For further information please contact:

Dr Michael Stewardson
CRC for Catchment Hydrology
School of Anthropology
Geography and
Environmental Studies
The University of Melbourne
Vic 3010 Australia
mjstew@unimelb.edu.au

River Restoration

Project 6B: Predicting Spatial and Temporal Variations in Channel Form

Project Leader: Michael Stewardson (The University of Melbourne)
Deputy Project Leader: A/Prof Ian Rutherfurd (The University of Melbourne)

Project Objectives

- To develop the capacity to predict channel dimensions and hydraulic habitats across catchments of south eastern Australia.
- To develop the capacity to predict the effects of changes to bed load and discharge on the spatial distribution of channel dimensions and physical habitat.
- To deliver channel dimension algorithms appropriate for use in hydrologic models, SedNet (see www.toolkit.net.au/sednet), the CRC's Land-use Impacts on Rivers research program and the Catchment Modelling Toolkit.
- To deliver models of bank erosion rates and migration of sand slugs.

Background

The form of rivers affects many of the issues of concern to the CRC for Catchment Hydrology, including transmission of flow, sediment and nutrients. It is an important consideration in the design of environmental flow regimes in regulated rivers and is one of the primary factors determining physical habitat – the physical living conditions of the stream and surrounding floodplains. Changes to the river form itself and the associated processes of riverbank erosion are one of the potential consequences of altered flow regimes, future land-use change and future climate change. The links between catchments, river morphology, physical habitat and reach hydraulics are the focus of this project.

Natural resource managers and the CRC for Catchment Hydrology are concerned with the downstream impacts of changed land-use and hydrology. Often the areas of concern are rivers and water bodies that are distant from the source of runoff, and pollutants and from the locations of land-use change. It is the river network that transports material from source to downstream. The form of the river network has been shown to have a strong influence on material transport. It can modify the shape of flood waves, it influences the velocity of flow and hence the ability of the river to transport pollutants, and the form of the river and surrounding valley control interactions between the river and floodplain. Floodplains are locations of deposition of sediment and transformation of nutrients. They are also significant aquatic environments in themselves, reliant on exchange of material between river and floodplain.

To date, the Catchment Modelling Toolkit has focussed on the catchment processes that affect the generation of runoff, sediment and nutrient and their delivery to the stream network. Models that examine routing through the river network often use highly idealised representations of the river form. Hydraulic geometry relations are used together with theoretical values for parameters such as bankfull discharge. It is known that many rivers do not conform to these relationships but they continue to be used because no research has gone into develop alternative expressions of river geometry for use in catchment modelling. This project aims to overcome this limitation.

COOPERATIVE RESEARCH CENTRE FOR CATCHMENT HYDROLOGY

Published July 2004

Project 6B:
Predicting Spatial and Temporal Variations in Channel Form

Project Focus

Flow through the river network can erode riverbanks, and this has been shown to be a significant source of sediment in assessments of the sediment budgets of particular catchments. Our understanding of the spatial patterns of bank erosion is poor, however, in comparison to other sources of sediment, such as gully and soil erosion. We need to be able to predict patterns of riverbank erosion in models such as SedNet and EMSS (the Environmental Management Support System) to have faith in the correct identification of sediment sources, and the likely response to catchment management activities which often include extensive riparian restoration. Riverbank erosion and river form are interrelated so these topics need to be considered together. Many Australian rivers are incised and widened, with very large bankfull capacity. This is often a result of catastrophic bank erosion in historical times. These rivers are not in equilibrium with their hydrological regime and that is partly why hydraulic geometry relations do not apply.

Future hydrological change, predicted by the catchment-scale tools of the CRC, may cause a response in channel form, either channel contraction or a phase of expansion including bank erosion. These changes need to be examined for us to understand the full implications of future land-uses, hydrological regimes and climates. Such changes need to be put in the context of other continuing adjustments to river forms, such as the propagation of sand slugs that continue to migrate through many rivers as a result of past erosion.

The net result of the interactions between flow, sediment transport and river form is a set of hydraulic habitats. These are the physical conditions that underpin aquatic ecosystems. Changes to these physical conditions may be beneficial or detrimental to the needs of a range of organisms. These changes need to be predicted to better understand the environmental flow needs of our rivers, and to put environmental flows in the context of other stressors on rivers.

Methodology

1. Catchment-Scale Models of Channel Metrics

Statistical and conceptual models of the spatial distribution of channel metrics will be developed based upon a collection of channel metric data from across south-eastern Australia. The models will predict channel metrics from a set of independent environmental attributes, which we expect to include attributes such as discharge characteristics, terrain properties, riparian vegetation, and geology or soil properties. Channel metrics to be predicted will be determined by examining the metrics that most influence the suite of catchment models and hydraulic habitat. We expect this to include channel width, channel depth, channel shape, channel capacity at bankfull discharge and frequency and extent of floodplain inundation. Collation of channel surveys is expected to be a large task to be undertaken early in the project. These data will be stored and documented on a database in a systematic way to facilitate ease of use by future projects. Data held by agencies, key consultants and researchers will be included in this database.

