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Inquiry into the management of the Murray Darling Basin

Canberra, 10 September 2012

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Upgrading Irrigation Infrastructure in the Murray Darling Basin: is it Worth it?

by

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General Paper No. G-228 June 2012

ISSN 1 031 9034

ISBN 978 1 921654 36 7

The Centre of Policy Studies (COPS) is a research centre at Monash University devoted to economy-wide modelling of economic policy issues.

Upgrading irrigation infrastructure in the Murray Darling Basin: is it worth it?

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Abstract

Infrastructure upgrades appear superficially to be a politically acceptable way of increasing environmental flows in the Murray-Darling Basin. From an economic perspective, their costs and benefits should be compared with other policy instruments. We do so using TERM-H2O, a dynamic regional CGE model with considerable basin detail. Voluntary and fully compensated buybacks are much less costly than upgrades as a means of obtaining a target volume of environmental water. Even during drought, when highly secure water created by infrastructure upgrades is more valuable, the upgrades remain too costly. As an instrument of regional economic management, infrastructure upgrades are inferior to public spending on health, education and other services in the basin. For each job created from upgrades, the money spent on services could create between three and four jobs in the basin.

Key words: CGE modelling, water buybacks, regional economies.

JEL:C54, Q11, Q15

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1. Introduction

COAG reforms introduced in the 1990s included important steps such as a cap on the volume of water extracted from the Murray-Darling Basin and the separation of land and water ownership. The Water Act 2007 was an attempt by the then Howard government to solve the problems of the Murray-Darling basin. Infrastructure upgrades featured in the 10 point plan to address problems arising from water allocation in rural Australia announced on 25 January 2007. Points dealing specifically with such upgrades included:

> 1. a nationwide investment in Australia's irrigation infrastructure to line and pipe major delivery channels;
> 2. a nationwide programme to improve on-farm irrigation technology and metering;
> 3. the sharing of water savings on a 50:50 basis between irrigators and the Australian Government leading to greater water security and increased environmental flows;
>
> Australian Government 2007, p. 1

Other parts of the plan concerned reducing water allocations to farmers. Clearly, the Howard government was concerned about the regional economic implications of reducing irrigation water availability in the Murray-Darling basin. Whereas $3.1 billion was allocated in the plan to buying water from farmers, almost $6 billion was allocated to infrastructure upgrades. The Murray-Darling basin's proportion of proposed infrastructure funding is around four-fifths.

Infrastructure upgrades are superficially appealing as a way of using irrigation water more efficiently. But the expense of such upgrades is a major issue. Comparative costs are the problem: buybacks of permanent water entitlements so far have cost the Commonwealth around $2000 per ML, based on average expected annual allocations. Infrastructure upgrades cost between $5,000 and $10,000 per ML.[1] Our argument concerns the balance of funding in the Water Act 2007, which may allocate more funding to upgrades than is socially optimal and too little funding to buybacks.

Buybacks entail full compensation at market prices and are voluntary.[2] However, infrastructure upgrades have been favoured by groups such as the Victorian Farmers Federation and National Farmers Federation. In part, they are responding to communities who have been through difficult times with ongoing structural change and drought-induced job losses. Industry representatives may see it as their role to exaggerate the importance of their industry to regional economies. However, in their enthusiasm to exaggerate the potential losses arising from reduced water availability, such lobbyists have underestimated

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[1] Market prices for sales of permanent water are downloadable from http://www.environment.gov.au/water/policy-programs/entitlement-purchasing/market-prices.html (accessed 4 June 2012). Water volumes arising from infrastructure upgrades reflect earlier estimates by the Department of Sustainability, Environment, Water, Population and Communities (SEWPAC), though subject to change. Infrastructure costs are based on the Water Act 2007.

[2] A significant impediment to water trading concerns the fixed costs of delivery shares charged by water authorities. When an irrigator sells permanent water, he or she must continue to pay for delivery shares. In some cases, these fixed charges on an individual farm may exceed $100 per ML. Delivery shares are emerging as an area for substantial reform.

the adaptability and flexibility of farmers.[3]

The economic argument for infrastructure upgrades appears to be even more tenuous when water accounting is based on net rather than gross extractions (Young and McColl, 2009). Since some of the expected water savings are calculated as arising from reduced leakages, they may amount to an increase in net extractions of water for a given gross extraction. We model an increase of 240 GL of highly secure water to farmers despite this concern. Our estimate of the economic returns to infrastructure is therefore an upper bound.

Using a CGE model of the Australian economy with a high level of regional and sectoral disaggregation of agricultural activity in the Murray-Darling Basin, we find that upgrades of irrigation infrastructure will have the following impacts:

1. During non-drought years, the value of water saved is insufficient to offset the cost of the investment in infrastructure relative to buybacks;
2. In drought years, with greater water scarcity the price of water is elevated and thus the value of highly secure water saved is greater, although still not sufficient to generate a positive return on the investment;
3. Upgrades to irrigation infrastructure represent a net inflow of funds to the Murray-Darling Basin region from the rest of Australia, with a short term positive impact on gross regional product and employment in the MDB. However, this is not sufficient evidence to support irrigation infrastructure upgrades. The funds could be used in the MDB region with three to four times the impact on jobs by investing in services in the region; and
4. Along with buybacks, infrastructure upgrades have a very small negative impact on national GDP (around one-fiftieth of one per cent, or $10 per person per year compared to business-as-usual), which may be considered as the cost of improving environmental flows in the basin. We do not account for the environmental benefits in the modelling.

Detailed results for three scenarios ((i) *buybacks only*; (ii) *buybacks plus upgrades*; and (iii) *buybacks plus services*) in relation to two baselines (no drought and periodic drought) are presented in Section 3. Before presenting results, in Section 2 we describe TERM-H2O, the economic model used in this paper. We finish with concluding remarks in Section 4.

2. The importance of CGE modelling in the water management debate

Before discussing the computable general equilibrium (CGE) approach, we acknowledge the contribution of other economic models in analysing basin water reforms. Griffith (2012) details the modelling effort over more than four decades. A prevailing theme arising from partial equilibrium studies is that water trading may play a substantial role in improving allocative efficiency. Such modelling influenced COAG reforms that started in earnest in the 1990s.

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[3] In early policy formation, it was unclear how the Commonwealth would implement sustainable diversion limits (SDLs). Prime Minister Gillard announced prior to the 2010 election that the purchases of acquiring environmental water would be entirely through voluntary purchases by the Commonwealth. This should have alleviated concerns about uncompensated acquisition.

In the past, the usual benefits of CGE models were overshadowed by a limited ability to represent catchment regions, as is highly desirable in a study of water issues in the Murray-Darling basin. The TERM approach to CGE modelling has overcome the spatial limitation (Horridge *et al.* 2005; Wittwer and Horridge, 2010). TERM-H2O combines catchment regions in the basin with composite regions depicting the rest of the Australian economy.

