Report

Allan Creek Poultry – Odour Assessment

Allans Creek Poultry Farm Pty Ltd ATF The Allans Creek Poultry Trust

Astute Environmental Consulting

Job: 22-116

Date: 16 February 2023

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Project Title	Allan Creek Poultry – Odour Assessment
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1 INTRODUCTION

Allans Creek Poultry Farm Pty Ltd ATF The Allans Creek Poultry trust ("ACPF") engaged Astute Environmental Consulting ("Astute") to perform odour modelling for the proposed expansion of an approved meat chicken farm on land described as Lot 50 on SP179833 ("the site").

1.1 Background

ACPF have an approval for a 417,000 bird, eight shed meat chicken farm at the site. The site is shown below in Figure 1-1 where the site outline is a blue polygon, the light green lines show cadastre, and yellow markers show sensitive receptors. The approved shed layout is shown in Figure 1-2

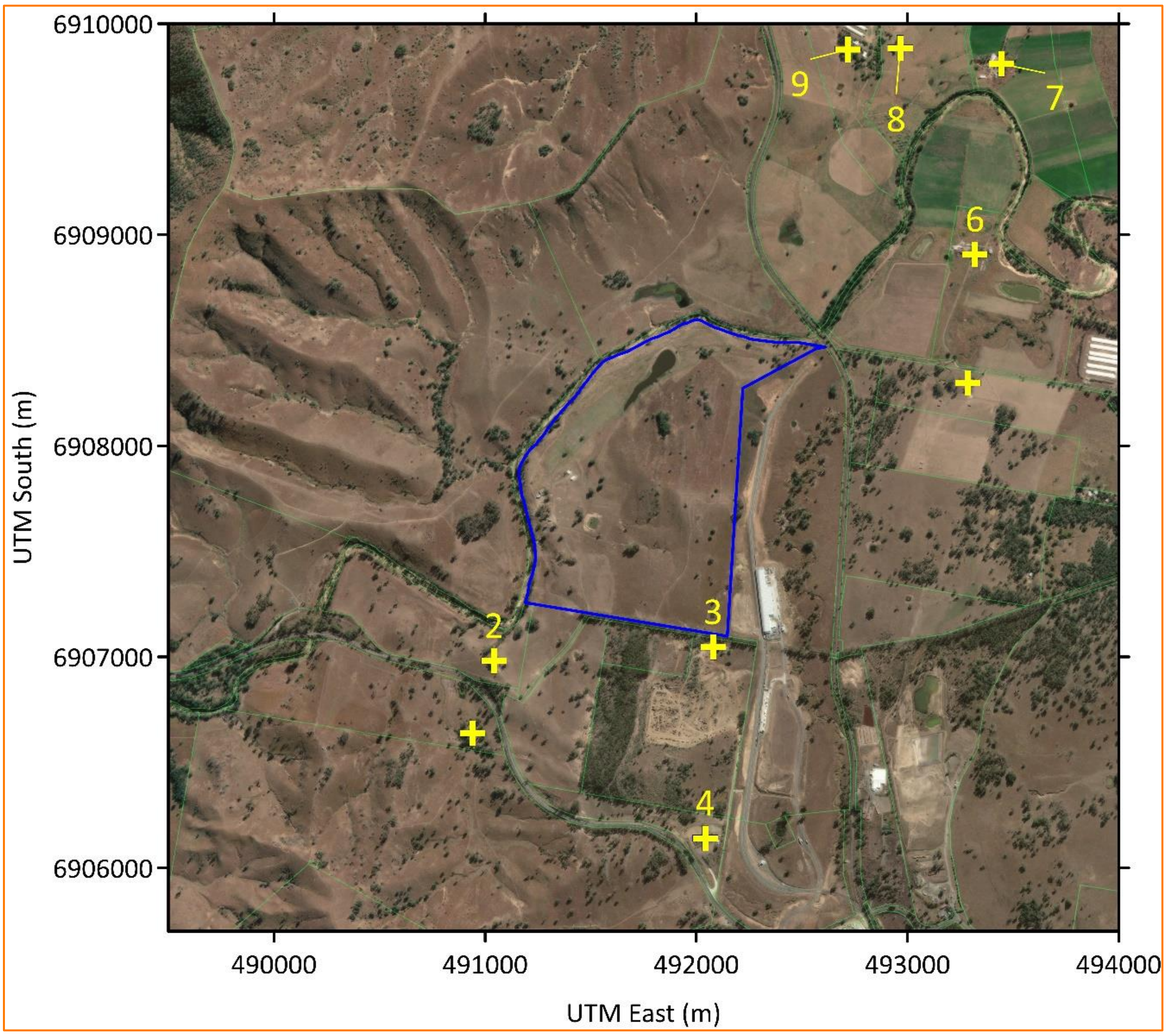


Figure 1-1: Site and Surrounding Area

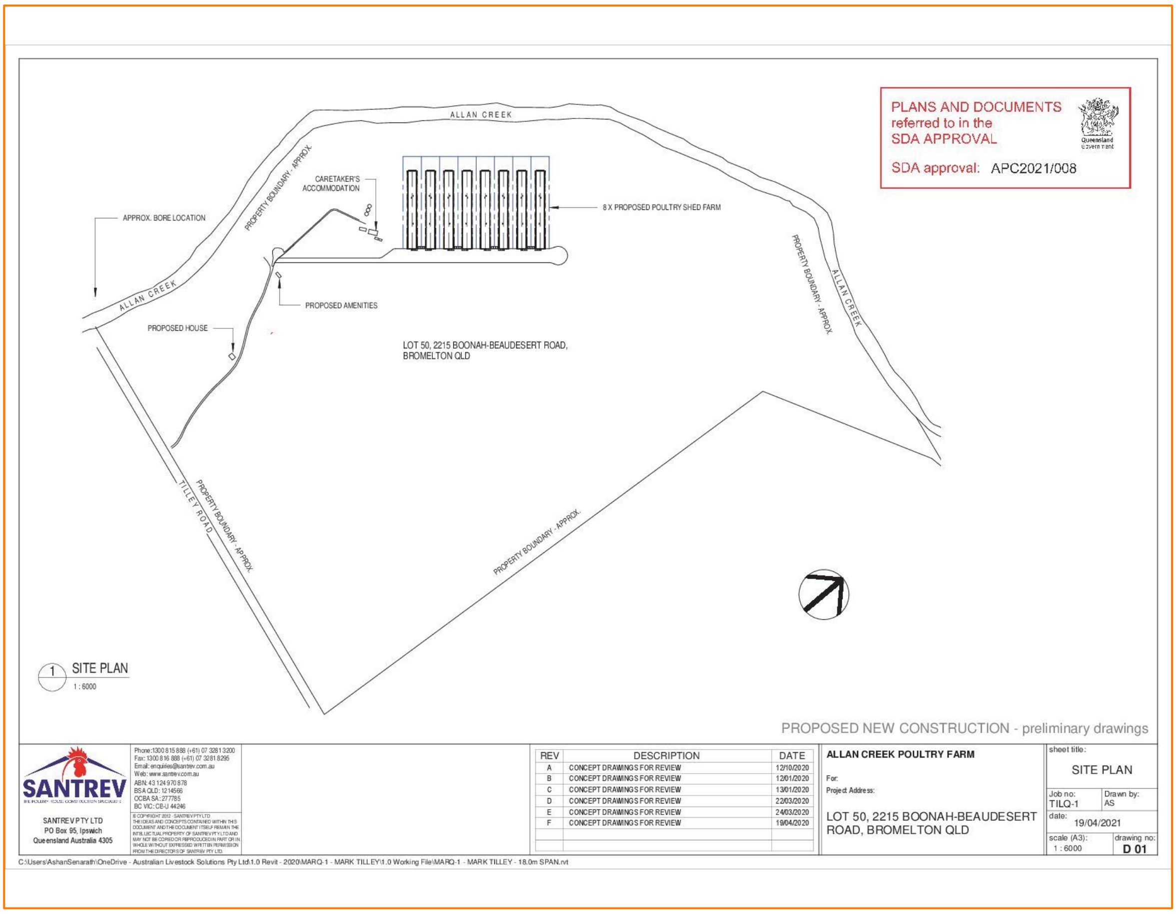


Figure 1-2: Approved Eight Shed Farm Layout

It is proposed that the approval be changed from an eight shed farm with a capacity of 417,000 birds (52,125 birds/shed), to a twelve shed farm, with each shed holding 52,125 birds per shed for a total of 625,500 birds. The new sheds will be placed in parallel to the north of the approved sheds.

The fan end of the existing sheds (i.e., source locations) are shown in Figure 1-3 below as yellow circles. The fan ends of the proposed four sheds are facing west and are shown in the figure as light blue circles.

Figure 1-3: Existing and Proposed Shed Fan Exit Locations

1.2 Scope of Work

The scope of work for the assessment included:

- Obtaining information about the existing and proposed sheds;
- Analysing on-site, local and regional weather data;
- Modelling meteorology for the area using TAPM/CALMET;
- Estimating emissions for the chicken farm in line with PAEHolmes (2011) and the Agrifutures Planning and environment guideline for establishing meat chicken farms – Guide 1 Assessment Guide (McGahan, et al., 2021)[1];
- Predicting odour dispersion using CALPUFF; and
- Preparing a report.

The methodology used is summarised graphically in Figure 1-4.

[1] The Planning and Environment Guideline

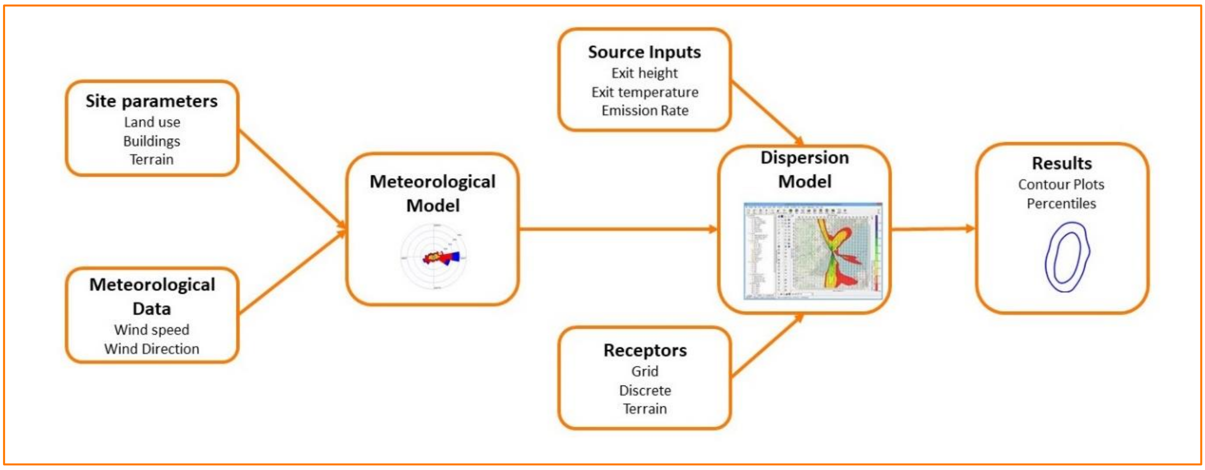


Figure 1-4 Modelling Methodology

2 ASSESSMENT CRITERIA

The *Guideline: Odour Impact Assessment from Developments* (DEHP, 2013) is the principal guidance document used in Queensland for assessing odour impacts ("the state criterion").

