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MURRAY-DARLING BASIN AUTHORITY

Northern Basin Program

Options for environmental water:
An evaluation of the 2008 Narran Lakes
environmental water purchase

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Tim Cummins
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Straw-necked ibis adults roosting; photographer Kate Brandis (28/01/2008).

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PREFACE

In April 2008, the Murray–Darling Basin Commission (the “Commission”, replaced in December 2008 by the Murray–Darling Basin Authority) purchased 10,423 megalitres of water from a private storage in Queensland to provide water across the border to the Narran Lakes in northern NSW. The water was purchased to sustain water levels in the Lakes system during a rare bird-breeding event that was judged to be at risk.

The breeding event was the largest observed in the area in nine years. It was initiated at lower than usual inflows and during the hottest period of the year. Water levels were falling in circumstances that had in the past led to mass desertion of nests and high chick mortality (Kingsford, 2008). There was a brief window of opportunity to intervene and maintain water levels long enough for the chicks to fledge.

The Narran Lakes water purchase was the first of its kind in Australia. A substantial volume of physical water was purchased at market prices for immediate environmental use. The purchase offers valuable insights and lessons for future water sharing arrangements. The agreement to fund the purchase included a commitment to evaluate the outcomes. This report presents the findings of the evaluation, commissioned in September 2008.

Terms of reference

This report’s key objective is to evaluate the Narran Lakes environmental water purchase and to provide advice, as requested by the Murray–Darling Basin Commission on 20 March 2008, to present:

1. An assessment of the process carried out to set up the acquisition of the environmental water and its subsequent delivery.
2. [Consideration of the question –] How can the approach and mechanism used for this acquisition of the environmental water and its subsequent delivery, be used to guide future acquisitions and delivery of water? In particular, assess the nature and effectiveness of the measures put in place to protect the water release as it travelled down the river. This should inform recommendations about what controls need to be in place to adequately “shepherd” environmental water from its source to the target environmental asset.
3. Details of the outcomes of the bird breeding event which includes an analysis of efficacy of the monitoring process undertaken and results obtained.
4. The preparation of strategic options, guidelines and principles for purchase of temporary water¹ for environmental outcomes that would inform future dealings of this nature.

The evaluation was informed by a review of extensive documentation of the event and reports from a range of research and modelling projects focussing on the Lakes system, and through interviews with people who were involved at each stage - in developing the case, approving and purchasing the water, managing the event, and monitoring the outcomes.

¹ Temporary water: Unlike in the southern connected valleys of the MDB, there are no temporary or annual allocations in Qld and the northern NSW rivers. For the purpose of this project, temporary water refers to water extracted from rivers or through floodplain harvesting under approved event flow management rules. This water is usually diverted to large on-farm storages until applied to crops.

KEY FINDINGS

The Narran Lakes water purchase was a success. It met its clearly articulated and simply worded operating objective: maintaining water depth at 300 millimetres in the nesting area for 30 days. The response drew on and enhanced, the goodwill and social capital of many agencies in different jurisdictions, local landholders, the local Aboriginal community and the broader Australian community. It provided knowledge to inform future management of the Narran Lakes and important insights into the future of environmental watering in other parts of Australia. It also revealed much scope for improvement in management of future waterings.

By the end of the event, despite high mortality as water levels receded, close to 50,000 ibis fledged (Kingsford et al., 2008). There would have been additional but largely unquantified benefits across the ecosystem for other bird species, and biota (Rolls and Wilson, 2008). It is possible that the ecological outcomes from this amount of water may have been greater if the water was available earlier in the event, although the responsiveness once the situation was known was fast.

It is unlikely the purchase would have taken place without the preceding investment by the MDBC to improve scientific understanding of the Narran Lakes system. It is also unlikely that it would have been so successful without the interdisciplinary skills and experience and the preparedness to act, of a few key individuals in each agency in each jurisdiction.

Response to the terms of reference

Assess the process used to acquire and deliver environmental water to the Narran Lakes

The Narran water purchase went beyond usual practice in water management and took the collaboration of agencies and the community to make it happen. The process for acquiring and delivering the water depended on a lot of things going right. It was an emergency response rather than a process, with an urgency to act, which helped enable rapid but considered decisions at each step. People involved were not following set procedures; they were improvising in real time based on regular observations and communication. They had access to significant experience, sound data and local knowledge, which gave them the confidence to take calculated risks in relatively unknown territory. The event clearly demonstrated the value of good data and showed that the better it is, the more confident decision makers will be in such events. Important conditions that contributed to success included:

- a clear objective underpinning the process
 - **to maintain water level at 300 mm at Back Lake (where the breeding colony was concentrated) for 30 days**
- strong social capital built up over many years through interagency and interstate cooperation, and community engagement in water sharing negotiations and planning
- good faith negotiations between the buyer and seller, stemming partly from the buyer being willing to negotiate a price based on gross margins and the seller valuing good corporate citizenship
- tried and tested risk management procedures for water quality which could be readily applied
- good procedures for water accounting
- no major transmission impediments through the system
- local rainfall in the vicinity of the lakes reduced transmission losses.

The conditions that favoured success in the Narran event could be difficult to recreate in other situations but provide valuable lessons for future purchases.

In the Narran case, for various reasons largely to do with monitoring equipment and operating urgencies, there was a missed opportunity to recalibrate hydrological models. Future purchases should make use of all best available information and take advantage of the opportunity to augment baselines and calibrate models in real time conditions. Monitoring programs should be carefully designed in advance to address specific information needs stemming from pre-agreed objectives for modelling and for evaluating results. This should include clear arrangements for supply and maintenance of adequate monitoring equipment, and agreed roles and responsibilities for data management and sharing.

Success of the Narran event stemmed largely from the engagement of committed, knowledgeable people who knew the local system. It would be risky to assume that these same outcomes could be achieved in other cases. Setting up pre-agreed operating procedures could reduce some of the risks without detracting from the need for good local knowledge and real-time decisions.

Consider the potential to use this process as a guide to future acquisition and delivery of environmental water

The Narran experience provides an important opportunity to inform the development of environmental watering plans at Basin level and under regional catchment water sharing plans. There is tension between purchasing water and addressing underlying causes, in terms of: cap compliance, total entitlements and total consumptive use. However, given that consumptive use will continue, some breeding events will fail that would naturally succeed. Therefore there will likely be a role for purchases in the portfolio of management tools used to meet ecological objectives.

Markets for allocations and for physical water are very thin –therefore it would be risky to wait and see if they are available when needed. Call-options are an alternative – these would give the environmental water manager the right, but not the obligation, to call on irrigators to provide water at a pre-arranged price. Another alternative is to purchase properties with entitlements and use the on-farm storages for environmental water. This approach has paradoxes; evaporation from storages is a consumptive use and maintaining properties and storages in operational readiness costs money.

These costs could be reduced by put-options giving the right, but not the obligation to put, or sell, water at pre-arranged prices. This raises questions – is it economically more efficient to have call-options on private storages or put-options on public storages? Does it matter which way around it is done? Would doing both provide a hedge?

Record the outcomes of the bird breeding event that inspired the purchase

The primary outcomes were:

- Water levels at Back Lake were maintained at 300 mm for 30 days.
- Water levels then fell at close to natural rates.
- Close to 50,000 ibis chicks fledged from two colonies.
- Mortality in the second colony appears to have been very high – of 120,000 eggs, 24,600 chicks fledged.
- Losses were most likely due to nest abandonment (falling water levels) rather than food shortages or predation (the latter occurred but more likely because of the high mortality rather than causing it).
- Other bird species, vegetation, fish and other biota, and the ecosystem generally would also have benefited.
- The watering was supported by the local community.
- The event coincided with an Aboriginal youth and elders camp at the reserve.

Other less tangible outcomes include the awareness raised by the event among the local and wider community and the relationship building in water management across borders, between agencies and the community and irrigators.