By including an interface between catchment regions and the rest of the economy, TERM-H2O enables the user to combine direct impacts that affect small regions, such as changes in water allocations with national influences such as labour market assumptions. For example, we would expect a scenario concerning water allocations to affect prices in local (non-traded) markets in the basin, notably housing, but not to affect wages, which tend to be set nationally. This means that strengthening or weakening of the basin's labour market will tend to result in inward or outward migrations of basin workers rather than changes in wages. Changes in water scarcity in the basin, on the other hand, will have a marked impact on water prices within the basin.

Furthermore, TERM-H2O includes significant detail in the agricultural sector (Dixon *et al.,* 2011), identifying ten agricultural activities, two production methods for most activities (irrigated and dry land), and water accounting for all activities.

In addition to these important regional and sectoral details, TERM-H2O preserves all the strengths of CGE modelling, in particular a macroeconomic framework in which the decision to allocate funds to regional infrastructure investment is accounted for by the diversion of resources from other productive activities. This precludes the model from producing unfeasibly large multiplier-type results.

Finally, three important features of TERM-H2O pertaining to water modelling are factor mobility assumptions, accounting for buy-back revenues and dynamics.

Factor mobility

We have seen how widely water scarcity varies over time. Between 2001 and 2010, the volume of allocated water in the basin ranged from more than 10,000 GL per annum at the beginning of the decade to less than 3,500 GL per annum during the prolonged drought near the end of the decade (ABS 2010). Over the same decade, Watermove data indicate that the average annual trading price of water varied from less than \$40/ML to more than \$500/ML. Such ranges in scarcity indicate that since the average product of water differs widely between crops, water trading will improve allocative efficiency substantially as the marginal product of water varies. Allowing water trading between irrigators increases the mobility of other farm factors between uses. Since water trading is possible between regions in the southern basin, and between users in the northern basin, useful economic modelling needs to include factor mobility.

The dairy industry in the Murray-Darling Basin provides an example of such adaptability and flexibility. In the middle of a prolonged drought in 2007-08, dairy output was 26 percent lower than in 2005-06. Water use by the industry at the same time was 75 percent lower than in 2005-06 (ABS 2010; ABS 2009; ABARES 2010). This shows that in response to drought, dairy producers managed a switch on an unprecedented scale from irrigation to dry-land (more specifically, feedlot) dairy farming. The price of irrigation water in the southern basin soared in 2007-08 to an annual average in excess of $500 per megalitre. Dairy farmers found it advantageous to sell water and buy fodder in such a circumstance. While drought provided extreme stress for farmers in the basin, the ability to switch between irrigation and dry-land activities and the possibility of trading water gave farmers helpful options in coping with drought.

Buyback revenue

In any buyback scenario, in which farmers are selling water to the Commonwealth and trading water, it is insufficient to estimate the impact on farmers' incomes by calculating changes in farm output. Without water trading, such estimates are defensible. But with water trading, the net sales of temporary water contribute to regional income, positively for net inter-regional water exporters and negatively for importers.

One may debate the proportion of buyback proceeds that remain in a region. Dixon *et al.* (2011) used sensitivity analysis to show that altering the assumption concerning proceeds remaining did not alter modelled outcomes significantly. The dynamic CGE study of Dixon *et al.* (2011) found that fully implemented buybacks in the southern basin raised aggregate household consumption relative to forecast. An initial guess of zero impact on consumption may be justified based on full compensation. This is modified by the impact of buybacks on the price of water and associated terms-of-trade gains. When the terms-of-trade improve, the ratio of real consumption to real income increases. This implies that it is possible to have an increase in real consumption relative to base even if there is a decrease in real GDP.[4] On the other hand, since water is removed from production, the rate of return on fixed factors (i.e., agricultural land) falls relative to base in the scenario.

Dynamics

One final advantage of a CGE approach concerns dynamics. A significant policy issue has been the timing and speed of buybacks. The buyback process commenced during drought, inevitably leading to buybacks becoming a scapegoat for drought-induced job losses. TERM-H2O has been used to model drought and buybacks separately. Drought modelling results in substantial job short-run job losses in the basin. Even a decade after full recovery, modelled long-term job losses that are a consequence of lost years of investment during drought are several-fold greater than the long-run job losses arising from buybacks (Wittwer and Griffith, 2012).

An implication is that the baseline matters in policy modelling. In the next section, we give a summary of results for buyback plus infrastructure modelling, using first a baseline that does

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[4] Even if farmers were not compensated for environmental water (a circumstance we regard as politically infeasible), some regions could still experience gains from water trading arising from reduced water availability.

not include droughts, and then a baseline that include droughts. The choice of baseline alters policy outcomes.

3. TERM-H2O modelling

The theory of TERM-H2O is detailed in Dixon *et al.* (2011). For a number of farm outputs, there is both an irrigation production technology and a dry-land technology (see Figure 1). For example, annual crops such as cereals (non-rice) may be produced as either an irrigation or dry-land technology. Rice and grapes, on the other hand, are treated as exclusively irrigated activities. Each irrigation sector requires a fixed volume of water per hectare (relying on irrigation water plus rainfall) subject to a given water-using technology. If water scarcity worsens, either farmers move to irrigation crops that require a smaller volume of water per hectare, or some irrigable land moves to dry-land farming. The model includes specific capital depicting orchards or vineyards for perennials: this feature reduces the flexibility of perennial sectors. Mobile farm capital, which includes farm machinery, for example, that can be applied to a number of different activities, following a CET (constant elasticity of transformation) specification. A CET specification also applies to dry land and a water-irrigable land composite. Owner-operator inputs across different farm activities also follow CET.

TERM-H2O includes a full input-output database for each region plus inter-regional and international trade matrices. The master database of TERM-H2O includes 46 statistical sub-divisions in the Murray-Darling basin. In this application of the model, these are aggregated to 18 Murray-Darling Basin regions. In addition, there are water accounts covering each irrigation sector in each region. Irrigation water, subject to the fixed requirement per unit of irrigable land for each irrigation activity, is tradable between users and regions of TERM-H2O in the southern basin and between users but not regions in the northern basin.

