BMT WBM Pty Ltd
Level 11, 490 Upper Edward Street
Brisbane 4000
Queensland Australia
PO Box 203 Spring Hill 4004

Tel: +61 7 3831 6744
Fax: + 61 7 3832 3627

ABN 54 010 830 421 002

www.wbmpl.com.au

Our Ref: MEB: L.B16676.002.Report.doc

6 July 2007

Department of the Environment and Water Resources
GPO Box 787
Canberra
ACT 2601

Attention: Mr Jon Millard

Dear Mr Millard

RE: PROPOSED GUNNS PULP MILL OUTFALL: ASSESSMENT OF MODELLING REVIEWS

Thank you for the opportunity to assist with regards to the above. Below is BMT WBM's response to the scope of works contained within the *Short Form Services Contract* between The Department and BMT WBM, dated 27th June 2007.

EXECUTIVE SUMMARY

In relation to the above, we believe that the modelling methodology requires strengthening in several key areas before sufficient confidence can be placed in its predictions. In particular, to resolve apparent issues, we find as follows:

1 Low frequency geostrophic oscillations (such as East Coast Lows) should be included in the model schematisation and all simulations rerun, reassessing hydrodynamic calibration and plume dispersion results;

2 Existing salinity data should be used to calibrate and validate mass transport and dispersion in the Tamar Estuary section of the model domain, and the results used to better inform corresponding parameter selection elsewhere in the model domain. Dye release experiments in the vicinity of the outfall should also be considered to improve model parameterisation in this critical region; and

3 The simulations, once adjusted as per above, should be executed for a much longer period of time (and appropriately reported) to reliably ascertain the long term build up of pollutants discharged from the proposed outfall.

DETAILED REPORT

Scope

The scope of works, extracted from the above contract is as follows.

"A concise report, based on a desktop study and your experience and understanding of hydrodynamic and dispersion modelling, and addressing the following tasks, is required. A review of the following documents:

- *Patterson Britton (PB) review of GHD reports of 30 March 2007;*
- *GHD's subsequent response to review of 18 April 2007;*
- *PB's secondary response to GHD of 31 May 2007; and*
- *Toxikos' response to the PB reviews of 23 April 2007.*

Possible resolution of the varying views expressed in the above documents, or failing that, what you believe to be the likely dispersion of pollutants from the outfall.

Explicit review of the original modelling reports was not been requested, although the following source documents have been referred to as needed throughout this commission:

- Draft IIS (Appendix 63, July 2006, http://www.gunnspulpmill.com.au/iis/V18/V18_A63.pdf);
- Addendum for Gunns Pulp Mill IIS 'Additional Modelling Works' GHD August 2006 (http://www.gunnspulpmill.com.au/iis/supp/ross_fryar_att_2.pdf);
- Addendum for Bell Bay Pulp Mill IIS 'Additional Modelling Works Report 2' GHD January 2007 (http://www.gunnspulpmill.com.au/iis/supp/ross_fryar_att_3.pdf)

Background

Gunns is seeking to discharge approximately 51 GL/yr (1.62 m^3/s) of effluent from a proposed pulp mill on the Tamar Estuary in Northern Tasmania. It is proposed to discharge the effluent from an outfall 2.7 kilometres offshore into Bass Strait. This effluent would contain an estimated 3.4 pg/L of dioxins and other persistent organic compounds as well as other pollutants such as chlorate (1-4 mg/L) and chloroacetic acid.

GHD undertook a modelling study of the proposed outfall and pollutant dispersion, with review provided by PB. Subsequent correspondence has ensued and BMT WBM has been asked to provide comment on this correspondence, with a view to facilitating resolution and progression of some outstanding matters.

Key Issues

BMT WBM has reviewed the above correspondence, and several key issues requiring resolution have been identified.

Firstly, it is noted that the reviewers are supportive of the selected modelling packages in terms of their suitability for use in the study. Notwithstanding this, the manner in which some models have been applied, and their results interpreted, has resulted in a divergence of opinion between reviewers and modellers on several key issues. BMT WBM perceives these key issues to be:

1 The impact, or otherwise, of low frequency geostrophic oscillations (such as East Coast Lows) on the hydrodynamic behaviour of the region of interest, and hence outfall plume dispersion behaviour;

2 The calibration and validation status of the hydrodynamic and dispersion models (or absence thereof) and the subsequent reliability of simulation predictions, particularly in terms of mass transport, dispersion and flushing characteristics of the outfall plume;

3 The duration for which simulation should be executed to reliably predict long term accumulation of pollutants in the far field, and any potential feedback to near field concentrations. Related to this is the presentation (or absence thereof) of timeseries pollutant data at a range of locations throughout the model domain to assist in identifying attainment of steady state conditions; and

4 The long term buildup (or otherwise) of particulate matter in the sediments within the area of interest, and the interaction of the proposed pollutant plume and fluvial discharges from the Tamar Estuary resulting in deposition of pollutants.

