

**Review by
Dr David Provis**

of

**“Inadequacies in the Hydrodynamic Modelling performed for Gunns Pulp
Mill IIS”**

by Dr Stuart Godfrey

Dr Godfrey presents mechanisms which he claims are not included in the hydrodynamic modelling presented by Gunns Ltd, the GHD modelling work, and which cause Gunns Ltd's modelling results to be seriously flawed.

His major concerns are whether there are mechanisms which have been overlooked in the work presented by GHD and whether high concentrations of specific contaminants from the discharge could occur beyond the 500 m mixing zone. According to the dilutions specified in table 2 of GHD report “Addendum for Bell Bay Pulp Mill IIS Additional Modelling Works Report 2 January 2007”, a dilution of about 700 is required for the concentrations of all the contaminants in the effluent to fall below critical levels. This review does not comment on whether or not specific contaminant concentrations are environmentally acceptable, only on whether the required dilutions are likely to occur, given the design effluent discharge parameters.

In order to assess the significance of the mechanisms for effluent transport proposed by Godfrey, some check calculations have been made. The aim of these calculations has been to understand the dilution which occurs due to the discharge of mill effluent from the seabed diffuser, and subsequent development of the plume (often termed the near field dilution), without including any significant mixing due to wind or tidal currents. A small amount of mixing due to these latter processes is included as mentioned below. The aim has been to assess what the initial dilution of the effluent might be before the processes described by Godfrey influence the transport and dispersion of the effluent in the upper water-column.

As a check on the outfall characteristics, the author used the program CORMIX, used by the US EPA for regulatory procedures, to examine the mixing in the near field of the outfall diffuser. This model has been verified at the Belmont ocean outfall in NSW using salinity as a tracer and found to be conservative. (This program is similar in principle to Visual Plumes which was used by GHD). The input parameters were based on table R1 in Ross Fryar's expert witness statement.

The mixing process for effluent discharged through a multiport diffuser, as proposed by Gunns Ltd, undergoes a number of stages. The first stage is dominated by the momentum of the discharge flowing under pressure out through the nozzles of the diffuser. This results in turbulent jets and mixing with the receiving seawater. Since the discharged effluent is less dense than the receiving water, the initially-mixed effluent then rises towards the surface as a buoyant plume and undergoes further mixing. By the time it reaches the surface, it has been diluted by a factor of about 100. The plume still has a density below that of the receiving water and further spreading takes place as buoyancy drives the plume to spread

horizontally with additional dilution. This initial dilution depends upon water depth, discharge characteristics, the ambient current speed and the density difference.

For the purposes of this basic checking analysis, the near field computations assumed an ambient current speed of 0.05 m/s. This is less than the median tidal current speed (based on current speed measurements at and near the site), but provides a guide as to the plume behaviour in a low-current situation. With this steady current, it takes the discharged material 2.78 hours to travel the 500 m to the edge of the nominated mixing zone. During this time, the plume spreads under action of buoyancy. At a distance of 500 m downstream, it has undergone a dilution of 460 at the plume centerline. Adopting the common assumption of Gaussian form for the plume, this corresponds to a dilution of about 840 when averaged over the plume cross-section. (The methodology used by GHD to define the mixing zone uses dilutions averaged over the grid cells with a horizontal dimension of 50 m).

The mixing considered in the discussion so far does not depend on ambient conditions, although the presence of a stratified surface-layer, for example due to surface heating or freshwater from the Tamar River, may have some small effect on the buoyancy-driven spreading, but not a major impact. The modelling used a wind speed of 2 m/s (about 4 knots), which is the value recommended for low-wind conditions, and a low tidal-current speed. There are a number of mechanisms which can provide additional mixing. The first is tidal mixing and transport, which is not included in Godfrey's computations, but which will always be present and will mix both vertically and horizontally. The second is wind-induced vertical mixing. This will be directly related to the distance the surface layer travels under action of wind in a given time. Godfrey shows a time series of mixed-layer depths from his model as well as a series of travel paths, but does not provide a relation between the two. It is reasonable to assume that the longer paths are associated with stronger winds and thus the deeper mixed-layers. The deeper mixed-layers will be associated with further dilution.

