Summary of Hydrodynamic Modelling for the Bell Bay Pulp Mill

10th March 2011

Introduction

The purpose of this document is to provide an overview of the scope and what was found from hydrodynamic research done for the Bell Bay Pulp Mill to meet Commonwealth Government requirements.

Under the Bell Bay Pulp Mill project design, waste water from the pulp mill will be released into the sea approximately 23 km to the northeast of the mill site at Five Mile Bluff through an undersea pipeline extending 2.7 kilometres offshore along the sea bed. The permitting of this discharge is under the Commonwealth Government's *Environment Protection and Biodiversity Conservation Act*, 1999 (EPBC Act) for the Commonwealth marine area and the State Permit under the *Pulp Mill Assessment Act*, 2007 (PMA Act) for State waters[1].

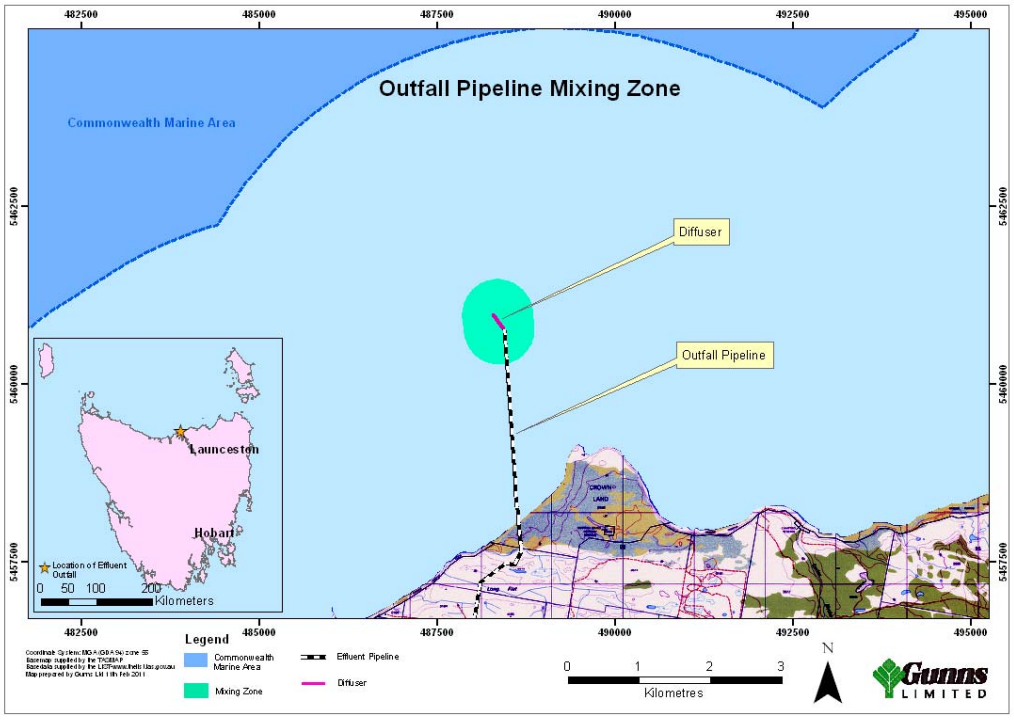


Figure 1. Map of Five Mile Bluff region on the north coast of Tasmania showing the boundary of Commonwealth and State waters, the proposed pipeline route, undersea diffuser and the defined regulatory Mixing Zone.

[1] The State's jurisdiction applies in State waters that are within 3 nautical miles of the Tasmanian coast, while the Commonwealth's marine area is that region beyond 3 nautical miles from the coast.

In October 2007, the Federal Minister for the Environment and Water Resources, Hon Malcolm Turnbull, approved the pulp mill subject to 48 conditions. These included detailed specifications of environmentally relevant aspects of the proposal that must be addressed, mostly via the project's Environmental Impact Management Plan (EIMP). The EIMP comprises 16 modules, of which the (then) Minister (Hon Peter Garrett) had approved 13.

