M. & H. LAWRENCE and OTHERS

ORFORD SEWAGE TREATMENT PLANT
ODOUR ASSESSMENT

Environmental Dynamics
Project ED5190
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The document is unchanged except for an addendum section that addresses comments by TasWater.

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ODOUR ASSESSMENT

Contents

Glossary and Terminology

GLC	Ground level concentration
OU	Odour unit
OER	Odour emission rate (OUV/s)
PST	Primary sedimentation tank
SOER	Specific odour emission rate (OUV/s/m^2)
WWTP / STP	Wastewater / Sewage Treatment Plant

Odour units (OU). One odour unit (1 OU) is defined as the concentration of odour just detectable by 50% of a panel of "expert sniffers". For example, if 1 m^3 of air has an odour concentration of 2 OU, and it is mixed with 1 m^3 of odourless air, the resulting 2 m^3 volume of air will have an odour concentration of 1 OU.

Odour Emission Rates (OERs). An odour emission rate (OER) is measured in OUV/s, sometimes written OU.m^3/s. Odour is treated by dispersion models as simply another airborne contaminant, and its different units are just a matter of convenience.

Basic relationship:	Concentration x flow rate = emission rate.
Odour emission rate	OU x m^3/s = OUV/s
Mass emission rate	g/m^3 x m^3/s = g/s

Averaging period. A measurement, or prediction, of odour concentration must be associated with an averaging period. This is the length of time over which the odour sample is taken, or the prediction is made, and it is called an averaging period because the odour concentration can fluctuate during the period, so the concentration is an average value. Typical averaging periods for odour are 1 hour, 3 minutes, and 1 second.

Lagoon OERs are measured using a flux hood to measure odour emissions per m^2 per second, called a Specific Odour Emission Rate (SOER), and multiplying by the area of the source gives the total OER.

Upset conditions refer to periods of significantly elevated odour emissions, for example due to the WWTP processing certain trade wastes, or equipment breakdown.

1. Introduction

A 91-unit residential subdivision has been proposed for Lot 2, Rheban Road, Orford. The proposed subdivision lies partly within the 350m attenuation distance of the Orford Sewage Treatment Plant (STP) and accordingly TasWater has requested an odour assessment be carried out by a suitably qualified person to determine whether the attenuation distance can be relaxed.

The proponents are M. & H. Lawrence and others. The proponents have engaged Aldanmark Pty Ltd to provide civil design services; and have engaged Environmental Dynamics (Dr Steve Carter) to carry out the required odour assessment.

Qualifications

Dr Carter is a consulting environmental engineer with dual qualifications as a physicist. He has carried out odour impact assessments of sewage treatment plants, a landfill, abattoir, compost facility, a mort (dead fish) processing plant, asphalt plants, poultry farms and other facilities. In 2017, he was engaged by the Macquarie Point Development Corporation to assess the odour impact of the Macquarie Point wastewater treatment plant, a project that involved extensive odour sampling and modelling, working in partnership with TasWater. The work was peer reviewed by TasWater's specialists and consultants, and the EPA. Cross-check modelling was also carried out.

2. The Orford STP and proposed subdivision

Figure 1 shows the location of the Orford STP on the south side of Rheban Road, on the eastern outskirts of Orford. The STP has an inlet works, an aeration lagoon and three secondary lagoons. The inlet works are located adjacent to the SW corner of the aeration lagoon, about 360m south of Rheban Road. TasWater has advised that the STP operates at an average daily inflow of 179 kL/day and has a design capacity of 473 kL/day. The Glamorgan Spring Bay interim planning scheme 2015 specifies an attenuation distance of 350m for an STP with a design capacity between 275 kL/day and 1,375 kL/day.

Figure 1. The Orford Sewage Treatment Plant and proposed subdivision.

Figure 1 also shows the location of the proposed subdivision on the north side of Rheban Road, where there is a single existing residence. The 350m attenuation distance is measured from the north side of the third (northern most) secondary lagoon and extends about halfway into the proposed subdivision.

3. Odour assessment methodology

Schedule 3 of the *Tasmanian Environment Protection Policy (Air Quality) 2004* specifies odour assessment criteria. For an unknown mixture of odiferous pollutants, a 2 OU design ground level concentration (GLC) is specified, over a one-hour averaging period. The maximum GLC predictions are used to assess compliance, unless high quality site-specific meteorology data and odour emission rate data are available, in which case the 99.5 percentile GLC predictions can be used to assess compliance. The standard approach is to make GLC predictions for a year of meteorology, producing 8,760 GLC (1 hour) predictions at each point in the prediction grid, in which case the maximum GLC is the highest GLC prediction at each point, and the 99.5 percentile GLC is the 44th highest GLC prediction at each point.

