. These airflows represent low odour risk areas of the plant because of the low odour concentrations associated with these activities and as such, have not been included in the odour impact assessment.

The emission rate from the scrubber stack has been calculated based on an approx. total extraction from the offal bay, defeathering/scald room and blood tank of 30,600 m^3/hour (8.5m^3/s), and an odour concentration in treated air off the scrubber of 2,000 ou_E/m^3. The extraction rate to the scrubber is calculated from extraction rates of 3 air changes per hour from the offal bay (9,500 m^3/hour) and feather pit/blood tank room (2,200 m^3/hour) and 3,600 m^3/hour for each end of the Aeroscalder and 250 m^3/hour per metre length of the scalder (33.5 m) plus 10% for contingency ventilation.

Odour emission rates for the effluent plant have been based on library data for analogous processes in wastewater treatment plants and it has been assumed that the balance tank will be in use continuously.

Table 2a Point Source Emission Rates from Stack

Source	Odour Emission Rate ou_E/s
Scrubber stack	17,000

Table 2b Area Source Emission Rates from Effluent Treatment Plant

Source	Height (m)	Length/ diameter (m)	Widt h (m)	Area (m^2)	Area Specific Emission Rate ($ou_E/m^2/s$)
Balance Tank	5	18	-	254.5	20
Sediment Tank 1	5	13	-	132.7	1
Sediment Tank 1	5	13	-	132.7	1
Aeration	5	18	-	254.5	10
Anoxic	5	5	-	19.6	20

Table 2c Volume Source Emission Rates from Effluent Treatment Plant

Source	Height (m)	Release Height (m)	Length	Width (m)	Volume (m^3)	Volume Source Emission Rate ($ou_E/m^3/s$)
DAF Tank	5	2.5	20	15	1,500	2.222

3.2 Dispersion Modelling

Dispersion modelling was undertaken using ADMS 5 (v5.1.2), which has been developed by Cambridge Environmental Research Consultants (CERC) Ltd. ADMS 5 is a steady-state atmospheric dispersion model that is based on modern atmospheric physics. It is a new generation model utilising boundary layer height and Monin-Obukhov length to describe the atmospheric boundary layer and a skewed Gaussian concentration distribution to calculate dispersion under convective conditions.

The model utilises hourly meteorological data to define conditions for plume rise, transport and diffusion. It estimates the concentration for each source and receptor combination for each hour of input meteorology, and calculates user-selected long-term and short-term averages.

ADMS 5 has been chosen because it is "fitted for the purpose of the modelling procedure" as defined by the guidelines published by the Royal Meteorological Society[9,10]. The group that leads the development of ADMS 5 is CERC, but the UK Met Office and others have made significant contributions. The model has been extensively validated against site measurements. Details of these validation studies and information on the development of ADMS are available on the CERC website.

3.2.1 Modelling Scenarios

The scenarios considered in the modelling assessment are summarised in Table 3.

Table 3 Dispersion Modelling Scenarios

Scenario	Modelled As Short Term
Odour	98^{th}%-ile 1-hour mean-

9 Guidelines issued by the Royal Meteorological Society. Meteorological Applications, 2: 83–88, Britter, R., Collier, C., Griffiths, R., Mason, P., Thomson, D., Timmis, R. and Underwood, B., 1995.

10 Guidelines for the Preparation of Dispersion Modelling Assessments for Compliance with Regulatory Requirements – an Update to the 1995 Royal Meteorological Society Guidance. Ireland, M.,Jones, J., Griffiths, R.,Nb, B. and Nelson, N., 2006.

3.2.2 Modelled Emissions

Model input parameters are summarised below in Table 4.

Table 4 Stack Model Parameters

Parameter	Value	Unit
Velocity	15	m/s
Temperature	20	˚C
Diameter	0.85	m
Release Height	16*	m

*Additional stack heights have been considered. The results are displayed in Table 11 in the Appedix.

Figure 2 in Appendix I provides a graphical representation of the modelled odour sources.

3.2.1 Assessment Extents

A 1km x 1km grid has been used to produce the contour map presented in the results of this study and was defined at a resolution of 50 m. The grid points were defined at a height of 1.5 m above ground level. Figure 3 in Appendix I provides a graphical representation of the nested grid.

3.2.2 Sensitive Receptors

A sensitive receptor is defined as any location which may be affected by changes in air quality as a result of a development. These have been defined for odour impacts in the following Sections.

A desk-top study was undertaken in order to identify any sensitive receptor locations in the vicinity of the site that required specific consideration during the assessment. These are summarised in Table 5.

Table 5 Sensitive Receptor Locations

Receptor		National Grid Reference (Coordinates) (m)	
ID	Location	X	Y
R1	Residential Properties to west-south-west	338397.5	346727
R2	Residential Properties to west-south-west	338303.7	346663.5
R3	Residential Properties to west-south-west	338283.5	346643.3
R4	Residential Properties to west-south-west	338264.7	346624.5
R5	Industrial premise to south	338635.8	346396.4
R6	Residential and agricultural properties to north-east	338801.8	346962.4
R7	Whitegate Cottage	338643	347075
R8	Residential and agricultural property off A525	338214.2	346452.7
R9	Residential property off A525	338074.1	346496
R10	Residential property off A525	337955.7	346602.8
R11	Residential property off A525	337900.8	346644.7
R12	Residential property off A525	337827.2	346722.7
R13	School Farm	337962.9	347079.3
R14	Mayfield House	338084.2	347293
R15	Mangre Cottages	338153.5	347337.8

Figure 4 in Appendix 1 provides a graphical representation of the modelled receptor locations.

