MORUYA/DEUA ESTUARINE PROCESSES STUDY

Summary Report

November 2003

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1 INTRODUCTION

This study has been undertaken in order to determine the estuarine processes that directly influence the future management of the Moruya/Deua River Estuary.

The Estuary Management Policy of the NSW Government is set out in the draft Estuary Management Manual of October 1992. The policy outlines a structured process leading to the implementation of a balanced long term management plan for the sustainable use of each estuary and its catchment in which all values and uses have been considered (Figure 1). Accordingly, the Moruya/Deua Estuary Management Committee was set up by Council in April 1999 for the purpose of preparing a management plan for the estuary.

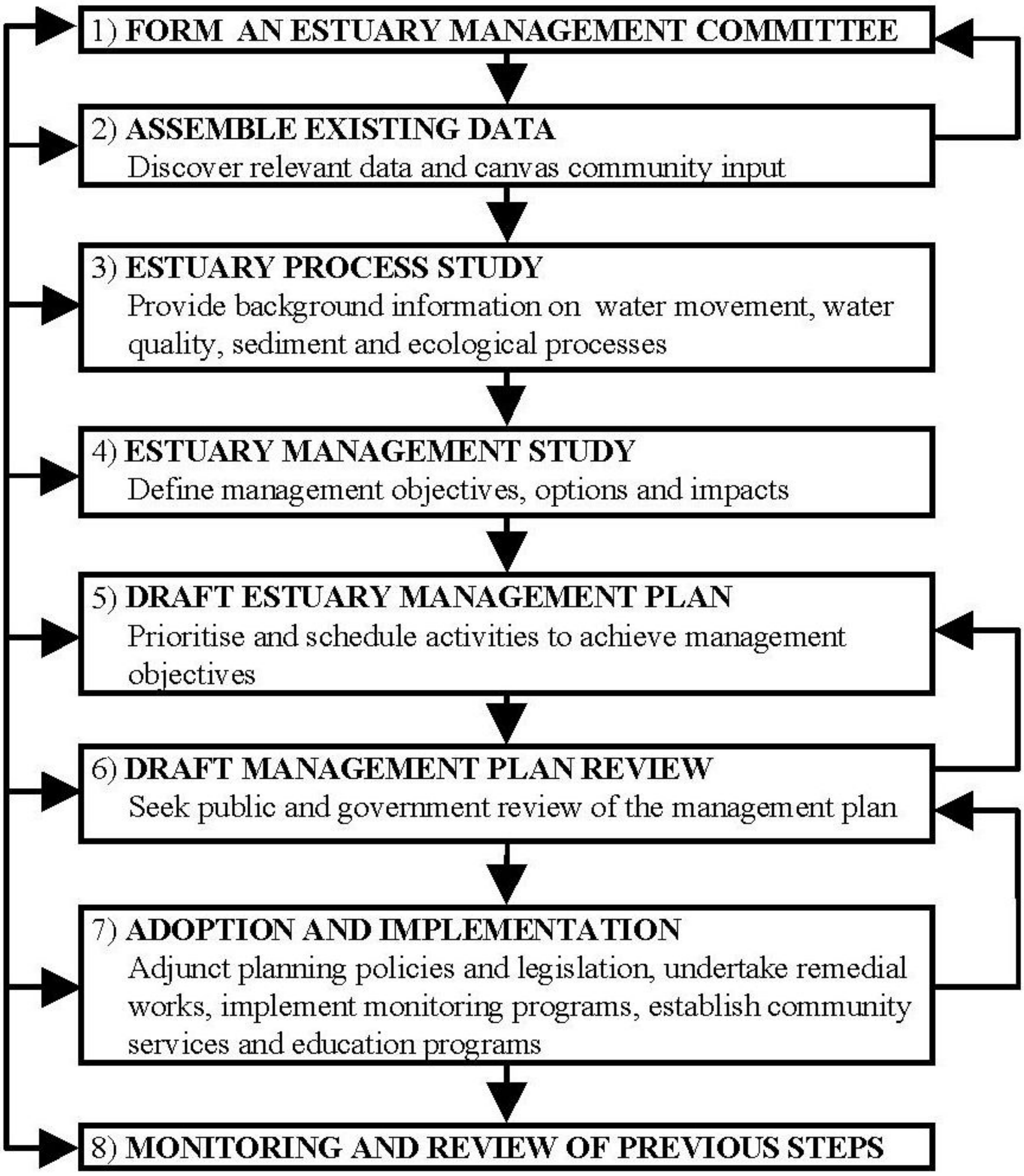

Figure 1: NSW Government's recommended steps for estuary management.

