BRISBANE WATER ESTUARY PROCESSES STUDY
WATER QUALITY MODELLING
APPENDIX E

Report Prepared for

Gosford City Council and
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1. INTRODUCTION

This report forms Appendix E of the Brisbane Water Estuary Processes Study. It was prepared by Cardno Lawson Treloar for Gosford City Council (GCC) and the Department of Environment and Climate Change (DECC). It describes the purpose, data, study approach and outcomes of water quality modelling investigations undertaken as part of the Brisbane Water Estuary Processes study.

The basis for many of these analyses is drawn from the catchment runoff and estuarine hydrodynamics investigations undertaken for this study and reported in Appendices B and C, (Cardno Lawson Treloar 2007a and b). Details of those tasks have not been repeated herein. A database of existing water quality data was prepared for GCC by WBM in 2003 and some of that data has been used to set model boundary concentrations as well as initial concentrations throughout the model domain for the selected pollutants, TN and TP.

Figure 1.1 provides an overall plan of the study region, and includes the MUSIC-model catchment runoff-load discharge point locations in Brisbane Water.

2. WATER QUALITY SETTING

The nature, distribution, seasonal and temporal variation of pollutant concentrations in Brisbane Water is likely to have a significant influence on the ecological health of the waterway and to potentially impact on human health, as it may be affected by direct contact and consumption of waterway fauna such as fish and molluscs.

Many pollutants are adsorbed to the fine silt and clay particles that form the suspended sediment loads that discharge to the estuary during rainfall/runoff events. Hence the transport and accumulation of many contaminants can be inferred from the results of suspended sediment (mud) modelling described in Cardno Lawson Treloar (2007c).

The relationship between seabed sediments and pollutants has been addressed also in reports by Sydney University (USEGG, 2007) and the University of Newcastle (Gladstone and Shokri, 2007).

3. STUDY APPROACH

The purpose of these investigations has been to describe nutrient loads, TP and TN, discharged from the sub-catchments of Brisbane Water, in terms of total annual loads for wet, average and dry years, and then to investigate the transport of those nutrients from a large number of source points in Brisbane Water, see Figure 1.1. Discharge and nutrient load hydrographs were developed from the work undertaken in the Catchment Modelling study undertaken as part of the overall Brisbane Water Processes Study (2007a).

Additionally, although not entirely appropriate for event based modelling, the MUSIC model (Cardno Lawson Treloar 2007a) was used to estimate discharge and nutrient load hydrographs for a 20-years average recurrence interval (ARI) wet weather event affecting the whole Brisbane Water catchment and estuary. The outcome of that analysis was applied to ecological assessment by other consultants within the study team formed for the Brisbane Water Estuary Processes Study.

The transport and dispersion of catchment loads was investigated using the calibrated Delft3D model of the estuary (Cardno Lawson Treloar, 2007b), generally in terms of flushing times.

The model was operated in 3D using five equal thickness water column layers. The buoyancy of creek flows was included by specifying the flows to “fresh water” with zero salinity versus saline water (32ppt representing a dry period prior to rainfall) in Brisbane Water.

The modelling was divided into summer and winter periods so that the seasonal rainfall characteristics, and hence pollutant loads and diffusers in freshwater plume transport, were described.

Wet (1998), average (1995) and dry (2000) years, in terms of total annual rainfall were selected for simulation in terms of catchment loads and then nutrient concentrations within Brisbane Water.

Initial and model boundary concentrations for TN and TP were selected from WBM (2003). The nutrient data at each available sampling point, assumed to be depth-averaged, that is, consistent throughout the water column; was averaged over the data period. Spatial interpolation was then applied to form initial distributions of TN and TP.

Each simulation was undertaken over a period of two weeks. In each case the six-month seasonal loads for each of the three cases (wet, average and dry) were summed for each discharge point in the estuary. The average nutrient loads and discharges were then determined and used as input to the Delft3D estuary model. For the 20-years ARI case direct MUSIC model outputs were applied.

Although modelling has been undertaken in terms of TN and TP with no physico-chemical reactions, the distribution of other conservative contaminants can be inferred from these results.

4. RESULTS AND DISCUSSION

4.1 Annual Results

The results of these simulations have been presented as time series plots of TN and TP concentration. They provide a basis for describing the likely ambient concentrations of those contaminants for different annual rainfall and seasonal conditions. Results from 40 model output locations are provided for each simulation, the locations of which are shown on Figure 4.1. Model output is presented for near surface and near bottom concentrations.

Figures 4.2.1 to 4.2.20 refer to the dry year (2000) - summer results.

Figures 4.3.1 to 4.3.20 refer to the dry year (2000) - winter results.

Figures 4.4.1 to 4.4.20 refer to the average year (1995) - summer results.

Figures 4.5.1 to 4.5.20 refer to the average year (1995) - winter results.

Figures 4.6.1 to 4.6.20 refer to the wet year (1998) - summer results.

Figures 4.7.1 to 4.7.20 refer to the wet year (1998) - winter results.

Generally, the TN and TP results exhibit similar characteristics, but at different concentration levels. There is also a noticeable stratification effect, but within the larger waterway areas – compare Figure 4.2.1 (Dry) with Figure 4.6.1 (Wet), there is little change in nutrient concentration between wet and dry years.

Generally, the highest concentrations occur in Fagans Bay; but comparison between Figure 4.2.3 (Dry) and Figure 4.6.3 (Wet) shows that concentrations there can be higher there in dry years because of different flows. However, a similar comparison for the winter periods, see Figures 4.3.3 (Dry) and 4.7.3 (Wet) shows that the highest concentrations in Fagans Bay – up to TN of 1.4mg/L, may occur in wet years.

