How to Increase the Cost-effectiveness of Water Reform and Environmental Flows in the Murray-Darling Basin

R. QUENTIN GRAFTON[1]

Abstract

The paper reviews the $12.9 billion Water for the Future *package in the Murray-Darling Basin from the perspective of cost-effectiveness and assesses the possible losses to irrigators from reduced diversions to achieve desired environmental-flow regimes. It argues that combining the $3.1 billion allocated to buying water entitlements with the $5.8 billion targeted by* Water for the Future *for water infrastructure subsidies into a purchase of water entitlements from willing sellers would maximise the water acquired for the environment per dollar of expenditure, provide greater assistance to holders of water entitlements, and reduce the expected gap between average water diversions for agriculture and sustainable diversion limits.*

Introduction[2]

Water reform in the Murray-Darling Basin is at a crossroad. The *National Water Initiative* of 2004, the *Water Act* of 2007 (that empowers the Murray-Darling Basin Authority to set sustainable diversion limits for the entire Basin), and the *Water for the Future* package of 2008 worth $12.9 billion (Lee and Ancev 2009) provide a unique opportunity to resolve environmental and structural problems decades in the making. Coincident with these reforms has been a decade-long

1 Crawford School of Economics and Government, The Australian National University; quentin.grafton@anu.edu.au

2 The helpful comments and assistance of Tim Stubbs of the Wentworth Group of Concerned Scientists, Daniel Connell and Qiang Jiang of the Australian National University, two referees and the Editor are much appreciated. Tables 1–3 are adapted from Grafton and Jiang (2010). All errors of omission and commission are attributable solely to the author.

drought in the southern part of the Basin that has reduced environmental flows proportionally more than declines in diversions by irrigators (Connell and Grafton 2008) and that has placed many environmental assets in a critical state (The Senate, 2008).

This paper focuses on the economics of water reform in the Murray-Darling Basin (MDB) and, in particular, the stated goal of the Commonwealth Government to achieve 'value for money' — defined in this paper as cost-effectiveness. It uses economic analysis to propose ways in which the stated reform goals of achieving environmentally sustainable levels of extraction can be delivered in a cost-effective way. It builds and extends on earlier reviews by Crase and O'Keefe (2008), Grafton (2007), Grafton (2010), and the Wentworth Group of Concerned Scientists (2010), among others, and also provides an analysis of the economic costs of reduced water diversions to irrigators.

The analysis of this paper shows that if the $3.1 billion allocated to buying water entitlements and the $5.8 billion targeted for water infrastructure subsidies under *Water for the Future* were combined to purchase water entitlements from willing sellers, the Commonwealth Government would be much more likely to achieve healthy working rivers within the Basin, and for no extra cost. Moreover, the budget available exceeds the losses to irrigators of reduced diversions in terms of both the estimated foregone profits and the possible costs of acquiring water entitlements.

The State of the Basin

The Basin's two main rivers are the Murray, which has its source in the Victorian Alps and dominates the southern part of the Basin, and the Darling, which originates in Queensland and connects to the Murray at Wentworth in New South Wales. The Murray and its major tributaries in the southern part of the Basin are 'regulated' rivers in that there are large water storages that adjust the flow to increase water availability in the drier summer months. This regulation has assisted in the development of irrigated agriculture, which accounts for most of the total water extracted within the Basin. By contrast, in the north of the Basin many of the rivers lack large, public storages so river flows follow the pattern of actual inflows. However, farmers with appropriate water licences in the northern Basin also have the right to capture and store flows for their own use.

The northern and southern parts of the Basin differ in their rainfall patterns. The southern connected or 'regulated' part of the Basin receives most of its rainfall in the winter months, while the north, subject to cyclonic activity, receives about half of its inflows during the summer. Consequently the type of irrigated agriculture differs across the Basin. Irrigation in the north, typically, is opportunistically based on the prevailing rain patterns (such as cotton production) while in the south, at least in the hotter and drier parts downstream, perennial irrigation (especially horticulture and viticulture) is based on reliably supplied water released from upstream dams.

The People

Agriculture dominates the water use within the Basin, but it accounts for only 10 per cent of employment, or some 100,000 jobs. It does, however, represent a higher proportion of total employment in smaller communities. Such towns and rural localities are, typically, areas of greatest socio-economic disadvantage (Australian Bureau of Statistics, Australian Bureau of Agricultural and Resource Economics and Bureau of Rural Sciences 2009: 113–14).

About half of the population in the Basin lives in communities larger than 10,000, about a quarter in towns between 1000 and 9999 and the remainder, or a little over half a million people, live in rural localities or independently (Australian Bureau of Statistics 2008, chapter 2). It is these smaller communities and rural localities, with their greater dependence on irrigated agriculture and with less-diversified economies that will be most affected by the current water reforms.

Irrigated Agriculture

The gross value of agricultural production in the Basin was some $15 billion in 2005–2006, of which irrigated agriculture contributed about one-third of the total (Australian Bureau of Statistics 2008, chapter 4). While farming occupies 84 per cent of the total land area in the Basin, irrigated agriculture accounts for about 2 per cent of the total and, thus, generates much higher returns per hectare than dryland agriculture (Bryan *et al*. 2009).

Overall, there are about 18,000 farm businesses that irrigate within the Basin while the number of farming enterprises (dryland and irrigation) totals 61,000. Despite the recent drought, the gross value of irrigated agricultural production increased, in nominal terms, by 9 per cent between 2000–2001 and 2005–2006 (Australian Bureau of Statistics, Australian Bureau of Agricultural and Resource Economics and Bureau of Rural Sciences 2009: 58). In large part this is because of water trade that has allowed water to move from low- to higher-valued uses despite reduced water allocations to farmers.

Water Diversions and Entitlements

Water diversions in the Southern Basin are managed from storages via controlled releases and natural inflows. Holders of water entitlements receive water allocations every season based on the amount of water in storages, expected inflows and other factors. These allocations are defined as a percentage of the nominal quantity of the water entitlement. Water entitlements have different levels of 'reliability', where higher-reliability entitlements receive their allocations before holders of lower-reliability entitlements within the same catchment. Water entitlements with 90 per cent reliability would expect to receive a full allocation 90 years out of 100. The quantity of water an entitlement holder would expect to receive is denominated by its long-term cap equivalent (LTCE) and this amount, rather than the nominal quantity of water assigned to an entitlement, is what is expected to be delivered, on average, in actual allocations of water.

In addition to allocating water to entitlement holders, States also provide 'planned' or 'rules-based' water to the environment under water-resource plans. This planned or rules-based water is, however, not a fixed entitlement because of the operational rules of water management. In many water-sharing plans, the proportion of rules-based water allocated to the environment declines with inflows to accommodate the needs of irrigators (Connell 2010). CSIRO (2008: 43) reports that in the highest water-use regions (Murray, Murrumbidgee and Goulburn-Broken) in the MDB there is a high degree of protection to water-entitlement holders, and thus low levels of protection for environmental flows, associated with reduced surface-water availability. As rules-based water is determined by States, allocations are based on the perceived needs and interests of the individual states rather than the needs and interests of the entire Basin. The discretionary nature of rules-based water has prompted the purchase of water entitlements by governments, especially the Commonwealth Government, to ensure volumes of water are available for environmental flows.

