ANNEXURE 5

ANNEXURE 5

Air Quality and Odour Impact Assessment

prepared by

GHD Pty Ltd

Manildra Pty Ltd

Odour and Air Quality Assessment

Shoalhaven Starches Expansion Project - Modification to Approved DDG Dryers, Cooling Towers and Biofilters

May 2016

Glossary

Abbreviation	Description
DDG	Distiller's dried grain
DECC	NSW Department of Environment and Climate Change (formerly DEC)
Odour Unit	The number of odour units is the concentration of a sample divided by the odour threshold or the number of dilutions required for the sample to reach the threshold. This threshold is the numerical value equivalent to when 50% of a testing panel correctly detect an odour. Reference: *NSW DEC Technical framework: assessment and management of odour from stationary sources in NSW.*
OER	Odour emission rate The odorant flow rate (odour emission rate) is the quantity of odorous substances passing through a defined area at each time unit. It is the product of the odour concentration, c_{od}, the outlet velocity, *v*, and the outlet area, *A*, or the product of the odour concentration, c_{od}, and the pertinent volume flow rate, *V*. Its unit is $OU.m^3/min$ or $OU.m^3/s$. NOTE: The odorant (emission) flow rate is the quantity equivalent to the emission mass or volume flow rate, for example in dispersion models. From AS 4323.3-2001.
PM_{10}	Particulate Matter with an aerodynamic diameter of less than 10 µm
SEMA	Stephenson Environmental Management Australia
TSP	Total Suspended Particulates, or all particles that are suspended in the atmosphere at a particular time. In practice this would refer to particulates up to 30 µm (i.e. diameter of 30 micrometres), but may include particles up to 50 µm in aerodynamic diameter under extreme (in this case higher wind speed) conditions.
$\mu g/m^3$	Micrograms per cubic metre

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1. Introduction

GHD was engaged by Manildra Pty Ltd (Manildra) to conduct an air quality and odour impact assessment for a proposed modification to the approved Shoalhaven Starches Expansion Project (SSEP). The existing Shoalhaven Starches factory is located at Bolong Road in Bomaderry, New South Wales.

Flour and grains are processed at the factory to produce ethanol, starch, gluten, glucose and distiller's dried grain (DDG). Shoalhaven Starches is the holder of Environment Protection Licence number 883 issued for the plant by the NSW EPA.

The Shoalhaven Starches Bomaderry plant currently produces around 225 million litres (ML) of ethanol per year. On 28 January 2009 the (then) Minister for Planning issued Project Approval MP 06_0228 for the Shoalhaven Starches Expansion Project. The Project Approval for the SSEP enabled Shoalhaven Starches, subject to certain conditions, to increase ethanol production in a staged manner at its Bomaderry Plant from the previous approved level of 126 million litres per year to 300 million litres per year. Following the Minister's determination Shoalhaven Starches have been implementing and commissioning works in accordance with this approval. Work on the change in operations has been completed, coupled to quarterly testing (independent audits) of emissions from licensed discharge points (a condition of the Licence), with the purpose to validate the predicted impacts against the original predictions in 2008 for the ethanol expansion. The 2008 assessment results are referred to herein as scenario C.

The increase in ethanol production associated with the SSEP Project Approval was made in response to the NSW Government's ethanol mandate which increased the mandated ethanol content by volume in petrol in NSW from 2% to 6% in October 2011. The SSEP sought to increase ethanol production capacity at the Shoalhaven Starches site to meet the expected increase in demand for ethanol arising from this site. The increase in ethanol production required upgrades to the Stillage Recovery Plant including six additional Dried Distillers Grains Syrup (DDGS) dryers. Demand for ethanol however has not met that which was anticipated following the introduction of the NSW Governments ethanol mandate. Under these circumstances, it is now proposed to reduce the number of approved DDGS Dryers from six to four. The reduction in Dryer footprint on the site will release land for other development purposes. In addition to the proposed reduction in number of DDGS dryers from six to four, the modification process also includes the following:

- A minor modification to footprint of the four DDG dryers
- Relocation of the cooling towers in the DDG Plant
- A Mill Feed Silo and structure to feed DDG dryers
- Expanded use of the existing coal and woodchip storage area within the SS Environmental farm
- The addition of two biofilters to cope with the increased number of DDG Dryers
- A forklift maintenance building adjacent to the relocated DDG dryers, along with a container preparation area adjacent to the relocated DDG Dryers

These changes, in turn, require an application to EPA accompanied by a report assessing the change (if any) to the predicted off-site impacts.

In order to meet EPA NSW requirements outlined in an email from Stefan Press on 4 March 2016; and in an email from Deana Burn (Department of Planning and Environment) on 12 January 2016, this report provides:

- A comparative analysis of the odour results/modelling resulting from the proposed modifications, compared with the odour impacts predicted in the original Air Quality Assessment for the Shoalhaven Starches Expansion Project.
- A comparison of odour results/modelling from the proposed modifications, with the odour results/modelling obtained from the most recent independent odour audits for the premises.
- Where necessary, details of all reasonable and feasible measures to mitigate odour impacts to a level of impact no greater than predicted in the original EA.
- An air quality assessment to demonstrate that the two new biofilters (to treat the DDG driers) will be sufficiently sized to adequately treat the volume and strength of odorous airstreams associated with the modified DDG dryers.

The odour assessment provided in this report is a Level 2 assessment as defined in the DEC Modelling Guideline[1] (ie "refined dispersion modelling technique using site-specific input data"). The Technical framework is used by the Department of Planning and Environment and NSW EPA to assess proposals and set licence and consent conditions, under the *Environment Planning and Assessment Act 1979*, the *Protection of the Environment Act 1997*, and the *Local Government Act 1993*.

It should be noted that some new odour sources in the proposed Packing plant and the Flour Mill areas have been characterised by others[2] (in terms of source dimensions and odour emission rate) and these have been adopted by GHD in this modelling.

The air quality and odour assessment is based on previous site visits, measured and estimated odour emission rates at the site, emission rate databases, an examination of local meteorology, and the outputs of odour dispersion modelling using CALMET/CALPUFF models.

The assessment has been conducted with reference to:

- Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in New South Wales (Department of Environment and Conservation, 2005)
- Assessment and Management of Odour from Stationary Sources in New South Wales (Department of Environment and Conservation, 2006)

1.1 Scope

The scope of work adopted to conduct the assessment is listed below.

1. Check the previous odour emission inventory to confirm if more recent emission rate measurements have been conducted at any identified source.
2. Check any source measurements of Total Suspended Particulates (TSP) available from significant dust sources. Assess whether the current TSP inventory is adequate to represent plant emissions of TSP.
3. Alter the coordinates of sources to be moved arising from the proposed modification and create new sources (coordinates, emission rates) for the two additional bio-filters. Set the emission rate of sources to be removed to zero.

[1] DEC 2005 "Approved Methods for the Modelling and Assessment of Air Pollutants in New South wales", 26 August 2005.
[2] Stephenson Environmental Management Australia (SEMA)

4. Check the performance of the existing biofilters as a guide for the efficiency of the proposed additional biofilters
5. Check the proposed changes arising from the proposed plant modification to identify where the built form array of the plant will change and make the required changes in BPIP (a program that assesses the influence of building wakes on air dispersion of nearby sources).
6. Conduct the simulations of off-site impact from plant emissions of odour and TSP.
7. Report the results for presentation to the NSW Department of Planning and Environment.

1.2 Limitations

This report has been prepared by GHD for Manildra Pty Ltd Pty Ltd (Manildra) and may only be used and relied on by Manildra Pty Ltd for the purpose agreed between GHD and Manildra Pty Ltd as set out in section 1 of this report.

GHD otherwise disclaims responsibility to any person other than Manildra Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

GHD has not been involved in the preparation of the planning submission and has had no contribution to, or review of the submission. GHD shall not be liable to any person for any error in, omission from, or false or misleading statement in, any other part of the submission.

The opinions, conclusions and any recommendations in this report are based on explicit assumptions made by GHD, described in section 1.3 and throughout the body of this document, and limitations of the modelling software CALPUFF. GHD disclaims liability arising from any of the assumptions being incorrect. GHD has prepared this report on the basis of information provided by Manildra Pty Ltd and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

1.3 Assumptions

The major assumptions used in this assessment are as follows:

- Stack emission testing reports from the past year are accurate and representative of normal operations, and do not vary significantly.
- The odour dispersion modelling using the NSW EPA and US EPA approved regulatory Gaussian puff dispersion model CALPUFF V 5, which was considered appropriate for the location. Limitations with the predicted odour are inherent within the model and in its ability to handle multiple buildings and stacks in a complex setup, with wake effects included. As such, the layout of the plant was simplified in order for the model to handle the setup.

- Odour emissions from the major sources of odour were modelled as both variable emission and fixed point, volume and area sources in CALPUFF with appropriate dispersion characteristics.
- The site representative meteorological data was obtained from previous assessments of the plant, which have been approved by EPA NSW in the past and evaluated against the most recent observations from Nowra in section 6.
- Small silos in the Packing Plant are conservatively assumed to be filled 24 hours a day.
- Odour sources with horizontal releases have conservatively been input with vertical velocities of 0.1 m/s.
- The VOC concentration in the biofilter exhaust is not high enough to induce density flows of the exhaust plume in ambient air.
- The emissions inventory, and therefore the dispersion modelling results, is largely based on estimates and on data measured on site by Stephenson Environmental Management Australia (SEMA). Actual measurements are dependent on site conditions at the time of measurement and these conditions may change. GHD does not accept any responsibility for updating the measurements or estimates made by SEMA.

1.4 Report structure

This report:

- Describes the operations of the plant
- Describes the site-representative meteorological data
- Describes the proposed modifications
- Characterises odour sources at the plant, accounting for the required changes to the original model setup in 2008
- Presents the results of odour dispersion modelling for the existing and proposed scenarios using CALPUFF
- Presents a summary of the results and draws conclusions as to the off-site impacts (both odour and dust)
- Outlines the limitations of the analyses and conclusions presented

2. Site location and context

2.1 Site description

Figure 1 shows the location and layout of the Shoalhaven Starches plant in Bomaderry, New South Wales. It is located between the Shoalhaven River and township of Bomaderry. The plant comprises a factory, a proposed (but not yet constructed) packing plant and environmental farm. The packing plant lies immediately to the north of the factory, while the environmental farm is situated approximately 400 m to the east.

Nearby Rural Residences

The site is proximate to a number of sensitive receptors. The township of Bomaderry lies to the northwest of the factory and west of the packing plant. Nowra is situated south of the plant. The nearest receptors to the factory, packing plant and environmental farm are identified in Figure 2, with the approximate distances and orientation of each residence from the plant in Table 1. These receptors were selected to be consistent with previous odour assessments of the plant. These residences qualify as sensitive receptors, as defined in the DEC odour assessment guideline as "a location where people are likely to work or reside; this may include a dwelling, school, hospital, office or public recreational area" (Department of Environment and Conservation, 2006).

Table 1 Location of identified sensitive receptors

Receptor	Range, m	To nearest odour source	Direction	Easting (m)	Northing (m)
R1	150	Packing Plant	W	281,430	6140,610
R2	1300	Factory	SW	280,400	6139,650
R3	700	Factory	S	281,510	6139,310
R4	1300	Factory	SE	283,000	6139,450

2.2 Odour audits

Odour audits are conducted at the plant to measure emissions from an updated list of sources identified by the EPA as described in Manildra's Environment Protection Licence 883 (last updated December, 2015).

The last odour audit was compiled in July 2015, where the EPA controlled sources (denoted by *EPA ID*) were modelled based on most recent measurements, as well as a run conducted for all identified odour sources at the plant.

1:5,000

0 50 100 150

Metres (at A4)

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid Of Australia, Zone 56

N

LEGEND

Shoalhaven Starches Factory

Packing plant (proposed)

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Manildra Group Pty Ltd
Shoalhaven Starches

Job Number | 3133842
Revision | A
Date | 22/3/2016

Site location

Figure 1

G:\31\33842\GIS\Maps\Working

8/180 Lonsdale St Melbourne VIC 3000 Australia T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com.au W www.ghd.com.au

Source: NearMap; Created by: B McKay

1:30,000

0 300 600 900

Metres (at A4)

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid Of Australia, Zone 56

N

LEGEND

- Shoalhaven Starches Factory
- Packing plant (proposed)
- Environmental Farm
- Sensitive receptors
- Effluent storage dams

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Manildra Group Pty Ltd
Shoalhaven Starches

Job Number | 3133842
Revision | A
Date | 22/3/2016

Site context

Figure 2

G:\31\33842\GIS\Maps\Working

8/180 Lonsdale St Melbourne VIC 3000 Australia T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com.au W www.ghd.com.au

Source: NearMap; Created by: B McKay

3. Operation description

3.1 General overview

Wheat flour and grains (wheat) are processed at the Shoalhaven Starches factory to produce ethanol, starch, gluten and glucose. Solid wastes are treated to produce distiller's dried grain (DDG), with liquid wastes being transferred to the environmental farm waste water treatment plant. Excess treated waste water is irrigated onto pasture. The main processing and materials treatment areas at Shoalhaven Starches comprise the:

- Flour mill
- Starch plant
- Glucose plant
- Ethanol and distillation plants
- DDG plant
- Packing plant
- Pellet Plant
- Environmental farm

A brief description of the production process associated (including emission control) with each plant is given below. Figure 3 shows the layout of the plant in terms of its operational areas, along with the major odour sources of the plant, accounting for around 80% of total odour emissions (excluding the environmental farm).

