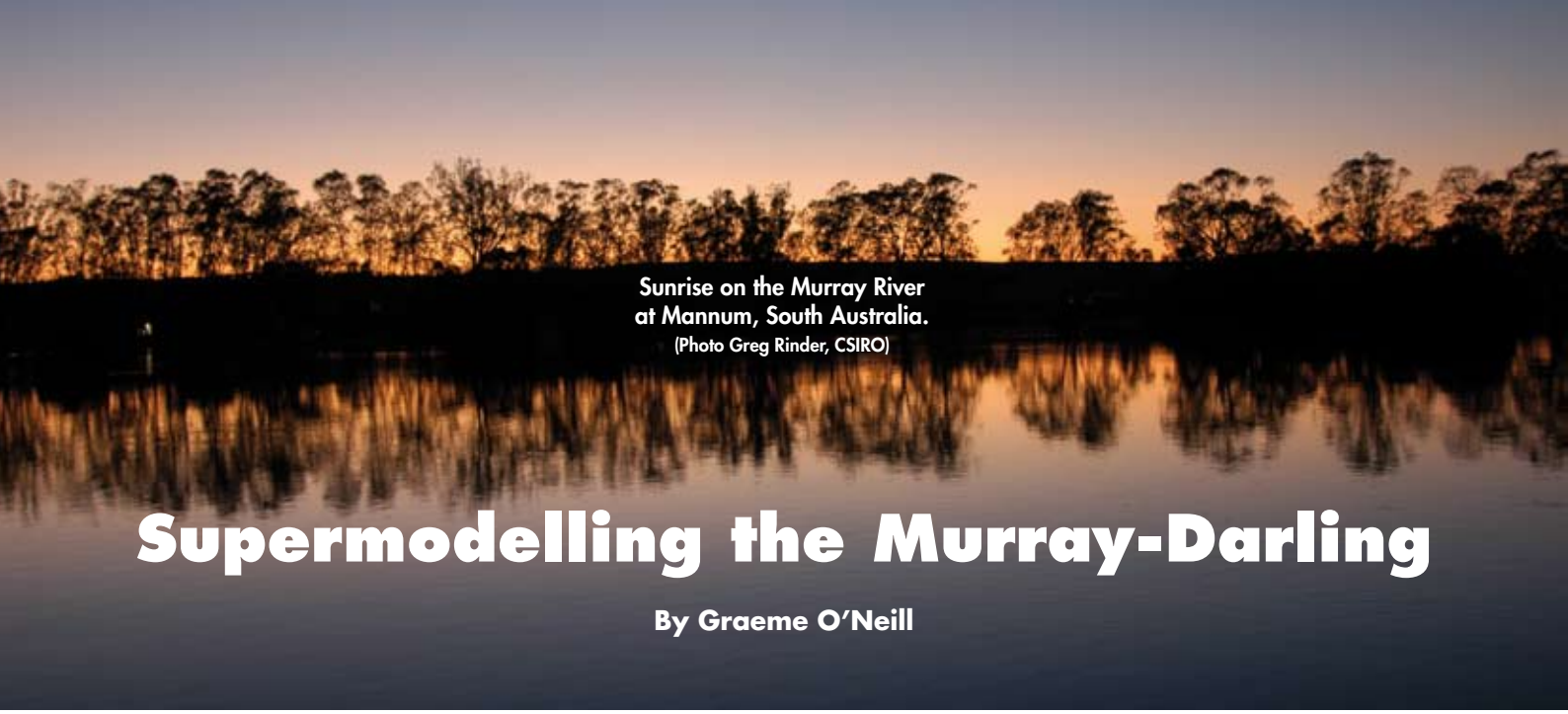

Sunrise on the Murray River at Mannum, South Australia. (Photo Greg Rinder, CSIRO)

Supermodelling the Murray-Darling

By Graeme O'Neill

The Murray–Darling Basin (MDB) is in the grip of one of the more severe droughts in the last century, adding climatic complication to a list of other severe pressures on the water system – overcommitment of its flows; salinity; the environmental effects of dams, weirs and locks; and, invasions by pests like European carp.