Water Trade

Irrigators are able to buy and sell water entitlements, although restrictions are in place to limit sales outside of irrigation districts. Restrictions on sales of entitlements have been imposed with greatest effect in Victoria. In particular, Victoria has imposed a 4 per cent annual limit on the revocation of association between its water entitlements and land in an irrigation district.[3] Sales of

3 The ACCC (2009) notes that only Victoria and, to a lesser extent, New South Wales have implemented the 4 per cent rule via legislation. Until June 2009, when an exemption was granted to the Commonwealth Government, the rule also constrained the sale of water entitlements for environmental purposes. Administrative difficulties/barriers resulted in no interstate tagged water-entitlement trade in 2008–09.

seasonal allocation water, the water assigned each season to water entitlements, are also widely bought and sold and have fewer constraints on trade than water entitlements.

Water trade in the Basin has occurred since the early 1980s and rapidly increased following the freeing up of some restrictions on trade and the establishment of the 'Cap' in the mid-1990s that was intended to limit further growth in water diversions. Trade volumes have also increased in response to reduced inflows and low seasonal allocations. In 2008–09 there were over 1000 GL of water entitlements and over 1700 GL of water allocations traded in the southern connected MDB (National Water Commission 2009a: 5) that collectively represented about a quarter of long-term average surface-water extractions in the Basin. This water trade generates very substantial economic returns to irrigators (both buyers and sellers) and their farming communities: the value of water traded in 2008–09 was worth over $2 billion.

Drought

The past decade has witnessed a sharp drying trend in the southern part of the Basin, which provides, on average, about 80 per cent of the river flows of the MDB. The consequence of the decade-long drought, with extremely dry years in 2002–2003 and 2007–2008, is that irrigators have had to manage with much less water. For instance, in the driest years there have been large falls in the production of annual water-intensive crops, such as cotton and rice (Australian Bureau of Statistics, Australian Bureau of Agricultural and Resource Economics and Bureau of Rural Sciences 2009: 60–1), with negative impacts on communities dependent on these farming activities.

The drought has been caused by both reduced rainfall and higher temperatures. Flooding in 2009 and 2010 has ended the drought in the northern part of the Basin and close-to-average rainfall in 2009/2010 the southern Basin has reduced the demand for water extractions. Nevertheless, large water storages in the southern Basin (Dartmouth and Hume dams), as of June 2010, still remain well below their average levels.[4]

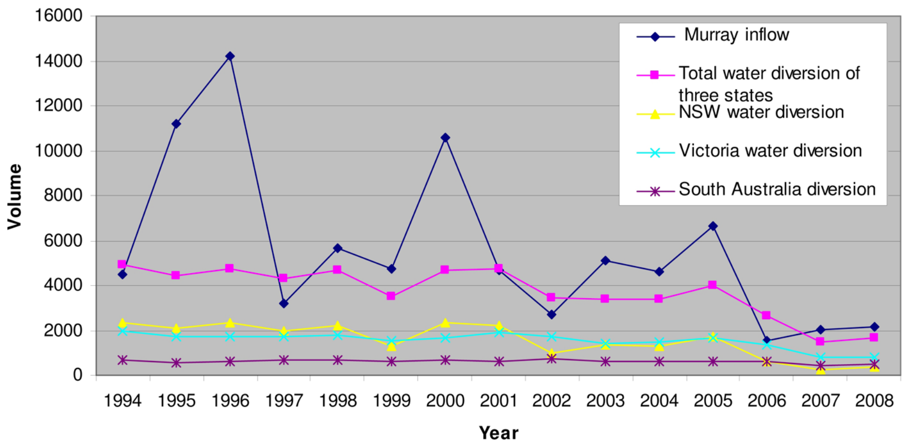
For the period 2002–2007, average annual net inflows in the Murray River totalled 3986 GL — the lowest recorded for a five-year period. By comparison, net inflows averaged 5501 GL over the drought period 1940–45 and 5707 GL

There are also limitations on the rights held by irrigators because of the bundling of rights, and deficiencies in market information (volume and price of trades) that reduce the efficiency of water markets. From May until September 2009 New South Wales had an embargo on the sale of water entitlements for environmental purposes and from July 2009 imposed a temporary embargo on allocation trade outside of New South Wales.

4 As of 2 June, 2010, total public storages in the Southern Basin were at 34 per cent of capacity. Details are available at http://www.mdba.gov.au/water/waterinstorage/southern?run-date=2010-06-02.

over the period 1897–1902 during the Federation Drought. In the recent past this has translated into much-reduced water diversions by irrigated farmers. It has also resulted in the proportion of inflows diverted for agriculture in the River Murray to increase from less than 50 per cent in the 1980s and 1990s to 76 per cent over the period 2000–2008 (see Figure 1).

Figure 1: Murray River Net Inflows and Water Diversions 1994-2008 (GL per year)



Source: Murray-Darling Basin Official Water System Database

Notes:

Net inflows are from the first column (Murray System Inflows — no Darling River or Snowy River inflows) in the Murray River inflows table.

Water use is the sum of Murray System diversions in NSW, in Victoria and South Australia.

Data is for the Murray River only and does not include other regions of the southern Murray-Darling Basin.

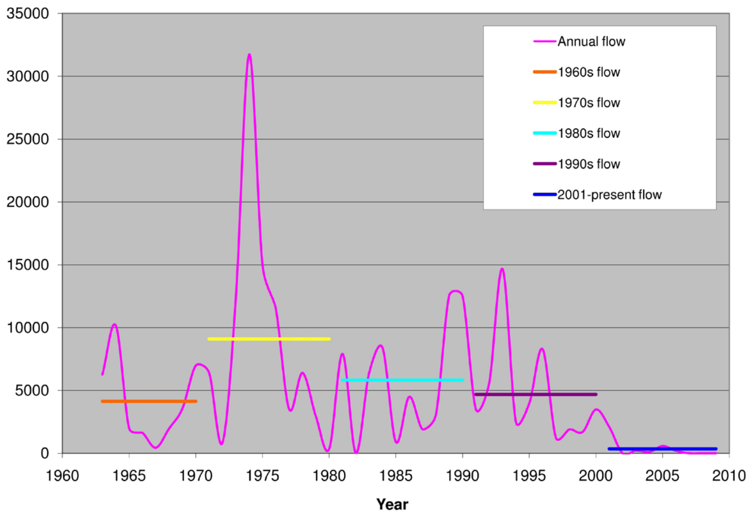
Less-than-proportional declines in water diversions by irrigators relative to inflows has arisen because 'rules-based' or 'planned' water for the environment is, typically, treated as a residual after allocations to water diversions (Connell 2010), and incurs a greater proportional reduction in volumes as inflows decline.[5] Suspension of several water-sharing plans in New South Wales in 2007, where the plans included specified volumes of water for the environment (Hamstead *et al*. 2008: xvi), exacerbated this problem.

