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27 November 2015

NSW Department of Planning and Environment
GPO Box 39
Sydney NSW 2001

Attention: Robert Byrne

Dear Robert

RE: ESTUARY HYDRODYNAMIC AND SOLUTE TRANSPORT MODEL CALIBRATION - WEST CULBURRA ESTUARINE MANAGEMENT STUDY (MP 09_0088). PEER REVIEW

Thank you for inviting BMT WBM to provide assistance with regard to the above. BMT WBM has worked closely over an extended period of time with the consultant undertaking the modelling study, and as the Department will be aware, the final calibration report has been prepared. This letter presents a review of that report.

I will be happy to discuss outcomes with the Department as required.

Yours Faithfully
BMT WBM

Dr Michael Barry
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Technical and Innovation Manager

1 Context

The first review of the consultant's modelling work was provided by BMT WBM in November 2014. Since that time, BMT WBM has provided ongoing advice that has seen the model construction and calibration brought to a standard that is sufficient for a second review to be undertaken. Specifically, BMT WBM's advice over the last twelve months has resulted in at least the following:

- Collection of hydrographic data to allow calibration of the model, specifically
  - Tidal water levels
  - Acoustic Doppler Current Profiler (flow) data
  - Salinity
- Critical interpretation of these data by the consultant, especially with regards to salinity measurements
- Reparameterisation of the downstream tidal salinity boundary condition
- Extension of the model domain to include estuarine waters to the tidal limits
- Re-examination of model roughnesses and grid sizes
- Re-examination of model dispersion coefficients
- Inclusion and correct implementation of flood gates within the system (as 1D elements with blockages), including their post-event release behaviour
- Correct inclusion of Culburra Road crest levels in the model
- Re-examination of catchment inflows and consideration of catchment storage
- Implementation of spatially varying salinity initial conditions
- Implementation of spatially variable dispersion coefficients.

There has been improvement in the model performance as a result of the above, and BMT WBM's review of this performance is presented below.

2 Review

The report reviewed by BMT WBM is entitled *Estuary Hydrodynamic and Solute Transport Model Calibration – West Culburra Estuarine Management Study (MP 09_0088) (P1203365JC26V03 November 2014)*.

2.1 Model Suite

As per previous review comments, the model suite is acceptable. If the consultant does believe that three dimensional processes are important (as claimed), then it may need to consider moving to a platform that can accommodate such simulation. This will be determined following outcomes of further works required below.

2.2 Modelling Process

The industry accepted modelling process in these types of studies is generally as follows:

(1) Develop hydrodynamic model.

(2) Calibrate hydrodynamic model.

(3) Develop AD model.

(4) Calibrate AD model.

(5) Define scenarios.

(6) Execute scenarios.

(7) Report results.

Each section below presents a review of items (1) to (5) above.

2.3 Develop Hydrodynamic Model

The hydrodynamic model has been constructed appropriately, noting however the possibility that moving to three dimensional modelling may be required if the consultant believes that 3D processes are important.

2.4 Calibrate Hydrodynamic Model

The model is appropriately calibrated to water level and flow. There is some evidence of phase differences between measured and modelled water level data at times, but this is not of material significance to the study.

2.5 Develop AD Model

The advection dispersion model has been constructed appropriately. The development of a relationship to predict salinity at the downstream boundary appears to reproduce, to an extent, measurements.

2.6 Calibrate AD Model

The calibration of the AD model has proven most difficult in this study, and BMT WBM has liaised at length with the consultant as to the progression of this task. The consultant has encountered a number of challenges, including:

- Specification of the temporal evolution of downstream salinity boundary
- Collection of reliable field data
- Interpretation of field data (especially at Billy's Island)
- Proper prediction of catchment derived fresh(er) inflows
- Inclusion and specification of a range of structures
- Simulation of potential three dimensional effects (in a two dimensional model).

