Report

Baiada Grenfell Breeder Complex Odour and Dust Assessment

Baiada Poultry

Astute Environmental Consulting

Job: 20-188
Date: 11 October 2021

Astute Environmental Consulting Pty Ltd
PO Box 6147, Clifford Gardens, QLD 4350
ABN - 50 621 887 232
Ph: +61 429 304 644
www.astute-environmental.com.au

TABLE OF CONTENTS

1 INTRODUCTION 1

1.1 BACKGROUND 1
1.2 SECRETARY'S ENVIRONMENTAL ASSESSMENT REQUIREMENTS 2
1.3 SCOPE OF WORK 3

2 ASSESSMENT CRITERIA 5

2.1.1 Odour 5
2.1.2 Particulate Matter 5

3 MODELLING METHODOLOGY 6

3.1 REPRESENTATIVE YEAR 6
3.2 METEOROLOGICAL MODELLING 8
3.2.1 TAPM 8
3.2.2 CALMET 9
3.3 ON SITE WEATHER STATION 10
3.4 DISPERSION MODELLING 11
3.5 EMISSIONS ESTIMATION 11
3.5.1 Farm Setup 11
3.5.2 Odour 13
3.5.3 Particulate Matter 15

4 EXISTING ENVIRONMENT 18

4.1 METEOROLOGICAL DATA 18
4.1.1 Wind Speed and Direction 18
4.1.2 Atmospheric Stability 21
4.1.3 Atmospheric Mixing Height 22
4.2 BACKGROUND AIR QUALITY DATA 23

5 RESULTS 26

5.1 METEOROLOGICAL METHODOLOGY VALIDATION 26
5.2 ODOUR 29
5.3 PARTICULATE MATTER 32
5.3.1 Contemporaneous PM_{10} Results 36

6 MITIGATION MEASURES 39

7 DISCUSSION 41

8 CONCLUSION 42

9 REFERENCES 43

Project Title	Baiada Grenfell Breeder Complex Odour and Dust Assessment
Job Number	20-188
Client	Baiada
Approved for release by	Geordie Galvin
Disclaimer and Copyright:	**This report is subject to the disclaimer and copyright statement located at www.astute-environmental.com.au.**

Document Control

Version	**Date**	**Author**	**Reviewer**
D1-1	14/09/21	W. Shillito	G. Galvin
R1-1	11/10/21	W. Shillito	G. Galvin

Astute Environmental Consulting Pty Ltd
PO Box 6147, Clifford Gardens, QLD 4350
ABN - 50 621 887 232

admin@astute-environmental.com.au
www.astute-environmental.com.au

1 INTRODUCTION

Baiada Poultry ("Baiada") engaged Astute Environmental Consulting("Astute") to perform an odour and dust assessment at a proposed breeder poultry farm located on 1130 Gooloogong Road, Grenfell ("the site"). The site can be described as Lot 1 on DP1022013, Lots 1-3 on DP1206485 and Lot 22 on DP866857 in the jurisdiction of the Weddin Shire Council.

1.1 Background

Baiada is seeking an approval for a 570,000 bird poultry breeder/rearer farm which will consist of four farm units, each with ten sheds. A rearer farm typically rears day old birds up to around 20 weeks of age, and these birds at 20 weeks, are then placed into the breeder (fertile egg) sheds.

The proposed farm is shown in Figure 1-1 Where:

- The yellow polygon is the site boundary;
- The black lines show cadastral lines;
- Each of the green rectangles represents one shed; and
- Yellow crosses show the nearest sensitive locations.

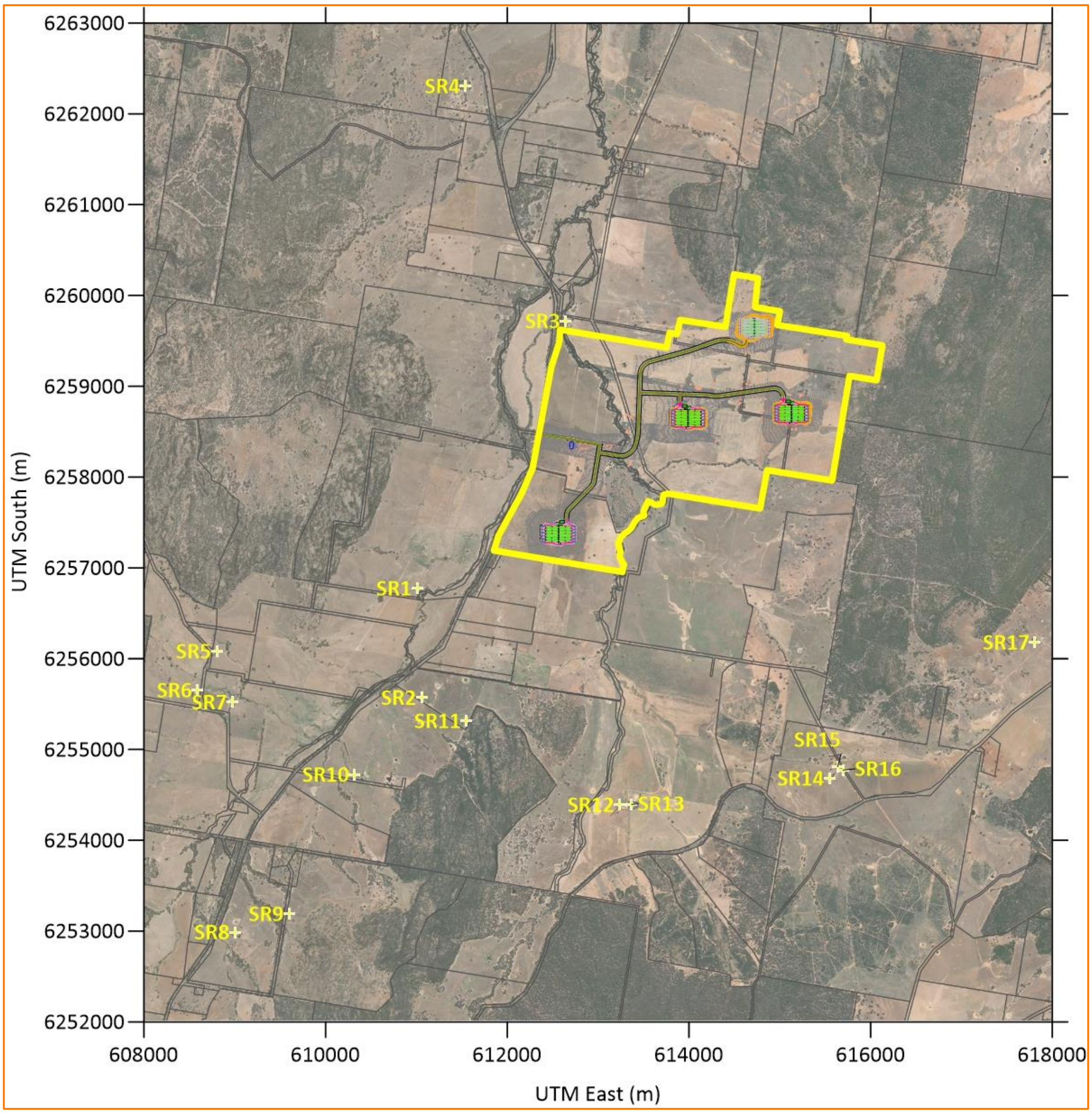


Figure 1-1 Proposed Grenfell Farm Layout and Receptors

1.2 Secretary's Environmental Assessment Requirements

This air quality assessment has been prepared in response to the Secretary's Environmental Assessment Requirements (SEARs) issued for the project. The SEARS was issued 26 February 2021 (Notice Number 1605818).

Broadly the SEARS requires an assessment of dust and odour generation and the management of potential impacts of dust and on adjacent sensitive locations.

The specific SEARS requirements are listed in Table 1-1.

Table 1-1 SEARS Requirements

Issue number	Report Section
3.1. The EA must demonstrate the proposal's ability to comply with the relevant regulatory framework, specifically the Protection of the Environment Operations POEO) Act (1997) and the POEO (Clean Air) Regulation (2002). Particular consideration should be given to section 129 of the POEO Act concerning control of "offensive odour".	All
3.2. The EA must include an air quality impact assessment (AQIA).	All
3.3. The AQIA must be carried out in accordance with the document, Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (2005)	All
3.4. The EA must detail emission control techniques/practices that will be employed at the site and identify how the proposed control techniques/practices will meet the requirements of the POEO Act, POEO (Clean Air) Regulation and associated air quality limits or guideline criteria.	6
3.5. Odour emissions must be assessed in accordance with the Technical Framework – Assessment and Management of Odour from Stationary Sources in NSW and/or Technical Notes-Assessment and Management of Odour from Stationary Sources in NSW (DEC 2006).	3 and 5
3.6. Odour assessment must include and investigation and assessment of odour impacts likely to be associated with cold air drainage effects on all identified and potential receivers.	3 and 5
3.7. It is strongly recommended the proponent install a meteorological station as soon as possible on or near the proposed site, or if applicable, utilise existing onsite meteorological data, to obtain site-specific meteorological data for a minimum of 3 months or ideally 6-12 months to aid in refining odour assessment and modelling.	3.3 and 5.1
3.8. Collection of wind speed data using an ultrasonic wind speed sensor to ensure accurate representation of low wind speed frequencies to allow more accurate prediction of likely katabatic impact receivers is recommended.	3.3 and 5.1

1.3 Scope of Work

The scope of work for the assessment included:

- Obtaining information about the proposed sheds;
- Analysing regional weather data to select a representative year;
- Modelling meteorology for the area using TAPM/CALMET;
- Analysing data from the on site weather station;
- Comparing the TAPM/CALMET dataset with onsite weather observations;
- Estimating odour and dust emissions for the poultry breeder/rearer farm in line with industry standard methods;
- Predicting odour dispersion using CALPUFF; and
- Preparing a report.

The methodology used is summarised graphically in Figure 1-2.

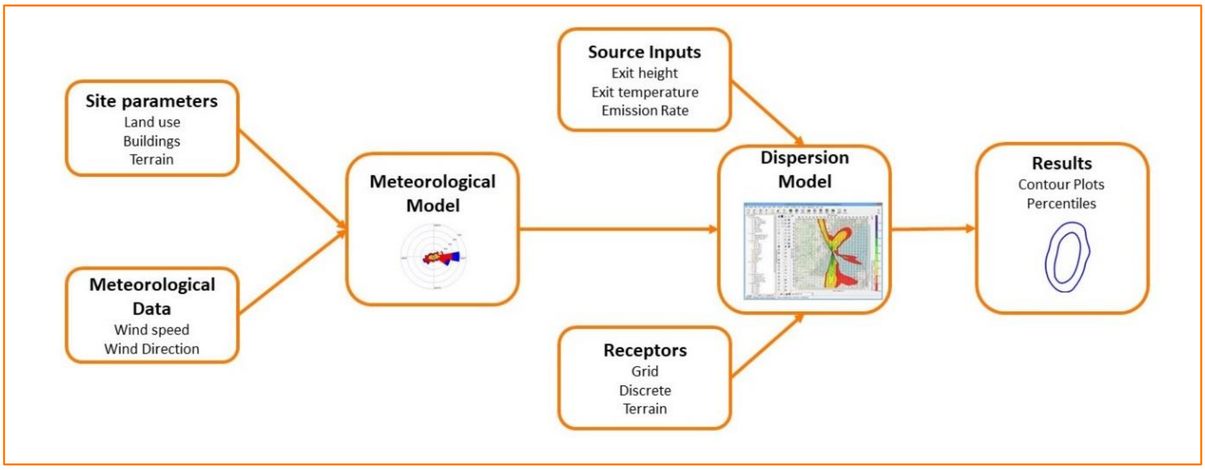


Figure 1-2 Modelling Methodology

2 ASSESSMENT CRITERIA

2.1.1 Odour

The odour criteria used in New South Wales are detailed in the Approved Methods (NSW EPA, 2016). For a complex mixture of odorants (i.e. odour measured as odour units), the criterion is selected based on the population density in an area. This is based on the concept that as population density increases, the number of people who may be sensitive to an odour increases. The criteria are summarised in Table 2-1.

Table 2-1: Impact Assessment Criteria from NSW EPA (2016)

Population of affected Community	Impact assessment criterion for complex mixtures of odorous air pollutants (ou)
Urban (≥~2000) and/or schools and hospitals	2.0
~500	3.0
~125	4.0
~30	5.0
~10	6.0
Single rural residence (≤~2)	7.0

Whilst no specific guidance is provided in the Approved Methods, the approach often suggested by NSW EPA for setting the odour criterion for a site is as follows:

- Model the site using standard methods;
- Prepare an odour contour plot showing the $C_{99\ 1sec}$ = 2 ou contour;
- Count the existing houses/dwellings within the 2 ou contour ;
- Determine the average population per dwelling based on the average data from the most recent Census data;
- Determine the total population and then determine the criterion to be used based on Equation 7.2 in the Approved Methods.

2.1.2 Particulate Matter

The Approved Methods (NSW EPA, 2016) also specifies the air quality assessment criteria relevant for assessing impacts from dust-generating activities. For this assessment, particulate matter less than 10 micrometres (PM_{10}) was included as the assessment parameter for dust emissions. PM_{10} is the size fraction that is generally the limiting dust parameter from poultry farms as it is generated by normal activities in the sheds (as opposed to combustion sources). This means that if the PM_{10} criteria are met, there is minimal risk of exceedances of dust deposition or particulate matter less than 2.5 micrometres ($PM_{2.5}$).

Particulate matter criteria relevant to the proposed farm are detailed in Table 2-2.

Table 2-2: Particulate Matter Impact Criteria (NSW EPA, 2016)

Pollutant	Averaging Period	Concentration (µg/m^3)
PM_{10}	24-hour maximum	50
	Annual mean	25

3 MODELLING METHODOLOGY

3.1 Representative year

The selection of a representative meteorological year for dispersion modelling is important. Typically, a single year of data is included in an assessment. Critical meteorological factors for air quality assessments include wind speed and temperature. These need to be assessed against long term data to determine which year is most similar to the average conditions rather than simply selecting a modelling year at random.

However, for sites where local data (including on-site data) is used, the selection of a representative year is not considered as significant as for a site where no local data is available.

The first step in the process was that we obtained 1-minute data from the Cowra Airport Automatic Weather Station and averaged the data to hourly averages in line with USEPA (2000).

We then averaged the hourly data by hour of day and by season for the years 2012 to 2019 for wind speed, temperature and humidity, and compared these data to the long term averages (i.e. all hours from 2012 to 2019).

The data are summarised below as box and whisker plots.

A box and whisker plot is a figure that presents information based on factors such as minimum and maximum values, the 25th and 75th quartile values and averages. They are useful for indicating whether a distribution is skewed and whether there are potential unusual observations (outliers) in the data set. They are particularly useful when large numbers of observations are involved and when two or more data sets are being compared (Statistics Canada, 2013).

Figure 3-1 below shows how a box plot is structured. In the case of the figure, the maximum, minimum, first and third quartiles and median values are shown. The Inter Quartile Range (IQR) in the figure shows the middle 50% of values (the difference between the 75th and 25th percentiles).