3.2 Flour mill

Shoalhaven Starches commenced full operations at the flour mill in June 2011. The flour mill was originally approved by NSW Department of Planning and Environment in 2007 and was consolidated into the ethanol expansion project approval in 2008.

Proposed modifications to the flour mill were approved in March 2016, which enabled an increase in the total flour production capacity on the site from the previously approved limit of 265,000 tonnes per annum to 400,000 tonnes per annum. The overall amount of flour used in the production process at the Bomaderry site will however remain within the previously approved 20,000 tonnes per week limit.

The flour is used in the plant to produce starch, gluten, glucose and ethanol. All remaining mill feed and pollard (flour sieving rejects) is processed through the DDG dryers for sale as stock feed. Flours from the various grinding operations are collected and blended together before passing through final treatment and weighing operations to bulk storage bins. Flour is taken from these bins for use in existing site production processes.

All air extracted from the mill is passed through Buhler Airjet bag houses prior to being discharged to the atmosphere vertically via four individual stacks. Approval has previously been obtained for the installation of additional plant to increase production, along with two additional exhausts from the roof of the building.

Flour mill stack testing was last conducted in September 2011 by SEMA, for both TSP, PM_{10} and odour.

3.3 Starch plant

Within the starch plant, flour is processed to separate the starch from gluten (the protein component of flour). The starch is graded, dried and packed for shipment. Different grades of starch are manufactured for food and paper making applications. Starch that is not used for these applications is used as a raw material for the ethanol plant. Gluten is dried and sold for use in the food industry.

Aqueous (water-based) wastes are reused within the plant or are transferred to the environmental farm waste water treatment plant.

Starch Dryer No.5 is to be relocated approximately 160 m east (see Figure 3) and increased in size. However, no change to the production volume is predicted.

3.4 Glucose plant

The glucose plant (contained within the starch plant area) houses two lines; the 'confectioners' glucose line and the 'brewers' glucose line. Confectioner's glucose is distinguished by having been demineralised to remove latent odours and flavours that might be carried through to the final product by the glucose.

Both processes use starch as the raw material. The starch is broken down to its constituent glucose molecules using enzymatic and hydrolytic processes. Water is removed from the resulting solutions using evaporation to produce glucose and brewer's solutions of desired concentration. The glucose product is shipped to customers in bulk containers.

The glucose manufacturing process generates aqueous wastes, mostly condensate from the evaporators, which is reused during regeneration of the ion exchangers.

3.5 Ethanol and distillation plants

Waste starch from the starch plant is transferred to the ethanol plant and fermented to produce ethanol. Starch (described in section 3.3), which is in suspension, is heated in jet cookers before being fermented.

Fermentation is carried out in fermentation vessels using the treated substrate to which an ethanol-producing yeast inoculum has been added. The yeast inoculum is generated using yeast propagator vessels, these being seeded using commercial strains of yeast.

Wastes from the fermenters are transferred to the DDG plant (refer to section 3.2) for processing. Fermentation liquor from the ethanol plant is transferred to the distillation plant where water and other impurities are removed to produce fuel quality ethanol.

3.6 DDG plant

Wastes from the ethanol and distillation plant are dewatered in decanter centrifuges and dried in steam dryers to produce granular DDG. Light phase from the DDG decanters is evaporated to recover soluble protein (syrup) and produce clear condensate (liquid line). The syrup is added to the dryer feed for recovery of the solids (solids line). DDG granular product is stored in a storage shed until it is loaded into trucks in the DDG load-out area.

Exhaust gases from the existing DDG dryers (three) are transferred to the boiler air intake in order to destroy odorous components of the gases by combustion.

3.7 Steam production

Steam is generated at Shoalhaven Starches by four gas fired boilers (numbers 1, 3, 4 and 7), one wood fired boiler (number 2) and two coal fired boilers (numbers 5 and 6) boilers. The combustion gases from these boilers are discharged via stacks, with boilers 5 and 6 having a combined stack. Exhaust from boiler 4 is treated in a cyclone and those from boilers 5 and 6 are treated in a bag house prior to discharge to atmosphere.

3.8 Environmental farm

A number of wastewater streams are produced at the factory. These consist of five clear condensate streams (distillation plant condensate, evaporator condensate, DDG condensate, a small flow from the carbon dioxide plant and boiler blowdown) and a combined 'dirty' stream from the factory processes. The 'dirty' wastewater streams are combined in the farm tank (located at the factory) and pumped to the waste water treatment plant. Treated water is pumped back to the factory for re-use, while excess treated water is stored in dams for irrigation on the farm.

3.9 Packing plant (proposed)

It is proposed that dried gluten/starch will be pneumatically transferred from the existing site to the proposed new packing plant via underground pipes. This dried material is proposed to be stored in silos.

At present, the approved packing plant has not been constructed at the Shoalhaven Starches sites. The proposed packing plant was assessed by SEMA in 2015 (Stephenson Environmental Management Australia, 2015).

The packing plant will consist of seven silos that will store either gluten or starch product. The medium and large silos are to be filled 24 hours a day, seven days a week, while the small silos can be filled at any time of the day for eight hours.

3.10 Other activities

3.10.1 Product load-out areas

Starch, glucose and ethanol products are loaded into road tankers from bulk storage silos and tanks. Load out of starch and glucose does not have the potential to generate odours, as these products have a low inherent odour characteristic.

Given the flammable nature of ethanol, the load out process is strictly controlled for occupational health and safety purposes. These controls have the secondary effects of minimising the potential for vapour generation and spillage.

3.10.2 Cooling towers

Cooling towers operate as part of the cooling water circuit for the ethanol glucose and DDG plants. The recirculated cooling water has the potential to absorb odours and to disperse the odours to atmosphere during the evaporative cooling (aeration) process within the cooling towers. In addition, contamination of the cooling water by-product, process intermediates or wastes can introduce odorous materials direct to the cooling water, which can greatly increase its odour generating potential. The aeration process readily strips the more volatile (and potentially odorous) compounds from the water, providing a high-volume potential source of odour that is released direct to atmosphere.

3.10.3 Biofilters

Exhaust air from odorous sources at the DDG plant is captured and ducted to two existing soilbed biofilters, each having a surface area of 110 m^2, located at the southwest corner of the factory (on the southern margin of the container storage area – placed to the left lower margin in Figure 3). The biofilters comprise a bed of organic bark and compost material (the matrix), with distribution of the odorous airstream through the floor of the biofilter via a manifold. Biological oxidation of odorous compounds takes place as the foul air percolates upward through the matrix. The oxidation is achieved by a population of microorganisms in the bed.

While the efficiency of biofilters destroying odorous components of the waste air varies according to a range of factors including soil moisture, composition and temperature, it is very high. Any odour in the exhaust air from the biofilter is due to the inherent odour of the matrix materials and typically has an 'earthy' characteristic. The odour level of the matrix is typically in the range of 250 to 500 OU, and it is this 'background' level that limits the efficiency of a soilbed biofilter.

The two biofilters at the site operate in parallel and are sized so that one biofilter can be taken offline during periodic replacement of the matrix of the sister filter.

As such, a soilbed biofilter operating as designed, with no malfunctions, will not vary significantly in its odour emissions; it will emit at the matrix background level independent of fluctuations in the input odour loading.

3.11 Proposed modifications

Manildra propose to change the configuration of the DDG Plant to the southwest of the factory site. These changes are shown in Figure 4 and consist of a staging process, and thus impacts have been assessed separately. The main changes affecting odour impacts and dust consist of:

- Reduction in the number of DDG dryers from 6 to 4
- **Scenario 1**
  - Installation of DDG dryer 4 to the new building to the north of the proposed container storage area, with air leakage to be collected and ducted to the existing biofilters
- **Scenario 2**
  - The installation of three DDG dryers to be ducted to two new biofilters
  - The relocation of the approved cooling towers

Further discussion of these scenarios is presented in section 6.1.2.

1:2,500

0 25 50 75

Metres (at A4)

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid Of Australia, Zone 56

N

LEGEND

- Shoalhaven Starches Factory
- Packing plant (proposed)
- DDG Plant
- Flour Mill
- Boiler house
- Starch plant
- Ethanol recovery and storage area
- Fermenters
- Odour sources

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Shoalhaven Starches

Site layout and major sources

Job Number | 3133842
Revision | A
Date | 22/3/2016

Figure 3

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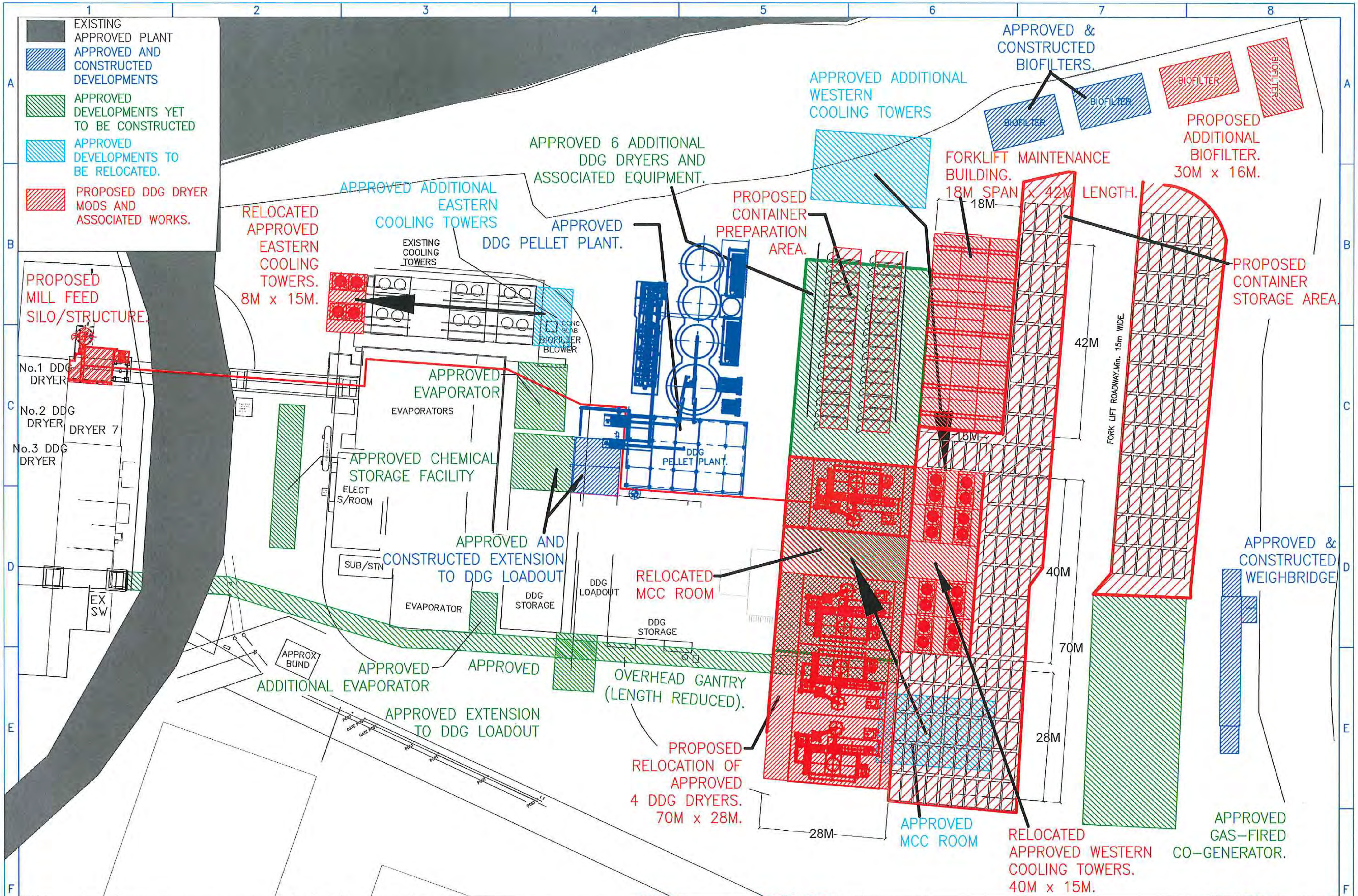
8/180 Lonsdale St Melbourne VIC 3000 Australia T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com.au W www.ghd.com.au

Source: NearMap; Created by: B McKay



ISS	DATE	ZONE	CHANGE AMMENDMENTS	BY	CKD
J	8-4-16	BS	Wording changed.	P.C.	C/ Stod.
I	30-3-16	ALL	proposals finalised.	P.C.	G.M.
I	15-9-15	ALL	proposal	P.C.	G.M.