Queensland, New South Wales, Victoria, South Australia and the ACT exploit the Basin's waters. Historically, each has competed for an equitable share of the system's resources – without being able to predict the likely effects of their policies and decisions on the system as a whole.

For the first time since Hamilton Hume and William Hovell discovered the Basin's major artery, the Murray River, in 1824, that capability now exists.

In November 2006, as the severity of the drought and its impacts on agriculture and urban water supplies became clear, former Prime Minister John Howard called the Premiers of the MDB states together to consider immediate measures to address the looming water supply challenges in the southern Basin.

The National Water Commission was instructed to engage CSIRO to take the first inventory of sustainable yields of all surface and groundwater systems within the Basin, against a background of climate change and other confounding factors – localised water storage in farm dams, plantation forestry and the effect of wildfires on catchments.

CSIRO's Murray–Darling Basin Sustainable Yields Project (MDBSY) has been the largest research contract the organisation has taken on in its 80-year history. It has generated a massive data set to drive a computer-based 'supermodel' of the Basin's water resources, created by linking 40 existing and new models of surface and groundwater flows and extractions within the Basin's 18 individual catchments.

The Murray–Darling Basin covers 1,061 469 square km or about 14 per cent of Australia. (CSIRO graphic)

How does the Murray–Darling's complex water system work, how do we measure its capacity and supply under increasing demands, and how do we understand the implications for local communities – in just a year? CSIRO's Murray–Darling Basin Sustainable Yields Project, probably the most ambitious resource inventory attempted anywhere in the world, has met that challenge.

The million-square-kilometre Basin covers a seventh of the continent, and supplies at least 40 per cent of the nation's agricultural production. Its waters sustain two million people, not counting the 1.4 million people of the South Australian capital, Adelaide, which use its supply downstream.

Three well-known rivers meander through the Basin – the Murray, the Darling and the Murrumbidgee. Other major rivers rising on the western slopes of the Great Dividing Range deliver episodic flows that regenerate a vast system of permanent and ephemeral creeks, lakes, billabongs and marshes.

Even Solomon might have baulked at the challenge of dividing the Basin's waters equitably between four thirsty states and one territory, while maintaining sufficient flows to ensure the system's ecological health.

Its well-publicised regression attests to the limited impact of decades of well-intentioned efforts by Commonwealth and state agencies to manage its water resources sustainably.

Inadequate understanding

Those efforts have long been frustrated by an inadequate understanding of the system's capacity, its complex hydrological machinery, and the aggregate effects of drought, floods and the varying demands of each state and territory for its waters.

A rapidly changing climate further complicates the picture.

Over the past decade, precipitation over the Basin's southern catchments has been significantly lower than the longterm average and global climate models are indicating that future rainfall will also be significantly lower than the historical average. What effects will changing water availability have on agriculture, horticulture, forestry, urban supplies and the environment? How can water management agencies plan for the effects of climate change on water availability? A year ago, these questions were largely unanswerable.

The MDBSY Project's development of the first integrated hydrological model of the entire Basin means water management agencies can now assess the potential consequences of their management policies and decisions under dry, moderate or wet future climatic scenarios, at the level of each catchment, or across the entire Basin.

"We believe there has never been a water resource inventory at this scale anywhere in the world," said Dr Tom Hatton, Director of the CSIRO-led Water for a Healthy Country Flagship, which is managing the project. "Nobody has looked at surface and groundwater resources under past and future climate scenarios at this level of detail.

"First we compared the past 10 years to the long-term record (1895–2006). This enabled us to look at the recent experience of drought in its historical context," Tom said.

"Then we took the scenarios presented in IPCC 4AR (the 2007 report of the Intergovernmental Panel on Climate Change), and modelled the likely effects of climate change on the availability of water at the scale of individual catchments within the Basin by 2030.

"The final scenario models the impact of future climate change, adding in developments that may affect the availability of water, like forestry, farm dams and increased groundwater extraction."