Discussion

Comment and potential resolution of the above is provided below for the Department's consideration.

1. Low Frequency Geostrophic Oscillations

Status

The reviewers are of the opinion that the impact of these low frequency oscillations on plume dispersion (and the general hydrodynamics within the model domain) requires more complete investigation. In particular, the reviewers believe that it needs to be clearly demonstrated that the impact of these oscillations is of secondary importance, as is claimed in the modelling reports. Further, the reviewers are of the opinion that excluding these oscillations is not necessarily conservative in terms of simulating the energy budget within Bass Strait, again as suggested in the reviewed reports. In particular, the reviewers propose that there is a possibility that these motions could conceivably act to *dampen* tidal mixing in the area of interest (rather than enhance it as suggested by the modelling team), resulting in a failure of the modelling framework to predict a commensurate reduction in plume dispersion.

In response, the modelling team has provided supplementary material that draws on independent published research and the results of prior (unrelated) modelling studies. The former was interpreted as suggesting that low frequency processes may be important in regions other than that of interest to this study (i.e. the Victorian coast), and hence it has been suggested that exclusion of these oscillations from the study will still provide a reliable 'first-order approximation' of the forces governing hydrodynamics on the Tasmanian coastline. The model calibration was used to support this position.

To provide evidence that exclusion of these oscillations is conservative in terms of energy available for tidal mixing and plume dispersion, timeseries of water surface elevation have been subsequently presented, along with current speed and current direction data (at Devonport) from simulations with and without the low frequency oscillation boundary conditions. This drew on prior (unrelated) modelling studies. These data showed that low frequency oscillations induced an increase in tidal range of up to 0.6 metres (15%) at that location, and only small changes in current speed and direction. It was subsequently argued that, as the oscillations induced a *greater* tidal range at Devonport, excluding these oscillations from the current study simulations should result in an underestimate (i.e. conservative estimate) of the dilution achievable within, and subsequent to, the discharged pollutant plume. Given this, it was argued that inclusion of the low frequency oscillations is not required.

Comment and potential resolution

BMT WBM is of the opinion that the supplementary results at Devonport (as described above) provide sufficient motivation for actually requiring the inclusion of low frequency oscillations in the modelling methodology. We take this view for the following reasons:

- The comparative analysis is presented for Devonport, and is discussed as being representative of 'the Tasmanian coast'. Devonport is approximately 20 kilometres from the mouth of the Tamar Estuary. It is not clear that data from this site can be extrapolated to encompass the entire Tasmanian coastline. It needs to be clearly demonstrated that this increase in tidal range is not reversed, or attenuated, at other locations along the coastline, particularly closer to the site of the proposed outfall. Any temporal variations in this impact also need to be more clearly elucidated. This is best achieved by revising the modelling framework (and calibration) to include the impact of these low frequency oscillations; and
- As noted by the modelling team, the supplementary results demonstrate that the oscillations can be responsible for a change in tidal range of up to 15% (0.6 metres) at the selected location. As such, the analysis shows that these oscillations play a non-trivial role in the hydrodynamics of the region (despite the quoted literature review to the contrary). As such, these results *support* inclusion of the low frequency signal in tidal boundary forcing data as part of this study, to ensure that the correct hydrodynamics are captured. The presented data shows that to exclude these oscillations would be to exclude an important process from the modelling methodology, which is unlikely to be satisfactory.

Given the above, it is recommended that these low frequency oscillations be included in the modelling framework (i.e. via tidal boundaries) to ensure appropriate and correct capture of the hydrodynamics of the region of interest. Given the modelling team's considerable prior experience in including these oscillations in preceding studies (albeit with different intents), it would seem that it is well equipped to also do so for the current study. Inclusion of these low frequency oscillations (and subsequent re-evaluation of the model hydrodynamic calibration) will provide a greater level of confidence in the modelling results and hence resolve this matter.

