Maximising returns from water in the Australian vegetable industry: Victoria

Murat Top and Bill Ashcroft

March 2005

State Government Victoria Department of Primary Industries

HAL Know-how for Horticulture™

AUSVEG

This project is facilitated by Horticulture Australia Limited (HAL) in partnership with AUSVEG and is funded by the National Vegetable levy. The Australian Government provides matched funding for all HAL's research and development activities.

Maximising returns from water in the Australian vegetable industry: Victoria

Authors: Murat Top and Bill Ashcroft

Published by NSW Department of Primary Industries

ISBN 0 7347 1723 7

First published August 2006

For updates to this publication, and for other reports (national and state) which are part of this AUSVEG project, see http://www.ausveg.org.au/

Note that some references within this report are to information and research generated by NSW Agriculture. NSW Agriculture became part of NSW Department of Primary Industries on 1 July 2004.

Disclaimer

jn 6648

CONTENTS

EXECUTIVE SUMMARY

This report is one in a series on vegetable industry water use at state and national levels, and has been funded by Horticulture Australia Ltd (HAL) and AUSVEG. This series outlines how water is used in the major vegetable production regions in Australia, and details the current irrigation practices, water use efficiencies and economics of the vegetable-growing industries in each state.

The vegetable sector is the largest segment of the horticultural industry in Australia. The most recent ABS survey (2000/01) revealed the vegetable industry had a gross value of around $ 2.1 billion, derived from some 2.9 million tonnes of produce. Export value of Australian fresh and processed vegetable products in 2004/05 was in excess of $192 million. The major crop types are potatoes (1.2 million tonnes from 36,800 ha), tomatoes (414,000 tonnes from 8,300 ha), carrots (283,000 tonnes from 7,000 ha) and onions (247,000 tonnes from 5,300 ha).

The 2000/01 ABS survey reported 5,300 vegetable establishments (with estimated value of agricultural operations worth $5,000 or more) Australia wide, employing 15,621 people directly. The industry is comprised mainly of single unit farming families, who generally specialise in vegetable production. Average farm size is about 25 hectares, from which produce worth $230,000 per annum at first point of sale is generated.

The 2005 ABS report 'Water Use on Australian Farms' stated that in 2002/03, the vegetable industry accounted for 439,229 ML or just 4.2 % of the total water used for irrigation. The report also estimated that average water use per hectare was 3.9ML/ha, compared to the estimated overall application rate for water across all crops of 4.4 ML/ha. The value return from vegetable production per ML increased from $1,762/ML in 1996/97 to $3,207/ML in 2000/01 (*Source ABS*).

This series of reports describes how water is used in the major vegetable production regions in Australia. The reports detail the investment made in technology to ensure maximum output and product quality from every ML used in vegetable production and processing. The rate of improvement in irrigation technologies since the mid 1990's has been significant, and has come at a time of increased publicly funded incentive programs (such as WaterWise on the Farm in NSW and Water for Profit in Queensland) for improving irrigation efficiency on farm.

The productivity increases achieved by the vegetable industry can be largely attributed to increased use of water-efficient delivery systems such as drip irrigation, increased use of recycling on farm, wide scale adoption of irrigation scheduling and soil moisture monitoring and a tendency towards whole farm planning and soil mapping. Although more difficult to measure, some part of the increase in product value and quality is also likely to be the direct result of improved irrigation practices.

VICTORIAN SUMMARY

Victoria is a major producer of fresh and processed vegetables, with an annual farm-gate value approaching $600M (ABS, 2001). Diversity of soil and climate allows the production of many vegetable crops across the state. In terms of value, the most significant crops (>$30M) are potatoes, tomatoes (fresh and processing), carrots, mushrooms, asparagus, broccoli and lettuce. With a strong focus on Asian markets, Victorian vegetable exports reached a total value of $95M in 2003/04. Fresh asparagus, seed potatoes, frozen potatoes and vegetable juice were major contributors to this figure, and Japan, Singapore, Hong Kong and Malaysia were key destinations along with New Zealand.

Most vegetable crops require irrigation for all or most of their growing season. Over 31,000 hectares of the major vegetable crops are grown under irrigation within the Southern Rural, Goulburn Murray and Wimmera/Mallee & Sunraysia irrigation districts of Victoria. Water is delivered through four major authorities, and costs for vegetable production vary from less than $3 per ML from unregulated waterways, to more than $250 per ML from reticulated domestic supplies. In terms of water use efficiency, Victorian vegetable crops achieve an estimated 4 to 8 t/ML of water applied (for cauliflowers and fresh tomatoes respectively), and a gross value ranging from $1894 to $8213 (for processing tomatoes and capsicums respectively).

Recent droughts have focussed attention on the value of water in Victoria as it has elsewhere in Australia. While the availability of high quality water for irrigation of vegetable crops has generally not been threatened, costs are rising along with competing demands for domestic, industrial and environmental purposes. Adoption of more efficient irrigation systems (such as drip) is increasing, along with the use of irrigation scheduling programs. Water trading has also been introduced, facilitating its use on higher value crops such as vegetables. The Victorian Government has been active in promoting water reform, with a number of policy instruments and initiatives to encourage more efficient practices and facilitate environmental outcomes.

SECTION 1 – INTRODUCTION

Irrigation districts covered in this report:

1. Sunraysia Region – Sunraysia Rural Water Authority [28]

The Sunraysia Rural Water Authority (SRWA) is a Government Business Enterprise operating in the Nyah to South Australian Border region of Victoria.

2. Wimmera Mallee – Wimmera Mallee Water [36]

Operating within the Wimmera and Mallee regions of Victoria. Wimmera Mallee Water provides rural water services over an area of three million hectares, from the Grampians in the south to the Murray River in the north, and across to the South Australian border.