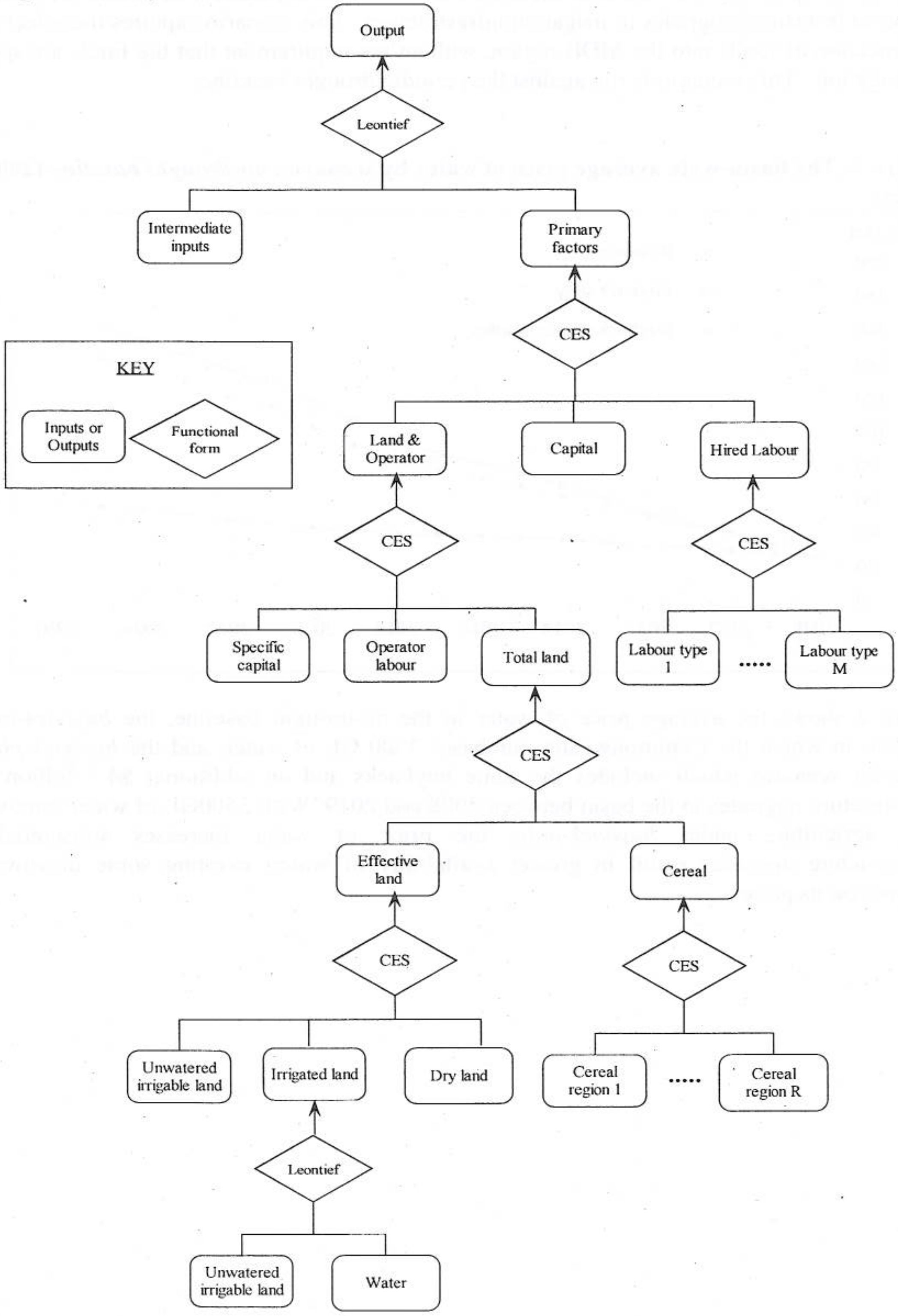
3.1 The scenarios

The *buyback-only* scenario involves basin farmers selling water to the Commonwealth starting in 2009 and gradually increasing to 3500 GL in 2021. This represents approximately 30 per cent of full annual water entitlements. This is an earlier target volume that the Murray-Darling Basin Authority chose; the target has since fallen to 2750 GL. Should it become apparent over time that the regional economic impacts of water buybacks are relatively benign as modelled, the target volume may increase.

The *buyback-plus-upgrades* scenario includes $4.7 billion of infrastructure upgrades in the basin in addition to the buybacks. This scenario accounts for the cost of the infrastructure and subsequent water savings (see footnote 1).

There are two variants of the two scenarios. The first variant assumes average rainfall years throughout the simulation period (*no-drought baseline*). The second variant assumes that moderate droughts occur twice a decade with consequent dry-land productivity losses and reduced rainfall (*periodic-drought baseline*). The judgment of water engineers is that infrastructure upgrades will create highly secure water. Since our drought scenario worsens water scarcity without reducing irrigation water allocations, this mimics the effect of highly secure water in drought. When completed, irrigation upgrades account for an additional 240 GL of water for farm use in all years. An additional volume of 570 GL is available to the environment, although not included in the modelling. This volume is contentious given concerns regarding gross and net water extractions (Young and McColl, 2009).

Figure 2: Farm production function in TERM-H2O



The *buyback-plus-services* scenario includes $4.7 billion of investment in public services in the basin instead of upgrades to irrigation infrastructure. This scenario captures the effects of the injection of funds into the MDB region, without the requirement that the funds are spent on irrigation. This scenario is run against the periodic-drought baseline.

Figure 2: The basin-wide average price of water by scenario, *no-drought baseline* (2007 prices)

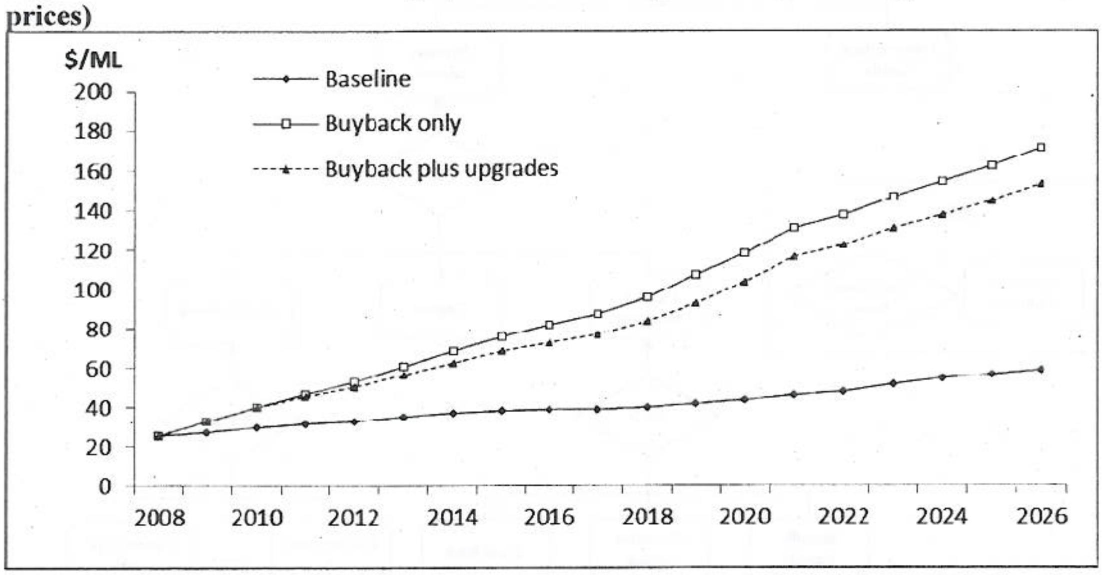
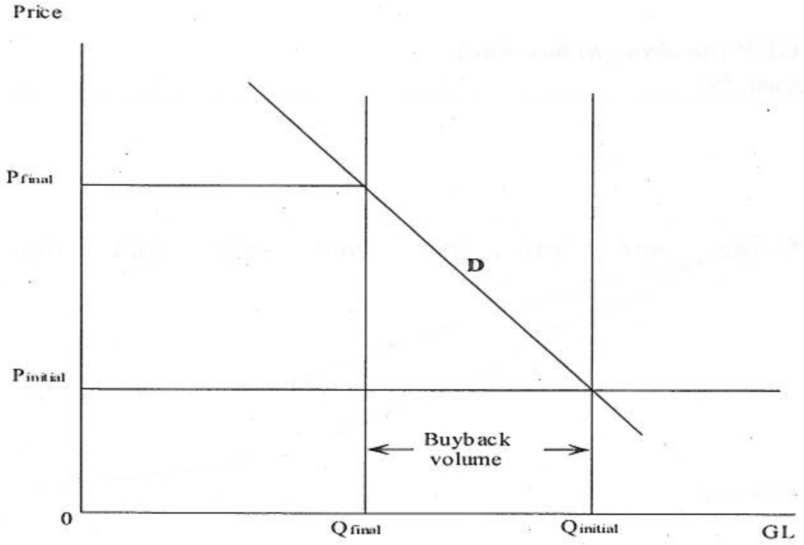