In addition to guiding how to estimate odour emissions and model the dispersion of odour, the *Guideline: Odour Impact Assessment from Developments* states that odour concentrations predicted by the modelling at the "most exposed existing or likely future off-site sensitive receptors" should be compared with the following guideline values:

- 0.5 ou, 1-hour average, 99.5th percentile for tall stacks; and
- 2.5 ou, 1-hour average, 99.5th percentile for ground-level sources and down-washed plumes from short stacks.

Thus, the criterion to apply to the site if air is discharged at ground level from poultry sheds is $C_{99.5\ 1hr}$ = 2.5 ou.

3 MODELLING METHODOLOGY

For this work, we used the NOOBS method described in Generic Guidance and Optimum Model Settings for the CALPUFF modelling system for inclusion into the 'Approved methods for the Modeling and Assessment of Air Pollutants in NSW, Australia' (OEH, 2011).

3.1 TAPM

TAPM (version 4), is a three-dimensional meteorological and air pollution model developed by CSIRO. The model is a prognostic model which uses synoptic-scale data to predict hourly meteorology in the area modelled. Details about TAPM can be found in the TAPM user manual (Hurley, 2008a) and details of the model development and underlying equations can be found in Hurley (2008b). Details of validation studies performed for TAPM are also available and include Hurley et. al. (2008c).

TAPM v4 predicts meteorological data including wind speed and direction in an area using a series of fluid dynamics and scalar transport equations (Hurley, 2008b) and it has both prognostic meteorological and air pollution (dispersion) components. The benefit of using TAPM is that key meteorological aspects including the influence of terrain induced flows are predicted both locally and regionally.

The TAPM default land use database was further refined to include more representative landuse in the 0.3 km modelling domain. The default and adjusted land-use files are presented in Figure 3-1. The TAPM setup is summarised in Table 3-1 and is consistent with good practice and the requirements in NSW EPA (2016). The year 2019 was selected as it is a recent year, and we used weather station data from a nearby site. TAPM was nudged with wind speed and direction data from the nearby site which was located just north of Beaudesert.

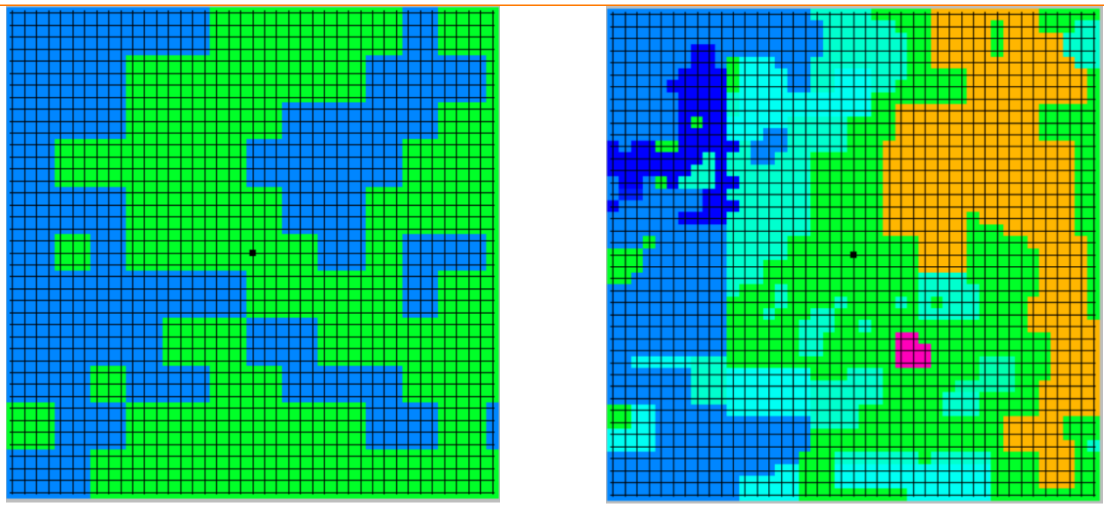


Figure 3-1: Default TAPM (left) and Adjusted Landuse (right) for the Site (300 m)

