Meeting environmental objectives in the Murray–Darling Basin

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Summary

The Murray–Darling Basin Plan is primarily concerned with reallocating water from irrigation to the environment. The Australian Government is committed to easing the transition to the new environmentally sustainable diversion limits identified in the Basin Plan by purchasing water and investing in water saving infrastructure. In November 2012 the Australian Government introduced the sustainable diversion limits adjustment mechanism that could offset the need to recover up to 650 gigalitres of water entitlements through supply measures and potentially return an additional 450 gigalitres to the environment through efficiency measures.

Water recovered for environmental use is to be managed by the Commonwealth Environmental Water Holder to meet environmental objectives specified in the Basin Plan. As the Australian Government’s water portfolio grows, it is important to clarify:

- a number of issues that will affect the way the portfolio is managed
- the effect of environmental water management on other water users (particularly the irrigation sector)
- the overall cost of achieving the environmental objectives of the Basin Plan
- management of water at the operational level.

Natural flows in the Murray–Darling Basin are highly variable, with water-dependent ecosystems developing and evolving within this flow environment. The high degree of uncertainty over future inflows and the variable nature of environmental demands point to the importance of flexible and adaptive institutional arrangements. To minimise the cost of satisfying environmental water requirements, environmental water managers need arrangements that allow them to respond quickly to changing conditions. The Murray–Darling Basin Authority, the Commonwealth Environmental Water Holder and other stakeholders have recognised the need for an adaptive approach to managing environmental water.

Two important tools within the existing property right system that could reduce costs are water allocation trade and carryover. An understanding of how the Commonwealth Environmental Water Holder’s activities may influence the water market would also be beneficial. Such understanding would contribute to developing a framework to allow the Commonwealth Environmental Water Holder to use available water market products to cost-effectively deliver environmental objectives, including how to manage the effects on other water users.

Costs can also be influenced by the level and stringency of site-specific environmental water requirements. It is important that new information on environmental responses to additional water can be factored into decisions on environmental water requirements at the catchment level and the sustainable diversion limits, as it becomes available.

An adaptive management framework could provide environmental water managers with some flexibility in the timing, duration and volume of environmental releases. Such a framework may significantly reduce costs for the Commonwealth and other water users.

The way in which environmental water is managed and how environmental water requirements are specified will influence the environmental benefits and socio-economic effects associated with holding a given portfolio of environmental water. Many of the opportunities to improve outcomes involve environmental water managers using available flexibility to manage their water holdings. Exercising flexibility is likely to require more comprehensive governance
arrangements than would otherwise be the case. These additional costs would need to be weighed against the potential benefits of increased flexibility.
1 Introduction

A primary catalyst for water reform in the past 20 years has been the environmental damage caused by over-allocating water to irrigation in the Murray–Darling Basin. The most significant early reform was the capping of surface water diversions at 1993–94 levels of development (NWC 2005) with the most important recent reform being the introduction of the Water Act 2007 (Cwlth). This Act created the Murray–Darling Basin Authority, which was responsible for developing the Murray–Darling Basin Plan.

The Basin Plan sets new environmentally sustainable limits on the volumes of surface water and groundwater that can be diverted from the Basin for consumptive use (surface water diversions are to be reduced by 2750 GL on average) and develops an environmental watering plan. The MDBA’s main objective is to achieve a healthy working Basin, including a healthy environment, strong communities and a productive economy (MDBA 2011). While the Basin Plan will deliver environmental benefits, it will also lead to a reduction in the value of irrigated agricultural production in the Basin, with the resulting social and economic effects likely to be concentrated in irrigation-dependent communities (ABARES 2011).

The Australian Government has made a commitment that all additional water needed to meet the environmental objectives of the Basin Plan will be either purchased directly from irrigators or obtained as water savings through investments in improved irrigation infrastructure (DSEWPaC 2012a). This water is to be managed by the Commonwealth Environmental Water Holder (CEWH)—an independent statutory position created under the Water Act 2007 (Cwlth)—to protect or restore water-dependent environmental assets and ecosystems in the Basin in accordance with the environmental watering plan identified in the Basin Plan.

The Commonwealth Environmental Water Office (CEWO) supports the CEWH in making decisions on the use of Commonwealth environmental water. The management of water held by the Commonwealth is to be consistent with Basin Plan water trading rules, state trading rules, river operational rules and rules relating to the carryover of water (DSEWPaC 2011). The CEWO publishes an annual business plan that outlines, among other things, the process by which decisions on using Commonwealth environmental water are made (CEWO 2012).

The main purpose of this paper is to discuss some of the major challenges in meeting the environmental objectives of the Basin Plan. While many options are likely to be available for satisfying environmental demands, an important question is: What option or set of options can minimise the cost of achieving environmental objectives?

Several factors complicate the satisfaction of environmental objectives in the Basin and have the potential to influence costs, including the variable nature of environmental demands and uncertainty over future inflows. These factors imply that environmental water managers will need access to tools to help them respond quickly to changing circumstances; for example, to top up a natural high-flow event with an environmental release to flood a wetland. A number of options are currently available in most well developed water markets of the Basin, including carrying water over and trading in allocations or other water products.

Other major factors influencing costs are the level and stringency of site-specific environmental water requirements. Environmental water requirements are necessarily determined using current (imperfect) knowledge of ecological and ecosystem responses. While significant uncertainty surrounds environmental thresholds and responses to increased environmental flows, this knowledge will improve over time, providing an opportunity to refine site-specific
environmental water requirements. It will be important that this type of information be factored into reviews of environmental water requirements and sustainable diversion limits (SDLs) as it becomes available.

Apart from identifying the benefits of adopting an adaptive approach to managing environmental water, this paper also discusses some actions that have been taken to rectify the imbalance in the allocation of consumptive and environmental water and on the operation of the CEWH.