The sensitive receptors identified in Table 5 represent the most obvious potential receptor locations. However, this is not an exhaustive list and there may be other locations within the vicinity of the site that may experience odour impacts as a result of the development that have not been individually identified above. Impact at any other locations of interest can be assessed from the odour contours in Figure 5 in Appendix 1.

3.2.3 Terrain Data

Ordnance Survey Landform Panorama terrain data was not included in the main model for the site as the area around the site is very flat and does not contain any slope greater than 1:10. Terrain was however included in a sensitivity analyisis assessment and these results are shown in Table 12 in the appendix.

3.2.4 Building Effects

The dispersion of substances released from elevated sources can be influenced by the presence of buildings close to the emission point. Structures can interrupt the wind flows and cause significantly higher ground-level concentrations close to the source than would arise in the absence of the buildings.

Analysis of the site layout indicated that the plant structures should be included within the model in order to take account of effects on pollutant dispersion. As the buildings are not in a simple layout, they have been divided up into smaller rectangles using an average building height of 8m. Building input geometries are shown in Table 6.

Table 6 Building Geometries

Building		NGR (m)		Height (m)	Length/ Diameter (m)	Width (m)	Angle (°)
ID	Description	X	Y				
1	Plant	338558.3	346731.7	8	63.2	37.2	157
2	Plant	338521.3	346757.6	8	23.4	10.2	155.9
3	Plant	338488.5	346746.6	8	28.8	58.7	156.5
4	Plant	338510.7	346708.3	8	58.5	68.7	157.1
5	Plant	338545.9	346670.4	8	38.9	54.8	157.1

Figure 2 in Appendix 1 provides a graphical representation of the modelled building layout as used in the ADMS 5 model input.

3.2.5 Roughness Length

A roughness length (z_0) of 0.2 m was used in the dispersion modelling study. This value of z_0 is considered appropriate for the morphology of the assessment area and the meteorological station and is suggested within ADMS 5 as being suitable for 'agricultural areas (max)'.

3.2.6 Monin-Obukhov Length

The Monin-Obukhov length provides a measure of the stability of the atmosphere. A minimum Monin-Obukhov length of 10 m was used in the dispersion modelling study and the meteorological station and is suggested within ADMS 5 as being suitable for 'small towns < 50,000'.

3.2.7 Meteorological Data

Meteorological data used in this assessment was taken from Shawbury meteorological station, over the period 1st January 2010 to 31st December 2014 (inclusive). Shawbury meteorological station is located at

NGR: 355597, 322475 which is approximately 20 km to the south-east of the proposed development and is at a similar elevation to the proposed site. LAQM.TG(09)[11] recommends meteorological stations within 30 km of an assessment area as being suitable for detailed modelling.

All meteorological data used in the assessment was provided by the ADM Ltd. Figure 6 in Appendix 1 shows the wind rose for Shawbury meteorological data. It is important to note that the wind rose shows the direction from which the wind blows. The windrose shows that the prevailing wind direction is westerly, that is wind blowing from the west.

3.2.8 Modelling Uncertainty

Uncertainty in dispersion modelling predictions can be associated with a variety of factors, including:

- Model uncertainty - due to model limitations;
- Data uncertainty - due to errors in input data, including emission estimates, land use characteristics and meteorology; and,
- Variability - randomness of measurements used.

Potential uncertainties in model results have been minimised as far as practicable and worst-case inputs used in order to provide a robust assessment. This included the following:

- Choice of model - ADMS 5 is a commonly used atmospheric dispersion model and results have been verified through a number of studies to ensure predictions are as accurate as possible;
- Meteorological data - Modelling was undertaken using 5-years of annual meteorological data sets from the closest observation site to the facility to take account of local conditions;
- Plant operating conditions - Plant operating conditions were provided Maelor Poultry. As such, these are considered to be representative of operating conditions;
- Receptor locations - A Nested Grid was included in the model in order to calculate maximum predicted concentrations throughout the assessment extents. Receptor points were also included at sensitive locations to provide additional consideration of these areas; and,
- Variability - All model inputs are predicted as accurately as possible and worst-case conditions were considered as necessary in order to ensure a robust assessment of potential odour concentrations.

Results are considered in the context of the relevant odour benchmark level. It is considered that the use of the stated measures to reduce uncertainty and the use of worst-case assumptions when necessary has resulted in model accuracy of an acceptable level.

3.2.9 Modelling Period

The EA, in the H4 guidance, recommends that a minimum of three years, and preferably five years, should be used to calculate the 98th percentile of the hourly mean odour concentrations, in order to represent conditions for an "average year". The Institute of Air Quality Management (IAQM) (2014) also recommends that five years of data should be used and that individual years should be modelled. Comparisons of single yearly statistics will show the range, or sensitivity, of the modelled 98th percentile odour concentrations to meteorological data. For example, a particular year may have a number of periods where dispersion conditions are very poor, leading to higher annual 98th percentile values. ADAS has used the mean 98th percentile of the hourly mean odour concentrations over a five year period to provide statistically robust results, smoothing out inter-annual variations.

3.2.10 Assessment of Significance

In accordance with the IAQM (2014) guidance on the assessment of odour, the significance of the odour impact has been assessed in relation to the magnitude of the impact and the sensitivity of the receptor.

[11] Local Air Quality Management Technical Guidance LAQM.TG(09), DEFRA, 2009.