5 The National Water Commission (2009b: viii) has expressed that it '…is increasingly concerned about the security of environmental water access entitlements and rules-based environmental water, particularly during drought. The Commission considers that water plans should clearly and transparently specify desired environmental outcomes and fully define environmental watering protocols to achieve them under all inflow scenarios (including sequences of dry years).' CSIRO (2008: 32) also observes that '…in dry years when availability is low, a greater fraction of the available water is diverted for use.'

The Environment

The recent drought has made it transparent that there is insufficient water flowing to key environmental assets to maintain them in a healthy state. The biggest impact is at the Murray Mouth at the end of the system as it has received virtually no flows in the past decade (see Figure 2). However, assets throughout the southern Basin are in major state of decline (The Senate 2008: 39). The root cause is that regulation of inflows has meant that flood events that would regularly occur within the Basin now happen only rarely, at least in the southern part of the Basin. It is these flood events that allow the 'flushing out' of salts harmful to plant growth and enable inundation to ensure bird- and fish-breeding events. Periodic flooding is also necessary to maintain healthy ecosystems, such as River Red gum forests.

Figure 2: Flows at the Murray Mouth 1963-2009 (GL per year)



Source: Murray-Darling Basin Official Water System Database

Flow is measured at the barrages near the Murray River Mouth.

These much-less-regular flood events and minimal flows during dry periods have also exposed acid-sulphate soils in substantial parts of the Basin that contribute to die-offs associated with high acidity. As a result, 20 of the 23 river valleys in the Basin are classified as being either in poor or very poor state of health (Davies *et al*. 2008).[6] Some of these assets have been described as being in a critical state, such as the Lower Lakes and the Coorong, and also River Red Gum forests (New South Wales Natural Resources Commission 2009).

6 The report on the state of the rivers audit was released in 2008. Since its release there have been widespread floods in the northern Basin that should have contributed to improved catchment conditions.

Review of Recent Water Reform

The past decade or so has witnessed major water-policy reforms and initiatives. Following agreement at the Council of Australian Governments (COAG), an interim Cap was placed on surface-water diversions in the Basin in 1995. This was viewed as a first-step measure to avoid further over-allocation and an increase in water diversions. The Cap, however, is based on historical water use and not on what may be environmentally sustainable.

A five-year review of the Cap in 2000 and ongoing concerns about the environment, popularised by a landmark report by the Wentworth Group of Concerned Scientists in November 2002, provided the stimulus for further reform.[7] It prompted governments to implement in 2004 the *Living Murray First Step Initiative* and the *National Water Initiative*. The *Living Murray* sought to acquire 500 GL of water for the environment by 2009, a goal it has now achieved, by improving water-use efficiency with infrastructure investments and the purchase of water entitlements (Grafton and Hussey 2007).

National Water Initiative

A set of principles on water use and governance was agreed to by all governments in the Basin in 2004 in what is commonly called the *National Water Initiative* (NWI). For the first time, governments agreed to give primacy in water use to meeting the needs of the environment. It assigned a set of goals including the freeing up of water trade, nationally consistent and secure water entitlements in the Basin, and statutory water planning to achieve environmental, social and economic outcomes.

A key provision of the NWI is that water-entitlement holders are subject to the risk of changes in the 'reliability' of their entitlement. This risk is delineated under Sections 48 and 49 of the NWI. Beyond 2014, reductions in reliability in excess of 3 per cent of water allocations due to new knowledge or change in policies will be borne by governments. Importantly, water-entitlement holders are to bear the full risk of reductions in reliability due to changes in climate or drought.[8] To help implement the NWI, the National Water Commission was established to report on the state of water markets and progress towards all of the goals of the NWI.

7 This also coincided with a widely publicised program of dredging to keep the Murray Mouth open because of inadequate end-of-system flows.

8 See Productivity Commission (2010: 109) for further details on the risk-assignment provisions of the *National Water Initiative*.

Water Act 2007

Concerns about the lack of progress towards achieving the NWI, and State rivalries and inconsistencies in implementation, prompted the Commonwealth Government to legislate the *Water Act 2007*. This act represents the rules under which the Basin will be governed. A key aspect of the Act is the creation of the Murray-Darling Basin Authority (MDBA) that superseded the Murray-Darling Basin Commission. The MDBA is charged with developing and implementing a Basin Plan. The Basin Plan will be operational from July 2011 and will set sustainable diversion limits by catchment and for the entire Basin that will cap the 'take' or average surface and groundwater extractions.[9]

The Commonwealth Water Minister has the power under the Act to require State and regional water-resource plans to conform to the overall Basin Plan. However, States are not legally obliged to have their water-resource plans be consistent with the Basin Plan until State plans expire. In the case of New South Wales, these plans expire in 2014, but in Victoria existing plans remain in force until 2019. The Act was amended in 2008 to give additional responsibilities to the Australian Competition and Consumer Commission (ACCC) in the setting of market rules for the Basin and to specify arrangements for meeting critical human needs for water.

Water for the Future

In March 2008, following a change in the Federal government, a third pillar of water reform — called *Water for the Future* — was announced, with a budget of $12.9 billion to be spent over 10 years. It allocates $5.8 billion for infrastructure subsidies under the rubric of Sustainable Rural Water Use and Infrastructure (SRWUI) programs. The stated intention of SRWUI is to deliver substantial and lasting returns for the environment *and* secure a long-term future for irrigation communities while delivering 'value for money' (DEWHA 2009). *Water for the Future* also includes a $3.1 billion program for the purchase of water entitlements from willing sellers called Restoring the Balance (RTB). Its stated goal is to obtain water for the environment that represents 'value for money'. The Federal Water Minister has stated that the RTB program will also be used to'...ease the transition to lower diversion limits expected under the [Basin] Plan.' (Wong 2008) As of the end of 2009, over $1.2 billion had been spent, or was in the process of being spent, to purchase approximately 800 GL of water entitlements, which translates into about 500 GL of long-term cap equivalent.

9 Sustainable diversion limits (SDLs) are to represent an environmentally sustainable level of take which, if exceeded, would compromise: (1) key environmental assets of the water resource; or (2) key ecosystem functions of the water resources; or (3) the productive base of the water resource; or (4) key environmental outcomes of the water resource.

Water for the Future, funded entirely by the Commonwealth Government, provides the means by which State priorities for water reform are realised. Financing these State priorities of at least $3.7 billion out of the $5.8 billion allocated for the SRWUI program, as detailed in the July 2008 Intergovernmental Agreement on Murray-Darling Basin Reform Agreement, was crucial in ensuring State acceptance of the jurisdictional reforms detailed in the *Water Act 2007* and its 2008 amendments. Thus, *Water for the Future* includes irrigator incentives to achieve desired goals for the Basin as well as subsidies for State priority projects to ensure the co-operation of Basin states for water reform.

