Australian Government
Productivity Commission

Modelling Water Trade in the Southern Murray-Darling Basin

Staff Working Paper

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November 2004

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Citation, with permission from the author(s), should read:

Peterson, D., Dwyer, G., Appels, D. and Fry, J. 2004, *Modelling water trade in the southern Murray-Darling Basin*, Productivity Commission Staff Working Paper, Melbourne, November.

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Contents

Contents		**III**
Preface		**VII**
Acknowledgements		**VIII**
Abbreviations and explanations		**IX**
Key points		**X**
1	**Introduction**	**1**
2	**Water trade and irrigation in the southern Murray-Darling Basin**	**3**
	Irrigation water sources and irrigation districts	3
	Water entitlements and seasonal allocations	5
	Utility charges	6
	Quantities of water traded	8
	Water trade prices	9
	Constraints on water trading	11
3	**Overview of the modelling approach**	**19**
	Development of a water module within TERM	20
	Incorporating water trade	23
	Model simulation	27
4	**Long run effects of reduced water availability with trade**	**29**
	Macroeconomic effects of water trade	29
	Further analysis of a specific case	30
	Model design considerations	39
5	**Short run effects of reduced water availability with trade**	**43**

A Irrigation industry data **53**

B Simulations **57**

Experimental framework 57

Simulation details 59

C Examples of regulatory arrangements affecting water trade **65**

Regulatory arrangements in selected districts 65

Water trading across subdistricts in the Goulburn-Murray 67

D Data tables and simulation results **69**

References **83**

BOXES

2.1 Trading water upstream 12

2.2 Trading water between rivers 13

3.1 Regional CGE modelling of water trade and use 19

3.2 TERM's water module 22

3.3 The price of water entitlements and seasonal allocations 24

3.4 Water substitution assumptions 25

3.5 Illustrative gains from trade in water 26

3.6 Trade experiments conducted using TERM 28

FIGURES

2.1 Major Irrigation Districts in the Murray-Darling Basin 4

2.2 Average weekly prices per megalitre for seasonal allocations in major irrigation districts 10

2.3 Average monthly prices for trade in water entitlements, Goulburn-Murray Water and Murray Irrigation 11

3.1 Irrigation areas and statistical divisions 21

A.1 Major irrigation districts in Australia 53

TABLES

2.1	Seasonal water allocations and usage	7
2.2	Examples of utility charges, 2000–01	8
2.3	Net New South Wales trade in seasonal allocations	9
2.4	Net trade in water entitlements, by state	9
2.5	Congestion constraints on major supply networks	14
4.1	GDP and GRP effects of trade after water availability reductions of different magnitudes	30
4.2	GDP and GRP effects under different trade and water availability experiments	31
4.3	Net water trades among industries in the southern MDB	33
4.4	GRP and GDP effects under different trade experiments	34
4.5	Changes in regional primary factor use	35
4.6	Sectoral differences in value added from expanded water trade	37
5.1	Reductions in water availability compared to 1996-97	43
5.2	GRP and GDP effects of 1997–98 water availability under different trade experiments	45
5.3	GRP and GDP effects of 1998–99 water availability under different trade experiments	46
5.4	GRP and GDP effects of 1999–2000 water availability under different trade experiments	47
5.5	GRP and GDP effects of 2000–01 water availability under different trade experiments	48
5.6	GRP and GDP effects of 2001–02 water availability under different trade experiments	49
A.1	Net water consumption for selected industries, 1996–97	54
A.2	List of regions and their irrigation companies	54
A.3	Irrigation scheme entitlements in the southern Murray-Darling Basin, 2001–02	55
A.4	Ratios of gross trade in seasonal allocations to total allocations, and trade in entitlements to total allocations	55
A.5	Channel capacity constraints on the River Murray system	56

B.1 Simulations reported in this paper 59
B.2 Assumed values for SIGTOP 61
B.3 Changes in regional water availability 62
B.4 Regions modelled in TERM-Water 63
B.5 Industries and broad sectors modelled in TERM-Water 63
C.1 Examples of NSW government regulatory arrangements affecting water trading in the Murray and Lower Darling district 65
C.2 Examples of utility-specific arrangements affecting water trading in the Murrumbidgee Irrigation Area 66
C.3 Examples of Victorian Government regulatory arrangements affecting trades in the Goulburn and Victorian Murray districts 67
C.4 Goulburn Murray-Water exchange rate trade matrix for seasonal allocation and entitlement trades 68
D.1 Industry contributions to gross regional product 69
D.2 Industry contributions to regional water use in the southern Murray-Darling Basin 71
D.3 Price rises in southern Murray-Darling Basin regions 71
D.4 Change in industry output under different experiments 72
D.5 Decomposition of GRP impact by broad sector 75
D.6 GRP and GDP effects of a non-proportional reduction in water availability under different trade experiments 76
D.7 GRP and GDP effects of increased SIGTOP (rice industry) under different trade experiments 77
D.8 GRP and GDP effects of increased SIGTOP (all industries) under different trade experiments 78
D.9 GRP and GDP effects in the short run under different trade experiments 79
D.10 GRP and GDP effects of a 20 per cent reduction in water availability under different trade experiments 80
D.11 GRP and GDP effects of a 30 per cent reduction in water availability under different trade experiments 81

Preface

This staff working paper reports on the progress of recent modelling initiatives within the Productivity Commission that have a capability to consider water policy issues. This work is part of an ongoing research program at the Commission related to water reform.

Acknowledgements

In conducting this study, the Commission benefited from information from a number of Australian Government and state agencies, as well as irrigation authorities. The Commission is grateful for this assistance, and welcomes comments on this study which is part of a range of research to inform policy debate and development on water issues.

This study was overseen by Commissioner Neil Byron and conducted within the Environmental and Resource Economics Branch. Useful comments and suggestions were provided by Jonathan Pincus, Geoff Edwards and Patrick Jomini. The assistance of Robert Douglas, Andrew Dolling and Alex Maevsky is also gratefully acknowledged.

Abbreviations and explanations

Abbreviations

ABARE	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
CES	constant elasticity of substitution
CGE	computable general equilibrium
COAG	Council of Australian Governments
GDP	gross domestic product
GRP	gross regional product
GL	gigalitre
GMW	Goulburn-Murray Water
MDB	Murray-Darling Basin
MDBC	Murray-Darling Basin Commission
MI	Murray Irrigation
MIA	Murrumbidgee Irrigation Area
ML	megalitre
MMRF	Monash Multi-Regional Forecasting model
VMP	value of the marginal product of water

Explanations

Megalitre	A million (10^6) litres.
Gigalitre	A thousand megalitres.

Key points

- Markets for trading irrigation water enable water to be re-allocated to more productive uses — with gains to buyers and sellers. Water trade can also lessen the impact of reductions in irrigation water availability.
  - If markets for seasonal water allocations continue to develop, further productivity gains may be made even if trades in water entitlements remain constrained.
- A general equilibrium model provides preliminary analysis of the long run regional and industry impacts of reductions of 10, 20 and 30 per cent in water availability in the base year in the southern Murray-Darling Basin (MDB), under conditions of no trade, intra-regional trade only, and both intra- and interregional trade.
- The model estimates that moving from no trade to intra- and interregional trade together more than halves the impact of the reductions in water on the gross regional product (GRP) of the southern MDB.
  - Moving from no trade to intra-regional trade lessens the impact by 35 to 42 per cent. Including interregional trade reduces it another 22 to 24 per cent.
- For a 10 per cent reduction, the model estimates:
  - without water trade, GRP declines by around 1 per cent ($356 million in 2003)
  - with intra-regional trade only, GRP declines by around 0.7 per cent
  - with intra- and interregional trade, GRP declines by around 0.5 per cent
  - with interregional trade, the Murrumbidgee and Murray regions in New South Wales become net exporters of water, while the northern Victorian regions and the Murray Lands region in South Australia become net importers.
- A 20 per cent reduction in water availability has more than double the effect on GRP of a 10 per cent cut, while a 30 per cent cut has an almost fourfold effect. The relative effects of expanding trade in all cases is similar.
- The ten per cent reduction in irrigation water leads to an output decline in most industries. However, in most industries, declines in output are lower when intra- and interregional trades are allowed. In the southern MDB:
  - dairy industry output falls by 8 per cent under intra-regional trade, and by 4 per cent under intra- and interregional trade
  - perennial horticulture industry output decreases by 1.4 per cent under intra-regional trade, and by 0.7 per cent under intra- and interregional trade
  - rice industry output falls by 15 per cent under intra-regional trade and by 20 per cent under intra- and interregional trade
  - for each industry, there can be significant differences in effects across regions.
- In years with low water availability, water reductions would have a larger effect on GRP than if the cut had occurred in years with higher water availability.
- Short run analysis of the expansion of trade under variable seasonal allocations shows similar effects.
- This analysis does not take into account the impact of changes in water trade on environmental conditions such as salinity.

1 Introduction

On 25 June 2004, the Council of Australian Governments' (COAG) agreed to a National Water Initiative covering a range of areas in national water management. This initiative seeks, among other things, to expand water trade to bring about 'more profitable use of water and more cost effective and flexible recovery of water to achieve environmental outcomes' (COAG 2004). This paper examines the likely economic impacts of expanding water trade in the southern Murray-Darling Basin.

Water trade in Australia involves trade in both water entitlements and seasonal water allocations:

- Trade in water entitlements (sometimes referred to as 'permanent trade') involves transferring the ongoing right to access water for the term of the right.
- Trade in seasonal water allocations (sometimes called 'temporary trade') involves transferring some or all of the water allocated to the entitlement for the current irrigation season or an agreed number of seasons.

In the three major irrigation districts of the southern Murray-Darling Basin (the Murray Irrigation district, the Murrumbidgee Irrigation Area, and the Goulburn-Murray Water district), gross trade in entitlements accounted for less than 2 per cent of total water allocations in 2002–03, while gross trade in seasonal allocations accounted for around 20 per cent (appendix A, table A.4).

In addition to seasonal conditions and allocations, a variety of factors affect trade within and between irrigation districts. Some are physical capacity constraints — for example, limitations on the volume of water able to pass through the 'Barmah Choke'. Others are regulatory in nature — for example, Victoria's regulation that entitlements to, and allocations of, irrigation water can be transferred only between those who own land that can be irrigated. Also in Victoria, water authorities may refuse trades that would result in more than 2 per cent of the total water entitlement being transferred from an irrigation district per year. Administrative restrictions on interregional trade are also imposed by private irrigation authorities — for example, in New South Wales there are constraints on net trade out of districts.

With trade, water can shift to uses where it yields higher marginal returns (net of transfer costs). Revenue from water sales can supplement farm income and provide finance for other on-farm or off-farm activities, or facilitate exit from an industry. Water trade can also lessen the impact of reductions in irrigation water availability.

Of interest are the magnitude and distribution of the effects of expanding water trade at the national and state levels, as well as the impact on industries and regions as irrigation activities adjust. Using a general equilibrium model of the Australian economy, the long run effects of trade given 10 per cent, 20 per cent and 30 per cent reductions in the amount of water available to irrigators in the southern Murray-Darling Basin and short run reductions based on observed allocations for 1997-98 to 2001-02 are examined to gain insights into these questions. This study compares the effect of these reductions in water in three experiments: first, assuming no trade in water; second, assuming only intra-regional trades; and, third, assuming both intra- and interregional trades. The model is concerned only with costs reflected in market prices for goods and services, and therefore does not account for 'externalities'.

The next chapter provides an overview of irrigated agriculture, water markets and constraints to water trade in the southern Murray-Darling Basin. Chapter 3 presents the model and data used in the analysis, and outlines the simulations and sensitivity analysis. Chapter 4 presents and discusses results of long run simulations and identifies the key assumptions and limitations of the analysis. Chapter 5 discusses the results of short run simulations.

2 Water trade and irrigation in the southern Murray-Darling Basin

Irrigation water represents around 70 per cent of all water used in Australia (ABS data, appendix A, table A.1). The 'livestock, pasture, grains and other agriculture' industries, which include dairy farms, account for around 57 per cent of irrigation water use (table A.1). Horticulture, which includes vegetable growing, fruit growing and grape vine growing, accounts for around 13 per cent, while cotton and rice account for 12 per cent and 11 per cent respectively. In the southern Murray-Darling Basin (MDB), the rice, dairy and horticultural industries are the largest users of irrigation water, accounting for 32 per cent, 21 per cent and 16 per cent respectively (TERM database, appendix D, table D.2).

Irrigation water is used to supplement rainfall on farms. In most cases, rainfall in the regions in which irrigation districts are located is insufficient on its own to sustain current farming practices. In an average season, a rice crop in southern New South Wales, for example, needs 13 megalitres of irrigation water per hectare (the equivalent of 1300 millimetres of rainfall) in addition to average rainfall during the growing season (NSW Agriculture 2003). By comparison, the average annual rainfall in this region is about 400–450 millimetres per year.

Irrigation water sources and irrigation districts

Irrigators can source irrigation water from:

- on-farm storage and diversion of surface water flows across farms
- on-farm pumping and diversion of groundwater
- diversions of water from on-farm water courses
- major storage, diversion and delivery infrastructure managed by public and private utilities — sometimes referred to as supplemented irrigation schemes.

The last is the main form of irrigation water supply in Australia and the focus of this study.

Irrigation districts are concentrated in the eastern states of New South Wales, Victoria and Queensland and draw water from Great Dividing Range catchments (appendix A, figure A.1). Over 70 per cent of irrigation use occurs within the MDB, with most supplemented irrigation located within the southern MDB (figure 2.1).

Figure 2.1 **Major Irrigation Districts in the Murray-Darling Basin**

Data source: Murray-Darling Basin Commission.

Most irrigated farms in the southern MDB are grouped within discrete irrigation districts located adjacent to the Murrumbidgee, Murray, Goulburn and other rivers. Diversions of water from rivers supplying these districts represent around 70 per cent of all diversions in the MDB (MDBC 2003a, p. 7).

Major irrigation districts include the Murray Irrigation (MI), Murrumbidgee Irrigation Area (MIA) and Coleambally Irrigation districts in southern New South Wales, and the Goulburn-Murray Water (GMW) district in northern Victoria. These districts account for around 90 per cent of water entitlements in the southern MDB (appendix A, table A.3). Several smaller irrigation districts located along the River Murray between Swan Hill in Victoria and Murray Bridge in South Australia encompass the 'Sunraysia' and 'Riverland' districts.

Water entitlements and seasonal allocations

In the southern MDB, irrigators hold entitlements that define access rights to a specific quantity of water each irrigation season. The supply reliability of these entitlements varies between jurisdictions and depends upon storage capacity and the volume of entitlements distributed — for example:

- In Victoria and South Australia, entitlements are specified in perpetuity and are likely to be fully met around 96 and 99 years in 100 respectively (MDBC 2003b).
- In New South Wales, entitlements are for 15 years, being either high security (with similar reliability to the Victorian and South Australian entitlements) or general security (likely to be met around 75 years in 100 and only after high security entitlements have been met) (MDBC 2003b). The New South Wales government recently announced such entitlements will be made perpetual (Knowles 2004). Around 90 per cent of New South Wales entitlements (in the southern MDB) are general security.

Within an irrigation season, each entitlement holder can (for a charge — see below) access a percentage of their entitlement — this is called a 'seasonal allocation'. Irrigation utilities determine this percentage according to the availability of water supplies from storages. Entitlement holders can call on allocations (in full or part) for delivery at any stage during an irrigation season. In each year, the total volume of water made available by utilities is shared among water entitlement holders according to their priority and entitlement to the resource. In Victoria, if a seasonal allocation is not used, it cannot be carried over and used in the following season. In contrast, in New South Wales, irrigators can carry over part of the unused seasonal allocations to use in the following season.

In some years, in some jurisdictions, utilities offer seasonal allocations to irrigators in excess of, but proportional to, their entitlement. This practice is most common in Victoria where these extra allocations are known as 'sales water'. (In New South Wales the term is 'supplementary water' — previously 'off allocation water'). Victoria has utility rules that constrain the trade in sales water (see below).

Reflecting seasonal conditions and the distribution of general security allocations in New South Wales, seasonal allocations as a percentage of entitlement between 1996–97 and 2002–03 were generally lower in the MI district than in the MIA (table 2.1). In contrast, this percentage was highest on average in the GMW district.

Utility charges

Utilities charge irrigators for services to meet entitlements and deliver water to farms. These charges are designed primarily to recover the operational, maintenance and some capital costs associated with supply activities, including harvesting, storage, diversions and delivery. In most districts, utilities charge irrigators a two-part tariff comprising a fixed and variable component.

- The fixed component is based on the irrigator's water entitlement volume. Some water utilities announce this charge at the beginning of the irrigation season based on anticipated costs and deliveries (for example, the GMW district), while others calculate it at the end of the season based on actual costs and deliveries (for example, the MI district).
- The variable component is based on the volume of water either allocated or delivered during the irrigation season.

Examples of utility charges in the southern MDB are provided in table 2.2. The charges are significantly higher in districts in which delivery requires pumping (such as Sunraysia) than those with gravity feeding.

Table 2.1 provides details of irrigation water allocated for the major New South Wales and Victorian irrigation districts from 1996–97 to 2002–03. Data for the GMW district and the MIA are based on volumes allocated — actual consumption varies from these volumes because of trade between districts, and the seasonal carryover of water in the MIA. In contrast, data for the MI district are based on usage (including trade and carryover). The 2002–03 data for the MI district illustrate the importance of trade and carryover in altering water use patterns. In that year, seasonal allocations were just 8 per cent of entitlement, but water usage was over 30 per cent of average use.

Table 2.1 **Seasonal water allocations and usage**[a]

	MIA		GMW district[b]		MI district[c]
	High security	*General security*	*Goulburn Basin*	*Murray*	
	Volume of allocations (GL)				**Volume of usage (GL)**
1996–97	242	987	1 543	1 020	1 472
1997–98	249	878	1 225	839	1 046
1998–99	251	825	1 041	945	1 168
1999–2000	283[d]	725	949	740	675
2000–01	269	837	1 071	923	1 295
2001–02	269	669	1 109	1 024	1 240
2002–03	269	353	659	844	340
Average	**262**	**753**	**1 085**	**905**	**1 034**
	Percentage of entitlements allocated (%)				
1996–97	100	100	100+100 sales	100+100 sales	93
1997–98	100	90	100+20 sales	100+30 sales	68
1998–99	100	85	100+0 sales	100+100 sales	77
1999–2000	100	78	100+0 sales	100+30 sales	29
2000–01	95	90	100+0 sales	100+100 sales	78
2001–02	95	72	100+0 sales	100+100 sales	86
2002–03	95	38	57+0 sales	100+29 sales	8
Average	**98**	**79**	**100+11 sales**	**100+70 sales**	**63**

a The total water entitlement for each district may change from year to year as a result of permanent trade between districts. **b** Allocations do not include diversions. **c** Aggregate of high and general security, because high security entitlements and allocations are small. **d** Increase reflects conversion of general security entitlements to high security entitlements.

Sources: Goulburn-Murray Water, pers. comm., 1 April 2004; MIA, pers. comm., 7 and 27 April 2004; Murray Irrigation Limited (2003).

When an entitlement holder decides to trade some or all of their seasonal water allocation, the buyer is responsible for the variable charge for the delivery of the water to the buyer's farm, while the seller is responsible for meeting any fixed charges associated with the seasonal allocation. In the case of water entitlement trades, the buyer of water becomes the new entitlement holder and is thus responsible for all fixed and variable charges. This arrangement has raised concerns about 'stranded assets' — that is, if water is permanently traded out of an irrigation district, utility costs are spread across smaller water volumes and fewer irrigators (resulting in higher charges for remaining irrigators). For further discussion of the stranded asset issue, see Goesch (2001) and Gordon, Kemp and Mues (2000).

Table 2.2 **Examples of utility charges, 2000–01[a]**

Utility	*Fixed*	*Variable*
	$/ML of entitlement	$/ML delivered
Murray Irrigation Limited[b,c]	5.65	8.18
Goulburn-Murray Water (Greater Goulburn subdistrict)	21.48	8.30
Sunraysia Rural Water Authority (Robinvale subdistrict)	52.45	47.15
Central Irrigation Trust (Medium pressure)	14.32	40.10

a Excludes drainage and miscellaneous charges and non-volume related charges. **b** For flood irrigation districts only, excluding drainage and Land and Water Management Plan charges. **c** Excludes the utility operational cost recovered from shareholders at the end of the irrigation season.

Sources: Goulburn-Murray Water, pers. comm., 1 April 2004; MI, pers. comm., 16 April 2004; Sunraysia Rural Water Authority, pers. comm., 31 March 2004; Central Irrigation Trust, pers. comm., 1 April 2004.

