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30 April 2005

Mr Peter Moore
General Manager Planning and Infrastructure
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Dear Mr Moore

As requested, Consulting Environmental Engineers (CEE) is pleased to provide this report on the findings and implications of the CSIRO reports into air ponding at the proposed Site B for the Alkimos wastewater treatment plant.

1. Background to Alkimos Wastewater Treatment Plant

The Water Corporation plans to establish a major new wastewater treatment plant at Alkimos, 30 km north of Perth, to serve an ultimate population of 640,000 persons in the northern suburbs of Perth as the metropolitan area expands along the coast.

The sites for the Alkimos plant that have been examined in detail include:

- Site A, near the coast, where the plant would be located on the existing land surface at elevation RL 6 m; and
- Site B, about 1.4 km inland, where the plant would be located in a 20 m deep basin excavated within existing sand dunes. The current development plan for Alkimos shows an embankment of fill along the west side of the basin, to provide a platform for residential sites overlooking the ocean.

In 2001, CEE carried out an initial odour dispersion study of the future plant. Using winds recorded at other sites in Perth, it was concluded that an odour buffer zone of at least 450 m width would be required, and up to 600 m width in some directions, depending on local wind patterns and the topography.

Recognizing the need for onsite data, the Water Corporation instigated an extensive meteorological monitoring program at Alkimos with measurement of winds, solar radiation and ambient temperature over a three year period from March 2002.

2. Results of Previous Odour Modelling

In 2003, CEE carried out a second odour dispersion study using the wind and other meteorological data measured on the site, and an updated arrangement of the proposed treatment processes. The scope of work involved the following tasks:

1. Develop estimates of odour emissions based on the ultimate layout of the future Alkimos treatment plant as supplied by the Corporation;
2. Examine on-site wind and meteorological measurements made for the Corporation and develop parameters suitable for odour modelling;
3. Undertake *Ausplume* modelling of odour from the 160 ML/d ultimate plant and agreed odour emission rates to predict odour contours using on-site wind files;
4. Advise on the location of odour sources to minimise the buffer area; and
5. Advise on the location and size of the buffer zone, and related issues on the plant arrangement and buffer zone requirements.

The Alkimos plant will incorporate best practice odour control with extensive covers over all tanks to capture and treat odours. The odours will be treated in scrubbing systems and the treated gases released via 50 m high stacks (the same height as at the Beenyup treatment plant).

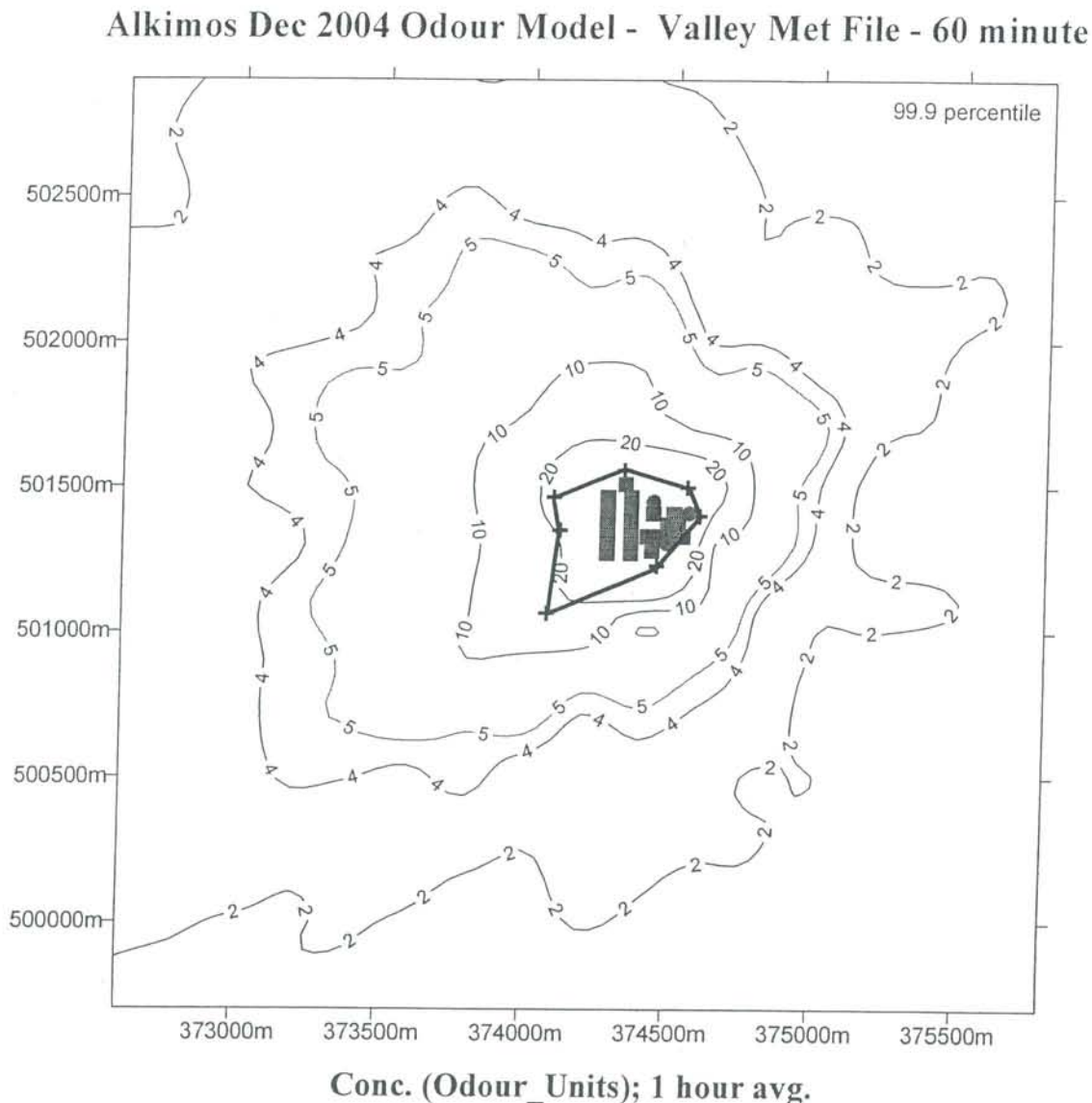
The predicted odour emission rates for the various treatment units under the assumed stringent degree of odour control are based on an assessment of measured emissions from similar process units at other treatment plants, allowing for the odorous nature of the incoming sewage. It should be noted that the emissions represent the sum of residual odour leakage from the covered tanks as a result of minor leaks, pressure variations under the covers due to wind effects, inspections to enable plant operations, and maintenance activities (when sections of the cover have to be removed).