3.2 CALMET

CALMET is the meteorological pre-processor to CALPUFF and generates wind fields that include slope flows, terrain effects, and can incorporate factors including terrain blocking. CALMET uses meteorological inputs in combination with land use and terrain information for the modelling domain to predict a three-dimensional meteorological grid (which includes wind speed, direction, air temperature, relative humidity, mixing height, and other variables) for the area (domain) to be modelled in CALPUFF.

A 10 km x 10 km domain with a terrain resolution of 100 m was modelled with the centre of the domain to the northeast of the site. A terrain resolution of 30 m was used throughout the domain and was initially taken from the SRTM dataset using CALPUFF view. This was then converted to a 100 m resolution for the model runs.

Land use was initially based on the Australia Pacific Global Land Cover Characterisation (GLCC) dataset at 1km resolution. The land use was then manually edited at 100 m resolution based on a recent aerial photograph of the area using Google Earth Pro and CALPUFF View.

Table 3-1: TAPM And CALMET Setup

Model	Parameter	Value
TAPM (v 4.0.5)	Number of grids (spacing)	30km, 10km, 3km, 1km, 0.3km
	Number of grid points	41 x 41 x 25 (vertical)
	Year of analysis	2019
	Centre of analysis	27°57'00" South (latitude), 152°55'00" East (longitude)
	Meteorological data assimilation	Yes, ROI 3km
	Station; Radius of Influence; Data quality; Vertical levels	N/A
CALMET (v 6.334)	Meteorological grid domain	10 km x10 km
	Meteorological grid resolution	0.10km
	South-west corner of domain	X = 486.80 km, Y = 6903.350 km
	Surface meteorological stations	N/A
	Upper air meteorological data	N/A
	3D Windfield	m3D from TAPM (0.3km) input as in initial guess in CALMET
	Year of analysis	2019
	Terrad	3.0 km
	Cloud	4 - Gridded cloud cover from Prognostic Relative Humidity at all levels

3.3 CALPUFF

CALPUFF (Exponent, 2011) is a US EPA regulatory dispersion model and is a non-steady state puff dispersion model that simulates the effects of varying meteorological conditions on the emission of pollutants. The model contains algorithms for near source effects including building downwash, partial plume penetration as well as long range effects such as chemical transformation and pollutant removal. CALPUFF is widely recognised as being the best model for odour studies as it handles light wind conditions and terrain effects better than simpler steady state models such as AUSPLUME and AERMOD. As such it is accepted as a regulatory model in all states of Australia.

CALPUFF simulates complex effects including vertical wind shear, coastal winds including recirculation and katabatic drift. The model employs dispersion equations based on a Gaussian distribution of puffs released within the model run, and it takes into account variable effects between emission sources.

Key inputs used in CALPUFF for the project are summarised below in Table 3-2. In line with standard practice, the sheds were represented as quasi point sources with a diameter the same size as the shed width, with vertical momentum turned off.

Table 3-2: CALPUFF Setup

Model	Parameter	Value
CALPUFF (v 6.40)	Meteorological grid domain	10km x10km
	Meteorological grid resolution	0.10km
	South-west corner of domain	X = 486.80 km, Y = 6903.350 km
	Method used to compute dispersion coefficients	2 - dispersion coefficients using micrometeorological variables
	Minimum turbulence velocity (Svmin)	0.5 m/s[2]
	Building downwash included	No
	Default settings	All other CALPUFF defaults have been used in line with OEH (2011).

3.4 Emissions Estimation

The odour emissions model of Ormerod and Holmes (2005) was used for this assessment. The methodology is the basis of the *Best Practice Guidance for the Queensland Poultry Industry - Plume Dispersion Modelling and Meteorological Processing* (PAEHolmes, 2011) and is widely used in Australia. The method is based on real-world odour test data from a variety of poultry broiler farms and uses a series of equations, which enable emissions to be predicted as a function of:

- the size and number of birds present;
- the stocking density of birds; and
- the ventilation rate, which varies by bird age and ambient temperature.

The odour emissions rate is predicted using the following equation (Ormerod & Holmes, 2005):

$$OER = 0.025 \times K \times A \times D \times V^{0.5}$$ **Equation 1**

Where ***OER*** = odour emission rate (ou/s), ***A*** = total shed floor area (m^2), ***D*** = average bird density (in kg/m^2), **V** is the ventilation rate in m^3/s and **K** is the K factor.

The K factor is a scaling factor that is used to reflect the performance of a farm. For the farm, we have adopted a K Factor of 2.2 and also K = 1.9 based on the Planning and Environment Guideline. A K factor of 1.9 is ~16% lower than a K factor of 2.2, and as noted in the Planning and Environment Guideline (McGahan, et al., 2021), a K factor of 1.9 represents the upper range of measured K factors from farms in Australia, in particular those in Queensland.

As part of the approval conditions for the existing farm, odour testing was performed by The Odour Unit on 24 January 2023 immediately prior to the first pickup. At the time, the bird ages ranged from

[2] Planning and environment guideline for establishing meat chicken farms – Guide 1 Assessment Guide - Publication 21-080 (McGahan, et al., 2021)

32 to 29 days. The test results are summarised in Table 3-3 below. Of note is that the odour characters assigned to the odour samples of dry dog biscuits or cabbage water that indicate a relatively inoffensive odour. A copy of the test report is attached.

Table 3-3: Summary of Test Data

Shed	Bird Age	Fans Running	Ventilation Rate (Nm^3/s)	OER (ou/s)	K Factor
1	32	13/13	114	13,492	0.5
2	32	13/13	110	20,718	0.8
3	30	13/13	97	17,638	0.8
4	29	13/13	106	10,067	0.5
5	29	13/13	114	12,871	0.6

Note: Duplicate testing performed in each shed, K factor is average of two samples per shed.

The K factors and their relevant to the farm, including test data collected at the farm are discussed in Section 6 below

Batch length was based on other farms in the area and current industry standards. Based on shed areas and stocking densities required under RSPCA methods, the sheds were assumed to have a maximum stocking rate of 52,125 birds per shed. The modelled thinning followed normal practices where 50% of birds were removed at day 30.

Maximum shed ventilation rates used to estimate emissions were based on a standard flow of 10 m^3/hr/bird at maximum, and then varied by ambient temperature. Table 3-4 shows the shed ventilation rate (% of maximum) as a function of how much the ambient temperature is above target temperature based on PAEHolmes (2011).