Subsequently, a Data Study (Young and Thoms, 2000)) was undertaken to reference all data held by Government Departments, Academic Institutions, the CSIRO and other research organisations. Issues were to be discussed and prioritised, data gaps identified and the scope of process studies identified.

The Moruya/Deua River (Figure 2) has a large catchment compared to many other NSW South Coast estuaries (about 1,500 km^2 - Warner 1981, Young and Thoms 2000). The catchment is 10% flat coastal plain, 30% undulating and hilly, and 60% rugged mountains (Young and Thoms, 2000). Rural lands exist around the estuary, along the river valley and in the north-east corner. The rural lands are basically used for grazing, beef, dairy cattle and sheep. Gold mining has taken place within the catchment.

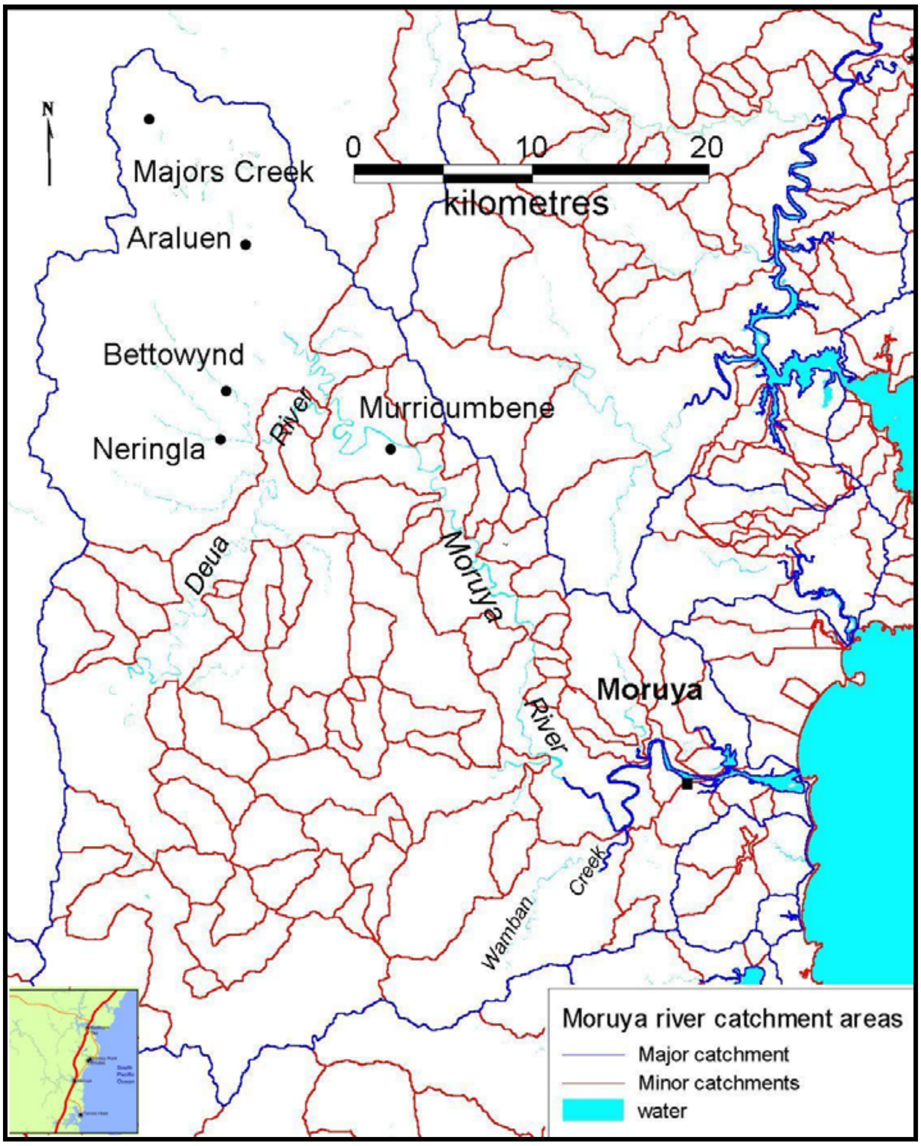

Figure 2: Locality map of the study area.

Figure 3: Loss of natural vegetation by erosion.