In order to ensure the environmental impacts of the outfall in particular are acceptable, and before approving the final three modules (L, M & N) of the EIMP, the (then) Minister required Gunns to complete a specific research project on the interactions between the pulp mill effluent and the receiving waters (referred to as the Hydrodynamic Project) and use information obtained by the project in order to develop further or refine the final three modules.

The majority of the detailed preliminary design of this project was provided to Gunns by the Commonwealth Government[2]. This design was largely undertaken and overseen by the Minister's Independent Expert Group (IEG), which provides the Minister with independent advice on scientific aspects of the overall pulp mill project.

The hydrodynamic project comprised:

1. **Field measurement** activities, to get a good understanding of the existing marine and atmospheric conditions relevant to modelling the area around Five Mile Bluff.
2. **Effluent studies** investigating chemical composition, toxicology and particulate characteristics, using effluent from an operating pulp mill in Brazil similar to the one proposed for Bell Bay and fed with plantation Eucalyptus feed stock, and
3. **Computer modelling** of the movement of effluent and sediment from the outfall.

This $5 million research project took two years to complete. The research team included scientists and engineers from RPS MetOcean (components 1 & 3), the University of NSW Water Research Laboratory (component 2), Worley Parsons (component 3), Ecotox Services Australasia, Toxikos, and the National Measurement Institute (all component 2).

Findings from the research

The detailed findings from the research are contained in extensive technical reports, which are available through the project website www.gunnspulpmill.com.au.

Gunns Ltd has prepared a *Final Report on Commonwealth Requirements*, which collates the information from the research reports and interim reports to the Commonwealth and provides an overarching interpretation and integration of the project's findings. This is also available on the website.

[2] With State Government consultation

1. Field Measurements

High quality data from the environment where the effluent is to be discharged is needed to test, validate and calibrate hydrodynamic models. This is to provide local data to compare to model input data, such as that supplied by the National Centre for Environmental Prediction.

Oceanic data covering water temperature at different depths (stratification), currents, sea levels, waves and salinity were collected over 12 months at three moored measurement stations (1. mouth of Tamar Estuary, 2. site proposed for mixing zone, 3. NW of Five Mile Bluff). Meteorological data were collected from a meteorological station on shore near Five Mile Bluff. The large amount of data generated through these field studies, which runs to several thousand pages of reports, has provided a solid understanding of existing oceanic and atmospheric conditions for predicting the behaviour of the effluent and its constituents.