Economics of Water Reform

The ability of governments to alter course and improve current water reform is limited by past agreements and current budgets. This means that what might be recommended by economists if given a 'carte blanche' to undertake water reform is different from what can be done under existing governmental agreements and a fixed budget. In the carte-blanche scenario, a full cost-benefit analysis would be undertaken to consider all benefits and costs of public expenditures of various water reforms. In the 'constrained scenario' an economic analysis is restricted to promoting cost-effectiveness of the planned expenditures so as to maximise the benefits from the given budget.

This paper only evaluates the cost-effectiveness of the current reform, and suggests ways to progress the goals of water reform further with the same or lesser budget. Thus, this paper is *not* a cost-benefit analysis of water reform, but rather an evaluation as to how the Commonwealth Government can more effectively achieve its stated objectives of environmental sustainability and 'value for money' within its existing $8.9 billion budget.[10]

Before evaluating *Water for the Future* it is important to list the key components of water reform that are treated as given when considering alternatives to current policy:

- A maximum of $8.9 billion is available for either purchase of water entitlements for the environment or subsidies for water infrastructure;

---

10 Nevertheless, there is preliminary evidence that the benefits of current water reform may exceed the expected costs. For instance, Morrison *et al*. (2010) find that the total willingness to pay to improve the quality of the Coorong, at the Murray Mouth, that would increase the frequency of water-bird breeding from every 10 years to every seven years, raise native fish populations from 30 per cent to 40 per cent of original levels, and increase the area of healthy native vegetation from 50 per cent to 60 per cent, equals $1.6 billion per year for 10 years. If taken at face value, and if these benefits were to arise from increased flows, then the benefits of reform exceed the $8.9 billion allocated over 10 years for water infrastructure and the buyback of water entitlements as part of *Water for the Future*.

- The at least $3.7 billion, in dollar amounts, that has been allocated to States to co-operate on water reform will be honoured by the Commonwealth Government, but *not* the specific actions or investments defined by State priority projects;
- The establishment of a Basin Plan to be implemented July 2011 will define water entitlements for the environment as part of 'no take' or non-consumptive water allocations in the setting of SDLs.

Market-based Water Recovery versus Infrastructure Subsidies

The purchase of water entitlements to increase environmental flows, as currently practised by the Commonwealth Government, involves a series of 'rolling tenders' whereby holders of water entitlements provide an offer price to sell their entitlements to the Department of Environment, Water, Heritage and Arts (DEWHA), which is charged with undertaking the purchases. If the offer price is deemed to represent 'value for money' relative to competitive water markets, and if the entitlement is in a catchment where there are key environmental assets (such as Ramsar wetlands), then DEWHA accepts the bid and the eventual sale takes place after the necessary conveyancing.

The actual water available for the environment is less than the nominal volume on the entitlement as the long-term cap equivalent, which represents the average allocation to the entitlement, can be much less. As of September 2009 the long-term cap equivalent of water-entitlement purchases undertaken by the Commonwealth Government up until that date was about 64 per cent.[11] Thus, if the Commonwealth had 1000 GL of water entitlements then, on average, it would only expect to receive 640 GL for these entitlements. In dry years, it would receive much less than the long-term cap equivalent.

An important issue with market-based water recovery is the existence of trade restrictions. Although the Commonwealth Government has secured an exemption for its purchases of water entitlements for the environment under the 4 per cent rule in Victoria, in September 2009 it signed a Memorandum of Understanding with the New South Wales Government that limits its purchases in that state. This agreement restricts Commonwealth Government purchases of general security water entitlements (or equivalent) to a maximum of 200 GL until 2011–2012 (Gillard and Rees 2009).

11 Details on water recovery by the Commonwealth Government are available at http://www.environment.gov.au/water/policy-programs/entitlement-purchasing/2008-09.html. Prices for high-security water entitlements in New South Wales average over $2,300/ML, while general-security water entitlements have a lower price in the same catchment. The purchase costs of general-security entitlements in the Murrumbidgee are about $1,100/ML.

Water-reform subsidies for infrastructure are in two principal forms. They include upgrades to public or supply infrastructure off-farm, and improvements in on-farm irrigation to increase water-use efficiency. In return for providing infrastructure subsidies, the Commonwealth Government, through the Commonwealth Environmental Water Holder (CEWH), receives water entitlements that it can use for the environment. Typically, the CEWH will receive 50 per cent of the expected water savings from infrastructure subsidies in the form of water entitlements. The actual cost of the water delivered for the environment varies substantially by project, but are typically much more expensive than purchasing water entitlements from willing sellers (Crase and O'Keefe 2009). For instance, some of the planned projects, such as the Northern Victoria Irrigation Renewal Project will deliver 175 GL at a cost of over $11,000 per ML.[12] By comparison, the median price of high-reliability water entitlements per ML in Northern Victoria in 2008–2009 was $2300/ML (National Water Commission 2009a: 87).

The Commonwealth Government expectation is that both market-based water recovery and infrastructure subsidies should deliver 'value for money', but it does not define how 'value for money' is to be operationalised.[13] In the case of subsidies, the government also wants SRWUI to secure a long-term future for irrigation communities. An evaluation by the Productivity Commission in May 2010 that compares water entitlement purchases and subsidies for irrigation concluded that '…the Australian Government may pay up to four times as much for recovering water through infrastructure upgrades than through water purchases. In other words, a premium of up to $7500 ML may be paid for recovering water through infrastructure upgrades…' (Productivity Commission 2010: 129).

Research by Qureshi *et al*. (2010) supports the economic arguments for the cost-effectivenesss of market-based water recovery relative to subsidies for infrastructure (Grafton 2007; Crase and O'Keefe 2009; Lee and Ancev 2009). In their modelling of the Murrumbidgee catchment they account for return flows from irrigation that subsequently becomes available for downstream and aquifer users while also augmenting environmental flows. An improvement in

12 The Northern Victoria Irrigation Renewal Project aims to achieve water savings in the order of 425 GL at a cost of $2 billion. Stage 1 will deliver 225 GL of savings at an estimated cost of $1 billion, of which 75 GL will be allocated to the environment. In Stage 2200 GL of expected water savings will be delivered at a cost of $1 billion. Stage 2 will allocate 100 GL to the environment. Much of these water savings will be achieved by improving metering of water, which does not provide more water to the environment and by reducing leakage it may actually reduce flows to the environment. Thus, at best, the Northern Victoria Irrigation Renewal Project is expected to deliver 175GL of environmental water at a total cost of $2 billion or $11,429/ML.