Table 3-4: Example Calculated Shed Ventilation as Percentage of Maximum Ventilation

Bird Age (weeks)	1	2	3	4	5	6	7	8
Temperature (°C) above Target	Ventilation Rate (Percent of maximum)							
<1	2	3	5	8	10	11	17	17
1	2	13	13	25	25	25	25	25
2	2	25	25	38	38	38	38	38
3	2	38	38	50	50	50	50	50
4	2	38	38	50	50	50	50	50
6	2	38	38	63	75	75	75	75
7	2	38	38	63	75	75	88	100
8	2	63	63	63	75	75	100	100
9	2	63	63	88	100	100	100	100

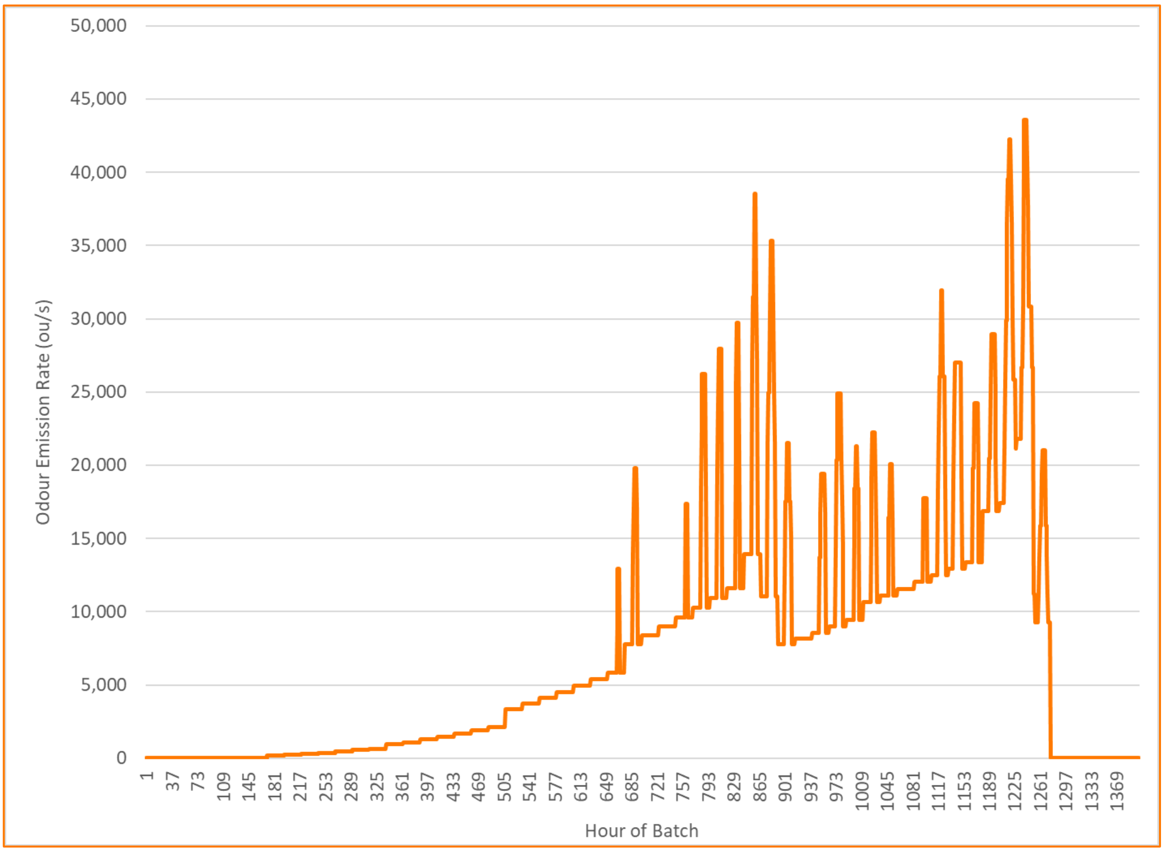


Figure 3-2: Example Batch Odour Emission Profile (52,125 birds)

4 EXISTING ENVIRONMENT

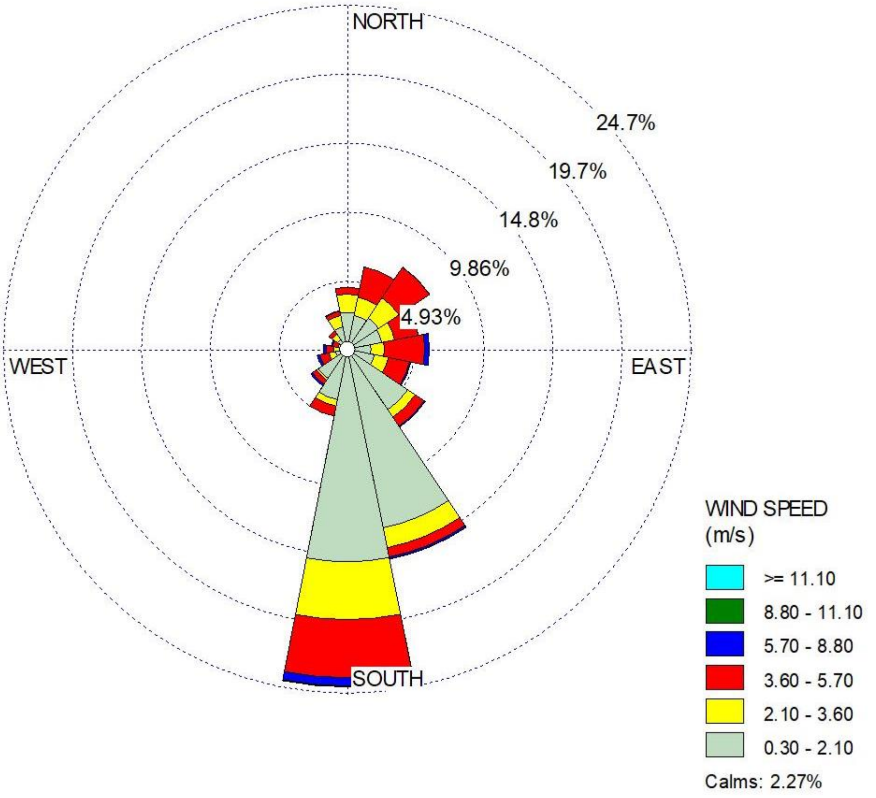
The principal meteorological parameters that influence plume dispersion are wind direction, wind speed, atmospheric stability (turbulence) and atmospheric mixing height (height of turbulent layer). This section presents a summary of the key meteorological features

4.1 Wind Speed and Direction

Wind roses are used to show the frequency of winds by direction and strength. The bars show the compass points (north, north-north-east, north-east etc) from which wind could blow. The length of each bar shows the frequency of winds from that direction and the different coloured sections within each bar show the wind speed categories and frequency of winds in those categories. In summary, wind roses are used to visually show winds over a period of time.

The wind roses below were created from data extracted from CALMET and are presented in Figure 4-1 and Figure 4-2. The annual wind rose shows that the site is dominated by southerly winds with a noticeable north easterly component. This is a function of the region in which the farm sits.

