Expert Review of “Munmorah Power Station Rehabilitation Project Review of Elevated Sulfur Dioxide Emissions” Report

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Final Report for Aurecon Australia Pty. Ltd.

19 February 2010

1 Introduction

As part of the assessment for the Munmorah Power Station Rehabilitation project, potential air quality impacts were predicted using CSIRO's air pollution model TAPM Version 3 (Aurecon, 2009). Hourly ground-level concentrations (glc) of SO_2 were predicted across the Central Coast region for each hour of the year 2004. On two occasions, the highest predicted SO_2 glc in the modelled domain exceeded the relevant assessment criterion, for one hour in an area of sensitive receptors and once in an area of non-sensitive receptors. The aim of The Report by Malfroy Environmental Strategies, reviewed in this document, is to compare actual conditions in the boundary layer on the two days of predicted elevated concentrations with TAPM predicted meteorology, in order to assess the validity and likelihood of the predicted elevated concentrations occurring in reality

The Report performs this task by closely examining observations and model simulation results for the two days in question and carrying out an analysis of the model's performance. The author makes good use of a previous report analysing the capabilities of three models, including TAPM, for simulating dispersion from tall stacks in the Central Coast region (Lilley et al., 2007).

2 Assessment

In the following section, consideration is given to those points raised in Aurecon's commissioning letter.

2.1 Used appropriate data (observational and modelled)

Early morning and afternoon wind and temperature profile data from Williamtown (60 km north of Munmorah) and Mascot (90 km south of Munmorah) were obtained from the Bureau of Meteorology. While not ideal (due to the distance of these stations from the area of interest), the author has made the most of these data sets in his analysis.

Data from Delta Electricity surface sites in the Central Coast region were also obtained and were useful in determining the presence of a sea breeze at the time of the predicted high concentrations.

I am not aware of any other data that could have been used in the analysis for the Report.

2.2 Used observational data to accurately describe conditions in the lower atmosphere on the days in question

Data from Williamtown and Mascot make useful, though limited, contributions to the analysis, due to their considerable distance from Munmorah. Comparison of simultaneous profiles from each site reveals differences, though not large, that illustrate the changing nature of the winds with distance, and caution against too much detailed extrapolation to conditions at Munmorah.

On both days, the surface anemometers in the vicinity of Munmorah reveal very light and variable winds prior to the late-morning arrival of the sea breeze. However there is no indication in either the Mascot or Williamtown data of such weak winds at higher levels including at the plume height of 300m, as predicted by TAPM, and which the author correctly asserts are a key contributor to the high ground-level concentrations predicted near Munmorah.

I believe that the author has made optimal use of the observations in describing the meteorological and dispersion conditions on the two days under consideration, and has been able to make good use of them in his analysis.

2.3 Used TAPM modelled data to accurately describe predictions in the lower atmosphere on the days in question

TAPM modelled data employed for both days included vertical profiles of wind speed, wind direction, temperature, potential temperature, turbulence kinetic energy and relative humidity at three different times of day. The profile times were chosen to mostly coincide with the Williamtown and Mascot profiles, although TAPM profiles from these locations could also have been shown for a better comparison of model against observations. As it is, the TAPM profiles in The Report are for Munmorah and serve the purpose of illustrating well the meteorological and dispersion conditions predicted for each day.

Vertical SO_2 concentration profiles confirm that downward fumigation of the plume is responsible for the maximum ground-level concentrations and show that prior to mixing down the plume was centred about 300m and 400m above the ground on the two days. While there could have been further comparisons of the model results with observations (e.g. time series of surface winds), the key points have been identified, i.e. the underestimate by TAPM of wind speeds in the boundary layer prior to fumigation, the very little shear in these winds, and the existence of convective mixing and hence plume fumigation on both days.