The magnitude scale has been developed based on the suggested odour benchmarks above for odours in the moderately offensive category. The magnitude is combined with the receptor sensitivity to determine the significance of the impact as shown in Table 7.

It is important to note however that there is limited evidence of the dose related odour impact in the community and therefore assigning significance is not as straightforward as simply following the matrix in Table 7. Although the matrix acts as a guide, professional judgement still needs to be used to take into account various factors such as a community's existing tolerance of odours.

Table 7 Matrix for Assessing the Significance of Impacts Predicted by Modelling

Odour Exposure Level C_{98}, ou_E/m^3	Receptor Sensitivity		
	Low	Medium	High
>10	Moderate	Substantial	Substantial
5 – 10	Slight	Moderate	Moderate
3 – 5	Slight	Slight	Moderate
1.5 – 3	Negligible	Slight	Slight
0.5 – 1.5	Negligible	Negligible	Negligible
<0.5	Negligible	Negligible	Negligible

3.3 Assessment Criteria

In order to provide a robust assessment, predicted ground level odour concentrations have been compared with an odour benchmark range of 3.0 to 5.0 ou_E/m^3 as a 98^{th}%-ile of 1-hour mean as a guideline to assess the point above which some loss of residential amenity may start to occur.

4 Results

4.1 Odour Impacts

Dispersion modelling of odour emissions was undertaken with the inputs described in Section 3 over the five year weather file so that the results represent "average year" data as set out in the H4 guidance.

Figures 5 in the Appendix shows a graphical representation of predicted odour concentrations as contours in the area around the site based on results of a 16m stack

Five year average mean 98th%-ile 1-hour mean odour concentrations based on emissions from a 16m stack and the effluent treatment plant individually and in combination at modelled discrete receptor locations are summarised in Table 8.

In addition to the long term average data, Table 10 in the Appendix also details individual year average mean 98th%-ile 1-hour odour concentrations, Table 11 looks at stack height analysis and Table 12 details terrain sensitivity analysis based on emissions from a 1m stack and he effluent treatment plant.

Table 8 Predicted Odour Concentrations

Receptor		Predicted Five year Average Mean 98th%-ile 1-hour mean Odour Concentrations (ou_E/m^3)		
		16m Stack and ETP	16m Stack Only	ETP Only
R1	Residential Properties to west-south-west	1.46	0.62	1.34
R2	Residential Properties to west-south-west	1.07	0.34	0.90
R3	Residential Properties to west-south-west	0.98	0.29	0.78
R4	Residential Properties to west-south-west	0.89	0.25	0.72
R5	Industrial premise to south	0.78	0.28	0.64
R6	Residential and agricultural properties to north-east	1.43	0.37	1.42
R7	Whitegate Cottage	0.73	0.29	0.61
R8	Residential and agricultural property off A525	0.55	0.12	0.44
R9	Residential property off A525	0.49	0.12	0.35
R10	Residential property off A525	0.44	0.12	0.29
R11	Residential property off A525	0.41	0.12	0.28
R12	Residential property off A525	0.40	0.12	0.23
R13	School Farm	0.30	0.10	0.17
R14	Mayfield House	0.27	0.10	0.15
R15	Mangre Cottages	0.28	0.11	0.15

The results set out in Table 8 show that predicted odour impacts, assuming a 16m stack discharging air from a chemical scrubber, at all receptors are all well below the precautionary impact benchmark range of 3.0 to 5.0 ou_E/m^3 and are also below a more precautionary 1.5 ou_E/m^3 benchmark.

Figure 5 provides a graphical representation of 5-year average mean predicted odour concentrations throughout the assessment area. This map shows the highest odour impacts in close proximity to the odour sources, with concentrations reducing over short distances from the plant. Assessment of Significance

An assessment of the significance of odour impacts from the proposed development scenario at each receptor are assessed below in Table 9 using the IAQM criterion. As a precautionary measure a sensitivity rating of 'high' has been applied to all receptors considered in the modelling.

Table 9 Significance of Modelled Odour Emissions at Surrounding Receptors

Receptor		Predicted 98^{th}%-ile 1-hour mean Odour Concentrations (ou_E/m^3)	Significance
R1	Residential Properties to west-south-west	1.46	Negligible
R2	Residential Properties to west-south-west	1.07	Negligible
R3	Residential Properties to west-south-west	0.98	Negligible
R4	Residential Properties to west-south-west	0.89	Negligible
R5	Industrial premise to south	0.78	Negligible
R6	Residential and agricultural properties to north-east	1.43	Negligible
R7	Whitegate Cottage	0.73	Negligible
R8	Residential and agricultural property off A525	0.55	Negligible
R9	Residential property off A525	0.49	Negligible
R10	Residential property off A525	0.44	Negligible
R11	Residential property off A525	0.41	Negligible
R12	Residential property off A525	0.40	Negligible
R13	School Farm	0.30	Negligible
R14	Mayfield House	0.27	Negligible
R15	Mangre Cottages	0.28	Negligible

At all discrete receptor points included in the assessment, the significance of the predicted odour impact are assessed to be 'negligible'. It is therefore is very unlikely that there would be any loss of local residential amenity as a result of the proposed poultry processing facility.

Based on the assessment results, it is not anticipated that there is a significant risk of adverse odour impacts occurring at any sensitive location as a result of emissions from the proposed development. As such, the potential for adverse odour impacts at sensitive receptor locations is considered to be low.