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Commitment to Excellence

DRAWN P.J.C.	TOLERANCES		MANILDRA GROUP.NOWRA.
TRACED ----	LINEAR ±.2		
CHECKED	ANGULAR ±.5°	MATERIAL	TITLE DDG DRYING.
APPROVED	FINISH		LAYOUT OF DDG DRYER MODS.
DRG PRACTICE AS1100	NA	NA	

SIZE A3 | SCALES 1:750 | SHT
ISSUE 5765A
DRG № MN261-001-J

4. Criteria for assessment

4.1 Odour

Odour Concentration

Odour 'strength' or concentration is measured in odour units (OU), where 1 OU represents the concentration of a sample that can just be detected by 50% of people in a controlled situation where there is no background 'ambient ' odour.

Measurement of Odour

The most common method of measuring odour concentration is Dynamic Olfactometry using the 'forced choice' method. Dynamic olfactometry simply dilutes the odour sample in known ratios with odour free air. At each dilution, the diluted odour and a zero odour is presented in turn to six panellists via two 'sniffing' ports. Further, the selection of the port with the diluted odour sample is randomly reassigned at each presentation. Each panellist is required (forced) to nominate the port (left or right) from which the diluted odour emanates. Each panellist's response (i.e. 'guess', 'likely' or 'certain') is recorded. The sequence of presentations generally follows a decreasing dilution ratio, and when half of the panellists have correctly returned a 'certain' response, that dilution ratio is numerically equal to the concentration of the original, undiluted odour sample. Hence, for example, if the dilution needed to get the 50% response was 250:1, then by definition the original sample had an odour concentration of 250 OU.

EPA Criterion for Odour

EPA has defined an odour criterion and the Odour Guideline specifies how it should be applied in dispersion modelling to assess the likelihood of nuisance impact arising from the emission of odour.

Odour impact is a subjective experience and has been found to depend on many factors, the most important of which are:

- The **F**requency of the exposure
- The **I**ntensity of the odour
- The **D**uration of the odour episodes
- The **O**ffensiveness of the odour
- The **L**ocation of the source

These factors are often referred to as the FIDOL factors.

DEC defined the odour criterion to take account of two of these factors (**F** is set at 99 percentile, **I** is set at from 2 to 7 OU). The choice of criterion odour level has also been made to be dependent on the population of the affected area, and to some extent it could be said that population is a surrogate for location – so that the **L** factor has also been considered. The relationship between the criterion odour level **C** to affected population **P** is given below.

$$C = [\log P\text{-}4.5] \div \text{-}0.6 \qquad \text{Equation 1}$$

Table 2 lists the values of C for various values of affected populations as obtained using equation 1.

Table 2 Odour criterion for the assessment of odour

Population of affected community	Odour performance criteria (nose response odour certainty units at 99th percentile)
Single Residence (≤ ~2)	7
~ 10	6
~ 30	5
~ 125	4
~ 150	3
Urban (~2,000)	2

The NSW Approved Methods specifies a criterion of two odour units at the 99th percentile over a short term averaging nose-response time of one second for a complex mixture of odorous air pollutants in an urban area (population greater than 2000 or with schools and hospitals). The criterion is applied at the location of the nearest sensitive receptor or likely future location of sensitive receptor.

5 OU is commonly taken as a conservative measure of the odour level which can be distinguished against the ambient background level of odour, and which if offensive, could result in complaint.

1 OU generally cannot be detected in a non-laboratory situation (i.e. where the ambient background odour levels reduce the detectability of a given odorant).

As the CALPUFF dispersion model (utilised in this assessment), when operating in micrometeorological mode can only predict concentrations over an averaging period of one hour, a ratio between the one second peak concentration and 60 minute average concentration has been applied to the source odour emission rates. In this manner, the predicted one hour odour levels predicted in CALPUFF represent the corresponding one second short-term levels required to be compared to the DEC criterion. The ratio is known as the peak to mean ratio (PM60). PM60 is a function of source type, stability category and range (i.e. near or far-field), and values are tabulated in the modelling Guideline[3]. This is reproduced below.

Table 6.1: Factors for estimating peak concentrations in flat terrain (Katestone Scientific 1995 and 1998)

Source type	Pasquill–Gifford stability class	Near-field P/M60*	Far-field P/M60*
Area	A, B, C, D	2.5	2.3
	E, F	2.3	1.9
Line	A–F	6	6
Surface wake-free point	A, B, C	12	4
	D, E, F	25	7
Tall wake-free point	A, B, C	17	3
	D, E, F	35	6
Wake-affected point	A–F	2.3	2.3
Volume	A–F	2.3	2.3

* Ratio of peak 1-second average concentrations to mean 1-hour average concentrations

Figure 5 Extract from NSW Approved Methods

3 Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (DEC, 2005).

4.2 Dust

Dust impacts can be assessed against several criteria, namely:

- Total suspended particles (TSP)
- Deposited dust
- Fine particulate matter less than 10 micron equivalent aerodynamic diameter PM_{10}

Table 3 below summarises the criteria for pollutants relevant to the operation of the plant from the Approved Methods for the Modelling and Assessment of Air Pollutants (Department of Environment and Conservation, 2005).

Table 3 Air quality impact assessment criteria - other pollutants

Pollutant	Averaging period	Criterion -
Particulate Matter PM_{10}	24 hours	50 $\mu g/m^3$
	Annual	30 $\mu g/m^3$
TSP	Annual	90 $\mu g/m^3$
Deposited Dust	Annual	4 g/m^2/month

5. Meteorological data

A 12-month dataset was constructed using the 3D prognostic modelling package, TAPM and the diagnostic 3D meteorological model, CALMET for the period from January to December 2004. This 12 month period was chosen to be consistent with previous modelling undertaken for the 2008 Air Quality Assessment, approved at the time by EPA and to allow to a direct comparison to previous modelling. Further detail is provided in Appendix A in regards to the selection and construction of the meteorological dataset used in the modelling.

The CALMET modelling can be summarised as follows:

- Prognostic models TAPM and CALMET were used for initial wind field 'guesses'
- Observations from both the environmental farm Automatic Weather Station (AWS) and Nowra AWS were used to optimise and check the prognostic model simulations
- Wind speeds and direction observations from the environmental farm AWS were assimilated into the prognostic model to make the data site-specific

The result of assimilating this data into the CALMET simulations makes the data site-specific (required for a Level 2 assessment), and inter-annual variability is not required to be accounted for, with the conditions of the Approved Methods met for using "*at ;least one-year of site-specific meteorological data*".

An annual wind rose generated using CALMET is provided in Figure 6 to show the wind field at the factory. The following trends are evident from Figure 6:

- Annual average wind speed of 3.2 m/s
- Winds are most prevalent from the west and west northwest, accounting for around one third of all winds
- Winds are least prevalent along the north-south axis
- Light winds (shown in grey) are more prevalent from the northwest
- Drainage flows occurring during stable conditions at night time are dominated by the following distinct features (in order of scale):
  - Shoalhaven River running west to east through the site
  - Browns Mountains to the northwest of the site
  - Yalwal State Forest mountain range to the west

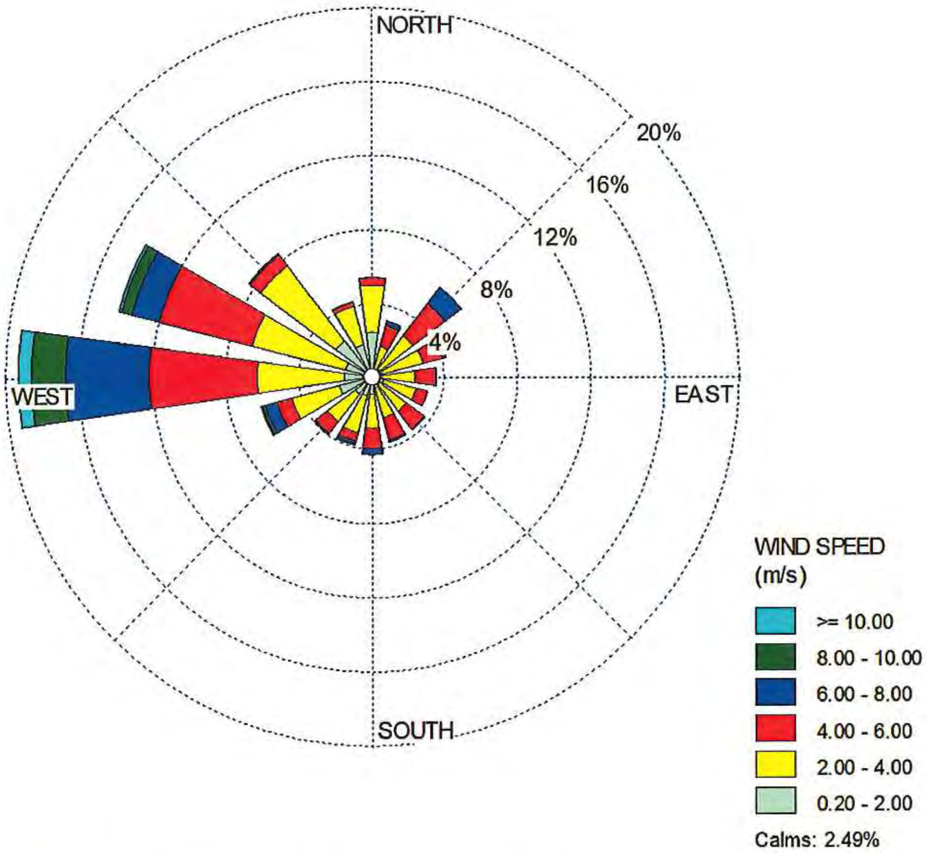

Figure 6 CALMET wind rose for the factory

6. Emission inventory

6.1 Odour

6.1.1 Source identification

Odour emanating from Shoalhaven Starches is comprised of a complex mixture of primarily odorous volatile organic compounds (VOCs). VOC speciation data from a range of principal odour sources indicates that the individual VOCs within the mixture tend to be classified under odour-based air quality criteria rather than toxicity-based[4] criteria. Therefore, the identified sources of odour are modelled collectively as odour.

Consistent with the 2008 Air Quality Assessment (GHD, 2008), the following sources contribute to the majority of the odour impacts from the Shoalhaven Starches sites, in order of significance:

- Environmental farm (effluent treatment and storage system)
- DDG Plant (including Pellet Plant exhaust stack and biofilters)
- Starch Plant (Gluten and Starch Dryers)
- Ethanol Plant (yeast propagators and retention tank)

A number of other minor odour sources contribute to the remainder of the plant's odour impact. These are detailed in Appendix B.

6.1.2 Proposed modifications

The proposed modifications, as described in section 3.11, are summarised below.

Approved and existing (baseline) operations

The approved and existing operations consists of all odour sources at the Shoalhaven Starches plant, including EPA monitored sources and all minor sources, conservatively scaled for a 300 ML per year production. It also includes approved operations that are sources of odour, but yet to be constructed. This consists of:

- Silos at the proposed packing plant. The Air Quality Impact Assessment: Modifications to Packing Plant conducted by SEMA (Stephenson Environmental Management Australia, 2015), calculated a maximum modelled odour concentration of 0.7 OU from a combined OER of the silo vents of 1,882 OUm^3/s.
- Proposed upgrades to the flour mills. The Air Quality Impact Assessment: Modifications to Existing Flour Mill conducted by SEMA (Stephenson Environmental Management Australia, 2015) calculated a maximum modelled odour concentration of 0.3 OU from a combined OER of the mill baghouses of 471 OUm^3/s.
- Starch Dryer 5, to be constructed in the factory building on Bolong Road near the (proposed) Maintenance Workshop. The Air Quality Impact Assessment: Dryer 5 Relocation conducted by SEMA (Stephenson Environmental Management Australia, 2015) calculated a maximum modelled odour concentration of 0.54 OU from an increase in OER of 6,800 $OU/m^3/s$ associated with Dryer 5.