Where necessary, additional data will be collected to fill knowledge gaps and to extend the 'population' of catchments over which this work can be applied. Additional data collection is not a major activity in this project

2. Modelling Channel Change

As part of the development of the channel metric models, we will specifically consider bank erosion, and migration of sand slugs. Many channels have been modified by bank erosion or the migration of sand slug. For the channel metrics model to be useful in rivers throughout eastern Australia, including those subject to historical channel change, it will be necessary to explicitly consider these particular processes. This part of the project will focus on developing models to represent these processes in order to enhance our capability to model channel metrics throughout river networks and to support management of bank erosion and sand slugs.

Current Projects
2003-2006

Project 6B:
Predicting Spatial and Temporal Variations in Channel Form

Riverbank erosion is a significant sediment source to rivers, yet relative to the other major sediment sources (gully and surface wash erosion) we have little information on the broad scale patterns and the factors controlling them. The SedNet model currently predicts bank erosion from a modification of a relationship derived from global data by Ian Rutherfurd (The University of Melbourne). Only three studies of Australian rivers are included in that review and for many rivers there was little known about the independent factors that could be controlling bank erosion. This activity will improve the situation by assembling a Geographic Information System (GIS) database of recent bank erosion rates in Australian rivers from a range of sources, including aerial photographs, historical surveys, and the literature. The rates of bank erosion found will then be related to a range of environmental variables, including riparian vegetation, hydrological variables, and valley morphology to produce improved empirical relationships for use in regional predictions of sediment sources and river loads. The final relationships will be used in the SedNet model and tested through the construction of catchment sediment budgets. We will also refine sand slug sub-models for the SedNet Model (which at present is a steady-state model) to incorporate the understanding developed from field-based research. These will predict future changes to sand slugs.

As part of the channel metrics work, we will examine the specific case of assessing likely channel change as a consequence of the kind of catchment management activities considered within the toolkit. Most of the CRC research effort is directed at predicting the hydrological and pollutant consequences of land-use change. Up to now these predictions have lacked geomorphic feedback. This activity will provide algorithms (both conceptual and numerical) to predict changes in channel morphology (width, depth, bench formation, bed material transport) in response to predicted hydrological changes The scope of the study will be limited to the hydrological changes predicted by the CRC's Toolkit (flow duration and flood frequency) and to case studies based in three focus catchments (Goulburn, Murrumbidgee and Brisbane). Models will predict average reach conditions over decades (e.g. "10% increase in mean width", "deposition of a bench at the 0.5 yr flood level").

3. Relating Channel Metrics and Hydraulic Habitat Characteristics

In Project 6A, 'Development of Flow-Ecological Response Models', we will identify key hydraulic characteristics of streams which have a direct influence on stream biota. These hydraulic characteristics include the inundated area of the channel bed, inundated area of in-channel benches, plan-area of the channel that has deep water and plan-area of the channel that is slow flowing water. In this project we will develop empirical relationships to predict these hydraulic habitat conditions for a river reach as a function of discharge and channel metrics. In this instance, we define a reach to be a segment of the river network which is homogeneous in terms of channel dimensions and important channel features (~10-100km long).

These empirical relations will be developed using existing channel survey data collated as part of this project. Hydraulic models will be used to derive the hydraulic habitat characteristics at a range of discharge. The relation between the hydraulic habitat conditions and discharge will be parameterised and the parameters related to channel metrics. This approach has been successfully used in France to model relationships between fish habitat and discharge. If there are insufficient reach surveys available to develop this model, synthetic channel survey data will be generated using a stochastic procedure. We will check that the synthetic channels are realistic by comparing model residuals for the synthetic and real channel data.

Current Projects
2003-2006

Project 6B:
Predicting Spatial and Temporal Variations in Channel Form

Project Team

Project Leader

Mike Stewardson (The University of Melbourne)

Researchers:

Ron de Rose, (CSIRO Land and Water)

Ciaran Harman (The University of Melbourne)

Ian Rutherfurd, (The University of Melbourne)

Ian Prosser, (CSIRO Land and Water)

Andrew Hughes, (CSIRO Land and Water)

Brian Finlayson, (The University of Melbourne)

John Fenton, (The University of Melbourne)

Tony Ladson, (Monash University)

For further information

http://www.catchment.crc.org.au/riverrestoration