D Regional impacts of water buybacks

Key points

- There have been a number of studies that estimate the impacts of water buybacks (or other reductions in water availability) on regional communities in the Murray-Darling Basin.
- The studies suggest that the impacts are unlikely to be large at the Basin level. The most robust modelling available estimates that the buyback will result in a small increase in real consumption in most southern Basin regions — that is, a net gain to the communities modelled. The model assumes that buyback participants will keep farming, which tends to bias the results.
- An increase in real consumption as a result of the buyback is possible because irrigators are paid for the water they sell. Without the payments, the impact of the buyback on real consumption in most southern Basin regions (excluding any benefits from reallocating water to the environment) would be unambiguously negative. However, with the payments, the impact could be positive or negative.
- While the impacts should be moderate at the southern Basin level, and could even be positive, some towns might experience large reductions in gross regional product.

This appendix reviews a number of studies that estimate the impacts of water buybacks and other reductions in water availability on regional communities. The main studies reviewed are:

- Dixon et al. (2009)
- Peterson et al. (2004)
- Qureshi et al. (2007)
- RMCG (2009)
- Judith Stubbs and Associates (2010).

These studies use a variety of modelling approaches to estimate the impacts of a reduction in water availability on the southern Murray-Darling Basin economy. The models and their limitations are discussed below.

D.1 Dixon et al. (Centre of Policy Studies)

The Centre of Policy Studies at Monash University modelled the regional impacts of the buyback using its computable general equilibrium model, TERM-H2O. The model has 17 southern Basin regions. The agricultural sector was modelled in detail, with 10 irrigated agricultural industries and seven dryland agricultural industries.

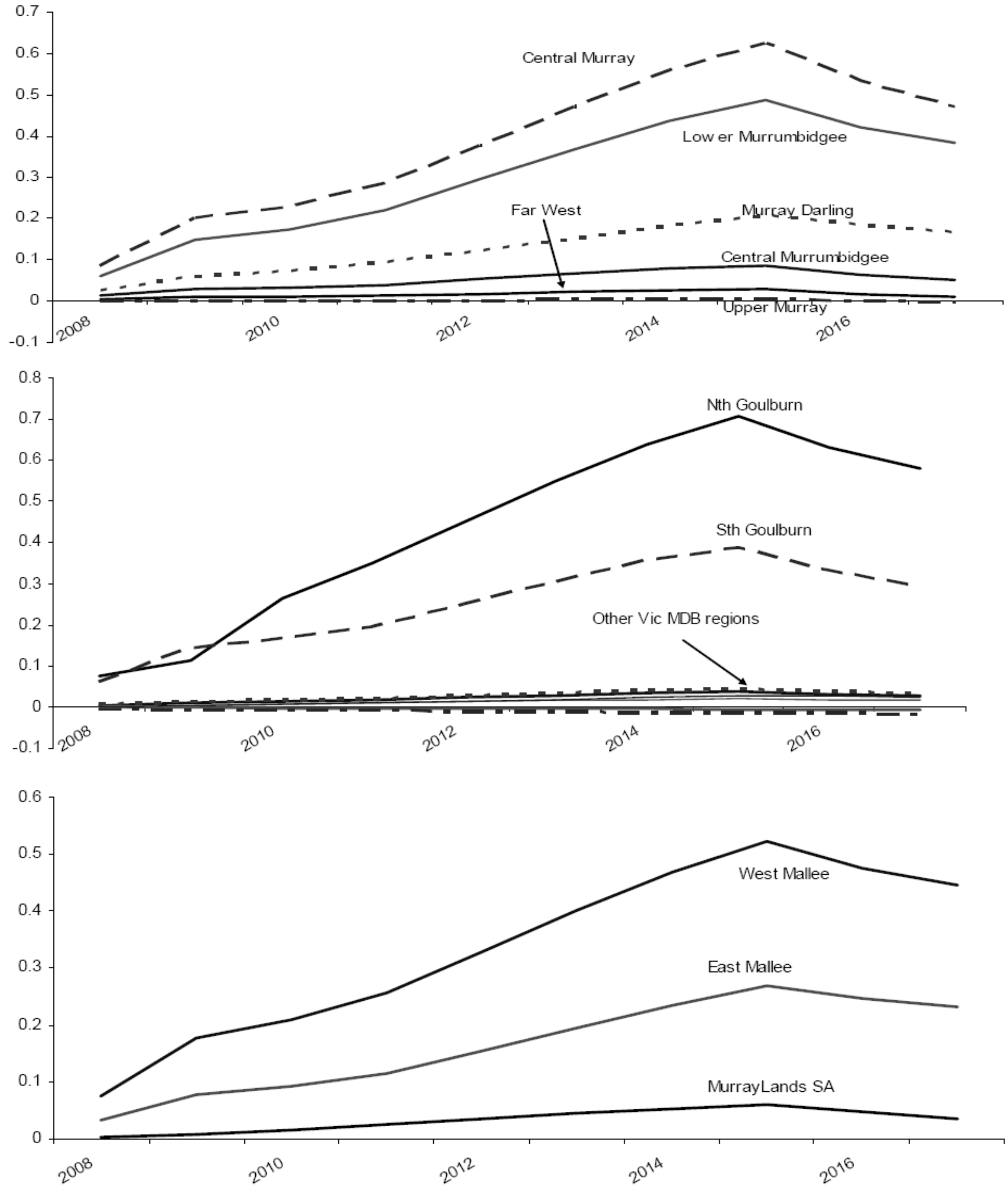
TERM-H2O compares the values of key variables, like real consumption, with and without the buyback. The main buyback scenario was a 1500 gigalitres (GL) acquisition over eight years in the southern Basin. This may understate or overstate the volume of water acquired in the southern Basin under Restoring the Balance. The buyback was modelled as an across the board reduction in water availability. Subsequent water trade was allowed across the southern Basin to reallocate water to the highest value uses. The payment to irrigators for buyback water was added to regional income.