Develop principles, guidelines and strategic options for the future purchase of temporary water for environmental outcomes

The following recommendations for future purchases are based on lessons learned from the Narran experience:

- Interim ecological objectives should be set for environmental watering of the target environmental assets.
- Based on these objectives, research and modelling should be carried out to determine how much water is needed and when.
- The objectives for the target environmental assets need a broad ecological base. They should not just be about birds. And the models should be modified to take account of the known broader ecological requirements.
- Water sharing plans, water allocation management plans and resource operations plan should be reviewed in accordance with existing schedules. The reviews should take account of the interim ecological objectives.
- An agreed set of triggers, capacity to purchase and an agency with authority to make decisions on flexible releases under the framework of a environmental water plan.
- Certain institutional arrangements would help to ensure that future temporary purchases are as efficient and effective as possible. These include:
 - decision trees to determine the spatial and temporal significance of breeding events
 - thresholds for those with delegated authority to commit the required resources with confidence
 - risk management plans
 - monitoring and evaluation procedures.
- There is a need for formalised ‘Incident Management’ arrangements (perhaps based on fire control arrangements). One person, preferably based in the region, should have ultimate decision-making responsibility but throughout the event they should have the constant support of people with river operating skills, ecological skills, modelling skills and communication expertise.
- Best available data and knowledge should be used to inform decisions and all opportunities taken to test and calibrate models under real-time conditions. Hydrological monitoring must be well designed to achieve agreed objectives, well coordinated and extend across the wetlands not just the river channels.
- All private storages built (or rebuilt) from now on should be fitted with the capacity to allow the inlet to also act as an outlet.
- The optimum portfolio of measures to provide water to the environment should be evaluated in contemplation of the interim ecological objectives. The portfolio could include:
 - the purchase and ‘decommissioning’ of some entitlements
 - the purchase of entitlements to be used specifically for environmental purposes
 - the purchase of strategically located on-farm storages
 - the strategic purchase of allocations
 - the strategic purchase of physical water
 - contracting with irrigators to forego pumping rights above a certain level
 - the buying of call-options
 - the selling of put-options.

EXECUTIVE SUMMARY

The Narran Lakes environmental water purchase was a unique event in Australia. For the first time privately-owned water held in on-farm storage was purchased and delivered, across a State border, to a high conservation value wetland.

This evaluation looks at the outcomes of that purchase with a view to informing future water purchases for the environment. It explores whether water purchases such as this are likely to form part of the long-term arrangements for protecting the values of aquatic ecosystems. It also examines the institutional arrangements necessary to ensure that purchases are as responsive, efficient and effective as possible.

Non-environmental outcomes are also included in the evaluation. The lakes, and bird breeding events are culturally significant for local Aboriginal communities, and it is important to understand how the purchase affected those values. Similarly, it is important to take account of the views of the broader community and landholders along the Narran River.

Overview

The Narran Lakes water purchase was a highly responsive action taken to maintain water levels in the lakes system during a rare colonial waterbird breeding event in the summer of 2008. It achieved its objective of maintaining levels at 300 millimetres for around 30 days. Despite high mortality in chicks of all ages towards the end of the event, close to 50,000 ibis successfully fledged. It is widely believed that the additional water enabled more chicks to survive (Kingston et al., 2008).

There is general consensus among stakeholders that the water purchase was the right thing to do and a rational reaction to compelling evidence that the breeding event was at risk. There were few other options. The stakes were high and it was generally felt that the water purchase, with all of its inherent risks and uncertainties offered a better outcome under the circumstances than the 'do nothing' scenario.

A number of conditions, some particular to the Narran case, helped in achieving the objective. Sound scientific evidence, the result of an ongoing commitment to monitoring by the Commission, state agencies and research institutions, alerted people to the problem and enabled accurate calculation of the water volume and rates required to maintain the desired level some 140 kilometres downstream. Strong community support, a willing seller, effective networks among water managers and good communication before and during the event meant that key stakeholders were engaged and cooperating to achieve the best possible outcomes.

The cooperation between agencies across the border was crucial and very effective in determining feasibility, negotiating the purchase, managing and monitoring the transmission and liaising with communities downstream. Fortunately, there had been substantial local rainfall, which minimised transmission losses and there were no major physical impediments to flow from the private storage to the Lakes system downstream.

In its early stages, the Narran Lakes water purchase was generally viewed as a one-off response to an emergency. As the event unfolded, however, the possibility of using water purchases such as this as a strategic and systematic adjunct to the purchase of water entitlements became apparent – at least for the unregulated streams and terminal lake systems of the northern Basin. This was partly due to the success of the event at both management and operational levels.

The event also, however, raised concern that the action taken in the Narran case, while justified under the circumstances at the time, does not address the underlying issue in the northern Basin. Had more

of the flood water been allowed to flow down the system without being harvested for irrigation, the breeding event would not have been at risk. Some stakeholders maintain that the situation can only be resolved in the long term through water sharing arrangements that provide greater security for the environment. In the real-world situation of past agreements, allocations and entitlements and after many years of negotiating water-sharing agreements, it is clear that governments will need to purchase water for the environment if environmental values are to be protected.

In the long term, Australian government policy is focussed on improving the health of aquatic ecosystems by purchasing water entitlements to reduce total consumptive water use. This will allow more water to reach wetlands and will help to bolster the small to medium floods that are most affected by consumptive use. In the meantime, the Narran purchase has demonstrated that the *active use* of water for the environment, in flexible, responsive and timely ways, can provide additional options and can be effectively managed. These options will be particularly important in systems such as the Condamine-Balonne where private storages hold eight times more water than public storages. The Narran experience should be taken into account in the development of environmental water plans for the Basin, but will be of specific value in the northern Basin where the conditions are perhaps best suited to responses of this nature.

The Narran experience offers valuable lessons about optimising future water purchases by reducing some of the associated risks. A very important lesson going to the heart of water management in Australia is that regardless of whether water is purchased as entitlements, allocations or physical water, it is very difficult to determine the volumes needed for the environment in the absence of clear ecological objectives. What ecological values (and indeed cultural values) do we want to protect in the long term? In setting these objectives, we need to know more about ecological triggers and responses to floods and drought across a broad ecological base in order to establish how much water is required and when.

The Narran purchase was triggered by the waterbird breeding event but this is unlikely to be the only circumstance in which more water is needed to maintain a functioning ecosystem overall. The preparation of Ecological Character Descriptions for Ramsar sites and other “key environmental sites” as required under the Water Act 2007, will assist in establishing these key ecological values and objectives for target environmental assets and the limits of acceptable change for the preservation of those key values.

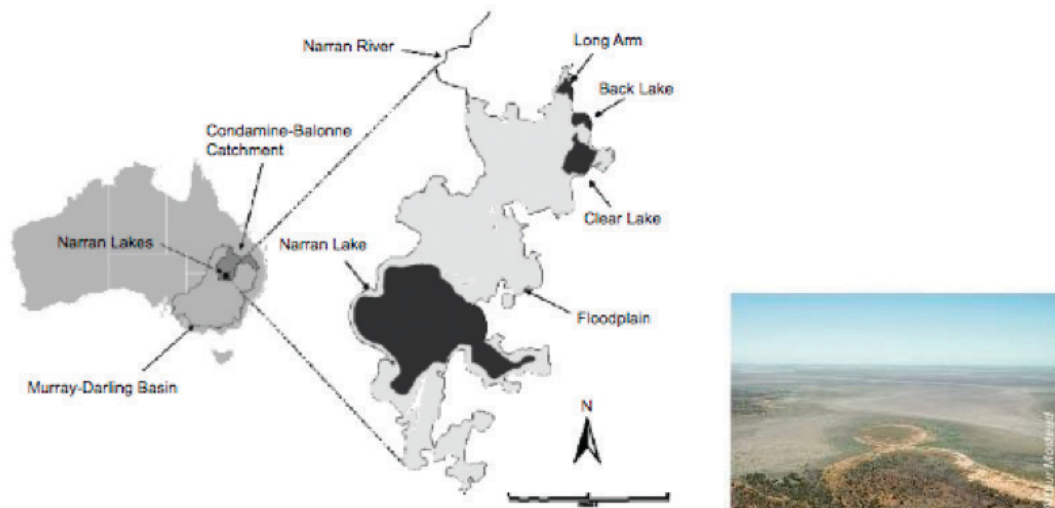
Another issue relates to the broader management of wetlands in the landscape. Water is only one element in this. The way land is managed in the catchment impacts on the ecology of wetlands. Furthermore, it is important to recognise that wetlands in the northern basin systems are interconnected ecologically and need to be managed as a network. It is also important to take account of outcomes other than ecological ones. The Narran purchase delivered important social and cultural benefits that added value to the overall outcomes.