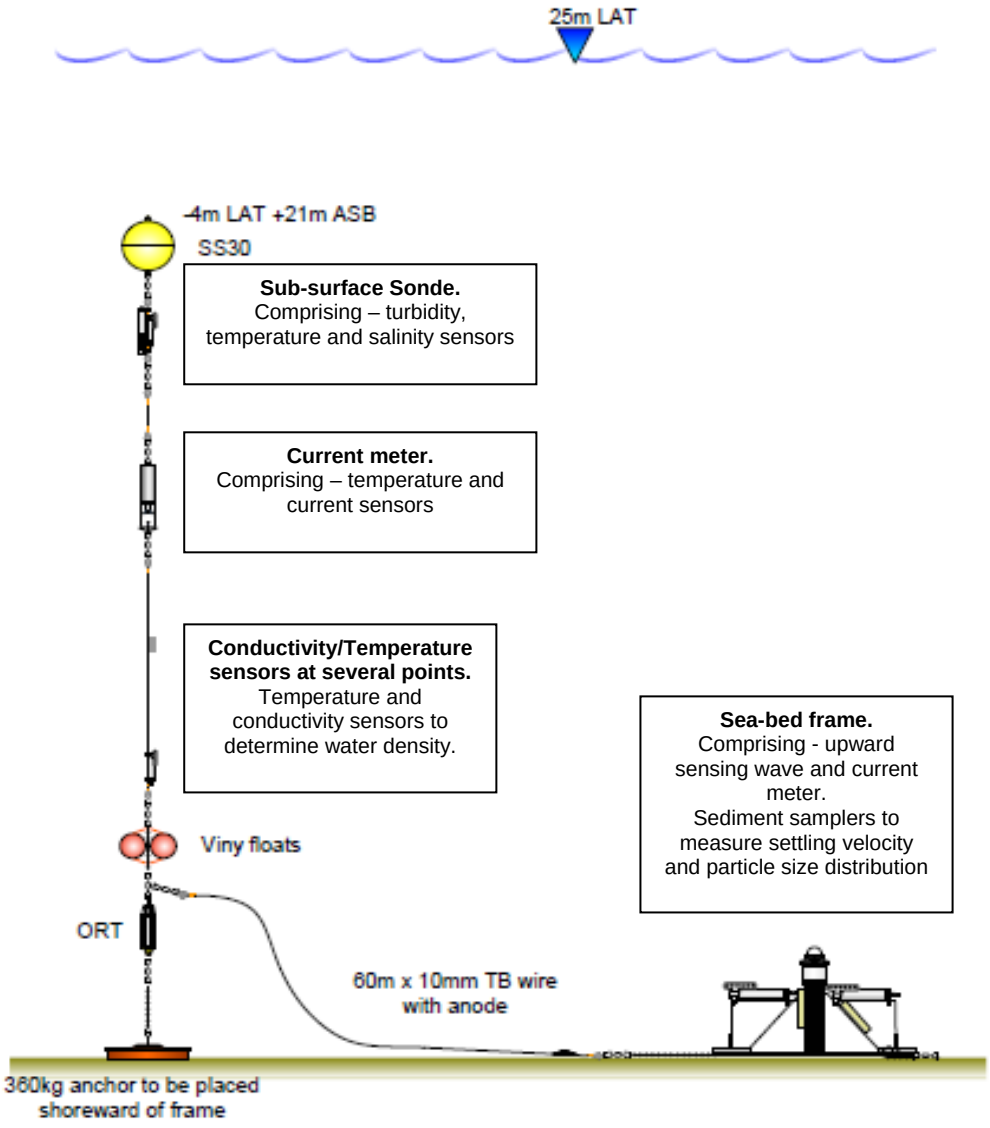


Figure 2. Diagram of a mooring used in the Field Measurement Program.

Figure 3. Sea-bed frame being deployed.

2. Effluent Studies

Effluent from an operating pulp mill in Brazil similar to the one proposed for Bell Bay and fed with plantation Eucalyptus feed stock was analysed under Australian laboratory conditions to find out its chemical composition, toxicology and particulate characteristics.

The findings of these analyses were consistent with the predictions and assumptions used for the Bell Bay pulp mill assessment process and were lower than the conservative assumptions used for the Marine Impact Assessment conducted for the pulp mill impact assessment. The scope of the analyses included a schedule of 140 individual determinands[3]. The classes of these determinands included; physico-chemical parameters (including nutrients), metals and many organic (e.g. 'dioxins') and some inorganic halogenated compounds. The schedule also included many natural plant-based chemicals that originate from the feedstock wood.

Toxicology studies assessed the effect of various dilutions of mill effluent on a range of sensitive Australian marine flora and fauna including bacteria, micro-algae, brown macro-algae, fish, sea urchin and scallop larvae.

Some key findings from the effluent studies and analysis of available data from other pulp mills were:

- The TEQ 'dioxin and furan'[4] analysis found levels were below the threshold for detection, which means concentrations of a range of compounds of concern were demonstrated to be below both Commonwealth and Tasmanian regulatory limits or possibly absent altogether

[3]Determinands are chemical substances, microbiological organisms, or some other characteristic of the water that can be measured

[4] The chemicals referred to in this summary as TEQ 'Dioxins and furans' are a range of 'dioxin like' congeners of polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzo furans. In this case the congeners are expressed in 'Toxicity Equivalents' (TEQ) to the toxicity of the individual congener 2,3,7,8-tetrachlordibenzo-*p*-dioxin.