Other outcomes of the modelling are that:-

- Although many sites display a tidal signal, there is no evident spring-neap tidal effect
- The adopted initial concentrations are generally not changed significantly by the modelled catchment inflows. Hence the MUSIC model loads are likely to be realistic and the model system could be used to assess potential changes to these loads that might arise from proposed developments

Additionally, results showing the spatial variation of nutrient concentrations throughout the estuary have been presented at two selected times for both TP and TN and for all three years; summer and winter.

Figures 4.8.1 to 4.8.4 refer to the dry year (2000).

Figures 4.9.1 to 4.9.4 refer to the average year (1995).

Figures 4.10.1 to 4.10.4 refer to the wet year (1998).

An inter-comparison amongst all of these results shows that:-

The highest nutrient concentrations occur upstream of Woy Woy in Woy Woy Bay, notably in Corren Bay, and in the Gosford Broadwater near Narara and Erina Creek entrances. There are some other smaller 'hot spots', each at the mouth of Kincumber Creek.

Again the highest concentrations occur in winter in wet years.

Upstream of Ettalong Point, it should be noted that concentrations of TN and TP are both generally above the ANZECC (2000) guideline concentrations for TN and TP, 0.3 and 0.03mg/L, respectively. Coupled with the long flushing times in much of the estuary, up to about 30 days, see Cardno Lawson Treloar 2007b, one might expect that algal blooms could occur from time to time, assuming TN and TP are the limiting nutrients. However this is not the case.

4.2 20-years ARI Event

A similar set of time-series (Figures 4.12.1-20) and spatial plots (Figures 4.13.1-2) have been produced for the 20-years ARI simulation. Figure 4.11 shows the inflow hydrographs for the major creeks with one major peak occurring on about 7 August, with another smaller event on 17 August.

An examination of Figure 4.12.1, for example, shows that during rare high rainfall events there will be rapid increases in ambient concentrations that persist for well over the two weeks of the simulation period. In the Gosford Broadwater concentrations may nearly double.

Inspection of Figure 4.12.3 shows that a similar rapid increase in concentration occurs in Fagans Bay, up to a TN concentration of about 2mg/L, this only lasts for about three days, before reducing to a much smaller elevated concentration level. The two concentration peaks were caused by the second runoff peak. Note that this figure does not show the same relative changes in the main body of Brisbane Water.

The St Huberts Island region and The Rip area, see Figures 4.12.13 &14, show more rapid returns to pre-storm concentrations, together with larger tidally caused variations in concentration. These tidal variations reflect a greater spatial variation in concentration closer to Broken Bay.

Results at Hardys Bay, see Figure 4.12.19, show that recovery to background concentration is quick, and that wet weather events have a much smaller impact.

Figure 4.13.1 shows that during rare events such as this, Narara and Erina Creeks cause the most significant changes in nutrient concentrations.

4.3 Comparative Results

4.3.1 Nutrients

Figures 4.14.1 to 4.14.8 present selected time series results for all of the annually based simulations. Note that all of these results refer to the surface layer. They show that generally, the wet year (1998) results led to higher nutrient concentrations, especially at sites such as Brisbane Water and Woy Woy Inlet, which are close to major drains or creeks.

None of the creek flows have affected the overall bulk hydraulics of the estuary, as is shown in Figure 4.15.1 which presents the water level time-series for all seasonal cases, although seen as a single line. That is, apart from near the creek and drain entrances themselves, there will be no noticeable changes to current structure.

Figures 4.15.2 to 4.15.5 show however, that surface layer salinity can be noticeably reduced throughout much of the estuary during wet years.

5. CONCLUDING REMARKS

This report presents the results of a range of water quality simulations undertaken using seasonally and weather based variations in catchment loads.

The data are presented graphically and demonstrate clearly that:-

- Narara and Erina Creeks, followed by Kincumber Creek, provide the greatest nutrient loads, and being located in the most upstream regions of the estuary, these are the areas flushed most slowly – as one would expect.
- Those areas in the upstream reaches of the estuary show less tidal variation in nutrient concentration than those areas close to Broken Bay

The results from these analyses provide background information for future ecological assessments that will form subsequent phases leading to the preparation of the Brisbane Water Estuary Management Plan.

6. REFERENCES

Cardno Lawson Treloar (2007a): Brisbane Water Estuary Processes Study. Catchment Modelling – MUSIC, Appendix B. Report Prepared for Gosford City Council and Department of Natural Resources.

Cardno Lawson Treloar (2007b): Brisbane Water Estuary Processes Study. Hydraulic Processes, Appendix C. Report Prepared for Gosford City Council and Department of Natural Resources.

Cardno Lawson Treloar (2007c): Brisbane Water Estuary Processes Study. Estuarine Morphology and Siltation, Appendix D. Report Prepared for Gosford City Council and Department of Natural Resources.

Gladstone, W. and Shokri, M.R. (2007) Spatial and Habitat Related Patterns in the Biodiversity of Brisbane Water Estuary: A Tool for Sustainable Estuary Management. Centre for Sustainable Use of Coasts and Catchments, University of Newcastle (Ourimbah Campus).

USEGG (2007): Heavy Metal Distribution and Sediment Quality in the Brisbane Water Estuary, NSW. Prepared for GCC and DNR.

FIGURES