THE NARRAN LAKES SYSTEM

The Narran River is one of a network of distributary channels of the Condamine-Balonne Rivers originating in southern Queensland (**Figure 1**). The other branches, including the Culgoa, Birrie and Bokhara Rivers, enter the Barwon River.

The Narran River has a small, shallow main channel and a contiguous floodplain. A number of lakes lie along the floodplain and the river terminates in the Narran Lakes wetlands system. The wetlands cover an area of over 10,000 ha east of Brewarrina in northern NSW. In earlier, wetter geological periods the river may have flowed to the Barwon. Large floods still reach the Barwon but these events are increasingly rare.

Figure 1: Location of the Narran Lakes system



There are two main elements to the Narran Lakes system; the main Narran Lake in the south and the Northern Lakes. The Northern Lakes include Clear Lake, Back Lake, Long Arm, an intervening channel network and lignum floodplains. A low rise runs from east to west separating the northern section from the southern.

The river flows intermittently as a result of heavy rainfall in Queensland and annual flows are highly variable. Flooding usually occurs in summer and autumn, consistent with flooding events in northern areas of the Murray–Darling Basin. Narran Lakes require higher flows to fill than the Northern Lakes. Consequently the Northern lakes fill more frequently. When Narran Lake proper does fill, however, it holds water for longer periods.

Flow data from upstream of the Narran system indicate that flows have reached the system in almost 90 per cent of years from the 1960s to the 1990s and that medium to large floods were relatively common (Thoms et al., 2007). However, the data show that flooding has decreased since 1997. This decrease is the result of lower annual rainfalls, significant increases in both floodplain water harvesting and upstream extraction for irrigation.

The Narran Lakes Nature Reserve was listed as a Ramsar Wetland of international importance in June 1988, in recognition of its significance for waterbirds both nationally and internationally (Kingsford et al., 1997). The lakes system is also important habitat for other flora and fauna. It is of

cultural significance for local Yuwaalayaay people, and it holds amenity and aesthetic values for the broader community. Long-term residents recall when flooding was a regular feature of the lakes and fish seemed more abundant (Narran Ecosystem Project, undated).

“We don’t think we’ll ever have floods like we used to have. We may get the river paddock flooded but we won’t get it much further out than that,” Robert Senior of Killarney Station (Narran Ecosystems Project, undated).

A COMPELLING CASE

The Narran Lakes water purchase was primarily triggered by a major colonial waterbird breeding event in early 2008. The event took place following substantial summer rainfall in the upper catchment and widespread flooding in the Condamine-Balonne, Warrego and Paroo river catchments. Surveys carried out at the time indicated that there was a large colony established at Narran Lakes (Kingston et al, 2008). The colony on Narran Lakes was the most significant of several colonies in the catchment and was predominantly ibis. Breeding began in January when around 21,181 nests were recorded. A subsequent flood submerged some of these nests but also triggered an increase in the size of the colony and an additional 50,914 nests. Monitoring in late February and early March indicated that water levels were falling and that the breeding event was at risk. Ibis are known to abandon nests if water levels fall, which leads to high levels of chick mortality.

This was the one of the largest waterbird breeding events recorded in the Narran Lakes and the most significant in the Basin since 1998. Narran Lakes' status as a protected breeding site under the Ramsar Convention added further significance to the event. Additionally, the birds have a breeding life of around ten years and had not bred for nine. As a colony, they were reaching the end of their reproduction window.

Opportunities for water bird breeding in the northern lakes are becoming rare; the result of ongoing low annual rainfalls and increased anthropogenic pressures on the water resource. This event was one of the few opportunities for a successful breeding event.



Straw-necked ibis chick crèche. Photo: Kate Brandis (09/02/2008)

A CHRONOLOGY OF THE RESPONSE

In December 2007, the Condamine-Balonne catchment was wet following widespread heavy rain. These antecedent conditions meant that the three flood pulses that emptied out of Queensland into northern NSW travelled further and had a bigger impact on lake levels than would otherwise have been anticipated. The first of these pulses arrived in the Narran Lakes in late-December early-January. An enquiry from the Queensland Press prompted a NSW Environmental Officer, with a background in river operations, to ask the Ranger for the Narran Nature Reserve and a regional ecologist to check whether a breeding event had started. The Officer had told the Queensland Press that he wasn't expecting anything, but he thought it best to check. An initial survey revealed 5,000 pairs of nesting birds, despite inflows remaining well below the modelled threshold for breeding to commence.

Looking at options

A number of NSW officers started researching the event. Fortunately the automatic gauging stations that were in place (not all of which were operational) provided real-time information about the hydrology of what was happening. By the end of February 2008, it appeared that the breeding event may fail due to inadequate inflows. By mid-March it was apparent that, in order to promote the breeding event, extra water would need to be brought into the system. The only workable option for doing this, if funding could be made available, and if water was available for sale, would be to purchase water to increase inflows into the Northern Lakes. NSW officers contacted their Queensland colleagues to see if it would be possible to buy water from their environmental reserve or to borrow water from Beardmore Dam. By late-March it was clear that a purchase of government-owned water would not provide the required inflows within the critical timeframe. The only option was to purchase water from a private farm close to the Queensland border. NSW officers approached the Commission to gauge the possibility of the Commission funding a water purchase. The affirmative answer came from the Commission's Natural Resource Management Committee within a week; the nominal budget was \$2.5 million.

The deliberations of this committee were difficult. There is an understandable tension between dealing with the underlying cause and treating the symptoms of environmental decline in the lakes. In many minds the main risk involved with treating the symptoms is that success in doing that may militate against maintaining the focus on dealing with the underlying problems. Nonetheless, this particular breeding event ultimately was judged to be so significant as to transcend those concerns. The money for the purchase was budgeted in that context.

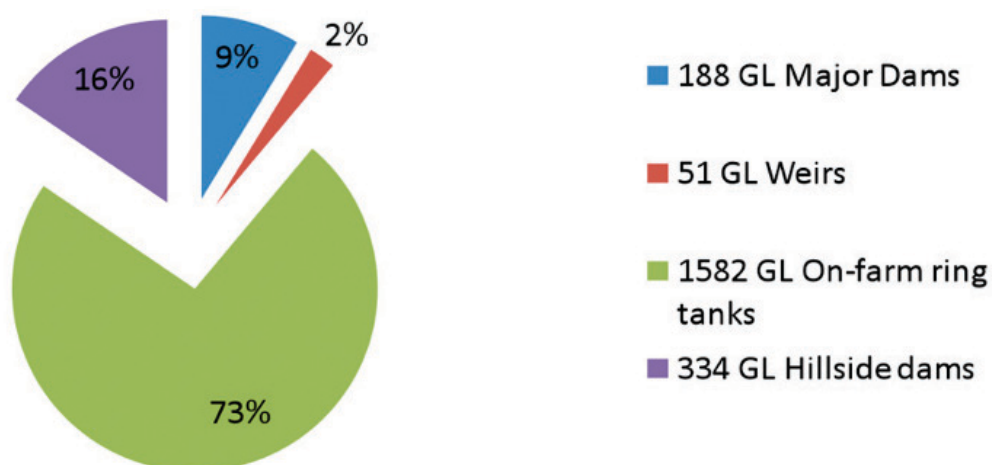
Negotiating the purchase

Finding a seller and setting a price were difficult tasks. To the extent that within-season water markets exist in the northern Basin, they are very thin. Beyond this, although State and Commonwealth agencies are now well practised in buying water entitlements, they have very little experience in buying allocations let alone physical water.