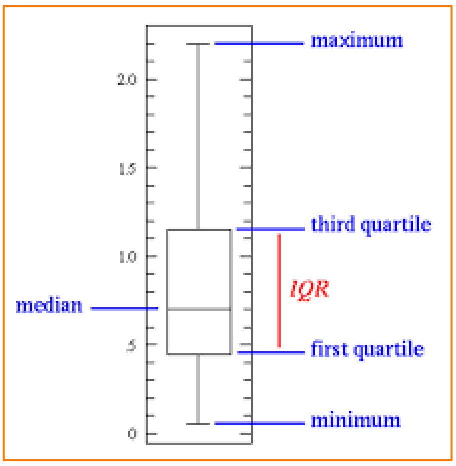


Figure 3-1: Boxplot Structure

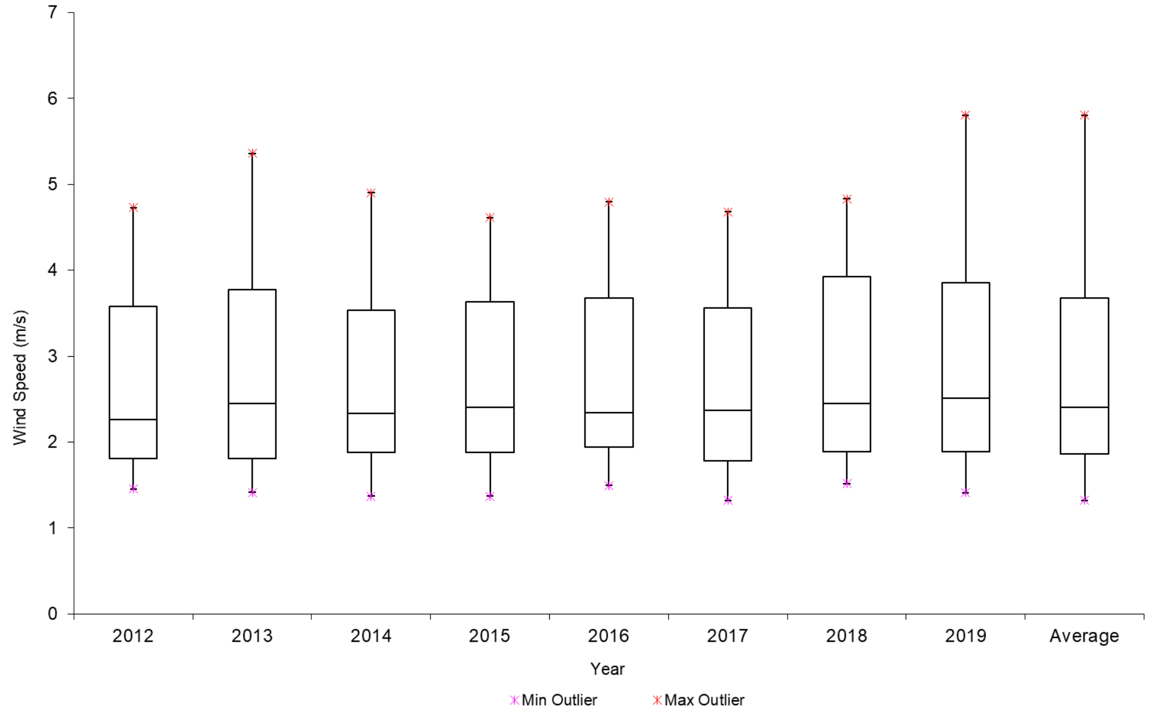


Figure 3-2: Average Wind Speed by Hour of Day

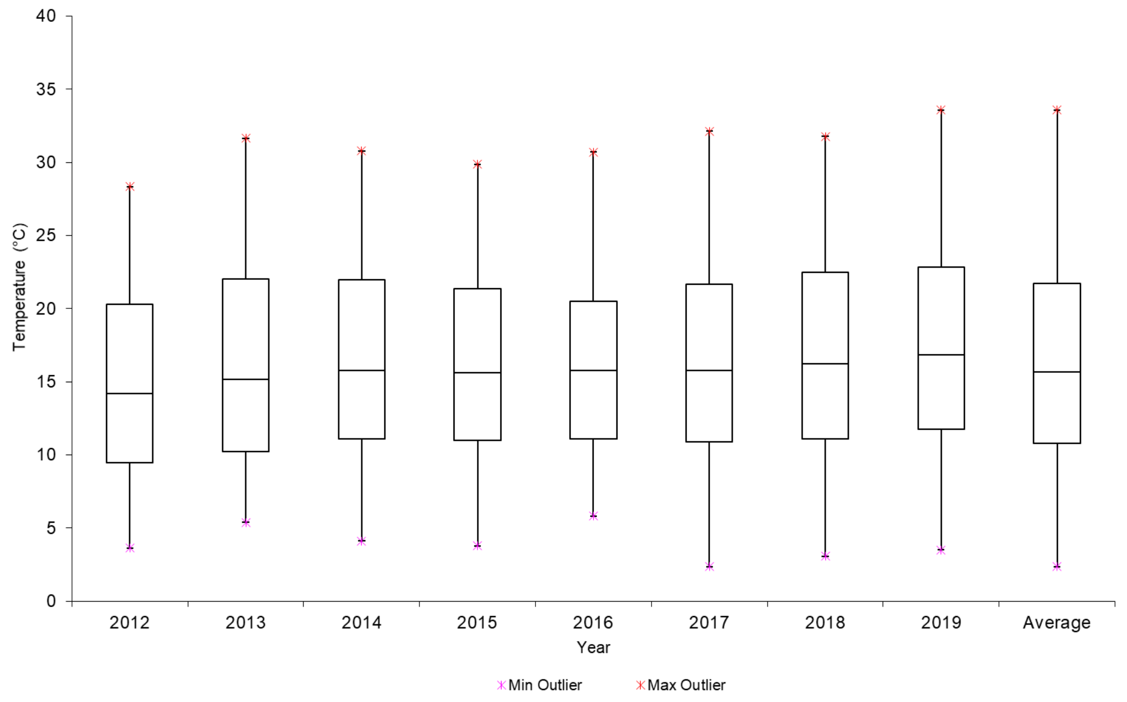


Figure 3-3: Average Temperature by Hour of Day

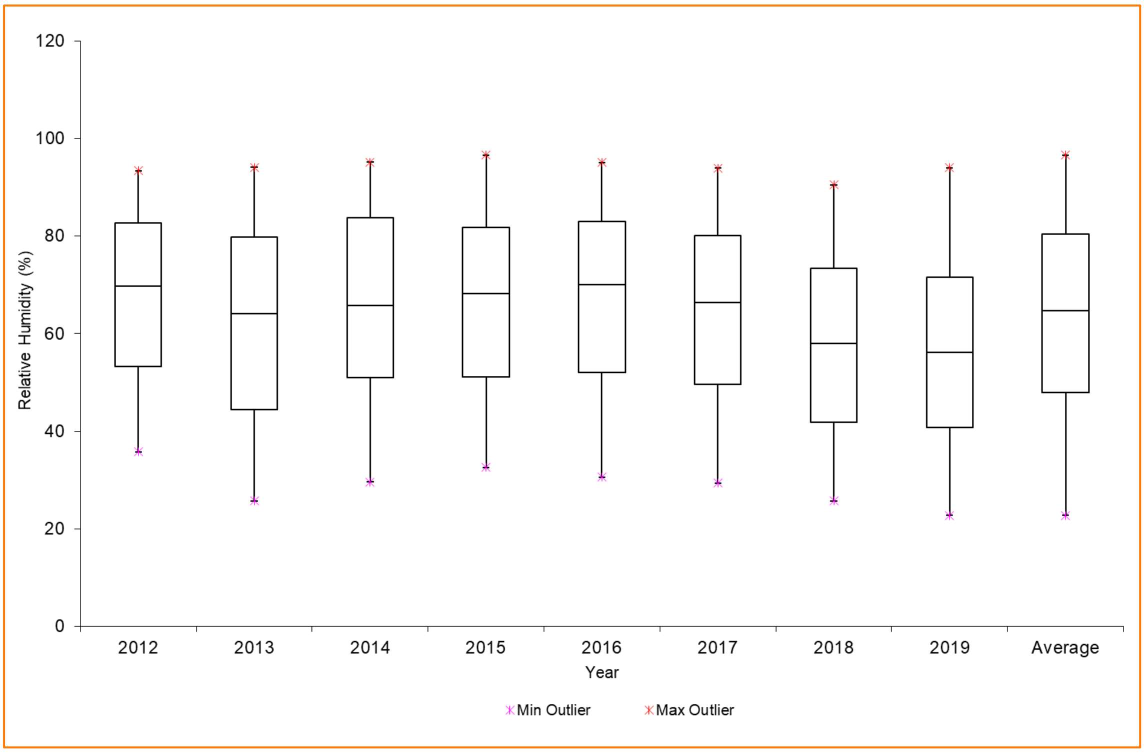


Figure 3-4: Average Relative Humidity by Hour of Day

The data in box and whisker plots can easily be used to see if two datasets are different. For example, if the boxes showing the IQR overlap they are not considered different, but if they do not overlap the two datasets can be considered different. The median lines are also critical in that even if the boxes overlap if the median of one dataset is above or below the IQR (box) of another dataset, they are also considered different.

Based on the data above, the representative year and dataset modelled here is 2017 as the data for 2017 was similar to the long-term averages.

3.2 Meteorological Modelling

3.2.1 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, TAPM V4 User Manual, 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, TAPM V4 Part 1: Technical Description, 2008b) and it has both prognostic meteorological and air pollution (dispersion) components. The benefit with using TAPM is that key meteorological aspects including the influence of terrain induced flows are predicted both locally and regionally.

The TAPM default landuse database was further refined as it poorly represented the landuse within the innermost modelling domain. The default and adjusted landuse files are presented in Figure 3-5. The TAPM setup is summarised in Table 3-1 below and is consistent with good practice and the requirements in NSW EPA (2016).

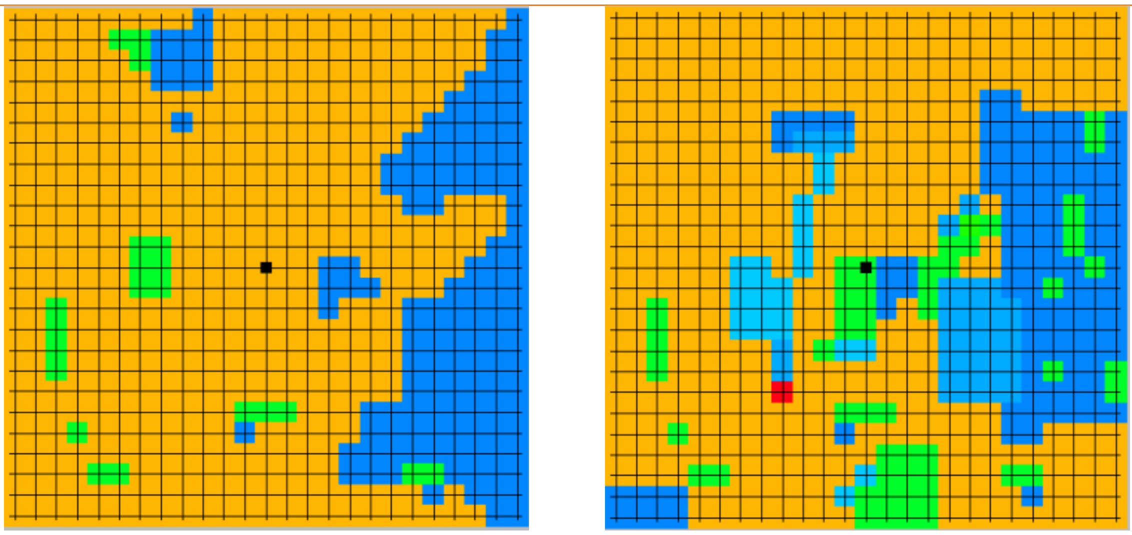


Figure 3-5: Default TAPM (left) and Adjusted Landuse (right) for the Site

3.2.2 CALMET

CALMET is the meteorological pre-processor to CALPUFF and generates wind fields which 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 20 km x 20 km domain was modelled for the proposed site with the centre of the domain near as possible to the middle 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.

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

Key inputs used in TAPM and CALMET are summarised below in Table 3-1.

Table 3-1: TAPM and CALMET Setup

Model	Parameter	Value
TAPM (v 4.0.5)	Number of grids (spacing)	30 km, 10 km, 3 km, 1 km
	Number of grid points	25 x 25 x 25 (vertical)
	Year of analysis	2017
	Centre of analysis	33°48'00" South (latitude), 148°14'00" East (longitude)
	Meteorological data assimilation	Yes
	Station; Radius of Influence; Data quality; Vertical levels	Young BoM; 13,000 m; 1; 2 Cowra BoM; 11,000 m; 1; 2
CALMET (v 6.334)	Meteorological grid domain	20 km x 20 km
	Meteorological grid resolution	0.10 km
	South-west corner of domain	X = 604.000 km, Y = 6249.000 km
	Surface meteorological stations	NA
	Upper air meteorological data	NA
	3D Windfield	m3D from TAPM (1km) input as in initial guess in CALMET
	Year of analysis	2017
	Terrad	3.0 km

3.3 On site Weather Station

Environdata was commissioned to install and manage an onsite weather station. The station meets the requirements in the *Approved methods: Sampling and analysis of air pollutants in NSW* (DEC NSW, 2006).

A summary of the details that have been provided to Astute are as follows;

- The station went live on the 22 April 2021 and from this date on collected data;
- Wind speed and direction is measured at 10 metres using a Vaisala WXT530 series Ultrasonic sensor package.
- Air Temperature is measured using a dedicated sensor supplied by Environdata with an accuracy of +/- 0.1 °C between -10 to +40 °C;
- A dedicated Relative Humidity sensor is used that includes a field replaceable tip with +/- 2% accuracy between 10% & 90%;
- Barometric Pressure is measured with a Environdata BP40 sensor with an accuracy of ±0.5 hPa between 800 to 1100 hPa; and
- A tipping bucket rain gauge that meets relevant standards is used to measure rainfall. The tipping bucket rain gauge on raised mount located adjacent to the weather station.

Dispersion modelling assessments are conducted over a period of at least 12 months of continuous meteorological data. Due to the limited data available, the weather station observations haven't been assimilated in the TAPM or CALMET modelling. At the time of writing the TAPM synoptic data has been released up until 31 of August 2021. A comparison of the modelling methodology presented in this report against the observed data for the period of available data is presented below in Section 5.1.

3.4 Dispersion Modelling

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 the preferred model for odour studies.

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.

Table 3-2: CALPUFF Setup

Model	Parameter	Value
CALPUFF (v 6.40)	Meteorological grid domain	20km x 20km
	Meteorological grid resolution	0.10km
	South-west corner of domain	X = 604.000 km, Y = 6249.000 km
	Method used to compute dispersion coefficients	2 - dispersion coefficients using micrometeorological variables
	Minimum turbulence velocity (Svmin)	0.2 m/s
	Building downwash included	No
	Default settings	All other CALPUFF defaults have been used in line with OEH (2011).

The proposed sheds will be tunnel ventilated and therefore have been represented as pseudo point sources at the fan end of the sheds. This means that each shed had a point source on the tunnel fan end of each shed with a diameter the same as the shed width. The vertical velocity in the point source was varied as a function of the maximum predicted ventilation rate to ensure that the momentum of the plume (and thus plume mass) was maintained. The vertical momentum was set to zero by using the ‘rain hat’ switch in CALPUFF. This ensures that the plume did not move vertically in the model but starts near ground level and disperses slowly from there.

Building wake has been shown to have negligible effect on the predicted concentrations of low-level sources such as chicken sheds therefore building wake has not been included in the modelling.