5 Conclusions

ADAS has been instructed by Mr Mulkh Mehta of Maelor Foods Ltd to produce a preliminary, odour impact assessment for a consented poultry processing facility at Pickhill Lane, Wrexham, LL13 0UE. Planning permission was granted for change of use of the Maelor Creamery site to a poultry processing facility on 2nd March 2015 (Ref; SES P/2014/0781).

Odours from a number of small sources on site have some potential to cause increases in ground level odour concentrations. An Odour Impact Assessment was therefore commissioned to consider potential odour impacts as a result of the proposed scheme. The modelling assessment inputs and assumptions are set out in the following report.

Process conditions of the proposed facility were used to quantify potential odour impacts at sensitive receptor locations around the proposed plant using dispersion modelling. The results were subsequently compared with appropriate odour benchmark levels to determine the potential for adverse effects in the vicinity of the site.

The results set out in Table 8 show that predicted odour impacts, assuming a 16m stack discharging air from a chemical scrubber, at all receptors are all well below the precautionary impact benchmark of 3.0 ou_E/m^3. Results suggest that the predominant odour source(s) will be from the effluent treatment plant.

The significance of the predicted odour impact is therefore assessed to be '**negligible**' at all receptor locations using the IAQM assessment criterion.

Based on the assessment results, it anticipated that odour impacts at receptor locations as a result of operation of the proposed poultry processing plant would be negligible. As such, the potential for adverse odour impacts in the vicinity of the site is considered to be low and would not result in loss of local residential amenity.