The markets in the northern Basin are very different to those in the southern-connected Basin where the government purchasers have greater experience. In the northern Basin, irrigation water is primarily retained in on-farm private storages; in the Condamine-Balonne, private storages hold eight times the total volume of public storages. By contrast, in the south public storages hold several orders of magnitude more than on-farm storages. In the north, water harvesting and on-farm storage, not water trade, are the main risk management tools for irrigators. Moreover, a seasonal allocation can become a limiting factor to the amount of water an irrigator may take from the river during the season rather than an institutional obligation to supply water from the public storage. The water to be bought

for the Narran Lakes was physical water in a private storage rather than an allocation to be called out from the public storage. In essence there is no established market for such water.

Figure 2: Water storages on the Condamine-Balonne



Source: Water storages on the Condamine-Balonne Source: Webb McKeown & Associates 2007, cited in Ballie 2007 and Frontier Economics (in press)

Queensland is moving toward a system of continuous accounting for allocations against entitlement on unregulated streams. Once done, the Condamine-Balonne will then, like the NSW unregulated Barwon-Darling river system, have three marketable forms of water: entitlements, allocations; and physical water.

Using available figures to calculate gross-margins, the NSW and Queensland officers attempted to assign a market value to physical water. It was judged the upper limit to the water's marginal value could be derived from the marginal returns from a hectare of wheat assuming a wheat price of \$350 per tonne, a likely yield in tonnes per hectare and a likely application rate. Using these figures, physical water was assigned a lower-bound market value of \$180 per megalitre.

According to some reports, the first irrigator approached offered to sell for a much higher price than these calculations could justify. The next property to be approached had more water and more capacity to let it out. The property had also just changed hands and was being managed by a local farmer with a lot of local knowledge. He answered to an international board of directors who were keen to be good corporate citizens.

The board of directors overseeing the vendor property were attracted to the idea of earning a comparable but more certain return from selling their water than might be expected from growing wheat. The new manager had calculated a net value of \$186 per megalitre on a significant part (but not all) of the water he had in storage. He agreed to take \$180 per megalitre for the more certain return. His board of directors were very supportive, not just because of the returns, but also because they wanted to do, and be seen to be doing, things of benefit for the environment.

The property had 30,000 megalitres in storage, but the manager wanted to keep some in reserve for cotton; he had done a water budget that covered wheat first and cotton later. The manager agreed only to sell the 11,000 ML earmarked for wheat production. Importantly, he was also willing and able to start releasing it the next day based on the NSW officers' calculated release rates - a short turnaround imperative to the success of the breeding event occurring on the Lakes.

It is important to stress here how much these negotiations, and how much the initial releases, depended on good faith. The negotiations hit their peak on Good Friday and the releases started over Easter, but all that could be done formally on the Friday was to issue a letter of intent. The directors of

the property were all overseas and the process of getting the appropriate signatures on the contract could not be completed until several weeks after Easter. Had the releases been delayed until after Easter it would have been too late to maintain the levels in the Lake. It is testament to the goodwill of all involved that the water started flowing and the letter of intent was honoured.

Everyone directly involved at this stage was keenly aware of how much the success or failure of the breeding event now depended on the successful transfer of water from the private storage to the Narran Lakes wetlands. From the beginning of the event, one of the NSW officers circulated a newsletter by email to an increasing number of recipients – 150 in the end. The farm manager was sending these to his board of directors throughout the world. The emails sometimes included evocative photos from researchers and field workers and other times interpretations of the hydrographs. Those on the list responded warmly to the emails. The officer worried that the list of recipients had become too big and offered to reduce the list but feedback said no please keep sending them – we love the photos. This real-time, informal newsletter was a wonderful innovation, but with the benefit of hindsight, it would have been better still to have also arranged ongoing formal feedback to the committee that had been charged with the responsibility of allocating the \$2.5 million to the task. As with formalised ‘incident management’ procedures in natural resource management agencies, it would be a good idea next time to have a dedicated officer other than the incident manager to concentrate on this aspect of communication.

Calculating the release

The logistics of the releases were informed by the hydrological model developed for the Commission’s Narran Lakes Ecosystem Project (Rayburg and Thoms, 2008). Some of the model’s assumptions were tested by this particular event. For example, the model assumed that higher flows would be needed to trigger breeding. In the event, the actual flows that triggered breeding were much lower, possibly because of local rainfall.

For practical reasons the actual releases differed from what would have been ideal under the model. For example, the vendor wanted to empty his three most inefficient storages first. The first two of these were low and had to be pumped rather than siphoned out. Moreover the dam inlets (which were being used as outlets for the release) were level with or slightly uphill of the base of the dams. Therefore the operators had to switch pumps on and off as they waited for water to reach pumping depths again. Such pulsing was not built into the model.

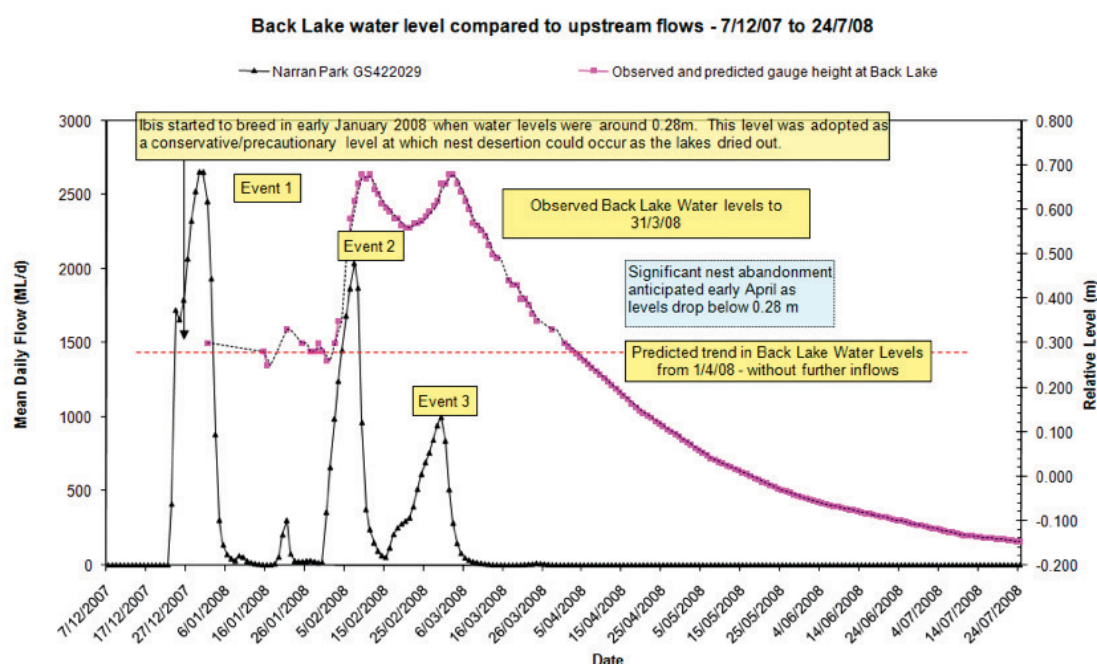
The model was helpful in informing decisions but real-time operating had to override some modelled projections. For example, because the landscape was already wet, actual transmission losses were lower than the model assumed. Moreover the real-time management challenges revealed significant discontinuities in the access to information. Specifically, the river operators could not make use of the information from automated height recorders used for the scientific modelling work. As it turned out, the scientists travelled to Narran, several weeks into the event, to locate and download continuous height data from two automated height recorders installed in 2003. A third recorder is still to be located. In learning from this experience, the NSW Government will now install two new permanent height-and-flow recorders at strategic locations. The river operators will then be responsible for integrating the management of these recorders with that of the previously installed recorders.