The paper concludes by identifying a number of steps that could be taken to:

- help reduce the level of uncertainty that could accompany the CEWH’s entry into water markets
- mitigate the risk that poorly defined water storage rights could lead to a scenario in which the CEWH’s intertemporal storage decisions have unintended consequences for other users, particularly irrigators. This would mean the continued reform of water storage rights remains an important policy objective.
2 Complexities in meeting environmental objectives

The primary focus of recent water reforms has been to recover water to protect or restore water-dependent environmental assets in the Basin. Given this policy goal, a key question is how to minimise the cost of achieving it. This will depend on institutional arrangements and the level of environmental protection. In general, the more restrictive the range of institutional arrangements or the higher the level of environmental protection, the higher the cost; for example, a total ban on access to irrigation water would most likely achieve a high level of environmental protection, but at significant cost.

When considering how to minimise the cost of achieving environmental objectives, policy makers are constrained by aspects of the physical environment. Two major factors complicating the cost-effective satisfaction of environmental goals in the Basin include the nature of water-dependent environmental demands and uncertainty over future inflows.

Natural flows in a river system vary in response to climate, seasonal conditions, land form and land use (MDBA 2011). Identifying the historical pattern of natural flows can provide important information on the nature of environmental watering demands, as it was within this flow pattern that water-dependent ecosystems developed and evolved. Figure 1 illustrates the total annual diversion and what annual flows would have looked like in the Murrumbidgee system over the past 114 years in the absence of regulation and consumptive extractions. The variability in natural flows suggests the watering needs of water-dependent ecosystems in this river system are also likely to be highly variable.

Figure 1 Modelled natural river flows and diversions in Murrumbidgee 1895 to 2009

Source: MDBA 2012b
The many different types of water-dependent ecosystems can be broadly categorised as those needing access to a relatively constant water supply (such as to maintain river connectivity) and those needing intermittent access to water that can only be satisfied during high-flow events (such as sporadically inundated wetlands). A major challenge in meeting environmental objectives in the Basin will be replicating some of the intermittent high-flow events not currently occurring due to river regulation and over-extraction. In the Basin Plan, SDLs have been established to reinstate selected high-flow events and the environmental flow outcomes consistent with these SDLs have been estimated (MDBA 2012c).

The variability in historical natural flows (Figure 1) also highlights significant uncertainty over future water availability, which complicates the decision on how much environmental water to release at a particular time and how much to hold for future use. For example, if an environmental water manager has just supplemented a high-flow event to flood a wetland that only needs flooding every three years, should the manager supplement a high-flow event the following year if conditions are favourable? This action would have the effect of extending the period before another flood is needed by another year, but bearing the risk of having less water to use to satisfy future environmental demands. It is important to recognise that any increase in climate variability (due perhaps to climate change), will further increase uncertainty over future water availability.

The combination of variable environmental demands and uncertain inflows implies that the key to cost-effectively satisfying environmental objectives is an institutional framework that allows environmental managers to adapt quickly as circumstances change. The institutional framework set up for the CEWH to manage environmental water provides some flexibility to environmental water managers. In addition, the Australian Government’s commitment to protecting existing property rights requires that water will be acquired and managed within the current property rights system. If environmental managers are to minimise the cost of achieving objectives, it is likely they will need to use a range of water management tools developed within the property rights system.

The main elements of water property rights in the Basin include permanent entitlements, temporary allocations and storage rights. Permanent water entitlements provide owners with long-term access to a share of water, whereas temporary allocations provide access to a physical volume of water within a given year. A key feature of surface water property rights in the Basin (specifically the southern Basin) is their tradability (both allocations and entitlements), which facilitates the transfer of water to higher-value uses. Storage rights provide entitlement holders with some flexibility to carry over some of their allocation into the following year, thereby enhancing the intertemporal efficiency of water use.

While water property rights in the Basin have been designed to provide relatively stable access to irrigation water (see annual diversions in Figure 1), they also provide significant flexibility when the full range of options is used. For example, in the context of satisfying environmental watering requirements, having access to the temporary water allocation market provides an opportunity to acquire a significant volume of water for the environment at relatively low cost in wet years when environmental releases are likely to be high and the marginal value of water for irrigation is low.

Another factor influencing the cost of achieving environmental demands is the level and stringency of environmental water requirements. Lower or more flexible flow targets imply lower environmental water requirements and costs. Significant uncertainty appears to exist over ecosystem responses to additional water. According to the MDBA, uncertainty surrounds estimates assigned to the various metrics which were used to define environmental water
requirements of plant and animal populations, and particularly uncertainty around the required frequency of flows’ (MDBA 2011). Specifically, ‘it is likely that there are thresholds for many plants and animals beyond which their survival or ability to reproduce is lost, but the precise details of these thresholds are mostly unknown’ (MDBA 2011, p. 43). Uncertainty over environmental responses reinforces the need to take an adaptive approach to setting and refining site-specific environmental watering targets.

Identifying robust environmental watering targets is likely to involve a significant amount of ‘learning by doing’, and refining of initial flow targets (Crase 2012). This process could yield significant benefits (in terms of reducing the cost of achieving environmental objectives) if it identified that it was possible to achieve environmental objectives with less water, which appears to be enabled by the SDL adjustment mechanism.

At a broad strategic level, the Basin Plan appears to accommodate this approach as it specifies that the MDBA must review and update the Basin-wide environmental watering strategy no later than five years after the strategy is first made or last reviewed and updated, and may do so at any time within that period (MDBA 2012d). The monitoring and evaluation program for the Basin Plan includes evaluations of the Basin Plan as a whole, reviews of water quality targets and environmental watering plan, and evaluations, reviews and audits to inform changes to, and implementation of, the Basin Plan. These evaluations and reviews indicate a move toward applying the ‘learning by doing’ principle to managing environmental water. However, it will be important to clarify how flexibility at the broader level is translated to operational environmental watering actions that will be implemented by environmental water delivery partners (such as catchment authority managers).

The stringency of environmental water requirements can also influence costs. For example, flexibility that would allow environmental managers to deviate from nominal flow targets (in terms of timing, duration or volume) in dry years could significantly decrease the opportunity cost of satisfying site-specific environmental objectives. However, it would be important to ensure these deviations do not lead to significant environmental costs.