In general, the estimated impacts of the buyback on real consumption were positive. The gains were largest in North Goulburn, Central Murray and West Mallee, with real consumption being around 0.5 per cent higher in 2017 relative to the no buyback baseline (figure D.1). In most regions the impact of the buyback on real consumption in 2017 was estimated to be an increase of less than 0.1 per cent. Dixon et al. (2009) attributes the positive impact on real consumption to an increase in disposable income as a result of buyback payments. In TERM-H2O, this more than compensates for the effects of reduced water availability.

These estimates are at the regional level and outcomes will vary for towns and individuals. At the industry level, the quantity of irrigated cereals was estimated to decline by around 33 per cent, and irrigated rice by around 22 per cent. The irrigated cotton and dairy industries were less affected, with output falling by around two per cent. The output of irrigated horticulture was essentially unchanged, even increasing slightly for fruits and vegetables.

TERM-H2O places the buyback within a conceptually robust economic framework. However, the results are a consequence of many assumptions, and different assumptions could generate substantially different results. Dixon et al. (2009) do not include any sensitivity analysis — showing how results change as key parameters are altered — so it is difficult to know how robust the conclusions are.

Figure D.1 **Change in real consumption as a result of the acquisition of around one third of irrigation water, by catchment**



Source: Dixon et al. (2009).

A number of important assumptions relating to the Dixon et al. (2009) analysis are outlined below:

- The volume of water applied per hectare irrigated was assumed to be fixed. In practice, irrigators may reduce their water application rates as the buyback increases the relative price of water compared with land. To take a related example, the substitution parameters (relevant in determining responses to the water buyback) do not appear to have a strong empirical basis. These limitations regarding the structure and parameterisation of the model mean that it may not adequately represent agricultural production systems in the southern Basin. This could result in unreliable estimates.

- The baseline and buyback scenarios include an increase in 'irrigation water efficiency'. However, the rate of growth in irrigation water efficiency is assumed to be the same in both scenarios. In general, the estimated 31 per cent increase in water prices under the buyback scenario would be expected to spur the development and adoption of new technology, leading to larger increases in irrigation water efficiency. These advances could offset some of the negative impacts of the buyback on agricultural output.
- TERM-H2O is a deterministic model. It does not account for random variation in climatic and market conditions. Introducing variation in rainfall tends to increase the attractiveness of opportunistic cropping activities, such as irrigated cereals and rice, compared with perennial activities. This could also influence the responsiveness of different activities to changes in water prices.
- Buyback participants are assumed to keep farming. This is implied by the assumptions that agricultural capital and operator labour are fixed, while buyback payments are added to regional income. This assumption is unlikely to strictly hold, and could cause the model to overstate the benefits of the buyback to regional communities. However, Dixon et al. (2009) argue that relaxing the assumption is unlikely to make a substantive difference to the results, since buyback payments are generally small relative to the size of regional economies.
- Like most other computable general equilibrium models, TERM-H2O assumes full employment and does not model adjustment costs. Thus, the model can not estimate the change in 'real consumption' that might happen if some people become unemployed as a result of the buyback.
- The benefits from increasing the allocation of water to the environment were not modelled. These benefits could include agricultural productivity gains from reduced salinity, which could be substantial, and increased tourism. Hence, the modelling could underestimate the benefits from the buyback.