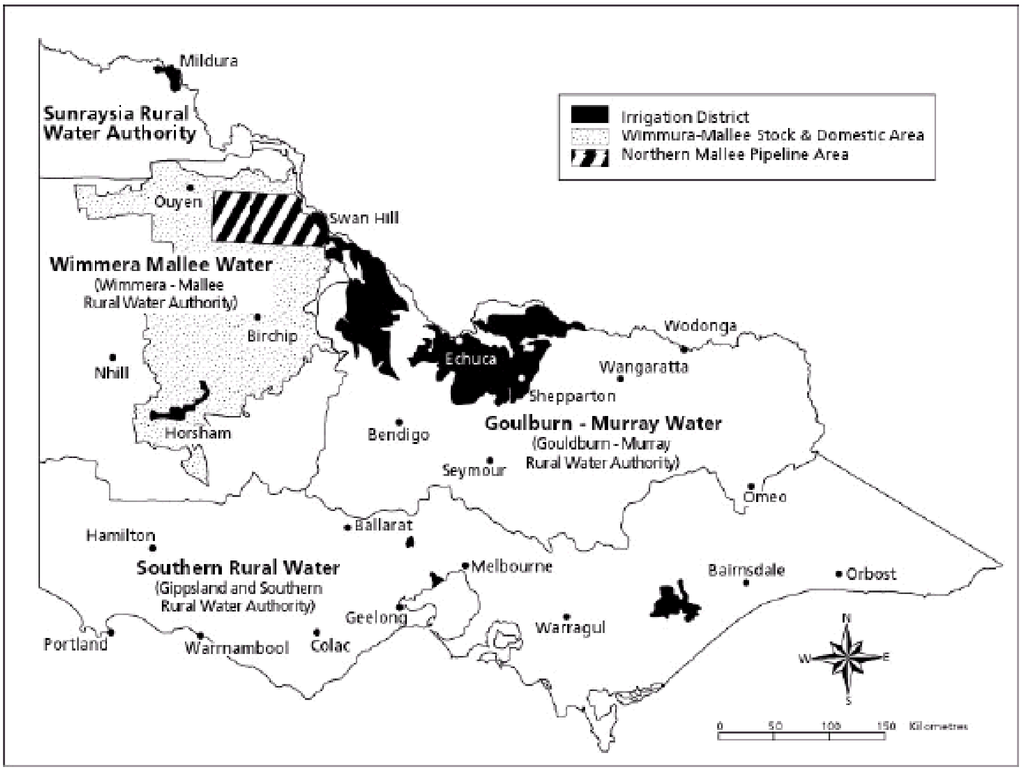
3. Goulburn Murray Region – Goulburn Murray Water [19]

Goulburn-Murray Water covers an area of 68,000 square kilometres, from the Great Dividing Range north to the River Murray and from Corryong down river to Swan Hill. The region includes the major storage and the major gravity irrigation areas in Victoria as well as pumped irrigation and waterworks districts.

4. Southern Region – Southern Rural Water [26]

Southern Rural Water is the trading name of the Gippsland and Southern Rural Water Authority, which is a statutory rural water authority established under the provisions of the *Water Act 1989*. SRW is responsible for rural water supply across the entire southern part of Victoria.

Figure 1 – Rural Water Authorities and Irrigation [17].



SECTION 2 – VEGETABLE CROPS IN VICTORIA

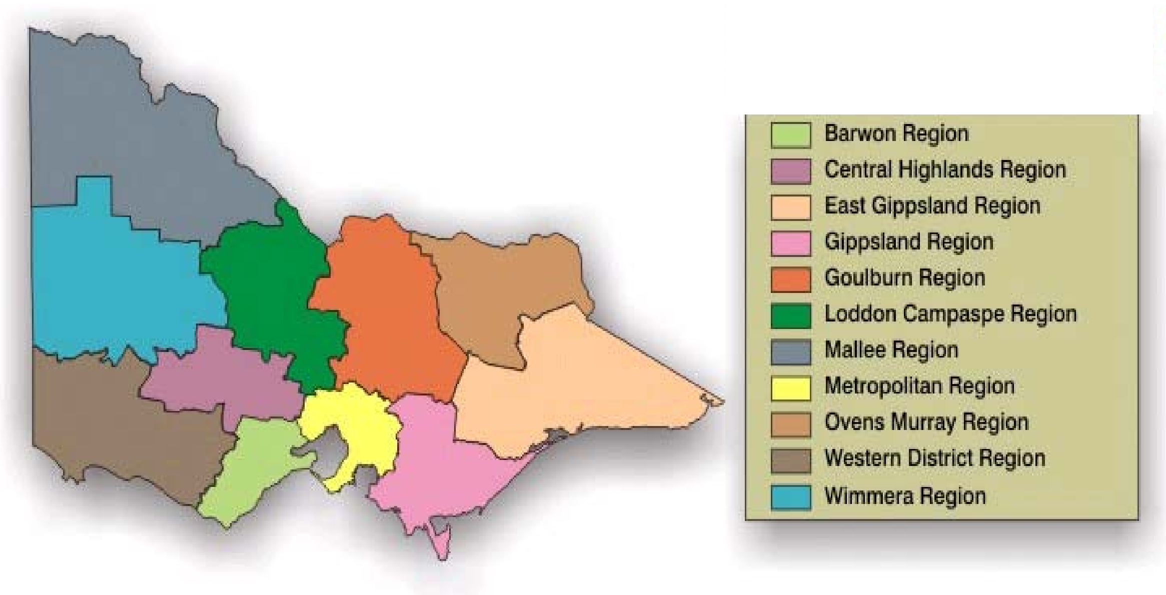
The value estimates in this report were mainly obtained from Australian Bureau of Statistics (ABS) collections, which were derived by the multiplication of price and quantity of agricultural commodities. A number of other information sources including DPI Victoria's statistic and information sites, Gross Margin Analysis, Ag-notes and Grower's Guides were also used to get more accurate economic estimates.

CROP AREA

Table 1 – Irrigated area planted to major vegetables [3]

District Subdistrict	Area Planted (ha)
SOUTHERN RURAL	
Metropolitan (Werribee, Bacchus Marsh & Cranbourne)	13,000
Barwon, Western District & South of Central Highlands	4,730
Gippsland	3,563
East Gippsland	3,032
	24,325
GOULBURN MURRAY	
Goulburn & Loddon Campaspe	4,472
Ovens Murray	19
	3,987
WIMMERA MALLEE & SUNRAYSIA	
Mallee, Wimmera & North of Central Highlands	2,639
State Total	**31,455**

Figure 2 – Victorian Vegetable Production Region [32]



CROP TYPES

Table 2 – Regional production of the 10 major vegetable crops as a percentage of total area grown[2]

Irrigation District / Region	Asparagus	Broccoli	Carrots	Cauliflower	Lettuce	Mushrooms	Onions – white and brown	Potatoes	Tomatoes P	Tomatoes F
SOUTHERN RURAL										
Metropolitan (Werribee, Bacchus Marsh & Cranbourne)	76.89	62.58	15.84	84.94	83.72	94.80	35.99	23.71	0.00	5.56
Gippsland	1.70	0.05	1.28	0.43	0.70	0.00	11.73	30.93	0.00	10.01
East Gippsland	10.56	23.07	13.01	2.36	9.27	0.00	0.00	0.62	0.09	0.83
Barwon, Western District & South of Central Highlights	0.54	4.81	2.94	5.64	0.00	0.62	2.13	6.09	0.00	1.49
GOULBURN MURRAY										
Goulburn & Loddon Campaspe	0.00	0.17	17.35	2.95	0.60	4.57	35.92	0.56	99.91	81.12
Ovens Murray	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WIMMERA MALLEE & SUNRAYSIA										
Mallee, Wimmera & North of Central Highlights	10.31	3.50	49.57	0.63	0.04	0.00	14.22	5.97	0.00	0.00

P: processing F: Fresh

ANNUAL RAINFALL

The climate of Victoria is characterised by a range of different zones, from the warm, dry Mallee region of the north-west to the alpine snowfields in the north-east. Median annual rainfall ranges from less than 300 mm in parts of the Mallee to in excess of 2500 mm in the wettest parts of the mountainous regions.