Unfortunately for this study, a good deal of the field data collected was either unusable or difficult to interpret, and this made the consultant's modelling tasks more challenging. Of particular note were the

failure of the salinity sensor at the estuary mouth (and other locations), and the reported unusual behaviour of the continuous salinity measurements recorded at Billy's Island. Notwithstanding this, the consultant has shown determination in overcoming these issues and this determination has been evidenced in moderate model improvement.

Overall, the following is noted in terms of the salinity calibration:

- The model is generally able to capture some gross trends in estuarine salinity over the calibration period at the sites presented. This is consistent with the model's ability to reproduce hydrodynamics well and some of the reported spot salinity measurements, although the latter comparison needs to be made with caution given the temporal paucity of these spot measurements.
- The model is able to generally predict some of the salinity trends and (to a degree) the diurnal variation of salinity at Curley's Bay, although again this comparison is hindered by problems with the field data leading to a shortened record availability.
- The model was not able to predict continuous salinity measurements at Billy's Island, either in trend of diurnal variation. The consultant therefore discarded these data in the calibration report (see below). This will most likely attract criticism and presents some concerns to this reviewer.
- The model is able to generally predict the salinity trend at Culburra Road Bridge, although it underpredicts salinity for a significant period of time near the commencement of the simulation. Following this period, however, the model is able to capture some of the low frequency variation in salinity at this location.
- The diurnal variation of salinity predicted by the model at Culburra Road Bridge is consistently too great, other than for a short time period towards the end of the simulation.

The report offers some reasons for some of the above differences in modelled and measured data. These include:

- The sensor at Billy's Island being not representative of main stream salinity conditions. This may be the case, but no evidence is presented in support of this position.
- The estuary may exhibit some three dimensional behaviour not able to be captured by the two dimensional model with regard to salinity dynamics. Again, this may be plausible however no evidence is presented to support this position.

Overall, the AD calibration has encountered a number of issues that whilst they have been earnestly addressed by the consultant, have nonetheless had a detrimental impact on the ability of the model to defensibly reproduce measurements. As such, the AD model calibration is not of the highest standard, and will attract criticism from third parties as it currently stands. For example, pointing to the model's significant overestimation of diurnal salinity amplitudes at Culburra Road Bridge might be one way to relatively easily cast doubt over the model's overall predictive capability. If this report is made public then it would be reasonable to expect a degree of criticism in this, and potentially other, regards. This presents a concern to this reviewer.

The question that then arises is to whether or not the model as it stands is fit for purpose, and whether more work on the model could materially improve its predictions. In this case, this relates to how well it might predict the fate and transport of stormwater runoff from the site within the estuary, particularly as related to interaction with nearby aquaculture leases. On the balance of the evidence presented to date,

this reviewer believes that the model could potentially be used to this end, but further work is required to demonstrate this.

In order to advance, this reviewer requires that:

- The performance of the current model over the time period originally presented in the August 2014 report be investigated via executing the most recent model over that period. The results should be reported and submitted for review.
- Following the outcome of that review, an assessment of the model's capability with regard to this project will be provided.
- If this review permits scenarios to proceed, a range of dispersion coefficients will be required to be used in those scenarios to demonstrate the likely range of impacts. The scenarios should not adopt a single dispersion coefficient, but present results from a range of coefficients, and present commentary on same.

2.7 Select Scenario Period

Commentary on this matter from previous reviews stands. In particular, 'worst case' scenarios should be examined in all cases, that is, scenarios that have high discharge from the proposed development site but have low co-temporal background riverine discharges occurring. It is suggested that the makeup of scenarios be reviewed before investing time in their setup and execution.

2.8 Summary

The report reviewed presents a model that has benefited from considerable investment both by the consultant and BMT WBM. The hydrodynamic calibration is acceptable (with the caveat around possible 3D processes). This review has recommended further work on the advection dispersion model calibration be undertaken in order to determine model suitability.