4. Choice of model

Wind prediction model

Historically, the lack of good site specific meteorological data reduced the credibility of many dispersion modelling exercises. This problem can now be avoided by using computer models to produce the required meteorology. This study uses CSIRO's model The Air Pollution Model (TAPM). It predicts fully 3-D winds from synoptic scale meteorological data gathered by the Bureau of Meteorology from weather stations across the country, supported by data sets of land use, soil and vegetation, sea surface temperature, and terrain. TAPM Version 4.0.5 is used by this study. Calmet is the other model often used in Australia to predict 3-D winds to drive a dispersion modelling exercise.

Dispersion model

Four dispersion models are commonly used in Australia. Ausplume and Aermod are workhorse Gaussian plume models, making "lighthouse" predictions based on a single set of meteorology data each hour. TAPM (dispersion model) and Calpuff are more sophisticated models with algorithms that take advantage of the 3-D meteorology that TAPM (wind prediction model) and Calmet can provide. TAPM V4.0.5 was chosen for the dispersion modelling work. The model has been verified using Australian and international datasets and is described by papers available on the CSIRO's web site www.cmar.csiro.au.

TAPM vs Calmet/Calpuff vs Ausplume

A common fallacy is that Ausplume should be used for odour modelling, presumably because it facilitates the use of the units used for odour emission rates and odour concentrations. However, odour is just another airborne contaminant, and if TAPM or Calpuff are better models for other gaseous contaminants then they are also better for odour modelling.

A recent WWTP odour assessment project compared the wind predictions of Calmet and TAPM and the odour dispersion predictions of Calpuff and TAPM. TasWater and the EPA are aware of this comparison exercise and that there was little difference between the predictions.

5. Wind predictions

Table 1 gives the TAPM meteorology model inputs for the wind predictions. The year 2013 was chosen because it was a typical year and came before the unusual weather conditions that produced record low rainfall across Tasmania.

Default file	*Orford.def* (available on request)	
Meteorology	2013 with two days in December 2012 used for model spin-up, and one day in January 2014 used to ensure clean end of year predictions.	
Terrain, land use.	*Geodata* 9-sec DEM	~250 m resolution
and soil type data	*Tas100mgrid.txt*	~100 m resolution
	Vege.aus 3-min grid	~5 km resolution
	TasSVLU250m.txt	~250 m resolution
	Soil.aus 3-min grid	~ 5km resolution
Wind grid centre	147° 20.5' E, 42° 52.5' S	GDA 94 datum
	{527,905 m E, 5,253,009 m N}	GDA 94 datum
Meteorology grids	25 x 25 horizontal grid points, all five grids 30 km, 10 km, 3 km, 1 km, 300 m resolution	
	25 vertical grid points. At {10, 25, 50, 100,…,6000, 7000, 8000 m}.	

Table 1. TAPM wind prediction model inputs.

Figure 2 shows the digital terrain used for wind prediction modelling over the 4th of the 5 nested prediction grids, a 24 km x 24 km grid with 1 km grid spaces. The high ground south of the STP will tend to suppress the southerly winds at the STP, which is important because the proposed subdivision is located due north of the STP and can only be impacted by odour from the STP when winds are from the south,

Figure 3 shows the annual surface (10m) 2013 wind rose predicted at the WWTP by TAPM. The dominant west to SW wind signature is associated with the flow of weather systems across Tasmania from west to east, together with terrain channeling of winds including nocturnal katabatics. The digital terrain plot in Figure 2 clearly shows that terrain blocking / channeling is expected. The east to NE wind signature is due to the afternoon sea breeze and becomes more prominent in a wind rose showing the 3pm winds.

The wind rose confirms that winds from the south, towards the proposed subdivision, are rare.