13 The Victorian Auditor-General (2010: viii) concluded that in the reference to the Northern Victoria Irrigation Renewal Project the business cases for the projects, as developed by the Victorian Government, '…lacked the evidentiary rigour appropriate to the risk and cost of the proposed projects. Analysis of costs and benefits was superficial and information to support the basis for water savings was lacking.'

on-farm efficiency that reduces return flows will have an offsetting and negative impact on environmental flows. As a result, in locations where there are lower levels of irrigation efficiency and return flows are larger, the cost-effectiveness of water recovery from purchasing water entitlements is enhanced relative to infrastructure subsidies. They find that improvements in water-use efficiency in the Murrumbidgee would, at most, deliver 143 GL of increased environmental flows for a cost of up to $6000 per ML. By contrast, market-based water recovery could deliver up to 733 GL of environmental flows at a cost of $3000 per ML. This research supports the findings of the Productivity Commission (2010) and emphasises that the most cost-effective method for governments to acquire water for the environment is to purchase water entitlements from willing sellers.

A key reason for the cost-effectiveness of water buybacks is that, in contrast to infrastructure subsidies, they provide farmers with flexibility as to how to use less water. Farmers who voluntarily choose to sell their water in a buyback and remain farming can employ deficit irrigation, change their land use and/or tillage practices or invest in improvements in irrigation efficiency. In the subsidy approach, water is acquired only through efficiency improvements whether it is the least costly method or not. Water-efficiency improvements may also have a 'rebound' effect in effecting reduced return flows and economically disadvantage irrigators and irrigation districts that, at their own expense, have already installed efficient irrigation systems.

Environmental Benefits and Environmental Flows

Securing increased environmental flows is an important component to ensuring environmental sustainability. While this is necessary, the timing and location of flows and the size of the individual volumes released for the environment are equally critical. This is because the flow regime, rather than just the quantity of environmental flows, affects habitat quality, population of native species, biodiversity, recreational values and so on.[14] To account for these multiple benefits an environmental benefits index (EBI) should be used when determining 'value for money' when acquiring water for the environment.[15] In other words, the benefits of acquiring water near to a key environmental asset may be such that the EBI per dollar spent may be greater than in another catchment, even if the cost per ML to acquire the water entitlement is higher.

14 King and Louw (1998) developed a 'Building Block Methodology' (BBM) to determine in-stream requirement that accounts for geomorphology, water chemistry, and biotic data that is built into monthly blocks of water. The approach is currently in use in South Africa in Kruger National Park. Researchers working on Victoria's Thomson River are currently monitoring how to accomplish the desired environmental objectives with less water (Dickson 2008).

15 EBIs have been used in the U.S. to rank how public funds should be allocated for conservation programs and in market-based frameworks in Australia to procure multiple environmental outcomes in land-use management (Eigenraam *et al*. 2007). The approach is also being developed for environmental flows in Victoria for multiple environmental objectives (Chee *et al*. 2009).

When purchasing water for the environment, a key question is how much water should be secured in a given environmental watering plan. Jones *et al*. (2002) argued that, on average, 3350 GL of extra environmental flows from Basin-wide sources and improved operations would be required to have a high probability of restoring the River Murray to a healthy working river. The Wentworth Group of Concerned Scientists (2010), based on findings of an Expert Reference Panel that reviewed studies of six large rivers in the MDB, has argued that working rivers are unlikely to be in a healthy state if flow regimes are reduced below two-thirds of their natural level. Using this as a guide the Wentworth Group of Concerned Scientists has calculated that environmental flows should increase, on average, by some 4400 GL per year in the MDB.

The *Living Murray First Step*, the RTB program as of May 2010, and various State initiatives collectively will contribute about 1200 GL of increased environmental flows, on average. Thus, to achieve a high probability of restoring the Murray River to a healthy state would require an *additional* 2150 GL per year of environmental flows on average delivered along the Murray. An extra 3200 GL of water per year would be required to achieve the two-thirds rule for all major catchments in the MDB (Wentworth Group of Concerned Scientists, 2010: 14).

Opportunity Costs and Acquisition Costs of Increasing Environmental Flows

The opportunity cost of forgone profits to irrigated agriculture from achieving the two-thirds rule can be calculated using an integrated hydro-economic linear programming model of the Basin developed for this purpose. This model is described in more detail in Grafton and Jiang (2010) and is a hydro-economic model of the Murray-Darling Basin.[16] It uses previous hydrological studies in the MDB and data from various sources to simulate the river flow and agricultural production in the Basin (Jiang 2010). In the hydrological component, the model includes water-delivery loss rates between regions obtained from the CSIRO sustainable-yields project (CSIRO 2008). In the economic component, it uses data from the Australian Bureau of Statistics and Bryan and Marvanek (2004) to model the seven largest uses of water diverted by irrigators: pasture and hay, rice, cotton, cereals (excluding rice), grapes, fruit (excluding grapes), and vegetables.

The model is optimised by maximising the profit from irrigated agricultural production across the Basin accounting for hydrological realities and irrigated land availability in the 18 regions in the model. On a Basin level, the model

16 Mainuddin *et al*. (2007) developed a hydro-economic model of the southern Basin and investigated the effects of reduced water diversions on irrigated agriculture of up to 1500 GL/year. Grafton and Jiang (2010) are the first to make such a hydrological-economic assessment for much larger reductions, for the entire Basin and to use the CSIRO sustainable yields regions in the model.

calibrates well to recorded data on irrigated land use (1.819 million ha. in model versus 1.824 million ha. actual) and water use (10,147 GL versus 10,516 Gl actual) in 2000–2001 (Jiang 2010). The value of the model is that it provides a quantitative assessment of the opportunity costs, or forgone profits in irrigated agriculture, from reduced water diversions at the Basin level.

The predicted annual opportunity costs to irrigated agriculture measured in reduced profits from reduced water diversions, assuming unrestricted water trade, are summarised in Table 1. The results indicate that if surface-water extractions to irrigators were to be reduced by 30 per cent to approximate the increased environmental flows to achieve a high probability of a healthy Murray River, profits from irrigated agriculture would fall by about 10 per cent. To achieve the two-thirds rule at a Basin level, surface-water extraction by irrigators would need to fall by about 40 per cent and this would reduce annual profits by about 16 Per cent. The opportunity costs would be higher (lower) if the surface-water diversions were lower (higher) because the marginal value of an extra ML of water to agriculture is greater the less water is available for extraction.

Table 1: Profit ($ million/year) and Change in Profit (%) from Reduced Water Diversions to Irrigated Agriculture in the Murray-Darling Basin, based on 2000–2001 Surface-water Extractions

	No buyback	10% reduction	20% reduction	30% reduction	40% reduction
Profit ($ million)	1578	1539	1484	1428	1320
Net change	0.00%	-2.4%	-6.0%	-9.5%	-16.3%

Source: Adapted from Grafton and Jiang (2010).