The predicted total odour emission at ground level is 27,000 OU/s (odour units per second). This represents a very high level of odour containment and control, and is below the odour emission from Beenyup or Subiaco treatment plants, which are considered plants with national best practice odour control.

Figure 1 (on the following page) shows the predicted odour contours using the winds measured at 10 m above the floor of the existing basin at Alkimos. The rectangles in the figure depict the location of treatment units; the irregular shape around them is the treatment plant boundary. Various contours are shown; the 5 odour unit (OU) contour (shown in red) represents the "distinct" odour level and is the Corporation's preferred measure of odour impact.

It can be seen that for the "valley" meteorological file, the 5 OU contour is approximately 750 m to the west and north of the boundary of the plant. Using the "hill" meteorological file, the 5 OU contour is closer to the plant site.

Figure 1. Predicted Odour Contours in 2003 Using On-site Meteorological Data



CEE concluded in December 2003 that:

"Taking all factors into account, and recognising the uncertainty in conditions, it is our considered view that a nominal buffer zone of 600 m distance from the plant boundary should be provided for the future Alkimos WWTP, with a smaller distance to the south. In the interests of efficient land use, the Corporation must aim to minimise the size of the buffer, by using world class odour management technology. Land use planning must recognise that a reasonable buffer zone is essential, and should provide compatible uses in the buffer zone around the treatment plant, particularly uses requiring reclaimed water."

The significant difference in wind speeds and temperatures between the hill and the valley measurements showed that an almost stagnant layer of air formed inside the existing basin at Alkimos on cold nights with low wind speeds. CEE considered that the incidence of stagnation would increase if the basin was deepened (as planned) to locate the top of the treatment units at elevation RL 11 m (about 15 m below the surrounding sand dunes).

3. Ponding Process

The CSIRO was engaged to study the potential odour risk at Alkimos as a result of "ponding". They studied the process of ponding using on-site meteorological measurements and identified the conditions that cause ponding. Essentially, ponding occurs on cold nights with low wind speeds so that the layer of air within the basin becomes colder than the air flowing across the top of the basin. This creates a stable temperature inversion across the top of the basin, between the cold (more dense) air in the basin and the warmer, faster-moving air aloft. As a result, turbulent mixing decreases and the air in the basin exchanges less effectively with the air flowing past.

The CSIRO concluded that ponding occurred when the following three conditions were satisfied:

1. The wind speed in the basin was one-third of the wind speed outside the basin;
2. The air temperature in the basin was at least 2 degrees lower than outside the basin; and
3. The wind speed outside the basin was low, generally less than 2 m/s.

The air then becomes trapped in the basin. This situation is termed "ponding". The diffuse odours released from the treatment units in the basin accumulate within the basin, leading to high odour concentrations in the air within the basin. While the concentration of odour builds up in the air within the basin, there are low emissions of odour from the edge of the basin and hence better odour conditions downwind.

After a period an equilibrium situation is reached where the loss of odour due to entrainment of a thin layer of air (with a high concentration of odour) at the inversion level equals the rate of release of odour from the plant.