D.2 Peterson et al. (Productivity Commission)

In 2004, the Productivity Commission modelled the impacts of reduced water availability on regional communities using an earlier version of the TERM model.

This work was undertaken with the Centre of Policy Studies. Instead of 17 southern Basin regions, the model had just seven. The agricultural sector included 15 irrigated agricultural industries. There were a similar number of inputs compared with TERM-H2O. However, the production functions which describe the relationships between inputs and outputs were substantially different.

Peterson et al. (2004) did not model the water buyback. Instead, the scenarios represent 'across-the-board' reductions in the availability of irrigation water of 10, 20 and 30 per cent. The reason for the reduction in water availability is not specified and there is no compensation. To place these reductions in perspective, the Dixon et al. (2009) simulations discussed above, assume a 33 per cent reduction in water availability from 2005-06 levels (which is equivalent to 1500 GL). The scenarios reported below assume costless water trade between regions and activities in the southern Basin. The model uses long run closure assumptions (allowing capital to move between industries and regions).

The reductions in water availability are estimated to reduce gross regional product in the southern Basin by 0.5 per cent in the 10 per cent scenario, and 2 per cent in the 30 per cent scenario. The results show that the negative impact of reductions in water availability on gross regional product in the southern Basin are likely to be nonlinear (and increasing at an increasing rate). Peterson et al. (2004) decomposed the results, demonstrating that around 70 per cent of the estimated reduction in gross regional product came from the primary industry sector. There was also a reduction in gross regional product contributed by the services sector. The reductions in gross regional product under the 30 per cent scenario are largest in the NSW Murray (4.4 per cent) and Murrumbidgee (3.2 per cent) regions (table D.1).

Table D.1 **Gross Regional Product effects of a 30 per cent reduction in water availability**

Relative to the baseline

Region	*Estimated impact*
	%
Murrumbidgee	-3.2
NSW Murray	-4.4
Mallee	-1.8
Goulburn	-1.7
Loddon Campaspe	-0.6
Ovens Murray	-0.2
Murray Lands South Australia	-1.3

Source: Peterson et al. (2004).

The industry level breakdown is only reported for the 10 per cent scenario. Rice output falls most, by 20 per cent. Dairy output declines by four per cent, while the output of irrigated horticultural industries generally declines by less than one per cent (table D.2). Given these estimates are for a 10 per cent reduction in irrigation water availability — compared with a 33 per cent reduction in the more recent Dixon et al. (2009) simulations — it seems reasonable to conclude that the agricultural impacts in this version of the TERM model are many times larger, for the same reduction in irrigation water availability.

Table D.2 **Change in industry output associated with a 10 per cent reduction in water availability**

Relative to the baseline

Industry	*Estimated impact*
	%
Sheep	-1.5
Other broadacre	-2.4
Beef cattle	-2.1
Dairy cattle	-3.8
Rice	-20.3
Citrus	-0.5
Apples and pears	-0.4
Stone fruits	-0.4
Other fruits and nuts	-0.5
Premium irrigated grapes	-0.6
Irrigated pasture	-3.2
Vegetables	-1.0

Source: Peterson et al. (2004).

This modelling shares many of the same assumptions as Dixon et al. (2009), but the irrigation module is substantially different. In particular, Peterson et al. (2004) assumes that irrigation industries have very little capacity to profitably substitute towards other inputs as water becomes more expensive. Sensitivity analysis shows that the more limited the substitution possibilities, the larger the agricultural, and hence regional, impacts. This could explain many of the differences in the results. The other substantive difference is that in this modelling, water is withdrawn without compensation, unlike Dixon et al. (2009) where water is implicitly sold to the government on a voluntary basis. Ignoring the benefits from buyback payments is likely to cause bias in the application of this modelling to a water buyback scenario.