Quantities of water traded

Currently, irrigators trade primarily with other irrigators in their irrigation district, and trade is predominantly in seasonal water allocations. Markets for trade in seasonal allocations are well established within major irrigation districts, such as the MIA and the MI and GMW districts, with electronic exchanges and brokers facilitating trade. In 2000–01 to 2002–03, aggregate trade in seasonal allocations represented, on average across the three districts, 11–20 per cent of allocations (appendix A, table A.4) — trade volumes vary considerably from year to year and across districts depending on seasonal conditions and allocations. In contrast, trade in entitlements usually represents a much smaller share of annual total allocations — on average, 1–2 per cent across the three major districts between 2000–01 and 2002–03 (appendix A, table A.4).

Of interest in this study is the net trade (exports minus imports) of seasonal allocations and entitlements to and from irrigation districts. This is because the total water available for use within a district in a year represents the seasonal allocations (including carryovers) and the combined net trades in seasonal allocations and entitlements to the district within the year. The volume of entitlements at the start of the year includes all net trade in entitlements from previous years.

The volume of net trade in seasonal allocations is relatively small and can vary across irrigation districts from year to year (see, for example, table 2.3; appendix A, table A.4). In most years, South Australia is a net seller of seasonal allocations to New South Wales and Victoria (6100 megalitres exported in 2000–01). The direction of net trade between New South Wales and Victoria differs across years, but New South Wales is usually a net buyer of seasonal allocations from Victoria (reflecting the lower reliability of allocations in New South Wales).

Table 2.3 **Net New South Wales trade in seasonal allocations[a]**

	2000–01	2001–02	2002–03
	ML	ML	ML
Murray[b]	(20 842)	20 729	(35 726)
Murrumbidgee	26 597	(31 487)	14 152
Victoria	(2 792)	1 657	15 581
South Australia	(2 963)	9 101	5 993

[a] Figures in parentheses denote net imports. [b] Incorporates irrigators on the lower Darling River from the Menindee Lakes to Wentworth.

Data source: State Water South, pers. comm., 1 April 2004.

Net trade in entitlements is relatively minor and fluctuates from year to year (table 2.4). Irrigators in South Australia have consistently purchased water entitlements, while Victorian irrigators and, to a lesser extent, New South Wales irrigators have been sellers.

Table 2.4 **Net trade in water entitlements, by state[a]**

	1998–99	1999–00	2000–01	2001–02	2002–03	Total
	ML	ML	ML	ML	ML	ML
New South Wales	2 747	3 016	176	(222)	(274)	5 443
Victoria	351	2 214	3 099	2797	503	8 964
South Australia	(3 098)	(5 230)	(3 275)	(2575)	(229)	(14 407)

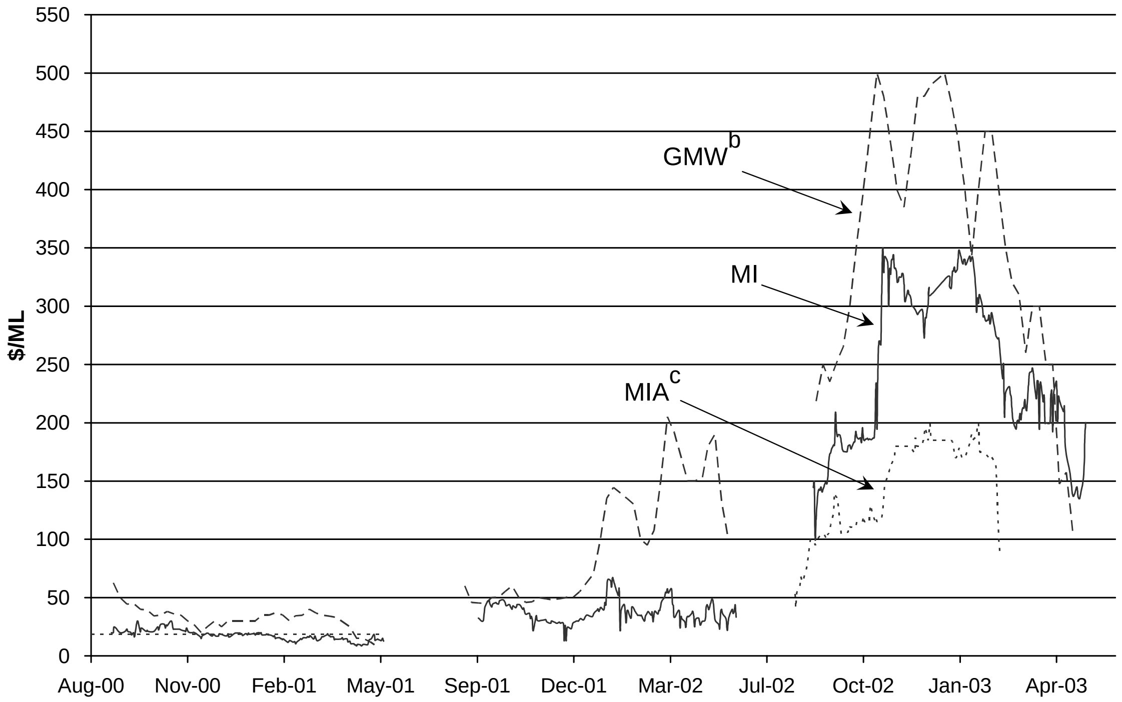
[a] Figures in parentheses denote imports.

Source: MDBC, pers. comm., 26 February 2004.

Water trade prices

Prices paid for traded seasonal water allocations display significant spatial and temporal variation, illustrating that the markets for water can differ from district to district, from year to year and, within a year, from week to week (figure 2.2). Between 2000–01 and 2002–03, for example, seasonal allocation prices were generally higher in the GMW district, followed by the MI district and then the MIA. In 2000–01, the average weighted price for traded seasonal allocations was $33 per megalitre, $16 per megalitre, and $18 per megalitre in the three districts respectively.

Figure 2.2 **Average weekly prices per megalitre for seasonal allocations in major irrigation districts[a]**



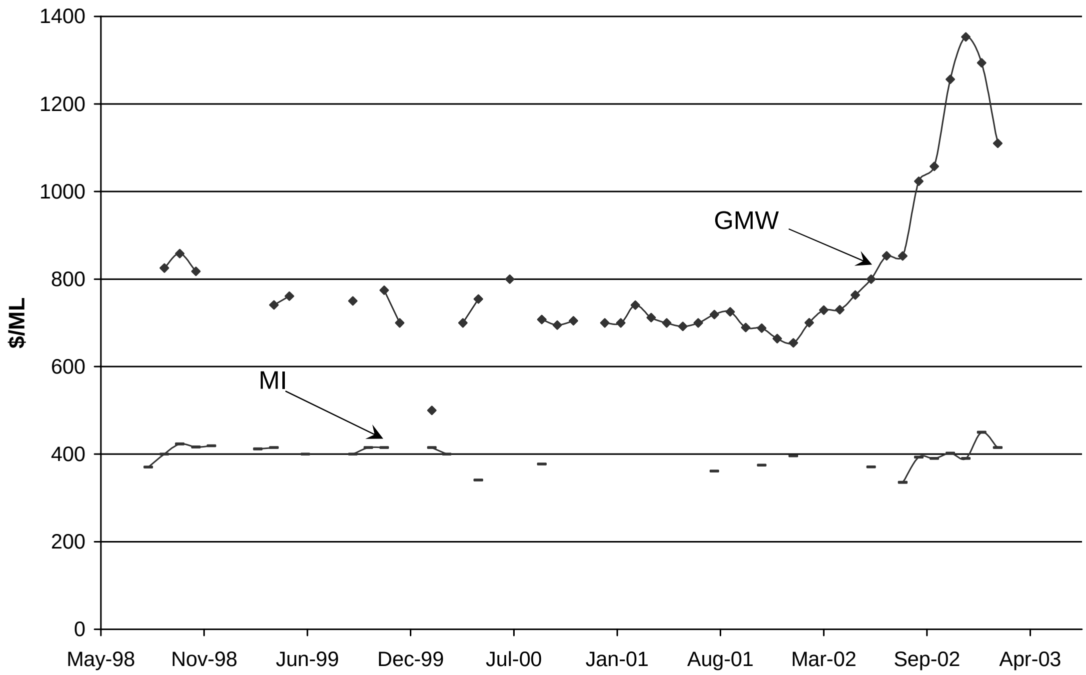
a Average weekly pooled price per megalitre; MIA price for 2000-01 is a yearly average. **b** GMW data for the Greater Goulburn subdistrict. **c** MIA data for 2001-02 were not available.

Data sources: Goulburn-Murray Water, pers. comm., 1 December 2003; MI, pers. comm., 22 December 2003; MIA, pers. comm., 2 February 2004.

Prices for traded seasonal allocations rose significantly during the recent drought and traded well above utility charges. In 2002–03, the average weighted price for seasonal allocations was $364 per megalitre in the GMW district, $210 per megalitre in the MI district and $114 per megalitre in the MIA. However, during flood periods or after harvests, for example, the opposite situation can arise, and utility charges may exceed the marginal value and traded price of water.

The price of water entitlements is significantly higher than the price for seasonal allocations because entitlements buy a stream of future allocations as well as the current allocation. Prices for water entitlements differ across irrigation districts, partly as a result of the differing rights attached to the entitlements. The price of water entitlements from the GMW district, for example, is substantially higher than that in the MI district, reflecting in part the lower reliability of general security water in New South Wales (figure 2.3).

Figure 2.3 **Average monthly prices for trade in water entitlements, Goulburn-Murray Water and Murray Irrigation**



Data sources: Goulburn-Murray Water, pers. comm., 1 April 2004; Murray Irrigation Limited (2004).

Constraints on water trading

Constraints to water trading in the southern MDB can reflect:

- hydrological and environmental considerations
- economic or 'market-based' factors
- administrative and regulatory arrangements.

In some cases, constraints are interconnected — for example, regulatory arrangements developed to reflect hydrological impediments. This chapter provides a brief background description of some of these constraints to trade, which are not separately represented within the model.

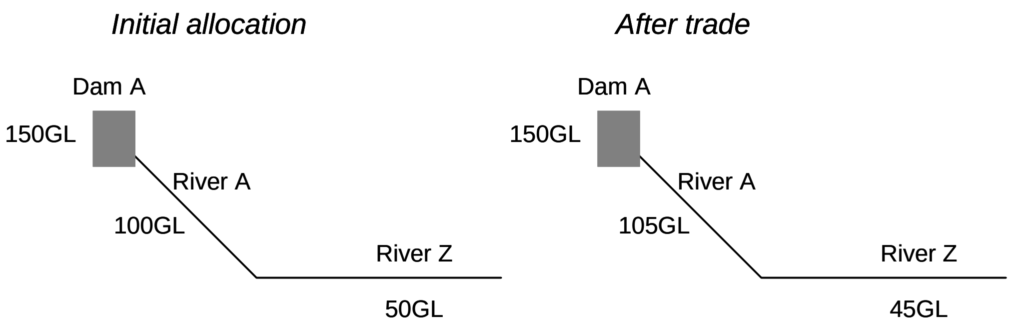
Hydrological and environmental constraints on trade

Without regulatory, institutional and economic constraints, hydrological factors (such as the paths and linkages of rivers) would limit where and when water can be used and traded. It is also often thought that gravity provides a binding constraint to trade. However, while gravity provides a significant impediment to the movement of water (given the costs of transporting water upstream), and most irrigation water in the MDB is delivered via gravity distribution systems, it may not always constrain trade since the three main rivers of the southern MDB are hydrologically linked (box 2.1).

The Murray and Murrumbidgee rivers share a common catchment in the Snowy Mountains. The Snowy Mountain Scheme's dam and channel infrastructure make it possible to divert water (at the margin) from one river to another. More importantly, because the Goulburn and Murrumbidgee rivers are tributaries of the Murray, it is possible to trade water between each river above their confluences (intersections) (box 2.2).

Box 2.1 **Trading water upstream**

Although water cannot run uphill (and the feasibility of pumping or 'trucking' water is limited), irrigation water can be traded upstream as well as downstream. This is because allocations and entitlements can be traded across the same basin before water is released from physical storage (see diagram below).

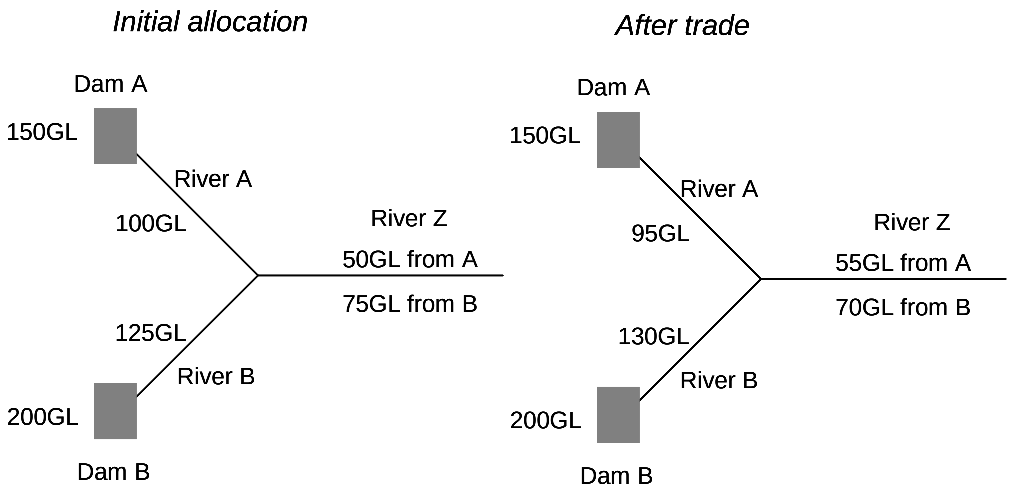


Assume River A flows into River Z, and that 150 gigalitres per year of irrigation water can be released from a dam on the head waters of River A. Assume also that there is an initial allocation of 100 gigalitres to irrigators on River A and 50 gigalitres to irrigators on River Z. Irrigators on River A could trade with other irrigators on River A, and with irrigators on River Z. In the diagram, it is assumed that there is a net trade of 5 gigalitres from River Z upstream to River A. This would mean that 105 gigalitres could be used by irrigators on River A, and 45 gigalitres by irrigators on River Z, but the total volume released from the dam on River A would remain at 150 gigalitres.

A further constraint on the volume of trade can be congestion in the distribution network, such that moving greater than a certain volume of water is either physically infeasible (given current technologies) or likely to create severe environmental problems (table 2.5). These constraints can vary in significance between and within seasons. Congestion may be a problem only during a relatively small number of peak demand days.

Box 2.2 **Trading water between rivers**

While it may not be feasible to move water between some rivers, trade in the use of water can occur where rivers are inter-connected, although an 'intermediary' may be needed. Continuing the example given in box 2.1, assume River B also flows into River Z, and that 200 gigalitres per year of irrigation water can be released from a dam on the head waters of the River B of which there is an initial allocation of 125 gigalitres to irrigators on River B and 75 gigalitres to irrigators on River Z (see diagram below).



Further, assume it is desired to trade a net 5 gigalitres from River A to River B. This could occur by first trading 5 gigalitres from River A downstream to River Z, then by trading the same volume upstream from River Z to River B. In effect, an extra 5 gigalitres would be used on River B in exchange for 5 gigalitres less being used on River A, such that the amount flowing in River Z remains unchanged. As a result, in that season, 95 gigalitres would be used on River A, 130 gigalitres on River B and 125 gigalitres on River Z (sourced 55 gigalitres from River A and 70 gigalitres from River Z).

It should be noted that the net trade between Rivers A and B does not have to balance. However, trades would be limited by:

- the maximum flow of the exporting river (River A) minus its contribution to the combined river (River Z)
- the contribution of the importing river (River B) to the combined river (River Z).

In this example, 75 gigalitres could be traded from River A to River B. However, because trade is likely to be at the margin, and successive trades may be in different directions, it is unlikely that these limits would be tested.

In practice, it may be hard for individual irrigators to negotiate such trades because of the difficulties in locating potential traders on other rivers, and any necessary 'intermediaries'. However, there are several methods by which the trading process could be facilitated. One method would be to allow arbitrageurs (whether irrigators or not) to trade in seasonal allocations, hence increasing the number of possible market participants. Another could be to create a 'clearing house' which listed offers to buy and sell seasonal allocations on all connected rivers in the southern MDB, and recorded net transactions between valleys.

Table 2.5 **Congestion constraints on major supply networks**[a]

Location	*Daily flow limit (ML)*
River Murray — between the Hume and Yarrawonga weirs	25 000
Barmah Choke — on the River Murray	8 500
Mitta Mitta River — between Dartmouth Dam and the Hume Weir	9 000
Tumut River — between Blowering Dam and the Murrumbidgee River	9 000

a A summary of all channel flow capacities is presented in appendix A, table A.5.

Source: MDBC, pers. comm., 7 April 2004.

In some cases, water utilities can avoid these constraints (to some extent) by delivering water from upstream to downstream storages before the irrigation season and by diverting water around congestion points through other distribution channels. If the existing non-physical constraints on water trade were relaxed, however, congestion constraints could become more prominent. If so, various mechanisms exist for expanding capacity or for prioritising use of limited capacity (PC 2003).

If trade results in changed downstream water flows, it may impose costs or benefits on downstream users such as altered salinity patterns (see, for example, Beare and Heaney 2002, and Bell and Heaney 2001). Irrigation districts and state governments may regulate trade to manage externality problems, although some districts are using other policy instruments that may be more effective and efficient (such as taxes or tradeable salinity credits).

Economic or 'market-based' constraints

Poorly defined rights of access to water are said to be a key impediment to trade (Hassall & Associates in association with Musgrave 2002). If so, uncertainty over future water allocations may deter irrigators from selling entitlements, and from entering into longer-term seasonal allocation contracts, so as to hedge against any future reductions in their entitlements.

Other important constraints to trade are a lack of reliable information and, in some cases, a poor understanding of trading markets. In many cases, irrigation and water authorities are not required to keep or share information that is useful to buyers and sellers, such as prices of recent trades. Different definitions of tradeable water — in terms of reliability and tenure — may discourage trade in entitlements. Further, lack of a clearing house may hinder trade in both entitlements and seasonal allocations. For example, although there is at least one electronic exchange for each water utility, these may not list inter-valley trading opportunities, nor are there links to other exchanges. However, brokers also facilitate trade within irrigation districts, and it is possible that they may facilitate trade between districts.

The trade in entitlements is characterised by a relatively small number of participants (Crase, O'Reilly and Dollery 2000). Such market 'thinness' could hinder competition in water trade and increase transaction costs. The spatial and temporal differences in water flows, and the heterogeneity of demands for it, can exacerbate this problem (Colby, Crandall and Bush 1993).

Administrative and regulatory arrangements affecting trade

Administrative and regulatory arrangements constrain trade within and between irrigation districts. The arrangements are set at both the state and district levels. Such arrangements appear to be imposed for a variety of reasons including perceived:

- hydrological limitations to water movement
- environmental impacts of changing the current patterns of the supply and use of water
- concerns over 'stranded assets'
- social and economic adjustment costs associated with water being exported from particular districts.

In some districts, some regulations are designed to manage broader policy goals. For example, Murrumbidgee Irrigation appear to use a variety of trade rules to manage MIA compliance with the MDB Cap.

In New South Wales and Victoria there is a combination of high level government regulation and localised regulation by water utilities. In South Australia, Trust boards formulate most rules affecting water trading, although government regulations apply in the few government irrigation districts awaiting privatisation.

All trades must be approved by the appropriate authority. Most trades are approved unless they contravene environmental objectives or reduce the water use and supply reliability to other irrigators. Trades in entitlements tend to be subject to more scrutiny than trades in seasonal allocations given that an entitlement trade is likely to be long term.

While most constraints apply to the nature and extent of trades, some determine which parties can undertake trades — such as the requirement for a purchaser to own land that can be irrigated (as in Victoria), or hold a water entitlement before engaging in seasonal trades.

Regulation of trade in seasonal allocations

In general, there are few regulatory arrangements constraining trade in seasonal allocations within an irrigation district. Some that do exist appear to be based on hydrological or environmental constraints.

Examples of intra-district regulatory arrangements include the:

- MIA's provision that selling a seasonal allocation removes access to any carryover water
- GMW district rule that irrigators are not allowed to trade more than 30 per cent of sales water and that those who do trade are unable to use the balance.

Generally, there appears to be more constraints to trade in seasonal allocations between irrigation districts than within districts. For example, the New South Wales Water Allocation Plan 2003–2004 for the Murray-Lower Darling Valleys specifies that:

> Due to the low water availability in both the Murray and Murrumbidgee River valleys at the start of the 2003–2004 seasons, there will be no temporary (annual) trades between these valleys. This restriction may be relaxed with a significant improvement in available water resources. (DIPNR 2003, p. 14)

This rule appears to be temporary in nature to reflect the prolonged unseasonal conditions currently experienced in New South Wales, and there are no equivalent rules for intra-district or interstate trade. In addition, the plan prohibits the sale of water from districts above the Barmah Choke to districts below the Barmah Choke if the sale requires that additional water to be delivered down stream of the Barmah Choke during periods of peak demand — a similar rule also applies for Victorian irrigators.