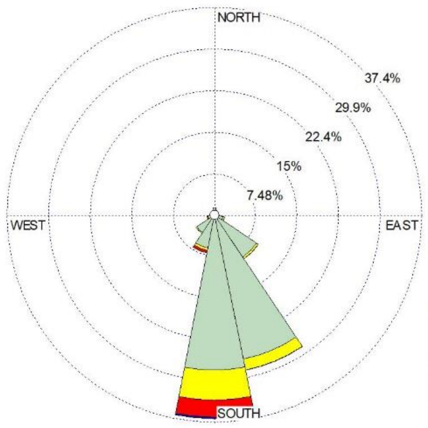
The wind roses show a relatively high proportion of calm winds (~2.3%) with light winds over the year (up to 3 m/s) occurring ~70% of the time. The wind speed frequencies are summarised graphically in Figure 4-3.



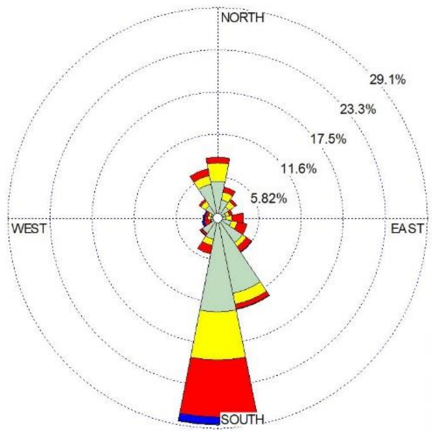
Location: Farm Site	*Year:* 2019	*Data Source:* CALMET extract
Calm winds: 2.3 %	*Average wind speed:* 2.3 m/s	*Creator:* G. Galvin

Figure 4-1: Annual Wind Rose at Farm Site

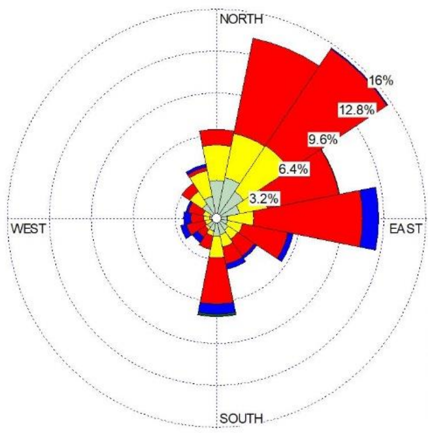
1 AM to 6 AM



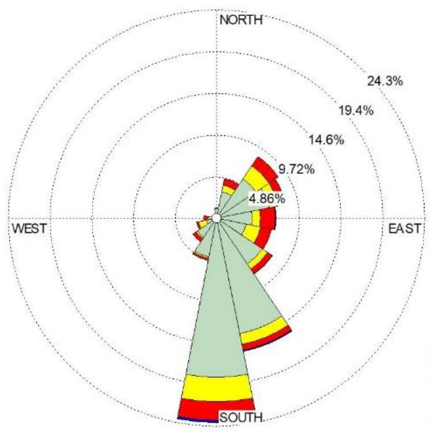
7 AM to 12 PM



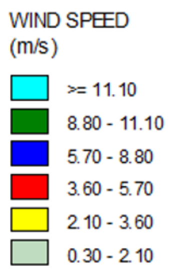
1 PM to 6 PM



7 PM to 12 AM



Period	*Average wind speed (m/s)*	*Calm winds %*
1 AM to 6 AM	1.3	4.2
7 AM to 12 PM	2.3	1.9
1 PM to 6 PM	3.5	0.2
7 PM to 12 AM	1.7	2.8



Location: Farm Site	*Year:* 2019	*Data Source:* CALMET extract	*Creator:* G. Galvin

Figure 4-2: Time of Day Wind Roses

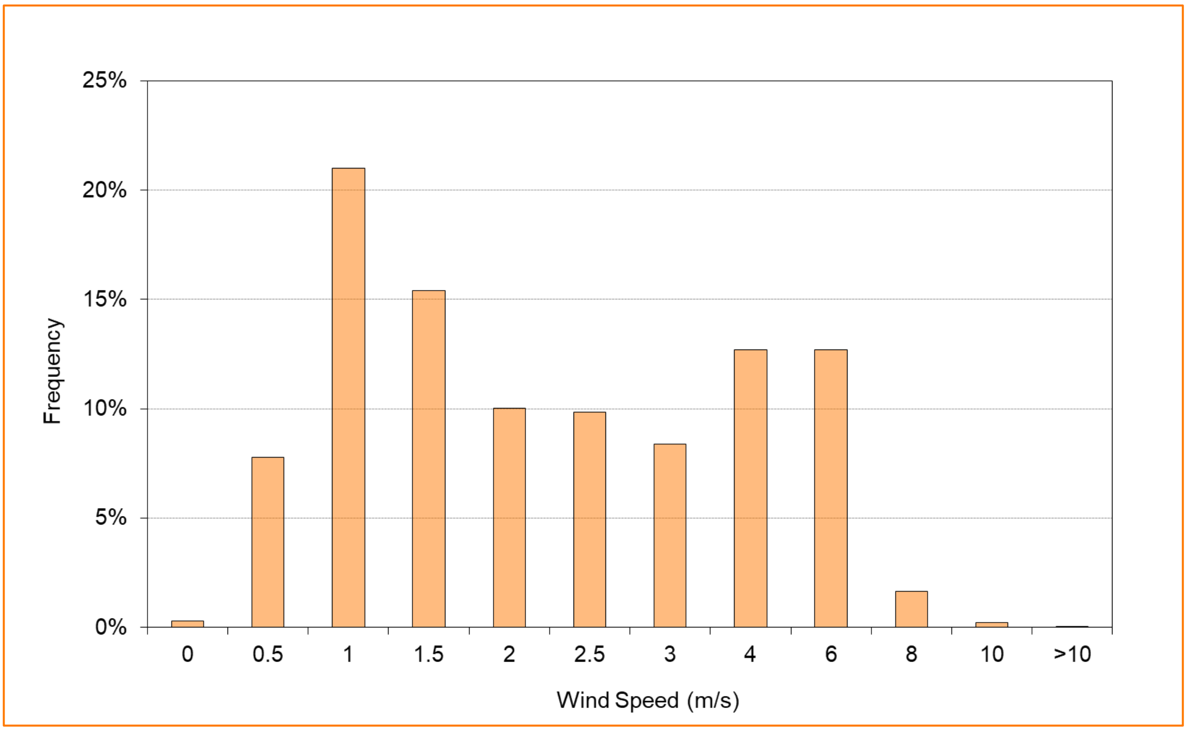


Figure 4-3: Wind Speed Frequency from CALMET

4.2 Atmospheric Stability

Atmospheric stability is a key factor in dispersion modelling and is used to describe turbulence in the atmosphere which is an important factor in plume dispersion. Turbulence increases the width of a plume due to random motion within the plume. This changes the plume cross-sectional area (width and height of the plume), thus diluting or spreading the plume. As turbulence increases, the rate at which this occurs also increases. Limited or weak turbulence, therefore, does not dilute nor diffuse the plume as much as strong turbulence and leads to high downwind concentrations. This is often associated with low wind speeds (<0.3 m/s).

The Pasquill-Gifford stability scheme has been in use for many years to define turbulence in the atmosphere. The scheme uses stability classes from A to F[3]. Class A is highly unstable and at the other end of the scheme are class F conditions, which are very stable conditions that commonly occur at night and in the early morning. As noted above, under stable conditions, plumes do not disperse as well as during the day (unstable conditions) and these conditions can lead to impacts, especially for ground level sources.