D.3 Qureshi et al. (CSIRO)

The CSIRO has also modelled the impacts of reallocating water to the environment. Qureshi et al. (2007) estimated the impact on agriculture in the southern Basin of a reduction in water availability. Unlike the other models, Qureshi et al. (2007) does not estimate the impacts on regional communities. However, understanding whether the agricultural impacts are substantial is a first step towards understanding the regional impacts. It also enables a comparison of the agricultural results generated by a 'purpose-built' agricultural model, with the agricultural results reported from the computable general equilibrium models above.

The model used in Qureshi et al. (2007) covers 13 regions in the southern Basin. There are 12 agricultural activities. The model allows substitution between water and other inputs. These other inputs, 'land' and 'other costs', must be used in fixed proportions. The model is a short-run model. The area of land used for 'permanent plantings' like horticulture is assumed to be fixed. The model includes five different states of nature, representing different annual climatic conditions. The area of land used for 'annual cropping' activities is allowed to expand and contract, within limits, depending on seasonal conditions.

The main scenarios investigate a 500 GL reduction in expected water availability in the southern Basin (notionally due to a water buyback). The reduction varies across states of nature, with more water being reallocated to the environment in wet years. The model was run with and without water trade between regions. Two buyback scenarios were run for each trade scenario. The first scenario represents an 'across-the-board' reduction in water availability from all regions. The second scenario reduces water availability more in 'lower-value' regions, referred to by the authors as a 'targeted buyback'.

In the simulations without trade between regions, the buyback is estimated to reduce irrigated agricultural income in the southern Basin by 1.4 per cent under the 'targeted buyback' scenario, and 2.4 per cent under the 'across-the-board buyback' scenario. The difference arises because the marginal value of water varies substantially across regions in the baseline (no buyback) scenario. For example, the value of an additional ML of water was estimated to be $6 per ML in the Goulburn region (the least expensive region) and $156 per ML in the Mallee (the most expensive region). Given these differences, the cost of buying water can be reduced by acquiring more water from the Goulburn and less water from the Mallee than in the 'across the board buyback' scenario.

According to Qureshi et al. (2007, p. 301), their conclusion that 'spatially targeted water acquisition for environmental flows from low opportunity cost regions can substantially reduce costs of acquiring environmental flows' does not apply when trade is introduced. In the simulations with trade between regions, the differences in marginal values across connected regions are almost eliminated (the model limits the volume of water that can be traded, so some differences persist). The gains from buying water mainly in cheaper regions are therefore largely eliminated, and hence there are no appreciable benefits from running a 'targeted buyback'.

Qureshi et al. (2007) also models the impact of a 1000 GL buyback. This is estimated to reduce irrigated agricultural income in the southern Basin by 5.4 per cent under the 'targeted buyback' scenario and without trade between regions. Like Peterson et al. (2004), this shows the cost of reduced water availability increasing at an increasing rate.

As mentioned above, the scenarios assume that the volume of water allocated to the environment increases in wet seasons. Qureshi et al. (2007) also modelled the implications of allocating the same volume every year (equal to the long-term average under the variable scenario). This increased the agricultural cost of water acquisition, but not substantially. This could be because, in the model, water prices are relatively insensitive to weather conditions.[1]

There are reasons to doubt the model's ability to accurately estimate the impact of reduced water availability on irrigated agriculture. The model was calibrated so that the baseline scenario roughly corresponds to 2001 land and water use. Since there was considerable trade in water allocations in that year, it is unlikely that substantial differences in the marginal value of water could have persisted across connected regions. By contrast, the calibrated baseline simulation shows substantial variability in expected marginal values across regions (table D.3), raising questions about the implied regional water demand functions in the model. As these implied regional water demand functions more or less determine the cost of reduced water availability, this brings into question the robustness of the estimates. It should also be noted that some of the differences in shadow prices could be because the model uses a number of different states of nature.

A related concern is that minimum area constraints in the model were used to prevent unprofitable annual activities from disappearing. A consequence of this assumption is that, beyond a point, increasing water prices will not influence the area of land used for some irrigated activities.

1 Average water prices in the baseline scenario range from $21 per ML in the wettest years to $42 per ML in the driest years.