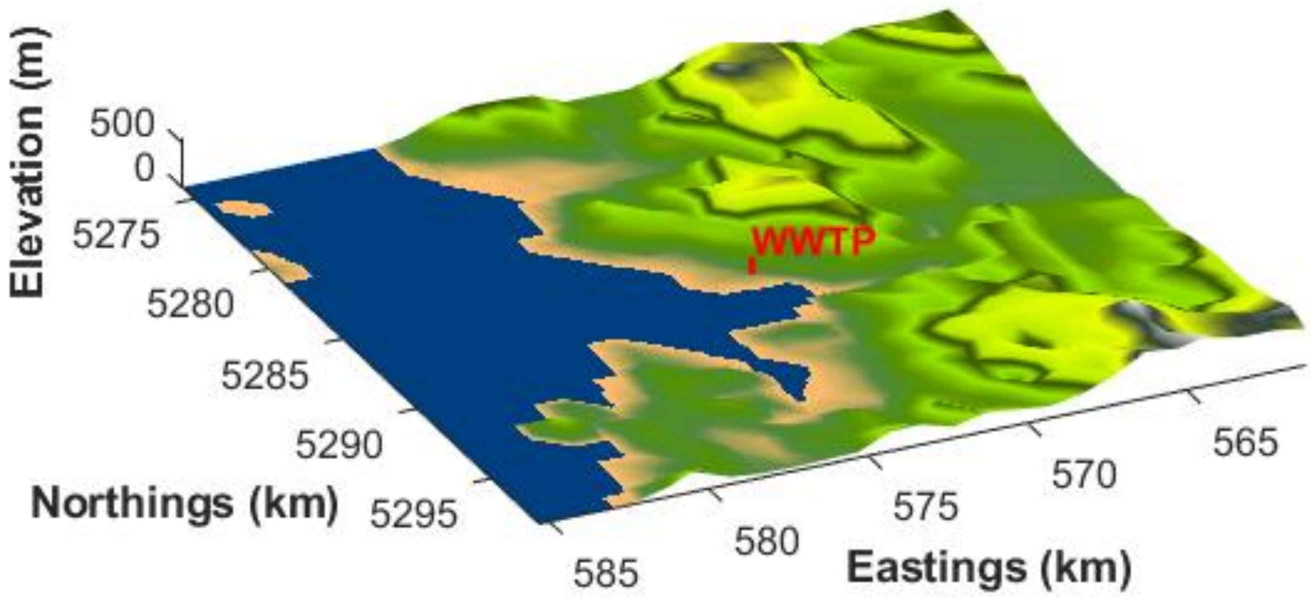

Figure 2. **Digital terrain used by the model. This figure shows the terrain for the 4th of the 5 nested wind prediction grids, which is a 24 km x 24 km grid with 1 km spacing. The data has approximately 100 m resolution. The view is looking SW.**

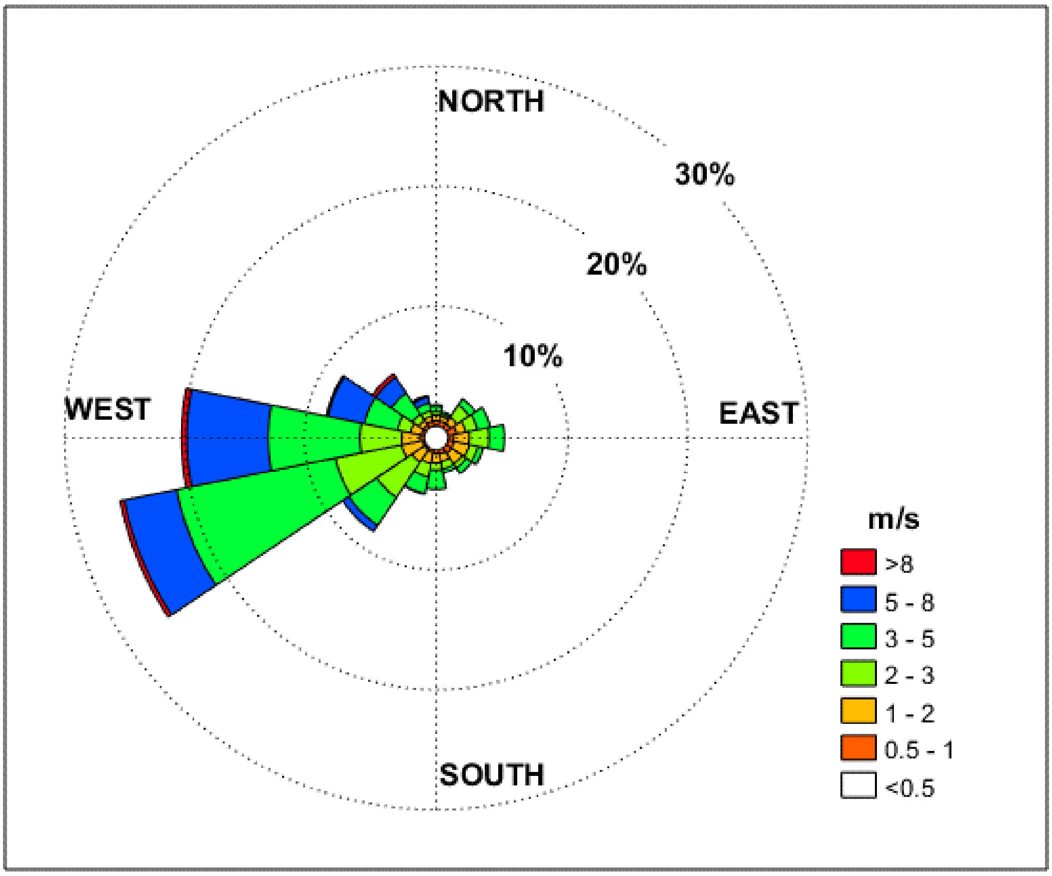

Figure 3. 2013 surface wind roses (m/s) predicted at the STP by TAPM.