In this event, the urgency of managing the releases militated against communication between the river managers, the modellers and the different groups of scientists. As a result, the full potential of the model was not realised and policy makers missed an opportunity to refine and recalibrate the model to better inform future releases in the Narran system. Similar opportunities were also missed regarding waterbird and ecosystem response data and modelling from the Ecosystem Project.

The operational aim of the release was to extend the period of inundation for that part of the lakes that had already been inundated to 300 millimetres for a minimum of 30 days. The depth of inundation is important in making it difficult for predators to raid the nests. Once the water level around a nest starts to drop below a threshold level it is common for adult birds to desert the eggs or hatchlings in the nest.

Framing the project with a simple objective, it was possible to determine how much flow was required to at least maintain the crucial level and if possible to increase it. Given that the lakes were already receding by 10–20 millimetres a day, the operational question was: what flow was required to bring the levels back up to and then to maintain them at 300 millimetres? The minimum height they wanted to maintain was 280 millimetres. Or, in the worst case scenario, they wanted to at least slow down the rate of decline. In the event, when the released water actually got there, the targeted area was at 260 millimetres. The releases were able to bring that back up to 300 millimetres and then to hold it there for four weeks or so. When the releases stopped after the purchased water had been exhausted, the levels started to fall again.

Figure 3: Back Lake water level 07/12/07 to 24/07/08



Source: Peter Terrill, Department of Environment and Climate Change

Managing the risks

Given that the practice of environmental watering is in its infancy, political risk was high. The breeding event had a high public profile, and as such perceived failure may have cast doubts over all future efforts to deliver water for the environment. Paradoxically, inaction may have been seen to carry the least risk politically. However, the failure to deliver any water to the Narran Lakes would have resulted in a failed breeding event and the ultimate collapse of the waterbird population. The environmental risk resulting from inaction was thus much higher than the risk of future attempts to secure water from private vendors for ecological outcomes. The framing of the objective was an important part of managing the risks associated with this initiative. Rather than setting the objective as maintaining the breeding event through to successful fledging, the objective was set at maintaining water levels in the nesting area at 300 millimetres for 30 days as a way of reducing the risk of nests being abandoned.

The delivery of environmental water, although addressing issues of quantity, may not address water *quality* issues. Quality concerns had to be managed to the satisfaction of the Queensland Environmental Protection Agency, as recycled water from farming systems is more likely to contain high levels of nutrients and pesticides. In this case, the vendor's dams had not been used to store any recycled water on the farm. This risk was judged to be low. Nonetheless, the river operators took voucher samples before the release to ensure quality control was maintained.

The main risk in the delivery of environmental water to the Narran Lakes was an accounting risk, as both buyer and seller had strong economic interest in ensuring accurate volumetric measurements. Extensive research had been undertaken to calculate the amount of water that needed to be released in order to deliver the required quantity to the appropriate sites. The accurate interpretation of gauging station data was an important part of this process.

As well as volumetric concerns, the rate of release needed significant consideration, thus reaffirming the requirement for accurate accounting. For the Murray–Darling Basin Commission, given that the target was to maintain a specific water level for a specific period, the rate of release was just as important as the total volume. Measuring the volume released was difficult as no purpose-built metered outlets operated within the system. Rather it was being pumped and syphoned from three different dams. Thus the volumes had to be calculated from hydrographic information and from the physical characteristics of the pumps and syphons².

On top of this, care was needed to ensure that the water released back into the river actually made its way through all the private weirs on the Narran River between the vendor's property and the Lakes. For this event that task was relatively straightforward, but it would be much more complicated on other river systems or if water were being moved along more than one river reach. In that context the current debates about shepherding environmental water between river reaches, and between different states, will need to be resolved before environmental water purchases can be certain of providing environmental benefit in the future. In this case there were only four or five irrigated properties in between the release point and the Lakes. Queensland officers were able to talk to each licence-holder individually; they then marked the water levels in the weirs before the release and made sure the water was drawn down to these levels immediately after the released water passed through.

The detailed calculations of release volumes were done by Queensland officers, but running estimates were continuously communicated to both the seller and the buyer – both of whom had to have faith in the final calculations. As it turned out the releases stopped when the running estimates hit 11,000 megalitres, but when the detailed calculations were completed soon after they showed a figure several hundred megalitres less. NSW officers met with the farm manager to go over the figures. He was satisfied with the calculations, but he also felt that the storages were then as low as he would like to have them. Both parties agreed to stop at that point, and the final purchase was therefore shy of the original agreement for 11,000 megalitres.

Greeting the water

The arrival of the purchased water at the Narran Lake Nature Reserve coincided with an Aboriginal youth and elder's camp at the reserve. These camps aim to establish links between elders and youth and to pass on cultural knowledge. The multi-day camp included visits to cultural sites, Yuwaalaraay/Gamilaraay language learning and trips to gather bush foods and medicine. It also included traditional dancing and the retracing of dreamtime stories. The camp was hosted by the NSW National Parks and Wildlife Service and reported on the ABC AWAYE! Program.

Aboriginal people along the Narran River maintain a strong connection with the traditional cultural values of the natural environment. The strength of this connection is increasingly being recognised in natural resource management in the region. This is demonstrated by the NSW Government's move towards co-management, with Aboriginal people, of the Narran Lake Nature Reserve.

² An associated risk was that some of the released water may have been inadvertently diverted to another farm. Communication, monitoring and accounting were important in making sure this did not happen.

The Narran Lakes area has been occupied by Aboriginal people for tens of thousands of years. Shell middens, hearth sites with clay ovens, quarries, rock wells, scarred trees and burial sites occur throughout the region. The shell middens are the most extensive known in north-western NSW. They provide evidence that the abundance of food and other resources meant the Narran area supported a large population, acted as a meeting place for people of different groups and provided sites for ceremonies. Narran Lake has cultural importance as a site where several Aboriginal dreaming paths come together. Springs, waterholes and bends along the Narran River are part of the dreaming path of Baayami, who, starting from an important creation site, shaped the landscape and set down laws and customs.

Because of its concentrated use, the Narran Lake area, and the nature reserve in particular, contain a great abundance and complexity of archaeological material, which is exposed in every eroded area along the shoreline. Middens are present along the river and on the boundary of the floodplain and there are scarred trees along the river and lake shore and in the sand ridge woodland. Artefact scatters occur on the sand ridge country and quarries are found in some of the silcrete outcrops. Burials also occur in the reserve.

Before the reserve was established for scientific and educational purposes, the land was used for stock grazing, which destabilised the dunes and accelerated erosion. Significant sites are now gradually being stabilised to prevent further erosion and therefore to prevent the loss of cultural and scientific values. These archaeological sites are testament to the great antiquity of Aboriginal culture. Local Aboriginal people take a strong interest in the nature reserve and they wish to be actively involved in its management. The traditional knowledge held by Aboriginal people is important for nature conservation. Where appropriate this knowledge is being recorded for use by non-Aboriginal people. Co-management will help to ensure that other traditional knowledge is taken into account in managing the reserve, and that traditional knowledge is actively maintained by Aboriginal people.

Aboriginal people have access to the reserve for purposes related to maintenance of traditional links with the land. Aboriginal sites are now protected from human disturbance other than for authorised research purposes. As far as possible, Aboriginal sites are protected from accelerated erosion resulting from past stock grazing. All new works proposed for the nature reserve are preceded by a survey for Aboriginal sites. The location of Aboriginal sites is not publicised. Supervised educational access is permitted in set circumstances. And vehicle tracks are being rerouted if they are located on significant archaeological material.

Aboriginal visits are the main human use of the Narran Lakes Nature Reserve. The reserve is an important education setting for the intergenerational transfer of traditional knowledge such as the traditional ways of gathering foods from the area, particularly freshwater crayfish and mussels. In that context the bird breeding event was a great opportunity for the youth at the youth and elders camp to contemplate the cultural significance of such events. The dancing on the shores of the lake that night helped to maintain that connection.