Major issues related to the estuary identified by the Data Compilation Study were:

- Erosion of banks and vegetation along the river;
- Loss of natural vegetation filters/buffers;
- Increased sedimentation in the estuary;
- Loss of seagrass due to sedimentation;
- Impact of sediment load on oysters in the lower estuary;
- Water quality particularly nutrient levels and faecal contamination, and their effects on the ecology and amenity of the estuary;
- Potential for acid sulphate soil disturbance and acid drainage to the estuary;
- The effect of commercial fishing on fish stocks;
- Impacts of boating activity on the upper estuary and
- Sediment mobility, affecting navigation and access.

The issue of the impact of individual developments on water quality is covered under the New South Wales Government's Development Application Process and has been omitted from consideration in the Process Study.

The Estuarine Processes Study was undertaken to develop an understanding of:

- The catchment and estuarine processes behind the erosion, sedimentation and water quality problems identified in the data compilation study;
- Sediment characteristics, sediment dynamics and hydrodynamic processes in the estuary;
- Water quality characteristics of the estuary including mixing and flushing behaviour; and
- The scale and nature of bank erosion in the estuary, an assessment of the likely causes and appropriate remedial measures.

The Estuarine Processes Study has been undertaken to provide information leading to the next stage in the estuarine management process; the preparation of a management plan for the estuary.

Figure 4: Sandbanks near the mouth are formed by natural processes.

2 ESTUARINE HYDRODYNAMICS

A numerical computer model was developed which uses the shape of the estuary, freshwater inflow from the catchment and tidal heights to predict water movement in the estuary. Knowledge of the water movement can then be used to understand sediment and water quality patterns in the estuary.

Using information on sediment particle sizes present in the estuary, transported in from the ocean and carried into the head of the estuary from the catchment, the sediment module predicts the transport, scouring and deposition of sand and silt particles.

The water quality module uses information about chemical reactions to predict the dispersal and attenuation of pollutants. Also, the water quality model has the ability to make predictions about dispersal of biological agents such as bacteria and viruses.

The output of the model is demonstrated with a number of different scenarios for the movement of sediments and dispersal of pollutants in the report and accompanying CD. However, the real value of the model is that now it has been constructed it can be used to run different scenarios that managers may need information about.

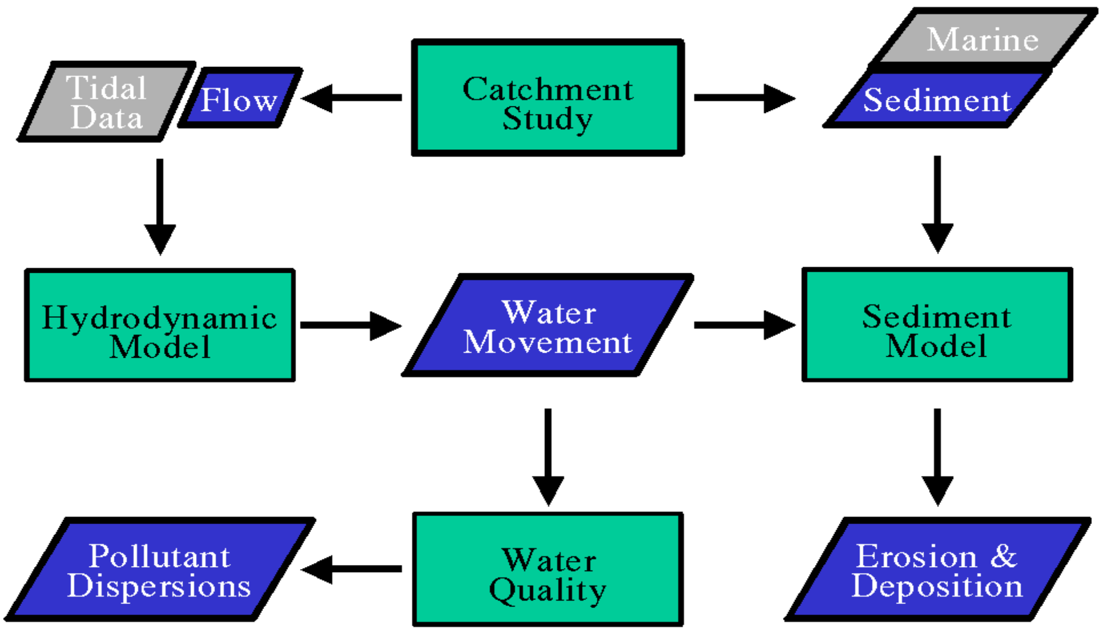

Figure 5: Hydrodynamic modelling process

The mouth of the estuary is permanently open, under most conditions there is a significant input of freshwater from the catchment and there are extensive reaches of the estuary exposed to wind. As a result of these features, the estuary is well mixed with a gradient of increasing salinity with distance from the mouth.