Figure 4 shows the distribution of stability classes in 2013 predicted by TAPM. Stability classes A, B and C refer to unstable atmospheric conditions. Class A conditions are associated with hot sunny days, with excellent dispersion due to substantial mixing of the air by vertical eddies. Classes B and C are also associated with good dispersion conditions. Together, these atmospheric conditions occur about 25 percent of the time in the vicinity of the STP.

Stability class D refers to neutral atmospheric conditions, which occur just over 40 percent of the time near the STP. Stability classes E and F refer to stable and very stable conditions respectively, for example due to a temperature inversion under which vertical mixing of the air is suppressed. These conditions are associated with poor emission dispersion and occur about 35 percent of the time near the STP.

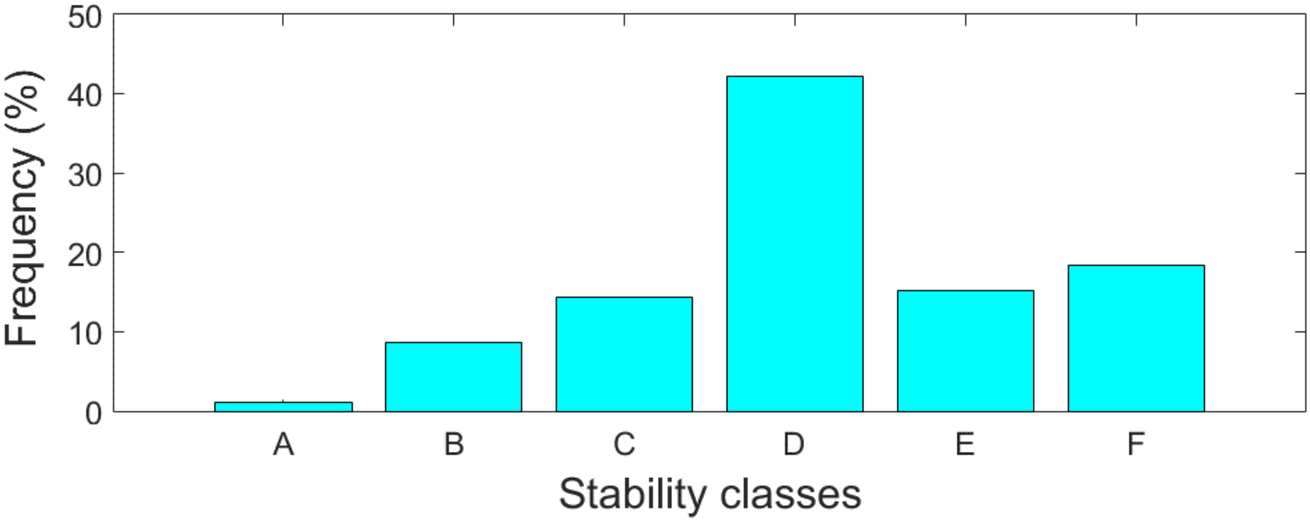

Figure 4. Frequency distribution of 2013 stability classes predicted at the STP by TAPM.

6. Odour emission rates and source representation

Aeration lagoon

The Assured Monitoring Group (AMG) was engaged to carry out odour sampling of the STP's lagoons. The aeration lagoon was the only source of detectable odour, mainly near the small inlet works located at the SW corner of the lagoon. The inflow to the STP was intermittent.

The aeration lagoon was sampled near the inlet works in the SW part of the lagoon; near the outflow to the first of the secondary lagoons in the NW part of the lagoon; and about halfway between these two points. As can be seen in Figure 5, conditions were calm, and the flux hood measurements were high quality.