Regulation of trade in water entitlements

There appear to be few regulatory arrangements constraining trade in water entitlements within an irrigation district. Some of these appear to be based on hydrological or environmental factors. For example, similar rules relating to the seasonal allocation trade via the Barmah Choke also apply to the trade in entitlements.

Examples of constraints on inter-district trade are:

- In New South Wales, only high security entitlements can be traded interstate; also high security entitlements converted from general security cannot be traded interstate for five years from the date of the conversion.

- In Victoria, annual net exports of entitlements are limited to 'two percent of the total volume of water rights' for most irrigation districts (the same regulation prevents net trade from the Murray system to the Goulburn system and from the Goulburn system to the Campaspe system).
- In the MI district, trades in entitlements to Victoria and the Murrumbidgee valley are currently not permitted.

Again similar rules affecting water flows through the Barmah Choke apply in NSW and Victoria for inter district trade of entitlements. For example:

- Interstate trade in entitlements is only permitted in irrigation districts included in the Murray-Darling Basin Pilot Interstate Trading Scheme. The main areas excluded in the southern MDB are irrigation districts above the Barmah Choke (including the MI district and some sub districts of the GMW district).

Appendix C provides a more detailed listing of regulatory arrangements for the transfer of water allocations and entitlements for selected States and water utilities.

Summary and implications

Markets for trading water are enabling water to be reallocated to more productive uses. However, there are a number of constraints to trade. While some arrangements constraining trade appear to be hydrologically and/or environmentally based (such as curtailing downstream trade through the Barmah Choke), others may be designed to address broader issues.

In general, trade in seasonal allocations and entitlements within a district are less constrained by regulatory arrangements than trade between districts. Also, trade in seasonal allocations is less constrained than trade in entitlements. If markets for seasonal water allocations continue to develop, further productivity gains may be made even if trades in water entitlements remain constrained.

3 Overview of the modelling approach

TERM is a computable general equilibrium (CGE) model of the Australian economy that the Centre of Policy Studies at Monash University developed (box 3.1). The economy is classified into 144 industry sectors and 57 regions. Each region is modelled as a separate economy with links to the other regions to account for product and factor mobility between regions. TERM draws on national input-output data and disaggregated regional data.

Box 3.1 **Regional CGE modelling of water trade and use**

Multi-region, multi-sector CGE models of Australia can demonstrate the widespread flow-on and feedback effects that are likely to occur throughout the economy as a result of changes in water trading arrangements and water use. Such changes are likely to vary across regions and can have national ‘macro’ effects (for example, effects on international trade). Regional CGE models capture the regional and national effects resulting from a region-specific change.

Regional models generally contain (1) a detailed description of the structure of the economy at the regional level and (2) a set of mechanisms that describe the economic behaviour of five types of agent in the economy: producers, investors (capital creators), households, government and foreigners. In these models, each region is modelled as a separate economy with links to the other regions to account for product and factor mobility between regions. The models calculate changes at the national level by aggregating changes for each region, so are characterised as ‘bottoms up’ models.

The two main multi-region models for Australia are the Monash Multi-Regional Forecasting model (MMRF) and TERM. MMRF uses states and territories as regional economies. Each region may then be disaggregated (post-simulation) to the statistical division level.

TERM was developed as a more disaggregated tool than MMRF, for regional policy analysis. It can be used to model each of Australia’s 57 statistical divisions as a distinct economy with its own input–output and trade relationships.

Further details of the structure of TERM are available in Horridge, Madden and Wittwer (2003) and Wittwer (2003).

Development of a water module within TERM

To improve understanding of the likely regional impacts of water policy reform, the Productivity Commission and a consortium of other agencies funded the Centre of Policy Studies to incorporate a representation of the irrigation sector within TERM, resulting in TERM-Water. This new model explicitly recognises water as a factor of production for irrigated agricultural industries by incorporating stylised hierarchical production relationships between water and other factor inputs such as labour and capital. It also represents water as a tradeable asset among irrigators (box 3.2).

The Australian Bureau of Statistics (ABS) water accounts (2000), representing water use in 1996–97, are used to define water allocation and use within the model — hence, 1996–97 is referred to as the 'base year' for this analysis. New accounts for 2000–01 were released in May 2004 but were not incorporated into the TERM database for this modelling exercise.

As part of the model development, TERM has been reconfigured to 48 industry sectors and 20 regions to provide TERM-Water with a detailed representation of irrigated industries in the southern Murray-Darling Basin (MDB) (appendix B tables B.4 and B.5). Irrigated sectors include: sheep, other broad acre, beef cattle, dairy cattle, rice, cotton, four different fruits, three different forms of grape production, irrigated pasture, vegetables and other crops. Regions outside the MDB have been aggregated to the state or 'rest of state' level. The model has retained disaggregation to statistical division level within the MDB (figure 3.1).

The borders of regions are based on ABS statistical divisions, which have a reasonable concordance with existing boundaries of irrigation districts (appendix A, table A.2). One notable exception is the area supplied by Goulburn Murray Water, which lies partly in the Mallee region, as well as providing the vast majority of irrigation water in the Goulburn, Ovens Murray and Loddon Campaspe regions.

In TERM-Water, a variety of products are produced within each region. Each regional farm is specialised, in that it produces only one output and by only one technique. (Irrigated grapes and non-irrigated grapes, for example, are produced by different farms.) In the model there is no threshold for use of a particular input (such as water) below which production ceases. Land, labour and capital are mobile to varying degrees in TERM-Water. When water allocations and prices change, the output mix of a region thus changes in response, and these specialised farms expand or shrink as needed. For this reason, despite the difference between the way in which farms are modelled in TERM-Water and the way in which farming is organised in the real world of the agricultural sector, TERM-Water can model changes in product mixes and inputs.

TERM-Water has only one such specialised farm per region — for example, all the fields devoted to wheat in a region are as if they are operated by one farmer — therefore some caution is needed in the interpretation of the results. A reduction in the output of wheat, for example, is not necessarily a good estimate of what would happen to the incomes of real farmers who may have a mix of crops including wheat.

Figure 3.1 **Irrigation areas and statistical divisions**

Source: Murray-Darling Basin Commission.

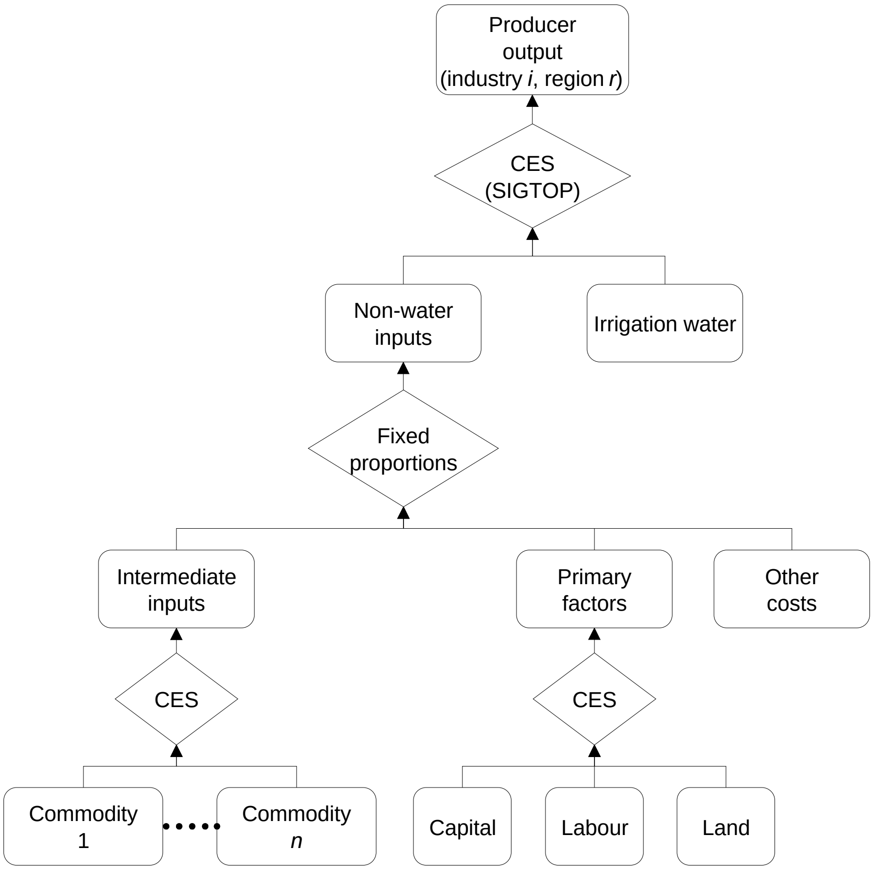
TERM-Water models production and consumption relationships as annual flows of goods and services. Changes in water prices and allocations within a year reflect changes in annual averages.

Box 3.2 **TERM's water module**

TERM-Water includes irrigation water in production as an endowment rather than as an intermediate input and the production of irrigation water is not accounted for in the model. Output is produced using a combination of irrigation water and a bundle of non-water inputs. As represented in the diagram below, each regional irrigation industry has a constant elasticity of substitution (CES) production function that allows non-water inputs to be substituted for irrigation water in response to changes in their relative prices. The elasticity parameter is SIGTOP and usually takes the value 0.01, 0.03 or 0.05, depending on the industry. For non-irrigation industries, production is proportional to non-water inputs because these industries do not use irrigation water.

The bundle of non-water inputs consists of intermediate inputs, primary factors and other costs, used in fixed proportions (as shown in the diagram below). The use of particular commodities as intermediate inputs varies with changes in their relative prices. The bundle of primary factors consists of capital, labour and land. The composition of the primary factor bundle also varies with changes in relative factor prices.

Water utilities are represented as an industry in TERM-Water. This industry produces sewerage and drainage services, and delivers non-irrigation water. Purchases from water utilities are represented as intermediate inputs in the production process.



Source: based on Wittwer (2003).

Incorporating water trade

In TERM-Water, the total water supply available is fixed exogenously. A statistical division's endowment of water within TERM-Water is derived from data on the observed use of irrigation water. This means either the initial equilibrium assumes that water entitlements, seasonal allocations and use all coincide (so there is no net trade) or, more realistically, water use may represent some re-allocation but not sufficient to equalise prices across irrigation districts.

Consequently, the data on use includes water trade that did occur in 1996–97 but which is, from the point of view of the model, unobserved. When water availability is reduced, however, the model generates estimates of additional trade, thereby induced. Soon, the Australian Bureau of Statistics is expected to release data for the year 2000–01 on water use (but, again, not on water allocations). For some regions of the southern MDB, water availability was lower in 2000–01 than in 1996–97; and the water market had developed between the two years. Therefore, the 2000–01 data on use may incorporate more unobserved trade than do the earlier data. If so, (all else being equal) in any model simulations based on later data, reductions in water availability would be expected to produce smaller additional water trades than those reported in this study.

In the base year (1996–97), water entitlement holders share the total volume of water available according to their priority and entitlement to the resource. Once water has been allocated, the current model does not distinguish between a megalitre of water conferred from a high security entitlement and one conferred from a low security entitlement. Effectively, 'a megalitre is a megalitre' within the present model.

Water use is the amount of water that an irrigator uses on a farm. Water may be sourced through the seasonal allocations that irrigators receive from their water entitlements (at the price charged by the water utility), through water trades or on-farm resources (including ground water). In the model, the source of the endowment of water is not identified.

The decision on how much water to use or sell is determined by the price at which trade is occurring, because this price represents the opportunity cost of using allocated water. TERM-Water re-allocates water according to its marginal value product between trading groups. This reflects the incentive that irrigators have, in the real world, to purchase or sell water until equality is achieved between the water trade price and the value of the marginal product of water. Each irrigator then faces the same opportunity cost of water because each can chose to buy or sell the right to receive water from the water supply company or authority at the market price.

The model simulates the long run equilibrium allocation of water use across industries and regions. In the real world, the re-allocation embodied in this final equilibrium can occur through trade in seasonal allocations or trade in water entitlements, or both; in the model, there is no such distinction. The implications of trade in water on different water sources is not considered (chapter 4). The trading price of seasonal allocations and entitlements are likely to be closely related (box 3.3).

Box 3.3 The price of water entitlements and seasonal allocations

Conceptually, the value of a water entitlement is equivalent to the value of an (infinite) series of seasonal water allocations. The price of water entitlements can thus be given by:

$$P_{ent} = \sum_{t=0} \frac{\left(s_t . P_{alloc,t}\right)}{(1+r)^t}$$

where:

- P_{ent} is the price of water entitlements.
- $P_{alloc,t}$ is the price of seasonal water allocations in period *t*.
- s_t is the entitlement share allocated in period *t*.
- r is the interest rate by which future revenues are discounted.
- t is an annual measure of time.

Note: The variables s_t and $P_{alloc,t}$ would be expected to be negatively correlated.

A high security water entitlement is like a financial asset that pays a high dividend in dry (water scarce) years: its value moves contrary to that of some other agricultural returns. Some risk averse irrigators may thus prefer to hold such entitlements and engage in temporary water allocation trades. They may be willing to pay (or forgo) a premium, therefore, to retain high priority entitlements and reduce some uncertainties associated with rainfall and storage levels, for example.

Considerations of uncertainty and risk are absent from the TERM-Water model. If variability is removed in shares and allocations, the price of water entitlements can be represented as:

$$P_{ent} = \sum_{t=0} \frac{P_{alloc}}{(1+r)^t}$$

where: P_{alloc} is the price of seasonal water allocation in every period.

In full trading equilibrium, the price of water becomes equal to the (common) value of the marginal product of water.

Water and irrigators' substitution choices

A critical parameter of the model is irrigators' choice of input substitution possibilities between water and other inputs (box 3.4). Appels, Douglas and Dwyer (2004) highlight the complex substitution choices that exist and how they differ across major agricultural enterprises such as dairy, rice and perennial horticulture.

Box 3.4 **Water substitution assumptions**

SIGTOP is the input substitutability between water and a bundle of all other inputs. It is represented in the production nest as a constant elasticity of substitution (the top-most CES production function in box 3.2). A very low value of SIGTOP means there is little substitutability between water and the non-water aggregate input: even if the price of water rises significantly, the ratio of inputs used remains relatively unchanged.

The assumed value of SIGTOP affects the way in which an industry reacts to the increased scarcity of water and thus to water's increased price. A higher elasticity of substitution means farms can more readily move to those inputs that are relatively cheaper. Consequently, as water quantities used in production fall, the output of a farm can readily be maintained by increasing the intensity of capital, land and/or labour use. This means the effects of water quantity shocks are 'diluted'.

For all irrigated industries in TERM-Water, SIGTOP is assumed to be low, reflecting the importance of water as an input to production (little scope for substituting between water and other inputs). For each of these industries, SIGTOP takes one of three possible values. In each irrigation region, SIGTOP is assumed to be 0.01 for the rice growing industry and 0.05 for the beef and dairy industries. For all other industries in the irrigation regions, SIGTOP is assumed to be 0.03. Sensitivity testing is performed on these parameter value choices (see chapter 4 and appendix B).

Higher parameter values allocated to particular industries account for the greater opportunities that the industries have to substitute other inputs for water. The dairy industry, for example, can purchase feed grains (which may not be derived from irrigated farming) for (irrigated) pasture and thus has been allocated a higher SIGTOP value than that for most other industries.

Trade restrictions

A number of examples of trade restrictions were presented in chapter 2. These are not separately identified in the model. In the model, trade restrictions are used to broadly represent these trade constraints in total.

Aside from the prices charged for water by utilities, the determinants of the rents accruing to holders of water entitlements include the productivity of and relative scarcity of water in each region. When water trade is unrestricted within a region, the observed water price will be the value of the marginal product of water (which would be common to all water using industries in the region, adjusting for differential delivery costs). Similarly, water price differentials occur across regions if trade is restricted, and would disappear if restrictions were removed (box 3.5).

The issue of congestion is handled outside the model. Results are checked to ensure average annual water trade volumes do not breach the congestion constraints.

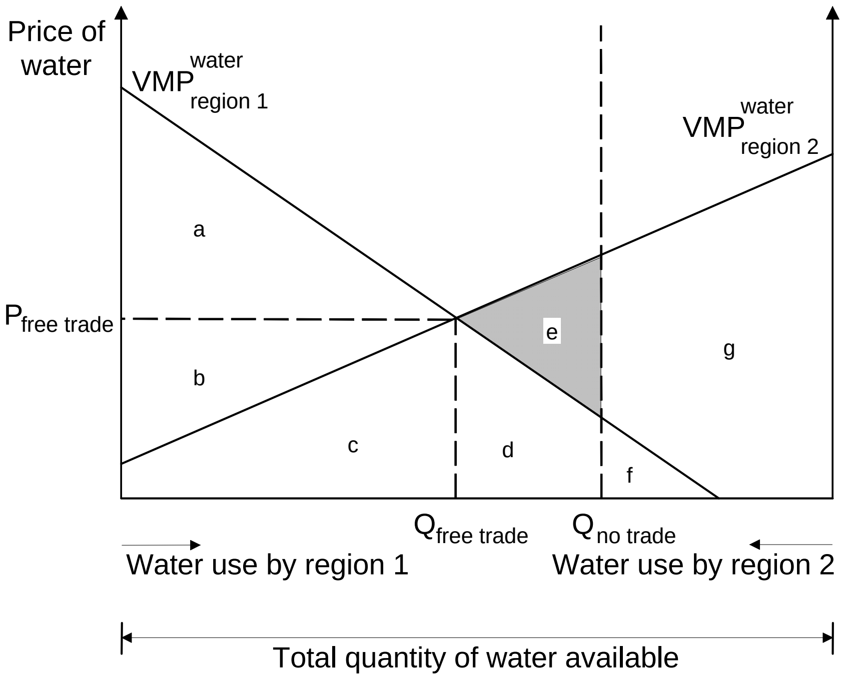
Box 3.5 **Illustrative gains from trade in water**

The diagram below shows gains from water trade that would occur if barriers preventing the re-allocation of water were removed and free trade occurred between two regions. The horizontal axis shows the total quantity of irrigation water available and its distribution between the two regions. Diminishing returns to water in both regions implies the value of the marginal product of water (VMP) schedule for each region slopes downwards from the relevant origin.

Initially, region 1 has an available quantity of water given by $Q_{no\ trade}$ and the remaining water is used by region 2. Under this allocation, production revenue for region 1 is given by the area *a*+*b*+*c*+*d* and revenue for region 2 is given by the area *f*+*g* (unless water is supplied to irrigators at zero charge, its cost must be deducted to obtain net revenue). At $Q_{no\ trade}$, $VMP_{region\ 2}$ is greater than $VMP_{region\ 1}$.

Removing the restrictions in trade results in some water use shifting via trade from relatively low value use (at the margin) in region 1 to relatively high value use in region 2. This reallocation of water continues until $VMP_{region\ 1}$ equals $VMP_{region\ 2}$. That is, the final allocation of water occurs at $Q_{free\ trade}$. Production revenue for region 1 is now given by area *a*+*b*+*c* and revenue for region 2 is *d*+*e*+*f*+*g*. The area *e* shows the net total gain from trade in water resulting from the removal of barriers to water trade. The part of the net total gain accruing to irrigators in region 1 would be $P_{free\ trade} \cdot (Q_{no\ trade} - Q_{free\ trade})$ less area *d*, with the remainder accruing to irrigators in region 2.

The above analysis makes standard partial equilibrium assumptions. These include zero transaction costs in trading water. It is also assumed that the VMP schedules correspond to social valuations as well as private (irrigator) ones. That is, there are no externalities from the use of water, so the barriers to water trade could not have been serving a welfare-enhancing role.



Model simulation

The economic impacts of expanding trade in the southern MDB are estimated by comparing the effects of reductions in water availability under various water trade assumptions. In the model, water is permanently removed from use by agricultural industries and is not re-allocated to any other sector. The value of this water is not explicitly valued in the model. The increased opportunities for re-adjustment that exist under expanded trade would mean reductions in water availability would have different effects than in the presence of restricted water trade. With water trade, those industries and regions in which water generates relatively low values of marginal product will sell water to those where it has higher marginal value.

In long run simulations using TERM-Water, labour and capital are mobile between industries and regions, and will tend to follow the water trade flows. Land is also assumed to be mobile between industries within a region. Under a reduction in water availability, national gross domestic product would be larger, therefore, than if trade were prevented, but the gross regional product could be larger or smaller.

In short run simulations, capital is fixed and the ability for labour to migrate between industries and regions is reduced. This means that for a given water allocation reduction, the southern MDB may not have as significant reduction in GRP in the short run as in the long run, because in the short run capital and labour inputs cannot leave the southern MDB to seek higher returns in other parts of Australia.

Each simulation compares three trade experiments that differ by the type of additional water trades allowed to occur (box 3.6). The sensitivity of the results to variations in some parameters of the model and to changes in the level and distribution of reductions in irrigation water allocations is then assessed (appendix B).