The Australian Government is pursuing a number of strategies to protect and restore water-dependent environmental assets and ecosystems in the Basin while minimising the socio-economic effects on the Basin economy and community. These strategies include:

- development of the Basin Plan and provision of an SDL adjustment mechanism
- acquisition of water for the environment by the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) under the Water for the Future initiative
- creation of the CEWH to manage this portfolio of water.

The next sections provide more detail on the complexities of meeting environmental objectives, the strategies the MDBA, DSEWPaC and the CEWH are adopting to address them and issues that should be considered as the Basin Plan is implemented.
3 Environmental water use

The Basin Plan includes an environmental watering plan and new SDLs for surface and groundwater systems that are consistent with the environmental watering plan. The SDL reduction for surface water in the basin is 2750 GL. This reduction can increase or decrease under the SDL adjustment mechanism introduced in November 2012. The type of activities that can be considered under the adjustment mechanism will either allow equivalent environmental outcomes to be achieved using less water (supply measures) or increase the volume of water available for environmental use so long as there are no negative socio-economic effects (efficiency measures).

Supply measures have the potential to reduce the volume of water that needs to be recovered by up to 650 GL, and include activities such as environmental works and measures, rule changes and improved river operations. These investments are to be funded by reallocating some existing funds currently allocated to water purchases.

Efficiency measures, in turn, allow for the recovery of additional water for the environment so long as there are no negative socio-economic effects. Efficiency measures include investments that improve the efficiency of on-farm irrigation, with any water savings being transferred to environmental use. The Commonwealth is providing $1.575 billion to recover 450 GL of additional water for the environment through efficiency measures and $200 million to ease or remove key constraints in river systems that impede the delivery of environmental water (DSEWPaC 2012b).

In establishing SDLs (and thereby defining how environmental water will be used) the MDBA identified a range of flow targets using the 'hydrological indicator site' approach. In particular, the MDBA identified 122 hydrological indicator sites to determine environmental water requirements and to monitor environmental flows throughout the Basin (MDBA 2012c). This strategy is based on the assumption that meeting flow targets at a hydrological indicator site will satisfy the water needs of a number of environmental assets. The water requirements for environmental assets located within a region are likely to be less than the sum of water requirements for individual assets located in that region because flows that maintain one asset often provide water for other assets (MDBA 2011).

An environmental flow regime refers to the volume, timing, duration, frequency and quality of flows provided to the environment (VEWH 2012). An example of the specification of a flow regime that is estimated to achieve site-specific ecological targets in the Mid-Murrumbidgee River Wetlands is provided in Table 1. Environmental outcomes in each ecosystem depend on different combinations of these flow requirements. Environmental outcomes are defined in the Water Act 2007 (Cwlth) to include ecosystem function, biodiversity, water quality and water resource health (MDBA 2011).

The annual flows needed to achieve the site-specific ecological targets in the Mid-Murrumbidgee River Wetlands are seen to be quite variable (Table 1). This also appears to be the case for the Basin generally; Figure 2 represents a time series of modelled environmental water use in the southern Basin.
### Table 1 Environmental water requirements in the Mid-Murrumbidgee River wetlands

<table>
<thead>
<tr>
<th>Site-specific ecological targets</th>
<th>Flow rate required (ML/d)</th>
<th>Duration</th>
<th>Timing</th>
<th>Proportion of year’s event required (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>– ensures the current extent of native vegetation of the riparian, floodplain and wetland communities is sustained in a healthy, dynamic and resilient condition</td>
<td>26 850</td>
<td>45 days in total</td>
<td>July to November</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>26 850</td>
<td>5 consecutive days</td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>– supports the habitat requirements of waterbirds and is conducive to successful breeding of colonial nesting waterbirds</td>
<td>34 650</td>
<td></td>
<td>June to November</td>
<td>35</td>
</tr>
<tr>
<td>– supports recruitment opportunities for a range of native aquatic species</td>
<td>44 000</td>
<td>3 consecutive days</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>– supports key ecosystem functions</td>
<td>63 250</td>
<td></td>
<td></td>
<td>12</td>
</tr>
</tbody>
</table>

Note: Flow rate needed is measured at Narrandera.
Source: Abbreviated from MDBA (2011a)

**Figure 2 Commonwealth environmental water use pattern in the southern Murray–Darling Basin (based on the 2750 GL MDBA modelled reductions in diversions)**

![Commonwealth environmental water use graph](image)

Source: ABARES (2011)

The time series of the use of environmental water held by the Commonwealth (Figure 2) was constructed using the MDBA hydrological modelling for the 2800 GL SDL reduction scenario for
a 114-year sequence of historical climate (for the southern Basin, the 2800 GL scenario analysed here is consistent with the 2750 GL scenario contained in the Basin Plan as the 50 GL difference is in the northern Basin). The approach the MDBA adopted to model environmental water use was to estimate the environmental flow outcomes that could be achieved from a specified reduction in diversions (MDBA 2012b). Water held by the Commonwealth for environmental use is, therefore, modelled as the reduction in current diversion limits to the new environmentally sustainable diversion limits (Box 1 provides more details on assumptions and limitations of MDBA modelling), after taking into account other water use for environmental purposes.

What is clear from Figure 2 is that annual environmental water use can be very different from long-term average use (2354 GL for the southern Basin). This is confirmed by Figure 3 which shows the ranking of annual environmental water uses, from lowest to highest, as modelled by the MDBA over the 114-year historical climate sequence. From the ranking, modelled annual environmental water use is found to be higher than average use in 60 per cent of the years.