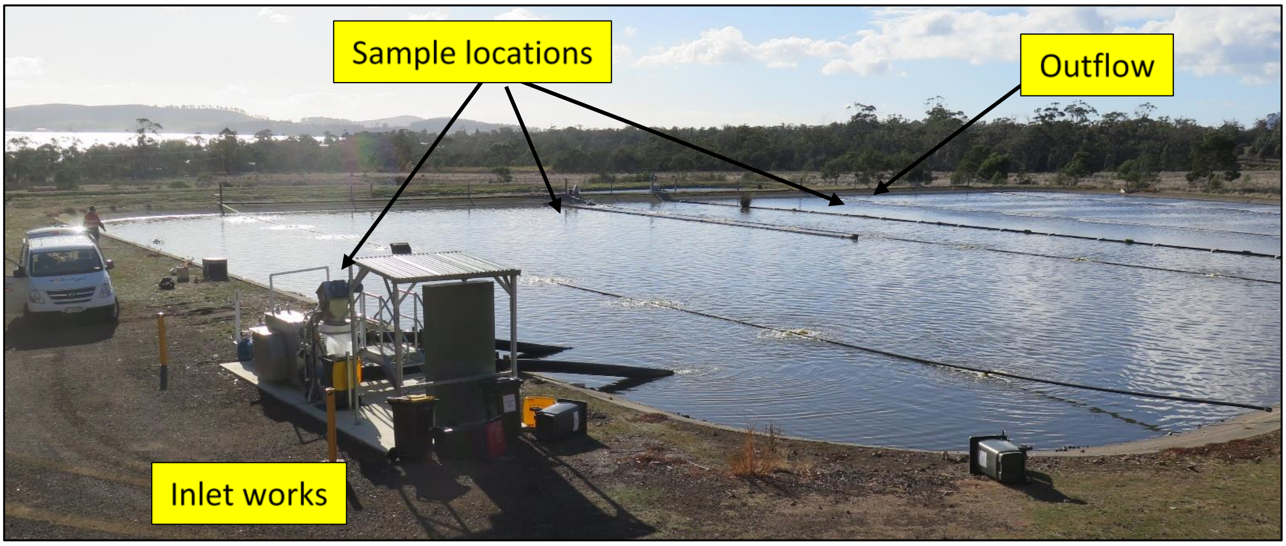

Figure 5. The STP's inlet works and aeration lagoon, showing odour sampling locations.

The measured specific odour emission rates (SOERs) were 0.42 OUV/s per m^2 near the inlet works, 0.20 OUV/s per m^2 near the lagoon outflow, and 0.37 OUV/s per m^2 halfway between these two locations.

These measured SOERs accord with expectations. The Honeywood STP near Brighton is similar to the Orford STP, and a 2012 study estimated SOERs of 0.32 OUV/s per m^2 for its aeration lagoon, using the Sydney Water Corporation's STP odour emission database, in consultation with the database specialist, Rod MacKenzie. To be conservative, this study assumes an SOER of 0.42 OUV/s per m^2 for the aeration lagoon.

Secondary lagoons

No odour was detectable around the three secondary lagoons. The SOERs for the secondary lagoons were not measured because it is conservative to assume all three lagoons have an SOER of 0.20 OUV/s per m^2, in other words the SOER of the aeration lagoon near its outflow. This SOER is conservative. An SOER of 0.12 OUV/s per m^2 was estimated for the secondary lagoons of the Honeywood STP, obtained from the Sydney Water Corporation's WWTP odour emission database, in consultation with the database specialist, Rod MacKenzie. And the SOER of the secondary ponds of the Macquarie Point STP was recently (2017) measured to be 0.16 OUV/s per m^2

Inlet works

The inlet works is only a minor source of odour compared to the total OER of the aeration lagoon. This study conservatively assumes an OER of 100 OUV/s, higher than the 5 OUV/s used by the Honeywood STP study.

Source representation

The inlet works can be modelled either as a small volume source or as a low-level point source with a small discharge. The distance of prediction interest is several hundred meters, so GLCs depend mainly on the OER of the source, not its geometry. This study models the inlet works as a low-level point source.

The lagoons are modelled as area sources, represented by rectangles aligned north-south and east-west. The Orford STP's lagoons are already close to this alignment and this study uses a single rectangular area to represent each lagoon.

Tables 2 and 3 give the source details.

Height (m)	Diam (mm)	Speed (m/s)	Temp (°C)
1	1,000	0.1	15
Easting (m)	**Northing (m)**	**OER (OUV/s)**	
572959	5286104	100	

Table 2. Inlet works representation.

	Easting (m)	Northing (m)	Size
Aeration lagoon	572967	5286069	96m x 60m
South secondary lagoon	573000	5286137	95m x 29m
Middle secondary lagoon	572014	5286179	94m x 31m
North secondary lagoon	573029	5286221	88m x 30m
	SOER (OUV/s/m^2)	**Area (m^2)**	**OER (OUV/s)**
Aeration lagoon	0.42	5,722	2,403
South secondary lagoon	0.20	2,718	544
Middle secondary lagoon	0.20	2,900	580
North secondary lagoon	0.20	2,623	525

Table 3. Lagoon representation. The eastings and northings are of the SW corner of the lagoon.

7. Odour GLC predictions

Odour GLCs were predicted across a grid with 31 east-west points x 31 north-south points, a grid spacing of 30m and the GDA 94 coordinates of the south-west corner of the grid were {572,690m E, 5,286,159m N}.

As noted, the *Tasmanian Environment Protection Policy (Air Quality) 2004* specifies that the maximum odour GLC predictions should be used to assess compliance with the design GLC of 2 OU (1 hour), unless good site-specific meteorology and odour emission rates are available, in which case the 99.5 percentile GLC predictions can be used to assess compliance. In this case, good input data are indeed available, but both sets of GLC predictions are presented for the sake of completeness.

Figure 6 presents the maximum odour GLC (1 hour) predictions, and Figure 7 presents the 99.5 percentile odour GLC (predictions.