[4] Based on VOC speciation data for selected sources in the DDG plant: DDG dryers, palmer cooler and condensate tanks.

The following assumptions and additions apply to the audit modelling:

- Average odour emission rates were taken from the odour monitoring conducted by SEMA between May 2015 and February 2016 (four quarters) for EPA ID sources
- Specific odour emission rates from the effluent storage dams were based on most recent testing (May 2015) in conjunction with historical results
- Odour emission rates were assumed to be unchanged for sources originally measured in 2008 that have not been measured since

New sources:

- Pellet plant exhaust stack, taking odorous air from the pellet coolers, drag chains, container loading/aspiration channel, DDG cyclones and DDG silos
- No. 5 starch dryer
- Seven silos for the new packing plant
- Pellet plant fugitives, consisting of the wheat silos, barley intake fan, barley silo fan, barley grinding fan and bulk bag aspiration fan (non-DDG odour sources)

Scenario 1 and 2: DDG dryers installed, with the cooling tower relocation

Scenario 1 consists of the installation of one new DDG dryer (DDG dryer 4) and Mill Feed silo, along with the relocation of the eastern cooling towers and the addition of the building to house the dryers (included in the model to update building wake effects).

Scenario 2 consists of the installation of an additional three dryers as well as DDG dryer 4, all to be ducted and captured via the two new biofilters. This incorporates the additional sources:

- Western cooling towers adjacent to the new DDG dryer building, assumed to have the same odour emissions and source characteristics as from the existing cooling towers
- Two new biofilters, adjacent to the existing biofilters

At present, two biofilters operate on a combined design air flow of 15,000 m^3/h, with the flow split between two biofilters, each with a surface area of 110 m^2. The biofilters receive air from a combination of odorous sources in the existing DDG plant, including DDG dryers 1 to 3, feed dump, condensate, finish feed, finisher pump tank, dryer feed tank, feed holding tank and CIP (fresh caustic).

Air leakage from DDG Dryer 4 is to be captured and ducted to the existing biofilter. The air leakage is estimated to be 1500 kg/h at 54°C. At a density of air, this equates to 0.38 m^3/s of additional exhaust air to feed to the biofilters. Each biofilter is designed for an air intake/treatment of 15,000 m^3/h (4.17 m^3/s).

A summary of the existing biofilter operations is provided below in Table 4. As stated in the (The Odour Unit, 2010).

"the odour destruction performance of the biofilter is not dependent to any significant extent on inlet odour concentrations less than 50,000 odour units".

If this odour concentration is exceeded, the surface loading requires an update in the design to cope with the additional odour.

Table 4 Summary of biofilter operations

Parameter	Unit/measure	Parameter
Exhaust air flow rate ducted to biofilter (2014/2015)	Flow rate	2.9 to 5.0 m^3/s
Current total odour emission rate ducted to biofilter (2014/15)	Odour concentration	9,000 to 11,000 OU
Biofilter A	area	110 m^2 (55% split)
	Air flow split	55 %
Biofilter B	area	110 m^2
	Air flow split	45 %
Max capacity for one biofilter	Flow rate	15,000 m^3/hour 4.17 m^3/s
Bed depth	Length	1.8 m
Contact time	Time	48 s
Spare capacity (at maximum observed flow rate 2014/15)	Flow rate	3.3 m^3/s
Additional exhaust air from DDG dryer 4 (proposed)	Flow rate	0.38 m^3/s
Additional exhaust air likely from DDG dryers 5 to 7 (proposed)	Flow rate	Up to 5.0 m^3/s

The biofilter design for a bed depth of 1.8 m gives a contact time of 48 seconds – this is considered more than adequate to allow either biofilter to accept double the load while its' sister biofilter is off-line for replacement of the bed matrix.

With the two existing biofilters operating at around 50% of capacity, an additional 0.38 m^3/s of exhaust air could be absorbed by the two existing biofilters, resulting in no changes required to connect DDG dryer 4 to the system for Scenario 1.

The addition of DDG dryers 5 to 7 (Scenario 2) is expected to also involve the addition of numerous decanters and other potential odour sources which are yet to be fully defined. As a result, for this scenario it is assumed that the new system would be equivalent to the existing system for the DDG building and will require an additional two biofilters (with flow splitting) on site.

6.1.3 Source summary

Existing and Approved (Baseline) scenario

Modelling for the approved baseline scenario comprised the following sources:

- 49 point sources (each assumed at constant OER) throughout the factory area
- Three point sources with variable emissions within the factory area
- 11 area sources (consisting of two biofilters and the effluent treatment ponds)
- Five volume sources within the factory area

Scenario 1 (addition of DDG 4 and the buildings) has the following additional two sources:

- Cooling towers located on the western side of the proposed DDG building, adding an additional 0.1% (172 OUm^3/s, based on measurements from the existing on-site cooling towers) to total existing OER from the plant.
- Mill feed silo, located to the south of the existing DDG building, adding an additional 0.1% (173 OUm^3/s, based on measurements from the existing Gluten 1 B silo) to total existing OER from the plant.

Scenario 2 (addition of DDG dryers 5 to 7) has the following additional sources:

- Two biofilters, located adjacent to the existing biofilters in the southwest corner of the plant, adding an additional 0.4% to total existing OER from the plant (based on doubling the current OER from the two existing biofilters).

These sources are detailed in Appendix B. A summary of the top 12 contributing sources to total plant OER is given in Table 5. These sources represent around 80% of all odour emissions.

Table 5 Summary of major odour sources- Existing & Approved Scenarios

Source	Source ID	Source type (according to NSW approved)	Total OER – measured (or scaled) OUm^3/s	% of total OER
Combined boiler stack for 5/6 boilers	BOILR5	Tall wake free point	49,270	16.9%
Pellet Plant exhaust stack	PPES	Tall wake free point	48,800	16.7%
Yeast propagators 4 and 5 (combined)	E15Y4 & E15Y5	Wake-affected point	28,330	9.7%
No. 3 Gluten Dryer	S03	Wake-affected point	22,690	7.8%
No. 4 Gluten Dryer	S04	Wake-affected point	14,930	5.1%
Ethanol recovery scrubber discharge	ERESC	Wake-affected point	12,830	4.4%
No. 6 Gluten Dryer	GD6	Wake-affected point	12,570	4.3%
No 7 Gluten Dryer	GD7	Wake-affected point	9,550	3.3%
Fermenters 10-16	FERM	Volume	7,160	2.5%
No 5 Starch Dryer	8	Wake-affected point	6,800	2.3%
No 1 Gluten Dryer	S02	Wake-affected point	6,430	2.2%
Effluent treatment area (environment farm)	SOBAS, POND1-6	Area	6,140	2.1%
All other sources (36 total)	Miscellaneous	Miscellaneous	65,850	22.6%
		Total	**291,350**	**100**

6.1.1 Comparison of site total odour emissions for nominated Scenarios

A summary of total odour emissions from the Shoalhaven Starches operations for the following scenarios is provided in Table 6:

- Shoalhaven Starches ethanol expansion (2008) – Scenario C
- Previous odour audit from 2015
- The existing and approved scenario
- The proposed scenarios (Scenario 1 and Scenario 2) presented in this report

Comparison of Scenario C to Scenario 1 and 2

As evident from the table, total OER has decreased significantly from the 2008 assessment, by around 10.5 %. This is due to a number of changes to plant configuration and odour sources since 2008.

Comparison of Odour audit to Scenario 1 and 2

As the odour audit does not consider approved sources that are yet to be constructed, the OER from the previous 2015 odour audit is significantly less than the total OER for the proposed scenarios 1 and 2

Comparison of Existing and Approved scenario to proposed Scenarios 1 and 2

Table 6 shows that the addition of the proposed cooling towers, reconfigured DDG dryers, mill feed silo and two new biofilters in Scenario 2 result in a marginal increase in total plant OER of 0.5% from the existing and approved scenario.

Table 6 Total site wide emissions

Modelled Scenario	Description		Total OER – $OU.m^3/s$
Comparison to previous assessments			
C	2008 AQ assessment – factory odour Stage 1 plus upgrade (scenario C): after control *does not include environmental farm sources		207,897 (factory + upgrade) 192,147 (boilers and scrubber) **TOTAL – 328,252**
	Odour audit – existing sources July 2015	EPA sources	127,590
		All existing sources, at 300 ML	243,790
This assessment – Proposed modification to DDG dryers, cooling towers and biofilters			
Existing and Approved	Existing and approved operations (Baseline scenario) – 300 ML		**291,350** total
Scenario 1	Proposed operations (Scenario 1)		**291,690**
Scenario 2	Proposed operations (Scenario 2)		**292,910**
Percentage increase in total OER from approved/existing scenario to Scenario 2			0.5%

6.2 Dust emissions

6.2.1 Source identification

The main sources of dust, consisting of TSP, PM_{10} and $PM_{2.5}$, are listed below:

- Gluten and starch dryers
- Boilers:
  - Boiler 1 – Gas fired
  - Boiler 2 – Wood fired
  - Boiler 3 – Gas fired
  - Boiler 4 – Gas fired (converted from coal)
  - Boiler 5/6 – Coal fired
  - Boiler 7 – Gas fired
- Flour Mill baghouses
- DDG Pellet Plant exhaust stack
- Product silos
- Coal and woodchip stockpiles

No dust emissions are expected to arise from a normal-functioning biofilter, which acts as an impassable filtration device due to the density of its matrix. As a consequence, all new emissions from the proposed DDG dryer 4 (and subsequent DDG dryers 5 to 7) are expected to be captured in the biofilters. No net increase in particulate emissions from the plant as a result of the proposed modifications is therefore predicted. The addition of the cooling towers and mill feed silo are also expected to add negligible particulate emissions to the current footprint of the plant.

The relocation of the coal and wood chip storage area is expected to improve predicted dust impacts caused by wind erosion of unstable/uncovered surfaces. At present, the coal stockpiles cover an area of approximately 550 m^2. The relocation of the storage area to the environmental farm north of Bolong Road will increase the distance to sensitive receptors R1 to R4, along with the town of Bomaderry. With appropriate dust controls, including currently used practices of watering and suitable design dimensions, it is predicted that this would result in lower levels of dust due to wind erosion encountered at nearby sensitive receptors.

As dust impacts are only predicted to improve as a result of the proposed modifications, no modelling was undertaken.

7. Dispersion modelling

The odour dispersion modelling was conducted using the US EPA regulatory Gaussian puff model CALPUFF Version 5.8. This model is also a recognised regulatory model in NSW. Where the modelling of odour dispersion is in complex terrain (as is the case at the Shoalhaven site), CALPUFF is recommended for use under NSW Guidelines. CALPUFF is especially suited for modelling light to calm wind conditions.

7.1 Model configuration and parameter selection

The following settings were used in the simulations:

- Model: CALPUFF Version 5.8
- The receptor grid was 25 km x 25 km, with a 200 m grid resolution
- The nearest receptors from the townships of Bomaderry (to the west) and Nowra (to the south) were used as sensitive receptors, along with a few isolated residences around the factory and environmental farm
- Emissions were scaled based on a nose-response time for odour of one minute, applying a peak-to-mean ratio to the one hour average concentration of 2.3 for wake affected point sources and volume sources, and variable scaling for non-wake affected sources and area sources
- Meteorology was taken from the CALMET 2004 synthesised dataset, approved for use in previous studies.

7.2 Building wake effects

Building wake effects were modelled to the extent practicable. A summary of building heights input in to the model is provided below, with area sources shown in red and building footprints shown in grey. For proposed Scenarios 1 and 2, additional buildings and structures were added to the southwest area of the factory.

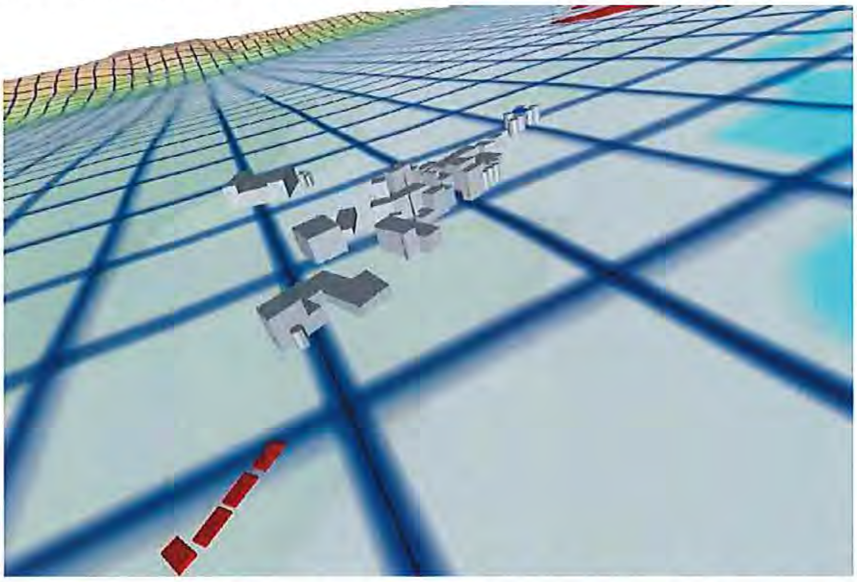

Figure 7 Model setup for building wake effects – Existing and approved scenario (source: Lakes CALPUFF View, CALPUFF 3D 7.5.0)

7.3 Odour assessment

Table 7**Error! Reference source not found.** shows the predicted odour levels for the existing situation and the two proposed scenarios.