Between Class A and Class F are stability classes that range from moderately unstable (B), through to neutral (D), to slightly stable (E). Whilst classes A and F are most often associated with clear skies, class D is linked to sunset and sunrise, or cloudy and/or windy daytime conditions. Unstable conditions most often occur during the daytime and stable conditions are most common at night.

[3] Note that CALPUFF uses a more accurate micrometeorological scheme for turbulence.

The stability classes predicted by CALMET for the Development Site are summarised in Figure 4-4. The data shows that E and F class stability occurs 40% of the time. The frequency of D class stability (39%) is commonly seen in areas with winds above 2.5 m/s at night or site with a high frequency of cloudy days.

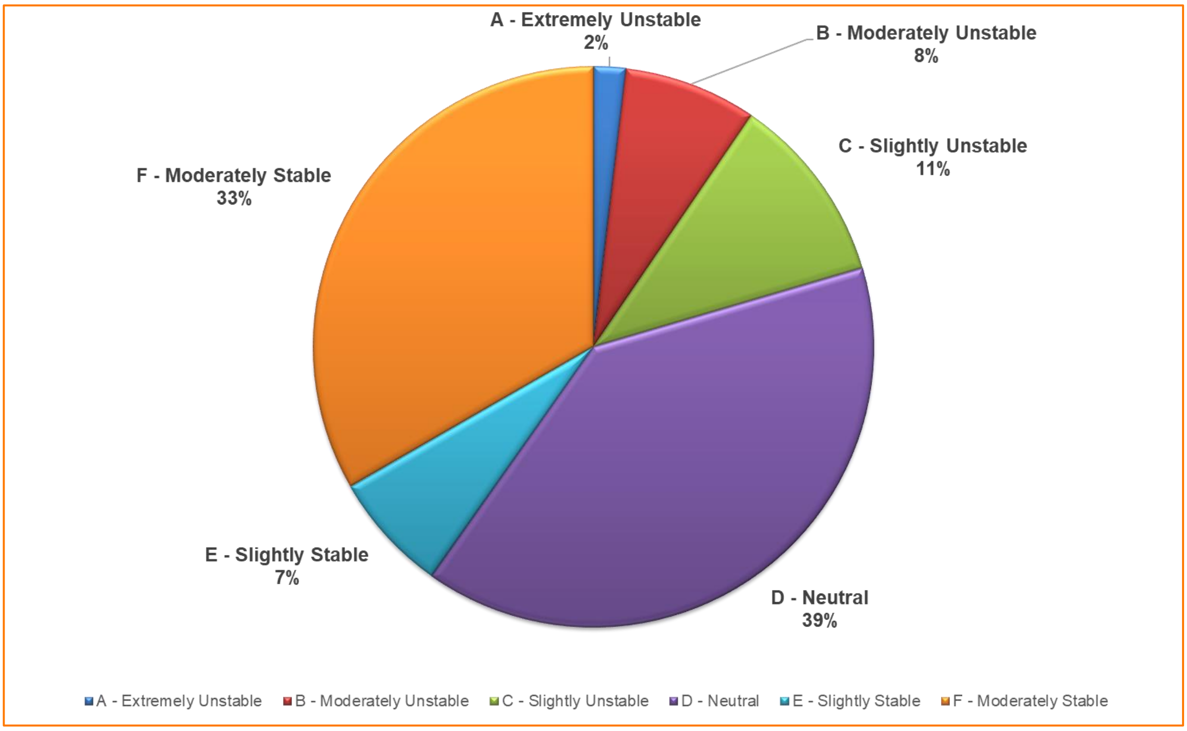


Figure 4-4: Atmospheric Stability

4.3 Atmospheric Mixing Height

The mixing height is the height of the vertical mixing of air and suspended gases or particles above the ground. This height can be measured by the observation of the atmospheric temperature profile. A parcel of air rising from the surface of the Earth will rise at a given rate (called the dry adiabatic lapse rate). As long as the parcel of air is warmer than the ambient temperature, it will continue to rise. However, once it becomes colder than the temperature of the environment, it will slow down and eventually stop (University of Michigan , 2004).

The mixing height is commonly referred to as an inversion layer. It is an important parameter when assessing air emissions as it defines the vertical mixing of a plume. This is because the air below the layer has restricted dispersion vertically and therefore the higher the mixing height, the more potential for dispersion.

The estimated variation of mixing height over time predicted at the site by CALMET is shown in Figure 4-5. The diurnal cycle is clear in this figure, whereby at night the mixing height is normally relatively low and after sunrise, it increases as a result of heat associated with the sun on the Earth's surface. Overall, the estimated mixing height shown below is as expected albeit that overnight mixing heights are relatively low.