Figure 2 shows the average price of water in the no-drought baseline, the *buyback-only* scenario in which the Commonwealth purchases 3500 GL of water, and the *buyback-plus-upgrades* scenario which includes the same buybacks and an additional $4.7 billion of infrastructure upgrades in the basin between 2008 and 2019. With 3500GL of water removed from agriculture under *buyback-only*, the price of water increases substantially. Infrastructure upgrades result in greater availability of water, exerting some downward pressure on its price.

Figure 3: Market for irrigation water



In Figure 3, we see the impact of the accumulated buyback volume for a given year on the price of water, with the price rising from $P_{initial}$ to P_{final} as a consequence of an accumulated volume equal to the gap between $Q_{initial}$ and Q_{final}. Income-side GDP consists of the sum of returns to primary factors over all industries, ignoring indirect tax income. Our *buyback-only* scenario consists of removing water from production. The decrease in real GDP therefore should be equal to the area under the demand curve in Figure 3 between $Q_{initial}$ and Q_{final}, assuming that the scenario does not change other primary factor quantities.

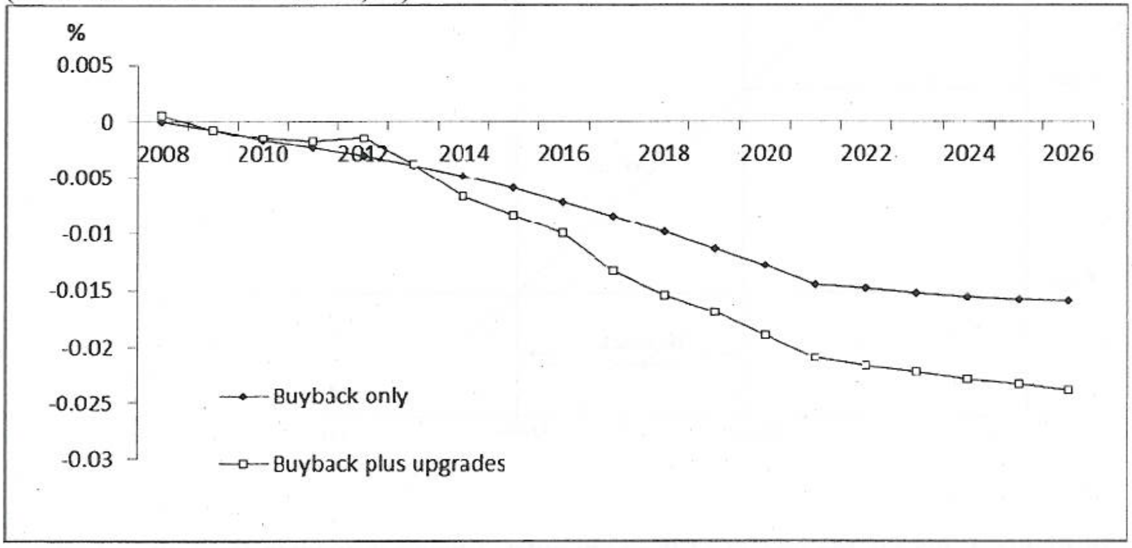
The value added from irrigation water in the MDB accounts for around 0.02 per cent of national GDP. By the completion of buybacks in 2021, the removal of 30 per cent of irrigation water accounts for a decrease in real GDP of 0.014 per cent, according to TERM-H2O. A back-of-the-envelope calculation based on Figure 3 confirms this. With buybacks, the price of water is 184 per cent above the baseline in 2021. Therefore, using the average of the base and policy water prices, the effect on GDP (lowercase denotes percentage change) is:

$$gdp = 0.0002 * -30 * (1 + 1.84/2) = -0.012$$

That the modelled change in real GDP is slightly worse reflects a small modelled decline in aggregate capital relative to forecast in the scenario.

Figure 4 shows the impact of both the *buyback-only* and *buyback-plus-upgrades* scenarios on national real GDP. That the *buyback-plus-upgrades* decline in real GDP relative to forecast is larger than for buybacks alone reflects the excessive costs of infrastructure upgrades. The benefit of the accumulated $4.7 billion investment falls short of the cost. Admittedly, the modelling does not include the environmental benefit of the additional 570 GL of water, although it would be cheaper to purchase the volume through an extension to the buyback process.[5]

Figure 4: National real GDP (*no-drought baseline*)
(deviation relative to forecast, %)



So far, the modelling results are consistent with economic orthodoxy: the infrastructure upgrades remain too expensive to be economically justifiable. Next, we examine the case in which there are several years of drought in the baseline.[6]

The periodic-drought baseline

From figures 2 and 3, we see that the modelled price of water enables us to calculate the impact of buybacks on real GDP. We gather an approximate measure of welfare from national real GDP. Without droughts in the baseline, the *buyback-plus-upgrades* scenario is unambiguously worse than *buyback-only*. However, the price of water may rise many-fold during drought. This implies that the additional absolutely secure water arising from upgrades is much more valuable during drought than in normal years. Does the story change significantly if we include droughts in the baseline?

Figure 5 shows basin-wide nominal water prices and Figure 6 repeats the national GDP impact, with hypothetical drought years in 2014, 2015, 2021 and 2022. The gap between the *buyback-only* and *buyback-plus-upgrades* scenarios (Figure 6) remains similar to that of the

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[5] The price of high security entitlements is around $2000/ML, implying that 570 GL of entitlements could be purchased for $1.14 billion.

[6] In each drought year, there is no change in water allocations. Moderate drought is represented by decreases in rainfall of 20% relative to an average year. Dry-land productivity worsens such that for each unit of output, input requirements increase by 40%. Both the rainfall decrease and dry-land productivity losses raise the value of the marginal product of water. The increase in the price of water indicates the severity of the drought: our hypothetical droughts are less severe than the drought of 2007-08 when the price of irrigation water exceeded $500 per megalitre.

scenarios with a no-drought baseline (Figure 4) in years without drought. But since the additional water available from upgrades is more valuable in drought, as is evident in the price hikes in the drought years shown in Figure 5, the gap in real GDP between the *buyback-only* and *buyback-plus-upgrades* scenarios is smaller in drought years. Using the data provided by SEWPAC, even in drought years the *buyback-only* scenario provides a better outcome in later years.

