Australian Government
Department of the Environment, Water, Heritage and the Arts

Marine and Tropical Sciences Research Facility (MTSRF)
June 2008 Milestone Report

Project 3.7.4 – Wetlands and floodplains – connectivity and hydro-ecological function

Project Leader: **Dr Jim Wallace, CSIRO.**

Summary

Summary of Milestone report

The project has accelerated its progress in the last 6 months since the Hydro-dynamic software (MIKE21) has been obtained. Initial model runs and calibration have been completed and preliminary wetland connectivity indices calculated. The new LiDAR data has been processed and is proving invaluable in the identification of wetlands and flow pathways between them. Strong interaction between projects 3.7.4 and 3.7.3 continues to grow with mutual benefits. Preliminary results on flood loads and wetland connectivity have been presented at the MTSRF Annual conference. The project is also gaining international recognition via the invitation to present results at a UNESCO eco-hydrology meeting in Europe; these will be published in the International Journal of eco-hydrology and hydrobiology.

For reference: Milestone extracted from Project Schedule

Project 3.7.4 ***Date 30 June 2008***

Report 2 submission:

(a) Draft progress report on the development and testing of hydro-dynamic modeling for use in floodplain sediment and nutrient transport and wetland connectivity. [CSIRO]

(b) Information transfer between agencies: Data collected in this project by CSIRO, JCU and GU will be made freely available amongst these parties on request. Responsible officers: J Wallace (CSIRO), R Pearson (JCU) and A Arthington (GU)

Project Results

Description of the results achieved for this milestone

(a) Draft progress report on the development and testing of hydro-dynamic modeling for use in floodplain sediment and nutrient transport and wetland connectivity.

Progress with the hydrodynamic modelling has accelerated in the last 6 months as the issues with IP and software licences have all been resolved. The MIKE21 model has now been fully implemented on computers at the CSIRO Davies lab. Initial model runs took very long, e.g. an 8 day flood would take 2 days to run on our computer. We have invested in a new high speed computer that has greatly reduced runs times, in the previous example to 6 hours. This now means we can carry out the numerous model runs required in the developing and testing phase of the project. Preliminary test runs of the MIKE21 model have been completed and comparison made with the earlier work by Connell Wagner in the Tully-Murray catchment. These comparisons have revealed some differences in the model set up which are being evaluated and where necessary rectified.

Preliminary estimates of the use of the MIKE21 model to calculate connectivity indices for a number of wetlands in the Tully-Murray catchments have been completed. These have shown how the connectivity of different wetlands is affected by their location and the size of any given flood. These wetland indices were developed in collaboration with Richard Pearson (JCU) and Angela Arthington (GU), who will continue to be involved in their further refinement. The results of this preliminary analysis were reported at the MTSRF Annual Conference in Cairns (abstract attached).

The use of the MIKE21 model for sediment and nutrient transport across the floodplain has been deferred while the above wetland connectivity work has been completed. However, in the meantime we have been able to estimate the loads of sediment and nutrients that are delivered to the ocean during floods in 2007. Although absolute concentrations of sediment and nutrient in flood water were quite low, the large volume of water discharged during floods means that they make a very significant contribution to the marine load. For example, during the 2007 wet season the 3 flood events alone carried sediment and nutrient loads that were large fractions (> 50%) of the total annual average river borne loads. Since much of the flood discharge is not measured by the river gauges, this flood load will add significant amounts to the currently estimated annual average riverine load. It also appears that flood waters carry more dissolved organic nitrogen (DON) than dissolved inorganic nitrogen (DIN) and this is the opposite of their concentrations in river water. Consequently DON loads to the ocean may be nearly twice those previously estimated from riverine data. These results have implications for Water Quality Improvement Plans, and these have been reported to TERRAIN for inclusion in their Tully-Murray WQIP.

Good progress has been made in analysing the LiDAR data that was obtained for the central portion of the Tully-Murray floodplain in October. All data corrections have been carried out and a vey high resolution Digital Elevation Model (DEM) completed. This DEM has also been merged within the coarser resolution DEM available for the entire floodplain.

This combined data set is now ready for use in the hydro-dynamic model. Inspection of the LiDAR data has revealed that it will not only be useful for DEM and hydraulic roughness data, but also a number of other floodplain applications including lagoon periphery DEM's, wetland identification and connectivity and riparian vegetation characterisation.

We have also continued to record flood depths, suspended sediment and nutrient concentrations in flood waters during over bank events in the Tully-Murray catchments during the 2008 wet season. This was done using the semi-automated flood water quality sampling system that was designed and installed in the Tully-Murray floodplain during 2006 (see Hawdon *et al*. 2007). We successfully recorded sediment and nutrient concentrations in all four of the flood events that occurred between January and March 2008.