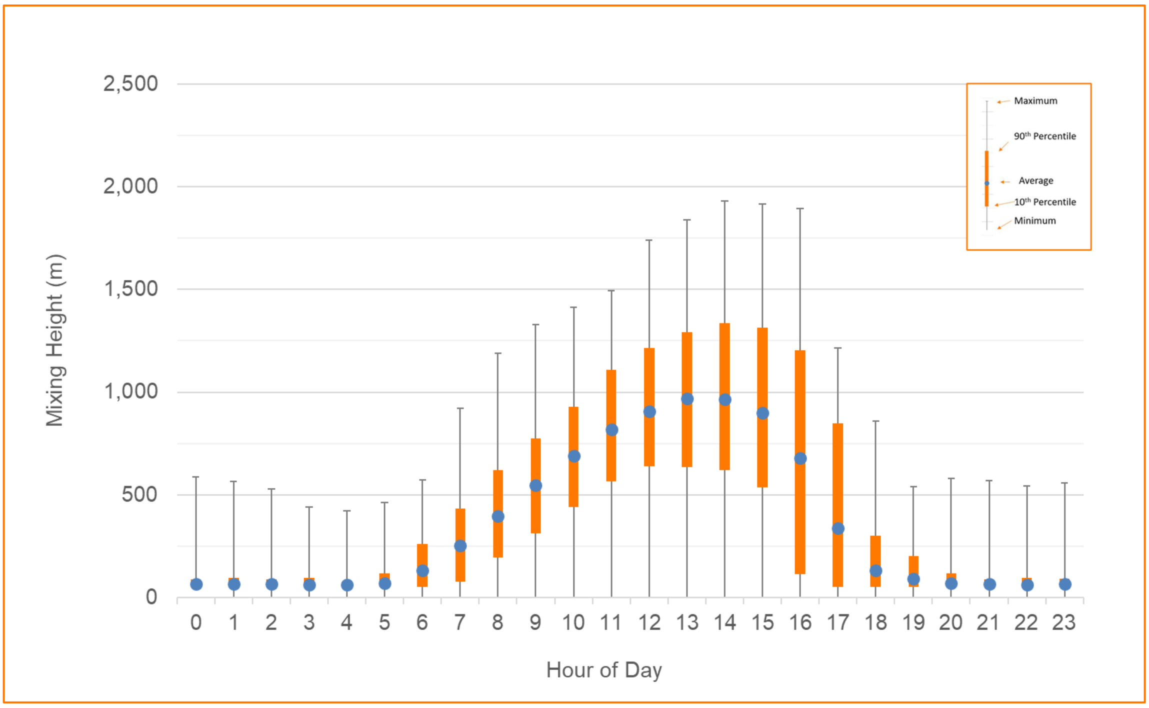


Figure 4-5: CALMET Extract – Predicted Mixing Heights

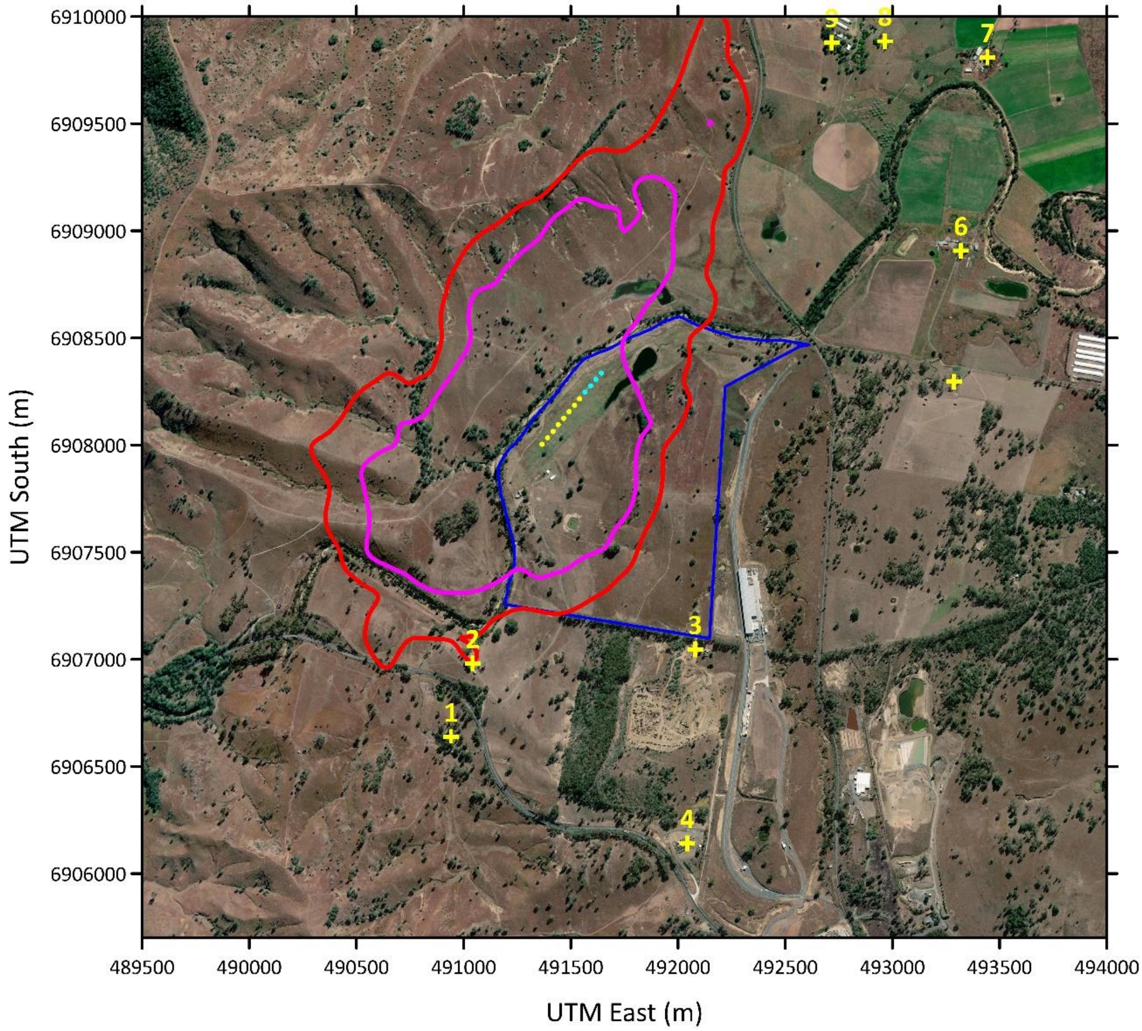
5 RESULTS

The results of the modelling for K=2.2 are shown below in Figure 5-1 where the 2.5 ou contour is shown as a pink line for the existing farm, and a red line for the proposed farm. The concentrations at the various identified receptors are shown for the existing and proposed farm in Table 5-1.

Note that the contours shown in Figure 5-1 are interpolated from the 100 m grid used in CALPUFF whereas the receptor concentrations are more accurate as they are calculated at each receptor.

Table 5-1: Closest Receptor Predicted Concentrations (K=2.2)

Receptor	Existing ($C_{99.5\ 1hr}$)	Proposed ($C_{99.5\ 1hr}$)
1	1.1	1.5
2	1.7	2.4
3	0.6	0.9



Species: Odour	Site: Allans Creek	Scenario: Existing – Pink Proposed - Red	Averaging Period: 1 hour	Percentile: 99.5th
Criterion: 2.5 ou	Units: ou	Meteorology: CALMET	Model: CALPUFF v 6.42	Author: G. Galvin

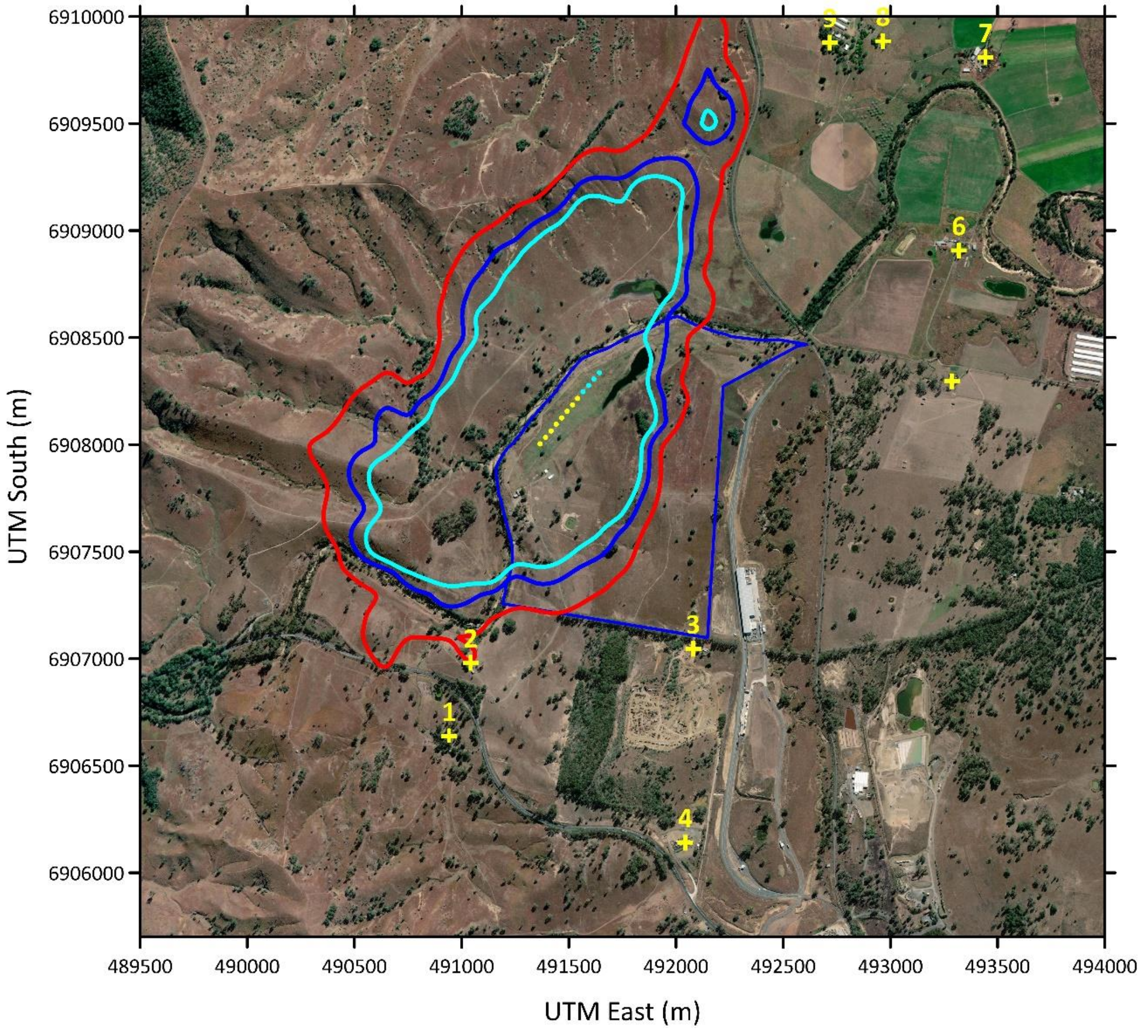
Figure 5-1: Odour - Proposed 12 Shed Farm (K=2.2)