Box 3.6 **Trade experiments conducted using TERM**

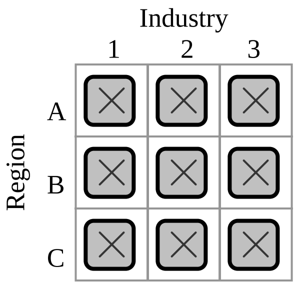
The following three trade experiments were compared to examine the impact of expanding trade. They differ by the type of additional water trades they allow to occur.

‘No trade’ — water cannot be re-allocated between industries or regions, so every industry uses only the water that it is allocated (a).

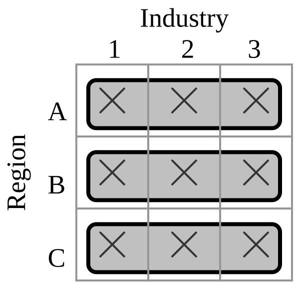
‘Intra-regional trade only’ — water re-allocation can occur among industries in the same region, but regions cannot export or import water to/from other regions (b).

‘Intra- and interregional trade’ — water can freely flow among all trading regions and all industries within these regions (c).

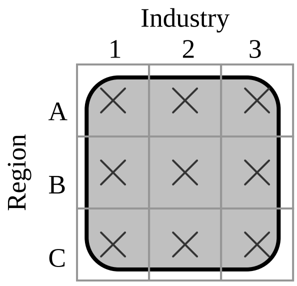
The diagrams below use shading to illustrate the water trade areas in each experiment.



(a)



(b)



(c)

4 Long run effects of reduced water availability with trade

This chapter summarises the results of the long run TERM-Water simulations specified in the previous chapter. It also presents the sensitivity of the results to underlying model and experiment assumptions, and outlines some model design features that must be noted when considering the results.

Reductions of 10 per cent, 20 per cent and 30 per cent in irrigation water availability in the southern Murray-Darling Basin (MDB) are modelled. Initially all industries in all regions are assumed to face the same percentage declines in water availability. This means industries and regions that use larger volumes of water face larger volumetric reductions than those with lower use. An alternative distribution of reductions in water availability is later considered.

Three trade experiments are compared. In the first, irrigators cannot trade within or between regions (no trade). In the second, irrigators can trade within regions but not between regions (intra-regional trade only). In the third, trade is allowed both within and between regions (intra- and interregional trade). The 10 per cent reduction is used as a reference case for sensitivity testing of model assumptions.

Macroeconomic effects of water trade

The national macroeconomic effects of reduced water availability vary according to the water trade assumptions. Water reductions have the greatest effect if no water trade is allowed to occur within or between regions. If trade can occur between industries within a region, but the trade between regions is still constrained, then the resulting decreases in gross domestic product (GDP) and gross regional product (GRP) of the southern MDB are lessened. GDP and GRP effects are further reduced if both intra- and interregional water trade can occur. Moving from no trade to intra- and interregional trade together more than halves the impact of the reductions in water on the gross regional product (GRP) of the southern MDB.

The *relative* gains from allowing intra-regional trade, and intra- and interregional trade are remarkably similar between the different allocation reductions (see table 4.1). For example, the effects of moving from intra-regional trade only to allowing both intra- and interregional trade on southern MDB GRP are reduced by

23, 24 and 22 per cent, when water allocations are cut by 10, 20 and 30 per cent respectively. There is a 98 per cent correlation between the trade effects on GRP resulting from the various per cent reductions in water availability.

The regional effects of a ten per cent reduction in water availability in the southern MDB are not large. Larger cuts in water availability have disproportionately larger effects on GRP and GDP. Doubling the cut in allocation more than doubles the effect on GRP for each region in the southern MDB and on national GDP (table 4.2). When intra- and interregional trade are both permitted, for example, a 10 per cent cut in water allocations reduces GRP for the southern MDB by 0.52 per cent, a 20 per cent cut reduces it by 1.17 per cent, and a 30 per cent cut decreases it by 2.02 per cent — almost four times the loss from the 10 per cent cut.

Table 4.1 **GDP and GRP effects of trade after water availability reductions of different magnitudes**

	Relative effects of moving from no trade to allowing intra-regional trade only [a]			*Relative effects of moving from intra-regional trade only to allowing interregional trade* [b]		
	10% reduction	20% reduction	30% reduction	10% reduction	20% reduction	30% reduction
	%	%	%	%	%	%
New South Wales						
Murrumbidgee	49	52	52	–32	–32	–32
Murray	41	43	43	–35	–34	–34
Victoria						
Mallee	49	57	61	42	38	31
Goulburn	16	21	22	56	55	52
Loddon Campaspe	25	30	34	42	36	26
Ovens Murray	22	30	36	70	72	71
South Australia						
Murray Lands	21	29	33	75	76	75
Southern MDB	35	40	42	23	24	22
Australia	31	36	39	22	30	32

a Proportional difference between GRP/GDP changes in the no trade and intra-regional trade only experiments. **b** Proportional difference between GRP/GDP changes in the intra-regional trade only and intra- and interregional trade experiments.

Source: Tables 4.4, D.10 and D11.

Further analysis of a specific case

In the following sections, detailed analysis is provided of a 10 per cent reduction in irrigation water availability. In particular, information is provided on sectoral and regional impacts, as well as the results of variations in some of the key assumptions of the model as part of sensitivity testing.

Table 4.2 **GDP and GRP effects under different trade and water availability experiments**[a]

	10 per cent reduction in water availability			*20 per cent reduction in water availability*			*30 per cent reduction in water availability*		
	No trade[b]	Intra- trade[c]	Inter- trade[d]	No trade[b]	Intra- trade[c]	Inter- trade[d]	No trade[b]	Intra- trade[c]	Inter- trade[d]
	%	%	%	%	%	%	%	%	%
New South Wales									
Murrumbidgee	–1.29	–0.66	–0.87	–3.02	–1.45	–1.92	–5.11	–2.45	–3.23
Murray	–1.52	–0.90	–1.21	–3.48	–1.98	–2.65	–5.78	–3.30	–4.42
Victoria									
Mallee	–1.39	–0.71	–0.41	–3.67	–1.57	–0.98	–6.64	–2.59	–1.78
Goulburn	–1.07	–0.90	–0.39	–2.63	–2.09	–0.94	–4.57	–3.54	–1.72
Loddon Campaspe	–0.30	–0.22	–0.13	–0.70	–0.49	–0.31	–1.18	–0.78	–0.58
Ovens Murray	–0.24	–0.19	–0.06	–0.66	–0.46	–0.13	–1.26	–0.81	–0.24
South Australia									
Murray Lands	–1.50	–1.18	–0.30	–4.08	–2.89	–0.70	–7.48	–4.99	–1.27
Southern MDB	–1.04	–0.67	–0.52	–2.55	–1.53	–1.17	–4.43	–2.58	–2.02
Australia	–0.008	–0.006	–0.004	–0.027	–0.017	–0.012	–0.059	–0.036	–0.024

a GDP includes market sales of water. Purchases of water are treated as an input cost. **b** No water trade permitted between industries within the same region or between regions. **c** Trade permitted between industries in the same region, but not between regions. **d** Trade permitted between industries in the same region as well as with other regions in the southern MDB.

Source: Tables 4.4, D.10 and D.11.

Re-allocation of water with trade

As water becomes scarcer, its relative value (opportunity cost) increases. With intra- and interregional trade, irrigators can respond by moving water between industries and regions. Irrigators with higher water intensities (water use per unit of output) in production, those with water expenditures representing a higher proportion of total costs, and those for whom other inputs can be substituted more easily for water (that is, with higher SIGTOP values) are more likely to use less water and to sell unused water to generate income. As water moves to different industries and regions, labour and capital tend to move with it, increasing the growth effects in importing regions and increasing the falls in output in exporting regions. Within a region, land can also be re-allocated between industries to some degree (appendix B).

The top panel of table 4.3 summarises the patterns of net water trade (exports minus imports) under intra-regional trade. When trade is allowed within a region, the rice and dairy industries in most regions reduce water use and become net sellers of water to the remaining (net purchasing) industries.

With only intra-regional trade permitted, the opportunity cost of water differs across regions (appendix D, table D.3). When trade is allowed between regions as well as within regions, prices equalise and industries that were net sellers of water under intra-regional trade tend to become net exporters to water purchasing industries in other regions (see the lower panel of table 4.3). Similarly, interregional trade allows industries purchasing water under intra-regional trade to become net importers of water.

The Murrumbidgee and Murray regions are estimated to be net exporters (each exporting in excess of 46 gigalitres of water) and the Murray Lands and northern Victorian regions are likely to be net importers of the water — reflecting the distribution of industries across regions. Water is primarily exported from the rice industry in the Murrumbidgee and Murray regions, with almost all industries in the importing regions being purchasers of water. (An individual industry can be a net exporter in one region while being a net importer in another. This happens when the 'exporting' region has plentiful water, compared with the 'importing' region).

Total *net* water trade within the southern MDB is a relatively small share of total water allocations, with only 2.3 per cent of total allocations traded among regions. Similarly, net water exports or imports from a region are a small percentage of total water allocations in that region (table 4.3). Imports to the Murray Lands region, for example, represent approximately 8 per cent of total allocations in that region, while exports from the Murrumbidgee region represent around 4 per cent of total allocations for that region.

Table 4.3 **Net water trades among industries in the southern MDB**[a]

After a 10 per cent reduction in water availability

	Murrumbidgee	*Murray*	*Mallee*	*Goulburn*	*Loddon Campaspe*	*Ovens Murray*	*Murray Lands*
	ML	ML	ML	ML	ML	ML	ML
Intra-regional trade only							
Sheep	10 601	7 735	1 857	1 614	2 324	0	303
	(8.0%)	(8.2%)	(3.2%)	(6.7%)	(6.5%)	–	(5.2%)
Other broadacre	14 347	13 651	209	473	–528	5	66
	(7.6%)	(7.9%)	(7.7%)	(4.8%)	(–3.4%)	(7.4%)	(5.2%)
Beef cattle	4 796	3 967	45	783	320	299	–6
	(6.4%)	(6.9%)	(0.2%)	(0.7%)	(1.7%)	(3.7%)	(–0.1%)
Dairy cattle	736	6 613	–17 518	–8 072	–352	–531	–5 309
	(6.9%)	(6.6%)	(–8.3%)	(–1.6%)	(–0.9%)	(–1.3%)	(–9.9%)
Rice	–52 730	–43 926	–64	–709	0	0	0
	(–8.2%)	(–5.6%)	(–9.1%)	(–12.9%)	–	–	–
Perennial horticulture	11 962	5 757	13 964	3 604	97	60	4 150
	(10.2%)	(9.9%)	(7.3%)	(5.2%)	(1.7%)	(0.5%)	(2.3%)
Irrigated pasture	672	1 094	–631	503	267	82	–200
	(7.7%)	(7.6%)	(–4.1%)	(1.4%)	(2.2%)	(2.3%)	(–5.4%)
Vegetables	2 690	1 774	1 148	859	275	0	793
	(8.2%)	(8.5%)	(7.0%)	(5.8%)	(7.2%)	–	(4.1%)
Other crops	6 928	3 334	989	945	–2 402	85	203
	(6.6%)	(6.9%)	(7.2%)	(3.8%)	(–5.8%)	(7.0%)	(4.6%)
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	(0%)	(0%)	(0%)	(0%)	(0%)	(0%)	(0%)
Intra- and interregional trade							
Sheep	9 208	6 673	3 811	2 142	2 959	0	530
	(7.0%)	(7.1%)	(6.5%)	(8.9%)	(8.2%)	–	(9.0%)
Other broadacre	11 996	11 343	256	833	484	7	120
	(6.4%)	(6.5%)	(9.4%)	(8.4%)	(3.1%)	(10.0%)	(9.5%)
Beef cattle	3 457	2 905	1 271	6 452	995	668	349
	(4.6%)	(5.0%)	(4.7%)	(6.0%)	(5.3%)	(8.2%)	(7.3%)
Dairy cattle	420	3 294	–121	24 748	1 420	2 809	2 623
	(3.9%)	(3.3%)	(–0.1%)	(4.9%)	(3.6%)	(6.7%)	(4.9%)
Rice	–89 692	–91 627	64	658	0	0	0
	(–14.0%)	(–11.6%)	(9.1%)	(12.0%)	–	–	–
Perennial horticulture	9 887	4 907	16 528	5 666	322	939	15 107
	(8.5%)	(8.5%)	(8.7%)	(8.2%)	(5.5%)	(7.6%)	(8.5%)
Irrigated pasture	494	755	393	2 392	689	294	241
	(5.7%)	(5.2%)	(2.5%)	(6.5%)	(5.6%)	(8.1%)	(6.5%)
Vegetables	2 329	1 533	1 414	1 256	330	0	1 706
	(7.1%)	(7.3%)	(8.6%)	(8.4%)	(8.6%)	–	(8.7%)
Other crops	5 161	2 484	1 208	1 903	497	115	394
	(4.9%)	(5.2%)	(8.8%)	(7.6%)	(1.2%)	(9.6%)	(9.0%)
Total	**–46 741**	**–57 734**	**24 824**	**46 051**	**7 696**	**4 832**	**21 071**
	(–3.6%)	(–4.3%)	(4.6%)	(5.7%)	(4.5%)	(7.1%)	(7.8%)

a Percentages in parentheses are net trades as a proportion of water allocations.

Source: TERM-Water simulations.

Regional impacts

Without trade in water, a 10 per cent reduction in water availability reduces GRP of the southern MDB by 1.04 per cent ($356 million in 2003) (table 4.4). That is, relatively small reductions in GRP occur despite the assumption that other productive inputs are not readily substitutable for water. With trade permitted in each region, the reduction in GRP is less, at 0.67 per cent; it is less again, at 0.52 per cent, when trade in water is allowed also between regions.

Table 4.4 **GRP and GDP effects under different trade experiments**[a]

After a 10 per cent reduction in water availability

	No water trade [b]	*Intra-regional trade only* [c]	*Intra- and inter-regional trade* [d]	*Relative effects of moving from no trade to allowing intra-regional trade only* [e]	*Relative effects of moving from intra-regional trade only to allowing interregional trade* [f]
	%	%	%	%	%
New South Wales					
Murrumbidgee	–1.29	–0.66	–0.87	49	–32
Murray	–1.52	–0.90	–1.21	41	–35
Victoria					
Mallee	–1.39	–0.71	–0.41	49	42
Goulburn	–1.07	–0.90	–0.39	16	56
Loddon Campaspe	–0.30	–0.22	–0.13	25	42
Ovens Murray	–0.24	–0.19	–0.06	22	70
South Australia					
Murray Lands	–1.50	–1.18	–0.30	21	75
Southern MDB	–1.04	–0.67	–0.52	35	23
Australia	–0.008	–0.006	–0.004	31	22

[a] GDP includes market sales of water. Purchases of water are treated as an input cost. [b] No water trade permitted between industries within the same region or between regions. [c] Trade permitted between industries in the same region, but not between regions. [d] Trade permitted between industries in the same region as well as with other regions in the southern MDB. [e] Proportional difference between the first and second columns. [f] Proportional difference between the second and third columns.

Source: TERM-Water simulations.

All regions' GRP losses are reduced from allowing intra-regional trade. Under a 10 per cent reduction in water availability, the loss in GRP is 16–49 per cent less than in the no trade experiment (table 4.4). Allowing interregional trade as well as intra-regional trade further reduces the GRP losses in most regions. The Murray Lands region in South Australia and northern Victorian regions become net water importing regions and experience reduced losses in GRP, moving from intra-regional trade only to allowing trade between as well as within regions. The Murrumbidgee and Murray regions in New South Wales experience larger declines in GRP (by 32 per cent and 35 per cent respectively) with expanded trade as the two regions export water.

The differences in the effects of trade on individual regions depend on differences in the price of water and value of marginal product of water between regions. The regional distribution of the water purchasing and water selling industries will reflect these differences (appendix D, tables D.1 and D.2). The effects of trade on GRP are larger for regions with a higher proportion of water sales to allocations than for regions where the proportion is low. Water selling industries (such as rice) are concentrated in the Murrumbidgee and Murray regions, while water purchasers (such as dairy and horticulture) are located in the northern Victorian regions (except for dairy in the Murray Lands region). As water is exported from a region, capital and labour also move to the regions that import the water (table 4.5). Unlike water, under 'no trade' capital and labour can move between regions. With larger intra-regional effects on industry under no trade, capital and labour also respond by larger movements from the regions. For example, capital and labour in the Murrumbidgee region decline 1.9 per cent and 1.0 per cent respectively under 'no trade', both more than with water trade.

Table 4.5 **Changes in regional primary factor use**

After a 10 per cent reduction in water availability

	Intra-regional trade only [a]			*Intra- and interregional trade* [b]			*Difference* [c]		
	Water	*Capital*	*Labour*	*Water*	*Capital*	*Labour*	*Water*	*Capital*	*Labour*
	%	%	%	%	%	%	%	%	%
New South Wales									
Murrumbidgee	–10	–1.3	–0.4	–13.2	–1.8	–0.6	–3.2	–0.5	–0.2
Murray	–10	–1.8	–0.6	–13.8	–2.5	–0.9	–3.8	–0.7	–0.3
Victoria									
Mallee	–10	–1.0	–0.7	–5.8	–0.5	–0.4	4.2	0.4	0.3
Goulburn	–10	–1.3	–0.8	–4.8	–0.6	–0.4	5.2	0.7	0.4
Loddon Campaspe	–10	–0.3	–0.2	–6.0	–0.2	–0.1	4.0	0.1	0.1
Ovens Murray	–10	–0.3	–0.2	–3.6	–0.1	0.0	6.4	0.2	0.1
South Australia									
Murray Lands	–10	–1.6	–1.2	–3.0	–0.4	–0.3	7.0	1.2	0.9

a Trade permitted between industries in the same region, but not between regions. **b** Trade permitted between industries in the same region as well as with other regions in the southern MDB. **c** The percentage point difference between the corresponding columns for the two experiments.

Source: TERM-Water simulations.

Within Victoria, under a 10 per cent reduction in water availability, the Goulburn and Mallee regions (which have a higher share of dairy output) experience a larger decline in output than that experienced by those regions with a larger share of perennial horticulture industries.

Also dampening the impacts of the reduction in water availability are the second and third round impacts on other agricultural industries that are not major water users. The effects on GRP of contracting irrigated industries, for example, are partly offset by growth in non-irrigated agricultural industries (such as wheat, barley and other crops) as labour and capital are freed to move to those industries.

Sectoral impacts

The primary sector accounts for most of the fall in industry value added after a reduction in water availability. Under a 10 per cent reduction, and allowing only intra-regional trade the primary sector accounts for 65 per cent of the relatively small decline in GRP in the southern MDB. Growth in the (non-food processing) manufacturing sector and income from water sales lessen this impact (appendix D, table D.5). With interregional trade, the primary sector contributes 72 per cent to the overall decline in GRP. This is because expanding water trade allows primary industries in some regions to substitute water sales for output sales as a source of income. As income sources change, output, employment and capital used in these industries declines as water trade expands and, as local primary industries contract, other industries (in, say, the food processing sector) switch the source of their inputs to other regions or overseas.

Local labour and capital become cheaper as wages and returns to capital decline when these factors are released from declining primary industries. Cheaper labour and capital reduce production costs for food processing, so food processing output in the southern MDB declines less under expanded trade. However, the smaller decline in the region's food processing is not sufficient to absorb all of the capital and labour released from primary industries as water trade expands. As a result, with national employment unchanged, remaining unused labour is absorbed by industries in other regions and output there expands.

In Victoria, primary industries contract less because they import water from New South Wales. The Victorian food processing sector contracts further as demand for its products is increasingly satisfied by food processing industries in New South Wales regions. As a result, manufacturing declines, although small, are more pronounced in the northern Victorian regions, which have larger food processing industries (such as dairy products). The transport industry is an important component of the regional services sector and, in most regions, is more affected than other service industries by moving from intra-regional trade only to intra- and interregional trade.

As a result of interregional trade, value added in the primary sector and, to lesser extent, the service and (non-food processing) manufacturing sectors in some regions decline as water trade expands. However, this is less than reductions in value added in other regions. Thus, value added for each of these sectors declines less for the entire southern MDB, as trade expands (table 4.6). The 10 per cent reduction in water availability leads to a 2.29 per cent and 1.91 per cent reduction in primary sector production in the southern MDB under intra-regional trade only and intra- and interregional trade respectively (appendix D, table D.4). This means that expanding water trade lessens the impacts of the water reduction by 16.4 per cent.

Table 4.6 **Sectoral differences in value added from expanded water trade[a]**
After a 10 per cent reduction in water availability

	Primary	*Food processing*	*Other manufacturing*	*Services*
	%	%	%	%
New South Wales				
Murrumbidgee	–40.9	47.7	7.9	–38.1
Murray	–44.7	22.3	42.0	–40.9
Victoria				
Mallee	41.9	47.8	–60.8	43.8
Goulburn	55.7	54.9	–13.7	56.3
Loddon Campaspe	41.5	41.4	–9.5	43.2
Ovens Murray	74.1	45.8	25.2	68.5
South Australia				
Murray Lands	77.8	63.6	156.6	73.3
Southern MDB	**16.4**	**53.8**	**3.7**	**15.4**

[a] Differences are calculated as the percentage difference between the intra-regional trade only experiments and the intra- and interregional trade experiment. Changes in sectoral output are presented in appendix D, table D.4.