Nonetheless, Aboriginal people have grave concerns that decreased flows have already altered of lignum distribution within the reserve. These changes are thought to have limited the abundance of waterbird rookeries and increased shelter for feral pigs. This in turn diminishes the distribution and the abundance of yabbies, mussels and the riparian plants harvested for food and medicines. Future environmental water purchases will increase Aboriginal people's ability to hold regular camping retreats to harvest traditional aquatic and riparian foods; this will help to promote the social health of Aboriginal communities.

MONITORING OUTCOMES

The Murray–Darling Basin Commission, the Department of the Environment, Water, Heritage and the Arts and the NSW Department of Environment and Climate Change committed funds to monitor and research the breeding event. Bird and nest numbers were closely monitored. Systematic transects were flown for the purposes of collecting aerial photographs. These were ground-truthed, and detailed counts of the total number of nests in each photograph were taken. Water levels and flows were monitored during the event, which gave a valuable opportunity to test models of Narran Lakes hydrology under real time conditions. Bird surveys and vegetation assessments were conducted after the event to assess outcomes for these components of the ecosystem.

The data on total bird numbers, and the spatial distribution of nests, were derived from high resolution (60 mm pixel size) digital vertical colour photography flown early in the event and again at its peak. A Dubbo-based contractor was able to respond rapidly to the request for this service. By contrast, the post-processing and digitizing of nest information was done offshore, in India, and the processing took too long to assist the real-time management decisions. Nonetheless, it will provide invaluable information for future management.

Monitoring provides:

- a good information base for assessing outcomes for some parts of the ecological system
- learning opportunities to inform future action in similar circumstances

One of the important lessons is that these events, because of their declining frequency, provide increasingly rare opportunities to test modelling in real time, monitor responses across a range of biota and thereby fine tune assumptions about the triggers of ecological responses to floods and drying.

The Narran water purchase achieved its objective of maintaining water levels above 300m for 30 days at Back Lake; the area where the breeding colony was concentrated. Water levels fell after that at close to natural rates.

Using water level data, it is reasonable to assume that the breeding event was prolonged and that more chicks successfully fledged due to the additional purchased water. Close to 50,000 ibis chicks fledged in total from two colonies. Mortality in the colony established following the second flood was apparently very high. Monitoring indicated that of 120,000 eggs laid, an estimated 24,571 chicks fledged (Kingsford et al., 2008), although observers in the area found these numbers surprisingly high based on on-ground observations of carcass numbers. The losses were most likely due to falling water levels and abandonment of nests by the adult ibis. Food resources appear to have remained high and were therefore unlikely to have contributed to the mortality. Predators increased late in the event but probably as a result, rather than a cause, of the high chick mortality (Kingsford et al., 2008).

The outcomes of the additional water for other components of the ecosystem are not as well documented as for ibis. Fish scientists from the University of New England did however survey fish after the event and document fish breeding in the lake (Rolls and Wilson, 2008). While the young fish provided a food resource for piscivores, the scientists also observed that the young could not move back into the river over Narran Park weir. In response to this observation there is now a Caring for our Country project proposal to reinstate fish passage along the Narran River. The proposal is based on the experience gleaned from this event.

The fish survey work recommended a framework for future monitoring of events such as the Narran purchase, including rigorous 'before' baselines in target systems, and sampling of a range of fish across the system at different stages including during the peak and one to two months later (Rolls and Wilson, 2008).

It is most likely that different bird species, vegetation, fish and other biota also benefited and that releases such as this will be crucial to maintaining certain ecological values and functions in the Narran system. Understanding what those values are and then determining how much water is needed and at what frequencies is a major challenge for water managers and ecologists. Nonetheless, it is a critical step in framing water management agreements to take account of environmental needs. The involvement of scientists from a range of disciplines was a factor in the success of the Narran event. The importance of these people working together to formulate future responses and long term environmental water needs is clearly apparent from the Narran experience.

The Narran water purchase was supported by the local community and had important cultural significance. This strong community response to the event indicates the importance of interventionist measures to maintain Australia's ecological health. Management tools which prevent the loss of environmental assets will have both direct and indirect benefits, as is reflected in the Narran Lakes experience.

The water purchase was widely seen in the irrigation community as a rational response and a way to marry the competing demands of food production and the environment for increasingly scarce water. In the context of many years of difficult negotiations over water sharing and rights, it was seen as a win-win option benefiting stakeholders through payment for environmental water at prices that made economic sense. That is, it represented the marginal benefit of producing the crop that would otherwise have consumed the water. It was also seen to represent a means for establishing the public cost of desired ecological outcomes (in this case the bird breeding event).

The Murray–Darling Basin Commission's action to purchase the water in response to the bird breeding event will help to meet obligations under the Ramsar Convention. This was acknowledged at the Oceania Regional meeting of Ramsar (Apia Samoa, April 2008).



Straw-necked ibis in flight. Photo: Kate Brandis (29/01/2008)

ENABLING SUCCESS

There were a number of conditions and factors that made the Narran event and water purchase more likely to succeed both in terms of building a case for the response and in managing the release to achieve the best possible outcomes. These success factors offer important lessons for future water purchases.

The high conservation value of the Narran system, its importance locally and culturally and its formal status under the Ramsar Convention set the scene for the intervention. The rarity of the event and the urgency for this cohort of birds to breed further emphasised the need to purchase physical water for the Narran Lakes system and deliver it in a timely manner which minimised transaction costs.

There was good information about some parts of the system. A four-year investment by the Commission in the Narran Lakes Ecosystem Project and long term monitoring of waterbirds had yielded substantial information about the hydrology and bird ecology of the lakes system. This data provided sufficient information to suggest that doing nothing could be catastrophic for the birds and meant that the river operators were able to use hydrological information to perform a simple risk assessment to set a clear operating objective. Water managers in state agencies in NSW and Queensland had strong working knowledge of the system and were able to accurately estimate the volumes and release rates to achieve the objective of maintaining an adequate water level in Back Lake. The case was championed by a network of well-informed, high profile scientists and water managers and proved convincing to decision makers. By the time the purchase proceeded, all of the relevant agencies had bought into a good understanding of the environmental needs and consequently they had developed a sense of commitment to doing what they could to help meet those needs. There was a willingness to take an informed risk. A less well-informed risk would have been much more difficult to deal with.

Open communication between stakeholders was imperative to the success of this project. Networks proved highly effective in building the response and in keeping stakeholders informed. There was a strong working relationship between the NSW and Queensland river operators, which was in part built on interstate involvement in the development of state-based water resource plans. Each agency understood the different states' approach to water planning. Moreover the main individuals in each state had long experience in various aspects of water management, farming and ecology. This pool of experience, coupled with willing and open communication allowed a coordinated and timely response to the Narran Lakes breeding event. These were experienced people with fresh perspectives and strong networks. They were able to fashion a timely, coordinated response. They also had the confidence and ability to adapt their management strategies in light of real-time hydrographic information. They got the flow volume and rate about right.

As the coordinating body, the Murray–Darling Basin Commission was responsible for ensuring that all involved parties were consulted throughout the project. The Commission as the coordinating investor in the Narran Lakes project felt it had a direct stake in helping to make sure the state-based operators were given their heads. And in particular, each of the individual staff members involved was able to combine a can-do attitude with a deep sense of obligation to ensure that the Commission was able to deliver on its commitments to providing water for the environment.

Importantly, NSW agencies had previous direct experience in managing the risks associated with this sort of release. The precedent was set in the drought year of 2002–03 when people growing perennial horticultural crops in Bourke had negotiated to have water released from on-farm storages upstream at Brewarrina for use on their downstream crops. The permission to do so depended on having processes in place for assuring the quality and quantity of the releases. Effective loss accounting and operating procedures had therefore already been developed in consultation with the NSW

Environment Protection Agency. These procedures enabled the NSW authorities to more confidently and efficiently deliver the required water.