Appendix I Figures and Tables

Figure 1. Location Plan

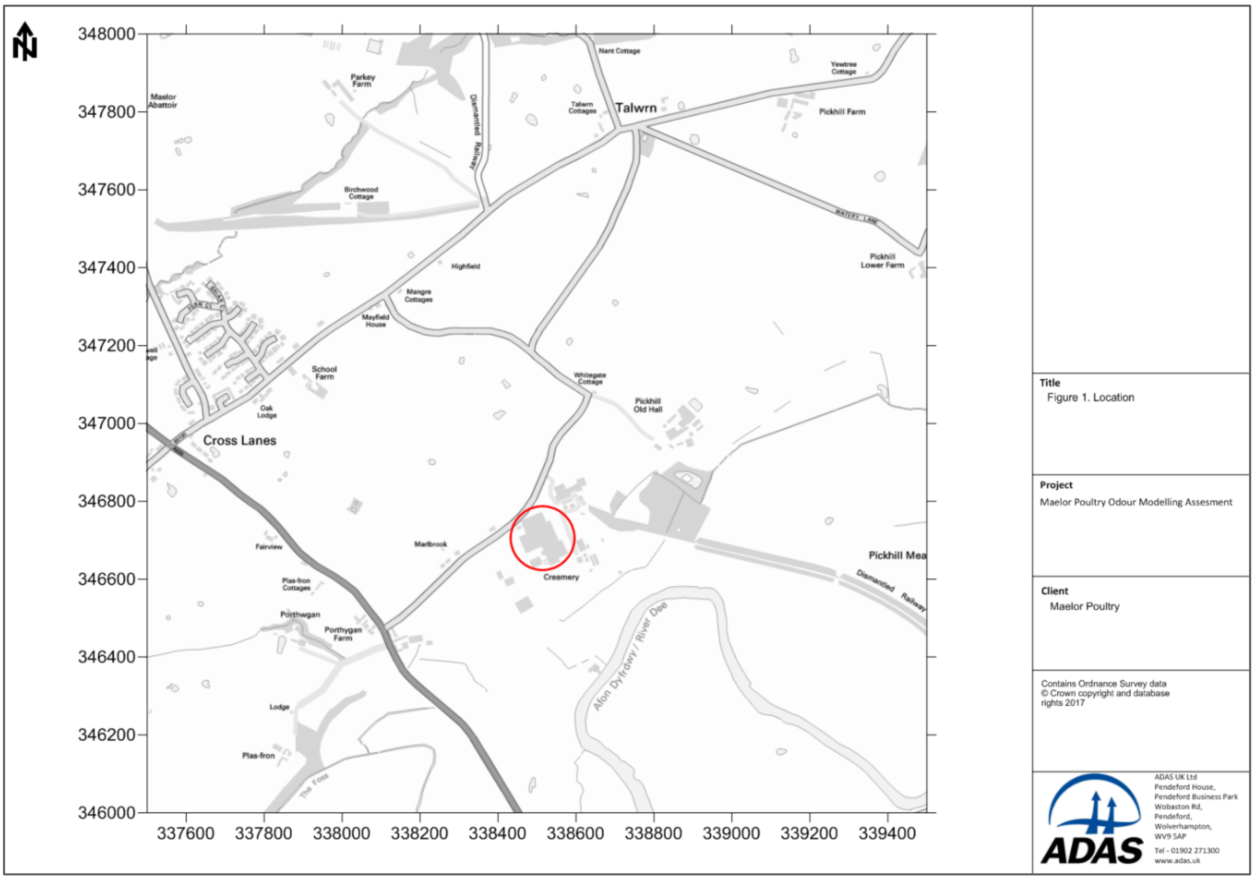

Figure 2. Modelled Sources

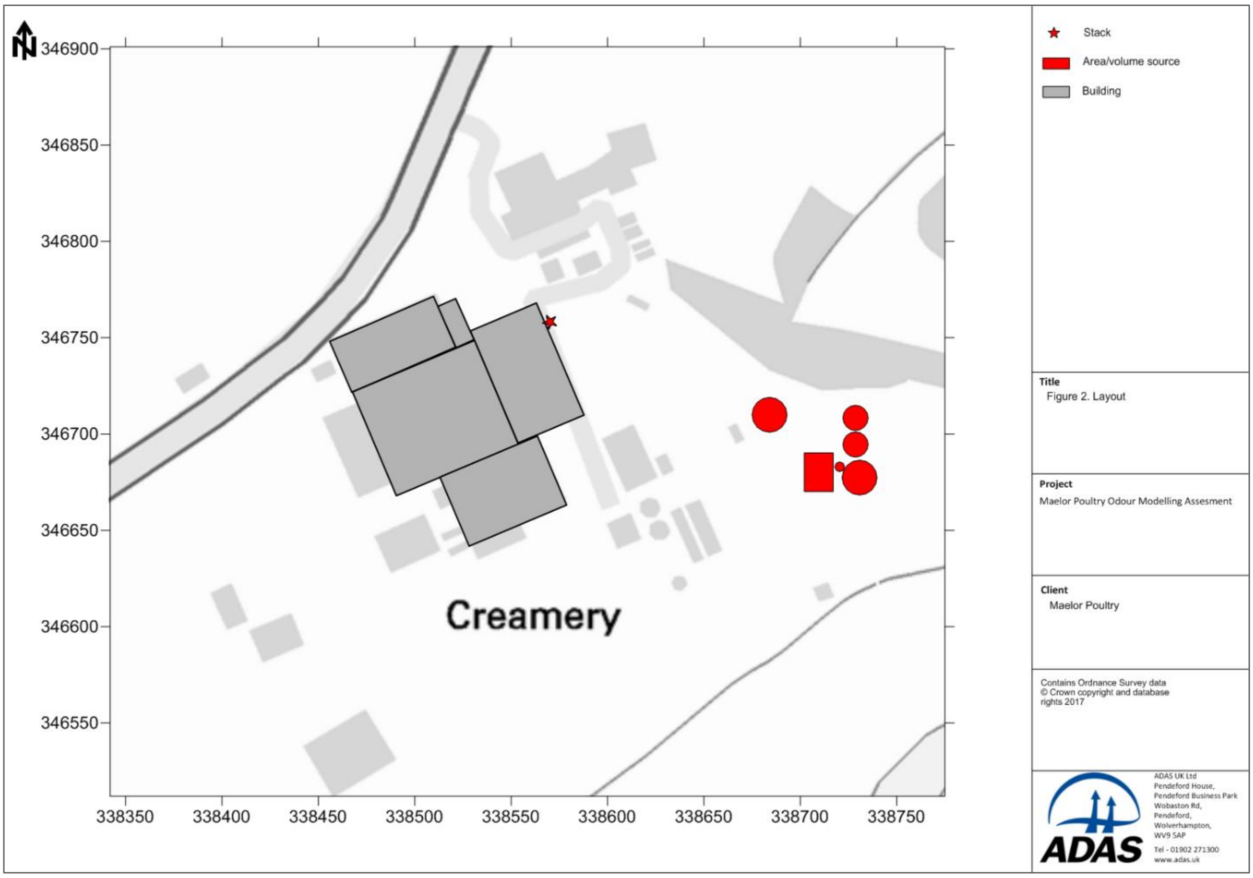

Figure 3. Nested Grid

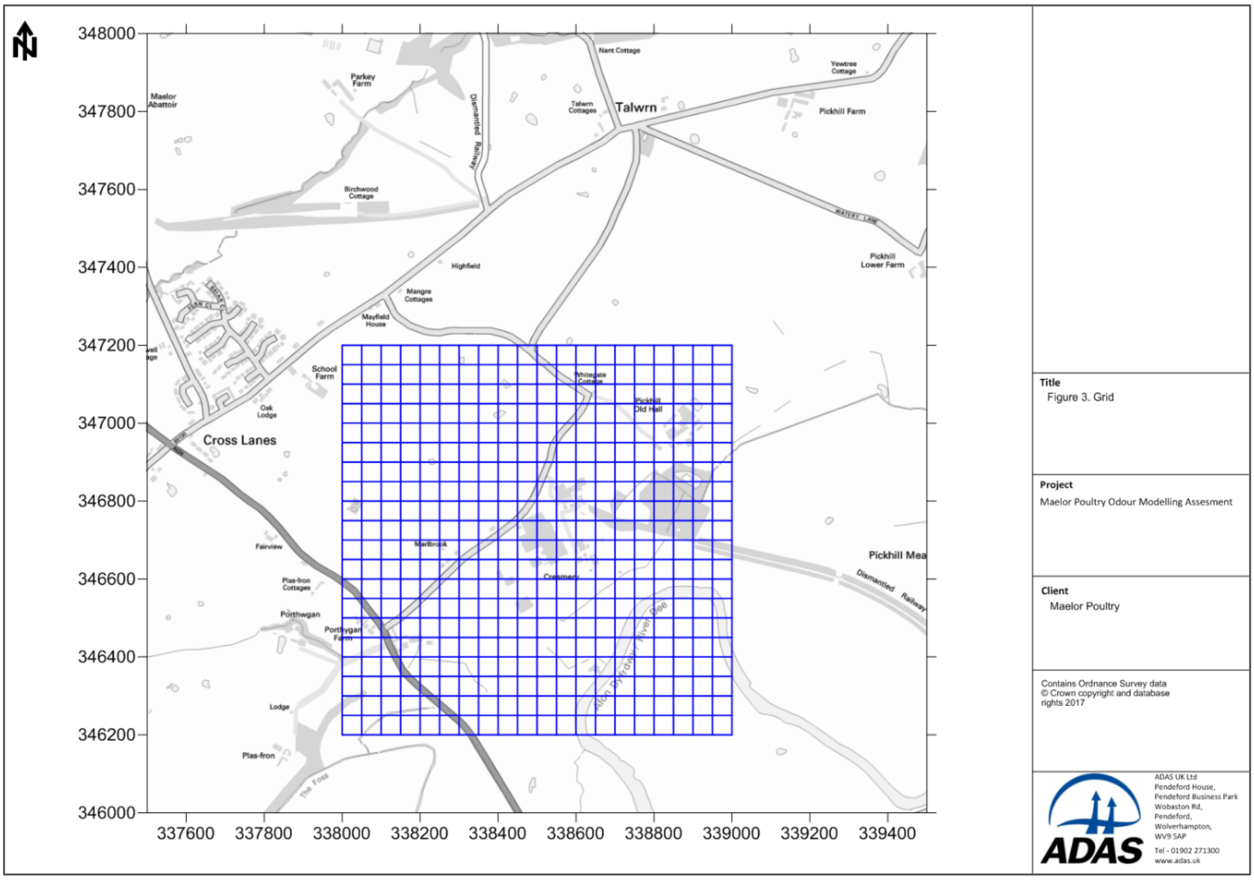

Figure 4. Identified Sensitive Receptors

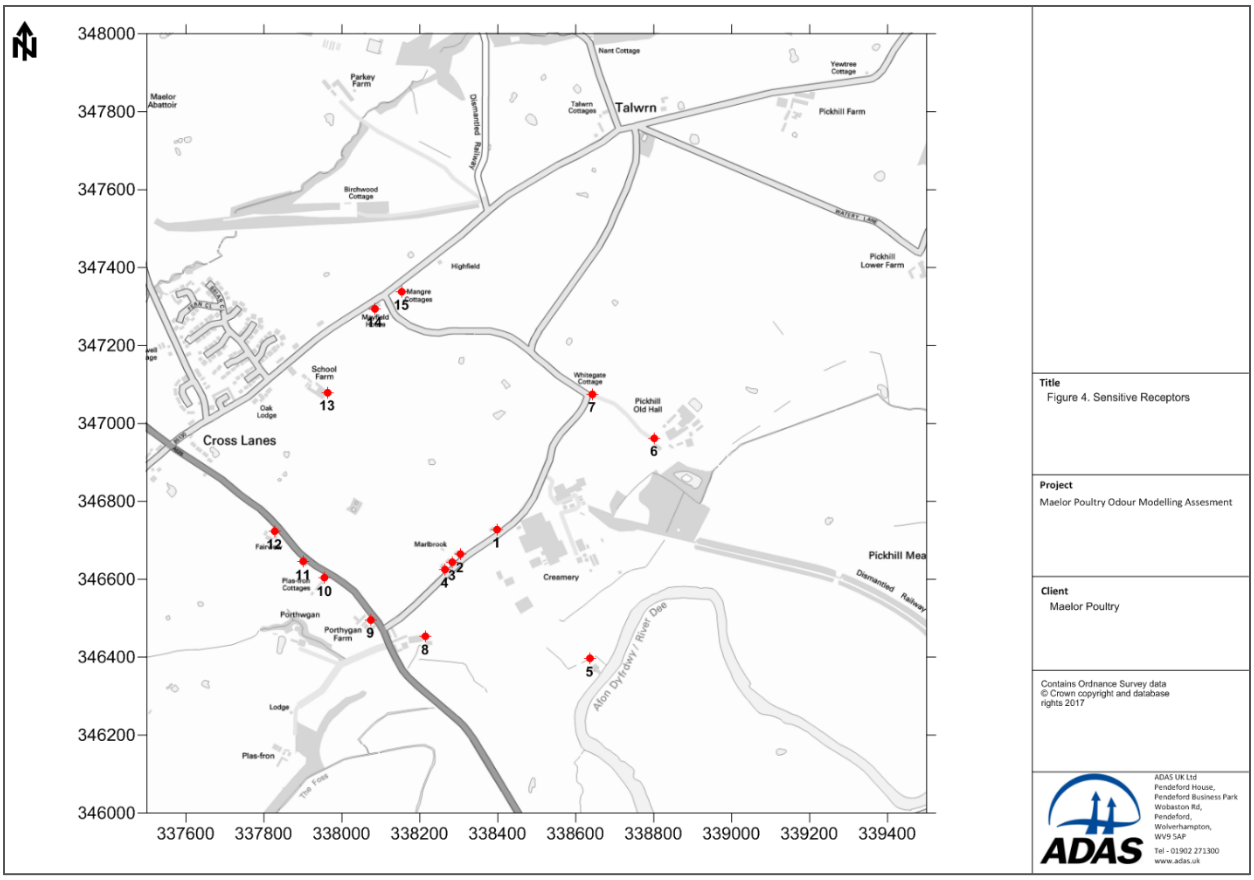

Figure 5. Five Year Average Mean 98th%-ile 1-hour Mean Odour Concentrations

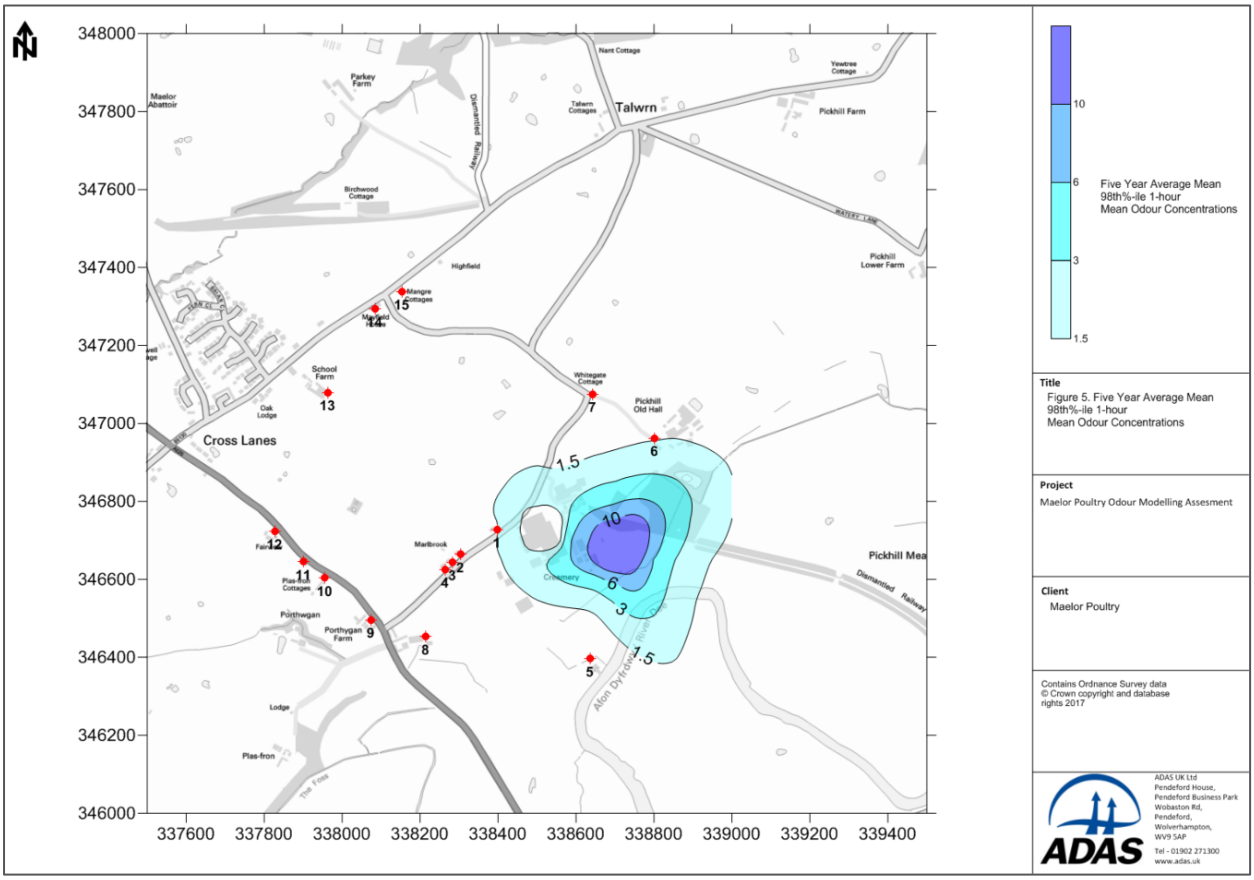

Figure 6. Windrose for Shawbury 2010-2014

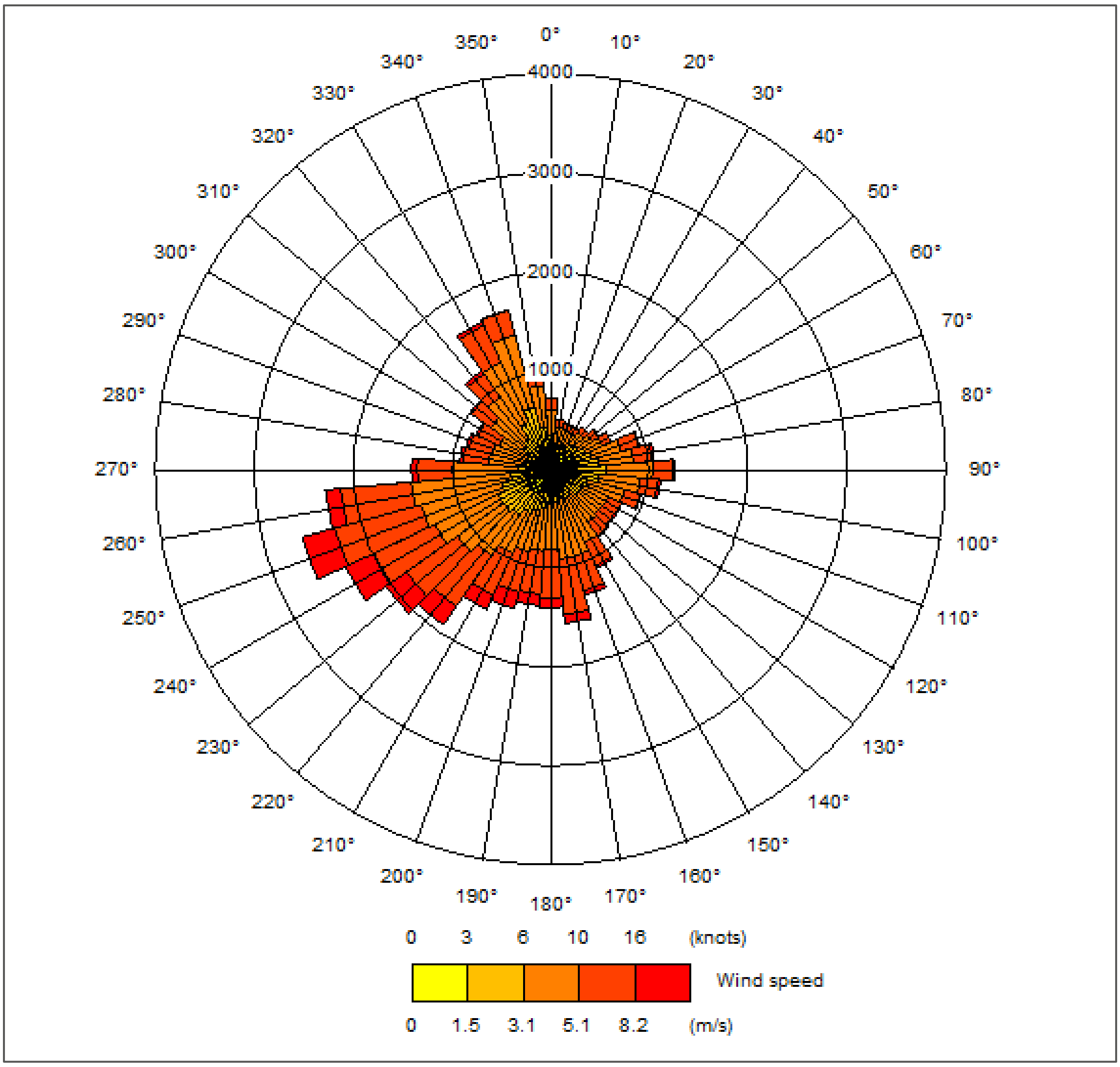

Table 10. Individual Year Predicted Odour Concentrations (16m stack and ETP combined)

Receptor		Predicted 5 year Average Mean 98th%-ile 1-hour Odour Concentrations (ou_E/m^3)				
		2010	2011	2012	2013	2014
R1	Residential Properties to west-south-west	1.45	1.35	1.58	1.42	1.51
R2	Residential Properties to west-south-west	1.10	0.93	1.21	1.01	1.11