(b) Information transfer between agencies: Data collected in this project by CSIRO, JCU and GU will be made freely available amongst these parties on request. Responsible officers: J Wallace (CSIRO), R Pearson (JCU) and A Arthington (GU)

Several meetings have been held between CSIRO staff in Project 3.7.4 and JCU staff and students. These have been extremely useful in helping to refine the focus of Projects 3.7.3 and 3.7.4 and the PhD work associated with them. There is now joint hydrological and ecological study of some common wetlands in the Tully-Murray. CSIRO bathymetry, flow and dissolved oxygen data recorded in Kyambul lagoon have been shared with JCU and GU to help in the interpretation of the chemical and ecological status of this wetland. Other wetlands identified by JCU and GU for ecological study will also form the focus of CSIRO wetland connectivity analyses (see above for preliminary results of this work).

(c) Summary of communications and liaison activities

a. Jim Wallace has been invited to give a keynote paper on floods and water quality in the GBR at the International UNESCO Conference on *Ecohydrological Processes and Sustainable Floodplain Management Opportunities and Concepts for Water Hazard Mitigation, and Ecological and Socioeconomic Sustainability. 19 – 23 May 2008, Lodz, Poland* (Draft paper attached).

b. Preliminary results from the wetland connectivity analysis performed using the MIKE21 hydro-dynamic model and LiDAR data were presented at the MTSRF Annual Conference in Cairns, 28 May – 1 June 2008 (see attached abstract).

c. Results from the flood water quality sampling in 2007 were presented at the MTSRF Annual Conference in Cairns, 28 May – 1 June 2008 (see attached abstract).

d. The flood water quality results were also presented at JCU, Cairns on 1 June 2008.

e. Freshwater quality sub-projects collaboration: Further meetings have taken place between Jim Wallace, Richard Pearson and Angela Arthington to develop sub-project details and collaborative links between projects 3.7.3 and 3.7.4.

f. The Cardwell Shire Floodplain Steering committee has been kept briefed on progress with the MTSRF projects 3.7.4 and 3.7.3.

g. Preliminary results from the flood water quality studies in the Tully have been reported to the RWQP (via Jane Waterhouse).

(d) Publications arising from the project and associated research include:

i. WALLACE, J.S., STEWART, L.S., HAWDON, A. and KEEN, R. 2008 The role of coastal floodplains in generating sediment and nutrient fluxes to the great barrier reef lagoon in Australia. *International Journal of Ecohydrology and Hydrobiology* (Submitted).

ii. WALLACE, J.S., STEWART, L.S., HAWDON, A. and KEEN, R. 2008. The impact of floods on sediment and nutrient fluxes from the Tully-Murray catchments to the GBR lagoon. CSIRO Land and Water Science Report No. /08; 53pp.

iii. KARIM, F.M AND WALLACE, J.S. 2008 (In Prep). Assessment of Sediment and Nutrient Transport across the Tully-Murray Floodplain using the SedNet Model. Report to the Marine and Tropical Science Research Facility. CSIRO Land and Water Science Report No. /08; 18pp.

iv. WALLACE, J.S., HAWDON, A., KEEN, R. and STEWART, L. 2007. Flood water quality and sediment and nutrient loads to the Coral Sea after cyclone Larry. In: *Abstracts: Cyclone Science Seminar: Impacts of cyclones on terrestrial tropical ecosystems – insights from severe cyclones Larry and Monica*. 27-18 September 2007, Australian Tropical Forest Institute, JCU, Cairns

v. HAWDON, A., KEEN, R., KEMEI, J., VLEESHOUWER, J. and WALLACE, J.S. 2007. Design and application of automated flood water quality monitoring systems in the Wet Tropics. CSIRO Land and Water Science Report 49/07; 27pp.

vi. WALLACE, J.S., ARTHINGTON, A.H., AND PEARSON, R.G. 2007. Hydro-ecological modelling in coastal catchments: connectivity and hydro-ecological function. Report from the MTSRF Workshop held at the CSIRO Davies laboratory, Townsville, 19 – 20 April 2007. CSIRO Science Report XX/07; 55pp.

vii. WALLACE, J.S., HAWDON, A., KEEN, R. and STEWART, L.S. 2007. Water quality during floods and their contribution to sediment and nutrient fluxes from the Tully-Murray catchments to the GBR lagoon. Report to FNQNRM for their Water Quality Improvement Plan. CSIRO Science Report Y/07; 35pp.

viii. WALLACE, J.S., BOHNET, I., DISHER, M., FORD, P., GEHRKE, P., HARTCHER, M.. HAWDON, A., HENDERSON, A., HODGEN, M., McJANNET, D., KEEN, R., McKEOWN, A., LARSON, S., METCALFE, D., ROEBELING, P., STEWART, L., VLEESHOUWER, J., WEBSTER, T., WESTCOTT, D. and WILLIAMS, K. 2006. Floodplain renewal research in coastal lowlands adjacent to the Great Barrier Reef, Australia. *Proceeding of the 2nd International Conference on Estuaries and Coasts*, Guangzhou, China 28-30 November 2006. Vol 2, 662-669.