A key to the success of this project was a highly trained staff body, who had previous experience in managing flooding events. Having staff with prior technical experience is imperative to the effective management of complex environmental projects such as the Narran Lakes releases. Many of the individuals involved had also had training and experience in what is generically referred to as incident management. This is the broad suite of skills and processes that are pressed into action when managing bushfires, floods and the like. The individuals involved were able to bring these skills to this incident as well.

There was widespread community support, stemming partly from the local importance of the Lakes, the engagement of local people in the Narran Lakes Ecosystems Project and through the recent developments in water sharing negotiations in southern Queensland. This support flowed through to irrigators and was a factor in the eventual seller's decision.

There was more than one willing seller, suggesting that a market for temporary water can emerge under the right conditions. These conditions were apparent in the Narran case, with high value biodiversity at high risk to justify the public cost. Water markets in Australia are developing and the progress to date in buying environmental water on open markets helped to enable the Narran purchase.

Despite the previous experiences in Bourke, no policies or procedures for managing the quality and quantity of water releases had been documented. Consequently the success on this occasion was largely the result of a good set of pre-existing circumstances and networks, and collaboration between agencies and the community. Moreover while the response was very rapid, the decision to act came very late in the event. The process could easily have been bogged down at any stage during the deliberations over each of the risks.

Although the consensus is that this was a significant event worthy of intervention, the fact remains that there is no systematic and agreed process for making the decision about whether to intervene and if so when to intervene. The crucial steps in determining ecological responses to floods and drought, what values we want to protect and how much water at what times and durations is needed are yet to be taken. Responses are consequently reactive and ultimate outcomes are uncertain and very difficult to predict.

LEARNING FROM THE EXPERIENCE

Many nests in the second cohort were abandoned. Whether this was a characteristic of the event, or because the intervention was not big enough or soon enough, is simply not knowable at this stage. While it is sensible to assume that environmental outcomes may be optimised if intervention occurs early, the institutional and policy arrangements required for this type of intervention do not yet exist, meaning simple and early intervention was not possible in this case. Without these arrangements, there is no guarantee that early intervention will be possible next time. The political risks associated with failing, or with being seen to fail, may have acted against future intervention if action had been taken earlier, at a less crucial point. Once the risk of failure was confronted, the other known risks were managed and managed competently. There was no explicit risk management plan – but the players involved had previous professional experience in managing similar projects.

The question at hand is: what should be done in the future? As already discussed, there is tension between this rational emergency response, this treatment of the symptoms, and the ongoing need to address the underlying causes with regard to cap compliance, total entitlement levels and total consumptive use in the catchment. The long-term responses are likely to include a portfolio of measures including the purchase and ‘decommissioning’ of some entitlements, the purchasing of entitlements to be used specifically for environment purposes and future purchases of both allocations and physical water.

Many people are still concerned that one potential negative outcome of this intervention is that its apparent success will focus attention on emergency ‘stop-gap’ responses, rather than maintaining focus on long-term environmental management objectives. Conversely, the Narran Lakes is an example of a highly modified catchment with small public storages, long lead times and residual ongoing consumptive use. In similar circumstances it is hard to imagine that there won’t be other significant breeding events that could fail for the want of physical water being released from farm storages near the Queensland border.

Assuming that future purchases of physical water will be one component of an environmental watering strategy for the Narran Lakes, what does this experience teach? Despite the lack of an established plan, the 2007–08 delivery of purchased water to the lakes system achieved its primary objective. But ongoing management without a plan would be imprudent. Equally, it would be reckless to assume that any explicit plan would be able to accommodate all contingencies. Environmental watering in the Narran Lakes is always going to rely on adaptive management and a strong working relationship with river operators. Any plan should be subject to previously agreed decision making processes to determine the spatial and temporal significance of the breeding event. Similarly it should be subject to triggers for pre-approved purchases. Plans should include some of the basic operating procedures around the accounting and the water quality assurance. These requirements must be documented in a procedures manual. Similarly the operations and communications responsibilities should be documented in an incident management policy document.

Given that the markets for allocations and for physical water are very thin, there are risks involved in waiting to see if there is any water available for sale when it is most urgently needed. Call options on water in farm storages would be one alternative approach. Contracting with irrigators to forego pumping once the river reached a specific height would also be an alternative. Another alternative would be to purchase properties with entitlements and retain the on-farm storages to be managed for environmental releases – but this approach would have its conundrums. Evaporation from these storages would be a form of consumptive use – exacerbating the underlying problems of too much consumptive use.

Purchasing properties for environmental water security would also have a set of associated maintenance costs. These would need to be built into any adequate cost model. These costs could be defrayed by having put options on the water in storage and having these used only when there was water travelling down the river to replenish the storages (again with the obvious implications for consumptive use). This brings us to the interesting question: would it be economically more efficient to have call options on privately owned storages or put options on storages held on behalf of the environment?

In general terms the logic behind options is relatively straightforward. Those with most at stake in the event of water shortages, those with high cost to income ratios, are thought to be most likely to buy *call* options. These options would give them the right, but not the obligation, to call on the other side to provide them with water at a prearranged price. Those with lower cost to income ratios are thought most likely to buy *put* options that give them the right to put, or sell, water at a prearranged price. The buyers of *call* options would effectively be insuring their production and insuring against the price of water rising. The buyers of *put* options might be prearranging a return from water that is greater than they can achieve by using it. Or, they may be insuring against the price of water falling.

The potential to use options as part of the portfolio of management arrangements for the Narran Lakes requires closer examination.

The key to learning from this experience lies in its clearly articulated and simply worded operating objective: maintaining a depth of 300 millimetres in the nesting area for 30 days. The objective embodies a wealth of scientific research and understanding and it translates this into something achievable. It is bold in the sense that managing the releases to make it happen calls for expert timing and a deep understanding of the river system. And yet it is humble in that it takes no more responsibility than the contemporary scientific understanding can bear. It makes no promises about a successful breeding event, but it does what is thought most important in making success possible. And subtly it is rigorously scientific in that it is measurable and monitorable. By contrast, if the objective had been to lift the number of fledged birds from x (without intervention) to y (with intervention) then its success would have been imponderable – there was no control experiment.

The power and purpose of this objective are in juxtaposition with high-level policies to “purchase water for the environment”. These provide no specific guidance on how to respond to specific events – or specific opportunities; they provide no guidance on what to do with the water once it is purchased. By contrast, the operating objective provides scope for learning. An ongoing commitment to monitoring coupled with the ongoing engagement of different agencies make it easier to think through the best way to hold and use, or to decommission, water entitlements and whether or not these holdings should be supplemented by the purchase of allocations or physical water under predetermined circumstances.

OPTIMISING FUTURE OUTCOMES

Clear long-term objectives are needed for the environmental management of the Narran Lakes. The long-term role, if any, of physical water purchases can only be meaningfully determined in contemplation of such objectives. In an ideal world, revised water sharing plans in both NSW and Queensland would obviate the need for such purchases. Given that consumptive use will continue, it is nonetheless conceivable that there could be a role for these purchases, along with entitlement purchases, in the portfolio of management tools used to fulfil environmental objectives.

It is unlikely that the environmental water purchase would have proceeded without wealth of scientific understanding developed over the past five years. More science will be needed in the future if we are going to manage environmental assets successfully. One immediate task is to think through the institutional arrangements necessary to do targeted research during environmental watering events in the future. Such arrangements will revolve around project governance, deliverables, timeframes, intellectual property ownership, data management and more. Ideally these arrangements should be explicitly stated in contracts.

One prudent low cost short-term response would be to ensure that all private storages built (or rebuilt) from now on are fitted with the capacity to allow the inlet to also act as an outlet. This capacity is hard to retrofit, but easy to fit at the time of construction.

There is also a suite of institutional arrangements that should be put in place as a matter of course. These include:

- Pre-agreed decision trees to determine the spatial and temporal significance of breeding events;
- Pre-agreed thresholds at which those with delegated authority to commit the required resources could do so with confidence;
- Pre-agreed risk management plans;
- Pre-agreed incident management plans (necessarily broad and adaptive);
- Functional separation of incident management and formal communication roles; and
- Monitoring and evaluation procedures.