Figure 5: The basin-wide average price of water by scenario (*periodic-drought baseline*) (2007 prices)

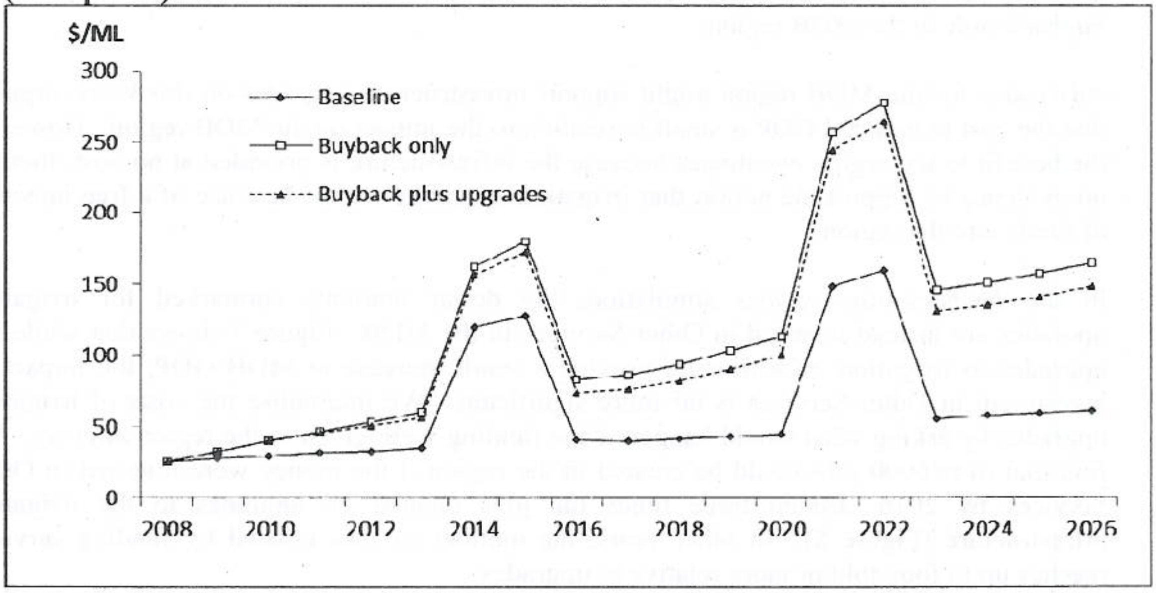
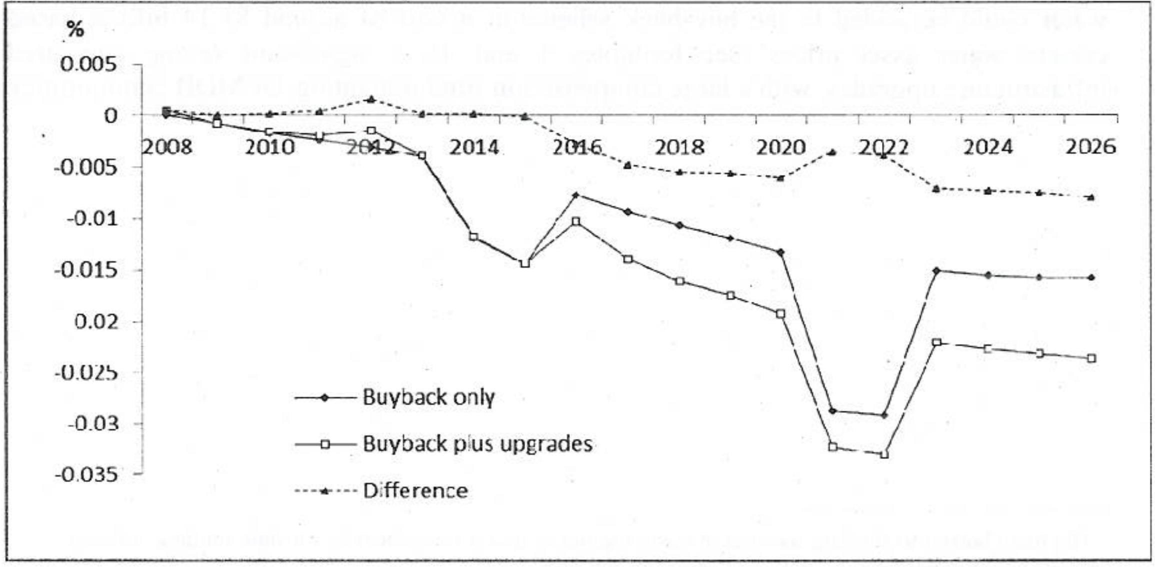


Figure 6: National real GDP (*periodic-drought baseline*)
(deviation relative to forecast, %)



Buyback-plus-facilities scenario

Using national GDP as a performance indicator for regional policy overlooks some of the redistribution effects of the policy. In the *buyback-plus-upgrades* scenario, the return on investment in upgrades is too low to offset the cost, leading to a negative effect on GDP. However, upgrades funded by the federal government are a windfall gain to the MDB regions at the expense of the rest of Australia. Upgrades represent an additional $4.7 billion in funds transferred to the MDB region, meaning that *buyback-plus-upgrades* outperforms *buyback-only* in the MDB region.

Advocates for the MDB region might support infrastructure upgrades on this basis, arguing that the cost to national GDP is small in relation to the impact on the MDB region. However, the benefit to the region eventuates because the infrastructure is provided at no cost: there is no evidence to support the notion that irrigation upgrades are the best use of a free injection of funds into the region.

In the *buyback-plus-services* simulation, the dollar amounts earmarked for irrigation upgrades are instead invested in Other Services in the MDB. Figure 7 shows that while the upgrades to irrigation infrastructure provide a small increase in MDB GDP, the impact of investment in Other Services is far more significant. We internalise the costs of irrigation upgrades by asking what would happen if the funding were given to the region anyway. We find that over 6000 jobs could be created in the region if the money were invested in Other Services by 2016, around three times the jobs created by upgrades to the irrigation infrastructure (Figure 8).[7] In other years, the number of jobs created by funding services reaches up to four-fold or more relative to upgrades.

The attraction of upgrades to irrigation infrastructure as a form of compensation to the MDB region is substantially reduced when compared to alternative uses of the funds. However, to invest in other services is to forgo the 570GL in water available to the environment. This water could be added to the buy-back scheme at a cost of around $1.14 billion based on current water asset prices (see footnotes 1 and 4), a significant saving compared to infrastructure upgrades, with a large compensation fund remaining for MDB communities.

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[7] The main barrier to funding services in basin regions is that it relies heavily on state funding, whereas infrastructure upgrades rely on Commonwealth funding.