The present value of the forgone profits from reduced surface-water extractions by irrigators can be calculated using a 50-year time horizon and a 3, 5 and 10 per cent discount rate. These results are presented in Table 2. The present value of forgone irrigated agriculture profits from a 30 per cent reduction in surface-water diversions is $3.87, 2.74 and 1.49 billion with a 3, 5 and 10 per cent discount rate, respectively. By comparison, the present value of forgone irrigated agriculture profits from a 40 per cent reduction in surface-water diversions profits is $6.64, 4.71 and 2.56 billion using a 3, 5 and 10 per cent discount rate, respectively. These results indicate that there are sufficient funds available in *Water for the Future* to fully compensate irrigators for up to 40 per cent reductions in surface-water diversions in the MDB.

Table 2: Present Value ($ billion) of Forgone Profits to Irrigated Agriculture from Reduced Surface-water Diversions in the Murray-Darling Basin, Based on 2000–2001 Surface-water Extractions

Discount Rate	10% reduction	20% reduction	30% reduction	40% reduction
3%	0.99	2.43	3.87	6.64
5%	0.7	1.72	2.74	4.71
10%	0.38	0.94	1.49	2.56

Notes: Direct losses are reduced on-farm profits in irrigated agriculture from base-case results based on a 50-year planning horizon.

Source: Adapted from Grafton and Jiang (2010).

If the reduction in surface-water diversions were accomplished by voluntary reverse tenders then holders of water entitlements would be fully compensated for these forgone profits. This is because owners would voluntarily sell their entitlements only if the amount they received in the tender process equalled or exceeded the present value of the profits they could have earned from using the seasonal allocations attached to their entitlements. To deliver environmental flows from the purchased water entitlements would require that there be 'carryover' rights of allocations from one irrigation season to the next so as to ensure that environmental water can be saved and stored to deliver 'pulse' events.

Table 3 provides the estimated costs *over and above* the $3.1 billion money allocated to acquiring water entitlements in the *Water for the Future* package to achieve 10 per cent to 40 per cent reductions in irrigated-agriculture surface-water diversions in the Basin, based on 2000–2001 data. These estimated costs are additional to funds already spent under the RTB for the *Water for the Future* and other initiatives and are the extra expenditures needed to acquire water entitlements to achieve the stated reductions.[17] By contrast to Table 2, the estimated costs of water-entitlement acquisitions are calculated based on the average price per ML acquired by the Commonwealth Government until 30 September 2009.

17 As of the end of 2009 the Commonwealth Government had acquired about 800 GL of water at a total cost of just over $1.2 billion. Water entitlements for the environment have also been obtained under other initiatives such as Water for Rivers (approx. 200 GL of entitlements) and Rivers for Environmental Restoration Program (about 100 GL of water entitlements).

Table 3: Additional Government Expenditures in the Murray-Darling Basin to Achieve Different Reductions in Surface-water Extractions by Irrigated Agriculture, Based on 2000–2001 Surface-water Extractions

	10% reduction	20% reduction	30% reduction	40% reduction
Total Irrigated Diversions (GL)	9133	8118	7103	6088
Increased environmental flows associated with reductions in surface-water extractions to irrigators (GL)	1015	2029	3044	4059
Water already acquired or expected to be acquired in Water for the Future and existing initiatives (GL)[1]	2070	2070	2070	2070
Additional water (GL) required over and above that expected to be acquired in Water for the Future and other initiatives[2]	NA[3]	NA	974	1989
Additional government expenditure ($ billion) at $2378/ML per long-term cap equivalent in excess of $3.1 billion budgeted in Water for the Future[4]	NA	NA	2.32	4.73

Notes:

1. Average purchase price of water entitlements until 30 September 2009 was $2,378/ML per long-term cap equivalent (LTCE). If this average price were maintained for the entire $3.1 billion 'Restoring the Balance' program, the government would acquire approximately 1300 GL of water entitlements defined in terms of long-term cap equivalent. If this amount is added to water already acquired for the environment through the Living Murray First Step (500 GL) and other initiatives (270 GL) as outlined in the Productivity Commission (2010, Appendix B), the expected total amount of water that will be, or has already been, recovered is about 2070 GL in LTCE under existing policies.

2. The increased environmental flows in the second row of numbers less the expected increased environmental flows in the third row of numbers gives the additional water required to achieve the specified reduction in surface-water extractions by irrigators.

3. NA = not applicable such that no additional water needs to be required.

4. The additional water required (if positive) multiplied by the average price of water acquired until 30 September 2009 under 'Restoring the Balance' of $2378/ML generates the additional government expenditures for water entitlements over and above the budgeted $3.1 billion in *Water for the Future*.

A 30 per cent reduction is similar to the water requirements to achieve a high probability of a healthy working Murray River. To achieve this objective, an additional $2.32 billion based on market prices of previous water-entitlement purchases, over and above the $3.1 billion allocated to RTB, for a total cost of $5.42 billion will be required for the purchase of water entitlements. A 40 per cent reduction in surface-water extractions by irrigators is similar to the amount of increased environmental flows required to achieve the two-thirds rule. To achieve this goal, an extra $4.73 billion based on market prices of previous water-entitlement purchases would be required to achieve these increased environmental flows for a total cost of $7.83 billion. Given the total budget for both RTB and SRWUI is $8.9 billion, this indicates that the two-thirds rule that achieves the largest increase in environmental flows, on average, is achievable with the existing funding allocated for *Water for the Future*. Unspent funds left over from the $8.9 billion could be used to invest in communities in various ways to help achieve a stated goal of *Water for the Future* to 'secure a long-term future for irrigation communities', or be used for other purposes.[18]

Important implications of Tables 1–3 and the underlying modelling are:

- There is a high probability that key environmental assets in the Basin can be sustained if there were about a 40 per cent reduction in surface-water diversions for irrigated agriculture and a concomitant increase in environmental flows.
- The funds budgeted in *Water for the Future* are sufficient to credibly achieve environmental sustainability if, and only if, there is a reallocation of funding from investments in infrastructure towards additional market-based water recovery.
- The $8.9 billion available in *Water for the Future* (RTB and SRWUI combined) exceeds both the forgone profits of irrigators from 40 per cent reduction in surface-water diversions and the expected cost of acquiring water entitlements based on the average cost to acquire water entitlements for the environment ($2378/ML per long-term cap equivalent) up until 30 September 2009.
- To allow environmental water to 'piggy back' on natural flood events and ensure required 'pulse' events, seasonal allocations assigned to environmental-water entitlements need to be allowed to be fully carried over in water storages from one season to the next.

Sustainable Diversion Limits and Market-Based Water Recovery

A draft Basin plan should be announced in 2010 and the final Basin Plan, as developed by the MDBA, should be implemented from July 2011. A key feature of the Basin Plan will be the SDLs for both groundwater and surface water defined for the entire Basin and by catchment (Murray-Darling Basin Authority 2009). These SDLs will replace the existing Cap that was developed based on historical use. Although the Basin Plan will be operational from July 2011, it will not be legally binding until the current water-resource plans of the States expire.

18 These investments would not be restricted to irrigation. A process of how these investments could be made is discussed by the Wentworth Group of Concerned Scientists (2010) and involves a process of active engagement with affected communities. Any investments in affected communities by governments should involve some form of co-funding such that communities and other investors would be required to put at risk some of their own equity into funded projects so that communities would have a stake in both the success and failure of the investments.