Box 1 Some limitations of MDBA environmental modelling

<table>
<thead>
<tr>
<th>The MDBA acknowledges that its environmental modelling involves a number of simplifying assumptions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The scheduling of environmental use assumes perfect foresight (that is, future water availability levels are known), and the scheduling of demands occurs on an annual time scale (MDBA 2012c).</td>
</tr>
<tr>
<td>• Environmental watering use patterns were developed in a way that aligns with the projected allocations associated with a pro-rata entitlement portfolio plus 20 per cent exceedence allowance (MDBA 2012c). The allocations attached to this portfolio establish the Basin Plan environmental watering accounts.</td>
</tr>
<tr>
<td>• A pro-rata entitlement portfolio assumes the government acquires the same proportion of entitlements of different securities within a region. For example, if the government purchases 29 per cent of entitlements within a region, these purchases will comprise 29 per cent of low security entitlements and 29 per cent of high security entitlements in that region.</td>
</tr>
<tr>
<td>• The MDBA uses the environmental event selection tools to ‘ensure that while seeking to reinstate a certain frequency of various events the demand volumes for fresh and overbank flow events for the multiple sites in a valley do not exceed the Basin Plan environmental watering account volume in a given year (except for a small number of years in which the volume is exceeded by 20 per cent to indirectly utilise full allocation, potential carry over or trading activity)’ (MDBA 2012c, p.27). The exceedence allowance is subject to a further constraint that the environmental watering account balances over a rolling five-year period.</td>
</tr>
</tbody>
</table>

In Figure 3 irrigation diversions are used to classify each year as wet (blue—top 25 per cent of diversions), normal (green—middle 50 per cent of diversions) or dry (red—bottom 25 per cent of diversions). It can be seen that the environmental water uses modelled by the MDBA are to be higher than average environmental water use in wet and moderately wet years while they tend to be lower in dry years.
The variable pattern of environmental water use is rather different from irrigation water use. This is because irrigation use tends to operate on an annual cycle that requires access to a stable water supply whereas environmental watering uses in hydrological systems such as the Basin are based on a multi-year cycle that is subject to significant variability in water availability. Given this cycle, many environmental assets in the Basin only receive access to water intermittently during high flow events (for example, a high flow that causes a river to breach its banks, flooding a wetland). In a natural flow environment, these high flows were usually followed by periods of lower flows where rivers and streams remained within their channels, and in some cases, ceased to flow. These drying periods were important to the natural river functions (MDBA 2011).

Some environmental assets that need intermittent access to water include nationally and internationally recognised wetlands. In the absence of engineering solutions, the environmental water requirements of these assets can only be satisfied during high flow events, hence the procyclical nature of some environmental uses and water availability (that is, they follow a similar pattern). One of the options for satisfying these water requirements in regulated systems is to top up a natural high flow event by piggybacking environmental releases to create an
overbanking event. In dry years, when the possibility of instigating a flood event is unlikely, environmental releases might be limited to maintaining minimum flows.

The positive relationship between environmental water use and water availability illustrated in Figure 3 raises a number of issues, including whether the costs (budgetary and opportunity costs of foregone irrigated production) of meeting environmental objectives could be reduced by engaging in allocation trade and whether a mix of entitlement types could minimise the cost of meeting environmental objectives. These issues are discussed in the next section.
4 Managing environmental water to achieve outcomes

As well as the Basin Plan, the Australian Government is implementing a number of other strategies to satisfy environmental objectives in the Basin. These include the acquisition of water entitlements under the Water for the Future initiative, the establishment of the CEWH and the introduction of institutional arrangements for environmental water trading and carryover.

Meeting environmental water uses with existing irrigation entitlements

Under the Water for the Future initiative run by DSEWPaC, more than $12 billion is being spent in the Basin reform (Burke 2011). This funding will help fulfil the commitment of supporting healthy rivers and helping communities adjust to a future with less water (DSEWPaC 2012b). The funding is spread over 10 years and includes two main components: a water entitlement purchasing program (Restoring the Balance program) and an infrastructure investment program (Sustainable Rural Water Use Infrastructure Program). In 2010 the Australian Government made a commitment to bridge the remaining gap between what has been returned to the environment and what is required to be returned under the Basin Plan through water purchases.

By 30 September 2012 the Commonwealth had recovered 1094 GL (in long-term average annual yield) for the environment under the Restoring the Balance program, with further purchases to continue until 2019 (DSEWPaC 2012c). The Australian Government is also expecting to obtain a further 600 GL of water savings from investments in water saving infrastructure under the Sustainable Rural Water Use Infrastructure Program by 2019, of which 316 GL was recovered or scheduled for transfer at 30 September 2012. Taking into account state government water recovery and other actions at 30 September 2012 a total of 1577 GL of environmental water have been recovered or contracted for recovery (DSEWPaC 2012b).

In addition, with the introduction of the SDL adjustment mechanism, the Australian Government committed to providing additional funding for environmental works and measures and other activities that have the potential to reduce the volume of water that needs to be recovered for the environment by up to 650 GL. The Commonwealth is also providing $1.77 billion in funding to ease or remove key constraints in river systems and to implement efficiency measures to recover 450 GL of additional water for the environment (DSEWPaC 2012b). Water entitlements acquired through these programs and the allocations attached to these entitlements will comprise the Australian Government’s environmental water portfolio.

In theory, the composition of the environmental water portfolio will depend on environmental water managers’ risk preferences and how adaptive they are allowed to be. For risk-averse managers, a portfolio of high security entitlements might be preferred as it will provide a more stable yield from its entitlements. However, the cost associated with obtaining such a portfolio is high because high security entitlements are exchanged at a premium. For example, in the September 2012 tender of the Restoring the Balance program, high security entitlements in the Murrumbidgee were traded at $1704 per ML (prices are for long-term average annual yield) while general security entitlements traded at $915 per ML (DSEWPaC 2012c). However, a less costly portfolio that contains more low security entitlements can expose the environmental water manager to higher risks of not having enough water in low availability years.
Data on the location and security of water purchases under the Restoring the Balance program indicate these purchases have been spread across entitlement classes in most regions (Table 2), although there has been a tendency to purchase higher proportions of entitlements from security classes where entitlements are more available.

For example, in the Goulburn–Broken catchment, the nominal number of high security entitlements issued is more than double the number of low security entitlements (993 921 ML of nominal high security versus 438 601 ML of nominal low security entitlements) (Table 2). By 30 September 2012 nearly 19 per cent of high reliability entitlements issued had been purchased under the Restoring the Balance program, compared with only 2.3 per cent of low reliability entitlements in the catchment. This pattern could change as the buyback progresses. However, the acquisition strategy under the infrastructure program appears to be to acquire similar proportions of entitlements from each security class within each region (Harwood 2012).