On a seasonal basis, most regions of Victoria receive their peak rainfall in late winter and early spring, and are generally dry over summer and early autumn. The exception is East Gippsland, which is sheltered by topography from both the winter cold fronts and the rain-bearing north-westerly winds that produce precipitation over the ranges. Consequently, this region does not display as marked a seasonal variation in rainfall.

There is also considerable variation in rainfall from year to year due to the natural variability of the weather. Large bands of cloud which stretch across the continent from the northwest bring moderate to heavy rainfall to the north of the state in some years. Low pressure systems off the east coast are responsible for heavy rainfall events in East Gippsland. These events may bring rainfall in excess of 100 mm in 24 hours.

Rainfall in the remaining southern areas is more even, with cold fronts regularly bringing showers. Thunderstorms also contribute significantly to the total rainfall, particularly in the spring and summer months [14].

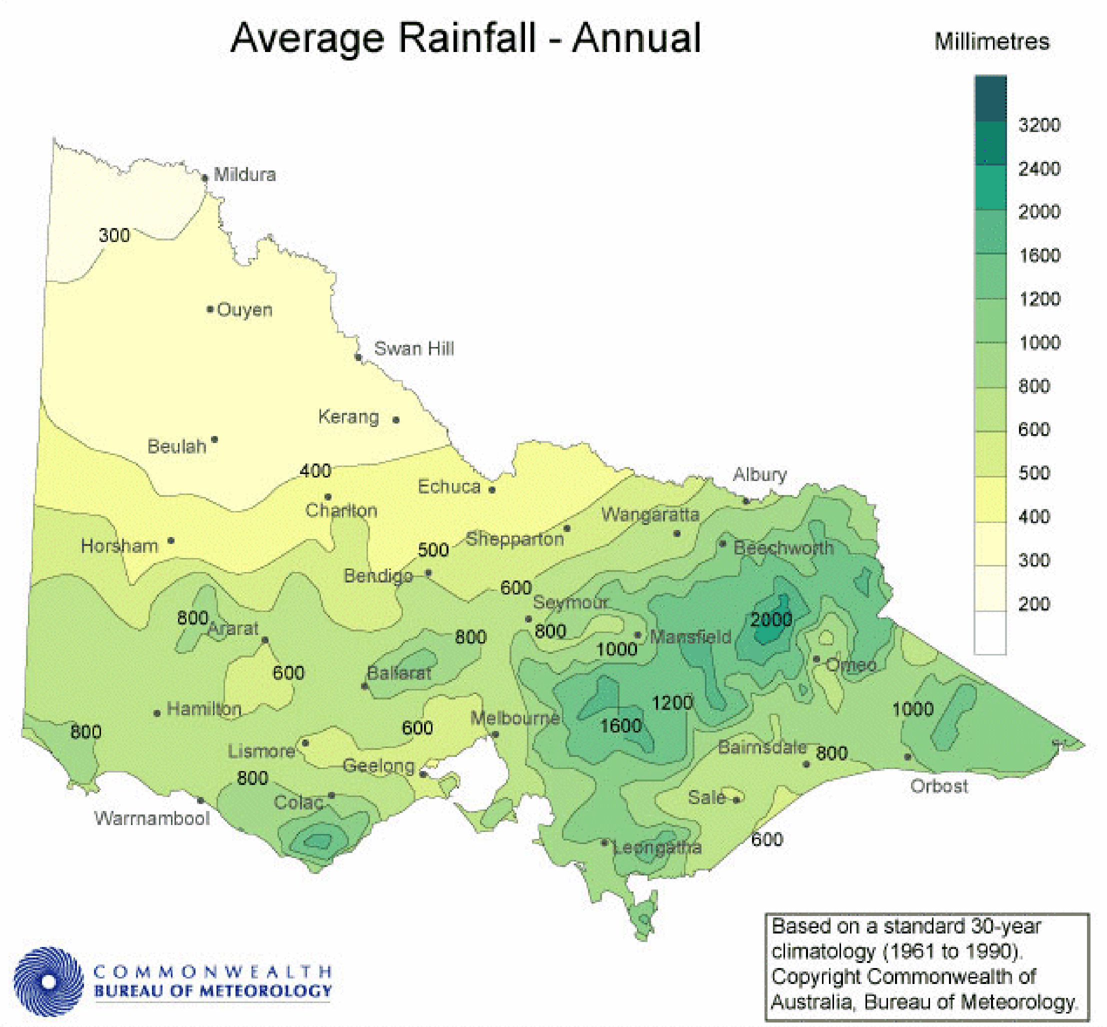


Figure 3 – Average annual rainfall of Victoria [9]

Table 3 – Rainfall in districts of Victoria (Bureau of Meteorology, Victorian Year Book, 2000)

District	Average for 85 years (1913 to 1998)	District	Average for 85 years (1913 to 1998)
North Mallee	316	East Gippsland	764
South Mallee	373	West gippsland	923
North Wimmera	424	East Central	890
South Wimmera	514	West Central	631
Lower North	443	North Central	754
Upper north	533	Western Plains	633
Lower Northeast	795	West Coast	783
Upper Northeast	1119		

VALUE OF VEGETABLE PRODUCTION (FARM GATE)

Table 4 – Farm gate value ($) of vegetable crop production [1]

Irrigation District Region	Total Vegetables	Potatoes	Tomatoes F	Tomatoes P	Carrots	Mushrooms	Asparagus	Broccoli
SOUTHERN RURAL								
Metropolitan (Werribee, Bacchus Marsh & Cranbourne)	240,728,168	47,499,466	2,131,506	4,971	7,833,731	45,540,705	3,121,139	26,212,225
Gippsland	96,213,862	45,561,234	2,112,913	3,277	2,567,229	-	31,196,980	125,413
East Gippsland	49,696,588	2,408,305	373,663	-	6,512,717	-	6,549,821	6,868,097
Barwon, Western District & South of Central Highlands	24,242,275	9,929,003	1,161,733	1,496,277	1,506,436	2,782,535	-	223,896
GOULBURN MURRAY								
Goulburn & Loddon Campaspe	81,276,563	3,351,999	42,213,403	27,911,406	3,720,963	-	-	-
Ovens Murray	1,617,390	134,479	98,303	-	-	-	-	-
WIMMERA MALLEE & SUNRAYSIA								
Mallee, Wimmera & North of Central Highlands	88,354,790	13,387,886	142,872	-	40,950,119	5,455,947	6,765,203	2,955,435
TOTAL	582,129,636	122,272,372	48,234,393	29,415,931	63,091,195	53,779,187	47,633,143	36,385,066

Value of vegetable crop production (cont.)