3.5 Emissions Estimation

3.5.1 Farm Setup

The emissions estimation methodology is summarised below with key inputs summarised in Table 3-3. As all four farms are stocked on different weeks of the year and ages of birds, the modelling assumed that a two year period was simulated with a single year. In simple terms, the modelling incorporated the overlapping nature of the production cycles to ensure that a continuous cycle was modelled.

The modelling was performed this way to provide a more realistic total farm population as shown in Figure 3-6, which shows that all farms are occupied (at various bird ages) at day 1 of the calendar year. Note that Figure 3-6 shows Farm 1 as a rearer only with Farms 2 to 3 being used for breeder production, and Farm 4 being 12 weeks of age at the start of the year and remaining stocked until 6 weeks of age.

Table 3-3: Emissions Estimation Inputs

Parameter	Farm 1	Farm 2	Farm 3	Farm 4
Farm type	Rearer	Production	Production	Rearer and Production
Shed length (m)	135	135	135	135
Shed width (m)	14	14	14	14
Shed area (m^2)	1,890	1,890	1,890	1,890
*Birds per shed	15,300	13,200	13,200	15,300
Stocking Density (birds/m^2)	8.1	7.0	7.0	8.1
Number of sheds	10	10	10	10
*Total birds	153,000	132,000	132,000	153,000
Age of batch start	Day old	20 weeks	20 weeks	Day old
Number of weeks per growing cycle	22	45	45	64**
Week placement of year?	1	20	40	30
Target temperatures °C	36-20	30-18	30-18	36-18

*NOTE: *total bird numbers include males and females, ** assumes both rearer and grower birds*

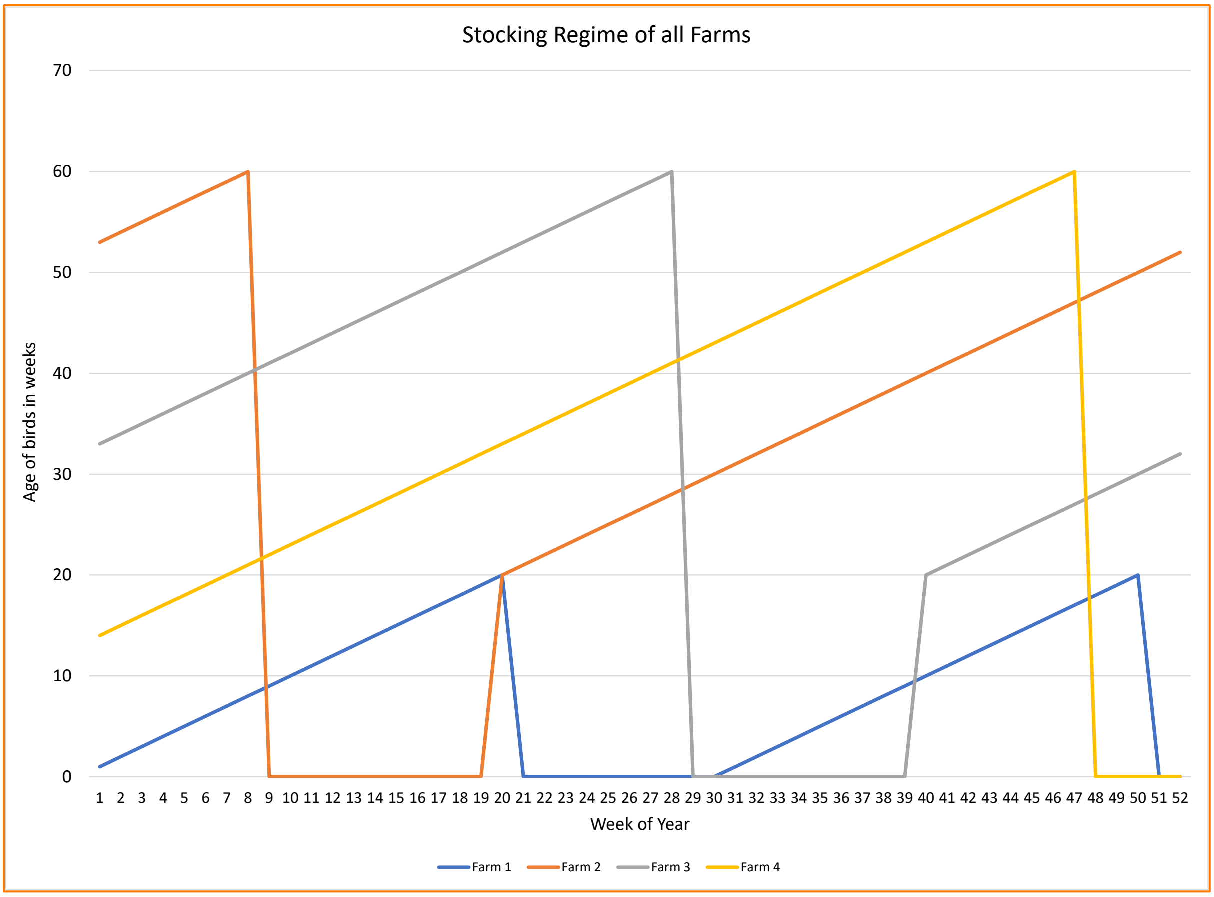


Figure 3-6: Bird Age On All Farms

3.5.2 Odour

The odour emissions model of Ormerod and Holmes (2005) was used as the basis of this assessment. The methodology is referred to in 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 odour test data at a number of 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; PAEHolmes, 2011):

$$OER = 0.025 \times K \times A \times D \times V^{0.5}$$ **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** if the K factor.

The K factor is a scaling factor which is used to reflect the performance of a farm. For the proposed farm we have used a conservative K factor of 2.2, even though a K factor of approximately 1 may be more relevant for breeder farms based on test data collected at various farms over time. We note that breeder farms typically have lower emissions, and less offensive odour than meat chicken farms with the same sized sheds.

Maximum shed ventilation rates were based on the proposed shed ventilation rates provided by Baiada (~30 m^3/hr/bird at maximum). Table 3-4 shows the shed ventilation rate (% of maximum) as a function of temperature above target temperature based on PAEHolmes (2011). Target temperatures were based on information provided by Baiada as presented in Table 3-3.

Table 3-4: 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	1.7	2.5	5.1	7.6	9.8	11.5	17.0	17.0
1	1.7	12.5	12.5	25.0	25.0	25.0	25.0	25.0
2	1.7	25.0	25.0	37.5	37.5	37.5	37.5	37.5
3	1.7	37.5	37.5	50.0	50.0	50.0	50.0	50.0
4	1.7	37.5	37.5	50.0	50.0	50.0	50.0	50.0
6	1.7	37.5	37.5	62.5	75.0	75.0	75.0	75.0
7	1.7	37.5	37.5	62.5	75.0	75.0	87.5	100.0
8	1.7	62.5	62.5	62.5	75.0	75.0	100.0	100.0
9	1.7	62.5	62.5	87.5	100.0	100.0	100.0	100.0

An example emission profile for Farm 3 is shown below in Figure 3-7. The removal of birds can be seen in the profile where the emissions drop.

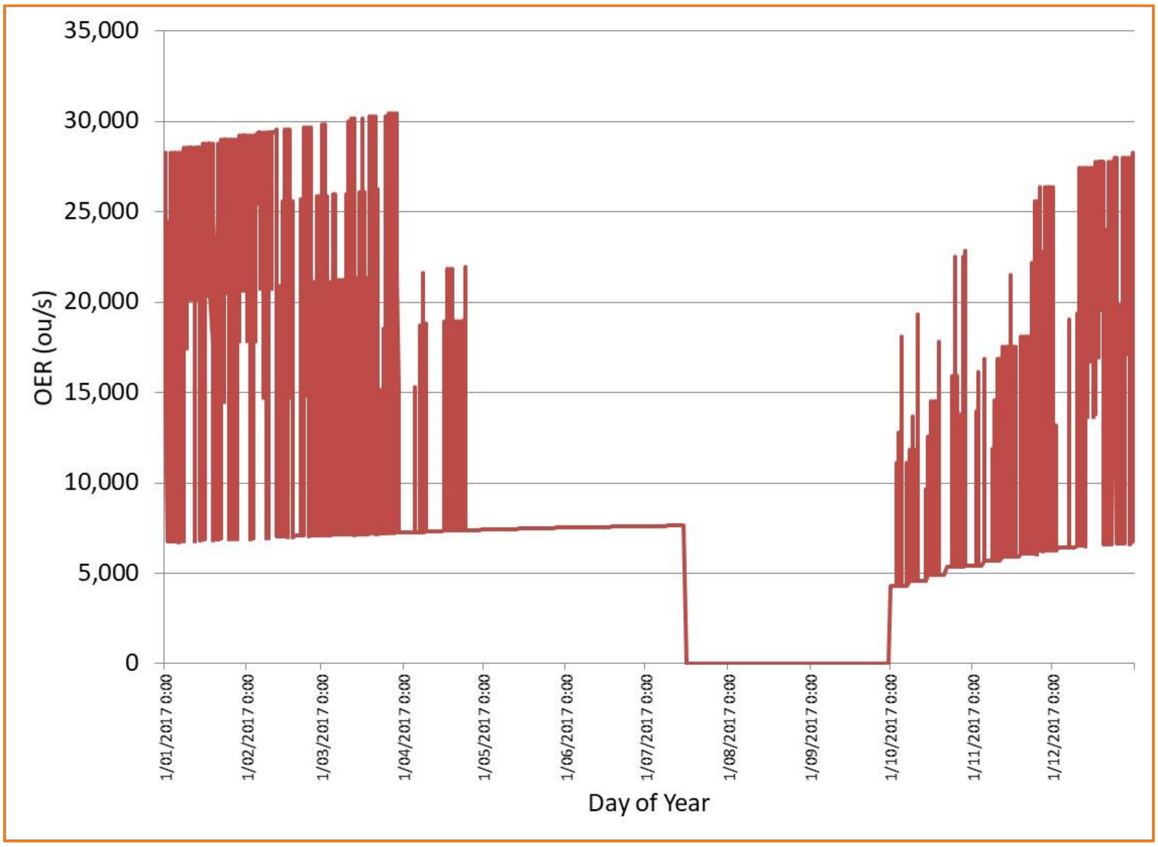


Figure 3-7: Example Shed Emission Profile (Farm 3) – K=2.2

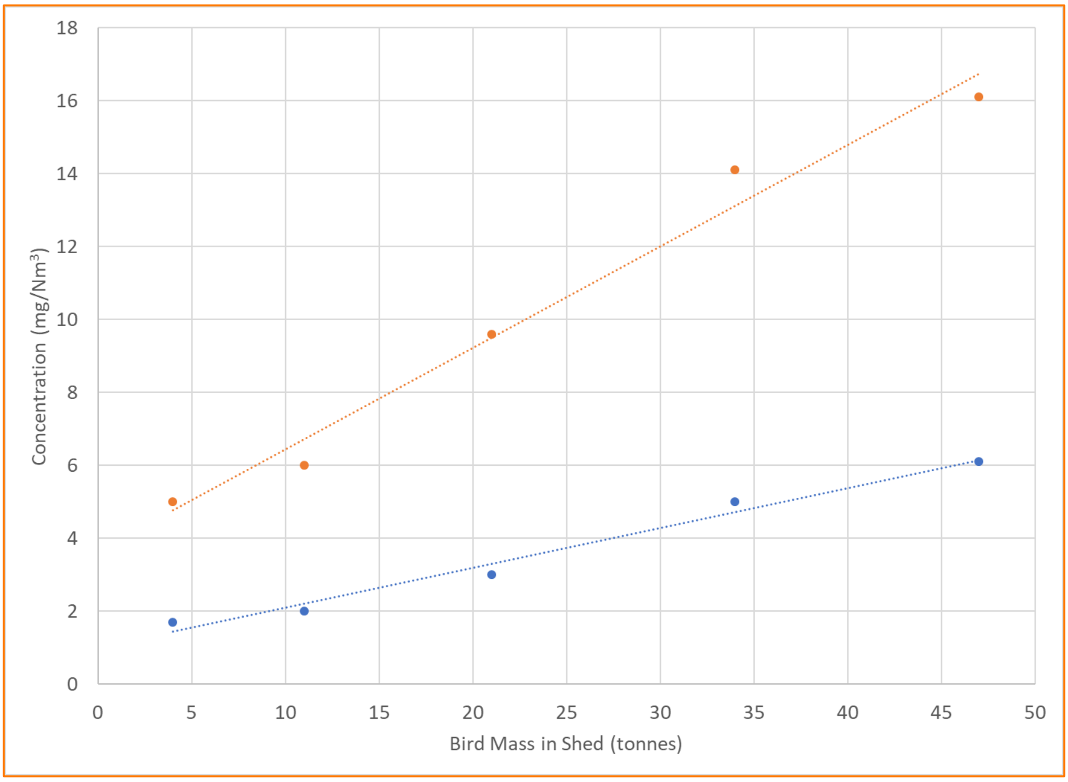
3.5.3 Particulate Matter

Particulate emissions were based on data collected at a meat chicken farm in New South Wales as well as theoretical considerations. The method derives an hourly varying emission rate for a shed based on:

- age and weight of birds present;
- ventilation rate; and
- shed management.

The method was based on Mirrabooka (2002) who reported dust emission rate data for a tunnel ventilated farm with nipple and cup drinkers across a range of bird ages. The data were gathered between July and August of the test year. Mirrabooka (2002) showed that at the time, the emissions measured were comparable to Victorian EPA recommended emission rates. More recent data including PAEHolmes (2012)[1] and Australian Poultry CRC (2011) has shown that emission estimation using Mirrabooka data leads to much higher emissions than what currently occurs. This is discussed further below.

To analyse the Mirrabooka data, it was first standardised to bird mass which is summarised in Figure 3-8.



[1] Collected using a DustTrak which was calibrated based on co-located Hi-vol results.