In the MDBA modelling of SDLs, it is assumed that the Commonwealth is recovering a portfolio with equal proportions of all entitlement classes (a pro-rata portfolio, see Box 1) to establish the Basin Plan environmental watering account (MDBA unpublished). Figure 4 compares the annual use of held Commonwealth water for the environment in the southern Basin (Figure 2) with annual water supplies from a notional pro-rata entitlement portfolio held by the CEWH that yields an allocation equivalent to 29 per cent of annual diversions under current diversion limits (that is, consistent with the surface water SDL of 2354 GL in the southern Basin).

**Table 2 Restoring the Balance program, progress at 30 September 2012**

<table>
<thead>
<tr>
<th>Catchment</th>
<th>Entitlement type</th>
<th>Nominal entitlements issued (ML)</th>
<th>Nominal entitlements purchased (ML)</th>
<th>Yield factor</th>
<th>Proportion of issued entitlement purchased %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gwydir (NSW)</td>
<td>High security</td>
<td>14 878</td>
<td>0</td>
<td>100</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>General security</td>
<td>509 665</td>
<td>88 520</td>
<td>36</td>
<td>17.4</td>
</tr>
<tr>
<td>Lachlan (NSW)</td>
<td>High security</td>
<td>26 685</td>
<td>733</td>
<td>100</td>
<td>2.7</td>
</tr>
<tr>
<td></td>
<td>General security</td>
<td>580 829</td>
<td>81 671</td>
<td>42</td>
<td>14.1</td>
</tr>
<tr>
<td>Murray (NSW)</td>
<td>High security</td>
<td>187 541</td>
<td>8 265</td>
<td>95</td>
<td>4.4</td>
</tr>
<tr>
<td></td>
<td>General security</td>
<td>1 667 723</td>
<td>248 136</td>
<td>81</td>
<td>14.9</td>
</tr>
<tr>
<td>Murrumbidgee (NSW)</td>
<td>High security</td>
<td>358 511</td>
<td>3 736</td>
<td>95</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>General security</td>
<td>1 891 994</td>
<td>183 492</td>
<td>64</td>
<td>9.7</td>
</tr>
<tr>
<td>Campaspe River System (Vic.)</td>
<td>High reliability</td>
<td>37 116</td>
<td>6 366</td>
<td>95</td>
<td>17.2</td>
</tr>
<tr>
<td></td>
<td>Low reliability</td>
<td>18 661</td>
<td>395</td>
<td>49</td>
<td>2.1</td>
</tr>
<tr>
<td>Goulburn–Broken River (Vic.)</td>
<td>High reliability</td>
<td>993 921</td>
<td>186 505</td>
<td>95</td>
<td>18.8</td>
</tr>
<tr>
<td></td>
<td>Low reliability</td>
<td>438 601</td>
<td>10 286</td>
<td>35</td>
<td>2.3</td>
</tr>
<tr>
<td>Loddon (Vic.)</td>
<td>High reliability</td>
<td>21 652</td>
<td>2 825</td>
<td>95</td>
<td>13.0</td>
</tr>
<tr>
<td></td>
<td>Low reliability</td>
<td>8 096</td>
<td>644</td>
<td>27</td>
<td>8.0</td>
</tr>
<tr>
<td>Murray River (Vic.)</td>
<td>High reliability</td>
<td>1 200 324</td>
<td>228 404</td>
<td>95</td>
<td>19.0</td>
</tr>
<tr>
<td></td>
<td>Low reliability</td>
<td>304 179</td>
<td>11 168</td>
<td>24</td>
<td>3.7</td>
</tr>
</tbody>
</table>

**Note:** These catchments are those in which there is more than one type of entitlement or the CEWH holds more than one class of entitlement. A pro-rata portfolio would contain equal proportions of all entitlement classes. If the purchasing strategy is to obtain equal proportions of all entitlement classes then the proportion of issued high and low security entitlements being bought back should be equal.

**Source:** environment.gov.au/water/policy-programs/entitlement-purchasing/progress.html and data from DSEWPaC on entitlements issued.
It is unlikely that annual allocations associated with a pro-rata portfolio of irrigation entitlements that yields the annual average SDL reduction will be sufficient to satisfy environmental water uses in all years (Figure 4). This is because satisfying environmental watering requirements involves restoring more natural (and inherently variable) flow patterns, while existing water entitlements are designed to provide relatively stable annual supplies for irrigation demands (ABARES 2011; and also Figure 1).

Figure 4 Commonwealth environmental water use versus allocations from a pro-rata entitlement portfolio (based on the 2800 GL MDBA modelled reductions in diversions), southern Basin

The MDBA constructed the environmental water use pattern (Figure 4) in a way that aligns the projected allocations associated with the pro-rata entitlement portfolio plus 20 per cent exceedence allowance (MDBA 2012c). It is this exceedence allowance that allows the discrepancy between environmental watering demands and environmental watering supplies (the difference between the two lines in Figure 4) to be bridged in some years (MDBA 2012c).

The MDBA modelling behind Figure 4 assumes perfect foresight. In a world with perfect foresight, environmental water managers would know exactly how much water is needed and when. In reality, decisions about when, where and how much water to release to satisfy environmental water requirements is imperfect and as a result more entitlements may be needed to satisfy environmental water requirements than is implied by Figure 4. In the absence of perfect foresight and in the presence of various sources of uncertainty, especially those from climate variability and climate change, a flexible and adaptive approach to managing environmental water, operational at the catchment level, is needed; the components of such an...
approach are discussed in the following section. The aim of this paper is not to determine the optimal mix of tools, but to identify some of the benefits that allocation trading and carryover could generate if used by environmental water managers to achieve environmental objectives.

**Environmental water portfolio management**

The CEWH was created under the *Water Act 2007* (Cwlth) to manage the portfolio of water being acquired for the Commonwealth. This water is to be managed to meet the objectives of the Act which include protecting and restoring environmental assets in the Basin.