Irrigation District Region	Lettuce	Celery	Cabbages	Parsnips	Cauliflower	Onions	Sweet Corn	Rock Melons
SOUTHERN RURAL								
Metropolitan (Werribee, Bacchus Marsh & Cranbourne)	25,821,537	17,481,371	5,849,900	10,757,238	9,456,940	6,869,624	285,880	-
Gippsland	36,861	38,876	1,491,346	-	175,229	1,705,888	819,715	-
East Gippsland	4,094,238	32,939	3,667,456	-	424,335	-	6,323,369	-
Barwon, Western District & South of Central Highlands	2,294,148	388,549	-	-	257,342	690,869		
GOULBURN MURRAY								
Goulburn & Loddon Campaspe	49,616	-	1,639,071	-	117,700	697,278	-	-
Ovens Murray	-	-	90,984	-	12,723	-	15,488	-
WIMMERA MALLEE & SUNRAYSIA								
Mallee, Wimmera & North of Central Highlands	1,120,163	-	50,233	-	22,004	572,138	1,389,593	7,161,566
TOTAL	33,416,563	17,941,735	12,788,990	10,757,238	10,466,273	10,535,797	8,834,045	7,161,566

Value of vegetable crop production (cont.)

Irrigation District Region	Pumpkins	Snow Peas	Leeks	French and Runner Beans F	Capsicums	Brussels Sprouts	Water Melons
SOUTHERN RURAL							
Metropolitan (Werribee, Bacchus Marsh & Cranbourne)	2,574,979	28,880	4,529,542	92,565	10,359	1,712,378	-
Gippsland	173,938	4,977,622	649,763	79,118	539,064	-	-
East Gippsland	86,147	579,239	67,991	4,037,041	395,461	-	-
Barwon, Western District & South of Central Highlands	249,288	1,176,572	386,396	56,070	59,527	-	-
GOULBURN MURRAY							
Goulburn & Loddon Campaspe	1,008,420	-	-	350	322,524	-	-
Ovens Murray	106,922	-	-	25,657	1,076,035	-	-
WIMMERA MALLEE & SUNRAYSIA							
Mallee, Wimmera & North of Central Highlands	1,961,381	166,641	-	90,220	915,752	-	1,780,347
TOTAL	6,161,075	6,928,954	5,633,692	4,381,021	3,318,722	1,712,378	1,780,347

Value of vegetable crop production (cont.)

Irrigation District Region	Spring Onions	Zucchini	Parsley	Chinese Cabbage	Cucumber	Green Peas F	Beetroot	Marrows and squashes
SOUTHERN RURAL								
Metropolitan (Werribee, Bacchus Marsh & Cranbourne)	1,281,566	344,969	1,032,056	733,040	7,708	33,678	144,635	14,801
Gippsland	117,075	52,382	79,178	15,107	-	106,417	33,930	-
East Gippsland		139,602		57,744	161,429	73,304		-
Barwon, Western District & South of Central Highlands	2	319,221	92	1,767	194	366,195	2,506	-
GOULBURN MURRAY								
Goulburn & Loddon Campaspe	-	47,828	-	-	-	-	-	16,382
Ovens Murray	-	-	-	-	-	-	-	-
WIMMERA MALLEE & SUNRAYSIA								
Mallee, Wimmera & North of Central Highlands	154,714	599,595	120	18,855	102,004	54,677	3,697	121,779
TOTAL	1,553,357	1,503,597	1,111,446	826,513	271,335	634,271	184,768	152,962

VEGETABLE VALUE AFTER VALUE ADDING

This information is likely to be generic. A reference from California [25] suggests that the economic multiplier for vegetable processing could be as much as 10.8.

VALUE OF PRODUCTION AND EXPORTS

Victorian vegetable exports were valued at $95 million in 2003/04 and over the past ten years the industry has increased its exports by 95%. Increased exports of potatoes and frozen and prepared vegetables have contributed greatly to this growth.

Major fresh vegetable exports in 2003/04 included asparagus ($A20 million), broccoli ($A4 million), seed potatoes ($A4 million), cauliflower and lettuce ($A1 million each). Processed vegetable exports in 2003/04 mainly comprised frozen potatoes ($A14 million), vegetable juice ($A12 million), prepared vegetables ($A5 million) and processed tomatoes and frozen mixed vegetables ($A4 million each).

Victorian vegetable exports are firmly focused on Asian markets, the largest being Japan, Singapore, Hong Kong and Malaysia. New Zealand, as the second largest vegetable export destination, is the only non-Asian country in the top 9 export destinations for Victorian vegetable products. As the largest vegetable export destination, Japan imported 88% of asparagus, 84% of vegetable juice and 91% of all processed frozen vegetables exported from Victoria in 2003/04. New Zealand is a significant market for frozen potatoes and vegetables and processed tomatoes [12].

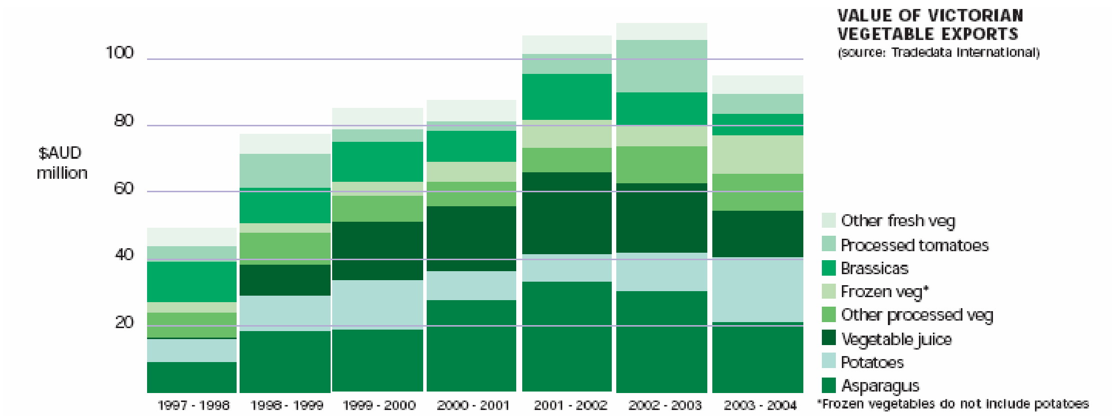


Figure 4 – Value of Victorian vegetable exports [12]

NUMBER OF FULL TIME EQUIVALENT JOBS

Table 5 – Persons employed by industry, Victoria [33]

Industry	Employees	Proprietors & Partners	Total Persons
Vegetables	15,615	6,110	21,725

TOTAL WATER USE AND HORTICULTURAL WATER USE

Table 6 – Total and estimated horticultural water use in Victoria [18, 26, 28, 36]

Irrigation District Subdistrict	TOTAL ML	Horticulture ML	Market Gardens ML
SOUTHERN RURAL*			
Werribee Irrigation District	9,455	6,950	6,902
Bacchus Marsh Irrigation District	3,661	2,215	920
Macalister Irrigation District	117,965		
GOULBURN MURRAY			
Shepparton Irrigation Area	156,636 ML (90% of WR)		
Central Goulburn	420,000	About 15%	
Rochester - Campaspe	198,057 Rochester 9,911 Campaspe	?	
Pyramid - Boort	222,349	20,000 (10%)	
Murray Valley	259,121	About 10%	
WIMMERA MALLEE & SUNRAYSIA**			
Red Cliffs	36,434		
Merbein	25,289		
Robinvale	18,489		
TOTAL	1,477,367		

*, ** In the 2003–04 Season. While the water delivery efficiency was 0.3% less than the previous season, the end result was still well above the target of 85%. Delivered water does not include the water taken via customers' un-metered garden connections.