Note that Godfrey does not appear to acknowledge mixing and the issues of acceptable contaminant concentrations in terms of national and state water quality guidelines. Moreover, where he discusses the onshore transport of the plume, see Godfrey figures 2 and 5, he does not consider the effects of tidal currents which are predominantly parallel to the shore and the principle reason why the Gunns Ltd plume moves parallel to the coast. Whilst there will be some onshore transport in the 'surface layers', as described by Godfrey, the effluent will have been diluted greatly in the near-field processes before it reaches the surface. The matter of the plume shown in Godfrey's figure 1 requires more information about the discharge and receiving environment before it could be addressed properly.

Godfrey discusses the possibility of material becoming attached to oil in the surface microlayer of the ocean. He gives the example of faecal material from the Sydney outfalls. It appears that the contaminants of concern in the present case are not particulate, but are in solution and hence attachment to the surface layer may not be an issue, however, the author is not qualified to comment on the details of this matter. Similarly, the likelihood of contaminants becoming concentrated in the surface foam during high wind conditions is beyond the author's expertise.

The foregoing analysis suggests that it is very unlikely that concentrations of contaminants beyond the specified critical levels will reach the beach, the Tamar estuary or Commonwealth waters. The plume will reach these areas, but with sufficient dilution to be below the water quality guideline concentrations set for this development.

General

Godfrey makes a number of comments in relation to potential breaches of the Guidelines set for the project IIS. As noted by Dr. Treloar in his reviews of the GHD reports, there are some concerns with the detail of the modelling (grid sizes, seasonal coverage), however, it is unlikely that these are issues which would lead to significantly different outcomes for the investigations.

In general, this reviewer agrees with many of Godfrey's comments in relation to the modelling:-

- The measurements are not sufficient to allow definition of modelling parameters or validation of the model.
- There is no treatment of seasonality in either the measurements or the modelling.
- The model has too coarse a resolution in the vertical direction, but could be improved by using a smaller horizontal grid close to the diffuser to properly resolve effects of stratification or wind-driven circulation, especially near the shore.
- With a much finer grid in the vertical, it may not be necessary to include surface heat flux, however, modern models do have this capability. An alternative is to "force" the stratification through boundary conditions.
- The horizontal eddy diffusivities used by GHD appear to be high and are not supported by field measurements at the site. Whilst Godfrey's field data method could be used, the technique is not as good as implied by Godfrey, and it is realistic to adopt appropriate values based on experience at other sites. Tracer releases can be used as an alternative.

However, as stated above, it is unlikely that resolution of these issues would lead to substantially different outcomes in terms of the mixing of the effluent, the size of the mixing zone or the far-field concentrations, although it is almost certain that more detailed investigations would result in a slightly larger footprint for the diluted plume at concentrations below the critical levels.

Reviewer's Qualifications

David Provis BSc(Hons), PhD, Grad Dip Bus Admin, CompIE Aust, is an oceanographer with over 30 years experience in coastal oceanography. He is a Senior Principal with the Cardno Group and Principal Oceanographer with Cardno Lawson Treloar Pty Ltd. He has wide experience in oceanographic measurements and modelling and most recently has been responsible for the Hydrodynamic and Coastal Processes Modelling studies for the Channel Deepening Project for the Port of Melbourne Corporation. This involved extensive measurement programs and modelling of a wide range of phenomena. He is also familiar with the Tamar estuary and the site of the proposed outfall having undertaken investigations and modelling which were reported in Lawson and Treloar (1996) "Bell Bay Environmental Baseline Programme Physical Oceanographic Study" for Department of Environment and Land Management, Tasmania. This study involved two three month deployments, each of two currents meters, at the proposed location for an outfall off Five Mile Bluff and also modelling of the potential fate of discharged material. He also used the model to examine the fate of oil spilled into the sea when the "Iron Baron" ran aground off the mouth of the Tamar River in 1995.