Source: TERM-Water simulations.

Industry impacts

When water availability is reduced by 10 per cent, with or without trade, output declines in most industries (appendix D, table D.4). However, in most industries, declines in output are lower when intra- and interregional trade is allowed. The extent of the effects of trade differs across industries and regions, depending on whether trade is confined within regions or allowed across regions. Given the large number of industries considered in the model, the focus here is on selected irrigated industries that dominate agricultural output in the southern MDB. Results for all industries under a 10 per cent reduction in water availability are contained in table D.4.

- Dairy industry output falls by around 8 per cent under intra-regional trade, and by around 4 per cent under intra- and interregional trade.

- Perennial horticulture industry output (citrus, apples and pears, stone fruits, other fruits and nuts, dryland premium grapes, irrigated premium grapes and other grapes) decreases by around 1.4 per cent under intra-regional trade and by around 0.7 per cent under intra- and interregional trade.
- The output of the rice industry falls by around 15 per cent under intra-regional trade and by around 20 per cent under intra- and interregional trade.

For each industry, there can be significant differences in effects across regions.

Sensitivity testing

This section reports the sensitivity of the results to variations in parameters of the model and to cuts in total water allocations. The reference case (a 10 per cent reduction in irrigation water availability) was varied by changing:

- the input substitutability of water in (1) the rice industry and (2) all industries
- the distribution of the allocation reduction.

Variations to the water substitution assumptions

Although variations in the assumed value of the substitutability of water lead to sizeable variations in industry responses to the cut in water allocations, the effects of trade are not much changed.

In the reference case, the rice industry is assumed to have the lowest input substitution elasticity — a SIGTOP parameter value of 0.01. This assumption reflects the fewer options available to rice growers to alter inputs in response to changing water prices (Wittwer 2003; Appels, Douglas and Dwyer 2004). To test the sensitivity of the results to the choice of SIGTOP for the rice industry, the SIGTOP parameter value for rice is increased to 0.03. This change marginally reduces the impact of the 10 per cent reduction in water availability on the rice industry, and slightly increases the benefits from trade to the industry in the Murrumbidgee and Murray regions (appendix D, table D.7).

In further exploration of the sensitivity of results to the specification of SIGTOP, the SIGTOP parameter values are increased for all irrigated industries so all can more easily substitute other inputs for water. Without trade, this increase in substitutability lessens the effects of the reduction in water availability across all industries and all regions, and nationally (appendix D, table D.8). Similarly, when intra- and interregional trade are allowed, the falls in GRP and GDP from a 10 per cent reduction in water availability are less than in the reference case.

Consequently, the relative percentage effects from intra- and interregional trade are of a similar magnitude (but from a smaller base) for each region and nationally.

A redistribution of the 10 per cent cut in allocation

This sensitivity test redistributes the 10 per cent reduction in water availability such that it is no longer distributed in equal proportions across regions. The Murrumbidgee and Murray regions' allocations are reduced by 20 per cent and 25 per cent respectively, the northern Victorian regions each receive a 10 per cent increase in allocations, and the allocation to the Murray Lands region decreases by 3 per cent. This redistribution reflects the generally lower allocations (as a share of entitlements) in New South Wales compared with Victoria since 1996–97 (table 2.1).

Unsurprisingly, the GRP falls under no trade are larger in the regions experiencing larger percentage reductions in water availability, whereas the northern Victorian regions experience GRP growth (appendix D, table D.6). The effects of intra-regional trade on GRP are similar to those in the reference case in the Murrumbidgee, and Murray regions, but lower in the Goulburn and Loddon Campaspe regions. GRP in the Murray and Murrumbidgee regions increases from the transition from intra-regional trade alone to intra- and interregional trade compared with the reference case, as these regions become net importers of water rather than net exporters. In comparison, the northern Victorian and Murray Lands regions, although having a higher GRP than in the reference case, experience declines in GRP when moving from intra-regional trade to intra- and interregional trade, as they become net exporters of water.

Model design considerations

In the TERM database, the water use in each industry in each region is assumed to equal water allocations. Consequently, the effects of the transition from no trade to intra-regional trade have to be carefully interpreted.

In the model, the industries use exactly the water that they have been allocated: each industry in each region has water consumption that is assumed to be its initial allocation. The model does not consider how an industry obtained its initial endowment — that is, whether by water entitlements or by trade in seasonal allocations. It generates trades that are stimulated by reductions in water availability. A reduction in water availability means an equal reduction in the consumption of the entity experiencing the cut, unless there is trade. Under the no trade experiment, no trade (other than the trade outside of the model that led to the initial allocations and consumption in the database) is permitted after a reduction in water availability. However, in 1996–97, there was some net trade between industries within regions, but there was relatively little net trade between regions.

In addition, some regions and some industries tend to have higher allocations than normally required in an average year. Appels, Douglas and Dwyer (2004) argue that risk averse irrigators may choose to hold a larger water entitlement than needed to meet plant water needs in an average year. For example, many irrigators in the Murray Lands region of South Australia have larger entitlements as a buffer against dry years; in above average years, such as 1996–97, these irrigators are likely to be net exporters of water.

Consequently, trade patterns predicted in the model may not mirror historical trade patterns observed. Another implication is that the database from which the no trade experiment results are generated may include some net intra-regional trade in the pattern of industry allocations (and small net interregional trade also).

In the model, the production decisions of industries are based on annualised data and do not reflect how choices may change within an irrigation season. If, for example, reductions in water availability occur later in the season rather than at the start, as assumed in the model, the opportunity costs faced by industries may differ from those predicted in the model. In particular, annual crops producers (such as rice growers) are likely to face very different opportunity costs of water before planting than after planting (Appels, Douglas and Dwyer 2004).

The model does not include transmission losses of water (which can be caused by evaporation and accession to groundwater) associated with the intra- and interregional trade of water. The greater the trade between more geographically distant regions, the higher are the transmission losses likely to be. In some cases, transmission losses may become large, particularly if water is transported through open channels to farms distant from an irrigation system (ABARE 2002). The estimated effects of trade for the Murray Lands region, for example, are likely to be higher than if the model accounted for transmission losses. Nevertheless, transmission losses are generally a small share of all water transported (Brewsher Consulting 1999). Given that the model predicts relatively small net trades, the transmission impacts on net trade are likely to be minor. However, given that the model does not estimate the gross trade flows, it is not possible to predict whether the transmission losses would be significant.

In the current model design, only the irrigation industries use water; it is not possible to re-allocate the water to (or have it purchased by) other users, such as other industries or the environment. Further, the model does not distinguish between trade in seasonal water allocations and trade in water entitlements. Consequently, it is difficult to test directly the allocative efficiency effects of restricting either type of trade. Additionally, it is not possible to assess the impacts on the asset values of entitlements and, consequently, their implications for structural adjustment. Finally, it is not possible to consider implications of the cap introduced on water entitlements in 1995, because the model does not include ‘sleepers’ or ‘dozers’ (entitlement holders who do not draw or only occasionally draw their entitlement) who could sell unused entitlements.

The reductions in water availability may occur progressively, and trade may be liberalised over time. Given that the model is comparative static, however, it cannot assess such temporal scenarios. It can identify net trades between regions, but not the total trade flows. While the net trade appears to be relatively small, and congestion constraints are thus unlikely to be binding, it is not possible to assess how individual congestion constraints may affect trade flows within a year.

As noted in chapter 2, the majority of water used in the regions considered in the model is drawn from utilities. However, some water is from other sources, such as groundwater, on-farm storages and overland flows. The model does not distinguish the source of the endowment of water, so the reduction in water availability affects all water uses, for all sources — it is not exclusive to utility deliveries. A reduction in water availability means an identical (pre trade) cut in total consumption of water, with the model not allowing for switching to alternative sources.

In reality, if allocations from utilities were cut and other sources were not controlled, then irrigators would be likely to have a strong incentive to access other sources. Given the complex hydrological links among groundwater, surface water, overland flows and return flows, policy design would need to consider the implications of utility allocation cuts on *overall* water availability (and on third party impacts).

As the results of the model are specific to the experiments undertaken, care is needed in extrapolating. The effect on GRP in the southern MDB of a 20 per cent reduction in water availability are more than double those of a 10 per cent reduction — that is, the effects are not linear. The database year (1996–97) had above average allocations — a 10 per cent reduction in water availability in years of below average allocations would have larger GRP effects.

Finally, this analysis does not take into account the impact of changes in water trade on environmental conditions such as salinity.

5 Short run effects of reduced water availability with trade

Seasonal allocations can vary from year to year, within and between irrigation districts (chapter 2, table 2.1). These variations in seasonal allocations can be represented within TERM-Water as reductions in water availability relative to the base year 1996-97 (table 5.1).

Table 5.1 **Reductions in water availability compared to 1996-97**
Based on observed seasonal allocations

	1997-98	*1998-99*	*1999-00*	*2000-01*	*2001-02*
	%	%	%	%	%
Murrumbidgee	–8.3	–12.4	–18.0	–10.0	–23.7
Murray	–28.9	–20.7	–54.1	–12.0	–15.8
Mallee	–14.1	–15.2	–33.8	–16.4	–13.0
Goulburn	–22.8	–27.0	–34.3	–25.8	–19.1
Loddon Campaspe	–14.1	–15.2	–33.8	–16.4	–13.0
Ovens Murray	–5.0	–5.0	–5.0	–5.0	–5.0
Murray Lands	–5.0	–5.0	–5.0	–5.0	–5.0
Southern MDB	–17.7	–17.4	–33.2	–14.0	–17.4

Source: PC estimates.

Each year is modelled separately under short run assumptions with the corresponding cuts in allocations assumed to occur only in that year (tables 5.2–5.6). Consequently, within an individual year some regions face larger cuts in allocations than others. Those that face larger cuts are likely to be net importers of water.

In each year, moving from no trade to intra- and interregional trade together approximately halves the effect (between 47 and 55 per cent) of the reductions in water on the gross regional product (GRP) of the southern MDB.

The potential increases in GRP of the southern MDB from water trade are greater in drier years such as 1999–2000 ($555 million in 1999–2000 dollars) (table 5.4), compared with years when water is more abundant, as in 2000–2001 ($201 million in 2000–01 dollars) (table 5.5).

These estimates are the change in GRP of moving from no trade to both intra- and interregional trade when water availability is reduced from 1996–97 levels to 1999–2000 or 2000–01 levels. It assumes that the structure of the economy is relatively constant between years. The dollar value of altering the trading regime is estimated by comparing the results of the different trade experiments.

If variations in seasonal allocations are random (and do not exhibit long term patterns) irrigators are more likely to manage this short term risk through trade in seasonal allocations rather than trade in entitlements. Nevertheless, freeing up either or both kinds of trade will enable irrigators to better manage the variability associated with seasonal allocations.

Although TERM-Water is not a dynamic model and therefore does not consider the flow on effects of changing levels of production, the year to year effects of expanding trade can be summed to provide a rough indication of the longer term implications of expanding trade to manage seasonal variability in allocations. For example, in the five years between 1997–98 and 2001–02, the GRP of the southern MDB would have been around $1.4 billion (in undiscounted 2001–02 dollars) or about one per cent higher if intra- and interregional trade had been allowed to re-allocate water in response to variability in seasonal allocations (compared to no water trade). Given that variability in seasonal allocations is a common phenomena across the southern MDB, the long term benefits of expanding trade are likely to be larger than these estimates.

Table 5.2 **GRP and GDP effects of 1997–98 water availability under different trade experiments**[a]

	No water trade [b]	*Intra-regional trade only* [c]	*Intra- and interregional trade* [d]	*Relative effects of moving from no trade to allowing intra-regional trade only* [e]	*Relative effects of moving from intra-regional trade only to allowing inter-regional trade* [f]	*Relative effects of moving from no trade to allowing intra- and inter-regional trade* [g]
	%	%	%	%	%	%
New South Wales						
Murrumbidgee	–0.76	–0.56	–0.95	26.1	–69.0	–24.9
Murray	–4.18	–2.41	–1.92	42.3	20.4	54.1
Victoria						
Mallee	–1.58	–0.80	–0.74	49.2	7.5	53.0
Goulburn	–2.25	–1.71	–0.71	24.0	58.5	68.5
Loddon Campaspe	–0.36	–0.25	–0.24	30.0	4.5	33.1
Ovens Murray	–0.08	–0.06	–0.10	29.7	–75.2	–23.2
South Australia						
Murray Lands	–0.34	–0.34	–0.47	1.8	–40.1	–37.5
Southern MDB	–1.48	–0.97	–0.77	34.4	20.3	47.8
Australia	–0.09	–0.06	–0.05	38.0	17.3	48.7
GRP and GDP levels [h]	$m	$m	$m	$m	$m	$m
Southern MDB	24 750	24 878	24 927	128	49	177
Australia	561 686	561 884	561 940	198	56	254

[a] GRP and GDP include market sales of water. Purchases of water are treated as an input cost. [b] No water trade permitted between industries within the same region or between regions. [c] Trade permitted between industries in the same region, but not between regions. [d] Trade permitted between industries in the same region as well as with other regions in the southern MDB. [e] Proportional difference between the first and second columns, except the final two rows are differences in dollar amount. [f] Proportional difference between the second and third columns, except the final two rows are differences in dollar amount. [g] Proportional difference between the first and third columns, except the final two rows are differences in dollar amount. [h] In 1997–98 dollars.

Source: TERM-Water estimates.

Table 5.3 **GRP and GDP effects of 1998–99 water availability under different trade experiments**[a]

	No water trade [b]	*Intra-regional trade only* [c]	*Intra- and interregional trade* [d]	*Relative effects of moving from no trade to allowing intra-regional trade only* [e]	*Relative effects of moving from intra-regional trade only to allowing inter-regional trade* [f]	*Relative effects of moving from no trade to allowing intra- and inter-regional trade* [g]
	%	%	%	%	%	%
New South Wales						
Murrumbidgee	–1.26	–0.81	–1.03	35.4	–27.0	17.9
Murray	–2.77	–1.70	–1.64	38.4	3.5	40.5
Victoria						
Mallee	–1.78	–0.88	–0.74	50.4	15.6	58.2
Goulburn	–2.86	–2.13	–0.70	25.7	67.1	75.6
Loddon Campaspe	–0.39	–0.28	–0.24	30.0	13.0	39.1
Ovens Murray	–0.08	–0.06	–0.10	28.2	–72.5	–23.9
South Australia						
Murray Lands	–0.34	–0.34	–0.46	–0.3	–37.3	–37.7
Southern MDB	–1.53	–1.02	–0.74	33.5	26.7	51.2
Australia	–0.10	–0.06	–0.05	37.1	23.9	52.1
GRP and GDP levels [h]	$m	$m	$m	$m	$m	$m
Southern MDB	26 104	26 239	26 311	136	72	207
Australia	592 406	592 618	592 704	212	86	298

[a] GRP and GDP include market sales of water. Purchases of water are treated as an input cost. [b] No water trade permitted between industries within the same region or between regions. [c] Trade permitted between industries in the same region, but not between regions. [d] Trade permitted between industries in the same region as well as with other regions in the southern MDB. [e] Proportional difference between the first and second columns, except the final two rows are differences in dollar amount. [f] Proportional difference between the second and third columns, except the final two rows are differences in dollar amount. [g] Proportional difference between the first and third columns, except the final two rows are differences in dollar amount. [h] In 1998–99 dollars.

Source: TERM-Water estimates.

Table 5.4 **GRP and GDP effects of 1999–2000 water availability under different trade experiments**[a]

	No water trade [b]	*Intra-regional trade only* [c]	*Intra- and interregional trade* [d]	*Relative effects of moving from no trade to allowing intra-regional trade only* [e]	*Relative effects of moving from intra-regional trade only to allowing inter-regional trade* [f]	*Relative effects of moving from no trade to allowing intra- and inter-regional trade* [g]
	%	%	%	%	%	%
New South Wales						
Murrumbidgee	–2.1	–1.4	–1.9	36.3	–43.7	8.4
Murray	–9.6	–5.5	–4.1	42.7	24.8	56.9
Victoria						
Mallee	–6.0	–2.4	–1.6	59.9	32.2	72.8
Goulburn	–4.2	–3.1	–1.4	25.4	55.4	66.7
Loddon Campaspe	–1.1	–0.7	–0.5	40.8	22.3	54.0
Ovens Murray	–0.1	–0.1	–0.2	51.7	–160.9	–26.2
South Australia						
Murray Lands	–0.4	–0.4	–0.8	2.1	–116.5	–112.1
Southern MDB	–3.5	–2.1	–1.6	40.7	23.9	54.9
Australia	–0.2	–0.1	–0.1	45.4	20.1	56.4
GRP and GDP levels [h]	$m	$m	$m	$m	$m	$m
Southern MDB	27 599	28 011	28 154	412	143	555
Australia	626 333	626 983	627 141	650	157	808

a GRP and GDP include market sales of water. Purchases of water are treated as an input cost. **b** No water trade permitted between industries within the same region or between regions. **c** Trade permitted between industries in the same region, but not between regions. **d** Trade permitted between industries in the same region as well as with other regions in the southern MDB. **e** Proportional difference between the first and second columns, except the final two rows are differences in dollar amount. **f** Proportional difference between the second and third columns, except the final two rows are differences in dollar amount. **g** Proportional difference between the first and third columns, except the final two rows are differences in dollar amount. **h** In 1999–2000 dollars.

Source: TERM-Water estimates.

Table 5.5 **GRP and GDP effects of 2000–01 water availability under different trade experiments**[a]

	No water trade [b]	*Intra-regional trade only* [c]	*Intra- and interregional trade* [d]	*Relative effects of moving from no trade to allowing intra-regional trade only* [e]	*Relative effects of moving from intra-regional trade only to allowing inter-regional trade* [f]	*Relative effects of moving from no trade to allowing intra- and inter-regional trade* [g]
	%	%	%	%	%	%
New South Wales						
Murrumbidgee	–1.0	–0.6	–0.8	33.6	–32.6	11.9
Murray	–1.4	–1.0	–1.2	31.4	–22.5	15.9
Victoria						
Mallee	–2.0	–1.0	–0.6	51.4	33.0	67.5
Goulburn	–2.7	–2.0	–0.6	25.3	70.7	78.2
Loddon Campaspe	–0.4	–0.3	–0.2	30.3	31.3	52.1
Ovens Murray	–0.1	–0.1	–0.1	25.0	–54.0	–15.6
South Australia						
Murray Lands	–0.3	–0.3	–0.4	1.5	–17.2	–15.4
Southern MDB	–1.3	–0.9	–0.6	32.0	30.9	53.0
Australia	–0.1	–0.1	0.0	35.6	28.5	54.0
GRP and GDP levels [h]	$m	$m	$m	$m	$m	$m
Southern MDB	29 587	29 709	29 789	122	80	201
Australia	671 460	671 652	671 751	192	99	291

[a] GRP and GDP include market sales of water. Purchases of water are treated as an input cost. [b] No water trade permitted between industries within the same region or between regions. [c] Trade permitted between industries in the same region, but not between regions. [d] Trade permitted between industries in the same region as well as with other regions in the southern MDB. [e] Proportional difference between the first and second columns, except the final two rows are differences in dollar amount. [f] Proportional difference between the second and third columns, except the final two rows are differences in dollar amount. [g] Proportional difference between the first and third columns, except the final two rows are differences in dollar amount. [h] In 2000–01 dollars.

Source: TERM-Water estimates.