The environmental objectives for the Narran Lakes need a broad ecological base. They should not just be focused on discrete events, but rather take a 'whole-of-environment' approach to management. Models should be modified to take account of all known overarching ecological requirements. During managed watering events, thought should be given to real time recalibration of models.

More broadly, for the benefit of the Narran Lakes and other wetland systems, it would be worth considering the establishment of a discretionary fund with agreed operating guidelines for fast response, based on early warning, adequate monitoring and routine post-event evaluation and reporting. This could possibly be regionally based and managed with community input. The Murray Wetlands Working Group may provide some guidance on how this could be done.

A commitment to monitoring the Basin's important aquatic systems over the long term to determine ecological triggers and responses, thresholds, conditions that build resilience and values that need to be protected is required to underpin planning for water purchases. The implications of climate change need to be brought to this process. In many cases, particularly in overallocated systems, we may have to accept that these systems will move to new states of lower productivity and diversity and that present values will be very difficult to sustain unless allocations change significantly.

Another issue relates to the broader management of wetlands in the landscape. Water is only one element in this. The way land is managed in the catchment impacts on the ecology of wetlands.

Furthermore, it is important to recognise that wetlands in the northern basin systems are interconnected ecologically and need to be managed as a network.

Beyond ecological outcomes, the Narran purchase delivered important social and cultural benefits that added value to the overall outcomes. These indirect benefits need to be recognised and built into future models if models are to accurately calculate all the costs and benefits of similar water purchase initiatives.

BEYOND NARRAN

With regard to the implications of this water purchase for other valleys in the northern Murray–Darling Basin, and the potential risks and precedents set for future environmental watering, we make the following observations:

- Environmental water purchases need to be considered in the context of whole water sharing plans, based on agreed ecological objectives and supported by data and monitoring to establish baselines and estimates for watering regimes. All purchasing options should be considered.
- The measures of success for environmental outcomes start with the operating objective (in this case the depth and duration of the inundation). The next tier of measurements should count, in natural units, the measurable ecological outcomes (in this case the number of nests, eggs, hatchlings, fledglings and mortalities as well as the number of hectares inundated). But in the long run partial measures are misleading and possibly counterproductive when dealing with complex things like ecosystems. The development of some sort of index of wetland health may be more appropriate.
- In the context of the colonial waterbirds, given that they can breed in a number of different wetlands, what is needed is some sort of index of the viability or sustainability of the particular population. In economic terms this has to do with the *stocks* and *flows* of the population at a given point in time. As in the case of the Narran water purchase, intervention becomes more imperative as the interval since the last significant breeding increases.
- The Narran water purchase provides considerable guidance about how the risks related to in-stream water quality from water purchased out of farm storages should be managed in the future. Dams without a history of receiving tail drainage should be chosen ahead of those with such a history. In either case, voucher samples should be taken. Those with a history of tail drainage receipt should only be used if, on the balance of probabilities, they are likely to do more good than harm. Understanding these probabilities will require an understanding of any hazards involved and the possible magnitude of any problems. Balanced against this is the temporal and spatial significance of the breeding event, the risk of it failing and the consequence of it failing.
- For existing farm dams, the main regulatory issues associated with the discharge of water from farm storages, for the benefit of rivers and wetlands, have to do with the water quality issues discussed above. For new farm dams it would be prudent to require that all inlets to the dam be designed and built so that they can also act as outlets. This is relatively cheap to do at the time of construction, but it is difficult to retrofit.
- The availability of real-time river flow data was invaluable in the management of this event. The value would have been greater still had all the installed monitoring instruments had been operational and compatible. And in the long run it would have had even more value if the data had been used in real-time to help recalibrate and refine existing hydrologic models of the system.
- The markets for water in the northern Basin are thin. Therefore, establishing a fair and reasonable offer for the water, from both the vendor's and the taxpayers' points of view, depends on different government agencies using gross-margin information to determine the opportunity cost of forgoing a crop and the value of the potential environmental benefits – at least in terms of the spatial and temporal significance of the breeding event.
- Important questions raised by the Narran event include:
 - What provisions are in place for hydrological and ecological monitoring of wetlands to inform on water purchases in the way that the Narran event was informed through previous research?
 - Has this project set a precedent for allocating environmental water to high conservation value wetlands on unregulated, ephemeral systems? Were there any other options?

- What has been learned about intergovernmental agency support for delivering environmental water across State borders from this project?
- What are risks to future bird-breeding events and the need for urgent intervention? Are there currently processes in place to address environmental watering of wetlands in unregulated, ephemeral systems? How effective are the current water sharing rules in addressing the needs of ephemeral wetlands that have significant irrigation development in the upper catchment?

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ANNEX 1 AGENCIES/GROUPS CONSULTED

Murray–Darling Basin Commission (now Murray–Darling Basin Authority)

Department of Environment Water Heritage and the Arts

Condamine Balonne community representative

University of Canberra

NSW Department of Environment and Climate Change

NSW Department of Water and Energy

Queensland Department of Natural Resources and Water

University of NSW

NSW National Parks and Wildlife Service

ANNEX 2 EVALUATION FRAMEWORK AND CONSULTATION QUESTIONS

Evaluation framework for the Narran Lakes water purchase

Terms of reference

To:

1. Assess the process used to acquire and deliver environmental water to the Narran Lakes
2. Consider the potential to use this process as a guide to future acquisition and delivery of environmental water.
3. Record the outcomes of the bird breeding event that inspired the purchase and analysing the relevant monitoring procedures; and
4. Develop principles, guidelines and strategic options for the future purchase of temporary water for environmental outcomes.

Relevance; effectiveness; efficiency, institutional enabling arrangements, impact, sustainability

Relevance

Were the objectives in line with stated aims of relevant policy?

Effectiveness

What were the expectations of success?

What were the intended and unintended outcomes?

What are the measures of success?

Was the intervention successful by these measures?

How was success achieved?

What detracted from success?

Efficiency

Did the results justify the resources?

Are there more cost effective methods to achieve the same results in future?

Enabling mechanisms

What are the formal and informal agreements and arrangements for cooperation between the partners in the intervention?

How robust and resilient are these?

Other issues

What other issues need to be considered?

- Regulatory issues
- Water quality

- Adequacy and timeliness of monitoring data
- Pricing
- Expectations – have they been raised to high?
- Adequacy of water sharing rules in unregulated rivers- taking account of requirements of wetlands in ephemeral systems

Impact

What were the changes for people and ecosystems as a result of the intervention?

Target	Change
Birds	
Other species	
Lakes ecosystems	
Community	
Culture	
Government	
Partnerships	

What are the critical success factors?

Success Factor	Influence

Sustainability

Can the outcomes be repeated?

What would make it work better in Narran Lakes?

What opportunities are there for these interventions in other areas?

- Other terminal lakes systems
- Regulated systems

How can success be measured?

- Setting objectives
- Monitoring and evaluating achievements

Evaluation questions

1. Can you briefly describe your role in the Narran Lakes water purchase?
2. Was the Narran Lakes water purchase consistent with policy?
3. Was the case for the water purchase sufficiently compelling?
4. Were the formal and informal institutional arrangements and partnerships formed for the water purchase appropriate?
5. What were your expectations?

6. What did the water purchase achieve?
7. What contributed to success?
8. What detracted from success?
9. There were some risks- were they well managed?
10. Were there any negative outcomes?
11. How should we measure the success of water purchases in future?
12. Are water purchases an efficient use of resources?
13. Are there more efficient ways to do the same thing?
14. The Narran lakes water purchase was a one-off intervention – do you think there would be opportunities for similar purchases for Narran Lakes? Under what circumstances?
15. What other wetlands do you think could benefit from this type of purchase?
16. Would the arrangements be very different? How?
17. What would make these sorts of interventions more successful?
 - Institutional arrangements
 - Early warning
 - Evaluation of outcomes
 - Other?



Australian Government



MURRAY—
DARLING
BASIN AUTHORITY