The review of existing hydrodynamics data and subsequent results from hydrodynamics modelling of the Moruya Estuary yielded the following observations on the hydrodynamics of the Moruya/Deua Estuary:

NON-FLOOD CONDITIONS

Major observations for non-flood conditions were:

- Tidal gradients are steep in the lowest kilometre of the river, generating high velocities there;
- Tidal gradients are mild elsewhere in the estuary;
- The tide has only a small asymmetry with the outflowing tide lasting about 20 minutes longer than the inflowing tide;
- The small tidal asymmetry means that the velocities on inflowing tides are comparable with those on the outflowing tide being about 7% greater. (Consequently, potential for sediment movement is similar for inflowing and outflowing tides as wave stirring contributes to the inflowing sediment load offsetting the effect of higher outflow velocities.);
- Tidal flow velocities were similar for drought and average conditions indicating tidal generated velocities are the dominant source for water movement in the estuary; and
- At two sites, the entrance and near Quarry Wharf the shape of the estuary significantly affects tidal flows.

Under non-flood flow conditions, maximum current velocities are achieved at the entrance and along the rock wall at Pilot Station Backwater. Scouring of large sediment particles can be expected in these locations. In the rest of the estuary threshold flow velocities for scour of sand (approximately 0.1 - 0.4 ms^{-1}) occur up to the Mogendoura Creek junction. These generalisations ignore localised variations hence minor scouring is possible on the ebb tide upstream of the Mogendoura Creek junction. The model reveals that even during non-flood conditions there is a high potential for sediment movement in the lower reaches of the estuary.

Figure 6: Mid-estuary current velocities are sufficient to transport sediment.

FLOOD CONDITIONS

Major observations under flood conditions were:

- During floods, water levels are independent of the tide, except near the mouth for the once in one year flood;
- The maximum water level is predicted to rise steeply with distance from the ocean;
- Velocities under flood conditions greatly exceed the threshold for scour near the entrance on all floods and throughout the estuary on all floods greater than the once in one year flood; and
- Very high velocities also occur in most of the channel upstream of the hospital, particularly near the confluence with Mogendoura Creek, where there is a small section of the channel with extremely high current velocity.

Under flood conditions, the ebb velocities all along the estuary are increased significantly, particularly at the entrance. With distance upstream, the general trend is for decreasing ebb velocities. However, a local peak is observed on the model output point at approximately 11 km from the ocean, near the junction with Mogendoura Creek (Figure 7). Flow acceleration around these sites is due to constrictions in the channel; the smaller channel cross-section must accommodate the same volume of water passing through and hence leads to greater current velocities. For all flood conditions, current velocities are above the threshold for scouring and sediment transport all along the estuary.

From the study of hydrodynamics, areas of concern for consideration in the Water Quality and Sediment Transport Studies were identified.