R3	Residential Properties to west-south-west	1.01	0.81	1.10	0.93	1.05
R4	Residential Properties to west-south-west	0.92	0.75	0.98	0.86	0.96
R5	Industrial premise to south	0.85	0.70	0.75	0.76	0.85
R6	Residential and agricultural properties to north-east	1.10	1.29	1.82	1.59	1.35
R7	Whitegate Cottage	0.68	0.76	0.77	0.73	0.71
R8	Residential and agricultural property off A525	0.53	0.45	0.61	0.54	0.63
R9	Residential property off A525	0.48	0.41	0.60	0.44	0.54
R10	Residential property off A525	0.46	0.38	0.48	0.42	0.47
R11	Residential property off A525	0.44	0.34	0.44	0.38	0.44
R12	Residential property off A525	0.43	0.31	0.43	0.37	0.44
R13	School Farm	0.30	0.34	0.31	0.29	0.27
R14	Mayfield House	0.28	0.30	0.27	0.24	0.25
R15	Mangre Cottages	0.27	0.32	0.27	0.24	0.28

Table 11. Stack Height Analysis

Receptor		Predicted 5 year Average Mean 98th%-ile 1-hour Odour Concentrations (ou_E/m^3)			
		13m	14m	16m	20m
R1	Residential Properties to west-south-west	1.65	1.60	1.46	1.36
R2	Residential Properties to west-south-west	1.14	1.12	1.07	0.97
R3	Residential Properties to west-south-west	1.06	1.04	0.98	0.86
R4	Residential Properties to west-south-west	0.94	0.93	0.89	0.80
R5	Industrial premise to south	0.82	0.80	0.78	0.72
R6	Residential and agricultural properties to north-east	1.47	1.44	1.43	1.42
R7	Whitegate Cottage	0.78	0.76	0.73	0.67
R8	Residential and agricultural property off A525	0.57	0.57	0.55	0.51
R9	Residential property off A525	0.51	0.50	0.49	0.46
R10	Residential property off A525	0.46	0.46	0.44	0.42
R11	Residential property off A525	0.42	0.42	0.41	0.39
R12	Residential property off A525	0.40	0.40	0.40	0.37
R13	School Farm	0.30	0.30	0.30	0.29
R14	Mayfield House	0.27	0.27	0.27	0.26
R15	Mangre Cottages	0.27	0.27	0.28	0.27

Table 11. Terrain Sensitivity Analysis

Receptor		Predicted Five year Average Mean 98th%-ile 1-hour mean Odour Concentrations (ou_E/m^3)		
		16m Stack and ETP	16m Stack Only	ETP Only
R1	Residential Properties to west-south-west	1.37	0.67	0.97
R2	Residential Properties to west-south-west	0.97	0.36	0.78
R3	Residential Properties to west-south-west	0.90	0.31	0.71
R4	Residential Properties to west-south-west	0.84	0.27	0.66
R5	Industrial premise to south	0.81	0.29	0.66
R6	Residential and agricultural properties to north-east	1.26	0.37	1.25
R7	Whitegate Cottage	0.67	0.28	0.54
R8	Residential and agricultural property off A525	0.59	0.13	0.50
R9	Residential property off A525	0.48	0.14	0.37
R10	Residential property off A525	0.39	0.14	0.24
R11	Residential property off A525	0.35	0.14	0.19
R12	Residential property off A525	0.30	0.13	0.15
R13	School Farm	0.24	0.11	0.12
R14	Mayfield House	0.24	0.11	0.12
R15	Mangre Cottages	0.26	0.12	0.13