TONNES/ML/CROP

Table 7 – Total area, yield and average yield for major Victorian vegetable crops [3, 6]

Crop	Total Area[1] ha	Total Value[2] $	Total Yield[1] t	Average Yield t/ha	Average water use* ML/ha
Potatoes	*8,221*	122,272,372	171,075	20.81	5
Broccoli	3,100	36,385,066	22,836	7.37	5
Tomatoes - F	750	48,234,393	41,361	55.15	8
Tomatoes - P	2,588	29,415,931	169,480	65.49	6
Carrots	2,038	63,091,195	75,351	36.97	6
Lettuce	2,104	33,416,563	33,620	15.98	5
Cauliflower	1,059	10,466,273	19,017	17.96	4
Onions	418	10,535,797	16,328	39.06	6
Capsicum	119	4,398,061	988	8.30	6
Pumpkins	301	10,757,238	3,864	12.84	6

* Average water use per hectare was obtained from commercial practices and various resources.

SECTION 3 – WATER USE IN THE VICTORIAN VEGETABLE INDUSTRY

WATER COSTS TO FARM BOUNDARY

Price and value of water: The price paid for irrigation water affects the incomes of water authorities. In Victoria, charges vary considerably from one location to another. Table 7 provides an indication of this variation. It also indicates the low prices that are paid for irrigation water in most districts compared with urban water and water in a few irrigation districts.

The level of cross subsidy between charges for urban and non-urban supply may be less than it appears, however. Urban water is more costly than some others to supply, must be of potable quality and produces waste-water that requires expensive treatment.

Table 8 – Charges for water in representative locations [17]

Area	Charge per ML
Campaspe Irrigation District	$20.24
Central Goulburn Irrigation District	$24.39
Murray Valley Irrigation District	$19.35
Merbein Irrigation District	$84.10 based on full use
Red Cliffs Irrigation District	$105.49 based on full use
Werribee Irrigation District	$111.60
Macalister Irrigation District	$32.58
Bacchus Marsh Irrigation District	$96.46
Wimmera-Mallee Waterworks - dam fill	$253.00 effective charge
Wimmera-Mallee Irrigation	$59.30 effective charge
Melbourne Metropolitan reticulated urban supply	$690.00
Southern Rural Water - unregulated waterways	$46.10 fixed charge plus $4.30 per ML for most streams.
Goulburn-Murray Water - Murray - unregulated waterway	$66.00 service fee plus $2.86 per ML
Melbourne Water - unregulated waterway	$25-200 service fee plus $3.50 per ML

Valuing water: The concept of water value and the relationship between value and cost of water are not simple. Water is a commodity with many different uses, creating problems in determining its value.

Wimmera Mallee Water: The delivery of irrigation water is a small but important service to farmers around Horsham and Murtoa in the Southern Wimmera. The 250 existing licences give holders agricultural production opportunities that few others in the region have, and there is considerable opportunity for development of new enterprises.

Water charges in gravity irrigation areas are based on a two-part tariff. There is a fixed component, based on the volume of water entitlements held, and a pay-by-use component for consumption of supplies in excess of the entitlement volume (known as sales and allocated annually when resource is available). Prices for gravity irrigation supply range from $17.60/ML to $28.10/ML, with higher charges for some pumped and pipelined supplies [36].

Ground-water Management: Ground-water extraction in the west of the region towards the South Australian border is managed by Grampians Wimmera Mallee Water. This increasingly important resource supplies hundreds of farms, and towns such as Kaniva, Nhill and Murrayville with domestic and stock water requirements.

In recent years the use of ground-water irrigation on potatoes, carrots and onions has flourished. This development has provided opportunity for crop diversity on many farming properties in the area. Much of the suitable ground-water is now close to being fully utilised, so proper management and control of usage is important.

Management plans in the various ground-water areas are being developed in consultation with the community and with the support of government funding.
One initiative to protect ground-water quality in the Mallee region involves decommissioning and sealing of old bores. With the support of government funding over the last six years, 190 bores have been successfully treated. Irrigators have a three-part tariff in the region as detailed below:

- A services availability,
- A supply charge levied on each irrigation agreement held by customers
- A sales charge payable on the amount of water used in excess of the irrigation agreement volume.

Goulburn Murray Water: Water charges in gravity irrigation areas are based on a two-part tariff. There is a fixed component, based on the volume of water entitlements held, and a pay-by-use component for consumption of supplies in excess of the entitlement volume (known as sales and allocated annually when resource is available). Prices for gravity irrigation supply range from $17.60/ML to $28.10/ML, with higher charges for some pumped and pipelined supplies [19].

Table 9 – Goulburn Murray Water prices for gravity irrigation [19]

Irrigation District	Service Fee $	Additional Service Point Fee	Entitlement Storage Fee $/ML	Infrastructure Access Fee $/ML	Infrastructure Use Fee $/ML
Shepparton	100	50	6.55	28.7	6.37
Central Goulburn	100	50	6.55	23.74	7.49
Rochester	100	50	6.55	21.77	7.08
Campaspe	100	50	6.55	31.55	8.66
Pyramid-Boort	100	50	6.55	16.42	5.81
Murray Valley	100	50	7.53	21.19	6.97
Torrumbarry	100	50	7.53	19.46	6.99

Table 10 – Goulburn Murray Water prices for pumped irrigation [19]

Irrigation District	Service Fee $	Additional Service Point Fee	Entitlement Storage Fee $/ML	Infrastructure Access Fee $/ML	Infrastructure Use Fee $/ML
Woorinen	100	50	7.53	2531.00 /ML/day	20.00
Nyah	100	50	6.66	2697.00 /ML/day	14.89
Tresco	100	50	6.66	4168.00 /ML/day	10.00

Sunraysia Rural Water Region: Rates are higher than those in the irrigation districts of South Australia and New South Wales, although comparisons can be misleading as bulk water prices vary between states as do service levels provided and SRW service a pumped irrigation network rather than gravity-driven [28].

Table 11 – Sunraysia Rural Water Authority 2004/05 Prices [28].