Figure 3-8: Bird Mass and Total Shed Concentration

From Figure 3-8 Equation 2 was developed where **PEC** is the maximum particulate concentration (mg/m^3), **M** is the total mass of birds (tonnes), **a** is 0.115 for PM_{10} and **b** is 0.917 for PM_{10}.

$$PEC = a \times M + b$$ **Equation 2**

To account for the dilution of dust as a function of ventilation (see Figure 3-9), Equation 3 was used where **PEC_v** is the emission concentration in mg/m^3, **c** is 4.11 for PM_{10}, **V** is the ventilation rate in m^3/s and **d** is -0.58 for PM_{10}.

$$PEC_v = PEC \times (c \times V^d)$$ **Equation 3**

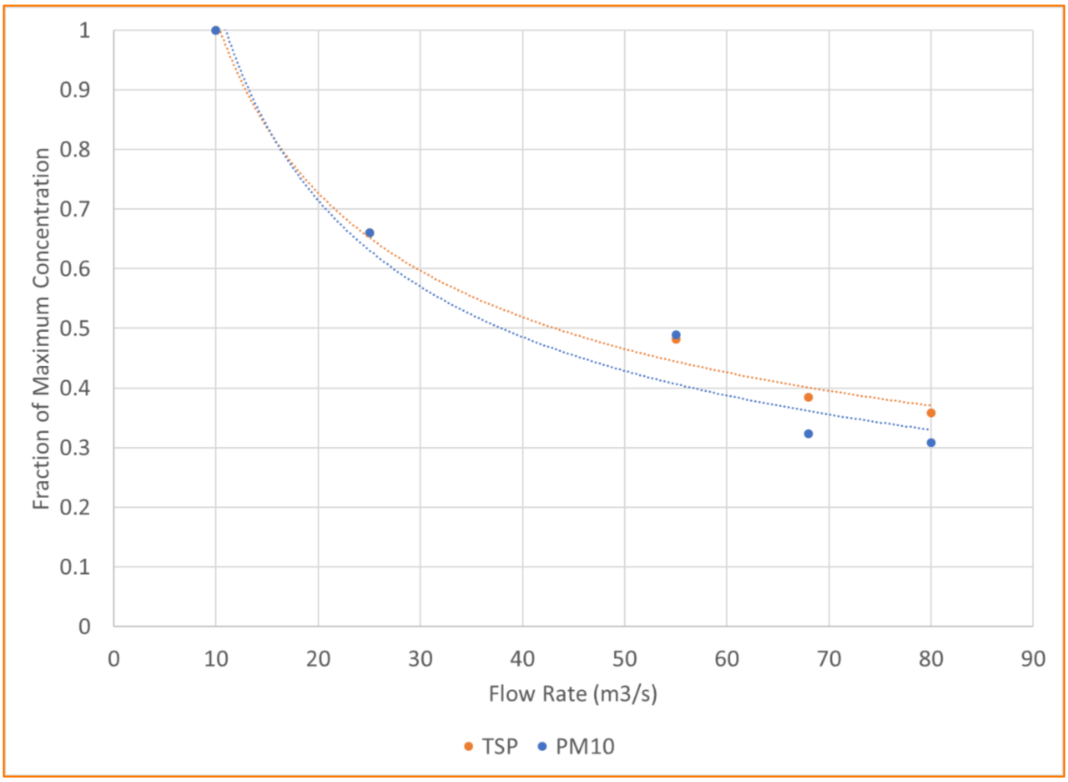


Figure 3-9: Particle Concentration and Flow Rate

The emission rate is then simply calculated at a point in time by multiplying PEC_v by the ventilation rate.

As noted above, Poultry CRC (2011) and PAEHolmes (2012) have shown the Mirrabooka method over estimates emissions by factor of at least two. As the Mirrabooka data and CRC data were both collected Isokinetically (where sample velocity matches airflow velocity), the data are directly comparable. To demonstrate this Figure 3-10 was prepared. The figure which shows in shed concentration by bird age per 1,000 birds should be read as follows:

- The orange markers are the predicted in shed concentrations using the Mirrabooka based method above for a meat chicken shed on a mg/m³/1000 bird basis;
- The grey markers show the Poultry CRC data on a mg/m³/1000 bird basis;
- The blue markers are the measured concentration data from PAEHolmes (2012) on a mg/m³/1000 bird basis.

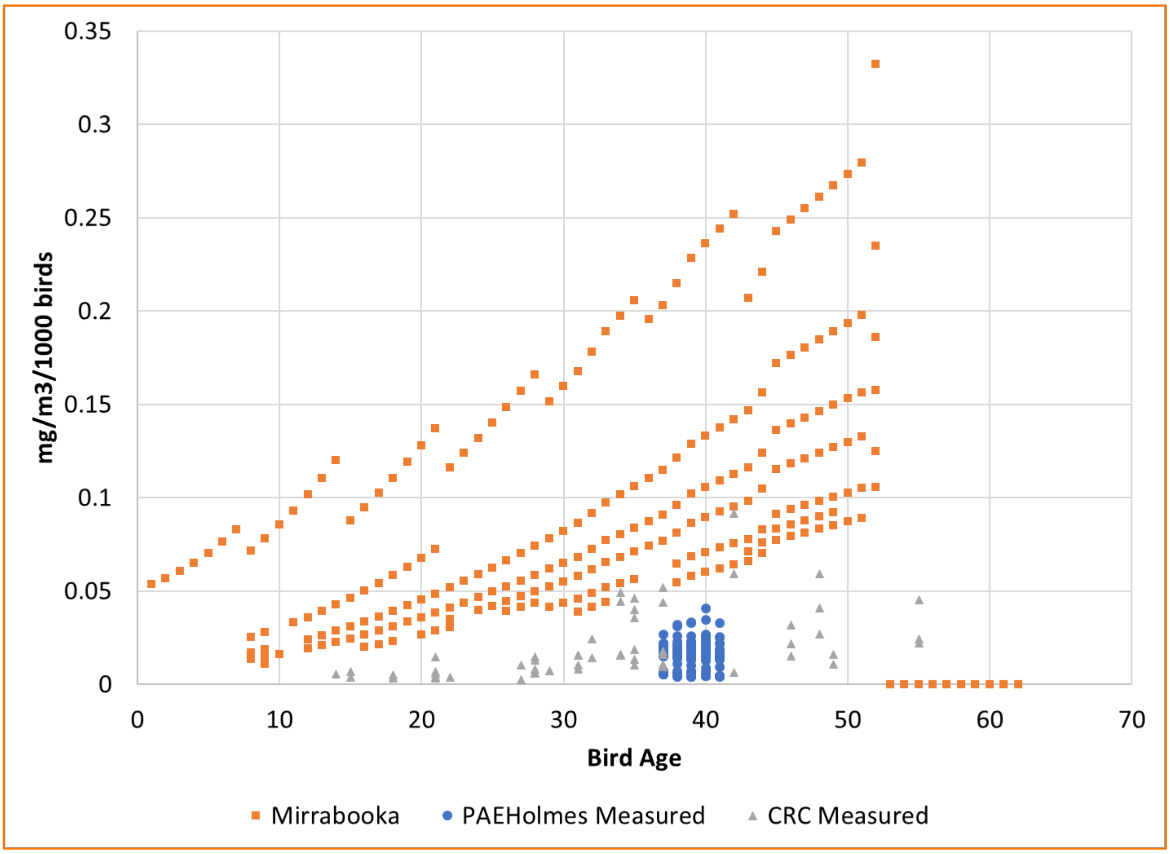


Figure 3-10: PM_{10} - Comparison of Mirrabooka Estimated Concentrations to CRC and PAEHolmes Data

Figure 3-10 shows that the method significantly over predicts dust emissions. Even if the Mirrabooka method were divided by two, the emission rate would still overpredict emissions. Recognising this, we modified Equation 3 by dividing the predicted emissions by two which will still result in a conservative estimate of impacts. The resultant equation, Equation 4, is shown below.

$$PEC_v = \frac{PEC \times (c \times V^d)}{2}$$ **Equation 4**

4 EXISTING ENVIRONMENT

4.1 Meteorological Data

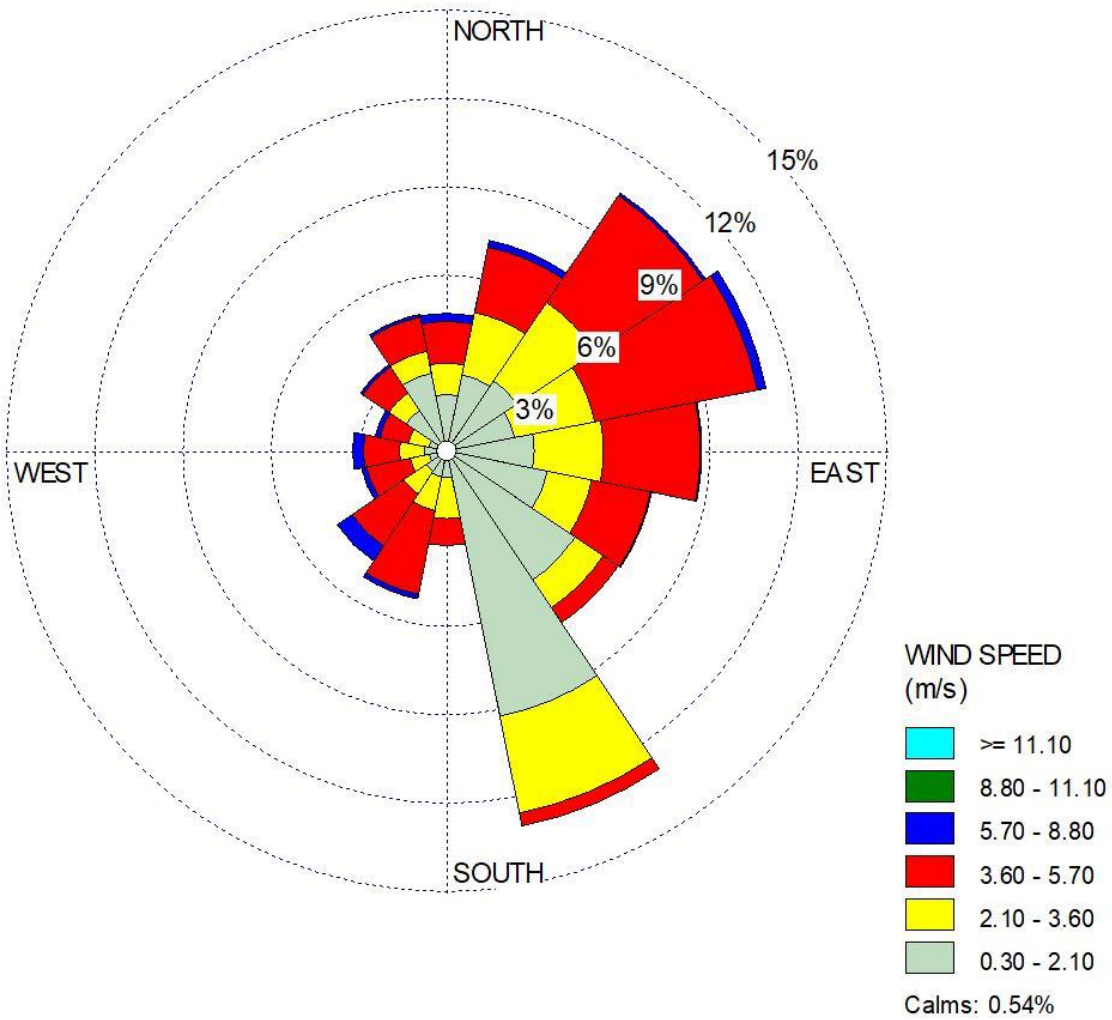
The principal meteorological parameters that influence plume dispersion are wind direction, wind speed, atmospheric stability (turbulence) and atmospheric mixing height (height of turbulent layer). This section presents a summary of the key meteorological features

4.1.1 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 (Figure 4-1) shows that the site is dominated by south easterly winds with a noticeable north easterly component.

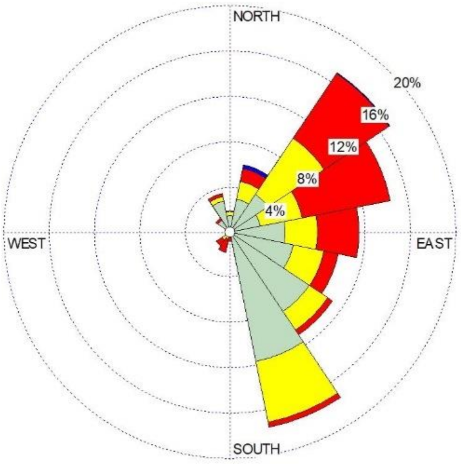
The wind roses show a relatively low proportion of calm winds (~0.5%) with light winds over the year (up to 3 m/s) occurring ~58% of the time. The wind speed frequencies are summarised graphically in Figure 4-3.



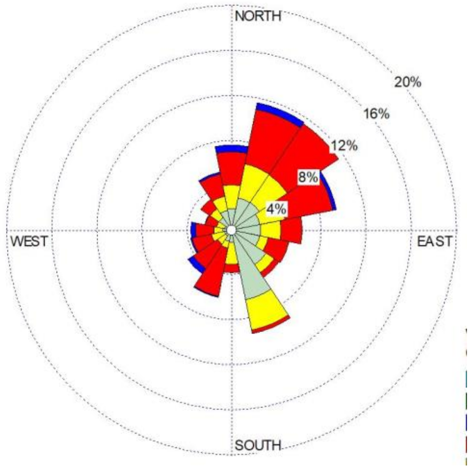
Location: Centre of domain	*Year:* 2017	*Data Source:* CALMET extract
Calm winds: 0.5 %	*Average wind speed:* 2.9 m/s	*Creator:* W. Shillito

Figure 4-1: Annual Wind Rose for the Site

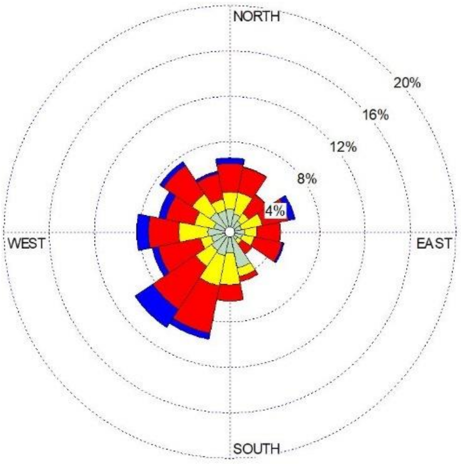
1 AM to 6 AM



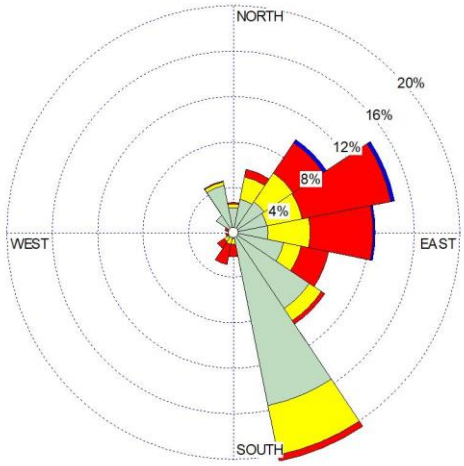
7 AM to 12 PM



1 PM to 6 PM



7 PM to 12 AM



Period	*Average wind speed (m/s)*	*Calm winds %*
1 AM to 6 AM	2.6	0.5
7 AM to 12 PM	3.3	0.7
1 PM to 6 PM	3.0	0.5
7 PM to 12 AM	2.6	0.5

WIND SPEED (m/s)

- >= 11.10
- 8.80 - 11.10
- 5.70 - 8.80
- 3.60 - 5.70
- 2.10 - 3.60
- 0.30 - 2.10

Location:	*Year:*	*Data Source:*	*Creator:*
Centre of domain	2017	CALMET extract	W. Shillito

Figure 4-2: Time of Day Wind Rose for the site

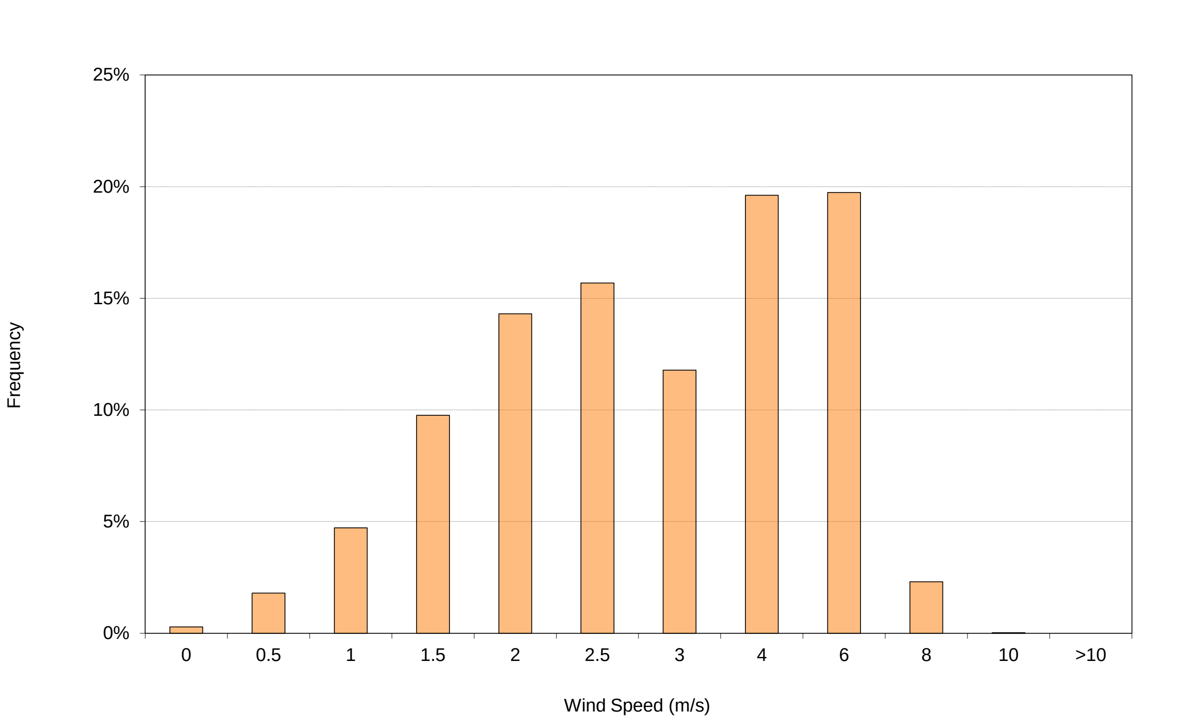


Figure 4-3 Wind Speed Frequency from CALMET

4.1.2 Atmospheric Stability

Atmospheric stability is a key factor in dispersion modelling and is used to describe turbulence in the atmosphere. Turbulence 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 or diffuse the plume as much as strong turbulence, and therefore leads to high downwind concentrations. This is often associated with very 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[2]. 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 can lead to impacts, especially for ground level sources.

