Science to support water sharing planning in New South Wales

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Abstract

Water Sharing Plans (WSPs) have been developed for most of the regulated rivers and some ground water systems in New South Wales and 'Macro' WSPs are currently being developed for most of the remaining water resources of the state. Case studies for four contrasting individual plans are presented: the Murrumbidgee River (regulated surface water dominated by irrigation demand); the Coxs River (surface and groundwater with uses that include mining, electricity generation and supply for metropolitan Sydney); Lower Murray groundwater (consumptive use and over-allocation) and Toorumbee Creek (high conservation value with proposed irrigation demand). The design of Macro WSPs and progress with the first plan for the Lower North Coast is described. In April 2006 the National Water Commission published concerns about the New South Wales Water Reform progress and proposed conditions under which the withheld competition payment of $13 million could be recouped. Concerns include the rigour of underpinning ecological science and the transparency of the process to stakeholders. The case studies describe how science has been used in the planning process so far and how improvements are being incorporated into Macro WSPs.

Keywords

Water sharing, environmental flow, risk, estuaries, adaptive management

Background

The catchments and sub-catchments chosen for the first round of Water Sharing Plans (WSPs) covered 36 stressed systems representing about 80 per cent of the water extracted in the state. Under the Water Management Act 2000, 31 plans were commenced in July 2004. Five alluvial groundwater plans were deferred and gazetted in December 2006 (NSW DNR, 2005). Macro Water Sharing Plans (Macro WSPs) are being prepared for most of the remaining unregulated rivers and groundwater where there is less intensive water use (NSW DNR, 2006b). In a recent audit of WSPs in New South Wales (NSW) the National Water Commission (NWC, 2006) concluded that the ecological science used was inadequate to inform decision making in some water systems; and that planning lacked transparency. Partly in response to these concerns, as lead agency in NSW, the Department of Natural Resources (DNR) commissioned two independent reviews. Consultants, URS, examined nine Stage 1 plans concluding that 'the extensive review provides clear evidence that NSW has fully met its obligations under the 1994 COAG Agreement and the ARMCANZ National Principles for the Provision of Water for Ecosystems' (NSW DNR, 2005). The Macro WSP process was also reviewed by an independent panel (Bowmer *et al*., 2006). Suggestions for improvement were recently adopted by DNR and relayed to the NWC. However, the NWC remains concerned about WSP processes and has recommended a suspension of 13 million dollars of 2004-05 competition payments to NSW, but proposes that the penalty could be recouped if it can be demonstrated that for the remaining WSP systems there is an improvement in planning and that, where WSPs already exist, the outcomes of water sharing rules and environmental allocations are adequately monitored. In this paper our purpose is to reflect on the lessons learned in planning, especially in the context of concerns about underpinning scientific rigour, and look to future challenges and opportunities for improvement.

The Murrumbidgee (regulated surface water)

The Murrumbidgee River is a regulated river surface water system providing water for irrigation which underpins the regional wealth and employment. Water is also required to maintain the ecological function of the river and its floodplains, to support a Ramsar convention wetland and endangered fisheries, and to provide water downstream to the main stem of the River Murray. In September 1997 the Murrumbidgee River Management Committee was established and directed to set rules for water sharing between the environment and other water users, and between water users with different types of licences. The Committee's membership was drawn from five state agencies, nature conservation organisations, local government and indigenous representatives. The Committee met 32 times over more than five years (Bowmer, 2003). The committee was briefed by experts on general principles of aquatic ecology, and reviewed the information available in the National Land and Water Resources Audit. Specific information on a river reach scale was obtained through two expert panels (Agribusiness Task Force, 2000; Buchan 2000) the State-wide program on Integrated Monitoring of Environmental Flow (NSW DNR, 2006a) and reports commissioned by the Committee which included: the status and restoration of fish populations (Lugg, 2000); non-flow options for wetland management (Maguire, 2000); the operation and benefit of the Environmental Water Allowance (Maguire *et al.*, 2000); and biological indictors for assessing river flow management (Watts *et al.*, 2001). Linear programming methods were used to assess the economic impact of the flow rules (Jayasuria & Crean, 2000) and choice modeling (Bennett & Morrison, 2001) provided insights on community preferences and preparedness to pay.