2. Model Calibration

Status

The reviewers are of the opinion that the model is not reliably calibrated for advection and dispersion of pollutants, and have used desktop analysis techniques to provide a qualified crosscheck of the internal consistency of the presented results. Based on this, the reviewers believe there to be inconsistencies in the reported results, and in particular, that the models may well over-predict pollutant transport and dispersion in the area of the plume. This has been related back to the selection of dispersion parameters within the model. It has been suggested that salinity measurements be used to calibrate dispersion parameters within the models to improve simulation confidence and associated predictive capabilities.

The modelling team has pointed to a lack of available salinity measurements to allow for the usual calibration and validation process to be followed. As such, it has adopted a range of different eddy viscosities and diffusivities for different model grid sizes, and used literature values and previous experience in setting the corresponding absolute values. A first pass qualitative sensitivity analysis (around the selected dispersion parameters) was presented in response to the review comments. Without providing details, the subsequent analysis reported that eddy diffusivity and pollutant concentrations were inversely related, which is not surprising.

The modelling team has also noted that it does not support the application of desktop techniques to evaluate model performance in the relatively complex hydrodynamic setting of this study.

Comment and potential resolution

BMT WBM is of the opinion that calibration of mass transport and dispersion processes within the far field modelling framework is critical to this study. As such, this issue deserves considerable attention, which, based on the review correspondence, it has yet to receive. The most detailed investigation appears to be the above sensitivity analysis (page 9 of 18 April response correspondence) that found that the eddy diffusivity and pollutant concentrations are inversely related. This fact has been well established in the literature for some time (e.g. Fischer *et al.*, 1979) and as such, this response (albeit qualified as incomplete) is inadequate.

BMT WBM is of the opinion that the most appropriate way to calibrate and validate the mass transport and dispersion within the modelling framework is to execute the model over two independent historical periods where relevant salinity data has been collected. Model parameters can then be altered (within acceptable ranges described in the literature) to provide adequate reproduction of field data over the calibration period, with subsequent verification of these calibrated values (unchanged) over the validation period. Ideally, a calibration period should encompass a flushing event (where ambient salinity levels are reduced due to freshwater inflows) and the ensuing period of salinity recovery. This usually ensures that the dynamic nature of mass transport and dispersion is appropriately captured, providing robustness to a modelling study.

Such field data exists for the Tamar Estuary from approximately 7km to 75km AMTD, and is held by the Tasmanian Department of Primary Industries, Water and Environment (DPIWE). These data have been used by BMT WBM for the purposes of calibrating and validating an advection-dispersion (and subsequently full water quality) model of the Tamar Estuary, constructed as part of a commission for Launceston City Council. We recommend that these same data be sourced and used for the purposes of calibrating the model constructed as part of this study.

Although the DPIWE data does not cover the entire area of interest to this study, the data can be used to provide a robust calibration and validation of the Tamar Estuary region, which is included in the model domain. The parameters derived as part of this process can then be used to better inform the subsequent selection of the corresponding parameters as applied to other parts of the model domain (still with checking against literature values) where salinity data is unavailable. This will provide a greater level of certainty in the model predictive capabilities than can currently be attributed.

It may also be possible that additional data (unknown to BMT WBM) have also been collected by DPIWE over a greater spatial area than solely the Tamar Estuary, and if so, would be of further use to this study. We recommend that enquiries be made to ascertain the status of any such data.

It is possible that others may be of the opinion that expending effort in properly calibrating the Tamar Estuary section of the existing model is of marginal assistance to the progression of this study, particularly since the proposed outfall is not directly within that domain. There may be some degree of merit in the argument, however we provide the following in support of our position in this regard:

- We believe that undertaking this calibration and validation exercise will provide a solid ground-truth for subsequent parameter selection throughout the model domain. This is a stronger position from which to defend modelling results, compared to sole reliance on literature values, which can vary by orders of magnitude; and
- The lower reaches of the Tamar estuary are deep and quasi-oceanic, so are at least partially representative of the environment of the proposed outfall, so calibration of the model in these areas may provide valuable insight into the likely dispersion characteristics at the outfall location.

Given that a correct dispersion parameterisation is critical to the success of this study, we recommend that, in addition to the above, consideration also be given to execution of dye tracer experiments in the vicinity of the outfall location. These are relatively easily undertaken using a dye such as Rhodamine, together with aerial plume tracking surveys over a suitable period following release. As the proposed outfall is buoyant, a surface release should be considered. Observations of plume spreading can then be used to derive dispersion characteristics using standard techniques (e.g. Fischer *et al.*, 1979). This technique has successfully been applied elsewhere (e.g. Port Curtis at Gladstone, Qld), the results of which typically add considerable strength to model predictions and reliability.