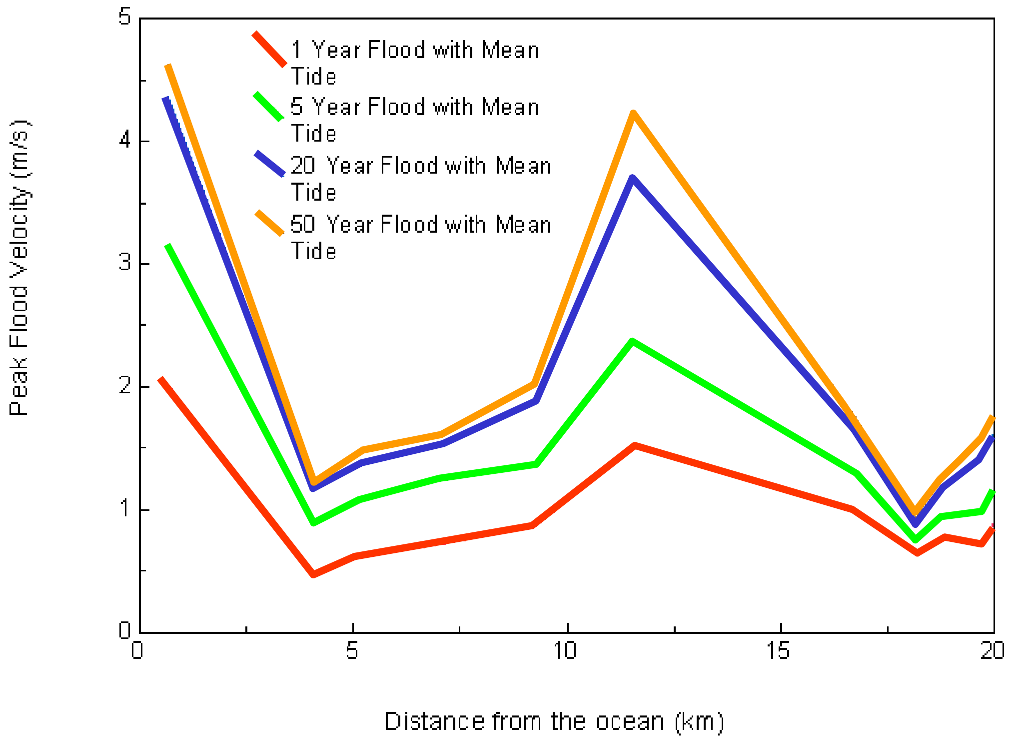

Figure 7: Model predicted peak flood velocity along the estuary.

3 SEDIMENTATION

The catchment geology is dominated by Paleozoic sedimentary (e.g. sandstone) and metamorphic rocks but with significant areas of granitic rocks also present. The sandstone and granites are particularly significant because they weather to sand and produce sandy alluvium. Thus weathering of rocks in the Moruya/Deua catchment is capable of supplying considerable amounts of sand. O'Brien (2001) identified that a large proportion of the sediment in the estuary came from areas where alluvial gold mining had occurred in the past. This may be because;

- gold mining mobilised the sediments;
- gold mining occurred where there were large deposits of sediment suitable for transport into the estuary; or
- A combination of the two.

Coastal sands are another major source of sediment. Under normal conditions, wave-stirred sediments are picked up by the incoming tide and carried into the estuary. They are then deposited inside the estuary. In the estuary there is less wave stirring than in the ocean so particles are less likely to become resuspended and carried out by the outgoing tide. Thus, for normal flow conditions, there is a gradual build up of coastal sand inside the estuary mouth. Sand (river and coastal) is exported from the estuary during floods when the outgoing current is much stronger than the incoming current.

Inspection of the estuary sediment revealed sediment is mostly derived from the catchment, with the sand in the lower 2 km being derived from the coastal sediments. There is considerable evidence that the Moruya Estuary has a large input to the local coastal sediment beds. Quantities of sediment input from bank erosion are insignificant in the total sediment budget.

Figure 8: Lower reaches of the river have large sand deposits.

It has been speculated rates of sedimentation have increased in the Moruya Estuary over the past 30 years (Pollock, 1999). There have been a number of changes in the catchment that singularly or in combination may have increased sedimentation in the estuary. These are:

- Long term weather patterns;
- Introduction of stock;
- Bushfires; and
- Human activities.

Because the sandbanks are frequently changing it is very difficult to determine if there has been an actual increase in sedimentation without undertaking a comprehensive survey. A review by AMOG of aerial photos, taken between 1940 and the present showed that in the main estuary there has been no obvious long-term growth of shoals. We found there were periods of gradual sediment accumulation as well as periods of rapid build up and rapid scouring of sandbanks. An exception to the general trend was the Pilot Station Backwater, which showed a constant sediment build up between 1940 and the present period.

The hydrodynamic model predicted significant scouring throughout the estuary under flood conditions. Sediment is carried down from the catchments with the flood and also picked up from the riverbed so that the water is carrying the maximum sediment load. As a consequence any areas where current velocities decrease sedimentation occurs and scouring occurs where current velocities increase. The shape of the estuary is such that there are a number of constrictions that form "jets" as floodwater passes them. Erosion is high in these areas and sediment is deposited before and after these "jets" (Figure 9).