D.4 RMCG

RMCG was commissioned to analyse the economic impacts of reduced water availability associated with the Restoring the Balance water buyback in the Wakool Shire (southern New South Wales). The Wakool Shire has an agricultural–based economy, with around 40 per cent of the workforce being employed in agriculture (RMCG 2009).

Table D.3 **Expected marginal values of water in different regions**
Baseline simulation

Region	*Marginal value*
	$/ML
Upper Murray	10
Kiewa	14
Ovens	20
Broken	9
Goulburn	6
Campaspe	12
Loddon	12
Avoca	22
Murray River	33
Murrumbidgee	12
Mallee	156
Wimmera	120
Lower Murray	117

Source: Qureshi et al. (2007).

There is no modelling in RMCG (2009). Instead it assumes that that each additional ML contributes $300 in additional agricultural output. The reasoning behind this assumption is not explained. To estimate the regional economic impacts, RMCG (2009) assume that every dollar of reduced agricultural output results in three dollars less regional output. Given these assumptions, every 1000 ML reduction in water through the buyback is estimated to result in a $900 000 contraction in the size of the regional economy.

In estimating the agricultural impacts, one limitation of the analysis is the assumption that every one per cent reduction in water availability reduces agricultural output by one per cent. In practice, agricultural output is likely to fall by less than one per cent. Another key assumption is that every dollar of reduced agricultural output results in three dollars less regional output. To have confidence in the results, the ‘regional multiplier’ would need to be based on robust empirical analysis.[2] While there is nothing inherently wrong with using multipliers to examine distributional issues, large multipliers, such as those derived from input-output models, often do not capture the potential for displaced labour and other resources to move into alternative productive uses. For example, when a factory closes, some workers will find employment elsewhere. This reduces the impact on regional output, and should be taken into account. Finally, RMCG (2009) does not seem to account for buyback payments, which should moderate the impacts of changes in the agricultural sector on the regional community.

D.5 Judith Stubbs and Associates

A similar approach was used by Judith Stubbs and Associates to estimate the employment impacts of the buyback. The study used ABS data to estimate the number of people employed per GL for a number of agricultural industries in the Basin. The vegetable and grape industries had the highest labour to water ratio, employing around 20 people per GL. By contrast, the rice and cotton industries employed around one person per GL on average.

Based on linear regression analysis, Judith Stubbs and Associates estimate that for each agricultural job, there are another 0.9 jobs within the local community. There are no details on the regression equations that were estimated, so the Commission is unable to assess whether this number is reliable or how it should be interpreted.

Judith Stubbs and Associates then estimated the employment impacts of a 790 GL reduction in the volume of agricultural water, assuming the labour to water ratio remains unchanged. At the Basin level, the estimated employment losses range from 1 800 to 26 500, depending on the type of agriculture affected. Another limitation of this analysis is the assumption that no displaced workers will find work elsewhere. This is likely to bias the results in the direction of higher employment losses, especially when viewed from a long-run or national perspective (Judith Stubbs and Associates, sub. 66).

2 RMCG (2009) includes a footnote explaining that the Riverina Regional Development Board uses a multiplier of three. However, the Board does not justify the decision. Having reported a direct impact of $2 million per year, the Board asserts that ‘the [Leeton] Shire considers that the application of a multiplier of three will result in an annual economic loss of $6 million from the Leeton and Yanco community’ (RRDB 2004, p. 3). There is no further discussion of the multiplier.

D.6 Discussion

Overall, the models suggest that the impacts of the buyback on gross regional product and real consumption in the southern Basin are unlikely to be large (table D.4). Dixon et al. (2009) estimates a small increase in real consumption at the Basin level in the southern Basin. By contrast, estimates based on RMCG (2009) analysis suggest a three per cent reduction in gross regional product as a result of the buyback. The quite small impacts reported are consistent with the relatively modest contribution irrigated agriculture and related activities make to the southern Basin economy (expressed as a share of gross regional product).