Figure 8 shows the predicted 99th percentile odour impacts (one minute nose-response time) for the existing and approved operations at the plant and environmental farm when compared to the incremental impact from the additional odour sources modelled in scenario 2 (incorporating the additional biofilters, cooling towers and mill feed silo).

Table 7 Predicted peak (99th percentile, short term averaged) odour impact at nearby receptors

Receptor	Range, m	To nearest odour source	Direction	Odour criterion	Odour impact, OU, 99th percentile, nose-response time			
					Existing (Baseline)- Scenario	*Scenario 1*	Scenario 2	% increase
R1 Bomaderry	150	Packing Plant	W	6	6.2	6.3	6.4	3%
R2 North Nowra	1300	Factory	SW	3	2.9	2.9	3.0	3%
R3 Nowra	700	Factory	S	5	6.0	6.0	6.3	5%
R4 Terara	1300	Factory	SE	5	5.9	5.9	6.0	2%

7.3.1 Proposed changes from Scenario 1 to existing/approved scenario

There is no discernible increase in predicted odour impacts as a result of Scenario 1 from the Existing and Approved Scenario, due to the low percentage contribution of the cooling towers and Mill feed silo. As such Scenario 1 is not shown in Figure 8.

7.3.2 Proposed changes from Scenario 2 to existing/approved scenario

As evident from Figure 8, the actual increase in predicted peak odour impact between the existing/approved baseline scenario and the proposed Scenario 2 is marginal, with the impact zones almost superimposed**Error! Reference source not found.**. The slight extension of the odour impacts out to the south west indicate that the biofilters, as ground based sources, are likely to be the main contributing factor. However, the actual differences in odour concentration at receptors between the scenarios are highly unlikely to be distinguishable as an increase in perceived odour intensity.

Predicted exposure at nearby residences

With only the cooling towers and mill feed silo as additional sources for Scenario 2, only a small increase in odour impacts at the receptors is predicted at 2 to 5% for all receptors. It is considered highly unlikely that this small increase in odour impacts would be detected at the sensitive receptor locations. The predicted impacts at receptor R1 is exceeded by 0.4 OU, while receptor R2 meets the criteria set. The predicted impacts at R3 and R4 exceed the criteria by 1.3 OU and 1 OU respectively. These results are discussed in further detail below.

7.3.3 Comparison to odour impacts predicted in the original EA for the ethanol expansion (Scenario C, 2008)

The 2008 predicted odour impacts from the modelled scenario C are shown in Figure 8 as the light blue line. When comparing the predicted impacts of scenario C (2008) to the two scenarios modelled in this report (viz. Existing & approved and Scenario 2), the following trends are evident:

- Similar odour impacts at the 5 OU impact zone to the north and west
- Slight extensions of the impacts by 100 to 200 metres to the south and up to 270 metres to the southwest compared to scenario C (2008)
- A very slight retraction in odour impacts at the 5 OU impact zone to the northwest, towards the town of Bomaderry

As such, the odour impacts predicted in 2008 for scenario C are similar to the impacts predicted at present, for the approved/existing scenario and for the proposed scenario 2. Table 7 indicates this further, with predicted odour concentrations at the sensitive receptors very similar to the levels predicted in 2008, with exception to a 1 OU increase at receptors R3 and R4. However, these impacts are marginally lower than the most exposed sensitive receptor R1. The slight extension in predicted ground-level odour impacts, despite the decrease in overall OER, is due to; (i) variations in the physical dispersion characteristics of a number of odour sources, and (ii) substitution/and/or replacement of some odour sources when compared to 2008.

7.3.4 Comparison to odour audit results – EPA sources and 300 ML

The predicted odour exposure from the last odour audit conducted in July 2015 is shown in Appendix C. An increase in odour impact is evident when comparing the predicted 99th percentile odour level pattern in Appendix C to the existing/approved operations and proposed (scenario 2) operations (Figure 8).

The difference is due to a number of sources with high OERs having been added to the model for approved (but not yet constructed) operations. As expected, the addition of these sources increases the odour impacts of the plant.

1:30,000

0 300 600 900

Metres (at A4)

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid Of Australia, Zone 56

N

LEGEND

- Shoalhaven Starches Factory
- Packing plant (proposed)
- Environmental farm boundary
- Identified sensitive receptors
- Odour impacts, Scenario C 2008 AQIA OU, 1 min response time, 99th %ile
- Odour impacts, Existing & approved OU, 1 min response time, 99th %ile
- Odour impacts, Scenario 2 OU, 1 min response time, 99th %ile

CLIENTS | PEOPLE | PERFORMANCE

Manildra Group Pty Ltd
Shoalhaven Starches

Job Number | 3133842
Revision | A
Date | 5/5/2016

Odour impacts
Scenario 2 vs Existing/Approved

Figure 8

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8/180 Lonsdale St Melbourne VIC 3000 Australia T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com.au W www.ghd.com.au

Source: NearMap; Created by: B McKay

8. Conclusions and implications

GHD was engaged by Manildra to conduct an air quality and odour impact assessment for a proposed modification to the approved SSEP.

The addition of the proposed sources of the DDG dryers requires the duplication of the two existing biofilters, taking the total number of on-site biofilters to four, in order to meet treatment requirements.

A marginal increase of less than 0.5% was observed in predicted odour impacts as a result of the addition of two biofilters, relocated cooling towers and the Mill feed silo when compared with existing operations plus those operations already approved. It is considered highly unlikely that this increase in odour would be detected at sensitive receptors.

As a result, it is predicted that no discernible increase in perceived odour impacts would be evident as a result of the proposed modifications to the plant.

Additionally, odour impacts were compared with previous odour assessments of the plant, with the following features observed from odour measurements and modelling results:

- An overall decrease in total odour emissions from the plant by around 10.5 % to the modelled Scenario C in the ethanol expansion assessment in 2008.
- Odour impacts from Scenario 2 are similar to those predicted in 2008; with the exception of a slight extension of impacts to the south, as a result of small changes to the layout of the plant. As such the current model validates those impacts predicted in 2008, with no significant differences between impacts as a result of changes to the plant design since 2008.
- Differences shown in the modelling between the most recent odour audit (July 2015) and the predicted Existing and approved scenario are the result of the addition of odour sources. These sources have been approved but are not yet constructed. Once these additional sources are constructed, they may be included in the odour audit to assess previous model predictions and assumptions.

9. References

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Appendices

Appendix A – Meteorological analysis

The following section is taken from the Shoalhaven Starches Report on Ethanol Upgrade: Air Quality Assessment (GHD, 2008), and describes the meteorology of the area and how the dataset was compiled.

A1 Meteorology

The three-dimensional meteorological data for a CALPUFF model simulation are provided by CALMET[5], its meteorological pre-processor. CALMET requires meteorological input from surface weather station networks and upper air stations.

The following sub-sections describe the available meteorological data, how the data was applied and the features of the dispersion meteorological data used to run CALPUFF.

A1.1 Data Available

Wind data were collected at three locations within the Shoalhaven Starches facility. Of these three stations, only one station, the automated weather station (AWS) located near the storage ponds at the environmental farm (hereafter referred to as Farm AWS), is compliant with the Australian Standard for the measurement of horizontal wind for air quality applications (AS 2923:1987). The other two stations, in particular the weather station located at the factory, are compromised by building and equipment infrastructure. Wind data have been collected at the Farm AWS since 2003, with the most complete data set collected in 2004.

The nearest source of additional surface meteorological data was the Bureau of Meteorology (BoM) Nowra AWS located approximately 12 km to the west at the Royal Australian Navy base at Nowra (HMAS ALBATROSS). This data source was considered to be too far from the subject area to be site-representative.

The nearest source of upper air meteorological data was also the HMAS ALBATROSS site, which does irregular upper air soundings based on operational requirements. However, the time gap between these vertical atmospheric soundings is too large to be suitable for use as model input.

A1.2 Data Application

To take full advantage of the CALPUFF features, described in Section 7.1, and make use of the available meteorological data described above, a combined prognostic/diagnostic meteorological modelling approach was used to synthesise the three-dimensional meteorological data input required by CALPUFF.

The regional-scale prognostic meteorological model, TAPM[6], was used to simulate the meteorology over the subject site with consideration to the DECC *Approved Methods*. TAPM is an approved model for specialist applications and its use, as part of this assessment, is described in the next section.

The observations from the Farm AWS and Nowra AWS were first used for optimising and checking the performance of the prognostic model simulation.

Wind speed and wind direction data from the Farm AWS were then assimilated into the prognostic model.

The subsequent TAPM output (with assimilated Farm AWS data) was then passed to meteorological pre-processor model CALMET (version 5.5).

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[5] Scire J.S., E.M. Insley, R.J. Yamartino, and M.E. Fernau, 1995: A User's Guide for the CALMET Meteorological Model. Report prepared for the USDA Forest Service by EARTH TECH, Concord, MA. See: http://www.src.com/calpuff/calpuff1.htm
[6] Hurley, P. The Air Pollution Model (TAPM) version 3. CSIRO Atmospheric Research Paper No. 31, 2005

A2 Prognostic Meteorological Modelling

TAPM (version 3.0.7) was developed at CSIRO Division of Atmospheric Research as a PC-based prognostic modelling system that can predict regional scale three-dimensional meteorology. TAPM accesses databases of synoptic weather analyses from the Bureau of Meteorology. The model then provides the link between the synoptic large-scale flows and local climatology, which includes characterising such factors as local land use and topography, and their influence on atmospheric stability and mixing height.

TAPM was initially configured with a nested model grid coverage designed to capture:

- Broad scale synoptic flows
- Regional to local scale wind channelling
- The influence of local land use

The nested grids were then configured with surface characteristics, such as terrain elevation, surface type (land use and vegetation type), soil type and deep soil moisture content.

Specific model settings were:

- Four nested grids at 1 000 m, 3 000 m, 10 000 m and 25 000 m resolution, with 55 x 55 grid points. The grid was set to ensure the locations of the Farm AWS and Nowra AWS were within the inner nested grid
- Surface vegetation and precipitation processes were included, whereas, non-hydrostatic processes were not included

Following an initial model run, the model output from the grid point nearest to the Farm AWS was compared with data recorded at that station. Specifically, the predicted hourly ambient temperatures and the annual wind rose (wind speed and direction distributions) were compared with corresponding recordings. Model output from the model grid point nearest to the Nowra AWS was also compared with an annual wind rose derived from data recorded at that station.

Figure A1 shows the scatter plot of observed and predicted ambient temperature at the Farm AWS. The determined optimal model configuration produced a correlation coefficient of 0.88 for predicted temperature. The strong correlation between predicted and recorded temperature indicates that the model is accurately calculating the surface energy balance, which, in turn, adds confidence to the hourly varying predictions made for atmospheric stability and the height of the mixed layer.