Irrigation District	Access Fee $/ML WR	Regional Environment Fee $/ML WR	District Environment Fee Full $/ML WR	Property Drainage Fee Full Fee $/ML WR	Property Drainage Fee Division 2 $/ML WR	Property Drainage Fee Division 3 $/ML WR	Property Drainage Fee Division 4 $/ML WR	Property Drainage Fee Division 5 $/ML WR
Merbein	26.08	0.32	1.29	16.64	12.48	8.32	4.16	0
Red Cliffs	39.01	0.32	2.04	21.05	15.79	10.52	5.26	0
Robinvale	52.09	0.32	1.56	13.78	10.34	6.89	3.45	0

Sunraysia Rural Water Authority 2004/05 Prices cont.

Irrigation District	Delivery Fee $ / ML Used	MCMA Salinity Levy $ / ML Used	Excess Water Charge $ / ML	Garden Fee Minimum Fee $
Merbein	46.86	1.15	1,000.00	346.5
Red Cliffs	54.66	1.15	1,000.00	346.5
Robinvale	46.54	1.15	1,000.00	346.5

GROSS RETURNS $/ML/CROP

Table 12 – Gross returns per ML for the main Victorian vegetable crops [4].

Crop	Total Area ha	Total Value $	Total Yield t	Total Average t/ha	Average water use ML/ha*	Total estimated Water use ML	Total estimated Gross Return $/ML
Potatoes	8,221	122,272,372	171,075	20.81	5	41,105	2975
Broccoli	3,100	36,385,066	22,836	7.37	5	15,500	2347
Tomatoes – F	750	48,234,393	41,361	55.15	8	6,000	8039
Tomatoes – P	2,588	29,415,931	169,480	65.49	6	15,528	1894
Carrots	2,038	63,091,195	75,351	36.97	4	8,152	7739
Lettuce	2,104	33,416,563	33,620	15.98	4	8,416	3971
Cauliflower	1,059	10,466,273	19,017	17.96	5	5,295	1977
Onions	418	10,535,797	16,328	39.06	6	2,508	4201
Capsicum	119	4,398,061	988	8.30	4.5	536	8213
Pumpkins	301	10,757,238	3,864	12.84	4.5	1,355	7942

* Average water use per hectare was obtained from commercial practices and various resources.

GROSS MARGINS $/ML/CROP

In 2003/04, Goulburn Murray Water started implementing tariff changes. The cost of supplying irrigation water was divided into fixed and variable costs.

The fixed costs include:

- Infrastructure access fee – fee to access the distribution system
- Additional service point fee is charged if a property has more than one service point
- Service fee

An Infrastructure Use Fee recovers the variable cost of using the distribution system. This variable charge is paid only on water that is delivered. The price of water varies greatly within the Loddon Murray region. Table 12 shows the 2004–05 pricing schedule from Goulburn Murray Water.

Table 13 – The 2004–05 pricing schedule from the Goulburn Murray Water [19]

PUMPED IRRIGATION	Service Fee A	Additional Service Point Fee B	Entitlement Storage Fee $/ML C	Infra-structure Access Fee $/Ml /day D	Infra-structure Use Fee $/ML E
Woorinen	$100	$50	$8	$2,531	$20
Nyah	$100	$50	$7	$2,697	$15
Tresco	$100	$50	$7	$4,168	$10

Table 13 outlines the gross margins for a number of vegetables. In each case, gross margins are calculated using typical cost and price information. These examples should not be interpreted as being a true reflection of what will be achieved on individual farms in the region. Rather, they should only be used to assist in calculating gross margins for a specific case, with costs, prices and management assumptions refined according to farming practices.

Table 14 – Average Gross Margin estimates per ML of irrigation water applied in Victoria [13, 21, 30]

Vegetable	Marketable Yield	Price $	Total Net Return $	Total Variable Cost $	Water Application Rate ML	GM per ha $	GM per ML $
Rock Melon (box)[1]	2,040	12.50	21,548	19,289	5	2,259	451.80
Tomatoes (Fresh-carton)[1]	6,000	10.00	50,820	45,831	8	4,989	623.63
Zucchini (box)[1]	2,160	10.00	18,278	16,471	5	1,807	361.40
Cabbage (deck)[2]	1,765	8.15	14,111	10,961	5	3,150	630.00
Cauliflower (deck)[2]	2,474	8.95	22,142	13,859	4	8,283	2070.75
Carrot (kg)[2]	46,258	0.70	32,381	10,345	6	22,036	3672.67
Lettuce (kg)[2]	32,100	0.60	19,260	10,989	4	8,271	2067.75
Broccoli (kg)[2]	8,051	1.51	10,837	9,788	5	1,049	209.80
Capsicum (kg)[3]	57,838	1.07	61,886	54,688	6	7,198	1199.67

IRRIGATION MANAGEMENT AND END PRODUCT QUALITY

Irrigation management can have a range of impacts on the quality of vegetable crops. Adequate water supply is essential to plant function, so water stress have a direct impact on growth and yield of quality produce. Irrigation for environmental control (using sprinklers) can reduce frost or wind damage, and reduce the amount of soil contamination of leafy vegetables such as lettuces. Irrigation to maintain a leaching fraction can protect plants from salt damage. Appropriate scheduling of irrigation can prevent stress that causes a range of damage to vegetable crops – including rots in solanaceous species (blossom-end rot in tomatoes, capsicums and egg-plant), or leaf burn in leafy vegetables.

Table 15 – Irrigation methods, water and product quality in Victorian production areas [18, 26, 28, 36]

Water District	Main Irrigation Method	Water Quality	Product Quality
Sunraysia	Sprinklers Drip Flood	River quality water, salinity 200–500EC	Good
Wimmera Mallee	Sprinklers Flood Travelling irrigators	Water is directly sourced from natural catchments and can vary from very low to medium salinity levels, (i.e. 70–700 EC). Ground-water salinity is dependent on location.	Good
Goulburn Murray	Drip Flood	G-MW supplies raw water in bulk to urban water supply Authorities, or delivers water to rural customers for irrigation and stock use. Water quality is typical of river water quality in northern Victorian streams. Salinity generally varies between 150–1000 EC units, with the higher salinities experienced in the western parts of G-MW's region. A small to moderate amount of leaching is required to control salt in the usual irrigation waters. Channel water is suited to a wide variety of crops but ground-water in the Kerang Region is unsuitable for irrigation. Where ground-water in the Shepparton Region is being considered for irrigation, each case is treated individually, with both chloride and sodium content of the water taken into account. Usual salinities in Northern Victoria: • Main rivers and irrigation supply channels: 80 to 500 EC units • Ground-water in the Shepparton Region: 300 to 10,000 EC units • Ground-water in the Kerang Region: 30,000 to 60,000 EC units	Good
Southern Rural	Sprinkler Flood Drip	Suitable for rural use.	Good

SALINITY IMPACTS ON PRODUCTION

Table 16 – General salinity impacts on crops under different irrigation systems [18, 23]