Between Class A and Class F are stability classes which range from moderately unstable (B), through 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.

[2] 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 (which can only occur at night, along with D class winds which can occur day or night) occurs 45% of the time. The elevated frequency of D class stability (24%) is commonly seen in areas with winds above 2.5 m/s at night or site with a high frequency of cloudy days.

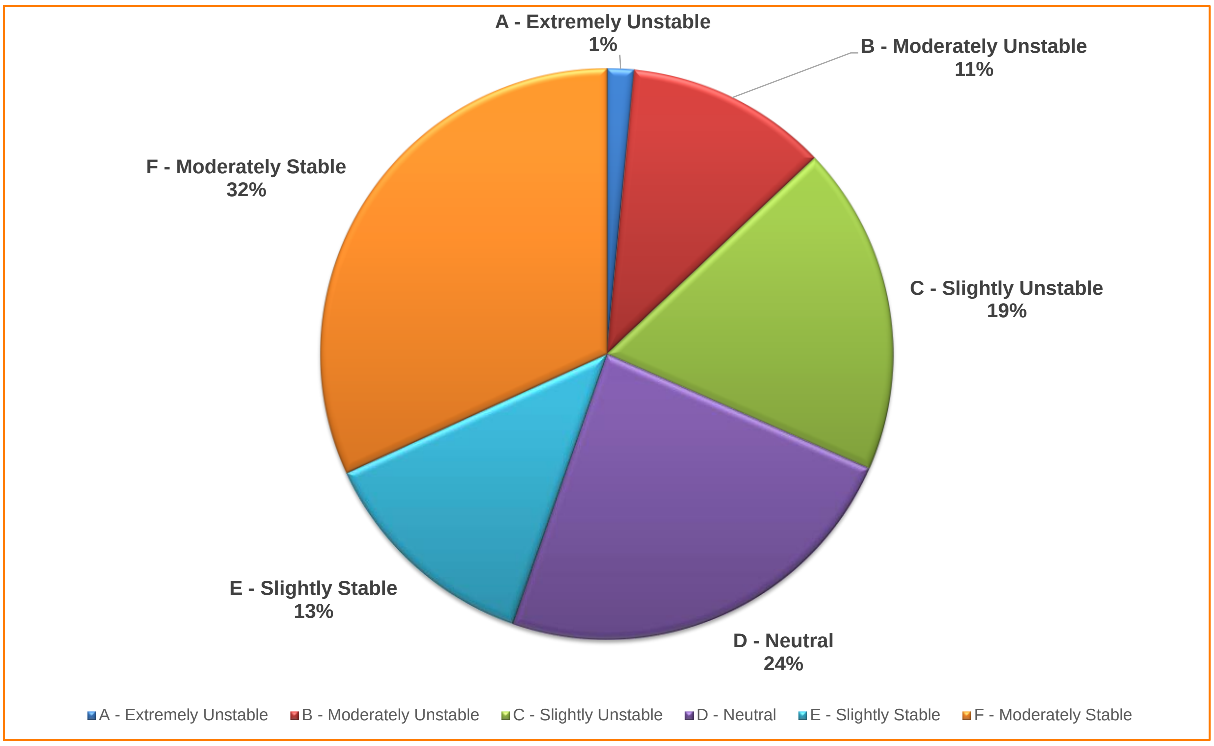


Figure 4-4: Atmospheric Stability

4.1.3 Atmospheric Mixing Height

The mixing height is the height of 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.

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.

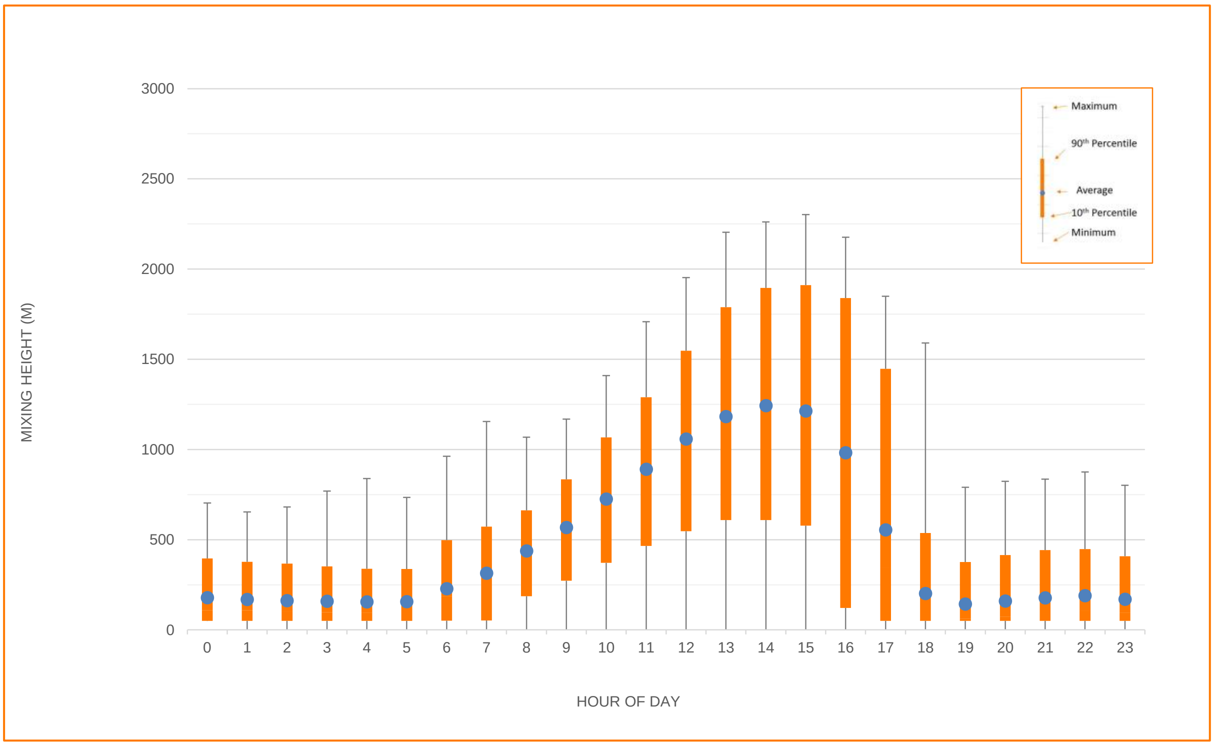


Figure 4-5: CALMET Extract – Predicted Mixing Heights

4.2 Background Air Quality Data

Existing air quality in the region surrounding the farms is influenced by the following sources:

- Dust from agricultural activities (ploughing, harvesting, bailing);
- Wind erosion from exposed areas; and
- Wheel generated dust from unsealed rural roads.

As the proposed poultry farms are situated in a rural area with no major sources of air pollution beyond typical rural sources, the local air quality is likely to be good and concentrations of pollutants are unlikely to exceed any of the air quality criteria except for during extreme events such as bushfires or dust storms.

No air quality measurements have been made specifically for this assessment however, the OEH operates monitoring stations throughout New South Wales. The closest monitoring station to the site considered suitable is in Bathurst, located approximately 130 km to the northwest. Cowra has a rural networking monitoring station located 40 km to the east however the data isn't available from the New South Wales Air Quality Monitoring Network download site as it is only an indicative station and therefore wasn't used.

A summary of the data at Bathurst is presented below in Table 4-1. The maximum 24-hr concentration PM_{10} for the year modelled was 49.9 µg/m^3.

Table 4-1: Summary of Bathurst PM_{10} data

Parameter	PM_{10} 24 – hour
Monitoring period	01/01/2017 – 31/12/2017
Averaging period	24 hours
Number of validated measurements	354
Data capture	99.9%
Average	14.1 µg/m^3
Percentiles and Concentrations (µg/m^3)	
25th	9.9
50th	12.8
70th	16.2
90th	21.1
99th	36.3
3rd highest	38.8
2nd highest	48.0 (24/09/2017)
Maximum	49.9 (23/09/2017)
Annual Average	14.1

Concerning the highest and second highest concentrations in the table above, it is noted that these are associated with a large dust storm event that caused exceedances across many parts of New South Wales during the same period (OEH, 2017). On 22-24 September 2021 many stations in NSW were defined as having an exceptional event influence measured concentrations (OEH, 2017).

As noted in OEH (2017), the dust storm moved from North Western NSW to the south east into the Sydney area (Bathurst is north west of Sydney). As the concentrations were not above 50 µg/m^3 over a 24 hour period (midnight to midnight as opposed to a rolling average) they didn't trigger the exceptional event rule.

The data for Bathurst for the period where the maximum concentration occurred is shown below in Figure 4-6. It can be seen in Figure 4-6, if a rolling 24 hour concentration was applied, the 50 µg/m^3, limit would have been exceeded and this would have been defined as an exceptional event. For example, the 24 hour concentration from midday to midday was 73 µg/m^3 which was, as noted by OEH (2017), being associated with an exceptional event.

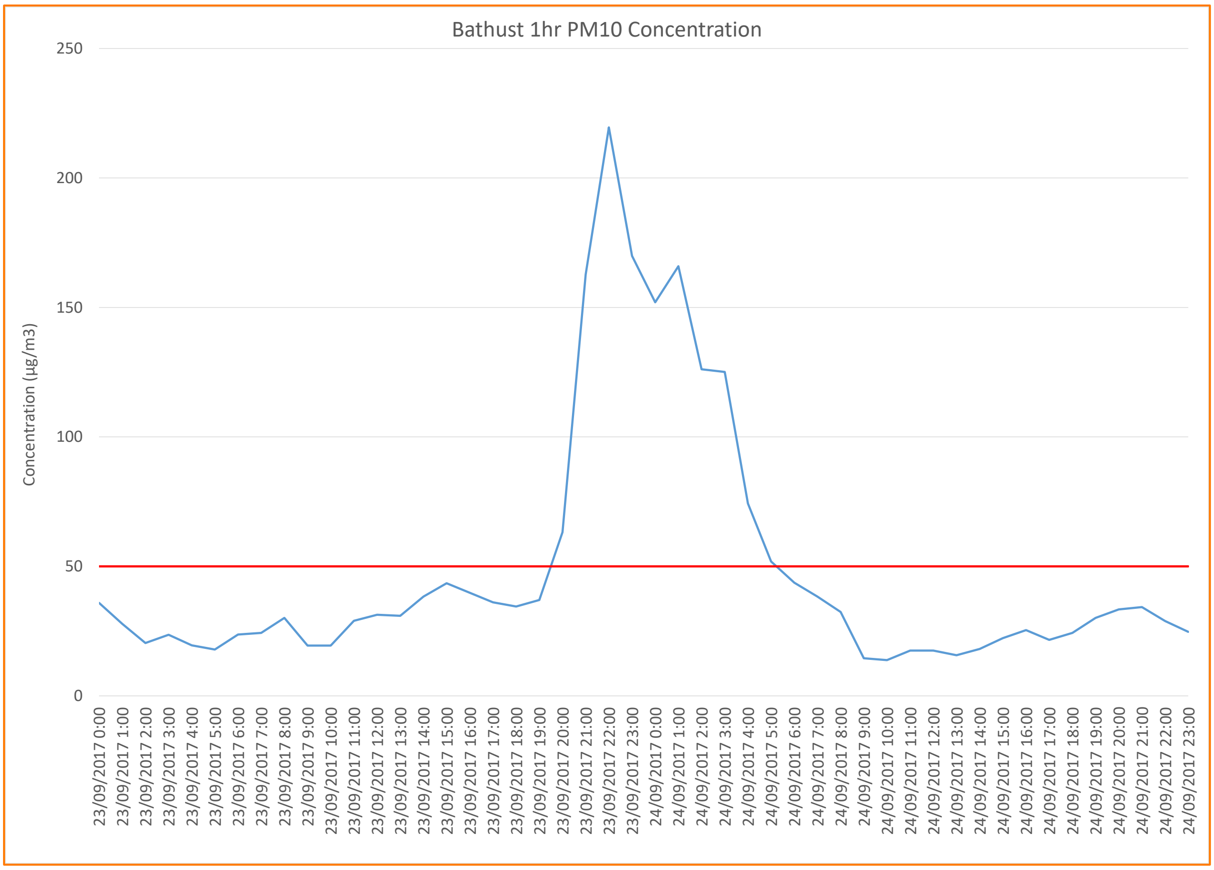


Figure 4-6: Rolling 1hr PM_{10} Concentration at Bathurst

Considering OEH (2017) and Figure 4-6, we have replaced the data on the 23rd and 24th of September 2017 with the 70th percentile of the values for the year as the use of the maximum 24 hour concentrations were shown to be associated with an exceptional event. The cumulative assessment is presented in Section 5.3.

5 RESULTS

5.1 Meteorological Methodology Validation

As noted in Section 1.2 above, the SEARS recommended the installation of a weather station. The weather station specifications were detailed in Section 3.3 above.

The paired hourly data from the weather station and the model were analysed using the methodology detailed in Emery et al. (2001) with the exception that daily wind direction analysis was also performed in line with Johnson (2019) who recommended daily gross error checks for direction as opposed to hourly.

An analysis of the weather station and TAPM/CALMET dataset is presented as follows:

- Table 5-1: Wind Speed Analysis;
- Table 5-2: Wind Direction Analysis;
- Figure 5-1: Wind Roses – Modelled and Measured; and
- Figure 5-2: Wind Speed Frequency Comparison.