The Act also defines the range of options available to the CEWH to manage this portfolio of water, which includes water entitlements and allocations. Of particular interest are sections 106(1) and 106(2) of the Act which specify the limits under which trade can occur (Figure 5). The Act states that allocations or entitlements can only be sold if:

- they are not required to meet environmental objectives in the current water accounting period and cannot be carried over to the next accounting period (section 106(1)), or
- the proceeds of the sale are used to purchase allocations and/or entitlements that improve the capacity of the holdings to meet environmental objectives (section 106(2)).

These rules appear to provide the CEWH with significant flexibility to satisfy environmental objectives while minimising costs. Whether this occurs in practice will depend on how the rules are applied. As it stands, the terms specified in the Act for trade and carryover are general and open to interpretation, with specific operating rules for trading and carrying water over yet to be defined. The CEWH released a discussion paper identifying a number of conditions under which trade and carryover could be beneficial (DSEWPaC 2011).

**Figure 5 Legislative provisions for trade of Commonwealth environmental water portfolio**

Source: DSEWPaC (2011)
Trade

Water trading is common practice among irrigators, and the Water Act 2007 (Cwlth) provides legislative rules governing trade between irrigators and environmental water managers. Water trade consists of trade in entitlements (permanent water trading) and seasonal allocations (temporary water trading). Other types of trading include trade in leases on entitlements, covenants and water options contracts (DSEWPaC 2011; Heaney & Hafi 2005; Productivity Commission 2010). In this paper, the focus is on entitlement and allocation trades.

Seasonal allocation trading may help address immediate excesses or shortfalls between environmental water needs and the volume of water associated with held entitlements in the environmental water portfolio. This type of activity is potentially consistent with the Water Act 2007 (Cwlth) provided the proceeds from sales of allocations are used to improve capacity to meet environmental objectives (Figure 5). In addition, once the Commonwealth’s commitment to bridge the gap to the SDLs is met (through direct entitlement purchase and investments in infrastructure and other water recovery projects) and as environmental water managers learn more about environmental water demand, it may be possible to improve environmental outcomes at no additional cost by changing the mix of the environmental water portfolio. For example, it might be worthwhile considering whether reducing entitlement holdings and purchasing seasonal allocations would improve capacity to meet environmental objectives.

The Productivity Commission (2010) identified a number of advantages in using seasonal allocations to target environmental water requirements. Allocation trades can be executed more quickly than entitlement trades, providing environmental water managers with more flexibility to engage in adaptive management. The certainty of obtaining purchased water makes allocations suitable for targeting immediate environmental needs, whereas their temporary nature allows better targeting of highly variable and sporadic environmental demands (Productivity Commission 2010). However, potential benefits would need to be weighed against the costs of ongoing allocation trades.

MDBA modelling (Figure 3) suggests that the pattern of environmental water use exhibits a degree of procyclicality when compared with water availability and hence a countercyclical pattern to irrigation water use (it is important to note that there will be years where environmental needs are likely to be high during low water availability years, say during an extended dry period, and low during high water availability years, say just after a flood). This procyclical pattern is illustrated again in Figure 6. Assuming diversions are a reasonable proxy for water availability this figure demonstrates that environmental water use pattern (larger percentage reductions in diversions represent higher environmental uses) tends to be higher in high availability years and lower in low availability years. This suggests the marginal value of additional water to the environment is higher in high availability (wet) years and lower in low availability (dry) years. In contrast, the marginal value of additional water to irrigation (reflecting irrigation demand) is lower in wet years and higher in dry years.
This countercyclical pattern of irrigation and environmental water uses suggests there might be opportunities for mutually beneficial trade between irrigators and the CEWH. In particular, it may be possible for environmental water managers to purchase allocations from irrigators in wet years when the opportunity cost is low, and sell allocations to irrigators in dry years when the value of water is likely to be low in environmental water uses and high in irrigation uses. Selling allocations to irrigators in dry years when environmental water allocations attached to held entitlements exceed the amount needed for environmental water use would also reduce the variability in water available for irrigation. Such a trading pattern could encourage investments in higher value irrigation activities that require access to more stable water supplies. For example, during the recent drought the allocation market allowed water to move between irrigated activities, significantly reducing the effect of the drought in the southern Basin. Many irrigators with permanent plantings were able to avoid or reduce the extent of plant losses due to low allocations by accessing the allocation market (Goesch et al. 2011).

A number of studies demonstrate the potential for countercyclical trade in allocations between environmental managers and irrigators to reduce the cost of achieving environmental objectives. For instance, a case study by Scoccimarro and Collins (2006) investigated different options to satisfy environmental watering demands in the Gunbower–Koondrook–Perricoota Forest. In this study, the net present value of the cost of using entitlements alone was estimated at $200 million (in 2006 dollars). When this constraint was relaxed, and the environmental water manager was able to combine an entitlement holding with trade in seasonal allocations, the budgetary cost fell to $19 million (in net present value terms). Another study by Kirby et al.
(2006) investigated the potential gains from allowing an environmental water manager, whose objective was to increase the amount of water that could be used for environmental flows over a 20-year time frame, to engage in countercyclical trade. The results of this study suggest that countercyclical trade could increase environmental flows by up to 60 per cent of environmental allocations at no net cost to government, excluding administrative costs.

While there may be benefits from allowing the CEWH to trade in the allocation market, there are concerns that the size of its holding may have implications for other market participants. These concerns were documented in submissions DSEWPaC received in response to the discussion paper on trading arrangements for Commonwealth environmental water (DSEWPaC 2011), which was released for public consultation in late 2011. Of the 43 submissions received from a range of interested parties, including industry groups, irrigation corporations, state government agencies, water brokers and individuals, nearly three-quarters noted the size of the Commonwealth’s environmental water holdings and the potential for the CEWH’s trading behaviour to influence markets. In addition, more than half the submissions raised concerns about the potential for the CEWH’s trading and carryover activities to adversely affect third parties due to the potential volumes involved (DSEWPaC 2012d). DSEWPaC is developing a trading position paper to respond to submissions received.