Dynamically link balances

This is the first attempt in the Basin to dynamically link groundwater balances with surface water availability.

"It calculates flows through and between the system's rivers, and groundwater – surface water interactions under current water-sharing arrangements, before estimating the water available under each scenario," Tom said. "Our involvement ends there. The issue of who should get how much water is a political decision."

He said that, given its scale, complexity and 12-month timetable, the project had been a 'monumental' undertaking.

"We've brought in people from the best organisations around Australia – from Commonwealth and state agencies, and leading hydrological consulting companies. It's been a real 'Team Australia' approach," he said.

Tom said the government would establish a new Murray–Darling Basin Authority under the Commonwealth Water Act that would set a new sustainable diversion limit for the Basin's water resources. The model would be crucial to quantifying these resources, and identifying stresses and strains within the system.

Assessing MDB water availabilty

Project Manager Dr Bill Young has led a team of over 100 technical staff from over a dozen organisations and managed internal and external review processes in order to deliver robust assessments of water availability across the MDB. The 18 individual catchment reports incorporate a fact sheet, a thematic summary of the findings describing runoff, river flows and groundwater recharge, and a detailed technical report.

A final report, due for release in early 2008, will encapsulate all the information across the 18 catchments to give a water yield assessment for the entire Basin.

Bill said the first phase of the project involved agreeing on the climate scenarios, and defining the regions and catchments to be modelled. Dr Francis Chiew then applied outputs from 15 IPCC global climate models to each catchment to model the effects on runoff.

Each climate scenario models runoff at a resolution of 5 km by 5 km using daily

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rainfall and potential evapotranspiration data. This then allows the impact that climate change and catchment development has on runoff to be estimated for each region.

"People have done this in bits and pieces before, using different hydrological models and different climate change projections, with mixed results," Francis said. "For the first time, we have produced a picture of runoff in the Basin during historic, recent and possible future climate changes, using a consistent, robust and well-documented approach."

The MDB before extractions

CSIRO was also asked to model the Basin as it existed before its dams, weirs and locks were built, and before extractions began, as a benchmark to assess the effects of development.

Dr Geoff Podger oversaw this work and also supervised modifications to around 70 river models to standardise their time steps and spatial units, as a prelude to linking them in a single 'supermodel'.

"In some catchments, the changes we saw from the pre-development phase to the present far outweigh any impact we might see under any of the climate change scenarios," Geoff said.

"But, in contrast, for some others it's under one per cent, and climate change will be the major influence on flows in the future. What will be most interesting in the final figure for the Murray is the cumulative effect of changes in tributaries that would have contributed a large proportion of its pre-development flows. It's likely to be big," Geoff concludes.

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CONTRIBUTIONS FROM EACH STATE

Dr Geoff Podger coordinated the modification of around 70 different river models, many developed by Queensland, NSW, Victoria and SA, for integration into a dynamic model of the entire MDB.

The Queensland Department of Natural Resources and Water (DNRW) contributed models for the Paroo, Warrego, Nebine, upper Condamine, mid-Condamine, St George, Lower Balonne and Moonie rivers.

Queensland DNRW and the NSW Department of Water and Energy (DWE) jointly contributed models for the Border Rivers. DWE also supplied other models, including for the Gwydir, Namoi, Macquarie, Darling, Lachlan and lower Murrumbidgee rivers. A new model was developed for the upper Murrumbidgee and its inflows into Lake Burrinjuck.

Snowy Hydro provided its Blowering, Burrinjuck and Hume dam inflow models.

Victoria's Department of Sustainability and the Environment made available its models of the Ovens, Goulburn–Broken, Campaspe, Loddon, Avoca and Wimmera rivers, while South Australia's Department of Water, Land and Biodiversity Conservation provided models of the Eastern Mt Lofty Ranges.

The Murray–Darling Basin Commission provided its models for the Murray system.

Members of the MDBSY reporting team discussing the project.
(CSIRO Land and Water)