Figure 7: Real GDP in the MDB (*periodic-drought baseline*)
(deviation relative to forecast, %)

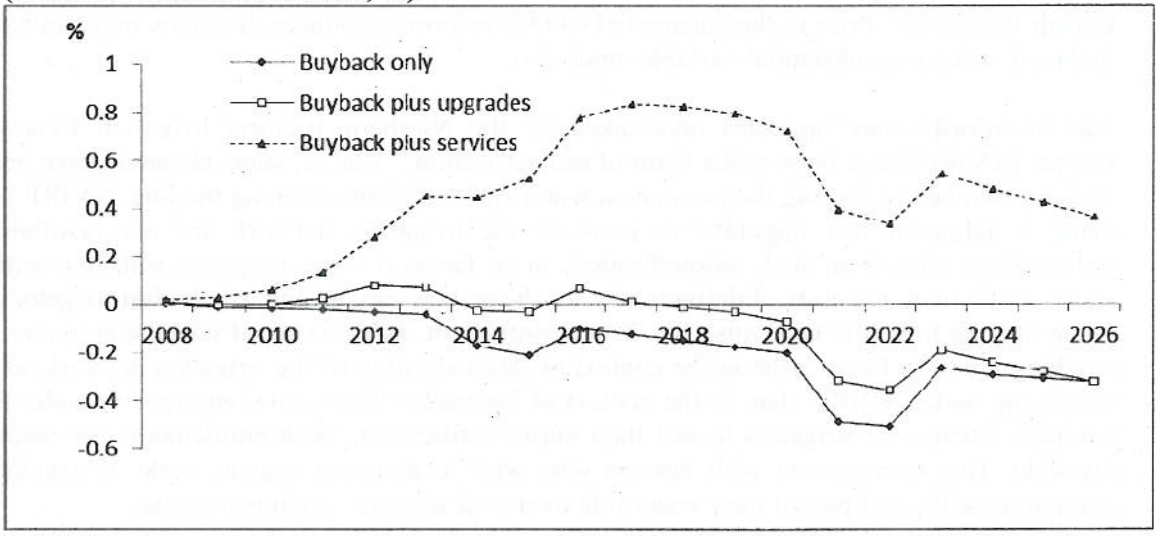
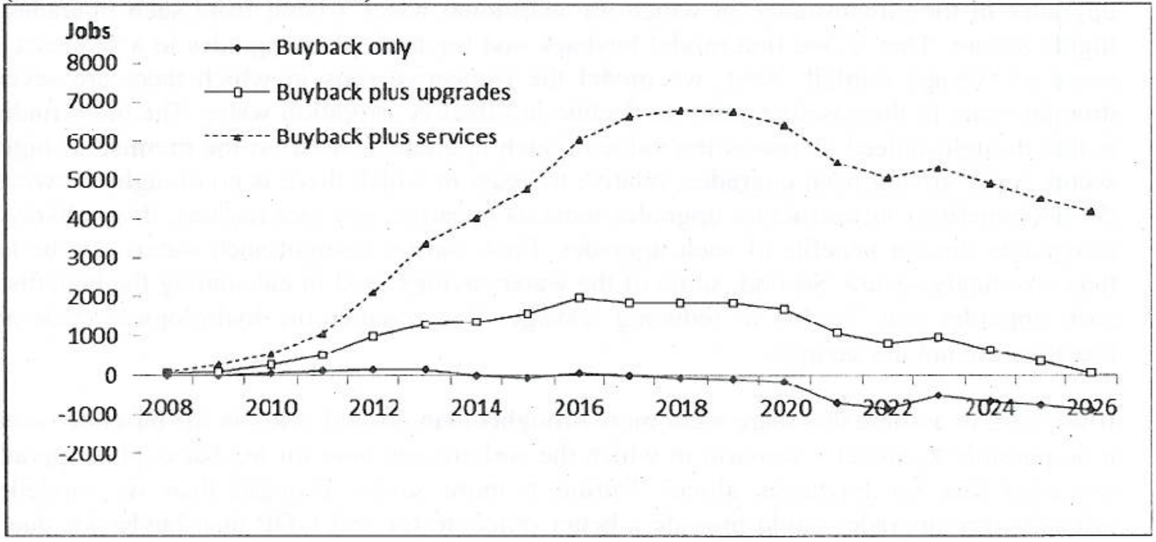


Figure 8: Jobs in the MDB (*periodic-drought baseline*)
(deviation relative to forecast)



Remaining arguments for infrastructure upgrades

Other arguments may persist concerning upgrades. Much irrigation infrastructure in the basin may be around 80 years old, aged, creaking and leaky. This does not mean that it is worth replacing. The economic foundations of basin irrigation suffer from the original sins of soldier settlement schemes established after both of the world wars. That is, left to market forces rather than economic planning by Commonwealth and state governments, irrigation schemes may not have been established on the scale that eventuated. However, once sunk capital such as irrigation infrastructure is in place, investments and labour tend to reflect prevailing market signals. If farmers are allocated water with little more than supply charges, and with limited opportunities to trade water, there may be no incentive to treat water as though it is scarce. Prior to the substantial COAG reforms, producer decisions may not have included water as a substantial variable input cost.

Part of infrastructure upgrades undertaken by the Northern Victoria Irrigation Renewal Project (NVIRP) have been in the form of rationalisation.[8] That is, some channels have been decommissioned by buying the permanent water rights of farmers along the line. NVIRP has made a judgment that upgrades to parts of the irrigation network are not justifiable. Externalities arise from such rationalisation, in so far as if other irrigators sell their entire water entitlement, the costs of delivery rise for those who remain. Indeed, the last irrigator on a line may be forced to relinquish his or her entitlement, as the costs of water supply rise. If anything, this is a larger issue in the context of rationalisation of the irrigation network, as is happening under NVIRP, than in the context of buybacks: there is no requirement under the buyback scheme for irrigators to sell their entire entitlement. Such entitlements are readily divisible. This is consistent with farmers who wish to maintain a given scale of irrigation operations selling off part of their water title over time as water savings increase.

4. Concluding remarks

The new contribution of this study is that we have modelled the impact of infrastructure upgrades in the circumstance in which the additional water arising from such upgrades is highly secure. That is, we first model buyback and buyback plus upgrades in a sequence of years of average rainfall. Next, we model the respective runs in which there are several drought years in the baseline, with no decline in effective irrigation water. The main finding is that drought indeed increases the value of such upgrades, based on the premise of highly secure water arising from upgrades, relative to years in which there is no drought. However, the net benefit of infrastructure upgrades remains negative. For two reasons, this is likely to exaggerate the net benefits of such upgrades. First, during drought such water may be less than absolutely secure. Second, some of the water savings used in calculating the benefits of such upgrades may be due to reducing leakages that re-enter the hydrological cycle and therefore are not net savings.

If we were to assume that there were more droughts than normal years in the baseline, would it be possible to model a scenario in which the welfare outcome for buybacks plus upgrades exceeded that for buybacks alone? During a more severe drought than we modelled, infrastructure upgrades could provide a better outcome for real GDP than buybacks, due to elevated water prices. However, in such a circumstance, investment in farming would fall over time (Wittwer and Griffith, 2011). Infrastructure upgrades in this setting would slow to a small extent the decline in farm investment. With many droughts in the baseline, farm output would be shrinking over time relative to a baseline without drought.

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[8] An example of a rationalisation agreement is downloadable from http://www.nvirp.com.au/downloads/Connections/Connections_Program/Sample_Legal_Agreement_R.pdf (accessed 4 June 2012).

The inclusion of drought years in the baseline does at least represent a setting in which infrastructure upgrades perform relatively well. The Water Act 2007 was introduced during a period of prolonged drought. Should there be relatively few droughts over the remainder of the decade, it is possible that advocacy for further spending infrastructure upgrades will wane.