Note that the TAPM/CALMET dataset was prepared using a standard setup, and was not adjusted in an attempt to obtain a better match (i.e. by adjusting model settings). This is discussed further below.

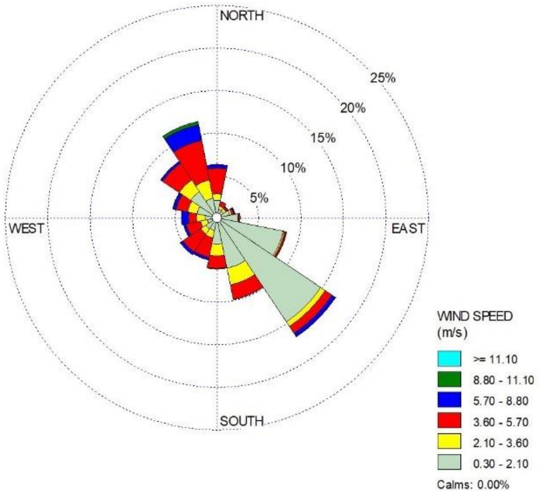
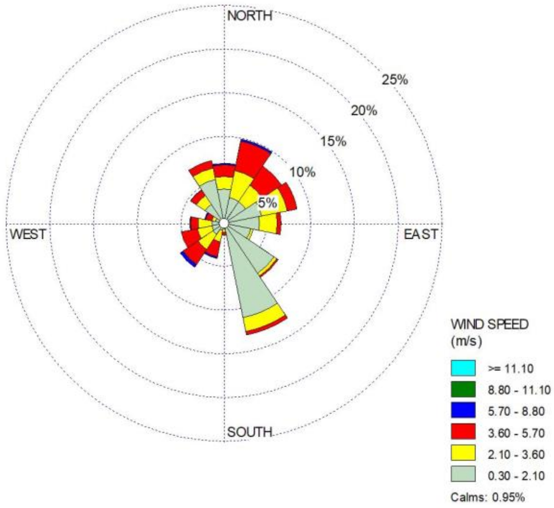
Table 5-1: Wind Speed Analysis

Variable	Calculated Value	Criteria	Meets Criteria?
Bias	-0.3	±0.5	Yes
RMSE	1.5	≤2	Yes
IO	0.75	≥0.6	Yes
SkillE	0.8	≤1	Yes
SkillR	0.6	≤1	Yes
SkillV	0.7	Close to 1	Yes

Table 5-2: Wind Direction Analysis

Variable	Calculated Value	Criteria	Meets Criteria?
Bias (hourly)	-38	±10	No
Gross Error (hourly)	49	≤30[3] - Standard sites ≤55 – complex terrain	No – Default Yes – Complex Terrain
Bias (daily)	-64	±10	No
Gross Error (daily)	-37	≤30 - Standard sites ≤55 – complex terrain	No – Default Yes – Complex Terrain

[3] Kemball-Cook et. al (2005) proposed a series of benchmarks for model performance under complex conditions including areas with variable terrain heights and land uses. Kemball-Cook et al. suggested a gross error benchmark of ≤55° for wind direction and a bias benchmark of ≤10° for areas with complex features. These benchmarks were subsequently adopted in reports including USEPA (2015) and USEPA (2020). The American Meteorological Society (2012) defines complex terrain as

Weather Station Observations	TAPM/CALMET Dataset
	

	Weather station	TAPM/CALMET	WIND SPEED (m/s)
Average wind speed	2.65 m/s	2.34 m/s	>= 11.10 8.80 - 11.10
Calm winds	0.0 %	0.95 %	5.70 - 8.80 3.60 - 5.70
Wind less than 3 m/s	65 %	74 %	2.10 - 3.60 0.30 - 2.10

Figure 5-1: Wind Roses – Modelled and Measured

“A region having irregular topography, such as mountains or coastlines. Complex terrain can also include variations in land use, such as urban, rural, irrigated, and unirrigated”.

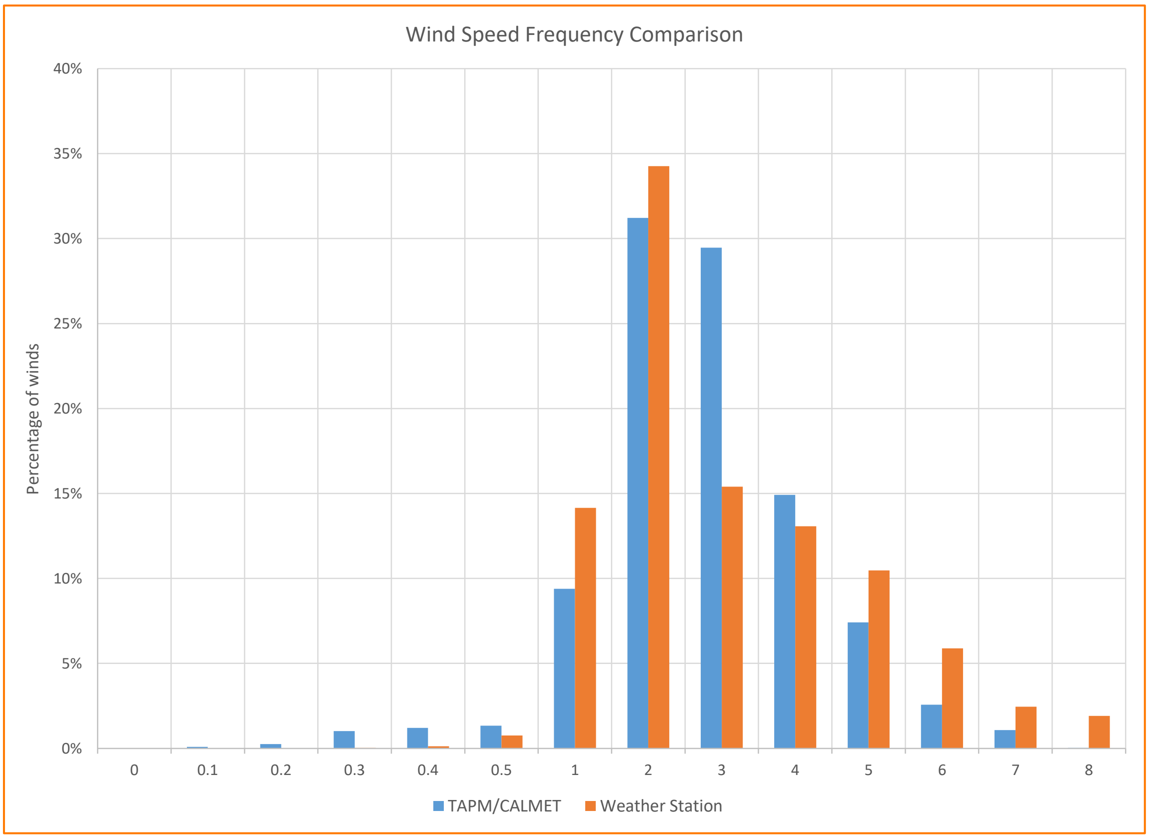


Figure 5-2: Wind Speed Frequency Comparison

The figures and tables above show:

- Wind Speed
  - Met all benchmarks;
  - Frequency analysis shows TAPM/CALMET predicts slightly more light winds and more calm winds (0% under 0.3 m/s vs 1%).
- Wind Direction
  - Did not meet bias benchmark;
  - Did not meet standard gross error benchmark, but met benchmark for complex terrain.

When using the benchmarks above, Emery et. al. (2001) noted that the purpose of the benchmarks is not necessarily to give a passing or failing grade to any one particular application, but rather to put the results into context. In other words, by assessing a variety of benchmarks for wind speed and direction, the relative accuracy of the dataset as a whole can be assessed.

For this site, the wind roses shown in Figure 5-1 provide additional information that enables the difference between the datasets (in terms of bias[4] and gross error[5]) to be evaluated using the standard model setup.

When looking at the windroses, it can be seen that both show south easterly winds, with a relatively high frequency of light winds up to 3 m/s. Overall, the observed data has slightly stronger winds but only marginally as demonstrated by the wind statistics. The main difference in this direction is that the model picks up more south south easterly winds compared to the observed data which shows more south easterly winds.

When looking at northerly winds, the observed data clearly shows north westerly winds which are light to fresh), whereas the TAPM/CALMET data shows north easterly and north westerly winds which are lighter (light to moderate). It is likely that the models are picking up the terrain elements to the north west, whereas the weather station is measuring winds which are influenced by large scale rather than local effects.

When looking at the location of the receptors and sheds shown in Figure 1-1 above and considering the wind roses and the use of percentiles and continuous emissions from the site, the difference in predicted concentrations could be larger to the south east and smaller to the south west. However, considering the results in Section 5.2 and Section 5.3 below, and the location of receptors, this is unlikely to be significant.

Concerning the issue of Katabatic drift raised in the SEARS, the data above shows that the TAPM/CALMET dataset would be more likely to include Katabatic drift than the observed data, as it had a higher number of calms (0% vs 1%) however both sets would address this issue in that the frequency of calms is relatively low.

5.2 Odour

Predicted odour concentrations associated with the proposed farm based on the modelling and emissions estimation methodologies detailed above are provided below. The model results are presented as $C_{99\ 1sec}$ values, including a peak to mean of 2.3.

The results are shown as follows:

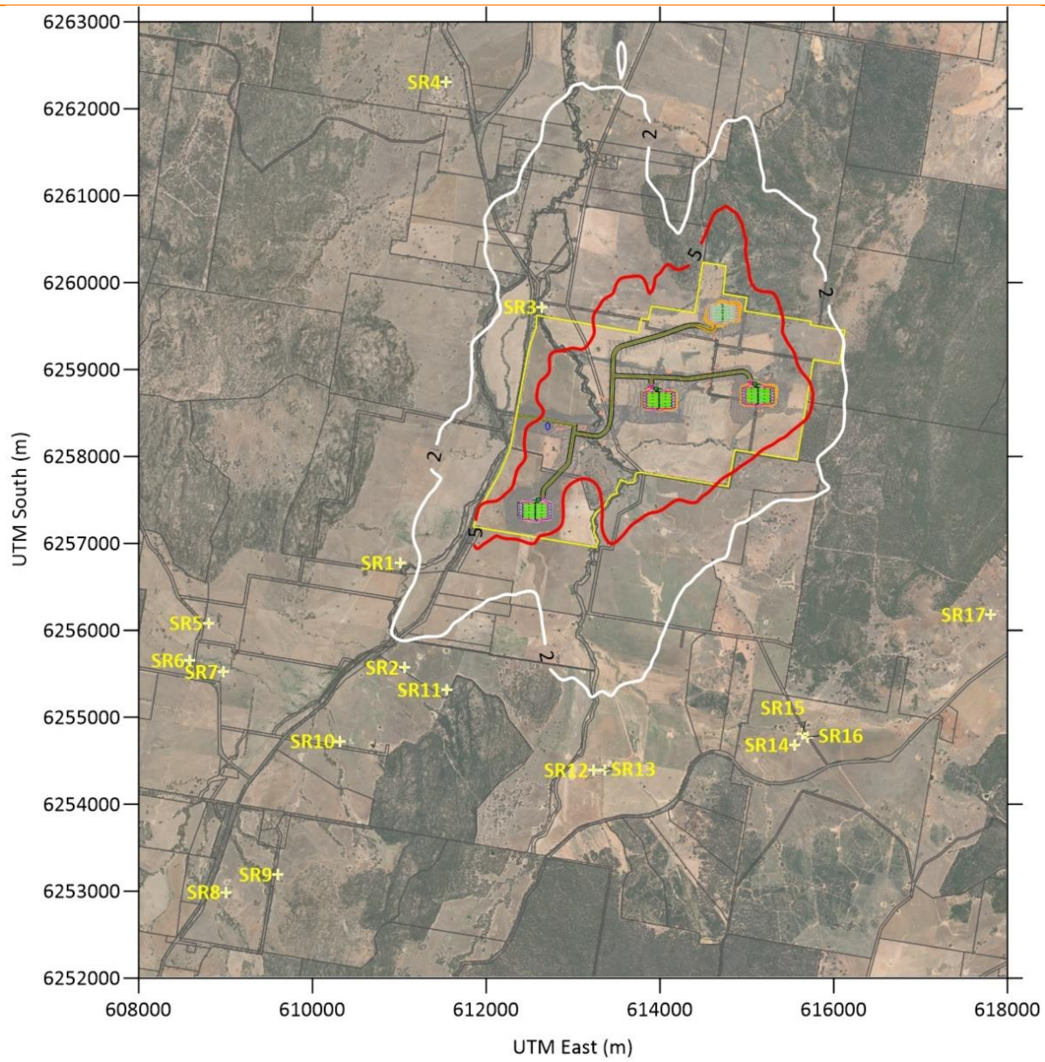
- Figure 5-3: Predicted 1 second 99th percentile Odour Concentrations K=2.2 ;
- Figure 5-4: Predicted 1 second 99th percentile Odour Concentration K=1; and
- Table 5-3: Predicted Receptor Concentrations .

As discussed in Section 2.1.1 the preferred method to determine the odour criterion is to count the existing houses within the 2 ou contour, calculate the total population, then determine the criterion to be used based on Equation 7.2 in the Approved Methods.

Figure 5-3 indicates that is one existing house within the 2 ou contour meaning that the criterion could be $C_{99\ 1sec}$ = 7 ou. However, we have adopted a conservative criterion of 5 ou for the site.

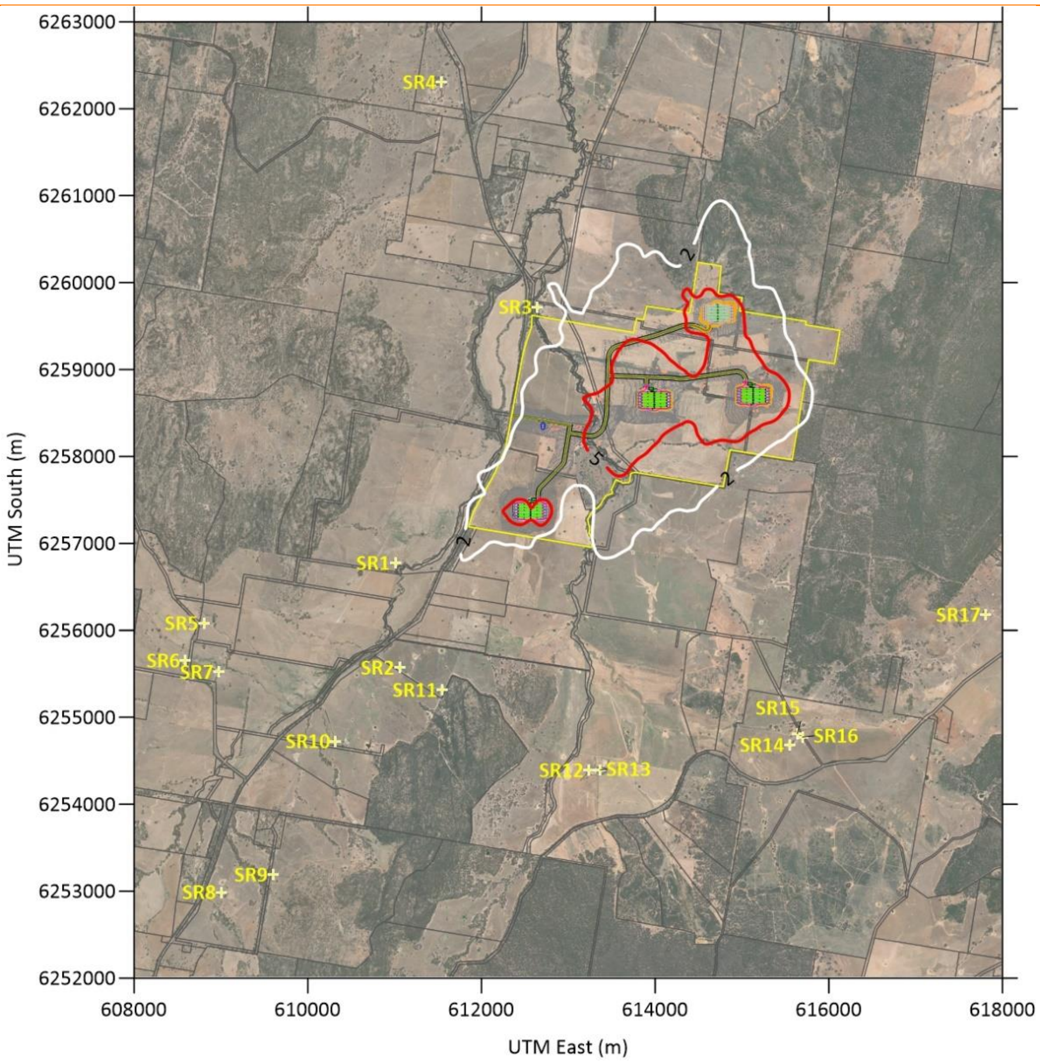
[4] Difference between average of datasets
[5] Difference between paired hourly points

The predicted ground level 99th percentile 1 second concentrations are predicted to comply with the odour criterion at all receptors for the proposed farm. The highest predicted concentration is 3.9 ou (K=2.2) at sensitive receptor 3 (SR3) as shown in Table 5-3 below.