2.4 Accurately used data and conclusions from other reports referenced, particularly in reference to the so-called meteorological parameters

The modelled meteorological dispersion conditions for the two days (very light winds in the lower atmosphere, late-morning fumigation of the plume by a growing mixed layer, very little dispersion of the plume prior to mixing down, and a sea breeze) are the same as those identified for other high-concentration days in a previous study for the Central Coast region in which meteorology and dispersion for 8 years were modelled (Lilley et al. 2007). As part of that work, three days on which high concentrations of SO_2 exceeded the assessment criterion were studied in detail, and the author of the Report under review has referred to this 2007 report and used its main findings in his analysis. Its key conclusion was that TAPM very occasionally predicts situations in which winds after sunrise at plume height and below are very light (less than 1 m s^{-1}). Over a period of a couple of hours or so, this leads to highly-concentrated and barely-dispersed emissions near the emitter in the stable layer above the growing mixed layer. When the latter reaches the plume, it is quickly fumigated to the ground in concentrated form. Emitters with relatively-low plume-rise height (and/or large emission rates) are more susceptible to producing these large concentrations. The analysis by Lilley et al (2007) found that while the conditions and parameter values predicted by TAPM were all physically plausible, such high concentrations had never been observed by Central Coast monitors, and no meteorological wind profiles had been measured in the immediate region that could be used for validation.

I know of no other work that could be referenced.

2.5 Presented discussion points clearly and used data appropriately in presenting the discussion

While the discussion points in Section 6 are good and lead to the correct conclusion that the TAPM ground-level concentrations on these days are highly likely to be an overestimate of the actual concentrations, I have a few comments on this section of the paper.

Shear

Although there will be some impact, I think that the wind shear factor does not play a very large part, compared to the very light wind factor, and especially in such light winds. There are no morning sea-breeze data at Williamtown or Mascot to calculate shear and compare to TAPM at the time of fumigation, and my calculations of directional shear on 31 March 2004 in the afternoon sea breeze, though not really relevant, show that there is little difference in

the shear values between the surface and the height at which the wind turns northerly for TAPM, Mascot and Williamtown. On 28 January 2004, there are no observational data between the surface and 600m.

Mixing height

I think that the author wants to make the point here that because the Munmorah plume is not a particularly buoyant plume, its final-rise height is moderately low (300m on 28 January and 400m on 31 March according to TAPM in Figs. 8 and 15) and this leads to a higher concentration when fumigated than if it was more buoyant and levelled out at a higher elevation. However the author seems to be arguing that it is low-mixing heights that lead to high glcs, whereas it is plume height, not mixing height that is the relevant factor. It just needs a bit of re-wording. Even if the mixing height in reality reached 600m by midday, this just means that the fumigation occurred earlier, when the mixing height reached 300m and 400m respectively for the two days, with the same glc result, all other things being equal.

Convection

Even if TAPM's convection was stronger than observed, I do not think that it would affect fumigation concentrations, for the same reason advanced in the previous paragraph, i.e. the plume may have been reached earlier by the growing mixed layer, but the plume would still have been mixed over the same depth. Stronger convection may even lead to slightly lower concentrations because the mixed layer would be growing faster and over an hour the plume would be mixed over a greater depth.

2.6 Presented conclusions which are based on the data presented

There are six conclusions in Section 7. I believe that these all follow from the data and analysis presented in earlier sections of The Report. However in dot point 2, I would say that TAPM performed 'barely satisfactorily' rather than 'well'. This is because in all probability it under-predicted the morning wind strength, which had the consequence of predicting ground-level concentrations that exceeded the assessment criterion. As pointed out by the author in Section 6, at such very low wind speeds it only needs an increase of 0.5 m s^{-1} to bring about a sizeable decrease in the concentration.

2.7 Presented conclusions which are robust, defensible and transparent

The essential conclusion of The Report is that the boundary-layer morning winds on the two days were extremely unlikely to have been as light as those predicted by TAPM in the Munmorah region, and therefore the actual concentrations on those days would have been lower. It is not possible to say by how much, but more realistic wind speeds would lead to concentrations lower than the assessment standard. I believe that the conclusions are robust, defensible and transparent, including the probability of occurrence estimate.

3 Summary

The Report by Malfroy Environmental Strategies is based on solid data and science, with conclusions that follow logically and are robust. There is no discussion in this expert review that affects the conclusions reached by the author of The Report.

4 References

Aurecon Australia Pty Ltd (2009) *Munmorah Rehabilitation. Updated Air Quality Assessment*, Attachments B and C. Reference 41442. Report prepared for Delta Electricity

Lilley W., Rae M., Malfroy H., Physick W., Borgas M., Edwards M. (2007) *Ambient Air Modelling Study for Power Stations in the Central Coast and Western Coalfields Regions of NSW*. CSIRO ET/IR 912. Prepared for Delta Electricity.