The design GLC of 2 OU (1 hour) is met everywhere on and beyond the boundary of the STP, which is where ambient air quality standards apply. Considering the proposed subdivision, the highest predicted GLCs are naturally along its Rheban Road boundary, with the highest maximum GLCs predicted to be 0.13 OU (1 hour) and the highest 99.5 percentile GLCs predicted to be just under 0.1 OU (1 hour).

Some jurisdictions (e.g. South Australia and Victoria) set odour design GLCs that have a three (3) minute averaging period. Odour concentrations fluctuate over an hour, and a GLC of 1 OU (1 hour) approximately equates to a GLC of 2 OU (3 minutes). Applied to the Orford STP, the highest maximum GLCs for a 3-minute averaging period are therefore predicted to be about 0.26 OU (3 minutes). The importance of this calculation is that the highest predicted odour concentration on the Rheban Road boundary of the proposed subdivision is less than 1 OU over a very short averaging period (3 minutes). Since 1 OU is the threshold of odour detection by humans, the modelling exercise is predicting that odour from the Orford STP will never be detected by residents of the subdivision. Moreover, this conclusion is supported by a factor of safety of nearly four (4) since $1/0.26 \approx 4$.

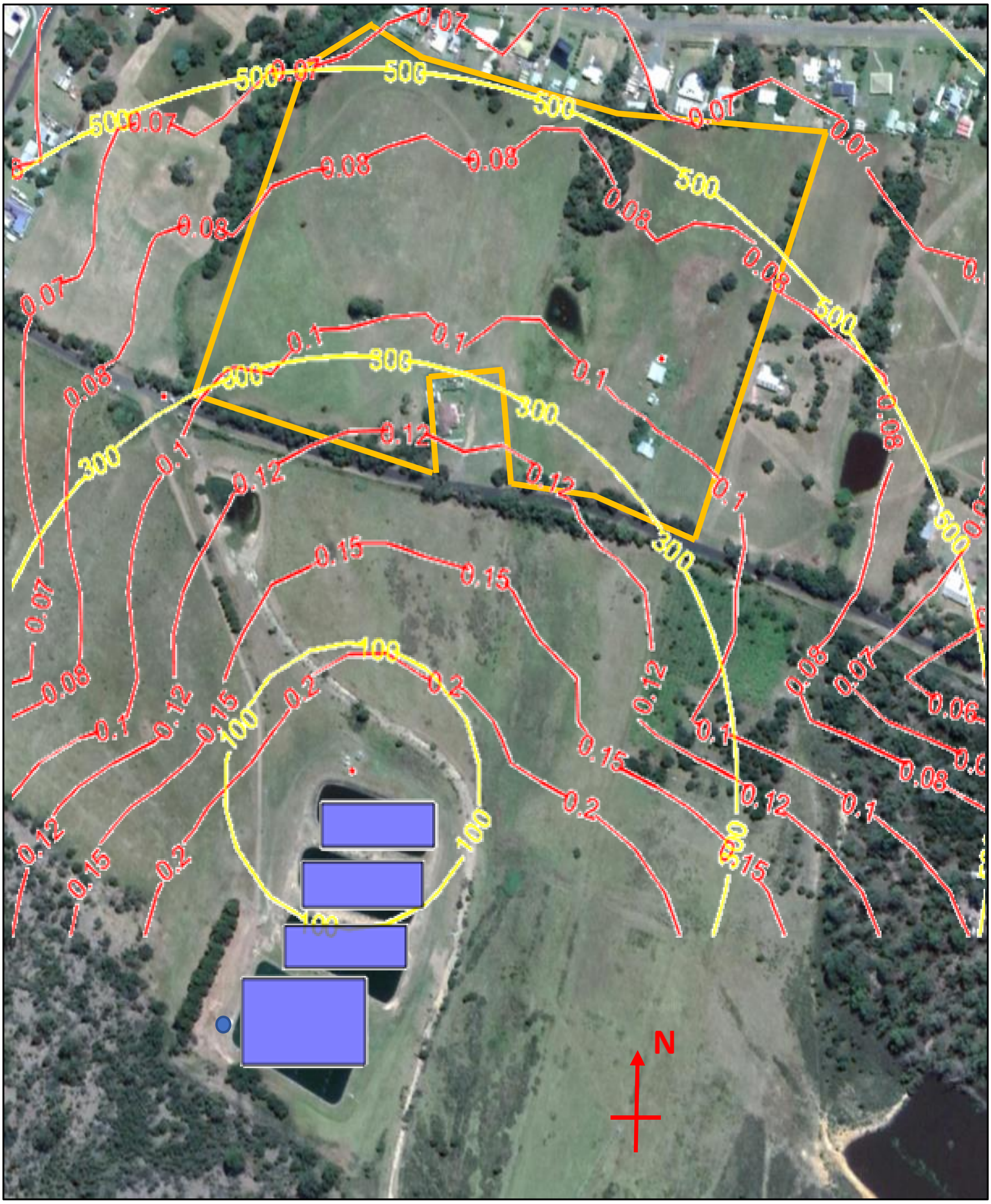

Figure 6. Maximum GLC (1 h) predictions (OU). Contours at {0.07, 0.08, 0.10, 0.12, 0.15, 0.2} OU. The yellow circles show distances (m) from the north side of the northern secondary lagoon.