Until the Draft Basin Plan is announced, it is not known what will be the proposed reduction in current diversions within the Basin. However, given the dire state of many of the environmental assets and the requirement of the *Water Act 2007* that water diversions under the Basin Plan be environmentally sustainable, the work of Jones *et al*. (2002) and the Wentworth Group of Concerned Scientists suggest that at least a 30 per cent reduction in agricultural surface diversions might be expected when setting the SDLs.

A difficulty in continuing market-based water recovery after the Basin Plan is implemented in July 2011 is that water entitlements purchased by governments for environmental purposes will not be considered as part of the 'take' or consumptive use. Consequently, market-based water recovery after the Basin Plan is implemented would require revisions to the SDLs to account for increased environmental holdings by governments. Rather than change the Basin Plan shortly after it is implemented, which will be difficult to do, it would be preferable to complete *all* the purchases of water entitlements for the environment prior to July 2011.

A Two-tender Process

A process to reduce surface-water extractions by irrigators in the MDB may be best accomplished through two reverse tenders *after* the announcement of the draft Basin Plan in 2010 and before its implementation in July 2011. Such a method for water recovery has been proposed by the Wentworth Group of Concerned Scientists (2010). A similar approach has also been used successfully in the past with the buyback of statutory fishing licences in Commonwealth fisheries in 2007.[19] Its principal advantage is that it allows supply (offers for sale by holders of entitlements) and demand (required flows for environmental assets and ecosystems services in the Draft Basin Plan) to balance via a market process. The two reverse tenders would allow for better targeting of purchases to meet the SDLs and may be achieved at a lower cost per ML of long-term cap equivalent water acquired than previous purchases by the Commonwealth Government. This is because the alternative, if there is a gap between long-term average extractions and SDLs in the Draft Basin Plan, is for irrigators to suffer reduced reliability of their water entitlements from July 2011.

All water-entitlement holders would all be allowed to participate in the two reverse tenders anywhere in the Basin, but the selection of what water entitlements were funded would be based solely on the expected environmental benefits per dollar spent or, if this proved impossible to implement, then on 'value for money' calculated on the basis of the cost to acquire per ML of actual

19 For further details, see http://www.daffa.gov.au/fisheries/domestic/fishingfuture/business_exit_assistance.

water restored to the environment. The dollar amount *spent* in each State could also be specified as a constraint, if necessary, to meet the spending targets agreed to by COAG in the July 2008 Intergovernmental Agreement on Murray-Darling Basin Reform. However, a reasonable condition by the Commonwealth Government for accepting state-by-state spending constraints in the tender process would be the full co-operation by all States in the removal of arbitrary restrictions on water entitlement and seasonal allocation trade. If State spending constraints defined by COAG agreements were maintained, the actual project spending or water entitlements purchased would *not* be constrained within each State and would be determined on the basis of cost effectiveness.

The purchase of water entitlements with two reverse tenders would provide the farmers in the Basin with the funds necessary to undertake autonomous adjustment to the Basin Plan. It would also provide the Commonwealth Government with a large holding of water entitlements prior to implementation of the Basin Plan that would be treated like other entitlements in water allocations. Thus, unlike rules-based or planned water in existing water-resource plans that lack rules aligned to objectives (Hamstead 2009), there would be an assurance that the actual water allocated to water entitlements would be used for environmental flows. This is particularly important given the poor state of many river valleys in the Basin, and the fact that it will not be until 2019 that all State water-resource plans need to become fully compliant with the Basin Plan.

Conclusion

Water reform in the Murray-Darling Basin is at a proverbial watershed. The principles in the form of the *National Water Initiative* are well defined and are agreed to by all governments. The 'rules' of reform are defined in the form of the *Water Act 2007* and its amendments. Together they provide the framework to implement reform. Unfortunately, the financial incentives for reform, as defined under the $12.9 billion *Water for the Future*, will not achieve the twin goals of ensuring environmental sustainability and 'value for money'.

Using the principal constraints on the amount of funding available faced by the Commonwealth Government, and the existing expenditure commitments to States, it is argued that the stated objectives could be achieved in a much more cost-effective way. In particular, if the $5.8 billion targeted for water infrastructure subsidies were added to the $3.1 billion allocated to buying water entitlements, the Commonwealth Government would be able to buy a sufficient volume of water entitlements from willing sellers to ensure a high probability of healthy working rivers within the Basin, and for no extra cost. Further, economic modelling suggests that the combined fund of $8.9 billion to purchase water entitlements for the environment exceeds the estimated forgone profits to irrigators from reduced diversions expected in the Draft Basin Plan, and also the expected acquisition costs.

If the combined fund were used to purchase water entitlements so as to maximise the expected environmental benefits per dollar spent, or to obtain the largest quantity of water per dollar of expenditure, then sufficient water could be obtained while fully compensating irrigators for reduced diversions. If this money were spent prior to the implementation of the Basin Plan in July 2011 with two reverse tenders it would greatly assist holders of water entitlements, and also irrigation communities, to autonomously adjust to lower water diversions.

References

Australian Bureau of Statistics 2008, *Water and the Murray-Darling Basin: A Statistical Profile 2001–01 to 2005–06*. Catalogue No 4610.0.55.007, Australian Bureau of Statistics: Canberra.

Australian Bureau of Statistics, Australian Bureau of Agricultural and Resource Economics, Bureau of Rural Sciences 2009, 'Socio-Economic Context for the Murray-Darling Basin', Descriptive report, MDBA Technical Report Series: Basin Plan, BP02.

Australian Competition & Consumer Commission (ACCC) 2009, *Water Trading Rules: Draft Advice*, Australian Competition & Consumer Commission, Canberra.

Bryan, B. A., Hajkowicz, S., Marvanek, S. and Young, M. D. 2009, 'Mapping Economic Returns to Agriculture for Informing Environmental Policy in the Murray-Darling Basin, Australia'. *Environmental Modelling and Assessment* 14: 375–90.

Bryan, B. and Marvanek, S. 2004, 'Quantifying and valuing land use changes for Integrated Catchment Management evaluation in the Murray-Darling Basin 1996/97 2000/01'. Stage 2 report to the Murray-Darling Basin Commission. Available for download at: http://www.clw.csiro.au/publications/consultancy/2004/MDBC_stage2_report_exec_summary.pdf

Chee, Y., Webb, J. A. Stewardson, M. and Cottingham, P. 2009, *Victorian Environmental Flows Monitoring and Assessment Program: Monitoring and Evaluation of environmental Flow Releases in the Glenelg River*. Report prepared for the Glenelg-Hopkins Catchment Management Authority and the Department of Sustainability and Environment. E-Water cooperative Research Centre, Canberra.