In the context of choosing between water buybacks or infrastructure upgrades, there is no need to attempt to monetise the environmental benefits. There appears to be broad acceptance in the community to sink substantial funds into the Murray-Darling basin. Indeed, the $8.9 billion allocated in the Water Act 2007 to the basin is equivalent to $588,000 per irrigator (Young 2011). At the heart of debate, once the need for substantial funds for remedial action is accepted, is how best to spend the money. Those who have lobbied against water buybacks have done so on the basis of economic impacts in communities. Following this line of argument, we find that were some funds earmarked for infrastructure upgrades redirected towards services such as health, education and aged care in basin communities, the community benefits would be greater. In the context of environmental restoration for which the funds have been earmarked, buybacks remain cheaper.

Our analysis of the economic benefits of infrastructure upgrades or the economic costs of water buybacks is based on TERM-H2O CGE modelling. By accounting for factor mobility and the costs of investment, CGE modelling does not suffer the pitfalls of multiplier analysis. Already, multiplier analysis has been proven wrong in the debate concerning the impacts of buybacks. Buybacks started during a period of drought and continued during the recovery years. Lobbyists using multiplier analysis attributed drought-induced job losses to buybacks. Drought led to the closure of the Deniliquin rice mill for three years as water became too scarce for rice production. The return of rain led to the reopening of the mill. The reopening of the mill is a reminder of the fallacies on which multiplier analysis has been undertaken to exaggerate both the regional economic losses from buybacks and benefits from infrastructure upgrades.

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Modelled Ecological Outcomes of the Proposed Basin Plan 2,750GL SDL scenario

The Murray-Darling Basin Authority (MDBA) has used computer modelling to predict the outcomes of the Proposed Basin Plan. This document summarises two key findings of the modelling:

1. the environmental outcomes for key environmental sites in the Basin
2. the impact of physical and operational constraints on the ability to achieve environmental outcomes

Environmental outcomes are defined as the achievement of specific ecological targets. These targets were developed by the MDBA using the best available science for each site. They are things like a healthy level of water bird breeding, or the maintenance of local wetland vegetation.

Because there is an always a degree of scientific uncertainty about how much water is required to achieve these targets the MDBA defined what it would take to achieve the desired outcome with a high level of risk (represented by the orange squares in table 2) or a low level of risk (green squares).

Achieving these targets does not mean returning the basin to natural conditions, it simply means achieving a healthy working river. The low risk scenarios are closer to what would of naturally occurred, but still with significantly less water. The high risk scenario represents what the Authority believes to be an ecological tipping point, beyond which the ecosystem beings to collapse.

The objective of the *Water Act 2007* is to achieve these targets with as little risk as possible. This means the aim of any 'adjustment mechanism' should be to move the outcomes from the red zone to the green.

In a limited number of cases, certain physical or policy **constraints** make it difficult to deliver enough water to achieve ecological targets (in table 2 this is represented by the diagonal cross-hatching), or impossible (square cross-hatching). These include things like the need to avoid deliberately flooding bridges and private land, or outdated intergovernmental agreements about where and when water can be released.

The MDBA modelling shows that in most cases extra water could achieve much better outcomes within current operating constraints. 34 'achievable' targets are failed simply because the Authority has chosen not to model the recovery of more water for the river. As a result, the Proposed Basin Plan would only achieve 57% of ecological targets for a healthy river.

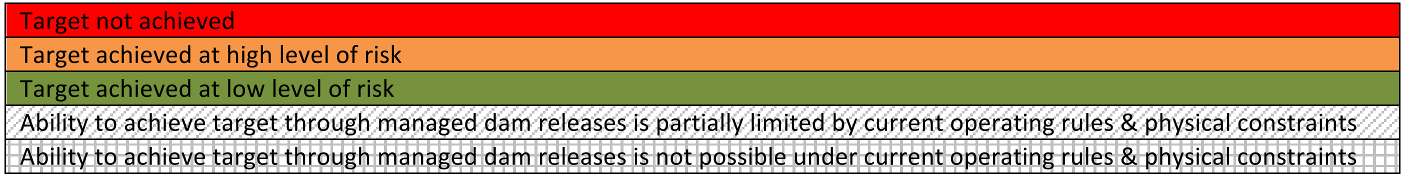
Note

For some sites it appears that ecological targets are repeated. In these cases the MDBA determined that a number of different types of flow events are required to achieve the target.

Table 1: Summary of overall performance

	No. targets reported against		**Met at low risk frequency**		**Met at high risk frequency**		**Not met but some improvement**		**No improvement**		**Achieved targets (total)**		**Failed targets (total)**	
Category	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1. Achievable under current conditions	91	81	27	30	30	33	27	30	7	8	57	63	34	37
2. Achievable under limited circumstances due to current operating constraints	12	11	1	8	5	42	6	50	0	0	6	50	6	50
3. Difficult to achieve due to current operating constraints	9	8	0	0	1	11	1	11	7	78	1	11	8	89
Total	**112**	**100**	**28**	**25**	**36**	**32**	**34**	**30**	**14**	**13**	**64**	**57**	**48**	**43**

Table 2: Site-by site outcomes



Key

- 🟥 Target not achieved
- 🟧 Target achieved at high level of risk
- 🟩 Target achieved at low level of risk
- ▨ Ability to achieve target through managed dam releases is partially limited by current operating rules & physical constraints
- ▦ Ability to achieve target through managed dam releases is not possible under current operating rules & physical constraints

Site	Flow Indicator and Ecological Target						
Lower Balonne Floodplain	🟥 (1) native fish	🟥 (2) riparian forest	🟥 (3) lignum shrublands & coolibah woodlands	🟧 (4) lignum shrublands & coolibah woodlands; river-floodplain connectivity	🟥 (5) native floodplain grasslands; river-floodplain connectivity		
Narran Lakes (Ramsar site)	🟧 (1) red gum, coolibah and lignum in Northern lakes	🟥 (2) lignum & river cooba at Clear Lake	🟥 (3) lignum, coolibah and grassland communities on broader floodplain	🟥 (4) colonial nesting waterbirds	🟥 (5) lignum stands on broader floodplain		
Lower Macintyre river	🟧 (1) native fish, in-stream habitat	🟧 (2) native fish, in-stream habitat	🟥 (3) native fish, in-stream habitat				
Gwydir Wetlands - Lower Gwydir & Gingham channel (Ramsar Site)	🟩 (1) native fish, frogs & turtles	🟩 (2) native fish, frogs & turtles	🟥 (3) wetlands; floodplain lignum, woodlands & grasslands	🟧 (4) wetlands; floodplain lignum, woodlands & grasslands	🟩 (5) wetlands; floodplain lignum, woodlands & grasslands	🟧 (6) wetlands, floodplain vegetation & colonial nesting waterbirds	🟩 (7) wetlands, floodplain vegetation & colonial nesting waterbirds
Gwydir Wetlands - Mallowa	🟥 (1) lignum; red gum & coolibah woodlands	🟩 (2) lignum; red gum & coolibah woodlands					
Namoi River	🟧 (1) anabranch vegetation, fish, in-stream habitat	🟧 (2) anabranch vegetation, native fish, in-stream habitat	🟧 (3) anabranch vegetation, native fish, in-stream habitat				
Macquarie Marshes (Ramsar Site)	🟩 (1) semi-permanent wetlands and red gum forest	🟩 (2) wetlands & red gum forest; colonial nesting waterbirds	🟧 (3) woodland communities; colonial nesting waterbirds	🟩 (4) woodland communities; colonial nesting waterbirds			
Barwon-Darling River	🟥 (1) Nutrient cycling	🟧 (2) Nutrient cycling	🟥 (3) Nutrient cycling	🟥 (4) In-stream habitat	🟥 (5) In-stream habitat	🟥 (6) In-stream habitat	