- The physical and chemical variability of effluent can be expected to be greatest in the first years of the operation and should decrease as the pulp manufacturing process is optimised and process variability decreases
- The key toxicant parameter, chlorate, will readily meet its dilution target and poses very low ecological risk to Commonwealth marine areas and elsewhere
- Adoption of 100% plantation fibre from the outset, and improved mill technology, enables a significantly lower average level of chlorate release to be achieved than originally proposed. A 40% decrease in equivalent maximum permitted chlorate discharge rate is achievable
- Only minimal dilution in the receiving environment (i.e. the ocean) is needed to achieve a high level of protection to sensitive local marine life. These dilution requirements will readily be met within the currently defined Mixing Zone (refer to Figure 1), and
- It is unlikely that any floc mat[5] will occur on the sea-bed as the low levels of particles expected to be emitted will either not settle or be continuously resuspended.

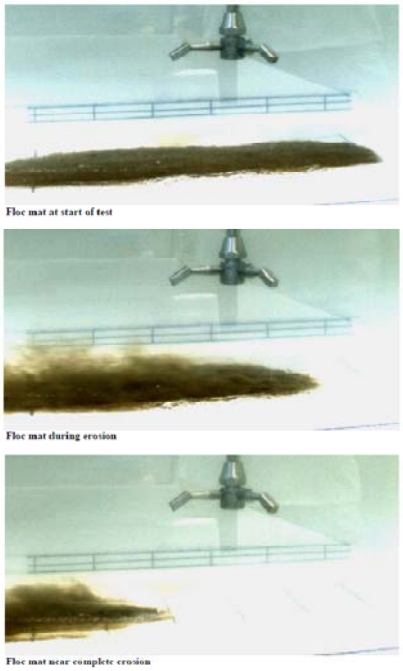


Figure 4. Images from a trial conducted as part of the overseas effluent study designed to test particle re-suspension characteristics within a glass sided flume tank.

[5]Particles that have settled on the seabed.

3. Modelling

Near-field modelling

The near-field (close to outfall) modelling studies were undertaken to get a good understanding of how the effluent will behave immediately on discharge from the pipeline via the diffuser[6]. These studies have also enabled the re-design of the outfall diffuser to maximise the initial dilution of effluent under the most challenging environmental conditions. This has resulted in a longer diffuser than was originally planned with new "duck bill" valves and optimised port spacing. The redesign does not require any change to the size of the currently defined mixing zone.

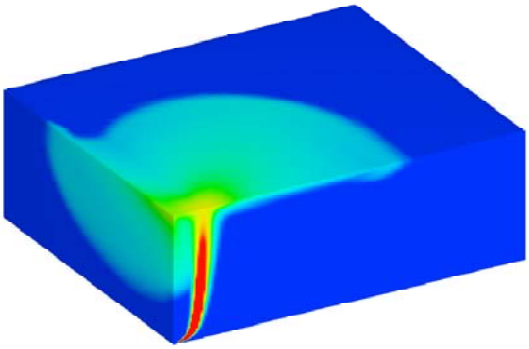


Figure 5. Near-field 3-D model image depicting a buoyant plume's rise through the water column after its release from a single point near the bottom.