Problems and opportunities

The initial analysis of bathymetry from Kyambul lagoon has revealed the vital importance of these data for both wetland filtering assessment and also freshwater habitat assessment and ecological function. We would therefore like to extend this type of survey to up to 12 other lagoons in the Tully-Murray catchments to be studied jointly by CSIRO, JCU and GU. This is estimated to cost $78000 in addition to the current project budgets. Projects 3.7.3 and 3.7.4 will therefore make a joint submission to MTSRF for these additional funds in 2008/09, so that this opportunity can be exploited.

Sediment and nutrient export from the Tully and Murray catchments during floods[1]

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Introduction

Concern over anthropogenically enhanced loads of sediment and nutrients to the Great Barrier Reef lagoon has led to the development of 'water quality improvement plans' (WQIPs) for a number of catchments adjacent to the Coral Sea, including the Tully and Murray catchments (Kroon 2007). These plans identify the current status of constituent loads along with a set of management practices to reduce them. In the Tully and Murray catchments the current sources and annual average loads of sediment and nutrient have been estimated using flow and concentration data (Furnas 2003) and the SedNet model (Brodie et al. 2003; Armour et al. 2007). Table 1 shows the high variability in the results of these studies, with the latest modelling study by Armour et al. 2007 estimating that 107652 tonnes of sediment, 2125 tonnes of nitrogen and 222 tonnes of phosphorus are transported to the GBR lagoon annually.

Both the above model (Brodie et al. 2003; Armour et al. 2007) and measurement (Furnas 2003) estimates are annual averages that would be delivered to the ocean by flows from the Tully and Murray rivers. However, these two catchments are subject to frequent flooding, when the water that runs over the bank can bypass the river gauges. During floods, therefore, the Tully and Murray river gauges do not record the total catchment discharge very well. For example, this study has shown that during the 2007 floods the Tully river gauge at Euramo only recorded 70–94% of the flood discharge and the Upper Murray only recorded 10–20% of the flood discharge. Clearly, during over bank floods large amounts of water may leave the Tully and Murray catchments that are not recorded by the catchment river gauges. Furthermore, current 'measured' ocean sediment and nutrient loads are based on concentrations measured within the rivers (Furnas, 2003), yet it is not known what the sediment and nutrient concentrations are in over bank flood waters. This paper addresses these issues by presenting the results of flood discharge estimates and water quality measurements made during four flood events that occurred in the Tully and Murray catchments during 2006 and 2007. The results are presented in more detail in a CSIRO Land and Water Report (Wallace et al. 2008).

[1] Reproduced from the Summary of the more detailed CSIRO Land and Water Report by Wallace et al. 2008

An assessment of wetland connectivity in the Tully-Murray floodplain using a hydrodynamic model

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Abstract

This paper describes an initial assessment of the present status of connectivity among the wetlands and streams of the Tully-Murray floodplain under flood conditions. The connectivity between a wetland and other water bodies is considered as one of the key determinants for habitat quality and ecological condition of a floodplain wetland. In this study, connectivity was quantified using a hydrodynamic model to calculate the timing, duration and spatial extent of the connections between a number of wetland types. The wetlands on the floodplain were identified using 3 m grid LiDAR data and water surface elevations at each wetland were simulated using a hydrodynamic model. A total of 10 wetlands of different sizes and types was selected and the connectivity of individual wetlands with the Tully and Murray Rivers was assessed for the flood events of 1-year and 20-year recurrence intervals. The hydrodynamic model domain was divided into 800000 computational grids (30 m $\times$ 30 m) and then the wetlands were reproduced within the model by matching each wetland boundary with model grids. An algorithm was then developed to identify the inter-connected computational grids at every 2-hr time interval during a flood using water depth information predicted by the model. By accumulating this information for the entire flood duration, the temporal history of connections between the wetlands and the Tully and Murray Rivers was established. The results of these simulations provide a means of identifying the degree of connectivity of different wetlands, ranging from those wetlands that are more permanently connected with streams to those that are connected only when there are overbank floods.