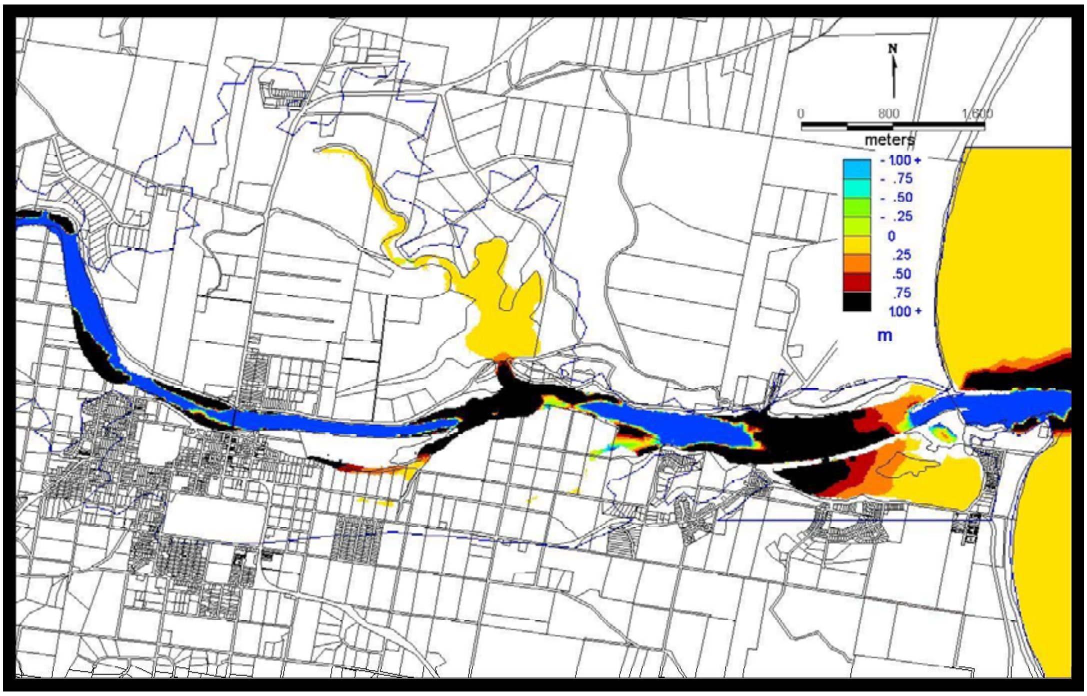

Figure 9: Bed change in the lower estuary for 50 Year Flood.
(Note black represents deposits greater than 1 metre high, dark blue erosion of more than 1 metre.)

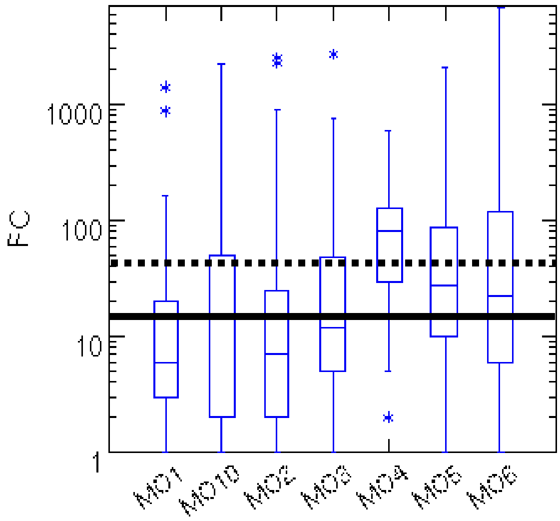

Figure 10: Spatial variation in faecal coliform counts
(Shown as FC) expressed as CFU/100ml
Solid line represents ANCECC (2000) guideline level that median values should not exceed for shellfish culture. (Median values are the line in centre of the boxes).
Dashed line represents ANCECC (2000) guideline level that no more than 10% of values should exceed for shellfish culture. (Above the top of the box represents 75% of values. The whiskers give the range where 95% of values are statistically expected).

4 WATER QUALITY

Since 1991 the Eurobodalla Shire had measured a range of water quality indices at seven sites, five between the mouth and the town, one at Kiora Bridge and the other in the lower reaches of the Deua River before it discharges into the estuary. The Deua River site is above the estuary. Therefore, this site does not measure estuarine water quality but is valuable in providing information on the quality of water flowing into the estuary.

Major points from the water quality review are:

- Faecal Coliforms (FC) - FC levels are of concern in the lower estuary and indicate potential problems for people eating wild caught oysters and other seafoods;
- Phosphate Concentration - At all sites the ANZECC guideline for Aquatic Ecosystem Protection for phosphate concentration was exceeded indicating high nutrient loading to the estuary. This can potentially contribute to algal blooms in the future, although available nitrogen is the limiting factor;
- NOx Concentration – At all sites nitrate concentrations were within acceptable limits;
- Ammonia Concentration – Ammonia concentrations were consistently above the ANZECC (2000) trigger levels for ecosystem maintenance. Ammonia is another source of nitrogen for plants and does indicate a potential for algal blooms.