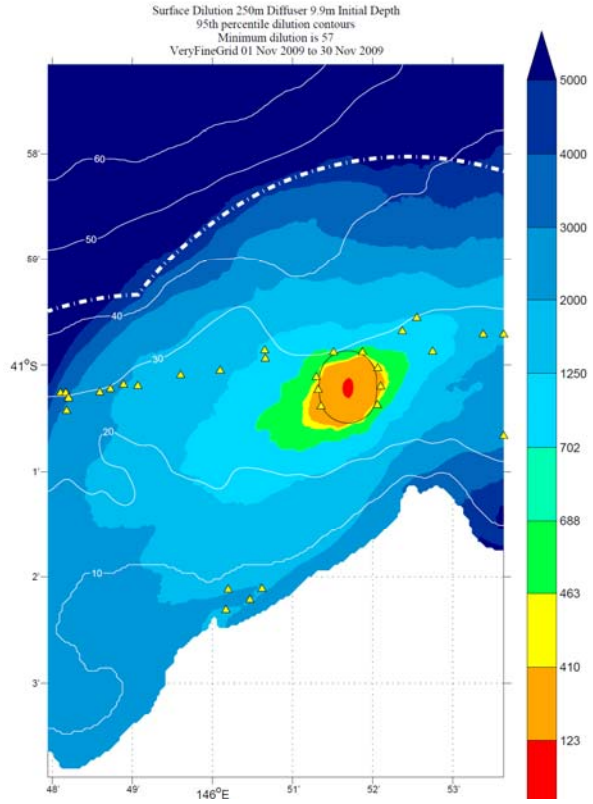
These near-field modelling studies have shown that the effluent plume should consistently rise to the surface, as is desirable to maximise initial dilution, under the majority of circumstances. Following major flood events from the Tamar and other catchments, stratification (i.e. layering) of the receiving waters could however trap the plume to some extent and prevent it from completely rising to the surface under absolutely all circumstances. The extent that incomplete plume rise could occur would be related to the frequency of strong flood events from the local North coast catchments.

Far-field modelling

The far-field modelling, which was designed to predict the movement of the outfall plume as it disperses into the waters of Bass Strait, was able to predict sea-level phase, temperature, salinity, tidal currents and residual currents with the required level of accuracy. Prediction of sea-level amplitude (i.e. tide height) was not sufficiently accurate to meet the design objectives for the model. MetOcean advised that this was not a serious deficiency as tidal amplitude has little bearing on effluent transport and diffusion.

The far-field modelling studies showed that effluent will be sufficiently diluted within the mixing zone to meet regulatory requirements as demonstrated by the example provided in Figure 6.

[6] A diffuser is a device to enhance initial dilution, by spreading the point of release over a larger area.



Explanatory note for Figure 6.
An important performance indicator for this particular scenario presentation is whether the 123:1 dilution contour (shown in red) enters Commonwealth Marine Area (boundary indicated by the white dashed line) or resides over sensitive algal habitat areas (e.g. along the coast in shallower water).
As can be seen, the red area resides wholly within the Mixing Zone, well clear of Commonwealth waters and sensitive areas.
Other dilution contours are presented to demonstrate attenuation with distance.

Figure 6. Image from Appendix I of the MetOcean Final Results Report.

The major conclusions that can be drawn from the far-field modelling are:

- longer-term effluent accumulation is not apparent within the overall Bass Strait region
- there is a low risk to Matters of National Environmental Significance (MNES[7]) under the maximum allowable loading for chlorate
- none of the non-toxicant parameters regulated by the Commonwealth (TN, TP, TSS, BOD[8]) present a credible risk to the receiving environment.
- the outfall configuration can also meet dilution targets relating to State limits for TN, TP, TSS and BOD within the mixing zone, and these limits are conservative and protective of Matters of National Environmental Significance, and
- the diffuser design can meet dilution targets relating to colour set by the State for the receiving environment within the mixing zone.

Note: the assessment of TEQ dioxins and furans focussed on the outputs of the sediment transport modelling (below) rather than the far-field modelling works described above.

[7] MNES refer to a range of environmental issues that are regulated by the Commonwealth under the EPBC Act.
[8] Total nitrogen (TN), total phosphorus (TP), total suspended solids (TSS) and biological oxygen demand (BOD).