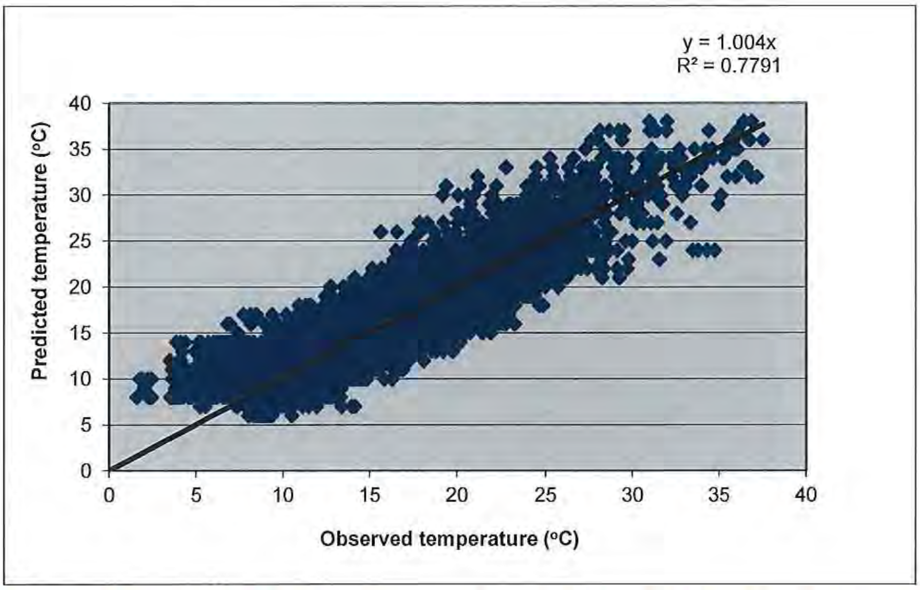


Figure A1 Scatter Plot of Observed and Predicted Ambient Temperature

A2.1 Wind Distribution

Figure A2 shows the predicted (a) and observed (b) wind roses for the location of the Nowra AWS. The directional distribution of winds predicted by TAPM shows reasonable agreement with the recorded observations and with the wind patterns expected for this region.

Figure A3 shows the predicted (a) and observed (b) wind roses for the location of the Farm AWS after the initial TAPM simulation. The directional distribution of winds predicted by TAPM shows reasonable agreement with the recorded wind patterns expected for this region.

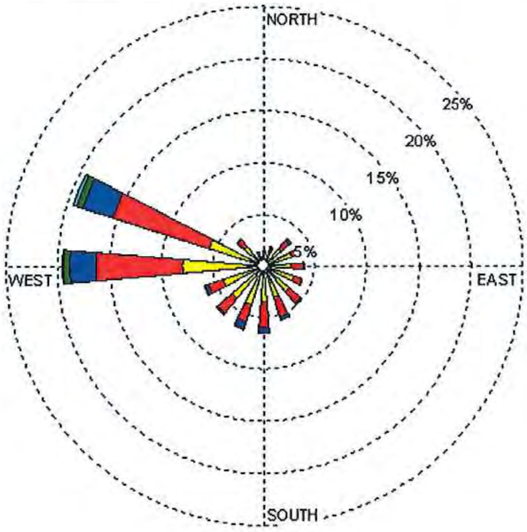
The wind speed and direction observations from the Farm AWS were assimilated into the prognostic model simulation to improve the ability of the model to capture the effects of local wind channelling and low wind speed conditions. The improvement to wind direction distributions in the model output is clearly evident in Figure A3(c). The marked improvement in the capture of low wind events is examined below.

It is understood that TAPM performs reasonably well at simulating low wind speeds when the atmosphere is unstable but is known to perform relatively poorly during stable atmospheric conditions[7]. This is a critical factor in this assessment given that odour emissions occur 24-hours per day, resulting in predictions of maximum odour impact dominating during these conditions.

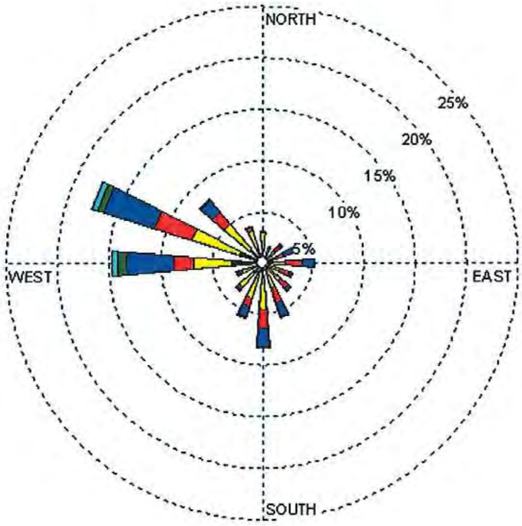
Figure A4 shows a histogram of wind speed distribution for observations at the Farm AWS, predictions from TAPM and predictions from TAPM after wind speed and direction data from the Farm AWS were assimilated into TAPM. It is clear from this figure that TAPM did reasonably well at originally predicting moderate to high wind speeds but did relatively poorly predicting low wind speeds. However, Figure A4 also shows that the representation of low winds in the TAPM output was significantly improved once the Farm AWS data were assimilated into the model.

[7] Luhar, A., Hurley, P. and Rayner, K. Improving Land Surface Processes in TAPM. Part 2: Low Wind Stable Conditions. 14th IUAPPA World Congress 2007

TAPM output at Nowra AWS grid point



Recorded at Nowra AWS



Legend

WIND SPEED (m/s)

- >= 11.1
- 8.8 - 11.1
- 5.7 - 8.8
- 3.6 - 5.7
- 2.1 - 3.6
- 0.5 - 2.1

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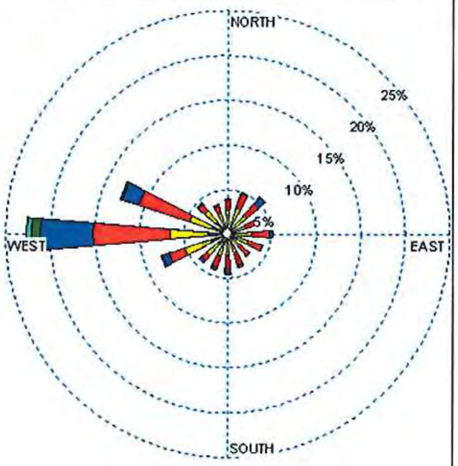
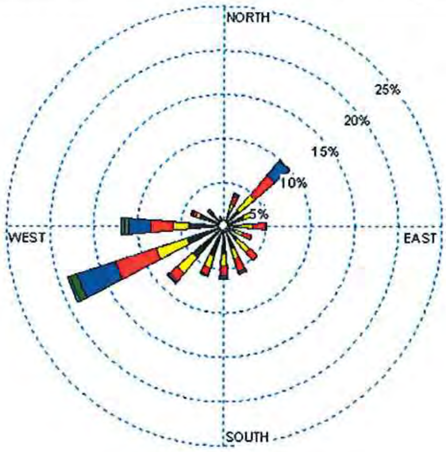
Figure A2 Nowra AWS - Annual Wind Roses (Year 2004)

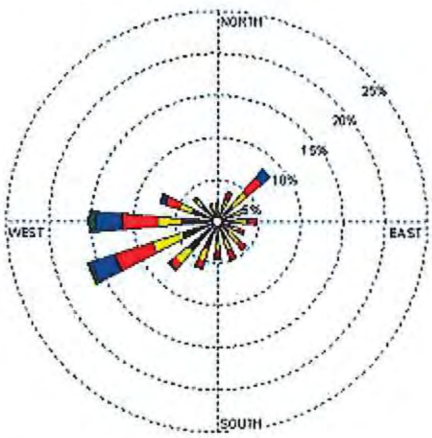
a) TAPM output at Farm AWS



b) Recorded at Farm AWS



c) TAPM output at Farm AWS grid point after Farm AWS data assimilated



Legend

WIND SPEED (m/s)

- >= 11.1
- 8.8 - 11.1
- 5.7 - 8.8
- 3.6 - 5.7
- 2.1 - 3.6
- 0.5 - 2.1

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Figure A3 Farm AWS - Annual Wind Roses (year 2004)

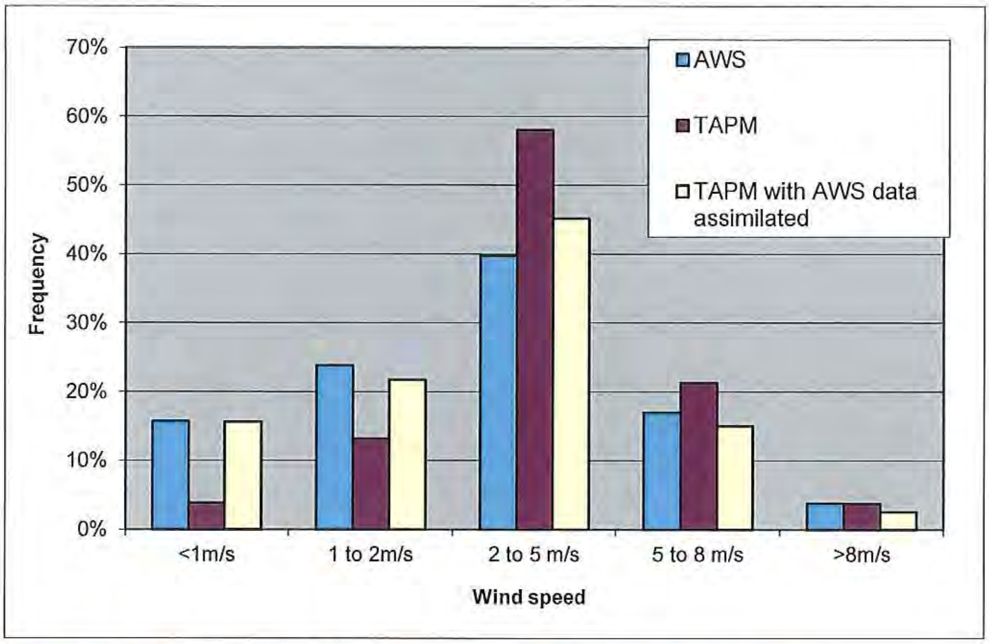


Figure A4 Wind Speed Distribution – TAPM and Farm AWS

To further investigate the effect of data assimilation on model output, a sensitivity analysis was conducted to compare the subsequent CALPUFF model predictions using meteorological input derived with and without the assimilation of observed wind speed and wind direction data from the Farm AWS into TAPM. Good agreement was found in the general pattern of dispersion (i.e. similar directions of poor dispersion), however, the highest ground level odour concentrations were predicted when the assimilated meteorological data file was used, which was expected given the higher frequency of light winds.

A3 Diagnostic Meteorological Model - CALMET

The TAPM output (with assimilated data) was then passed to model CALMET (version 5.5)[8], which is the 3D meteorological diagnostic model pre-processor to the CALPUFF 3D puff based dispersion model.

Hourly varying 3D meteorological data, at a 1000 m resolution, were extracted from the TAPM inner nested grid and passed to CALMET in their entirety as initial guess fields. Surface meteorological parameters and vertical profile data were also extracted from TAPM at a grid point near the factory, and used as if they were observations in the diagnostic model (i.e. pseudo-data).

CALMET was configured with a 15 km by 15 km grid at 200 m resolution and with local scale surface characteristics, such as terrain elevation and land use (e.g. forest or sparse growth, water or residential). The land use and terrain elevation information was derived from US Geological Survey and AusLig data, respectively, with adjustments based upon inspection of aerial photographs, topographical and land uses maps, and a site inspection.

CALMET was used to produce hourly site-representative winds and micrometeorological information, which was used with the CALPUFF 3D puff-based dispersion model to assess the impacts of the air pollutants on the surrounding land uses.

[8] Scire J.S., E.M. Insley, R.J. Yamartino, and M.E. Fernau, 1995: A User's Guide for the CALMET Meteorological Model. Report prepared for the USDA Forest Service by EARTH TECH, Concord, MA. See: http://www.src.com/calpuff/calpuff1.htm

A3.1 Site-specific meteorology

Figure A5 shows a wind rose that illustrates the distribution of wind speed and direction at the location of the Factory. On an annual basis the prevailing winds are from the west with winds also from the west-north-west, north-west, west-south-west and north-east. The mean wind speed is 3.2 m/s, with higher speed winds associated with westerly winds with speeds up to 11 m/s; such speeds are not reached from other directions. The highest frequency of light winds occurs from the south-west, west and north.

Figure A6 provides a seasonal breakdown of the predicted wind distribution at the Factory, this figure reveals a north-easterly predominance during summer (sea-breeze) and a westerly predominance during the other seasons, in particular during winter.