It is difficult to determine the extent to which the CEWH, as a player with large entitlement holdings, could affect market prices. This is because much of this influence would depend on differences in the pattern of trade by irrigators and the CEWH. The pattern of trade here refers to the scale of the Commonwealth’s trade, the locations (in which catchments) and timing of trade and the mechanism in which trade in both allocations and entitlements is conducted (in which market structures). To allay some of the concerns mentioned above, a range of governance issues relating to how the CEWH might behave in the market will need to be addressed. In its proposed water trading framework, DSEWPaC (2011) outlined the governance issues to include operating rules, portfolio management strategy, independent external advice and internal governance arrangements.

**Carryover**

Carryover is the other key management option identified in the Water Act 2007 (Cwlth) that has the potential to help environmental water managers, such as the CEWH, minimise the costs of achieving environmental objectives. Carryover rights associated with water entitlements held by the CEWH are the same as those that apply to irrigators holding the same type of entitlement. Carryover allows allocations from entitlements to be stored for future use. It provides additional flexibility for environmental water managers to release sufficient volumes of water to supplement a natural high flow event to create an overbanking event. It can also be used to reduce the risk of not achieving minimum flows in dry years, and to do so with less reliance on the water market, reducing uncertainty to other water market participants. To some degree, carryover and allocation trade can be thought of as substitutes.

The benefits of carryover may be considerable. In a study directly applicable to environmental water management, Heaney et al (2012) estimated the benefits of allowing an environmental water holder in the Goulburn River system in Victoria to carry over 25 per cent of its water allocations compared with a situation where no carryover is allowed. The economic benefits of allowing carryover are estimated to be about $75 million (net present value, measured in 2012 dollars for the period 1891 to 2004), of which about $20 million accrued to irrigators due to the reduced frequency with which they needed to compete with the environmental water holder in the allocation market.
While carryover has the potential to deliver significant benefits, where water property rights are ill-defined, users’ carryover decisions can have external effects on third parties. The nature of these effects can vary significantly depending on the type of storage rights system adopted. For example, the spillable water account system recently adopted in northern Victoria has a number of limitations (NWC 2011). Under certain circumstances (such as those that occurred in 2010–11 and 2011–12), users with large carryover volumes can have significant negative effects on other users (that is, lower allocation levels due to storage spill events). In contrast, in capacity sharing systems such as those that operate in southeast Queensland, water users with large carryover volumes may have positive effects through ‘internal’ spills that provide other users with earlier and higher allocations than would otherwise be the case (an internal spill occurs when a water user’s share in a storage facility fills and any additional inflows that would have been allocated to that user are allocated to other users). Given the potential for carryover to have external effects on other water users, and for these effects to be altered by differences in the pattern of water use and carryover between irrigators and the CEWH, the continued reform of water storage rights remains an important policy objective.

In the Basin, water storage rights are defined by the states and carryover arrangements are the responsibility of state governments. These rights currently differ among states, with some offering greater protection for third parties than others (Hughes et al. forthcoming). It will, therefore, be important for the states to ensure water rights are specified to minimise risks for third parties, given that these risks could increase with the entry of the CEWH (Hughes et al. forthcoming).

**Flexibility**

The level and stringency of site-specific environmental water requirements will affect how environmental water is managed and the cost of achieving local environmental objectives. Allowing site-specific flow indicators to be altered and refined as knowledge about future inflows and ecosystem responses improves may reduce the costs of achieving environmental objectives. The kind of flexibility referred to here is the ability to relax site-specific flow indicators in terms of timing, duration, frequency and volumes of environmental water releases.

Imperfect knowledge about ecological responses to returning additional water to the environment results in uncertainty in establishing robust environmental water requirements that satisfy site-specific ecological targets. This is because specifying local environmental water requirements ideally needs a significant level of information about environmental responses to additional water. However, it is usually difficult to measure ecological responses to flows given that river systems have a large range of environmental attributes that interact in complex ways (Productivity Commission 2010). As knowledge about ecological responses improves, so will knowledge about environmental watering regimes that satisfy specific environmental objectives, thereby allowing the refinement of environmental watering regimes.

Flexibility in timing, duration, frequency and volumes of environmental watering releases could significantly reduce costs for environmental water managers and other water users. In particular, when there is significant uncertainty over future inflows due to climate variability and climate change, the ability to delay meeting an environmental watering target in a very dry year could reduce costs for some irrigators, particularly those with perennial crops. Moreover, at the operational level, environmental water managers may wish to delay a scheduled event for wetter periods to piggyback already high flows rather than acquiring large amounts of water at high prices for an event that may have a lower probability of achieving its environmental objectives.
Heaney et al (2012) evaluated the trade-offs between the reliability with which environmental objectives in the lower Goulburn River floodplain could be met and the economic costs of achieving those objectives. A major finding was that increasing the median threshold inter-arrival time for one scenario by one year reduced the total economic cost by almost 25 per cent. The question as to whether it is appropriate to delay meeting flow targets depends on whether the environmental costs are acceptable. For example, as Heaney et al pointed out, if the goal of the environmental flow is to support a bird breeding event, the watering event must occur within a time frame that is compatible with the birds’ lifecycle.

A degree of flexibility was factored into the Basin Plan, as well as in the operating principles of the CEWH. In particular, the MDBA identified site-specific flow indicators for 122 sites. The environmental water requirements for each site (see for example Table 1) appear to be specified in a manner that provides sufficient flexibility for environmental water managers to manage held water to achieve the site-specific ecological targets. As such, environmental water managers will need to use that flexibility if environmental objectives are to be achieved. The CEWO reports on annual water use options indicate that it has adopted a flexible approach to environmental watering. For various inflow and resource availability scenarios, a range of water use options are presented for a number of catchments in the Basin (DSEWPaC 2012g). These options indicate the ability of environmental water managers to adapt to climatic conditions.