Water District	Salinity Impacts
Sunraysia Wimmera Mallee Goulburn Murray Southern Rural	When irrigating with saline water, closely observe the growth and condition of plants or herbage. Saline water can cause considerable yield loss before symptoms of leaf burn become obvious. Seedlings are more sensitive to salt than mature plants. In salty situations, it may help to grow seedlings using good soil in containers that bio-degrade when the plants are placed in their permanent positions. The suitability of water for irrigation is influenced not only by the total soluble salts and their composition, but also by the type of soil and drainage, the climate and the rainfall. The accumulation of salts from the irrigation water in the soil can cause major problems. Generally, 635 mS/m (or 3500 mg/L) of total salts is regarded as the maximum for safe watering of any plants. With this salt content, drainage must be excellent and each irrigation should provide enough water to leach accumulated salts below the roots of plants. Keep the water off the leaves to avoid burning. Saline water can be used more successfully on a well-drained light soil than on a poorly drained heavy soil, and also in districts where high seasonal rainfall leaches the salts accumulated in the soil. Trickle irrigation can reduce the effects of salinity by maintaining a continuously moist zone around the plant roots and providing steady leaching of salt to the edge of the wetted zone. It is important to reduce evaporation if using saline water for sprinkler irrigation. Water is best applied at night, early in the morning or late evening when the air is more humid. Watering in the heat of the day concentrates salts due to the high evaporation. Sprinklers can produce fine droplets. The use of intermittent (knocker type) sprinklers should be avoided if possible – especially slow revolution sprinklers, which allow drying and salt accumulation on the leaves. Watering during high winds also concentrates salts. Where irrigation is infrequent or only for short periods during the year, more saline water may be used.

OTHER WATER QUALITY IMPACTS ON PRODUCTION

Use of reclaimed water has been promoted by government for vegetable production in the Cranbourne and Werribee areas near Melbourne. Community perceptions of risk to human health could have negative impacts on production in these areas, although these schemes are just commencing. Alternatively, the need to utilise constant supplies of reclaimed water could lead to expanded production.

Quality wash water for carrots:
With an aim of improving the efficiency of water use, a project – *Insurance for clean food and minimising environmental impact (1999–2002)* – was conducted by Victorian DPI scientists to study an extended recycling system for water used to wash soil off produce. The water became heavily contaminated with dirt, and was analysed to see if it was safe to re-use. Water was sampled from carrot and other vegetable washing operations in five states to determine what nutrients, chemicals and plant and human pathogens may be present. A range of water treatments was then tested to find the most effective and economical method of de-contaminating the wash water. Wash water is generally used at a rate of 1,000

litres per tonne of produce, but usage can be as high as 20,000 litres per tonne for fresh cut and processed vegetables and 1,200 to 9,000 litres/tonne for carrots [20].

Considering the tonnage produced, the proportion washed and a conservative estimate of usage per tonne (1,000L/tonne), a total figure for wash water used in horticulture of 2.6 GL was derived (Table 16).

Table 17 – Statistics showing production and estimated wash water use 2000/01 [20]

Crop	Year	VIC (Tonnes)	Washed? Y/N	%
Tomato fresh	1997	15,000	Yes	100
Tomato Process	1997/8	225,880	To Processor	
Asparagus (t)	1997	4,252	Yes	100
Beans (t)	1997	2,038	No	
Beetroot (t)	1997	664	Yes	20
Broccoli	1997	19,198	Yes	60
Brussels Sprouts	1997	2,154	Yes	50
Cabbages	1997	23,221	No	
Capsicum	1997	3,353	Yes	100
Carrots	1997	99,274	Yes	100
Cauliflowers	1997	17,409	No	
Celery	1997	22,403	Yes	50
Chinese Cabbage	1997	899	Yes	25
Cucumbers	1997	795	Yes	50
Garlic	1997	20	No	
Leeks	1997	2,649	Yes	50
Lettuce	1997	36,557	Yes	10
Melons	1997	9,213	Yes	100
Onions	1997/8	31,000	No	
Peas	1995	15,000	No	
Potatoes	1997	315,727	Yes	60
Pumpkin	1997	4,595	No	
Spring Onions	1997	965	Yes	100
Sweet corn	1997	7,366	Yes	20
Zucchini	1997	931	Yes	25
TOTAL		860,563		

ACCESS TO WATER IMPACTS ON PRODUCTION

To date, there has been minimal threat to water supplies for vegetable production in Victoria, although recent droughts have raised the issue, particularly across the Melbourne Metropolitan region. The value of production has largely allowed growers to obtain their requirements e.g. through transferable water entitlements.

WATER TRADING FLEXIBILITY (PRICE)

Trading of Water Rights: The *Water Act 1989* provides for transfer of water on a permanent or temporary basis from the property to which a water right is registered. Permission is required from the supplying authority of the seller and, in the case of permanent transfers, the supplying authority of the buyer. Upon such transfer, the water right is recorded in the authority's register against the new owner. Both temporary and permanent interstate transfers are permitted, as well as transfers within Victoria. Water authorities can make by-laws in relation to water trading, including trading rules.

Transfer of water entitlements: Provisions in the *Water Act 1989* for 'transfer' of water allocated as bulk entitlement, water right, or under licence, made trading of water possible, as they allowed water allocations to be moved from one land title to another.

Transfers may be within Victoria or, under certain conditions, interstate as 'temporary' (less than a year) or 'permanent'. Only temporary transfers of bulk entitlements are allowed to another State. Approval is required from the Minister, but there is no requirement for public notice.

A feature of the water trading arrangements is that water is now an asset with a dollar value.

Trade of Bulk Entitlements*:* A bulk entitlement held by a water authority may be traded, with the approval of the Minister, in whole or in part, to another authority.

Matters to be considered before approval is given for the transfer are the same as those considered when authorities apply for bulk entitlements.

Although trading of water has been confined largely to the irrigation industry, transfer of water between sectors, for example, between irrigation, urban use and environmental uses, can occur as a result of water trading.

Trading Rules and Restrictions: Transfers are subject, in the first instance, to the feasibility of delivering the water – that is:

(a) in public irrigation districts, by channel capacity to deliver the water to the buyer and (b) resource assessment on unregulated streams. 'Trading rules' are used to protect the needs of other water users and the environment.

Trading of Licences: Temporary or permanent trading of licences from one property to another is permitted under the *Water Act 1989*. Both permanent and temporary transfer of a licence can be into an irrigation district or to another State. In considering the trade of a licence, regard is given to the effect of the transfer on 'usage of water, the impact of subsidies and any other matter that the Minister considers relevant'.

Mechanisms of Trading Water Rights and Licences: Applications to trade water are made to the relevant water authority by either the parties to the trade or brokers on their behalf. The relevant rural water authorities must approve the transfers involved before a sale can occur.