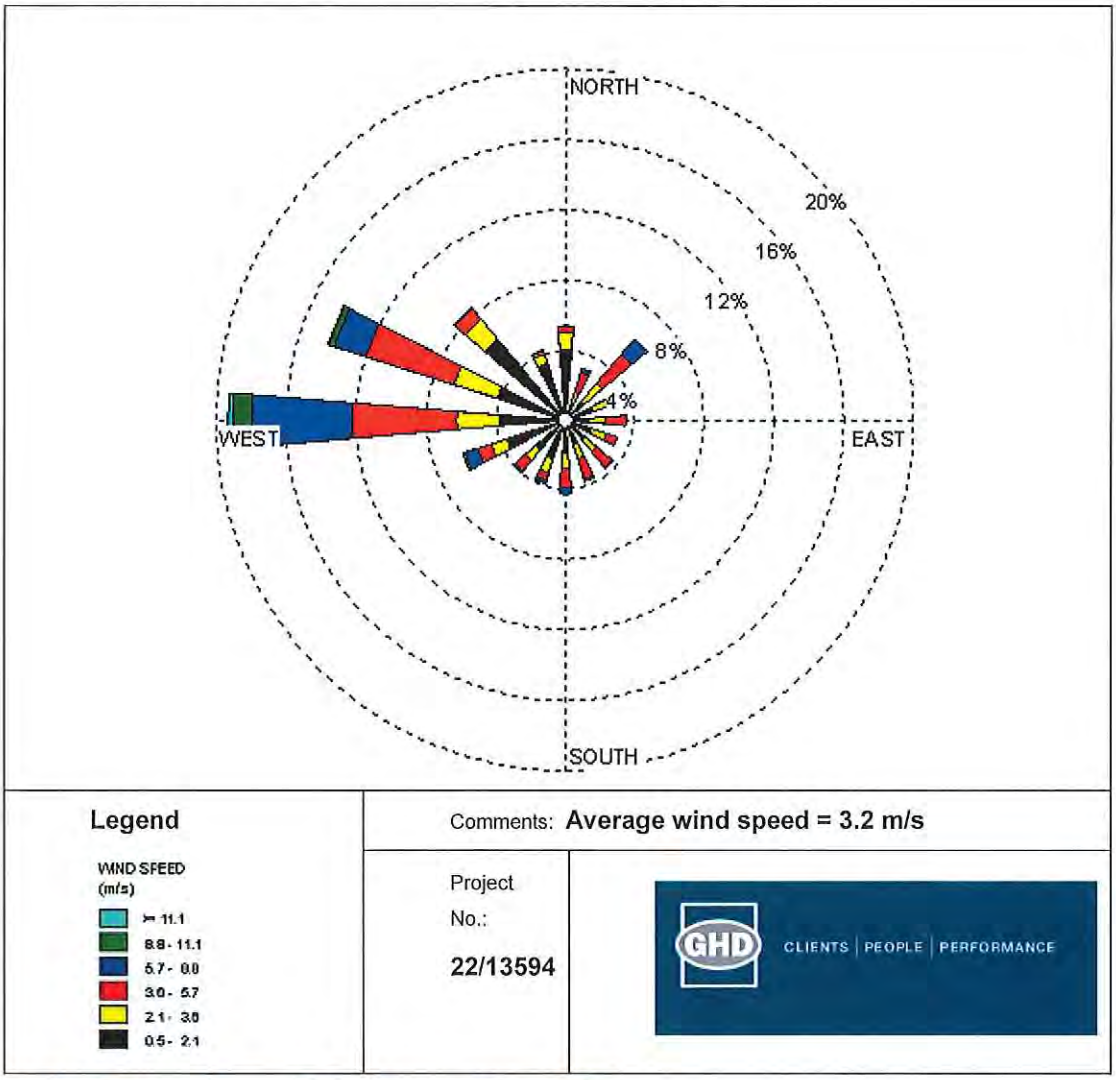
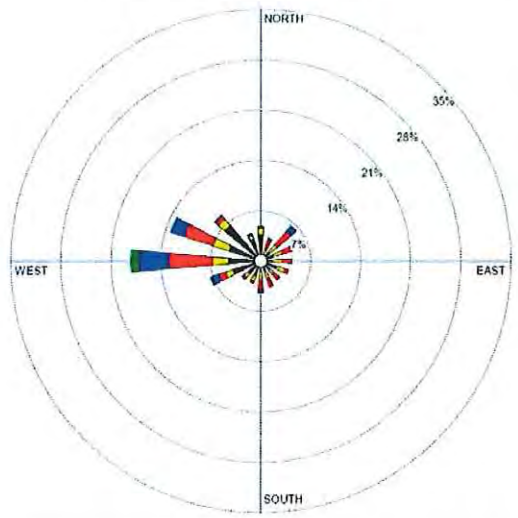
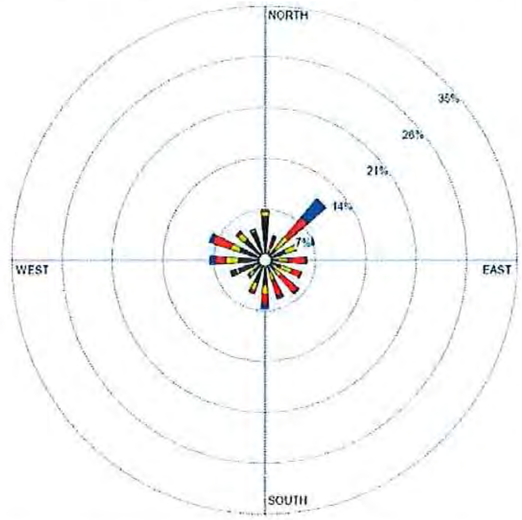


Figure A5 Factory Annual Wind Rose - Year 2004

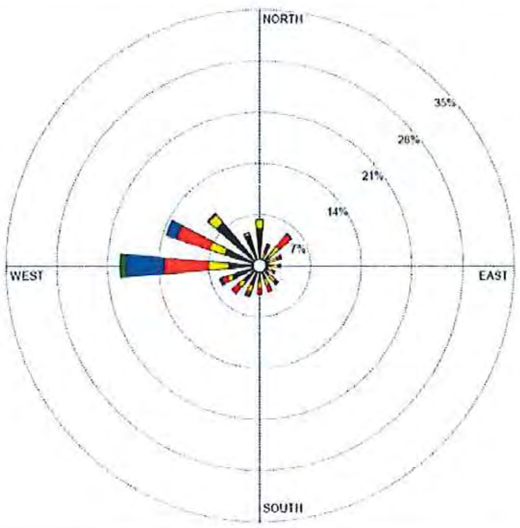
Spring (average wind speed = 3.1 m/s)



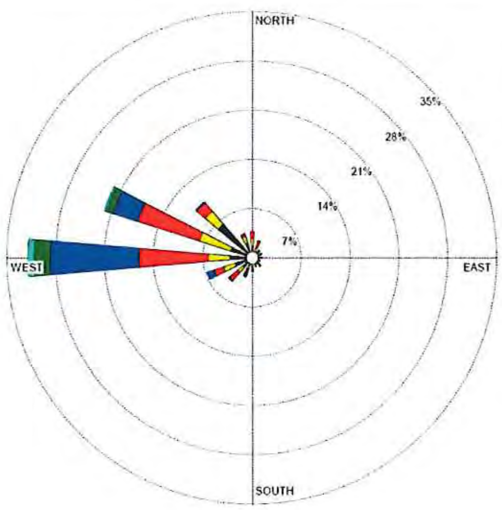
Summer (average wind speed = 2.8 m/s)



Autumn (average wind speed = 2.8 m/s)



Winter (average wind speed = 4.1 m/s)



Legend

WIND SPEED (m/s)

- >= 11.1
- 8.8 - 11.1
- 5.7 - 8.8
- 3.6 - 5.7
- 2.1 - 3.6
- 0.5 - 2.1

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Figure A6 Factory Seasonal Wind Roses - Year 2004

A categorised measure of atmospheric stability is also output from the model. These can be broadly defined as listed in Table A1.

Table A1 Atmospheric Stability Classes and Distribution

Stability Class	Description	Frequency of Occurrence [1]
A	Extremely unstable atmospheric conditions, occurring near the middle of day, with very light winds, no significant cloud.	2%
B	Moderately unstable atmospheric conditions occurring during mid-morning/mid-afternoon with light winds or very light winds with significant cloud.	14%
C	Slightly unstable atmospheric conditions occurring during early morning/late afternoon with moderate winds or lighter winds with significant cloud.	17%
D	Neutral atmospheric conditions. Occur during the day or night with stronger winds. Or during periods of total cloud cover, or during twilight (transition) period.	22%
E	Slightly stable atmospheric conditions occurring during the night-time with some cloud and/or light-moderate winds.	12%
F	Moderately stable atmospheric conditions occurring during the night-time with no significant cloud and light winds.	32%

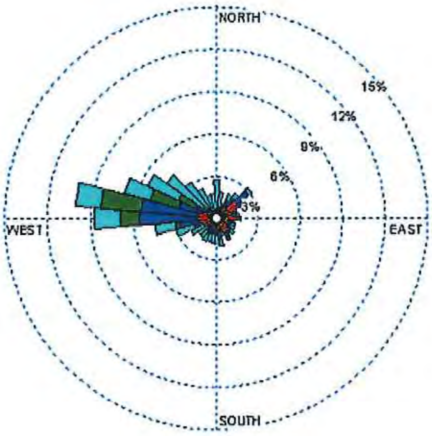
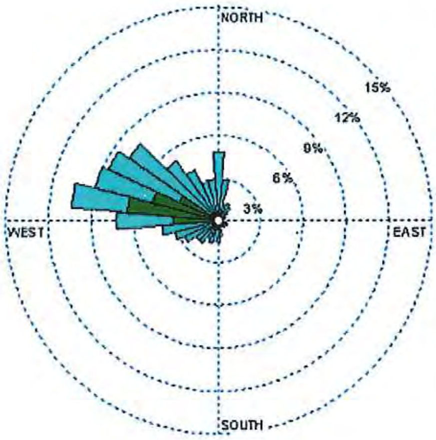
1. Stability data in this table extracted from Factory meteorological data

Potential off-site odour impact would tend to be maximised when winds are light and the atmosphere is stable, conditions that typically occur during the early evening and night-time. Table A1 shows that these conditions occurred for approximately 44% of the time.

The occurrence of stable air flows is of significance as these generally provide the conditions for worst case dispersion of emissions to air from ground based (or near-ground based) sources, and hence potentially the highest impact to odour amenity. This is due to the limited mixing in the vertical plane of these light wind airflows, and hence less dilution of the emissions from the majority of odour sources, which are either at ground level or wake affected short stacks. Therefore, the distribution of light wind stable flows can define the directions of "poor odour dispersion" from the factory and environmental farm.

Vertical mixing of airflows can be brought about by two mechanisms. The first is mechanical mixing caused by the shear stresses as air moves over rough terrain. The second is via thermal convective mixing, which has the potential to occur significantly only during daytime. The occurrence of unstable and strong-wind neutral air flows generally provide the conditions for the highest ground level concentrations due to emissions to air from elevated stack sources, such as the coal-fired boiler exhaust stacks found at the factory.

A rose that illustrates the directional distribution of the predicted atmospheric stability is shown in Figure A7. During these stable periods, the regional scale cool air drainage flows down the river valley from the west to dominate the transport and dispersion of emissions to air from the factory and environmental farm. To a lesser extent, local slope drainage flows from the elevated terrain located to the north, west-north-west and west-south-west of the site would also generate these conditions for poor dispersion.

All stability classes	E & F Stability classes (stable conditions only)
	

Legend

Stability Class

- F
- E
- D
- C
- B
- A

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Figure A7 Factory Annual Stability Rose - Year 2008

Appendix B – Complete odour emission inventory

The following Tables detail all sources modelled for both the existing approved scenario and scenario 2 (proposed).