The daily flow Integrated Quantity and Quality Model (IQQM) was not available initially and a monthly model was used to develop the initial set of environmental flow rules. Knowledge deficiencies included the desirable frequency of wetland drying and watering, and the river height and duration needed to achieve wetland connection. Some of the requisite information has been published since flow rules were developed (e.g. Hardwick *et al.*, 2002; Page *et al.*, 2005). Because of the advantages of developing a set of automatic procedures for environmental flow release, a set of translucency rules was developed in which the release from the storage was triggered according to prevailing run-off patterns. The objectives were: to optimise the release of water in late winter to spring, avoiding 'waste' of environmental water through dam spilling; and to return some of the natural variability in the release pattern to scour sediment buildup and prevent algal blooms caused by low flow. However the benefits of this strategy were limited to the upper reaches of the river.

The Environmental Water Allowance is a volume of water that was set aside in storage and can be released at the discretion of NSW DNR with the advice of a reference group. Three releases were made: in September 1998, in August 2000 and in October 2001. The first release failed to raise river height sufficiently to inundate many wetlands especially in the lower reaches of the river. The second release was used to supplement ('piggy-back') onto a peak of unregulated tributary flow downstream of the storage and combined with weir pool manipulation to maintain peak height with travel downstream. Many of the lower and mid-level wetlands on the floodplain were successfully connected to the river, some for the first time for several years (Hardwick *et al*., 2002). The last release was piggy-backed onto a surge peak provided for irrigation, with restriction on irrigation extraction during peak travel downstream, but achieved limited success. Following the success of the year 2000 EWA releases the Committee agreed by majority to increase the EWA account by transfer of up to 50GL from the translucency water allocation. Analysis of wetland inundation by 'piggy-backing', modeled retrospectively over 108 years of record showed an environmental benefit in numbers of extra events. These data will support the Reference Group to advise on targets and develop a set of automatic triggers for release of environmental water.

Coxs River (regulated surface water and groundwater)

The Water Management Committee was established in 2001 to develop a water sharing plan for the Coxs River surface and groundwater sources. It was also asked to make recommendations on aquifer interference as a result of mining, inter-valley water transfers as a result of coal mining; and Deltas Electricity's Water Management Licence. The committee stakeholders represented power generation, coal mining, environment, tourism and recreation, farming and landholders, aboriginal culture, local councils and Sydney Water. A significant proportion of the water in the Coxs River is recycled and includes Lithgow sewage treatment plant effluent. The water is a source for metropolitan Sydney so issues of health and safety would be prominent in current public policy now, but were less so when the plan was prepared.

Prior to all decisions the committee sought technical, scientific and socio-economic information from a wide variety of sources including three state agencies, Jenolan Caves Trust, Delta Electricity, CSIRO, Western Research Institute and individual experts. The committee also accessed a range of background reports on stressed rivers (NSW DLWC, 1999); groundwater-dependent ecosystems (NSW DLWC, 2002); monitoring of environmental flow (Chessman & Jones, 2001); as well as specific reports on the Hawkesbury Nepean

(NSW Healthy Rivers Commission, 1998) and hydrogeology of the Coxs River Catchment (Bish, 1999). Specific investigations on the Coxs River included reports on condition and proposed environmental flows (Young *et al*., 2000) and on experimental environmental flows and ecosystem monitoring (Booth *et al*., 1998).

In order to make decisions at a local level the surface water source was separated into five management zones which were named in recognition of the cultural significance of the Coxs River to the people of the Gundungurra nation. The determination of the bulk access regime and release options from Lake Lyell required major decisions. A daily hydrological model (IQQM), originally developed for Delta Electricity, was extended to 104 years of data, and, together with gauging station data, provided support for decision-making. Modelling demonstrated that construction of storages within the upper catchment had significant effects on flow regimes. Natural flow percentiles were used to define flow classes in each zone which were used in conjunction with the results of a volumetric conversion survey undertaken by DIPNR in 1998 on crop types and water usage to determine daily extraction limits for each zone. IQQM was also used to develop rules for environmental release from Lake Lyell that included drought triggers, transparent and translucent releases, flow duration, frequency of freshes, days of low flow, and daily flow variability.