- Dissolved Oxygen (DO) - Median DO concentration values recorded at all sites was within all ANZECC guidelines;
- pH - All sites recorded pH values within the ANZECC guidelines; and
- Turbidity - In the lower estuary turbidity values exceeded ANZECC guidelines for aquatic ecosystem protection. Turbidity values in the upper estuary were within the guidelines.

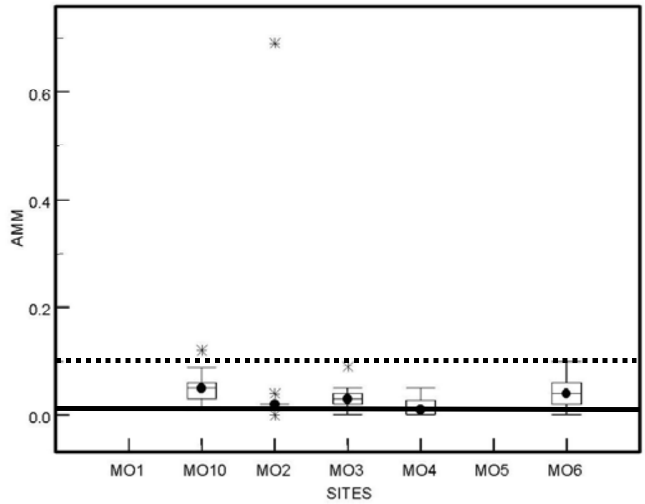

Figure 11: Spatial variation in ammonia concentration
(Expressed in mg/L.)
Dashed line ANCECC (2000) trigger level for contact with the water.
Solid line ANCECC (2000) trigger level for maintenance of aquatic ecosystems.

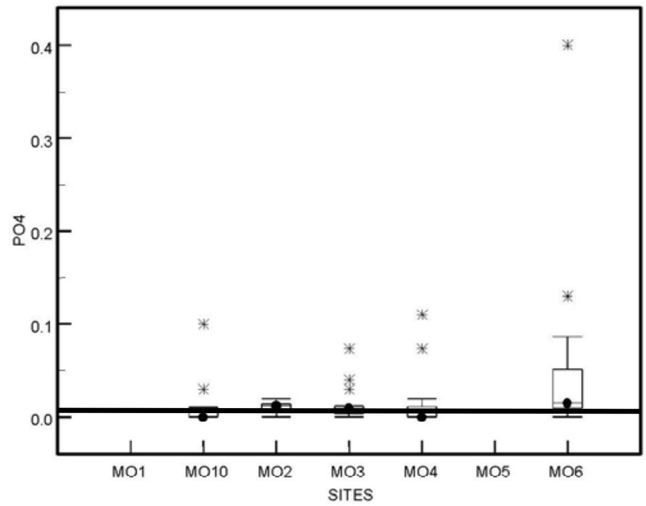

Figure 12: Spatial variation in phosphate concentration
expressed in mg/L.
Solid line ANCECC (2000) trigger level for maintenance of aquatic ecosystems.

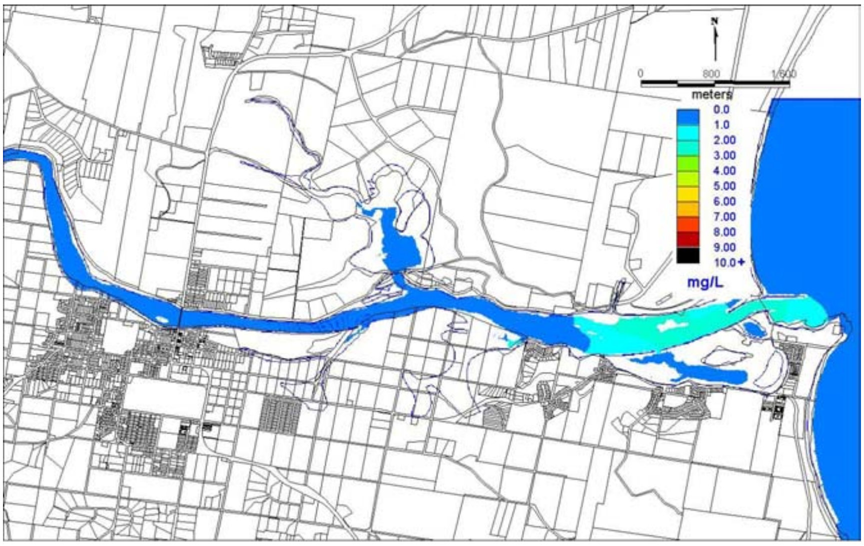

Figure 13: Dispersal of pollutants predicted by the estuary model.
Dispersal 6 hours after a discharge from Racecourse Creek on a spring tide.