Site	**Flow Indicator and Ecological Target**						
Talyawalka Anabranch (Darling River)	(1) billabongs & wetlands; red gum & black box woodlands; colonial nesting waterbirds	(2) billabongs & wetlands; red gum & black box woodlands; colonial nesting waterbirds	(3) billabongs & wetlands; red gum & black box woodlands; colonial nesting waterbirds				
Booligal Wetlands	(1) semi-permanent & permanent wetlands	(2) red gum and lignum communities	(3) colonial nesting waterbirds				
Lachlan Swamp	(1) semi-permanent & permanent wetlands	(2) red gum and lignum communities	(3) black box woodlands	(4) colonial nesting waterbirds			
Great Cumbung Swamp	(1) semi-permanent & permanent wetlands	(2) red gum; floodplain wetlands; colonial nesting waterbirds	(3) red gum; floodplain wetlands; colonial nesting waterbirds				
Mid-Murrumbidgee Wetlands	(1) Colonial nesting waterbirds	(2) riparian, floodplain & wetland communities; fish, frogs & turtles	(3) riparian, floodplain & wetland communities; fish, frogs & turtles	(4) riparian, floodplain & wetland communities; fish, frogs & turtles	(5) riparian, floodplain & wetland communities; fish, frogs & turtles		
Lowbidgee Floodplain	(1) floodplain & wetland communities; colonial nesting waterbirds; fish, frogs & turtles	(2) floodplain & wetland communities; colonial nesting waterbirds; fish, frogs & turtles	(3) floodplain & wetland communities; colonial nesting waterbirds; fish, frogs & turtles	(4) floodplain & wetland communities; colonial nesting waterbirds; fish, frogs & turtles	(5) floodplain & wetland communities; colonial nesting waterbirds; fish, frogs & turtles	(6) floodplain & wetland communities; colonial nesting waterbirds; fish, frogs & turtles	
Lower Goulburn Floodplain	(1) fish, frogs & turtles	(2) fish, frogs & turtles	(3) riparian, floodplain & wetland communities; colonial nesting waterbirds; fish, frogs & turtles	(4) riparian, floodplain & wetland communities; colonial nesting waterbirds; fish, frogs & turtles			
Lake Hindmarsh	(1) red gum woodland & aquatic fauna	(2) red gum woodland; native fish; colonial nesting waterbirds	(3) red gum woodland; native fish; colonial nesting waterbirds				
Lake Albacutya (Ramsar Site)	(1) red gum & black box woodlands; waterbird foraging; aquatic herblands	(2) red gum & black box woodlands; waterbird breeding; aquatic herblands					

Site	Flow Indicator and Ecological Target						
Barmah-Millewa (Ramsar Site)	(1) freshwater meadows & marshes; moira grass plains; red gum forest	(2) freshwater meadows & marshes; moira grass plains; red gum forest	(3) freshwater meadows & marshes; moira grass plains; red gum forest	(4) red gum forest & woodland; black box woodland	(5) red gum forest & woodland; black box woodland	(6) red gum forest & woodland; black box woodland	(7) colonial nesting waterbirds
Gunbower-Koondrook-Pericoota (Ramsar Site)	(1) permanent & semi-permanent wetlands	(2) permanent & semi-permanent wetlands	(3) red gum forest & woodland; black box woodland	(4) red gum forest & woodland; black box woodland	(5) colonial nesting waterbirds		
Hattah Lakes (Ramsar Site)	(1) permanent, persistent & semi-permanent wetlands	(2) permanent, persistent & semi-permanent wetlands	(3) permanent, persistent & semi-permanent wetlands	(4) red gum forest	(5) red gum woodland	(6) episodic wetlands & black box woodland	
Riverland-Chowilla (Ramsar Site)	(1) native fish	(2) wetlands & red gum forest	(3) wetlands & red gum forest	(4) wetlands & red gum forest	(5) red gum forest & woodland	(6) black box woodland	(7) black box woodland
Edward-Wakool (inc. Werai Ramsar Site)	(1) native fish	(2) reed beds & low-lying wetlands in Werai Forest	(3) colonial nesting waterbirds in Werai Forest	(4) ephemeral wetlands & watercourses; red gum forest & woodland	(5) ephemeral wetlands & watercourses; black box woodland		
Lower Darling River	(1) threatened ecological communities in Darling Anabranch	(2) Darling Anabranch floodplains & lakes; Lower Darling wetlands & waterbirds	(3) Darling Anabranch floodplains & lakes; Lower Darling wetlands & waterbirds	(4) in-stream habitat, native fish & riparian wetlands in Lower Darling	(5) red gum & higher level wetlands in Lower Darling		
Coorong, Lower Lakes & Murray Mouth (Ramsar Site)	(1) Southern Coorong average salinity	(2) Southern Coorong maximum salinity	(3) Southern Coorong maximum salinity	(4) Southern Coorong maximum salinity	(5) Northern Coorong average salinity	(6) Northern Coorong maximum salinity	(7) Northern Coorong maximum salinity
	(8) Barrage flow	(9) Barrage flow					

Source documentation

This document summarises the results of the Murray-Darling Basin Authority's hydrological modelling, based on the following reports:

MDBA (2010). Guide to the proposed Basin Plan: Technical background (Vol. 2). Canberra: Murray–Darling Basin Authority.

MDBA (2011). River management challenges and opportunities.

MDBA (2012). Assessment of environmental water requirements for the proposed Basin Plan: Barmah–Millewa Forest. Canberra: Murray-Darling Basin Authority.

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MDBA (2012). Assessment of environmental water requirements for the proposed Basin Plan: Gwydir Wetlands: Murray-Darling Basin Authority.

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MDBA (2012). Assessment of environmental water requirements for the proposed Basin Plan: Lower Goulburn River (in-channel flows). Canberra: Murray-Darling Basin Authority.

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MDBA (2012). Assessment of environmental water requirements for the proposed Basin Plan: Lower Namoi River (in-channel flows). Canberra: Murray-Darling Basin Authority.

MDBA (2012). Assessment of environmental water requirements for the proposed Basin Plan: Macquarie Marshes. Canberra: Murray-Darling Basin Authority.

MDBA (2012). Assessment of environmental water requirements for the proposed Basin Plan: Mid-Murrumbidgee River Wetlands. Canberra: Murray-Darling Basin Authority.

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MDBA (2012). Hydrologic modelling to inform the proposed Basin Plan - methods and results. Canberra: Murray-Darling Basin Authority.