It is BMT WBM's opinion that execution of the above two tasks be given the highest priority in progressing this study, as this issue is central to the successful execution of this study and construction of reliable and robust models. Once complete, the differing methods and views expressed in the review documents regarding the validity of desktop analyses, dilution and flushing will be, we believe, largely resolved, or at least, further progression of the issues will be better informed.

3. Long Term Accumulation of Pollutants

Status

The reviewers are of the opinion that the modelling framework has been executed over an insufficient time period to properly assess the likely long term build up of pollutants in the far field. A period of 100 days is suggested. It is noted that this far field build up can feed back directly into the near field concentrations, and as such have important implications for the likely near field concentration peaks and breaches of water quality objectives (WQOs).

The modelling team agrees that long-term build up of pollutants is likely, and that a flushing time of 100 days might be appropriate for Bass Strait as a whole. It is argued that additional (unreported) simulations over a longer period are nonetheless consistent with a 30-day period to reach equilibrium.

Comment and potential resolution

BMT WBM is of the opinion that this issue requires more attention. In the first instance, this should involve a detailed presentation of the results from the simulations mentioned briefly on page 6 of the April 18 response, as long as these encompass at least 100 days simulation time. If they do not, it is recommended that they be extended to do so. This detailed presentation should include:

- Timeseries of pollutant concentrations at a number of locations within the model domain (depth averaging within the 3D domain will be sufficient), including several points at a number of radii equally spaced between the outfall location and the modelling domain boundary; and
- Contour maps of pollutant concentration across the model domain at various stages throughout the simulation (depth averaging within the 3D section should again be sufficient), including at 10, 50 and 100 days duration.

Moving average concentrations for both the timeseries and contour maps could also be considered to remove concentration spikes and allow more clear elucidation of long term trends.

If it can be demonstrated (using the above) that after 100 days, there is no significant ongoing increase in pollutant concentrations within the modelling domain, then this issue will have been resolved. If this is not found to be the case, then further assessment of the long-term accumulation of pollutants within the modelling domain should be undertaken. This should most likely include additional model simulations (the detailed form of which could be determined following execution of the above) that encompass a longer duration.

An alternative to the above could be execution of further simulations including provision for flux boundaries within the model domain. Several of these should be constructed at equally spaced radii from the outfall location and the flux of pollutant across each monitored over time. If it can be clearly demonstrated (using full results presentation in the style of the above suggestions for timeseries and contour plots) that the outward flux across these boundaries equals (or sufficiently approximates) the inward outfall pollutant flux, then the system can be defensibly described as at steady state.

Once either of the above is undertaken and a time to steady state conditions clearly established, long term depth average pollutant concentrations (throughout the modelling domain) can be produced. It is BMT WBM's opinion that these concentrations (in the vicinity of the diffuser) should be assessed in an *additive* manner to those predicted by the near field diffuser model alone. The near field model concentration predictions should be considered as deviations above ambient, and if ambient concentrations are increased to a long term steady state value, then these need to be accounted for in reporting total plume concentrations in the near field.

4. Low Term Build up of Particulate Matter in Receiving Sediments

Status

The reviewers are of the opinion that simulation of particulates has not been properly undertaken, and as such a reliable estimate of the likely accumulation within receiving sediments is not possible. It is also pointed out that interactions with fluvial estuarine-derived sediments is a further possible mechanism by which additional adsorption (and subsequent deposition) of pollutants could occur.

Toxikos has reported that it does not believe this to be an issue, and that an analysis demonstrating this has been provided elsewhere in the IIS. The modelling team has deferred to the Toxikos report.

Comment and potential resolution

BMT WBM does not have explicit expertise in this area, but defers to the Toxikos letter findings for ambient deposition rates and accumulation.

If further investigating was warranted, a more detailed sensitivity analysis around the potential for augmentation of deposition considered by Toxikos via interaction with estuarine sediments could assist with resolution. Such an analysis could consider the frequency of such estuarine discharges, the likely concentration of suspended sediment, typical adsorption rates and subsequent flocculation behaviour. No further comment can be provided in this regard.

We trust that the above will assist DEWR in evaluation and progression of this study. In providing the above, we have attempted to offer guidance for the execution of well-defined tasks that will resolve the key issues identified and provide robustness to the modelling study. Please do not hesitate to contact me, or Tony McAlister, if you have any further queries or wish to discuss any matter above in more detail.

Yours Faithfully
BMT WBM Pty Ltd

Dr Michael Barry

(Associate)

Yours Faithfully
BMT WBM Pty Ltd

Tony McAlister

(Director)