Numerical modelling can be used to provide a large amount of information about pollution events in the estuary and four scenarios were used to demonstrate the model.

1. Pollutant inflow at the junction of Racecourse Creek and the Moruya River with a spring tide;
2. Pollutant inflow at the junction of Racecourse Creek and the Moruya River with a neap tide;
3. Pollutant spill in the vicinity of the Town Wharf with a mean tide; and
4. Pollutant spill in the vicinity of Kiora Bridge with a mean tide.

Figure 14: Water quality indicates potential eutrophication problems.

The output of these model runs demonstrated the problems with flushing in the upper estuary. Material entering into the upper estuarine reaches moved back and forth as a slug over several tidal cycles before any appreciable dilution occurred. During this time it was only downstream a little way by the fresh water input. On the other hand material released below the Princes Highway Bridge was rapidly dispersed and a large proportion discharged into the ocean within the first few tidal cycles.

Results from the hydrodynamics water quality model of the Moruya Estuary have shown that tidal exchange is important to estuarine water quality. Tidal exchange allows clean marine water to dilute pollutants within estuary water. The rate of pollutant dispersal within the water of the Moruya estuary was found to vary with distance from the sea. In the lower estuary, where tidal exchange was highest, more than 50% flushing of pollutant occurred within 30 hours of discharge. In the upper estuary pollutant flushing took longer than five days.

Figure 15: Infrastructure damage caused by erosion.

5 BANK EROSION

Bank erosion is considered by the community to be a major problem in need of management. Erosion is a natural process due to natural meandering of river, wave action and sometimes flood events. The Moruya Estuary is highly susceptible to erosion because in a large number of places the banks are composed of unconsolidated fine materials with sands and silts mixed in different proportions.

Figure 16: Rock riprap lining only at high tide.
The vertical extent of the rock riprap lining in some areas is limited to the area around and just above high tide level.

Our field investigations found that in the upper estuary undercutting of the bank was common but generally not severe. Undercutting of the bank is caused by the action of waves, with the sediment then being carried away by the currents. These waves can be generated by wind and boat wash. Bank undercutting occurred both at Yarragee and higher up the estuary, such as near Kiora Bridge where boating would be infrequent indicating that wind generated waves play an important part in bank erosion of the upper estuary.

Problems of trampling and overgrazing associated with both stock and wildlife were also contributing to the minor erosion problems in the upper estuary.

The Data Compilation Study identified concerns that catchment activities such as runoff from gravel roads, land clearing, mining, grazing, etc, were causing erosion in the estuary. Such activities would definitely cause erosion problems in the catchment. It is recognised that for estuaries where there is little natural sediment in the catchment increasing catchment erosion adds sediments to the stream loads. The added weight and mechanical impacts of this added sediment can result in increased erosion in the estuary during floods. Presumably such an effect is what the data compilation was referring to (assuming when talking about estuary erosion they did not mean catchment erosion). Because of high natural erosion in its catchment, the Deua River would naturally carry very high sediment loads. Consequently, it is extremely unlikely that increased erosion in the catchment due to human activities will have any appreciable impact on estuarine erosion rates. This theory was backed up during the geomorphological field survey, as no evidence was found that catchment activities were directly responsible for erosion in the Moruya Estuary.

Very slight erosion was observed around Malabar Lagoon caused by wind waves acting on a poorly vegetated shoreline.

Most of the banks in the lower estuary have had rock walls erected to protect them from erosion. These walls are basically dumped rocks and do not appear to be withstanding the loads due to currents, water level fluctuations and wave action.

Figure 17: Bank erosion behind the rock riprap.
Bank erosion behind the rock riprap lining was observed in a number of places.

Site inspections of the rock walls revealed:

- Slumping of rock walls due to loss of toe support;
- Erosion of banks above and behind rock walls; and
- Large voids in the walls, reducing their effectiveness and increasing their susceptibility to failure.

There is a need to undertake an engineering audit to determine where the walls need to be replaced or strengthened. Remedial measures such as repair or rebuilding of the walls, the provision of filter layers under the main rock armour, the raising of crest heights, and the termination of walls can then be designed, costed and planned.

Figure 18: Vertical banks subject to bank erosion at the rear of the motel.

6 REFERENCES

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Figure 19: Upper-estuary bank erosion due to stock and wildlife.
Animal damage, either stock or wildlife, is a contributory factor in bank erosion in some places particularly where the banks are of unconsolidated sediments.