Table 5.6 **GRP and GDP effects of 2001–02 water availability under different trade experiments**[a]

	No water trade [b]	*Intra-regional trade only* [c]	*Intra- and interregional trade* [d]	*Relative effects of moving from no trade to allowing intra-regional trade only* [e]	*Relative effects of moving from intra-regional trade only to allowing inter-regional trade* [f]	*Relative effects of moving from no trade to allowing intra- and inter-regional trade* [g]
	%	%	%	%	%	%
New South Wales						
Murrumbidgee	–2.8	–1.5	–1.2	47.7	16.5	56.3
Murray	–2.0	–1.3	–1.5	32.5	–12.5	24.1
Victoria						
Mallee	–1.4	–0.7	–0.7	49.8	–1.7	49.0
Goulburn	–1.8	–1.3	–0.7	23.5	47.9	60.1
Loddon Campaspe	–0.3	–0.2	–0.2	29.3	–3.0	27.2
Ovens Murray	–0.1	–0.1	–0.1	33.5	–64.8	–9.6
South Australia						
Murray Lands	–0.3	–0.3	–0.5	4.0	–43.3	–37.6
Southern MDB	–1.4	–0.9	–0.8	37.3	15.5	47.0
Australia	–0.1	–0.1	0.0	41.2	12.7	48.7
GRP and GDP levels [h]	$m	$m	$m	$m	$m	$m
Southern MDB	31 467	31 638	31 682	171	44	215
Australia	714 120	714 389	714 437	269	48	317

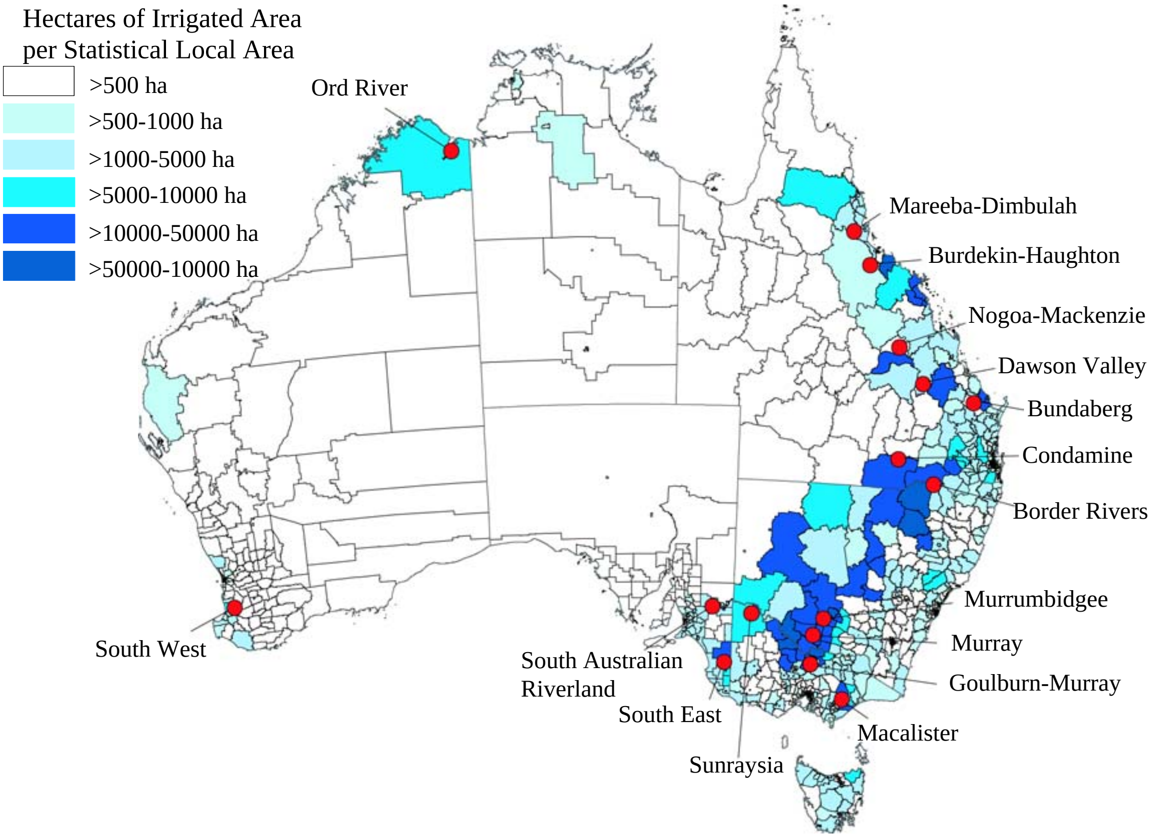
[a] GRP and GDP include market sales of water. Purchases of water are treated as an input cost. [b] No water trade permitted between industries within the same region or between regions. [c] Trade permitted between industries in the same region, but not between regions. [d] Trade permitted between industries in the same region as well as with other regions in the southern MDB. [e] Proportional difference between the first and second columns except the final two rows are differences in dollar amount. [f] Proportional difference between the second and third columns except the final two rows are differences in dollar amount. [g] Proportional difference between the first and third columns except the final two rows are differences in dollar amount. [h] In 2001–02 dollars.

Source: TERM-Water estimates.

APPENDIXES

A Irrigation industry data

Figure A.1 **Major irrigation districts in Australia**



Data source: Australian Bureau of Statistics 1997 data used in NLWRA (2001).

Table A.1 **Net water consumption for selected industries, 1996–97[a]**

Sector	*NSW–ACT*	*Vic*	*Qld*	*SA*	*WA*	*Tas*	*NT*	*Aust.*
	GL	GL	GL	GL	GL	GL	GL	GL
Livestock, pasture, grains and other agriculture	3 405	3 549	726	640	402	70	4	8 795
Vegetables	194	108	122	65	104	41	0.2	635
Sugar	0.4	–	1 176	–	60	–	–	1 236
Fruit	279	172	91	115	41	2	4	704
Grapevines	242	218	4	172	11	0.2	1	649
Cotton	1 417	–	423	–	–	–	–	1 841
Rice	1 643	–	–	–	–	—	–	1 643
Total for agriculture	7 181	4 047	2 542	992	619	113	9	15 503
Total Australia	8 716	6 687	3 680	1 261	1 424	314	103	22 186

a Net water consumption = mains water use + self-extracted water use – mains water supply. Excluding instream use.

Source: ABS (2000).

Table A.2 **List of regions and their irrigation companies**

Model region	*District irrigation company*
Murrumbidgee	Coleambally Irrigation Murrumbidgee Irrigation West Corurgan Irrigation
Murray	Murray Irrigation Limited Western Murray Irrigation
Mallee	First Mildura Irrigation Trust Sunraysia Rural Water Authority
Goulburn	Goulburn-Murray Water
Ovens Murray	
Loddon Campaspe	
Murray Lands	Central Irrigation Trust Golden Heights Irrigation Trust Renmark Irrigation Trust Sunlands Irrigation Trust

Table A.3 Irrigation scheme entitlements in the southern Murray-Darling Basin, 2001–02

Irrigation company	*Entitlement*
	ML
New South Wales	
Coleambally Irrigation	632 000
Murray Irrigation Limited	1 450 000
Murrumbidgee Irrigation	1 200 000
Western Murray Irrigation	61 000
West Corurgan Irrigation	78 000
Victoria	
First Mildura Irrigation Trust	85 055
Goulburn-Murray Water	1 600 000
Sunraysia Rural Water Authority	301 273
South Australia	
Central Irrigation Trust	120 000
Renmark Irrigation Trust	49 000

Source: Hassall & Associates in association with Musgrave (2002).

Table A.4 Ratios of gross trade in seasonal allocations to total allocations, and trade in entitlements to total allocations

	2000–01	*2001–02*	*2002–03*
	%	%	%
Murrumbidgee Irrigation Area			
Ratio of trade in seasonal allocations to total allocations	18.9	14.2	17.3
Ratio of trade in entitlements to total allocations	0.3	0.6	0.6
Murray Irrigation district			
Ratio of trade in seasonal allocations to total allocations	14.2	6.9	28.6
Ratio of trade in entitlements to total allocations	0.3	0.3	1.4
Goulburn-Murray Water district			
Ratio of trade in seasonal allocations to total allocations	9.7	12.2	18.4
Ratio of trade in entitlements to total allocations	1.7	1.7	2.5
Aggregate			
Ratio of trade in seasonal allocations to total allocations	10.9	11.1	19.5
Ratio of trade in entitlements to total allocations	0.9	0.9	1.8

Data sources: Goulburn-Murray Water, pers. comm., 1 April 2004; MI, pers. comm, 22 December 2003; MIA, pers. comm., 7 April 2004.

Table A.5 **Channel capacity constraints on the River Murray system**

	Daily	*Monthly*
	ML/day	GL/month
Mitta Mitta — Dartmouth to Hume	10 000	304
Murray — Hume to Yarrawonga	25 000	761
Mulwala Canal	10 000	304
Yarrawonga Main Channel	3 106	95
Murray downstream of Yarrawonga:		
(a) June to December (up to)	15 000	457
(b) At other times	10 600	323
Murray upstream of Barmah	8 500	259
National Channel offtake	4 400	134
Edward/Gulpa offtakes:		
(a) June to December	2 350	72
(b) At other times	1 950	59
Edward escape:		
(a) December to March	2 100	64
(b) At other times	2 400	73
Wakool escape	600	18
Yallakool escape	70	2
Edward River downstream of Stevens Weir	2 900	88
Darling River at Weir 32	9 000	274
Lake Victoria inlet	9 000	274
Lake Victoria outlet	9 000	274
Goulburn River — release from Eildon	14 700	447
East Goulburn main offtake	2 600	79
Inlets to Waranga Basin	7 290	222
Outlets from Waranga Basin	6 000	183
Tumut River at Oddys Bridge	9 000	274
Tumut River at Tumut	9 300	283
Murrumbidgee River at Gundagai	3 200	974
Yanco Creek at offtake	1 400	43
Murrumbidgee River upstream of Balranald	10 000	304

Source: MDBC, pers. comm., 7 April 2004.

B Simulations

The size of the economic effects of expanding trade in the southern Murray-Darling Basin (MDB) is estimated by conducting simulations with TERM-Water (see Wittwer 2003). These simulations portray the economy once all changes have occurred in response to a permanent reduction in water availability. This appendix contains an overview of the simulations reported in this paper.

Experimental framework

In the model, an industry in a region uses or consumes exactly what it has been allocated, by way of water. In the database, each industry in each region has water consumption, which is its initial 'endowment' of water. How the industry obtained this quantity of water — whether by entitlements or by trade in allocations — is not considered in the model. What is generated by the model are trades that are stimulated by cuts in water availability. A cut in water availability means an equal cut in consumption of the entity suffering the cut, unless there is trade. In the 'no trade' experiment, no further trade in water is permitted over and above that trade embedded in the database.

Simulations are grouped in sets of three, with each set showing the effects of shocks under each of three possible water trading experiments:

1. no trade — no (further) trade permitted between industries within the same region or between regions (experiment A). Trade is assumed to have occurred among businesses within an industry before the shock, but these prior trades are not reported;
2. intra-regional trade only — trade permitted between industries in the same region, but not between regions (experiment B); and
3. intra- and interregional trade — trade permitted between industries in the same region as well as with other regions in the southern MDB (experiment C).

Irrigation areas are defined in the model along statistical divisions. Trade within an irrigation area is possible among different irrigation activities.

All simulations are comparative static, each comparing a snapshot of the economy without the reduction in water availability with a snapshot of the economy after all adjustments to the lower level of water availability have fed through the economy. Most simulations are long run, allowing capital, labour and land to be re-allocated to varying degrees in response to the modelled changes. Full employment is assumed. Long run simulations also assume that people do not change their residence, but travel to new jobs that might be created in another region. In the end, some might change their residence. The implications of this assumption are that:

- there is no constraint on the movement of labour and therefore labour does not constrain the expansion of more profitable uses of water
- regional gross domestic product is still an accurate measure of production in a region, but some workers might spend their incomes in their region of residence, thus adding to that region's consumption and services activity.

One set of simulations shows the effects in a short run economic environment of a reduction in water availability, with no mobility of capital between industries or regions.

Overall gains from additional trade are indicated by differences between results from the intra- and interregional trade experiment and the no trade experiment.

All of the reported simulations model the effects of either a 10, 20 or 30 per cent reduction in water availability to the southern MDB. In each simulation, the water is permanently removed for use by the agricultural industries and is not re-allocated to any other sector in the model. The water removed is not expliticly valued in the model.

The 10 per cent reduction is used as a reference case for analysis of the sensitivity of the results to changes in the assumptions regarding key model parameters and the distribution of reductions in water availability. The reference case and its alternatives are designed to show how the effects of a proportional cut in water availability for each region of the southern MDB differ when no (further) trade, limited trade or full trade is allowed. Simulations underlying the sensitivity tests are designed to show:

1. how the effects in the reference case differ when the input substitutability of water in the rice industry is the same as that for all other (non-cattle) irrigation industries
2. how the effects in the reference case differ when the input substitutability of water in all irrigation industries increases

3. how the effects the reference case differ when the same overall cut in water availability is not split equi-proportionally across each region of the southern MDB
4. how the effects in the reference case differ from the short run effects (when capital use is fixed).

Simulation details

Table B.1 lists and describes the simulations and indicates the sections and/or appendixes in which the results are presented. Each set of simulations is described in more detail in the next section.

Table B.1 **Simulations reported in this paper**

Simulation set	*Description*	*Location of results*
Proportional cut (10 per cent) in water availability — long run (reference case)	Under three trade experiments (no water trade, intra-regional trades only and intra- and interregional trades), impose a 10 per cent reduction in initial water availability for each industry and region in the southern MDB with capital mobile.	Section 4 and appendix D
Proportional cut (20 per cent) in water availability — long run	Under each of the three trade experiments, impose a 20 per cent reduction in initial water availability for each industry and region in the southern MDB with capital mobile.	Section 4 and appendix D
Proportional cut (30 per cent) in water availability — long run	Under each of the three trade experiments, impose a 30 per cent reduction in initial water availability for each industry and region in the southern MDB with capital mobile.	Section 4 and appendix D
Sensitivity testing — rice industry's SIGTOP	Under each of the three trade experiments, impose a 10 per cent reduction in initial water availability for each industry and region in the southern MDB with increased substitutability of water for other inputs in the rice industry and with capital mobile.	Appendix D
Sensitivity testing — all irrigation industries' SIGTOPs	Under each of the three trade experiments, impose a 10 per cent reduction in initial water availability for each industry and region in the southern MDB with increased substitutability of water for other inputs in all irrigation industries and with capital mobile.	Appendix D
Differential cut in water availability	Under each of the three trade experiments, impose a 10 per cent reduction in initial water availability for the entire southern MDB, but impose the reduction in different proportions for each region with capital mobile.	Appendix D
Proportional cut in water availability — short run	Under each of the three trade experiments, impose a 10 per cent reduction in initial water availability for each industry and region in the southern MDB with capital fixed.	Appendix D

Proportional cut in water availability — long run

The first set of simulations is the reference case and shows the effects of a 10 per cent reduction in water availability for each industry and region in the southern MDB under each of three water trading experiments: no trade, intra-regional trade only and intra- and interregional trade.

Allowing for intra-regional trade means water use does not necessarily equate to pre-trade allocations as industries within a given region of the southern MDB buy and sell water. Water availability for each industry in each region is cut by 10 per cent. Industries in a region are free to trade water and adjust their use. As a result, water use by an industry may decline by more than 10 per cent, decline by less than 10 per cent or even increase according to trade.

With intra- and interregional trade possible, original water availability for each industry and region is reduced by 10 per cent. Irrigation industries are free to trade water with any other irrigation industry in the southern MDB. Depending on trade, total water use in some regions may decline by more than 10 per cent, decline by less than 10 per cent or even increase.

The second and third sets of simulations calculate the (long run) effects of proportional cuts in water availability of 20 and 30 per cent respectively, for each industry and region in the southern MDB under each of the three trading experiments.

SIGTOP sensitivity analysis

SIGTOP is a parameter in the model that represents the input elasticity of irrigation water. It determines the extent to which changes in the relative price of water affect substitution between water and all other inputs (box 3.4).

For all simulations, SIGTOP is assumed to be low, reflecting the importance of irrigation water in production. For simulations in the reference case SIGTOP is set at 0.05 for the meat and dairy cattle industries, to reflect somewhat higher opportunities for substituting other inputs for water (for example, substituting feed grains for irrigated pasture). SIGTOP is set at 0.01 for the rice industry, reflecting the importance of water in rice production. For all other irrigation industries, SIGTOP is set at 0.03.

The fourth and fifth sets of simulations are used to examine the sensitivity of results in the reference case to the choice of SIGTOP value, and are based on uniform cuts to industry and region water availability in the southern MDB under each of the three trading regimes. In the first test, SIGTOP for the rice industry is increased to

0.03 to match that for other non-cattle industries, removing the large difference in water substitutability in rice relative to other industries. The second test is used for more general sensitivity testing for SIGTOP, which is increased to 0.10 for the cattle industries and 0.05 for all other irrigation industries.

Table B.2 **Assumed values for SIGTOP**

Simulation set	*Meat and dairy cattle industries*	*Rice industry*	*All other irrigation industries*
Sensitivity testing — rice industry's SIGTOP	0.05	0.03	0.03
Sensitivity testing — all irrigation industries' SIGTOPs	0.10	0.05	0.05
All other simulations	0.05	0.01	0.03

Differential cut in water availability

The sixth set of simulations shows the effects of a 10 per cent reduction in water availability to irrigators in the southern MDB, with the reduction not split equi-proportionally across all regions. These simulations are used to test the sensitivity of the reference case results to the assumption of equi-proportional cuts in water availability.

The changes in water availability for each region are given in table B.3. For each region, the reduction in availability is based on historical trends in allocations relative to entitlements (table 2.1). For each region, these reductions are spread proportionally across all irrigation industries. Water availability for each industry in the Murrumbidgee region, for example, is reduced by 20 per cent. In total, across the southern MDB, the reductions add up to 10 per cent, so as to match the equi-proportional cut.

Under the no trade regime, water use *by each industry* in each region is reduced. A 25 per cent reduction in water availability for the Murray region in Victoria, for example, means each industry must use 25 per cent less water. This is an involuntary cut.

With intra-regional trade only, total water use *by each region* is reduced by the required proportion to match the region's total water availability. Given that industries in a region can now trade, water use for a particular industry may not decline by the same proportion as the reduction in water use for the region. Although total water use for the Murray region must decline by 25 per cent, for example, water use by some industries in that region may decline by more than

25 per cent as they sell water. That is, the involuntary cuts are modified further by voluntary changes in consumption.

With both intra- and interregional trade possible, the only constraint on water use is that the total *for the southern MDB* declines by 10 per cent — trade determines how the changed water availability translates into use by industries and regions. Although the water availability for each industry in the Murrumbidgee region declines by 20 per cent, for example, water use for the entire region may decline by more than 20 per cent if enough industries sell their smaller quantity of water to industries in other regions.

Table B.3 **Changes in regional water availability**

Region	*Change in water availability*	*Change in water availability*
	%	ML
New South Wales		
Murrumbidgee	–20	–291 368
Murray	–25	–376 065
Victoria		
Mallee	10	59 402
Goulburn	10	89 062
Loddon Campaspe	10	19 191
Ovens Murray	10	7 522
South Australia		
Murray Lands	–3	–9 124
Southern MDB	–10	–501 381

Source: Productivity Commission estimates.

Short run cuts in water availability

In short run simulations, labour is less mobile between industries and regions than in the long run and capital use is fixed in each industry and region.

Additional assumption — no water saving technical change

In the long run, irrigation industries may undergo water saving technical change as water availability to the southern MDB is reduced and industries find new ways to reduce water requirements per unit of output. Such technical change is not included.

Table B.4 **Regions modelled in TERM-Water**

Southern MDB regions	*Other MDB regions*	*Other regions*
Murrumbidgee, New South Wales	Northern New South Wales	Rest of New South Wales
Murray, New South Wales	North west New South Wales	Rest of Victoria
Mallee, Victoria	Far west New South Wales	Rest of Queensland
Loddon Campaspe, Victoria	Darling Downs Queensland	Rest of South Australia
Goulburn, Victoria	South west Queensland	Western Australia
Ovens Murray, Victoria		Tasmania
Murray Lands, South Australia		Northern Territory
		Australian Capital Territory

Source: TERM-Water database.

Table B.5 **Industries and broad sectors modelled in TERM-Water**

Industry[a]	*Broad sector*	*Industry*	*Broad sector*
Sheep	Primary	Beef products	Food processing
Barley	Primary	Other meat products	Food processing
Wheat	Primary	Dairy products	Food processing
Other broadacre	Primary	Fruit processing	Food processing
Beef cattle	Primary	Vegetable processing	Food processing
Dairy cattle	Primary	Flour and cereals	Food processing
Pigs and poultry	Primary	Sugar refining	Food processing
Rice	Primary	Seafood	Food processing
Cotton	Primary	Premium wine	Food processing
Citrus	Primary	Bulk wine	Food processing
Apples and pears	Primary	Other food products	Food processing
Stone fruits	Primary	Woven fibre manufacturing	Manufacturing
Other fruit and nuts	Primary	Other manufacturing	Manufacturing
Premium dry land grapes	Primary	Water, sewerage and drainage services	Services
Premium irrigated grapes	Primary	Utilities	Services
Other grapes (table)	Primary	Construction	Services
Sugarcane	Primary	Trade	Services
Irrigated pasture	Primary	Transport	Services
Vegetables	Primary	Communication services	Services
Other crops	Primary	Banking, financial services and insurance	Services
Agricultural services	Primary	Ownership of dwellings	Services
Forestry	Primary	Other business services	Services
Fishing	Primary	Government, defence, education and health	Services
Mining	Primary	Other services	Services

[a] Industries using irrigation water are shown in bold.

Source: TERM-Water database.

C Examples of regulatory arrangements affecting water trade

This appendix provides examples of the types of regulatory arrangements that can apply to the trading of seasonal allocations and water entitlements within, and between, irrigation districts. Because the Goulburn-Murray region comprises a number of subdistricts, a matrix showing possible trade between subdistricts is included.