Table B1 Summary of point sources

Source	EPA ID	ID	Source type	Height m	Diameter m	Exit velocity m/s	Exit temperature °K	Odour emission rate before control OUm^3/s	OER after control OUm^3/s	Peak to mean adjusted total OER OUm^3/s
Boiler house										
Boiler No. 4	42	BOILR4	Tall wake free point	39	1.1	14	417.2		2,200	variable
Combined Boiler Stack for No. 5 & 6 Boilers. Coal combustion odour	35	BOILR5	Tall wake free point	54	2.05	13.5	411.2		49,266	variable
DDG Plant										
Additional cooling towers to the west (proposed)		CTP	Wake affected point	54	2.05	6	411.2		172	variable
Pellet Mill Silo (proposed)		PMFS	Wake affected point	24	0.16	7.0	320		173	398
Cooling towers		DDG46	Wake affected point	10	4.5	6	295		172	396
Light phase recovery tank		DDG19	Wake affected point	11	0.1	3.3	362		20	46
Pellet Plant exhaust stack	46	PPES	Tall wake free point	49.2	1.5	14.1	318.2		48,800	var
Pellet silo		S12	Wake affected point	2	0.3	0.1	304		350	805
Stillage surge tank		SST	Wake affected point	2	0.2	3.3	360		149	343
Vent condensor drain		DDG25	Wake affected point	0.1	0.3	0.3	300		31	71

Source	EPA ID	ID	Source type	Height m	Diameter m	Exit velocity m/s	Exit temperature °K	Odour emission rate before control OUm^3/s	OER after control OUm^3/s	Peak to mean adjusted total OER OUm^3/s
Ethanol Plant										
Ethanol Recovery Scrubber Discharge	16	ERESC	Wake affected point	28	0.3	7.1	299.5		12,833	29,516
Fermenters (10-16)	44	FERM	Wake affected point	21	0.28	5.1	305.8		7,157	16,461
Yeast propagators - tanks 4 & 5		E15Y4	Wake affected point	17	0.4	3.2	302		14,167	32,584
Yeast propagators - tanks 4 & 5		E15Y5	Wake affected point	17	0.4	3.2	302		14,167	32,584
Starch and Glucose Plants										
cyclone and fabric filter		4	Wake affected point	33	1.6	6	313		679	1,562
cyclone and fabric filter		5	Wake affected point	33	1.6	6	313		96	221
cyclone and fabric filter		6	Wake affected point	33	1.6	6	311		449	1,033
cyclone and fabric filter		7	Wake affected point	33	0.8	9	297		932	2,144
Drum vacuum receiver		C4	Wake affected point	21	0.2	20	314		3,500	8,050
Dry gluten roof bin		S07	Wake affected point	25	0.7	0.1	328		4,500	10,350

Source	EPA ID	ID	Source type	Height m	Diameter m	Exit velocity m/s	Exit temperature °K	Odour emission rate before control OUm³/s	OER after control OUm³/s	Peak to mean adjusted total OER OUm³/s
Enzyme Tanks		B7	Wake affected point	6	0.5	0.3	327		2,042	4,697
Feed transfer to distillery		E22	Wake affected point	15	0.3	0.1	300		83	191
Flash Vessel Jet Cooker		C1	Wake affected point	21	0.1	0.1	350		970	2,231
Flour bin aspirator		S13A	Wake affected point	2.5	0.4	0.1	306		1,000	2,300
Flour bin aspirator		S13B	Wake affected point	2.5	0.4	0.1	306		1,000	2,300
Flour bin motor drive		S06	Wake affected point	24	0.3	0.1	307		283	651
Flour mill stack proposed and approved 1		FMP1	Wake affected point	33.4	4.53	0.7	320		266	472
Flour mill stack proposed and approved 2		FMP2	Wake affected point	31.8	4.67	0.2	360		205	610
Grain retention - tank 2 (now located in adjacent tank)		E8	Wake affected point	1	0.25	0.1	293		3,250	7,475
High protein dust collector		S08	Wake affected point	24.5	0.4	0.1	316		600	1,380
Incondensible gases vent		D6	Wake affected point	13	0.2	0.6	309		558	1,283

Source	EPA ID	ID	Source type	Height m	Diameter m	Exit velocity m/s	Exit temperature °K	Odour emission rate before control OUm^3/s	OER after control OUm^3/s	Peak to mean adjusted total OER OUm^3/s
Ion exchange effluent tank		C18	Wake affected point	2.5	0.32	0.1	307		250	575
Jet cooker 1 - retention tank		E13	Wake affected point	10	0.2	0.1	362		1,067	2,454
Jet cooker 2 & 4 - Grain retention		E7	Wake affected point	9	0.1	2.2	373		567	1,304
Molecular Sieve - Vacuum drum		D2	Wake affected point	10	0.1	13	337		1,350	3,105
No. 1 Gluten Dryer baghouse	8	S02	Wake affected point	25.5	3.2	106.1	344.7	-	6,426	14,780
No. 1 Starch Dryer	12	S01	Wake affected point	26	1.3	9.3	314.2	-	6,063	13,945
No. 2 Gluten Dryer baghouse (aka. No 2 Starch Dryer)	9	S04	Wake affected point	27	3.2	0.1	333.2	-	4,536	10,433
No. 3 Gluten Dryer baghouse	10	S03	Wake affected point	21	2.5	444.1	348.2	-	22,685	52,176
No. 3 Starch Dryer	13	S18	Wake affected point	20	1.2	21.8	317.2	-	4,189	9,635
No. 4 Gluten Dryer baghouse	11	S05	Wake affected point	30	2.7	0.1	349.2	-	14,930	34,339
No. 4 Starch Dryer	14	S19	Wake affected point	20	1.2	21.8	315.7	-	4,200	9,660

Source	EPA ID	ID	Source type	Height m	Diameter m	Exit velocity m/s	Exit temperature °K	Odour emission rate before control OUm³/s	OER after control OUm³/s	Peak to mean adjusted total OER OUm³/s
No. 5 Ring Dryer Starch		SDR5	Wake affected point	25	1.2	0.1	320	-	4,817	11,080
No. 5 Starch Dryer		8	Wake affected point	33.5	2.35	14.96	329.2	-	6,800	15,640
No. 6 Gluten Dryer		GD6	Wake affected point	35	1.7	22.4	346.2	-	12,568	28,906
No. 7 Gluten Dryer		GD7	Wake affected point	29	1.7	18.9	341.2	-	9,553	21,972
Spray dryer		S20	Wake affected point	19	1.4	0.1	335		738	1,697
Starch factory rejects collection tank		E10	Wake affected point	8	0.1	0.1	308		183	421
Packing Plant										
Large Starch Silo 1		PPL1	Wake affected point	26.5	0.16	18.6	323.2	-	86	199
Large Starch Silo 2		PPL2	Wake affected point	26.5	0.16	18.6	323.2	-	86	199
Medium Gluten Silo 1		PPM1	Wake affected point	20.7	0.16	6.8	323.2	-	173	398
Medium Gluten Silo 2		PPM2	Wake affected point	20.7	0.16	6.8	323.2	-	173	398

Source	EPA ID	ID	Source type	Height m	Diameter m	Exit velocity m/s	Exit temperature °K	Odour emission rate before control OUm^3/s	OER after control OUm^3/s	Peak to mean adjusted total OER OUm^3/s
Medium Gluten Silo 3		PPM3	Wake affected point	20.7	0.16	6.8	323.2	-	173	398
Small Gluten Silo		PPS1	Wake affected point	34.3	0.2	18.6	323.2	-	92	211
Small Starch Silo		PPS2	Wake affected point	34.3	0.2	18.6	323.2	-	35	81

Table B2 Summary of area sources

Source	EPA ID	ID	Source type	Area (m^2)	SOER – OUm/s	Total OER* OUm^3/s
Factory						
Biofilter A	40	Biofil	Variable area	110.0	8.5	935
Biofilter B	41	BioF2	Variable area	110.0	2.6	286
Biofilter C (proposed)	40	Biofil3	Variable area	110.0	8.5	935
Biofilter D (proposed)	41	BioF4	Variable area	110.0	2.6	286
Environmental Farm						
Effluent storage dam 1	19	POND1	Variable area	4,100	0.03598	148
Effluent storage dam 2	20	POND2	Variable area	2,970	0.55770	1,656
Effluent storage dam 3	21	POND3	Variable area	9,040	0.02120	192
Effluent storage dam 5	23	POND5	Variable area	30,840	0.01671	515
Effluent storage dam 6	24	POND6	Variable area	58,790	0.03020	1,775
Sulphur Oxidisation Basin	25	SOBAS	Variable area	12,070	0.06875	830
Membrane bio-reactor	-	MBR	Variable area	650	0.096	62

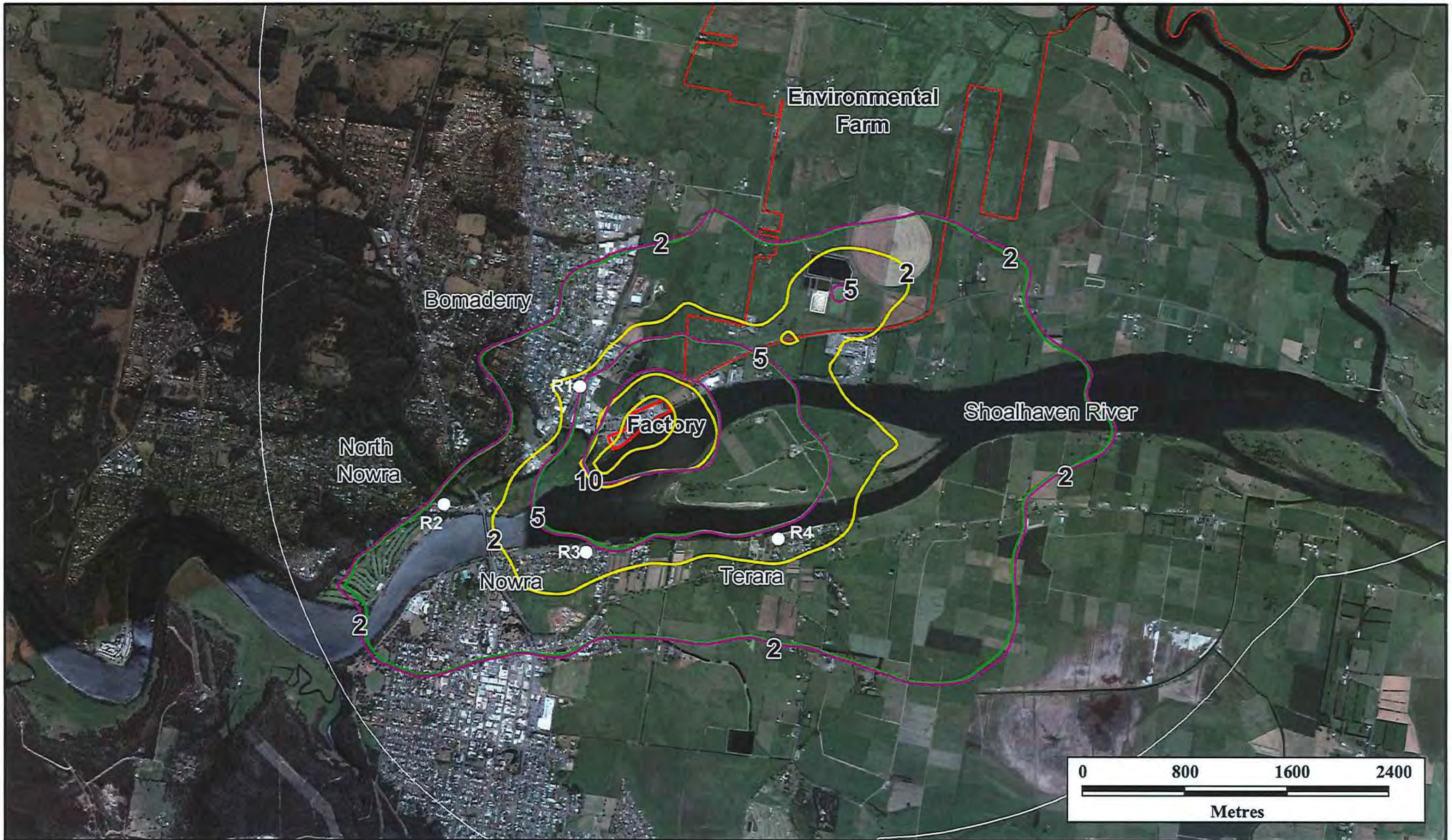
* total OER used as peak-to-mean ratios for OER are variable depending on stability class for area sources

Table B3 Summary of Volume Sources

Source	EPA ID	ID	Source type	Odour emission rate OER (OUm^3/s)	Peak to Mean adjusted OER OUm^3/s
DDG load out shed - awning	-	DDG35	Variable Vol	923	2,123
DDG product storage sheds	-	DDG34	Variable Vol	1,023	2,353
DDG tent storage area	-	DDG36	Variable Vol	1,929	4,437
Pellet plant fugitives (discharged direct to atmosphere)	-	PPF	volume	5,771	13,273
Farm tank	-	F18	Volume	3,834	8,818

Appendix C – Previous odour audit results

Beige: EPA Points at 232 ML p.a.
Yellow: EPA Points at 300 ML p.a.
Green: All Points at 232 ML p.a.
Purple: All Points at 300 ML p.a.



DATA SOURCE			
Prepared.	CMC	Workspace	Manildra
Checked.	DF	Location	G:\31\30861\GIS\Maps\Working\EPA_Points_2015.wo
Approved.	DK	Map Grid	GDA 94 (zone 56)

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180 Lonsdale Steet
Melbourne Vic 3000
Tel: 61 3 8687 8000
Fax: 61 3 8687 8111

Project: **Shoalhaven Starches - Odour Assessment**

Title: **EPA Points and All Sources at 232 ML p.a. and 300 ML p.a. Combined**
Predicted odour concentration OU, 99 percentile, 1-sec. avg.

Figure 3

Project No: 31/30861	Date: 23/06/15	A4	Scale: 1:40,000	Sh 1 of 1	Rev. 0

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		Name	Signature	Name	Signature	Date
A						
Draft B						05/05/16
0	B McKay	T Pollock		M Koller		17/05/16

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