Sediment transport modelling

The sediment transport modelling was primarily designed to assess the potential levels of TEQ dioxins and furans that could accumulate within seafloor sediments in Commonwealth waters as a result of an implied maximum loading from pulp mill effluent. Its secondary task was to determine likely deposition zones that would be appropriate for baseline or surveillance monitoring.

As the concentrations of TEQ dioxins and furans in pulp mill effluent are below the threshold of detection (as demonstrated from the effluent studies), the sediment transport modelling provided a conservative means of predicting whether the levels of these compounds could accumulate in sediment to a level exceeding that permitted.

In summary, the maximum levels[9] of TEQ furans and dioxins that might accumulate under a worst-case scenario as predicted by the model over 10 years of pulp mill operation are up to 8.5 pg TEQ kg^{-1} sediment in areas near and just to the east of the outfall. This level is approximately 1% of the maximum permitted concentration defined under the Commonwealth's Permit (850 pg TEQ kg^{-1}) and much lower than measured levels of TEQ dioxins and furans in the Lower Tamar (over 62 pg TEQ kg^{-1}) and may not even be detectable by modern ultra-trace analysis methods.

While levels of TEQ dioxins and furans at all locations are predicted to remain well below permitted levels (if they are present at all), the model identified the areas of greatest likely accumulation which would be suitable for monitoring sites, being from the mixing zone eastward toward and beyond Five Mile Bluff to near Tenth Island.

Application of the research

The various outputs of the research have enabled specific environmental management plans relating to the operations of the mill and the effluent treatment plant to be finalised.

Monitoring

Implementation of these management plans will include substantive ongoing scientific studies to provide a sound surveillance program continually assessing the environmental impact of the mill on the Bass Strait region. The surveillance program will ensure the operations of the mill are consistent with predictions of the modelling and other associated impact assessments, which have clearly demonstrated and with reasonable certainty that the environmental risk of the overall project is acceptably low.

Details of the Bell Bay Pulp Mill monitoring regime can be found on Gunns Ltd website. www.gunnspulpmill.com.au.

[9] Assuming emissions are at maximum permitted levels.

Revised regulatory regime

The Commonwealth regulates total nitrogen (TN), total phosphorus (TP), total suspended solids (TSS) and biological oxygen demand (BOD)[10] from the effluent released from the pulp mill under Condition 32 of the Approval Decision.

Condition 32 provided for concentration limits to be revised in the final EIMP if agreed by the IEG and approved by the Minister. As the physico-chemical parameters were clearly demonstrated to pose no credible risk to the Commonwealth's marine environment by the modelling project, these parameters were re-examined to ensure the regulatory regime was fit for purpose.

Existing State and Commonwealth compliance limits for TN, TP, TSS and BOD use different regulatory regimes, but when compared under equivalent regimes they are also set at different loading levels. The Commonwealth limits (when converted to a load basis) were lower than those proposed by the State as they were set based on an expected long-term performance level, and did not necessarily take into account all other factors.

In its permitting, the Commonwealth has agreed to align the compliance limits for TN, TP, TSS and BOD with the State limits, which are higher. This, along with other contributing factors has enabled it to set a 40% *lower* limit on chlorate emissions, which is the key toxicant of concern. The modelling demonstrated that limits set for TN, TP, TSS and BOD under the State regime are more than adequate to protect matters of interest to the Commonwealth and State. This revised Commonwealth regime, given the much more significant potential impact of chlorate on the marine environment than TN, TP, TSS and BOD, was considered to provide the best overall environmental outcome.

It has also been proposed that the State limits on chlorate loading be reduced to align with these 40% lower Commonwealth limits. The overall outcome of these changes to permitted levels of emissions is that the mill process can be optimised under a rigorous environmental management regime to minimise the release of all pollutants, with greatest priority given to the most important pollutants such as chlorate.

[10] These four parameters are members of group termed 'physico-chemical' parameters.