Regulatory arrangements in selected districts

This section provides examples of regulatory arrangements affecting trade in the Murray and Lower Darling district, the Murrumbidgee Irrigation Area (MIA), and the Goulburn and Victorian Murray districts.

Table C.1 **Examples of NSW government regulatory arrangements affecting water trading in the Murray and Lower Darling district**

Seasonal allocation trades		*Water entitlement trades*	
Intra-district	*Inter-district*[a]	*Intra-district*	*Inter-district*[a]
• Minor regulations based on environmental conditions	• Transfers can only occur downstream through the Barmah Choke if the water can be supplied from Lake Victoria during peak demand • Trade is prohibited from SA to NSW downstream of the Barmah Choke • Trade may be restricted between the Murray and Murrumbidgee valleys if water availability is low	• Minor regulations based on environmental conditions	• No downstream transfers through the Barmah Choke • Entitlements converted from general to high security cannot be traded for 5 years *Interstate trades* • Only high security water may be traded • Trade restricted to area from Nyah to SA barrages

[a] Trades will only be approved where the ability to supply other users is not significantly diminished and there are no adverse environmental impacts.

Source: DIPNR 2003.

Table C.2 **Examples of utility-specific arrangements affecting water trading in the Murrumbidgee Irrigation Area**

Seasonal allocation trades		*Water entitlement trades*	
Intra-district	*Inter-district*[a]	*Intra-district*	*Inter-district*[a]
• Early close off dates for intention to trade high security water (early August) [b] • Loss of 'bonus' access (eg, to carryover, off-allocation water etc) if there is net trade out of general security water (Valley rule) [c] • Early closing date for trade. Usually end of February [d] • Special regulatory arrangements within the area are related to delivery constraints, metering problems, and certain types of allocation (drainage re-use, "off-allocation", and urban water)	• Once approved for transfer out of the Company licence deliverability is a matter for DIPNR and other agencies involved • Transfers out of licence are subject to a requirement to retain about 25% on farm [e]	• All applications assessed for 3rd party impacts, especially environmental and deliverability impacts • High security — can trade up to 3 ML/ha if hi-tech direct to plant system is installed (without restriction) • High security must keep the greater of 6ML/ha or 25% of farm entitlement [e] • General security — must retain 25% of entitlement on farm [e] • Quantitative limit (4 ML/ha) on transfer of residential supplies [e] • Special regulatory arrangements related to delivery constraints, metering problems, and certain types of allocation (drainage re-use, "off-allocation", and urban water)	• Increased analysis of 3rd party impacts, especially environmental and deliverability impacts (for trades in and out) • High security — net export of up to 1% of high security entitlement plus 3 ML/ha under hi-tech system [f] • Annual limit on net trade out of General security licences equal to 0.5% of total MIA entitlement (about 4600 ML) [f]

[a] Requirements are in addition to those applying within the district. [b] Under review with likelihood that early statement of trade intent will apply to all types of security. [c] Under review with likelihood that losses will relate only to water acquired by the company. [d] Under review with likelihood that intra-valley trade will be extended to season end. [e] Under review with likelihood that all retention limits will be set at 20 per cent of entitlement (to be consistent with the average cap relative to entitlement in the Valley and environmental requirements). [f] Under review with likelihood that limits triggering reviews of socio-economic impacts will be changed.

Source: MIA, pers. comm., 21 April 2004.

Table C.3 **Examples of Victorian Government regulatory arrangements affecting trades in the Goulburn and Victorian Murray districts**

Seasonal allocation trades		*Water entitlement trades*	
Intra-district	*Inter-district*[a]	*Intra-district*	*Inter-district*[a]
• Only first 30 per cent of 'sales' water can be traded which forfeits access to all 'sales' water above 30 per cent • Other minor regulatory arrangements only based on environmental conditions	• GMW tends to replicate the regulation for water entitlements in its rules for trades in seasonal allocations • Transfers to NSW not allowed after February each year	• Prescribes a maximum water entitlement to be attached to each land holding • Imposes a $275 fee on all transfers	• Prevents trade between prescribed subdistricts • Prevents net exports from the 'Murray system' to the 'Goulburn system', and from the 'Goulburn system' to the 'Campaspe' system' • Prescribes a two per cent cap on net exports from most subdistricts • Only annual and permanent transfers allowed

[a] Requirements are in addition to those applying within the district. Also, trades will only be approved where the ability to supply other users is not significantly diminished and there are no adverse environmental impacts.

Source: Water (Permanent Transfer of Water Rights) Regulations 2001 (Victoria).

Water trading across subdistricts in the Goulburn-Murray

Table C.4 below shows which irrigation subdistricts can trade seasonal allocations and entitlements with other subdistricts in the GMW district, and at what exchange rates (as at April 2004). Irrigators in the Greater Goulburn (subdistrict 1A), for example, can sell water to and purchase water from most other subdistricts. In some cases, however, trade may be allowed in only one direction. For example, irrigators in the Greater Goulburn (subdistrict 1A) can purchase water from the Nyah-to-South Australia high impact subdistrict (subdistrict 8H) but not sell water to that subdistrict (because of potential environmental impacts). Limited trade in subdistricts 9A, 9B, 10A and 10B reflect their location above the Barmah Choke which restricts the flow of water.

Table C.4 also illustrates that exchange rates can be asymmetrical. An irrigator in the Murray Irrigation district (subdistrict 10B), for example, who purchases 1 megalitre from an irrigator in the Hume-to-Barmah (New South Wales) subdistrict (10A), will only receive 0.85 megalitres, but if they were to sell 1 megalitre to that subdistrict, then the recipient would receive 1 megalitre.

Table C.4 **Goulburn Murray-Water exchange rate trade matrix for seasonal allocation and entitlement trades[a]**

			Buyer																		
Seller	*Ref.*	*Subdistrict*	*1A*	*1B*	*1C*	*1D*	*1E*	*3*	*4A*	*5A*	*5B*	*6*	*7*	*8H*	*8L4*	*8L3*	*8L2*	*8L1*	*9A*	*9B*	*10A*	*10B*
	1A	Greater Goulburn	1	1	1	1	1	1	1	1	nt	1	1	nt	1	1	1	1	nt	nt	nt	nt
	1B	Boort	1	1	1	1	1	1	1	1	nt	1	1	nt	1	1	1	1	nt	nt	nt	nt
	1C	Pyramid–Boort	1	1	1	1	1	*	*	*	nt	*	*	nt	*	*	*	*	nt	nt	nt	nt
	1D	Rochester	1	1	1	1	1	*	*	*	nt	*	*	nt	*	*	*	*	nt	nt	nt	nt
	1E	Central Goulburn	1	1	1	1	1	*	*	*	nt	*	*	nt	*	*	*	*	nt	nt	nt	nt
	3	Lower Goulburn	1	1	*	*	*	1	1	1	nt	1	1	nt	1	1	1	1	nt	nt	nt	nt
	4A	Campaspe	1	1	*	*	*	1	1	nt	nt	1	1	nt	1	1	1	1	nt	nt	nt	nt
	5A	Loddon	1	1	*	*	*	1	nt	1	nt	1	1	nt	1	1	1	1	nt	nt	nt	nt
	5B	Bullarook	nt	nt	nt	nt	nt	nt	nt	nt	1	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt
	6	Hume to Barmah	1	1	*	*	*	1	1	1	nt	1	1	nt	1	1	1	1	nt	nt	1	0.85
	7	Barmah to Nyah	1	1	*	*	*	1	1	1	nt	1	1	nt	1	1	1	1	nt	nt	1	0.85
	8H	Nyah to SA Border HIZ	1	1	*	*	*	1	1	1	nt	1	1	1	1	1	1	1	nt	nt	1	0.85
	8L4	Nyah to SA Border LIZ4	1	1	*	*	*	1	1	1	nt	1	1	nt	1	1	1	1	nt	nt	1	0.85
	8L3	Nyah to SA Border LIZ3	1	1	*	*	*	1	1	1	nt	1	1	nt	1	1	1	1	nt	nt	1	0.85
	8L2	Nyah to SA Border LIZ2	1	1	*	*	*	1	1	1	nt	1	1	nt	1	1	1	1	nt	nt	1	0.85
	8L1	Nyah to SA Border LIZ1	1	1	*	*	*	1	1	1	nt	1	1	nt	1	1	1	1	nt	nt	1	0.85
	9A	Ovens	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	1	1	nt	nt
	9B	King	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	nt	1	1	nt	nt
	10A	Hume to Barmah (NSW)	nt	nt	nt	nt	nt	nt	nt	nt	nt	1	nt	nt	nt	nt	nt	nt	nt	nt	1	0.85
	10B	Murray Irrigation Limited	nt	nt	nt	nt	nt	nt	nt	nt	nt	1	nt	nt	nt	nt	nt	nt	nt	nt	1	1

a 1 means trade may be permitted at an exchange rate of 1, 0.85 means trade may be permitted but at an exchange rate of 0.85, nt means no trade permitted, * means asymmetries in trading rules (for example, rules whereby one subdistrict can buy from/sell to another subdistrict, but the latter subdistrict is not permitted to sell to/buy from the former). Asymmetries affecting subdistricts 1B, 1C, 1D and 1E occur because they have reached their 2 per cent cap on net exports for 2004 and only imports are allowed. Note that additional regulations can apply and these need to be considered on application (see Watermove 2004).

Source: Watermove 2004.

D Data tables and simulation results

Table D.1 **Industry contributions to gross regional product**

	Murrumbidgee	*Murray*	*Mallee*	*Goulburn*	*Loddon Campaspe*	*Ovens Murray*	*Murray Lands*
	%	%	%	%	%	%	%
Broad sectors							
Primary	17.30	19.09	28.08	15.29	7.20	6.44	27.07
Food processing	15.32	12.02	18.62	18.23	8.76	13.06	24.68
Manufacturing	7.15	10.01	3.78	11.24	18.09	16.97	4.71
Services	60.23	58.87	49.51	55.24	65.95	63.54	43.54
Total	100	100	100	100	100	100	100
Primary							
Sheep	2.20	2.26	1.46	1.20	1.30	0.40	1.61
Barley	0.66	0.61	2.36	0.08	0.18	–	1.52
Wheat	2.92	2.24	3.70	0.33	0.55	0.06	1.85
Other broadacre	1.71	2.22	0.24	0.16	0.10	0.04	0.20
Beef cattle	0.83	0.99	0.54	1.53	0.29	1.44	0.44
Dairy cattle	0.11	1.21	2.12	5.08	0.43	1.49	1.48
Pigs and poultry	0.32	1.29	0.76	0.52	1.07	0.13	1.22
Rice	1.74	2.91	0.01	0.03	–	–	–
Cotton	–	–	–	–	–	–	–
Citrus	1.32	0.85	1.78	0.07	–	–	3.90
Apples and pears	0.53	0.07	–	2.15	0.24	0.29	0.13
Stone fruits	0.45	0.05	0.61	0.87	–	0.13	2.23
Other fruit and nuts	0.50	0.58	3.26	0.05	–	0.11	2.66
Premium dryland grapes	–	–	–	0.04	0.01	0.10	–
Premium irrigated grapes	0.82	0.44	2.64	0.01	–	0.09	3.57
Multi-grape	–	0.54	3.66	0.01	–	–	0.22
Sugarcane	–	–	–	–	–	–	–
Irrigated pasture	0.09	0.17	0.16	0.37	0.13	0.13	0.10
Vegetables	0.53	0.51	1.29	0.43	0.18	–	2.52
Other crops	0.95	0.61	1.18	0.40	0.26	0.69	0.71
Agricultural services	1.02	1.10	1.58	0.93	0.36	0.37	1.50
Forestry	0.33	0.33	0.16	0.19	0.14	0.53	0.04
Fishing	0.01	0.01	0.04	0.25	0.02	0.09	0.44
Mining	0.25	0.10	0.54	0.61	1.93	0.35	0.73

(Continued next page)

Table D.1 (continued)

	Murrumbidgee	*Murray*	*Mallee*	*Goulburn*	*Loddon Campaspe*	*Ovens Murray*	*Murray Lands*
	%	%	%	%	%	%	%
Food processing							
Beef products	2.35	0.71	0.20	0.54	1.96	0.78	1.56
Other meat products	2.25	0.69	0.19	0.50	1.76	0.73	1.31
Dairy products	0.67	1.25	1.66	7.77	1.30	1.04	2.57
Fruit processing	0.85	0.22	1.47	2.73	0.04	0.14	0.44
Vegetable processing	0.89	0.29	1.50	3.10	0.22	0.25	0.45
Flour, cereals	2.96	4.55	–	0.43	0.39	3.78	0.25
Sugar refining	0.39	0.68	0.31	0.29	0.45	0.36	0.22
Seafood	0.20	0.45	0.21	0.29	0.38	0.50	0.47
Premium wine	1.99	1.04	5.69	0.27	0.05	0.93	8.13
Bulk wine	0.68	0.51	3.72	–	–	–	6.47
Other food products	2.09	1.64	3.68	2.32	2.21	4.56	2.80
Manufacturing							
Fibre, woven	0.64	0.50	–	0.36	1.00	3.80	–
Other manufacturing	6.51	9.51	3.78	10.88	17.09	13.17	4.71
Services							
Water drains	1.51	1.87	2.68	2.22	1.13	1.29	2.06
Utilities	1.41	1.05	0.49	0.84	1.16	3.43	0.85
Construction	5.20	5.26	3.93	5.11	6.09	5.29	3.76
Trade	15.84	17.80	15.98	15.48	16.03	15.28	14.37
Transport	5.20	4.68	3.78	4.86	6.18	3.67	3.60
Communication services	1.63	1.33	1.22	1.59	3.19	1.58	1.34
Banking and finance, insurance	2.46	2.54	2.00	2.31	3.78	2.32	1.71
Owner dwelling	6.00	6.07	4.25	4.61	5.42	4.64	3.88
Business services	6.93	6.04	4.34	4.81	6.89	5.80	2.44
Government defence, education, health	11.34	9.55	8.18	10.24	11.31	16.36	6.69
Other services	2.71	2.68	2.67	3.17	4.78	3.89	2.84

Source: TERM-Water database.

Table D.2 Industry contributions to regional water use in the southern Murray-Darling Basin

	Murrumbidgee	*Murray*	*Mallee*	*Goulburn*	*Loddon Campaspe*	*Ovens Murray*	*Murray Lands*	***Total***
	%	%	%	%	%	%	%	%
Sheep	10.0	7.0	10.9	3.0	20.8	–	2.2	7.8
Other broadacre	14.4	12.8	0.5	1.2	9.1	0.1	0.5	8.7
Beef cattle	5.7	4.3	5.1	13.5	10.8	12.1	1.8	6.6
Dairy cattle	0.8	7.4	39.3	63.4	22.9	62.3	19.8	21.4
Rice	49.0	58.1	0.1	0.7	–	–	–	31.8
Citrus	2.2	1.0	3.0	0.2	–	–	13.5	2.1
Apples and pears	0.9	0.1	–	5.2	2.4	3.7	0.5	1.4
Stone fruits	0.8	0.1	1.0	2.1	–	1.6	7.8	1.2
Other fruit and nuts	0.8	0.7	5.6	0.1	–	1.5	9.3	1.7
Premium dryland grapes	–	–	–	0.5	1.0	3.2	–	0.2
Premium irrigated grapes	4.2	1.1	10.9	0.3	–	8.3	32.5	5.0
Other grapes (table grapes)	–	1.4	15.1	0.2	–	–	2.0	2.4
Irrigated pasture	0.7	1.1	2.9	4.6	7.1	5.4	1.4	2.1
Vegetables	2.5	1.5	3.1	1.9	2.2	–	7.2	2.4
Other crops	8.0	3.5	2.6	3.1	23.8	1.8	1.6	5.3
Total	100	100	100	100	100	100	100	100

Source: TERM-Water database.

Table D.3 Price rises in southern Murray-Darling Basin regions

After a 10 per cent reduction in water availability

	Intra-regional trade only	*Intra- and interregional trade*
	$/ML	$/ML
New South Wales		
Murrumbidgee	31	41
Murray	30	41
Victoria		
Mallee	74	41
Goulburn	70	41
Loddon Campaspe	90	41
Ovens Murray	128	41
South Australia		
Murray Lands	153	41

Source: TERM-Water simulations.

Table D.4 **Change in industry output under different experiments**

After 10 per cent reduction in water availability. Intra- and interregional trade (intra-regional trade only)

	Murrumbidgee	*Murray*	*Mallee*	*Goulburn*	*Loddon Campaspe*	*Ovens Murray*	*Murray Lands*	***Southern MDB***
	%	%	%	%	%	%	%	%
Broad sectors								
Primary	–3.15 (–2.24)	–4.11 (–2.84)	–0.8 (–1.38)	–1.38 (–3.12)	–1.06 (–1.81)	–0.42 (–1.63)	–0.52 (–2.33)	–1.91 (–2.29)
Food processing	–0.07 (–0.13)	–0.11 (–0.14)	–0.3 (–0.58)	–0.62 (–1.38)	–0.31 (–0.53)	–0.2 (–0.36)	–0.44 (–1.2)	–0.32 (–0.69)
Manufacturing	0.07 (0.07)	0.02 (0.04)	0.02 (0.02)	0.03 (0.03)	0.02 (0.02)	0.03 (0.04)	0.02 (–0.03)	0.03 (0.03)
Services	–0.48 (–0.35)	–0.68 (–0.49)	–0.22 (–0.38)	–0.18 (–0.41)	–0.05 (–0.09)	–0.02 (–0.07)	–0.15 (–0.55)	–0.27 (–0.32)
Primary								
Sheep	–2.09 (–1.50)	–2 (–1.38)	–2.5 (–4.62)	–0.51 (–1.21)	–1.07 (–1.88)	0.1 (0.11)	–0.21 (–0.99)	–1.48 (–1.72)
Barley	0.11 (0.09)	0.11 (0.09)	0.05 (0.06)	0 (–0.03)	0.01 (0)	0 (0)	0.02 (0.06)	0.06 (0.06)
Wheat	0.12 (0.11)	0.13 (0.11)	0.06 (0.09)	0.01 (–0.01)	0.04 (0.05)	0.04 (0.06)	0.05 (0.07)	0.09 (0.09)
Other broadacre	–2.70 (–1.92)	–2.55 (–1.73)	0.05 (–0.49)	–0.95 (–2.99)	–5.86 (–11.05)	0.55 (0.26)	0.2 (–0.98)	–2.42 (–1.99)
Beef cattle	–3.20 (–2.16)	–2.84 (–1.82)	–3.13 (–5.77)	–2.17 (–4.96)	–2.79 (–4.82)	–0.14 (–0.81)	–0.71 (–3.13)	–2.14 (–3.3)
Dairy cattle	–3.89 (–1.82)	–4.49 (–2.14)	–7.6 (–13.89)	–3.24 (–7.23)	–4.43 (–7.35)	–1.56 (–5.59)	–2.99 (–12.71)	–3.79 (–7.78)
Pigs and poultry	0.10 (0.07)	0.09 (0.06)	0.02 (0)	0.03 (0.05)	–0.02 (–0.04)	0 (–0.01)	0 (0.03)	0.03 (0.02)
Rice	–21.64 (–16.6)	–19.5 (–14.2)	–0.63 (–16.62)	1.78 (–20.28)	0 (0)	0 (0)	0 (0)	–20.26 (–15.34)
Citrus	–0.52 (–0.15)	–0.49 (–0.12)	–0.32 (–0.57)	–0.38 (–0.89)	0 (0)	0 (0)	–0.6 (–2.56)	–0.5 (–1.1)
Apples and pears	–0.5 (–0.18)	–0.48 (–0.15)	0 (0)	–0.37 (–0.87)	–0.51 (–0.84)	–0.36 (–1.3)	–0.56 (–2.38)	–0.4 (–0.8)
Stone fruits	–0.44 (0.06)	–0.42 (0.11)	–0.25 (–0.3)	–0.31 (–0.61)	0 (0)	–0.29 (–1.06)	–0.5 (–2.16)	–0.39 (–0.99)
Other fruit and nuts	–0.54 (–0.2)	–0.5 (–0.14)	–0.34 (–0.57)	–0.4 (–0.88)	0 (0)	–0.37 (–1.31)	–0.6 (–2.46)	–0.45 (–1.02)

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Table D.4 (continued)