When the wind speed increases (which can occur for short periods during the night or in the morning), a deeper layer of air is entrained, removing a volume of air with a high odour concentration. As this volume of air disperses, it causes a sudden increase in the odour concentration downwind of the plant.

4. Incidence of Ponding at Alkimos

The first (April 2004) CSIRO report examined the incidence of ponding at Alkimos in the meteorological records from March to December 2002. Using the criteria for ponding listed above, 35 ponding events lasting 2 hours or more were identified (mostly occurring in the winter months). Three of the events lasted for 10 hours or more (these reflect nights with prolonged low speed winds).

The release of odour occurs when there is an increase in the wind speed across the basin. Usually these increases occur over short periods, when the wind speed increases to more than 2 m/s (and often to more than 4 m/s).

From the CSIRO analysis, it is apparent that ponding is a concern for a treatment plant in an excavated basin. The ponding problem will be increased by deepening the basin, which increases the sheltering of air in the basin from the overlying winds.

5. Ponding Model by CSIRO

CSIRO assumed the pond volume to be 1,000,000 m³ of air and the typical leakage (or entrainment from the top surface of the pond) to be 1,000 m³/s. For these parameters, the peak concentration within the pond rises to 27 OU over a period of about 30 minutes.

However for a small number of ponding events the inversion stratification can become very strong, so the entrainment rates decreases and the peak odour concentration can rise (theoretically, in the event of prolonged low speed winds) to about 100 OU. Calculations in the first CSIRO report show there are 5 ponding events with peak odour concentrations exceeding 20 OU.

The CSIRO model of ponding has two components:

1. An accumulation of odour within the pond under the inversion layer; and
2. A sudden release of odour from the pond due to an increase in wind speed;

A total of 13 ponding events are examined in the second (February 2005) CSIRO report. In the report, a model is developed which predicts the increase in odour concentration within the pond (in OU), the emission rate from the pond (in OU.m³/s) and the odour concentration at various distances downwind of the pond.

The results show that for 150 ten-minute ponding events (a total of 25 hours in the 10-month period of data examined) the odour concentration in the pond exceeds 20 OU. The peak concentration is very similar if 60-minute averages are considered (although the number of events is reduced six-fold).

The odour emission rate exceeds 40,000 OU.m³/s (a 50 per cent increase above the normal rate of 27,000 OU.m³/s) in only two events.

The downwind concentration depends on the odour concentration at release and the rate of subsequent mixing as the volume of air travels downwind. For comparison, CSIRO calculated the downwind concentrations for a baseline case - that is a continuous odour release without ponding. The results show that for at least 30 hours per year, the predicted odour concentrations after ponding are three times the odour concentrations without ponding. The reason for the large amplification is that the emission from the pond comprises a shallow layer of air with a high odour concentration.

In summary, the CSIRO results show that ponding will result in a substantial odour impact downwind of the plant site at night (generally to the west, northwest and southwest of the site).

6. Further Information

The CSIRO study assumed a relatively low rate of leakage from the pond at Alkimos based on the entrainment over the top surface of the pond. This is a conservative assumption and may apply if the embankment of fill along the west side of the basin extends around the whole of the western side. Alternatively, if there is some irregularity in the height of the surrounding dunes and embankment, for example, to provide road access) then there may be a greater rate of leakage. This would mean that the equilibrium concentration was less, and that the peak downwind odour levels would be correspondingly lower.

It also is of interest to note that at 500 m downwind, the peak odour level predicted with ponding is 39 OU, which is 1.5 times the peak odour level predicted without ponding of 26 OU.

Air quality measurements (of CO or NO_x) made in natural creek valleys that experience ponding show only a 10 to 20 per cent increase in concentrations (1-hour averages) over adjacent areas without ponding.

The key issue is the increase in peak concentration with ponding to that predicted without ponding. At 500 m west of the plant, the predicted 99.9 percentile 1-hour average concentration is 8 OU (see Figure 1). The comparable 99.9 percentile peak concentration with ponding is 13 OU. This indicates a peak odour level predicted with ponding of 1.6 times the peak odour level without ponding.

Taking all factors into account, and recognising the uncertainty in conditions, it is our view that there will be a 40 per cent increase in odour level due to ponding. Hence the buffer zone to the west and north-west of the plant should be extended to 800 m width.

7. Conclusion

The major findings of the study of ponding at Alkimos are (1) that there is a high risk and significant consequence of ponding at Alkimos Site B; (2) excavation to deepen the basin for the plant will increase the number of ponding events; (3) ponding increases the peak odour concentrations downwind of the basin, over relatively short time intervals; and (4) there is no simple engineering solution to the ponding problem.

In summary, it is considered that ponding:

1. Will lead to a 40 per cent increase in odour levels downwind of a treatment plant built within a deep basin, and
2. Site B will require a 800 m wide buffer zone to the west and north-west of the plant.

Yours sincerely



Dr Ian Wallis

Possible Wastewater Treatment Plant Sites