Table D.4 **Impact of 30 per cent reduction in the availability of irrigation water in the southern Basin**

Relative to the baseline

Source	*Estimated impact*	*Buyback payments*
Dixon et al. (2009)[a]	Small increase in real consumption (less than 0.6 per cent in 2017)	Yes (assumed to stay in the region)
Peterson et al. (2004)	2 per cent reduction in gross regional product	No
Extrapolation based on Qureshi et al. (2007)[b]	12 per cent reduction in irrigated agricultural income	No
Extrapolation based on RMCG (2009)[c]	3 per cent reduction in gross regional product	No
Extrapolation based on Judith Stubbs and Associates (2010) [d]	Reduction in Basin employment of between 3 400 and 50 000	No

[a] Dixon et al. (2009) estimated the impact of a 33 per cent reduction in water availability. Furthermore, there were no estimates of the impact for the entire southern Basin. Since the largest regional impact was a 0.6 per cent increase in real consumption, the aggregate impact will be less than this. [b] The estimate is based on the 'targeted buyback' scenario without water trade between regions. Qureshi et al. (2009) estimates the impacts of 500 and 1000 GL reductions in water availability on irrigated agricultural income in the southern Basin. Using a quadratic function, the Productivity Commission ran a simple regression to estimate the impact of a 1500 GL reduction in water availability. [c] RMCG (2009) estimates the impacts of reduced water availability in the Wakool Shire (southern NSW). In an attempt to make the results comparable with other modelling, the Commission has extrapolated results to the remainder of the southern Basin. RMCG (2009) uses regional multiplier analysis to estimate that every GL of reduced water availability will reduce gross regional product in the Wakool region by $900 000. If other regions experienced similar impacts on average, the estimated impact of a 1500 GL reduction in water availability on gross regional product in the southern Basin would be $1.35 billion per year. The database used for Peterson et al. (2004) values gross regional product in the southern Basin at $23.3 billion and (national) gross domestic product at $528 billion. These are outdated numbers, and gross regional product in the southern Basin is now probably substantially higher. ABS (2008b) estimates that gross domestic product was around $1133 billion in 2007-08. Under the assumption that the relative size of the southern Basin economy has remained unchanged since then, scaling the initial southern Basin gross regional product estimate by (1133/528) generates a value of $50 billion. Hence, the estimated gross regional product impact is (1.35/50) or 2.7 per cent, which is rounded to the nearest integer. [d] The Commission has assumed a linear relationship between the volume of water acquired and impact on employment.

The models are substantially different conceptually and in application, and these differences are reflected in the results. At a broad level, the divergent results can be attributed to three key areas:

- The sensitivity of agricultural output to reduced water availability — for example, Dixon et al. (2009) estimates that a 33 per cent reduction in water availability will reduce irrigated agricultural output in the southern Basin by 7 per cent, while RMCG (2009) assumes an equi-proportional (or 33 per cent) reduction in irrigated agricultural output. In this regard, the estimates by Dixon et al. (2009) are more plausible in the sense that a less than proportional reduction in output would be expected. In general, larger agricultural impacts will tend to result in larger regional impacts.
- Whether buyback payments are modelled — only Dixon et al. (2009) explicitly models a buyback scenario, where irrigators are compensated for selling water. The other models estimate the impacts of reductions in water availability without compensation. Buyback payments will tend to benefit regional communities, so not taking them into account results in the benefits of the buyback for those communities being underestimated.
- The transmission of agricultural impacts to the regional economy — for example, RMCG (2009) assumes that regional output falls by three dollars for every dollar reduction in agricultural output. This is substantially higher than Peterson et al. (2004), who estimated a $1.40 reduction in regional output for every dollar reduction in agricultural output (on average, under a 10 per cent reduction in water availability). Thus, the same reduction in agricultural output would generate more than two times the regional impact under the RMCG approach, compared with Peterson et al. (2004). The lack of empirical or theoretical basis for the RMCG (2009) multiplier assumptions means that the end results should be treated with some caution.

While the impacts of the buyback should be moderate at the southern Basin level, some towns and regional centres could experience large reductions in gross product. As mentioned above, the Basin-level impacts are moderated by the small share of irrigated agriculture in the Basin economy. By contrast, some towns are heavily reliant on irrigated agriculture (for example, Coleambally), and moreover, could experience substantially larger reductions in water availability than the southern Basin average. The impacts of the buyback could be substantial in these communities.

The impacts of the buyback in the northern Basin have not been modelled. However, the overall impacts are unlikely to be substantially different from those in the southern Basin. The percentage of workers employed in agriculture is a key determinant of the impact of a contraction in agricultural activity on the regional economy. In 2006, this was around 6 per cent in the Victorian MDB and 8 per cent in South Australian MDB. This is similar to the Queensland MDB, where around 7 per cent of the labour force was employed in agriculture (ABS 2008b).