	Murrumbidgee	*Murray*	*Mallee*	*Goulburn*	*Loddon Campaspe*	*Ovens Murray*	*Murray Lands*	***Southern MDB***
	%	%	%	%	%	%	%	%
Premium dryland grapes	0 (0)	0 (0)	0 (0)	–3.2 (–7.15)	–10.8 (–19.5)	–1.5 (–4.65)	0 (0)	–2.85 (–6.7)
Premium irrigated grapes	–1.07 (1.07)	–0.33 (1.71)	–0.02 (0.5)	–9.71 (–22.56)	0 (0)	–2.96 (–10.97)	–0.79 (–4.73)	–0.57 (–1.35)
Multi-grape	0 (0)	–1.4 (–0.72)	–1.05 (–1.93)	–11.3 (–26.76)	0 (0)	0 (0)	–1.85 (–7.64)	–1.16 (–2.02)
Irrigated pasture	–3.33 (–1.85)	–3.72 (–1.99)	–6.21 (–11.42)	–2.72 (–6.19)	–3.49 (–5.91)	–1.25 (–4.57)	–2.59 (–10.96)	–3.21 (–5.81)
Vegetables	–1.98 (–1.35)	–1.79 (–1.15)	–0.59 (–1.09)	–0.9 (–2.06)	–0.71 (–1.21)	0 (0)	–0.48 (–2.04)	–0.95 (–1.59)
Other crops	–4 (–2.82)	–3.77 (–2.56)	–0.41 (–0.88)	–1.68 (–3.92)	–7.57 (–13.32)	0.12 (–0.04)	–0.27 (–1.52)	–2.33 (–2.73)
Agricultural services	–0.36 (–0.37)	–0.4 (–0.45)	–0.33 (–0.51)	–0.36 (–0.64)	–0.37 (–0.6)	–0.17 (–0.33)	–0.29 (–0.66)	–0.35 (–0.52)
Forestry	0.12 (0.11)	0.11 (0.08)	–0.04 (–0.1)	–0.06 (–0.18)	–0.01 (–0.04)	0.03 (0.03)	0.01 (–0.03)	0.04 (0.01)
Fishing	0.18 (0.15)	0.19 (0.16)	0.07 (0.1)	0.1 (0.18)	0.04 (0.06)	0.04 (0.05)	0.01 (0.04)	0.06 (0.12)
Mining	0.38 (0.34)	0.47 (0.4)	0.21 (0.29)	0.2 (0.32)	0.13 (0.17)	0.12 (0.16)	0.17 (0.29)	0.18 (0.24)
Food processing								
Beef products	–0.55 (–0.55)	–0.63 (–0.52)	–0.69 (–1.26)	–0.45 (–0.98)	–0.34 (–0.57)	–0.14 (–0.33)	–0.24 (–0.49)	–0.43 (–0.59)
Other meat products	0 (0.01)	–0.05 (–0.03)	–0.16 (–0.3)	–0.02 (–0.05)	–0.07 (–0.11)	0 (0.01)	–0.01 (–0.02)	–0.03 (–0.04)
Dairy products	–0.43 (–0.76)	–1.48 (–1.26)	–2.64 (–4.98)	–1.4 (–3.09)	–1.05 (–1.91)	–0.71 (–2.05)	–1.21 (–4.46)	–1.38 (–2.97)
Fruit processing	0.17 (0.11)	0.14 (0.09)	0.02 (0.01)	0.01 (0.04)	–0.01 (–0.03)	–0.04 (–0.09)	–0.05 (–0.19)	0.04 (0.04)
Vegetable processing	0.24 (0.17)	0.12 (0.09)	0.13 (0.14)	0.1 (0.15)	–0.35 (–0.47)	–0.08 (–0.06)	0.07 (0.04)	0.11 (0.13)
Flour, cereals	0.04 (0)	0.05 (0.01)	0 (0)	–0.29 (–0.48)	–0.34 (–0.37)	–0.21 (–0.17)	–0.26 (–0.28)	–0.05 (–0.07)
Sugar refining	0.14 (0.1)	0.17 (0.14)	0.03 (0.05)	0.01 (0.02)	–0.02 (–0.03)	–0.02 (–0.03)	–0.02 (–0.02)	0.05 (0.04)
Seafood	0.18 (0.13)	0.17 (0.14)	0.04 (0.05)	0.04 (0.08)	–0.07 (–0.12)	–0.01 (0.01)	0.02 (0.08)	0.05 (0.05)

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Table D.4 (continued)

	Murrumbidgee	*Murray*	*Mallee*	*Goulburn*	*Loddon Campaspe*	*Ovens Murray*	*Murray Lands*	***Southern MDB***
	%	%	%	%	%	%	%	%
Premium wine	–0.18 (–0.42)	–0.07 (–0.44)	–0.23 (–0.54)	–0.54 (–1.1)	–0.78 (–1.52)	–0.58 (–1.4)	–0.39 (–1.21)	–0.29 (–0.8)
Bulk wine	–0.11 (0.07)	0.05 (0.05)	–0.1 (–0.08)	0 (0)	0 (0)	0 (0)	–0.29 (–0.98)	–0.18 (–0.47)
Other food products	0.14 (0.12)	–0.03 (–0.01)	–0.14 (–0.2)	–0.38 (–0.88)	–0.18 (–0.32)	–0.06 (–0.13)	–0.95 (–0.84)	–0.2 (–0.33)
Manufacturing								
Fibre, woven	–0.26 (–0.17)	–0.16 (–0.09)	0 (0)	0 (–0.02)	–0.15 (–0.26)	0 (0.04)	0 (0)	–0.08 (–0.07)
Other manufacturing	0.09 (0.09)	0.03 (0.05)	0.02 (0.02)	0.03 (0.03)	0.03 (0.03)	0.04 (0.04)	0.02 (–0.03)	0.04 (0.04)
Services								
Water drains	–1.03 (–0.79)	–1.53 (–1.13)	–0.28 (–0.35)	–0.2 (–0.37)	–0.11 (–0.15)	–0.09 (–0.16)	–0.2 (–0.35)	–0.51 (–0.5)
Utilities	–0.27 (–0.2)	–0.49 (–0.33)	–0.3 (–0.54)	–0.24 (–0.54)	–0.05 (–0.1)	–0.01 (–0.03)	–0.16 (–0.63)	–0.15 (–0.21)
Construction	–0.5 (–0.39)	–0.7 (–0.59)	–0.26 (–0.44)	–0.29 (–0.55)	–0.09 (–0.12)	–0.13 (–0.16)	–0.13 (–0.44)	–0.32 (–0.38)
Trade	–0.67 (–0.49)	–0.76 (–0.55)	–0.28 (–0.5)	–0.23 (–0.54)	–0.08 (–0.14)	–0.03 (–0.11)	–0.2 (–0.69)	–0.35 (–0.43)
Transport	–0.77 (–0.57)	–1.25 (–0.89)	–0.35 (–0.64)	–0.27 (–0.61)	–0.06 (–0.12)	–0.08 (–0.22)	–0.25 (–0.89)	–0.45 (–0.52)
Communication services	–0.45 (–0.32)	–0.61 (–0.42)	–0.26 (–0.48)	–0.22 (–0.51)	–0.06 (–0.1)	–0.02 (–0.09)	–0.15 (–0.62)	–0.23 (–0.31)
Banking and finance, insurance	–0.52 (–0.37)	–0.7 (–0.48)	–0.22 (–0.4)	–0.2 (–0.47)	–0.06 (–0.11)	–0.01 (–0.08)	–0.13 (–0.57)	–0.28 (–0.33)
Owner dwelling	–0.82 (–0.58)	–1.15 (–0.77)	–0.33 (–0.61)	–0.3 (–0.72)	–0.09 (–0.16)	–0.02 (–0.13)	–0.24 (–1.04)	–0.49 (–0.56)
Business services	–0.44 (–0.32)	–0.58 (–0.4)	–0.2 (–0.36)	–0.15 (–0.36)	–0.05 (–0.09)	–0.02 (–0.07)	–0.12 (–0.48)	–0.25 (–0.28)
Government defence, education, health	–0.05 (–0.03)	–0.08 (–0.05)	–0.04 (–0.08)	–0.03 (–0.07)	0 (0)	0.01 (0)	–0.02 (–0.11)	–0.03 (–0.04)
Other services	–0.22 (–0.16)	–0.33 (–0.22)	–0.1 (–0.18)	–0.1 (–0.22)	–0.03 (–0.05)	–0.01 (–0.04)	–0.07 (–0.27)	–0.12 (–0.15)

Source: TERM-Water simulations.

Table D.5 **Decomposition of GRP impact by broad sector**

After a 10 per cent reduction in water availability

	Contribution to decline in GRP				
	Primary	*Food processing*	*Other Manufacturing*	*Services*	*Water sales*
	%	%	%	%	%
Intra- and interregional trade					
New South Wales					
Murrumbidgee	79.9	0.7	–0.4	41.1	–21.2
Murray	80.8	0.7	–0.1	40.2	–21.5
Victoria					
Mallee	63.5	7.7	–0.1	29.1	–0.2
Goulburn	56.5	13.9	–0.6	30.2	–0.1
Loddon Campaspe	59.4	10.5	–2.1	32.2	0.0
Ovens Murray	49.5	26.1	–5.9	30.3	0.0
South Australia					
Murray Lands	54.6	21.1	–0.2	24.6	–0.1
Southern MDB	72.2	5.3	–0.4	36.5	–13.5
Intra-regional trade only					
New South Wales					
Murrumbidgee	73.3	1.7	–0.6	38.4	–12.8
Murray	72.7	1.2	–0.3	37.1	–10.7
Victoria					
Mallee	66.5	9.0	–0.1	31.5	–6.9
Goulburn	57.0	13.8	–0.2	30.9	–1.6
Loddon Campaspe	59.9	10.6	–1.1	33.4	–2.8
Ovens Murray	59.0	14.9	–2.4	29.7	–1.2
South Australia					
Murray Lands	63.4	14.9	0.1	23.7	–2.0
Southern MDB	65.2	8.7	–0.3	32.6	–6.1

Source: TERM-Water simulations.

Table D.6 GRP and GDP effects of a non-proportional reduction in water availability under different trade experiments[a]

	No water trade [b]	Intra-regional trade only [c]	Intra- and interregional trade [d]	Relative effects of moving from no trade to allowing intra-regional trade only [e]	Relative effects of moving from intra-regional trade only to allowing interregional trade [f]
	%	%	%	%	%
New South Wales					
Murrumbidgee	–2.93	–1.54	–0.99	47	36
	(–1.29)	(–0.66)	(–0.87)	(49)	(–32)
Murray	–4.42	–2.62	–1.41	41	46
	(–1.52)	(–0.90)	(–1.21)	(41)	(–35)
Victoria					
Mallee	0.79	0.61	–0.16	–23	–127
	(–1.39)	(–0.71)	(–0.41)	(49)	(42)
Goulburn	0.61	0.59	–0.20	–2	–134
	(–1.07)	(–0.90)	(–0.39)	(16)	(56)
Loddon Campaspe	0.18	0.18	–0.07	0	–139
	(–0.30)	(–0.22)	(–0.13)	(25)	(42)
Ovens Murray	0.07	0.09	–0.03	25	–130
	(–0.24)	(–0.19)	(–0.06)	(22)	(70)
South Australia					
Murray Lands	–0.29	–0.31	–0.29	–8	6
	(–1.50)	(–1.18)	(–0.30)	(21)	(75)
Southern MDB	–0.95	–0.45	–0.48	52	–6
	(–1.04)	(–0.67)	(–0.52)	(35)	(23)
Australia	–0.014	–0.009	–0.003	38	65
	(–0.008)	(–0.006)	(–0.004)	(31)	(22)

[a] GRP and GDP include market sales of water. Purchases of water are treated as an input cost. The non-proportion reduction in water availability involved the same volume of water (500 GL) as the uniform 10 per cent reduction experiment, but was allocated as: Murrumbidgee –20 per cent; Murray –25 per cent; northern Victorian regions +10 per cent; Murray Lands –3 per cent. Figures in parentheses are results for the reference case. [b] No water trade permitted between industries within the same region or between regions. [c] Trade permitted between industries in the same region, but not between regions. [d] Trade permitted between industries in the same region as well as with other regions in the southern MDB. [e] Proportional difference between the first and second columns. [f] Proportional difference between the second and third columns.

Source: TERM-Water simulations.

Table D.7 GRP and GDP effects of increased SIGTOP (rice industry) under different trade experiments[a]

	No water trade [b]	*Intra-regional trade only* [c]	*Intra- and interregional trade* [d]	*Relative effects of moving from no trade to allowing intra-regional trade only* [e]	*Relative effects of moving from intra-regional trade only to allowing interregional trade* [f]
	%	%	%	%	%
New South Wales					
Murrumbidgee	–1.26	–0.60	–0.81	52	–35
	(–1.29)	(–0.66)	(–0.87)	(49)	(–32)
Murray	–1.47	–0.81	–1.12	45	–38
	(–1.52)	(–0.90)	(–1.21)	(41)	(–35)
Victoria					
Mallee	–1.39	–0.71	–0.39	49	45
	(–1.39)	(–0.71)	(–0.41)	(49)	(42)
Goulburn	–1.07	–0.90	–0.38	16	58
	(–1.07)	(–0.90)	(–0.39)	(16)	(56)
Loddon Campaspe	–0.30	–0.22	–0.12	25	45
	(–0.30)	(–0.22)	(–0.13)	(25)	(42)
Ovens Murray	–0.24	–0.19	–0.05	22	72
	(–0.24)	(–0.19)	(–0.06)	(22)	(70)
South Australia					
Murray Lands	–1.50	–1.18	–0.28	21	76
	(–1.50)	(–1.18)	(–0.30)	(21)	(75)
Southern MDB	–1.02	–0.65	–0.48	37	26
	(–1.04)	(–0.67)	(–0.52)	(35)	(23)
Australia	–0.008	–0.005	–0.004	34	26
	(–0.008)	(–0.006)	(–0.004)	(31)	(22)

a GRP and GDP include market sales of water. Purchases of water are treated as an input cost. The value of SIGTOP for the rice industry was increased from 0.01 to 0.03. Figures in parentheses are results for the reference case. **b** No water trade permitted between industries within the same region or between regions. **c** Trade permitted between industries in the same region, but not between regions. **d** Trade permitted between industries in the same region as well as with other regions in the southern MDB. **e** Proportional difference between the first and second columns. **f** Proportional difference between the second and third columns.

Source: TERM-Water simulations.

Table D.8 GRP and GDP effects of increased SIGTOP (all industries) under different trade experiments[a]

	No water trade [b]	*Intra-regional trade only* [c]	*Intra- and interregional trade* [d]	*Relative effects of moving from no trade to allowing intra-regional trade only* [e]	*Relative effects of moving from intra-regional trade only to allowing interregional trade* [f]
	%	%	%	%	%
New South Wales					
Murrumbidgee	–0.95	–0.52	–0.67	45	–28
	(–1.29)	(–0.66)	(–0.87)	(49)	(–32)
Murray	–1.13	–0.70	–0.93	38	–33
	(–1.52)	(–0.90)	(–1.21)	(41)	(–35)
Victoria					
Mallee	–0.88	–0.53	–0.32	39	40
	(–1.39)	(–0.71)	(–0.41)	(49)	(42)
Goulburn	–0.69	–0.59	–0.30	14	49
	(–1.07)	(–0.90)	(–0.39)	(16)	(56)
Loddon Campaspe	–0.22	–0.18	–0.10	19	43
	(–0.30)	(–0.22)	(–0.13)	(25)	(42)
Ovens Murray	–0.13	–0.11	–0.04	19	60
	(–0.24)	(–0.19)	(–0.06)	(22)	(70)
South Australia					
Murray Lands	–0.91	–0.78	–0.24	14	70
	(–1.50)	(–1.18)	(–0.30)	(21)	(75)
Southern MDB	–0.71	–0.49	–0.40	31	18
	(–1.04)	(–0.67)	(–0.52)	(35)	(23)
Australia	–0.005	–0.004	–0.003	31	17
	(–0.008)	(–0.006)	(–0.004)	(31)	(22)

a GRP and GDP include market sales of water. Purchases of water are treated as an input cost. The value of SIGTOP was set at 0.10 for cattle industries and 0.05 for all other industries. Figures in parentheses are results for the reference case. **b** No water trade permitted between industries within the same region or between regions. **c** Trade permitted between industries in the same region, but not between regions. **d** Trade permitted between industries in the same region as well as with other regions in the southern MDB. **e** Proportional difference between the first and second columns. **f** Proportional difference between the second and third columns.

Source: TERM-Water simulations.

Table D.9 GRP and GDP effects in the short run under different trade experiments[a]

	No water trade [b]	*Intra-regional trade only* [c]	*Intra- and interregional trade* [d]	*Relative effects of moving from no trade to allowing intra-regional trade only* [e]	*Relative effects of moving from intra-regional trade only to allowing interregional trade* [f]
	%	%	%	%	%
New South Wales					
Murrumbidgee	–0.94	–0.62	–0.65	34	–5
	(–1.29)	(–0.66)	(–0.87)	(49)	(–32)
Murray	–1.12	–0.80	–0.89	28	–11
	(–1.52)	(–0.90)	(–1.21)	(41)	(–35)
Victoria					
Mallee	–0.96	–0.50	–0.44	48	10
	(–1.39)	(–0.71)	(–0.41)	(49)	(42)
Goulburn	–0.72	–0.59	–0.43	18	28
	(–1.07)	(–0.90)	(–0.39)	(16)	(56)
Loddon Campaspe	–0.22	–0.16	–0.14	26	13
	(–0.30)	(–0.22)	(–0.13)	(25)	(42)
Ovens Murray	–0.16	–0.13	–0.07	21	47
	(–0.24)	(–0.19)	(–0.06)	(22)	(70)
South Australia					
Murray Lands	–0.97	–0.75	–0.30	22	60
	(–1.50)	(–1.18)	(–0.30)	(21)	(75)
Southern MDB	–0.73	–0.51	–0.44	30	13
	(–1.04)	(–0.67)	(–0.52)	(35)	(23)
Australia	–0.047	–0.031	–0.027	34	14
	(–0.008)	(–0.006)	(–0.004)	(31)	(22)

a GRP and GDP include market sales of water. Purchases of water are treated as an input cost. Figures in parentheses are results for the reference case. **b** No water trade permitted between industries within the same region or between regions. **c** Trade permitted between industries in the same region, but not between regions. **d** Trade permitted between industries in the same region as well as with other regions in the southern MDB. **e** Proportional difference between the first and second columns. **f** Proportional difference between the second and third columns.

Source: TERM-Water simulations.

Table D.10 **GRP and GDP effects of a 20 per cent reduction in water availability under different trade experiments[a]**

	No water trade [b]	*Intra-regional trade only* [c]	*Intra- and interregional trade* [d]	*Relative effects of moving from no trade to allowing intra-regional trade only* [e]	*Relative effects of moving from intra-regional trade only to allowing interregional trade* [f]
	%	%	%	%	%
New South Wales					
Murrumbidgee	–3.02	–1.45	–1.92	52	–32
Murray	–3.48	–1.98	–2.65	43	–34
Victoria					
Mallee	–3.67	–1.57	–0.98	57	38
Goulburn	–2.63	–2.09	–0.94	21	55
Loddon Campaspe	–0.70	–0.49	–0.31	30	36
Ovens Murray	–0.66	–0.46	–0.13	30	72
South Australia					
Murray Lands	–4.08	–2.89	–0.70	29	76
Southern MDB	–2.55	–1.53	–1.17	40	24
Australia	–0.027	–0.017	–0.012	36	30

a GRP and GDP include market sales of water. Purchases of water are treated as an input cost. Water availability reduced by 20 per cent in all regions of the southern MDB. **b** No water trade permitted between industries within the same region or between regions. **c** Trade permitted between industries in the same region, but not between regions. **d** Trade permitted between industries in the same region as well as with other regions in the southern MDB. **e** Proportional difference between the first and second columns. **f** Proportional difference between the second and third columns.

Source: TERM-Water simulations.

Table D.11 GRP and GDP effects of a 30 per cent reduction in water availability under different trade experiments[a]

	No water trade [b]	*Intra-regional trade only* [c]	*Intra- and interregional trade* [d]	*Relative effects of moving from no trade to allowing intra-regional trade only* [e]	*Relative effects of moving from intra-regional trade only to allowing interregional trade* [f]
	%	%	%	%	%
New South Wales					
Murrumbidgee	–5.11	–2.45	–3.23	52	–32
Murray	–5.78	–3.30	–4.42	43	–34
Victoria					
Mallee	–6.64	–2.59	–1.78	61	31
Goulburn	–4.57	–3.54	–1.72	22	52
Loddon Campaspe	–1.18	–0.78	–0.58	34	26
Ovens Murray	–1.26	–0.81	–0.24	36	71
South Australia					
Murray Lands	–7.48	–4.99	–1.27	33	75
Southern MDB	–4.43	–2.58	–2.02	42	22
Australia	–0.059	–0.036	–0.024	39	32

a GRP and GDP include market sales of water. Purchases of water are treated as an input cost. Water availability reduced by 30 per cent in all regions of the southern MDB. **b** No water trade permitted between industries within the same region or between regions. **c** Trade permitted between industries in the same region, but not between regions. **d** Trade permitted between industries in the same region as well as with other regions in the southern MDB. **e** Proportional difference between the first and second columns. **f** Proportional difference between the second and third columns.

Source: TERM-Water simulations.

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