Connell, D. 2010, *Sustainability and the National Water Initiative*. Available for download at: http://cweep.anu.edu.au/pdf/publications/research_papers/10-06_NationalWater.pdf

Connell, D. and Grafton R. Q. 2008, 'Planning for Water Security in the Murray-Darling Basin', *Public Policy* 3(1): 67–86.

Council of Australian Governments (COAG) 2004, *Intergovernmental Agreement on a National Water Initiative*.

Crase, L. and O'Keefe, S. 2008, 'Acknowledging Scarcity and Achieving reform' in *Water Policy in Australia: The Impact of Change and Uncertainty* (L. Crase Ed.), Resources for the Future: Washington, D.C.

Crase, L. and O'Keefe, S. 2009, 'The Paradox of National Water Savings: A Critique of "Water for the Future"', *Agenda* 16(1): 45–60.

CSIRO 2008, 'Water availability in the Murray-Darling Basin'. A report to the Australian Government from the CSIRO Murray-Darling Basin Sustainable Yields Project, CSIRO, Australia: 67pp.

Davies, P., Harris J., Hillman T. and Walker K. 2008, 'Sustainable Rivers Audit: A report on the ecological health of rivers in the Murray-Darling Basin'. Prepared by the Independent Sustainable Rivers Audit Group for the Murray-Darling Basin Ministerial Council.

Department of Environment, Water, Heritage and the Arts (DEWHA) 2009, 'A Framework for Determining Commonwealth Environmental Water Actions', A Discussion Paper. Available at: http://www.environment.gov.au/water/policy-programs/cewh/pubs/cehw-framework-discussion-paper.pdf

Dickson, M. 2008. *Environmental Flows Monitoring for the Thomson and Macalister Rivers 2008–2011: Monitoring Design Report*. West Gippsland Catchment Management Authority. Mimeograph.

Eigenraam, M., Strappazzon, L., Lansdell, N., Beverly, C. and Stoneham, G. 2007, 'Designing Frameworks to Deliver Unknown Information to Support Market-Based Instruments', *Agricultural Economics* 37: 261–69.

Gillard, J. and Rees, N. 2009, Memorandum of Understanding in Relation to Water for the Environment. Signed 23 September 2009 between the State of New South Wales and the Commonwealth of Australia.

Grafton, R. Q. 2007, 'An Economic Evaluation of the National Plan for Water Security', *Dry Water*, Policy Briefs No. 3, The Crawford School of Economics and Government, The Australian National University. Available for download at: http://www.agrifood.info/connections/2007/Grafton_Bennett_Hussey.pdf

Grafton, R. Q. 2010, The Economics of Water Reform in the Murray-Darling Basin. Submission 81 to the Productivity Commission. Available for download at: http://www.pc.gov.au/__data/assets/pdf_file/0008/94850/subdr081.pdf

Grafton, R. Q. and Hussey, K. 2007, 'Buying Back the Living Murray: at what price?' *Australasian Journal of Environmental Management* 14: 74–81.

Grafton, R. Q. and Jiang, Q. 2010, 'Economics of Drought, Water Diversions, Water recovery and Climate Change in the Murray-Darling Basin', Centre for Water Economics, Environment and Policy (CWEEP) Research Paper 10-01. Available for download at: http://cweep.anu.edu.au/pdf/publications/research_papers/10-11_economics_of_water.pdf

Hamstead, M. 2009, *Improving Environmental Sustainability in Water Planning*. National Water Commission, Canberra.

Hamstead, M., Bladwin C. and O'Keefe, V. 2008, *Water Allocation Planning in Australia — Current Practices and Lessons Learned*. National Water Commission, Canberra.

Jiang, Q. 2010, 'An overview of the integrated irrigated agriculture water model', Centre for Water Economics, Environment and Policy Working Paper, Crawford School, The Australian National University: Canberra.

Jones, G., Hillman, T., Kingsford, R., McMahon, T., Walker, K., Arthington, A., Whittington, J. and Cartwright, S. 2002, 'Independent Report of the Expert Reference Panel on Environmental Flows and Water Quality Requirements for the River Murray System', Prepared for the River Murray Project Board. Canberra.

King, J. M. and Louw, D. 1998, 'In-stream flow assessments for regulated rivers in South Africa using the Building Block Methodology', *Aquatic Ecosystem Health and Management* 1: 109–24.

Lee, L, and Ancev, T. 2009, 'Two Decades of Murray-Darling Water Management: A River of Funding, a Trickle of Achievement', *Agenda* 16(1): 5–23.

Mainuddin, M, Kirby, M. and Qureshi, E. 2007. 'Integrated Hydrological-Economic Modelling for Analyzing Water Acquisition Strategies in the Murray River Basin', *Agricultural Water Management* 93: 123–35.

Morrison, M., Hatton-MacDonald, D., Boyle, K. and Rose, J. 2010, 'Ecological Values for a Major River System at Risk: Australia's Murray-Darling River System', Mimeograph.

Murray-Darling Basin Authority 2009, 'Issues Paper: Development of Sustainable Diversion Limits for the Murray-Darling Basin', MDBA publication no. 49/09. Available for download at: http://www.mdba.gov.au/files/publications/sustainable-diversion-limits-issues-paper-12-11-09.pdf

National Water Commission 2009a, *National Water Commission Australian Markets Report 2008–2009*, National Water Commission, Canberra.

National Water Commission 2009b, *Australian Water Reform 2009: Second biennial assessment of progress in implementation of the National Water Initiative*, National Water Commission, Canberra.

New South Wales Natural Resources Commission 2009, *Riverina Bioregion Regional Forest Assessment: River Red Gum and Other Woodland Forests*. New South Wales Natural Resources Commission, Sydney.

Productivity Commission 2010, 'Market Mechanisms for Recovering Water in the Murray-Darling Basin', Productivity Commission Research Report, Final report March, Productivity Commission: Melbourne.

Qureshi, M. E., Schwabe, K., Connor, J. and Kirby, M. 2010, 'Environmental Water Incentive Policy and Return Flows', *Water Resources Research* (In press). Available for download at: http://www.agu.org/journals/pip/wr/2008WR007445-pip.pdf

The Senate Standing Committee on Rural and Regional Affairs and Transport 2008, *Water Management in the Coorong and the Lower Lakes,* Parliament of Australia, October.

Victorian Auditor-General 2010, *Irrigation Efficiency Programs,* Victorian Government Printer.

Wentworth Group of Concerned Scientists in association with R. Q. Grafton, I. Kowalick, C. Miller, T. Stubbs, F. Verity and K. Walker 2010, *Sustainable Diversions in the Murray-Darling Basin: An Analysis of the Options for Achieving a Sustainable Diversion Limit in the Murray-Darling Basin*. Available for download at: http://www.wentworthgroup.org

Wong, P. 2008, 'Rudd Government to Invest $12.9 billion in Water', *Media release no. PW 56/08*. Available for download at: http://www.climatechange.gov.au/~/media/Files/minister/wong/2008/Media%20Releases/April/mr20080429.ashx