The geological formations of the Coxs River, documented for coal mining in the region, provided the foundation of the groundwater science used. The ground water source was sub-divided into four hydrogeological boundaries. Assumed values for average rainfall and infiltration were used to develop recharge estimates and therefore sustainable yields for each aquifer. Permian and Triassic aquifers were found to be significantly larger than the portion located in the Coxs River hydrological boundary and WSPs for these large aquifers were limited by lack of scientific information. More information was also required on the impact of mining on surface cracking and stream capture. To assist the committee in its deliberations and trade-offs between options an input-output model (based on West, 2003) was developed by the Western Research Institute to determine the contribution of various industries within the catchment. The model identified the critical role of coal mining and electricity generation in the catchment's economy and informed decisions about drought triggers and release rates from Lake Lyell Dam, and the Water Cap imposed on Delta Electricity.

Lower Murray (groundwater)

In most years extraction from the Lower Murray Alluvium aquifer was lower than sustainable yield but was assessed as 'high risk' by DLWC in 1998 on the basis that licensed entitlement (as opposed to use) exceeded sustainable yield approximately three-fold. In response, the Lower Murray Groundwater Committee was established, consisting of the Murray Groundwater Users Association, the Catchment Management Board, Nature Conservation Council, Berrigan Shire Council, Murray Irrigation and three state agencies. A comprehensive groundwater model was commissioned and peer- reviewed to aid confidence in decision-making about sustainable extraction rules.

Toorumbee Creek (unregulated surface water)

Toorumbee Creek is a sub-catchment of the Maclay River on the states mid north coast. The Mid North Coast Water Management Committee prepared a WSP for the Tooorumbee Creek sub-catchment in 2000/01. The subcatchment was classified as having high conservation values by the stressed rivers assessment (NSW DLWC, 1999). There were no irrigation licences in the sub-catchment, but several licence applications had been received and there was interest from some local landholders to develop irrigated agriculture. The Committee's role was to determine how much (if any) surface water should be made available for irrigation purposes, whilst at the same time protecting the natural values of the system. An expert group, co-ordinated by DLWC, provided the Committee with more detailed information about Toorumbee Creek's natural values.

The Committee's final decision was based on attempting to balance the natural values of the creek against the potential socio-economic benefits of allowing new extraction. The Committee was preparing WSPs for sub-catchments areas (rather than entire river basins) and members were prepared to trade off between WSP areas. The Committee decided that Toorumbee Creek warranted greater environmental protection whilst water sharing rules for Commissioners Waters, another sub-catchment of the Maclay River, were designed to maintain access for the economic sustainability of water users. Hydraulic studies for fish requirements indicated that the proposed water extraction licenses could be issued with flow conditions set by the plan. However, the Committee grappled with a more fundamental issue concerning whether the conservation value of the creek warranted a complete exclusion of all irrigation. Conservation principles adopted from terrestrial ecology (Dunn, 2000) were used to compare Toorumbee Creek, with neighbouring sub-catchments. The Committee concluded that the relative levels of rarity and diversity in Toorumbee Creek did indeed warrant a total exclusion of water extraction (except for basic rights).

Retrospective analysis and lessons from earlier planning: The preceding case studies show that science was a major driver in the decisions of the Water Management Committees but additions and improvements were required as follows:

1. Consideration of the boarder landscape scale questions
Standard environmental flow methods may miss critical higher order decisions. For example, as plans moved from areas of higher to lower extraction, the emphasis has moved from restoration to preservation of flows. Concepts from terrestrial biodiversity conservation were employed in the Toorumbee plan. However, for more widespread application there is a need to determine the relative number of sub-catchments which require high levels of protection. Also, for example in the Murrumbidgee, there is a question about the extent to which the balance between safeguarding icon sites and maintaining river function can be optimised.
2. Science needs to be coached within a risk framework
Flow requirements using hydraulic methods based on wetted perimeter or flow depth are appropriate in systems modified by large dams or where there are high levels of extraction but in systems with a few extractors these methods do not reflect the true impact of extraction and lead to rules that are too restrictive.
3. Groundwater quality and surface water connectivity
Great gains have been made in the development of groundwater models to aid decision making for management of volumes of water in the major aquifers. However the models do not handle the important water quality characteristics of sodicity and salinity, nor have the capacity to report on the effects on soil structure and permeability of using groundwater of lesser quality, yet these predictions are vital for the overall sustainability of farming systems. In some cases, studies did not inform changing relationships between surface and groundwater use, or impact of groundwater use on river base flow or groundwater-dependent ecosystems.
4. Adaptive management
When environmental water planning began in 1998-2000 it seemed appropriate to use a rule-based approach to environmental flows (i.e. translucency for release of water from storages to mimic some of the natural variability of flow for instream benefit). With better hydrological modelling capacity (IQQM) and new research information on the optimum frequency of river and wetland-floodplain connection it became possible to model a full range of options. As a result, for example in the Murrumbidgee, some of the translucency water was transferred to an 'environmental health allowance' which needs to be managed on a decadal, rather than annual, model. Also the recognition that floodplain connection can only be achieved in wetter years has resulted in a process of 'piggybacking' (combining environmental releases onto irrigation or natural tributary flow to achieve wetland and floodplain connection). Using a similar principle, countercyclical trading was piloted by the Murray Wetlands Working Group (NSW MWWG, undated). *River Reach* (Murrumbidgee CMA and Murrumbidgee Irrigation; J. Howe, pers. comm.) also proposes the allocation of water to the environment in wetter years.
5. Use of market mechanisms
Water sharing plans facilitate water markets and water trading. The *Riverbank* (NSW DEC, 2006a) program allocates water purchased from irrigators for specific environmental assets in the Gwydir, Macquarie, Murrumbidgee and Lachlan Valleys and provides a model for CMAs to engage in water purchase and trading on behalf of the environment. The emergence of environment as a customer raises questions about the optimum mechanisms for accessing environmental water through trading.

Macro Water Sharing
For the next round of planning in New South Wales, the Macro WSPs, planners and scientists have incorporated knowledge and experience derived from the first round of planning, noting particularly the five issues listed above. Central to the planning is the construction of a decision path to systematically filter and focus the development of rules using value and risk considerations, including local and indigenous review in accord with recommendations (NSW DEC, 2006b). Undertaking Macro planning at a catchment scale has allowed catchment-wide trade-offs to be more transparent and better documented. Manuals outline the technical and scientific elements of the planning process and the background documents detailing the science used in the decision process will be available for each individual plan (e.g. NSW DNR, 2007).

The best available scientific information and basic concepts from a number of sources have been accessed in the design of the Macro WSP process. These include: ecological values (Bennett *et al*., 2002);

socioeconomic values and decision support processes (NSW Healthy Rivers Commission, 2003); and geomorphic types (DWAF, 2004; Pierson *et al*., 2002). Although current information is often incomplete, sufficient information is available to establish a risk profile and determine the relative risk from extraction. This information has been used to develop both access and trading rules to protect higher risk rivers and streams. The plans define a range within which the final rules will fall giving a level of certainty to both users and the environment. For example, the Lower North Coast WSP specifies that the minimum estuarine flow for the Manning River will range between 50Ml/day and 220Ml/day. The final rule will lie somewhere between these two bounds. The completion of the Macro WSP does not mean that the science is comprehensive. However, plans can use available science now to reduce or eliminate risk while the detailed understanding is being developed.

The integration of surface and groundwater planning is a priority of the National Water Initiative. In connected systems surface and groundwater rules have been developed concurrently. Where there is a close connection between surface and groundwater they are covered under the same plan.

Looking to the future, Standards and Targets, against which Catchment Action Plans will be audited, have been announced recently (NSW NRC, 2005) and the NWC is refining its expectations of the planning process (Cullen, 2006). Changes to water supply and demand are anticipated including: increasing demand from metropolitan populations; reduction in water availability through climate change and interception by farm dams and afforestation; and new sources of environmental water through purchase and trading by environmental mangers (trusts and Catchment Management Authorities). There is also an expectation that a holistic approach to the water cycle should underpin planning, including integration of surface and groundwater management. Macro WSPs can account for some of these changes through the provisions in the plans.

Conclusion

In individual WSPs, as noted earlier, a range of methods including input-output analysis, asset and risk analysis, multi-criteria analysis, cost benefit analysis, linear programming and choice modelling were used to achieve trade-off and optimisation through the deliberations of individual agency and representative committees. In Macro WSPs the approach is to gather expert opinion and then subject it to local and indigenous review. Macro planning has built on experience with developing individual WSPs over the last five years. The process includes an overarching risk-based framework, explicit inclusion of regional and local knowledge and targeted and general public consultation facilitated by CMAs. The rationale for changes to access and trading rules at each stage will be documented and publicly available. An adaptive management procedure isolates areas of conflict for further research and investigation.

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