Flexibility has also been incorporated at broader levels. The MDBA specified as part of the Basin Plan that environmental watering is to be undertaken in a way that allows for improvement in knowledge that reduces uncertainty related to increased variability, climate change and ecosystem responses. The Basin Plan specifies that the MDBA must review and update the Basin-wide environmental watering strategy no later than five years after the commencement of the Plan and can do so at any time. The Plan also includes a requirement to develop a monitoring and evaluation program that reviews the long-term watering plans, the environmental watering plan, and the annual watering priorities (MDBA 2012e, f).

These reviews and subsequent updates seem to allow for adaptive management at a strategic level. The CEWH’s business frameworks and reports on annual water use options for catchments in the Basin also reflect adaptive management at a broad level (DSEWPaC 2012e, g). However, more work is underway to interpret and refine the options identified at these broader levels into implementable actions at the catchment level. It is flexibility in the implementable actions that may reduce the costs of achieving environmental objectives.
5 Next steps

The Australian Government is acquiring a portfolio of water entitlements to bridge the gap between current diversion limits and the new sustainable diversion limits to be implemented under the Basin Plan. As the size of this portfolio increases, it will be important to clarify a number of issues that will affect the way the portfolio is managed, the effect of environmental water management on other water users (the irrigation sector in particular), and the overall cost of achieving the environmental objectives of the Basin Plan.

Portfolio management

The CEWH manages the portfolio of environmental water being obtained under the Water for the Future initiative. Managing this portfolio in a way that minimises the cost of achieving environmental objectives points to the importance of the CEWH being able to respond to changes in short and long-term water availability and new information on environmental responses to additional water as knowledge improves. Additional analysis of the following questions is likely to help minimise the costs of meeting a given set of environmental objectives.

- To what extent can countercyclical environmental and irrigation patterns of water use allow for ‘gains from trade’ between the CEWH and irrigators?
- If significant gains are available, and if some shortfalls or excesses in environmental uses are to be met through trade in water allocations, what volume of permanent entitlements should the CEWH hold? What are the tradeoffs involved in the CEWH holding more or fewer entitlements?
- What mix of high, general and low security entitlements should the CEWH hold? Would the reduced cost of a mix with a higher proportion of low security entitlements outweigh the increase in risk that would be involved?

In managing its water holdings the CEWH is using water carryover as a management option (DSEWPaC 2012f). As such, it will be important to clarify how the CEWH’s trading and carryover activities could affect third parties. Further analysis to investigate the conditions under which allocations are likely to be traded or carried over and how this might affect third parties would be beneficial. In particular, work in this area could clarify to what extent, if at all, current carryover arrangements need to be modified to provide adequate protection to third parties in cases where carryover volumes are significant. An example of progress in this direction is the proposal for future carryover arrangements resulting in the final Northern Region Sustainable Water Strategy and the carryover report undertaken by the Victorian Government in 2012 (DSE 2010, 2012). However, a deeper understanding of how the CEWH’s activities are likely to influence the water market would be beneficial in developing a framework that allows the CEWH to use the range of water market products available to cost-effectively deliver environmental objectives, including how to mitigate any adverse effects on other water users.

Adaptive management framework

A strong case exists for the continued application of the adaptive management framework within which new information can be factored into decision making as it becomes available. This is recognised in the Basin Plan, where it states that one of the objectives of the environmental management framework is ‘to enable adaptive management to be applied to the planning, prioritisation and use of environmental water’ (MDBA 2012f, p.51). New information might include updated estimates of seasonal conditions or of longer-term changes in the variability
and availability of water due to climate change. It will be important to be able to adjust environmental flow targets as information about environmental responses to additional water improves.

The ability to adjust environmental flow targets provides environmental water managers at the operational level with some flexibility in the timing, duration and volume of environmental releases. This flexibility may significantly reduce costs for the Commonwealth and for other water users. In particular, the ability to delay meeting an environmental watering target in a very dry year could reduce costs for some irrigators, particularly those with perennial crops. It will be important to explore the benefits and costs of increased flexibility in flow targets, including the increased risk of not meeting environmental objectives.

A comprehensive monitoring and evaluation program is a key requirement of the Basin Plan and is integral to a well-functioning adaptive management framework. The MDBA is developing a monitoring and evaluation program. An effective monitoring and evaluation program would provide information on the progress of various components of the Basin Plan, as well as feedback to help improve outcomes. For example, this would not only include providing information on socio-economic effects and environmental responses from additional water delivered under the Basin Plan, but ideally also include information to assess how environmental and socio-economic outcomes could be improved.

**Governance and transparency arrangements**

The way in which environmental water is managed and how environmental water requirements are specified will influence the environmental benefits and socio-economic effects associated with holding a given portfolio of environmental water. Many of the opportunities to improve outcomes involve continuing to provide environmental water managers with flexibility to manage their water holdings and to set and meet environmental water requirements. Allowing for flexibility is likely to need more comprehensive governance arrangements than would otherwise be the case; additional costs will need to be weighed against the potential benefits of having more flexibility.

For example, while providing environmental water managers with flexibility to meet site-specific environmental water requirements has the potential to significantly reduce the cost of meeting local environmental objectives, clear guidelines should be produced about how this would be implemented in practice to ensure that community expectations about environmental outcomes, and the Basin-wide environmental objectives in the Basin Plan are met. Similarly, clear processes are needed for assessing and incorporating new information into specifying flow targets and managing environmental water.

Moreover, irrigators and other water users have raised concerns about the size of the CEWH’s water entitlement portfolio (as reported in DSWEPaC 2011), and the potential for the CEHW’s water trading and carryover activities to affect other entitlement holders and water users. Further clarification of the conditions under which the CEWH would use carryover and water trading, and the implications of this for water markets and water users is required.

It will be important for the CEWH and environmental water managers, at the state and catchment levels, to act transparently to avoid unnecessarily increasing uncertainty for other water users. Planned reviews of the Basin Plan as a whole and various components of it will contribute to that transparency. At the same time, the CEWO produces reports on annual water use options and portfolio management strategies for a number of Basin catchments, which helps increase transparency (DSEWPaC 2012g, 2012h). Other activities that will increase
transparency include releasing and regularly updating information on the annual and longer-term environmental watering targets to clearly define environmental objectives and flow requirements.
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