Species: Odour	Site: Grenfell	Scenario: Proposed K=2.2	Averaging Period: 1 second	Percentile: 99th
Criterion: 5 ou	Units: ou	Meteorology: 2017	Model: CALPUFF v 6.42	Author: W. Shillito

Figure 5-3: Predicted 1 second 99th percentile Odour Concentrations K=2.2



Species: Odour	Site: Grenfell	Scenario: Proposed K=1	Averaging Period: 1 second	Percentile: 99th
Criterion: 5 ou	Units: ou	Meteorology: 2017	Model: CALPUFF v 6.42	Author: W. Shillito

Figure 5-4: Predicted 1 second 99th percentile Odour Concentration K=1

Table 5-3: Predicted Receptor Concentrations (K=2.2)

Receptor Number	$C_{99\ 1sec}$ (ou) K=2.2	$C_{99\ 1sec}$ (ou) K=1	Compliance
SR 1	1.7	0.8	Yes
SR 2	1.7	0.8	Yes
SR 3	3.9	1.8	Yes
SR 4	0.8	0.4	Yes
SR 5	0.5	0.2	Yes
SR 6	0.6	0.3	Yes
SR 7	0.7	0.3	Yes
SR 8	0.6	0.3	Yes
SR 9	0.7	0.3	Yes
SR 10	1.3	0.6	Yes
SR 11	1.2	0.5	Yes
SR 12	1.5	0.7	Yes
SR 13	1.6	0.7	Yes
SR 14	0.5	0.2	Yes
SR 15	0.6	0.3	Yes
SR 16	0.5	0.2	Yes
SR 17	0.3	0.1	Yes

5.3 Particulate Matter

Predicted particulate matter concentrations associated with the proposed site based on the modelling and emissions estimation methodologies detailed above are provided below.

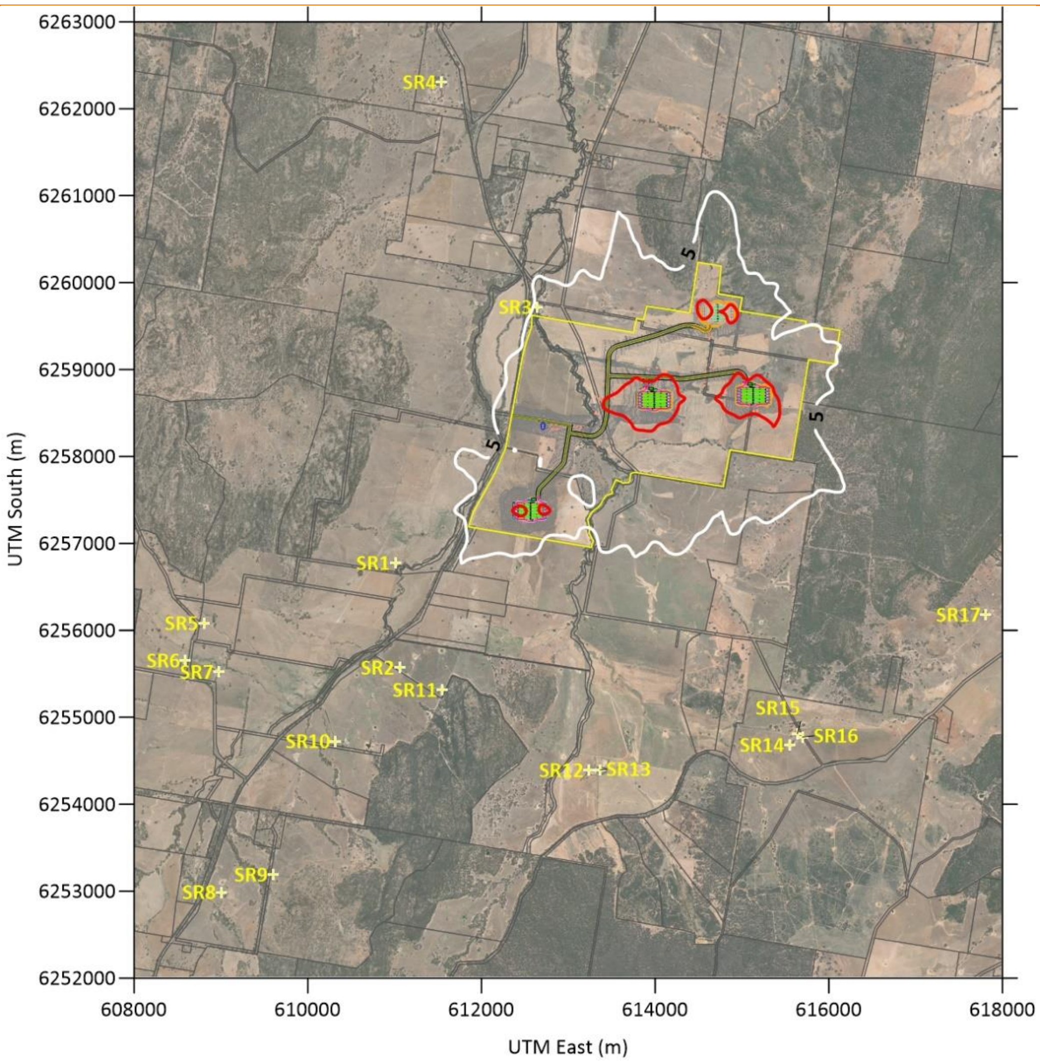
The results are shown as follows:

- Table 5-4: Predicted PM_{10} Concentrations for Sensitive Receptors in isolation;
- Figure 5-6: Predicted 24 hour maximum PM_{10} Concentrations –with background;
- Figure 5-5: Predicted 24 hour maximum PM_{10} Concentrations –without background; and
- Figure 5-7: Predicted Annual Average PM_{10} Concentrations – with background.

The predicted ground level concentrations including background for the 24 hour maximum and annual average results are predicted to comply with the criterion presented in Table 2-2 for the proposed farm. Note that the maximum increments are predicted to be minor.

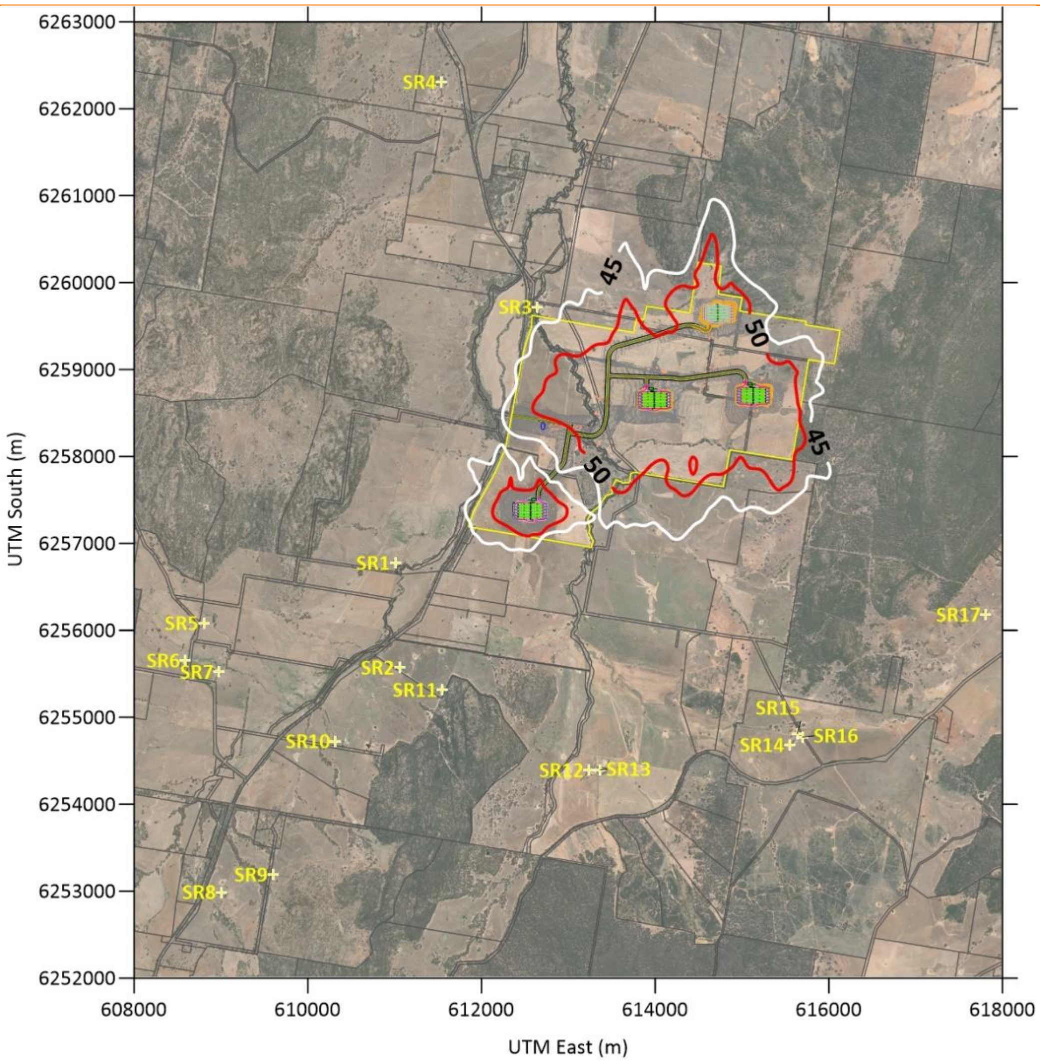
Table 5-4: Predicted PM_{10} Concentrations for Sensitive Receptors in isolation and with background

Receptor Number	Maximum PM_{10} 24 hour concentration in isolation (µg/m^3)	Maximum PM_{10} 24 hour concentration with maximum background (µg/m^3)	PM_{10} Annual Average concentration in isolation (µg/m^3)	PM_{10} Annual Average concentration with background (µg/m^3)
SR 1	2.1	40.9	0.2	14.3
SR 2	2.4	41.2	0.2	14.3
SR 3	5.2	44.0	0.5	14.6
SR 4	0.9	39.7	0.1	14.2
SR 5	1.1	39.9	0.1	14.2
SR 6	1.3	40.1	0.1	14.2
SR 7	1.2	40.0	0.1	14.2
SR 8	1.0	39.8	0.1	14.2
SR 9	0.8	39.6	0.1	14.2
SR 10	1.9	40.7	0.1	14.2
SR 11	1.2	40.0	0.1	14.2
SR 12	1.6	40.4	0.1	14.2
SR 13	2.0	40.8	0.1	14.2
SR 14	1.8	40.6	0.1	14.2
SR 15	1.7	40.5	0.1	14.2
SR 16	1.7	40.5	0.1	14.2
SR 17	0.4	39.2	0.0	14.1
Criteria	NA	**50**	NA	**25**



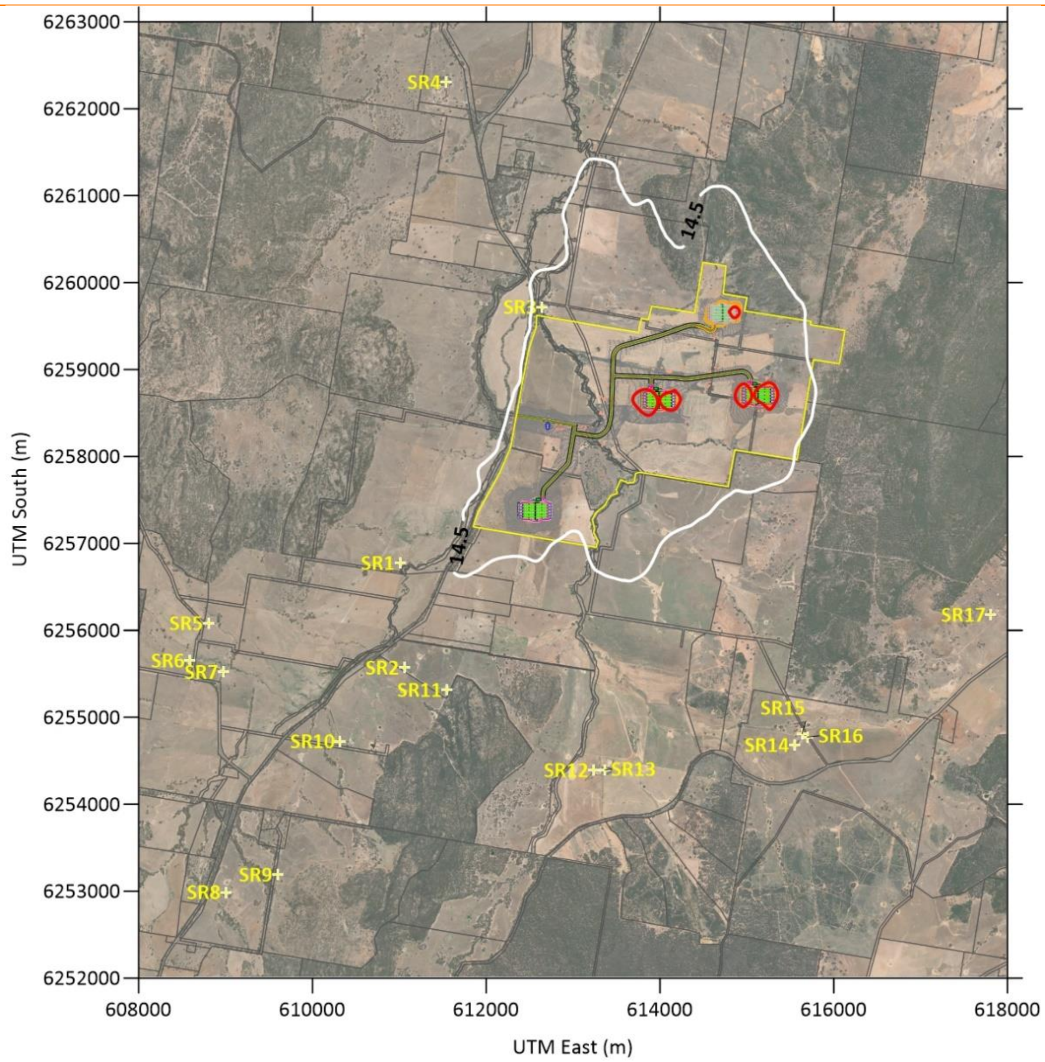
Species: PM$_{10}$	Site: Grenfell	Scenario: Proposed sheds	Averaging Period: 24 hour	Percentile: Maximum in isolation
Criterion: 50	Units: µg/m^3	Meteorology: 2017	Model: CALPUFF v 6.42	Author: W. Shillito

Figure 5-5: Predicted 24 hour maximum PM$_{10}$ Concentrations –without background



Species: PM$_{10}$	Site: Grenfell	Scenario: Proposed sheds	Averaging Period: 24 hour	Percentile: Maximum with max background of 38.8 µg/m^3
Criterion: 50	Units: µg/m^3	Meteorology: 2017	Model: CALPUFF v 6.42	Author: W. Shillito

Figure 5-6: Predicted 24 hour maximum PM$_{10}$ Concentrations –with background



Species: PM10	**Site:** Grenfell	**Scenario:** Proposed sheds	**Averaging Period:** Annual Average	**Percentile:** Average with background of 14.1 µg/m³
Criterion: 25	**Units:** µg/m³	**Meteorology:** 2008	**Model:** CALPUFF v 6.42	**Author:** W. Shillito

Figure 5-7: Predicted Annual Average PM_{10} Concentrations – with background

5.3.1 Contemporaneous PM_{10} Results

The hourly predicted PM_{10} concentrations at each receptor were added to the hourly background data from Bathurst for the same hour of the year. The 24-hour average concentration at each receptor for the year modelled was then calculated based on 24-hours of data.