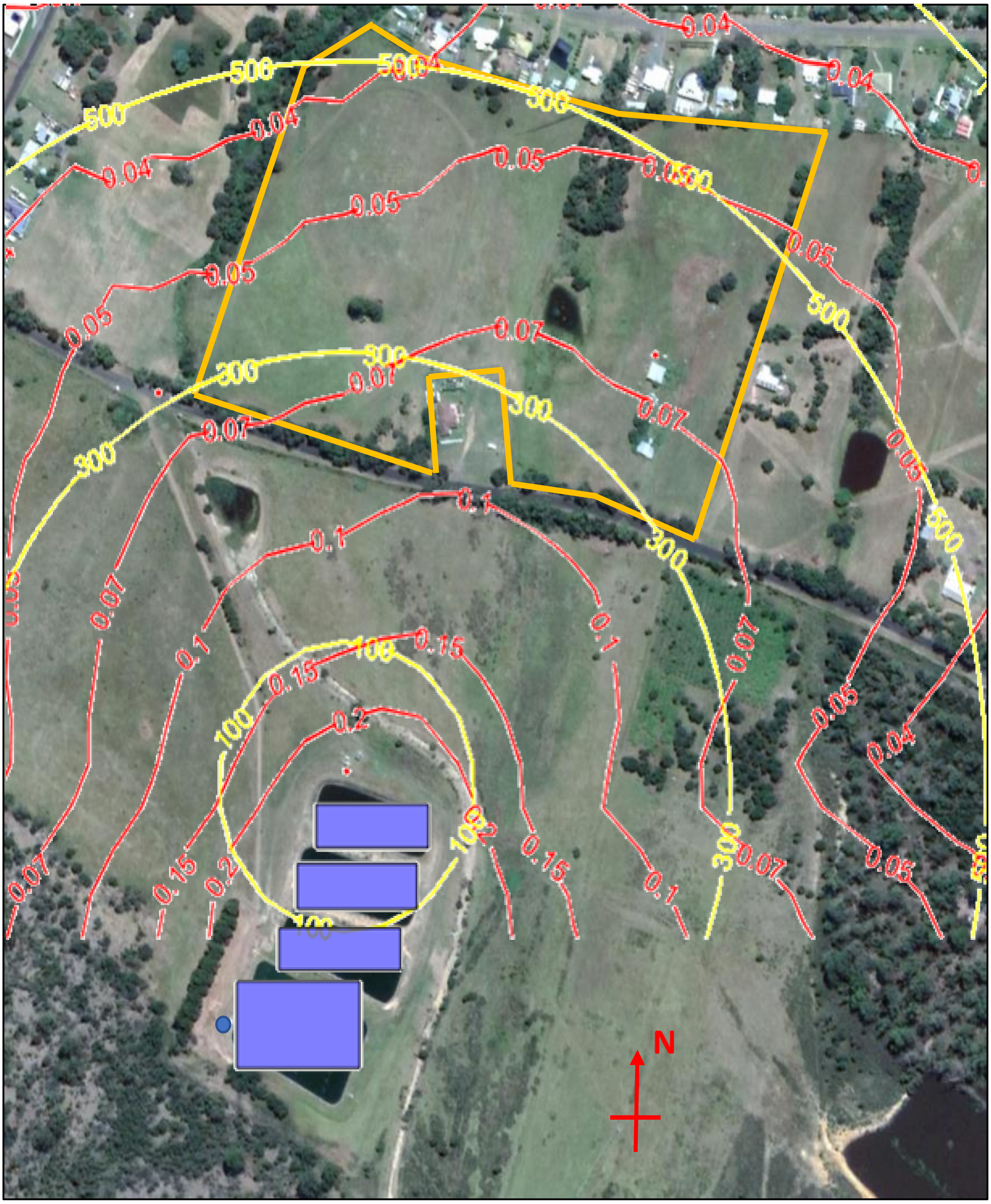

Figure 7. 99.5 percentile GLC (1 h) predictions (OU). Contours at {0.04, 0.05, 0.07, 0.10, 0.15, 0.2} OU. The yellow circles show distances (m) from the north side of the northern secondary lagoon.