As noted in Section 3.4 above odour testing was performed at the site. The results for a variety of K factors are shown below in Table 5-2 and Figure 5-2. As noted above, while the PAEHolmes (2011) recommends a K factor of 2.2, a lower K factor of 1.9 is currently recommended for new farms where no test data exist. The reduction from 2.2 is associated with the introduction of improvement management over time primarily associated with the introduction of RSPCA litter requirements.

The results and the K factors are discussed in Section 6 below.

Table 5-2: Closest Receptor Predicted Concentrations (varying K Factors)

Receptor	K=2.2	K=1.9	K=1.5	K=1
1	1.5	1.3	1.0	0.7
2	2.4	2.1	1.6	1.1
3	0.9	0.8	0.6	0.4



Species: Odour	Site: Allans Creek	Scenario: Proposed 12 Shed Farm Red K=2.2 Dark Blue K=1.9 Light Blue K=1.5	Averaging Period: 1 hour	Percentile: 99.5th
Criterion: 2.5 ou	Units: ou	Meteorology: CALMET	Model: CALPUFF v 6.42	Author: G. Galvin

Figure 5-2: Odour - Proposed 12 Shed Farm K=2.2, 1.9 and 1.5

6 DISCUSSION

The model results shown above are based on a standard meat chicken farm odour assessment methodology incorporating current stocking densities and thinning values for modern meat chicken farms.

As expected, the predicted impacts increase marginally when the new sheds are included.

The results in Figure 5-1 show that the 2.5 ou contour (red line) does not impact any existing receptors, but does travel to the north of the site, which is a function of both the size of the farm and the area in which the farm sites, with constraining terrain to the east and west. This combined with dominant southerly winds means the lateral spread of the plume (i.e., east to west) under southerly winds is limited.

The contour shown in Figure 5-1 is based on a K factor of 2.2. This was originally proposed in PAEHolmes (2011) based on farm management up to that point in time. In simple terms, the K factor is a scaling factor used to scale the emissions from a farm. A farm with a K factor of 2, would have twice the emissions of a farm with a K factor of 1.

With the introduction of RSPCA requirements for farming (see RSPCA (2014; 2017)), especially the requirements around litter management, measured K factors at existing farms have dropped significantly. Whilst the Planning and environment guideline for establishing meat chicken farms – Guide 1 Assessment Guide (McGahan, et al., 2021) recommends a K factor of 1.9 when modelling farms, recent testing at new farms (as opposed to old farms) in New South Wales and Queensland has shown that K factors can be below the K = 1.9. It is noted that the offensiveness of the odour from farms has also decreased over time meaning that the odour from farms is now less offensive.

This however is based on the realistic assumption that the farm will be operated to best practice and managed in a way to avoid abnormal odour emissions. This would include careful ventilation management to manage moisture in the litter, and also tilling (rotary hoeing) and/or wet litter replacement as required. Best practice management of litter in terms of reuse in the sheds is currently being applied at the site. It is our experience that most farms, including this one, are operated having regard to the aforenoted points.

Relevant to interpreting the results in this report are:

1. Testing at other farms in the area; and
2. Testing at this farm.

K factors are critical in understanding the modelling in that the K factor is a key factor when estimating odour emissions. Due to COVID limited odour testing was performed over the last few years at poultry farms in Queensland (and New South Wales). Testing at a new farm in the Scenic Rim region during December 2019 yielded an average of K=1.2 ± 0.1. The previous testing at that site in winter of the same year yielded a K factor of K=1.5 ± 0.2. This data supports the use of a K factor of 1.9 as an upper value for a new farm. As shown in Table 5-2 and Figure 5-2, compliance was predicted at K factors of 2.2, 1.9 and 1.5.

While preparing this report, testing was performed at the farm by The Odour Unit. Testing occurred on 24 January 2023 in sheds 1 to 5 where the birds were on average 31 days of age. The test data was summarised in Table 3-3 above and gave an average K factor of 0.6 ± 0.2. Concerning the tests, the odour character reported by the lab referred to dry dog biscuits and cabbage water, i.e., the odour was not found to be offensive. When asked, Mr Hayes of the odour unit indicated that based on the farms he had visited over time, this one had noticeably lower odour out of the sheds, which was confirmed by the testing.

Potential risks could be further mitigated by vegetative planting around the sheds. Research has shown that dust concentrations from livestock operations can be reduced by 35% to 65% using vegetative buffers (Laird, 1997; Thernelius, 1997; Malone, et al., 2006; Malone, et al., 2008). As a specific example, Malone *et. al.* (2006; 2008) showed an average dust reduction over three years of 56%. This was found to be associated with the dust impacting on a limited tree planting and depositing out. Concerning odour, studies have shown reductions in the order of 60% (Parker, et al., 2012) downwind of a vegetative barrier at a pig farm. Furthermore, Patterson et. al. (2009) reported a 34% odour reduction downwind of a layer farm with a four-row vegetative planting, and 46-54% reductions downwind of a five-row vegetative barrier. Other more recent work for road traffic emissions including Petit et al. (2021) have also demonstrated reductions in air pollution using vegetative screens.

If a vegetative buffer were established and or enhanced, it should have regard to the recommendations in the Planning Guidelines: Separating Agricultural and Residential land Uses (DNR, 1997).

7 CONCLUSION

This report has assessed potential odour impacts associated with the proposed expansion to the farm. Local land use, terrain and meteorology have been considered in the assessment and dispersion modelling was using CALPUFF.

The results in this report predicted compliance with the odour criterion of $C_{99.5\ 1hr}$ = 2.5 ou at all receptors for a K factor of 2.2.

8 RECOMMENDATIONS

Based on our assessment, we recommend that the farm is operated in line with Queensland Guidelines Meat Chicken Farms (DAFF, 2012) (or newer versions of this document) ensuring that the litter remains dry and friable as discussed in the Planning and environment guideline for establishing meat chicken farms – Guide 1 Assessment Guide (McGahan, et al., 2021). By managing the litter as such, emissions will be consistent with or more importantly better than modelled.

Further practical information including management strategies for litter on farms to ensure continually low emissions can be found in Table 3 in the Best practice litter management manual for Australian meat chicken farms (McGahan, et al., 2021).

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