The top 10 concentrations ranked by influence of the proposed site and influence of background concentrations from Bathurst are shown in each table below for the three most affected receptors (S1, SR2, SR3). The tables show that the highest background concentrations didn't occur at the same time as the highest predicted impacts.

No exceedances of the 24 hour PM_{10} are predicted to occur at any of the sensitive receptors.

Table 5-5: Cumulative 24 Hour PM_{10} ($\mu g/m^3$) – Receptor 3

Ranked by Background				Ranked by Incremental Concentration			
Date	Measured	Predicted increment	Total	Date	Predicted increment	Measured Background	Total
17/02/2017	38.8	0.0	38.8	22/04/2017	2.2	16.2	18.5
10/04/2017	37.2	0.0	37.2	24/11/2017	1.8	14.4	16.3
16/02/2017	35.5	0.5	36.0	14/05/2017	1.8	11.9	13.7
23/02/2017	31.9	0.0	31.9	6/04/2017	1.7	9.9	11.5
24/02/2017	30.4	0.1	30.5	3/10/2017	1.4	19.9	21.3
17/01/2017	30.2	0.0	30.2	22/11/2017	1.3	12.2	13.4
3/09/2017	29.6	0.0	29.6	15/12/2017	1.2	20.2	21.4
11/02/2017	28.5	0.0	28.5	25/03/2017	1.2	16.4	17.5
28/03/2017	28.0	0.0	28.0	19/05/2017	1.2	10.6	11.8
17/05/2017	27.9	1.1	29.0	17/05/2017	1.1	27.9	29.0

Table 5-6: Cumulative 24 Hour PM_{10} ($\mu g/m^3$) – Receptor 2

Ranked by Background				Ranked by Incremental Concentration			
Date	Measured	Predicted increment	Total	Date	Predicted increment	Measured Background	Total
17/02/2017	38.8	0.0	38.8	22/04/2017	2.4	16.2	18.7
10/04/2017	37.2	0.0	37.2	24/10/2017	1.4	14.5	15.9
16/02/2017	35.5	0.8	36.3	21/04/2017	1.3	10.4	11.6
23/02/2017	31.9	0.2	32.1	28/10/2017	1.1	12.0	13.1
24/02/2017	30.4	0.0	30.4	2/07/2017	1.1	18.6	19.6
17/01/2017	30.2	0.1	30.2	9/02/2017	1.1	13.4	14.5
3/09/2017	29.6	0.0	29.6	29/01/2017	1.0	19.9	20.9
11/02/2017	28.5	0.1	28.7	23/04/2017	1.0	19.8	20.8
28/03/2017	28.0	0.0	28.0	2/09/2017	0.9	21.0	21.9
17/05/2017	27.9	0.1	28.0	8/04/2017	0.9	9.0	10.0

Table 5-7: Cumulative 24 Hour PM_{10} ($\mu g/m^3$) – Receptor 1

Ranked by Background				Ranked by Incremental Concentration			
Date	Measured	Predicted increment	Total	Date	Predicted increment	Measured Background	Total
17/02/2017	38.8	0.3	39.1	10/12/2017	5.0	12.7	17.7
10/04/2017	37.2	0.0	37.2	3/02/2017	4.4	15.9	20.3
16/02/2017	35.5	0.0	35.5	10/02/2017	4.1	24.0	28.0
23/02/2017	31.9	2.4	34.3	11/12/2017	3.6	18.4	21.9
24/02/2017	30.4	3.1	33.5	22/05/2017	3.1	12.9	16.0
17/01/2017	30.2	0.0	30.2	24/02/2017	3.1	30.4	33.5
3/09/2017	29.6	0.0	29.6	2/08/2017	3.0	8.5	11.5
11/02/2017	28.5	0.2	28.8	16/05/2017	2.9	16.7	19.6
28/03/2017	28.0	0.6	28.6	22/06/2017	2.9	16.6	19.5
17/05/2017	27.9	1.4	29.3	10/01/2017	2.7	17.5	20.2

6 MITIGATION MEASURES

Good management practices play a significant role in reducing the potential for offensive odour and particulate matter emissions. Baiada have significant experience in operating poultry farms to best practice.

The following management measures are proposed for the farm units.

Odour

- Vegetative screens will be planted and maintained around the sheds as soon as practicable following construction. Vegetation screens reduce the magnitude and frequency of any adverse air quality impacts by effectively slowing and filtering air movement, which enhances dust deposition and odour dispersion.
- The poultry sheds will be tunnel-ventilated, which will allow improved control over internal moisture levels and promote optimum shed conditions and bird health.
- The sheds will be best practice which reduces the potential for additional moisture in the sheds which lowers the risk of high litter moisture content, which is known to be a potential risk.
- The feed silos will be fully enclosed to both prevent the entry of rainwater, with wet feed also identified as a potential odour source, and minimise emissions of dust/particulate matter when loading and unloading.
- Regular monitoring and maintenance of the tunnel ventilation systems and bird drinkers will be performed.
- Stocking densities and bird health within each of the poultry sheds will be regularly checked and, if necessary, appropriate corrective measures will be implemented to ensure compliance with relevant standards.
- Daily monitoring and maintenance of the bedding material will occur to minimise wet spots.
- Litter will be promptly removed from the sheds and transported off-site in covered trucks at the end of each production cycle during the clean-out phase.
- Dead birds will be collected from the sheds on a daily basis and stored in on-site chillers before removal from site.
- The insides of the poultry sheds and the surrounds will be maintained at all times to ensure a clean and sanitary environment.
- Shed access points will remain closed at all times other than for allowing access to the sheds.
- Where possible, activities that may increase odour emissions (for example, bedding material replacement) will be performed during daytime hours.

Particulate Matter

- Vegetative screens will be planted and maintained around the sheds as soon as practicable following construction. Vegetation screens reduce the magnitude and frequency of any adverse air quality impacts by effectively slowing and filtering air movement, which enhances dust deposition and odour dispersion.

- The feed silos will be fully enclosed to minimise emissions of particulate matter when loading/unloading.
- Vehicles will not exceed a general speed limit of 40 km/hr within the site and will be confined, where possible, to the internal access roads.
- Internal access roads will be appropriately maintained to minimise dust emissions.
- The poultry shed ventilation systems will be maintained to ensure air movement is at design levels.
- The poultry sheds will be thoroughly cleaned between batches, with a focus on the fan end of the sheds.
- The emergency standby generators will meet the relevant emission standards in Schedule 4 of the Clean Air Regulation.
- Where possible, the handling of bedding material and litter will be avoided during adverse climatic conditions and shed ventilation systems will not be used during little removal.
- Poultry litter will be promptly transported off-site in covered trucks at the end of each production cycle.

7 DISCUSSION

Before discussing the results, it is important to note the differences between Breeder and Meat Chicken (broiler) farms. A survey by Geordie Galvin of Queensland Councils that regulated poultry farms in the early 2000s (DPI&F, Unpublished) highlighted that odour complaints from poultry farms were always associated with broiler farms rather than breeder farms. This, along with anecdotal evidence regarding the distance between existing breeder farms and receptors shows that breeder farms (including rearer farms) have a much lower risk of odour complaints than meat chicken farms. This is consistent with our work at breeder farms over the last 10 years where relative odour emissions per bird have been shown to be lower, and the odour generated by the farms is found to be less offensive than broiler odour.

The aim of a broiler farm is to grow birds to maximum weight within a 7 to 8 week period. In contrast to this, a breeder rearer farm turns out birds with a lower maximum weight at 20 weeks of age. For a standard shed size, rearer sheds therefore have lower daily manure production due to better feed conversion and have a lower stocking density (birds/m^2). The slower growth rate enables the ventilation systems in the sheds to move more air per bird, meaning that the litter is easier to manage. Moreover, the rearer birds are fed on the litter, meaning that they scratch around during the day. The significance of this is at night, when the sheds are blacked out, and the birds rest, odour emissions associated with litter disturbances are lower and emissions drop.

At 20 weeks of age, the rearer birds transition to the breeder (fertile egg) production. While in this shed system they lay eggs for a 40 week period. During this time, they are fed a sustenance rather than growth ration, and therefore have good feed conversion resulting in a lower odour risk than broiler sheds.

Data previously collected in South East Queensland has shown that a rearer farm would have a K factor in the order of 1 to 2, whereas breeder sheds typically have a K factor of ≤ 1. For example, testing in August and December 2008 at the Baiada Purga breeder facility for a variety of stages through the batch yielded an average K factor of 0.9. Other testing at an Ingham's breeder farm near Beaudesert in 2005 for birds at a variety of stages through the process yielded an average K factor of 0.5. This is generally consistent with testing at another breeder farm near Killarney in Queensland in 2012 which yielded a K factor of 1.0. The most recent data we have in our database was for a rearer farm in South East Queensland which was collected in 2017 and yielded a K factor of 1.1.

Here we have adopted two K factors, K=2.2 and K=1 for all sheds. The results were shown in Figure 5-3 and Figure 5-4 above. The results show that even with a conservative K factor of 2.2, compliance is predicted.

8 CONCLUSION

The modelling presented in this report considers the proposed site and has been performed in accordance with the Approved Methods (NSW EPA, 2016).

With a conservative K factor of 2.2, the modelling indicates that the proposed site would not lead to any exceedances of the odour criterion at the nearest sensitive locations. The modelling has also demonstrated that the risk associated with particulate matter is low as there will not be exceedances at the receptors.

Therefore, the site is unlikely to have impacts on the amenity and character of the locality.

Based on our assessment we recommend the development be approved and operated in line with current industry best practice.

9 REFERENCES

American Meteorlogical Society . (2012). *Glossary of Meteorlogy - Complex Terrain*. Retrieved September 13, 2019, from http://glossary.ametsoc.org/wiki/Complex_terrain

Australian Poultry CRC. (2011). *Dust and odour emissions from meat chicken sheds.* Armidale: Australian Poultry CRC.

DEC NSW. (2006). *Approved methods: Sampling and analysis of air pollutants in NSW.* Sydney: NSW Environment Protection Authority.

DPI&F. (Unpublished). *Summary of intensive poultry environmental management issues in Southeast Queensland.* Toowoomba, Queensland: Department of Primary Industries and Fisheries.

Emery, C., Tai, E., & Yarwood, G. (2001). *Enhanced Meteorological Modelling and Performance Evaulation for Two Texas ozone Episodes. Report to the Texas Natural Resource Conservation Commission, College Station, TX, USA. .* Novato, CA, USA: Environ.

Exponent. (2011). *Calpuff Modeling System Version 6 Users Guide.* Menlo Park, California, USA: SRC/Exponent.

Hurley, P. (2008a). *TAPM V4 User Manual.* Canberra, Australia: CSIRO Marine and Atmospheric Research.

Hurley, P. (2008b). *TAPM V4 Part 1: Technical Description.* Canberra, Australia: CSIRO Marine and Atmospheric Research.

Hurley, P., Edwards , M., & Luhar, A. (2008c). *TAPM V4 Part 2: Summary of Some Verification Studies.* Canberra Australia: CSIRO Marine and Atmospheric Research.

Johnson, M. T. (2019). *Meteorological Model Performance Evaluation of an Annual 2002 MM5 (version 3.6.3) Simulation.* Iowa: Iowa Department of Natural Resources.

Kemball-Cook, S., JIa, Y., Emery, C., & Morris, R. (2005). *Alaska MM5 Modeling for the 2002 Annual Period to Support Visibility Modeling. Prepared for the Western Regional Air Partnership.* Novat, CA, SUA: ENVIRON Corporation.

Mirrabooka. (2002). *"Silverweir" Broiler Farm Development Approval Application, Air Quality Impact Assessment.* Brisbane: Mirrabooka.

NSW EPA. (2016). *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales.* Sydney: Environment Protection Authority.

OEH, N. (2017). *New South Wales Annual Compliance Report 2017.* State of NSW and Office of Environment and Heritage.

Ormerod, R., & Holmes, G. (2005). *Description of PAE Meat Chicken Farm Odour Emissions Model.* Brisbane: Pacific Air & Environment.

PAEHolmes. (2011). *Best Practice Guidance for the Queensland Poultry Industry - Plume Dispersion Modelling and Meteorological Processing.* Bribane: PAEHolmes .

PAEHolmes. (2012). *Environmental Evaluation - Monarch Nominees - Ford Road Farm (20 January 2012).* Brisbane: PAEHolmes.

Poultry CRC. (2011). *Dust and odour emissions from meat chicken sheds.* Armidale: Australian Poultry CRC.

Statistics Canada. (2013, July 23). *Constructing box and whisker plots*. Retrieved from Statistics Canada: https://www.statcan.gc.ca/edu/power-pouvoir/ch12/5214889-eng.htm

University of Michigan . (2004). *Central Campus Air Quality Model (CCAQM) Instructions*. Retrieved July 27, 2018, from http://www-personal.umich.edu/~weberg/mixing_height_inv.htm

USEPA. (2000). *Meteorological Monitoring Guidance for Regulatory Modeling Applications.* Research Triangle Park, North Carolina, USA: USEPA.

USEPA. (2015). *Combined WRF/MMIF/AERCOARE/AERMOD Overwater Modeling Approach for Offshore Emission Sources - Volume 2 – Evaluation of Weather Research and Forecasting Model Simulations for Five Tracer Gas Studies with AERMOD.* Seattle, WA, USA: USPEA .

USEPA. (2020). *2016 Alaska State-wide Weather Research Forecast (WRF) Meteorological Model Performance Evaluation.* Research Triangle Park, NC: USEPA.