8. Conclusions

The Orford STP has a current average daily flow of 179 kL/day and a design capacity of 473 kL/day. The Glamorgan Spring Bay interim planning scheme 2015 specifies an attenuation distance of 350m for an STP with a design capacity between 275 kL/day and 1,375 kL/day. Therefore, although the Orford STP triggers this clause, its design capacity is at the low end of the range and its current average daily low is only 40% of the low end of the range.

The attenuation distance is required to be measured from the nearest boundary of the nearest lagoon. In the direction of the proposed subdivision this point is the north side of the third secondary lagoon. None of the secondary lagoons have detectable odour and the north side of the aeration lagoon is 100m further from the proposed subdivision.

The odour impact assessment presented in this report follows the methodology expected by the *Tasmanian Environment Protection Policy (Air Quality) 2004*. Odour emission rates for the lagoons were obtained by flux hood measurements made under calm conditions, and these odour emission rates are both consistent and conservative when compared to those measured or estimated for similar STPs operated by TasWater.

The wind predictions are supportive of the location of the proposed subdivision. A southerly wind is required for odour from the STP to impact the proposed subdivision and the annual wind rose shows that a southerly wind is rare (due mainly to terrain blocking/channeling).

The maximum odour GLC predictions at the Rheban Road boundary of the proposed subdivision are well below the 2 OU (1 hour) design GLC. They are also well below an odour concentration of 1 OU (3 minutes), which means the model is predicting that odour from the STP will never be detected by residents of the subdivision. A factor of safety of four (4) applies to this statement.

This study has not considered upset conditions because there is little that can go wrong with the Orford STP and the STP does not accept trade waste.

Yours sincerely,

Steven JB Carter

Dr Steve Carter, FIEAust, CPEng
Environmental Engineer

Addendum: Response to comments by TasWater

TasWater comments

Please provide additional reassurance as to the accuracy of the model, the following should be provided and discussed within the report:

- *Local BoM station wind roses and the comparison to the TAPM generated wind roses*
- *Discussion of any odour complaint information / correlation associated with the plant (TasWater can provide on request)*
- *Analysis of the maintenance condition (desludging) using increased SOERs (to values typical of sludge lagoons)*

Responses

1. Model accuracy.

TAPM has been applied on numerous studies of WWTPs operated by TasWater, so it is a model that TasWater is very familiar with. As mentioned in Section 4, TasWater is also familiar with the recent odour assessment of the Macquarie Point WWTP which was subject to extensive peer review and cross-checks. TasWater contact people are Nigel Vivian, David Graham and Mike Brewster. The cross-checks included running the Calmet and Calpuff models. The wind predictions of TAPM and Calmet were very similar, and in agreement with data from the Ellerslie Road weather station. The odour GLC predictions of TAPM and Calpuff were also found to be very similar.

For the Orford WWTP modelling exercise, there isn't a weather station on the innermost wind prediction grid that has hourly wind speed and direction data, so wind predictions can't be compared to weather station observations on this project. But in addition to the Macquarie Point WWTP project I have used TAPM on many projects where comparison with weather station data was possible and also several projects where comparison with field GLC measurements was possible. The EPA was closely involved in one of these projects, for Cement Australia at Railton. Agreement between measured and predicted wind and contaminant ground level concentrations was good, including at a location 2 km from the plant.

Simpler models such as Ausplume and Aermod would also provide reasonably accurate predictions for this situation, given the situation is very straightforward with no buildings or complex terrain. However, TAPM (or Calmet) needed to be used to produce the site-specific winds and once those winds were available it doesn't make sense to switch to a simpler model.

2. Odour complaints.

The Spring Bay Glamorgan Council (Ms Jill D., pers. Comm.) has advised that they have never received a complaint of odour nuisance from the Orford WWTP. This is not surprising. The WWTP has a very small odour footprint.

2. Desludging odour emissions.

The concern about possible elevated odour emissions from desludging is valid and odour impact assessments often do need to consider such upset conditions.

However, desludging of the Orford WWTP is an infrequent and short term operation. The odour emission rate (OER) will depend on the method TasWater uses to desludge the lagoon(s), but desludging is not necessarily associated with unduly high odour emissions. For example, desludging using an excavator with subsequent dewatering can produce elevated odour emissions compared to desludging using a vacuum tanker.

The odour GLC predictions presented in this report were based on conservative and credible OERs and the maximum GLCs at the road were predicted to be about 0.13 OU (1 hour) during normal WWTP operation. The design GLC is 2 OU (1 hour) so the OER from a desludging operation can be about 15 times higher than the OERs used for the modelling exercise before the maximum GLCs are comparable to the design GLC, an SOER of about 6 OU/m^2 per second. That's an extremely high odour emission rate, almost certainly higher than a desludging SOER.

The other factor that means pond desludging should not be an issue for this WWTP is that the wind hardly ever blows towards the location of the proposed sub-division, so it should be easy to schedule desludging for a day when the wind is favourable.