The authority is required to consider the effects of the transfer on interests of other water users and the environment. In practice, there are three steps in this approval process. These relate to:

a. transfer of ownership of the primary water entitlement – that is, a specified amount of water at the source; b. capacity to supply the water – that is, the adequacy of the available infrastructure to supply the water, given total demands on it; and c. the right to use the water on the land to which the water is being transferred.

The 'right to use' water is affected by trading rules and restrictions described above in relation to the trading of water rights and others that occur under Stream-flow and Ground-water Management Plans, licensing regulations and salinity plans.

If water is traded permanently from one water authority's jurisdiction to another, an amendment of Schedules to the Bulk Entitlement Orders is made to reflect the change.

'Watermove' and Water Exchanges in northern Victoria: The registered business name of the water exchange will be 'Watermove'. The objectives of the public water exchange include:

a. providing a convenient and transparent brokerage system for the trade of water in all Victorian water markets within regulated water systems; b. establishing or expanding trading where it has not yet occurred or is underdeveloped; c. increasing the confidence of potential water traders in the market system through an open system that provides regular and comprehensive market information, disinterested pricing and fixed charges for the service provided.

Aspects of the proposal for Watermove are summarised as:

- Trading based on a system of zones that reflects physical constraints of the water-supply system – water will only be traded where it can physically be transferred.
- Trading rules for transfer of water between zones – these may change from time to time.
- Specification of water being offered for trade, including the trading zone and trading rules, volume of water, its security and whether it is permanent, temporary or lease.
- A pool price established each week, based on offers made by sellers and buyers so that the maximum amount of water will be transferred.
- The pool price calculated automatically, without human interference, conditional only on sellers receiving at least the price at which they offer to sell water and buyers paying no more than the price at which they offer to buy.

A fee will be deducted from payments made to successful Sellers. The fee will be:

a. 3% of the total sale value achieved at exchange;

b. $30.00 minimum fee; or

c. $500.00 maximum fee;

d. $1.70 per megalitre for each megalitre sold if the volume of water offered for sale is reduced during an exchange, or the maximum fee, which ever is the lower.
10% GST will be applicable to any fees charged. Withholding Tax at 48.5% will apply on the total sale price if the Seller's ABN is not supplied. Seller's who are ABN exempt need to provide a written declaration in the form of a 'Statement by a Supplier' form.

Sellers who trade their water to an interstate trading zone will be required to pay the Transfer Fee set by the selling Water Authority.
These Fees are:
$75.00 Department of Infrastructure, Planning & Natural Resources;
$75.00 First Mildura Irrigation Trust;
$65.00 Goulburn-Murray Water;
$75.00 Lower Murray Urban and Rural Water Authority;
Nil Murray Irrigation Limited;
Watermove will pay this fee to the relevant Water Authority once it has been paid by the Seller to Watermove

Sellers are responsible for the payment of all annual fixed charges and/or access fees raised in respect of Water Right, Licence Volume, High Security and General Security and Bulk Entitlements to the relevant Water Authority.

Payments to successful sellers by EFT (Direct Credit) will be made within 8 days of the exchange. Payments made by Cheque may take up to 30 days from the exchange.

Water Authorities may require sellers with outstanding debts to make satisfactory arrangements for payment prior to approving the offer for inclusion in an exchange [35].

ON FARM METERING AND WATER LICENSING

Licensing of water diversions and extractions: Licences are the primary provision in the Water Act 1989 for control of diversions directly from waterways or aquifers. Private diversions may be from regulated or unregulated rivers. They are estimated to contribute 5 per cent to Victoria's total consumptive water use. South of the Great Dividing Range, approximately 170,000 ML are diverted under licences to take -and use, mainly for irrigation.

Except for water used for stock and domestic purposes, individuals taking water from waterways must also have a licence issued, on behalf of the Minister, by the relevant rural water authority. Southern Rural Water is the delegated authority for issuing licences and controlling water taken from all rivers south of the Great Dividing Range.

A 'waterway' is defined under the *Water Act 1989* as: (a) A river, creek, stream or watercourse; or (b) A natural channel in which water regularly flows, whether or not the flow is continuous; or (c) lake, lagoon, swamp or marsh, being a natural collection of water (other than water collected and contained in a private dam or a natural depression on private land) into or through or out of which a current that forms the whole or part of the flow of a river, creek, stream or watercourse passes.

This provision applies to dams constructed on waterways that are used for purposes other than stock and domestic supply. As at June 2001, water collected from overland flows apart from a watercourse was specifically excluded from requiring a licence.

In theory, licences to pump water in winter can still be obtained across the counter, subject to an assessment indicating that this will create no difficulty for the local environment or existing users. These licences are used to fill dams for use in other seasons. In practice, water authorities are restricting the issue of new licences.

Types of Licences: These licences generally relate to the source and amount of water used rather than to the use to which the water will be put. An important exception is domestic and stock use, which is exempt from restrictions. Access to water for stock and domestic use is allowed, as of right, to persons with land on which the waterway flows or to which it abuts, or on which a groundwater bore is located. Southern Rural Water described the types of uses that are permitted under licence as follows:

a. Domestic - household and kitchen garden not more than 0.4 ha;

b. Stock - watering of stock or other farm animals;

c. Domestic and stock;

d. Irrigation - irrigation of crops, pastures, orchards, vines, etc., sporting grounds, gardens and golf courses;

e. Mineral water extraction - commercial extraction;

f. Industrial - manufacturing, washing, cooling, timber mills, mining, power generation, road making, etc.

g. Agro industrial - feed lots, piggeries, vegetable washing, cooling and washing sheds;

h. Aquaculture;

i. Dairying;

j. Commercial - caravan parks, guesthouses, hotels, plant nurseries, tennis courts;

k. Communal domestic; and

l. Miscellaneous - for example, for fire fighting.

Restrictions may be placed on licences by the granting authority (except for stock and domestic use), which may allow pumping in summer ('summer fill') or be 'winter-fill' licences only. 'Sporadic' licences can also be obtained. These are temporary licences that allow a specified volume of water to be taken in times of excess stream flow.

Metering of Licensed Water Diversions and Extractions: Metering of water diversions and extractions is necessary if accurate water accounting and allocations are to occur. Water supplied for irrigation in public irrigation districts is metered. Metering of stock and domestic diversions from waterways and irrigation channels is not required; nor has there generally been metering for licensed diversions and groundwater extractions. Metering of water used from new private dams for irrigation or commercial purposes has been recommended [17].

BENCHMARKING DATA - GENERAL

Water Application Method: The aim of irrigation is to have water supplied evenly to the full root depth of plants, with only the minimum amount required to prevent salt accumulation passing deeper into the soil.

There are two broad types of irrigation systems, those that are gravity-fed (flood or furrow) and those that require a pressurised system (sprinklers or drippers). Sub-surface irrigation delivers water directly to the root zone. The situations in which these systems are used in Victoria are summarised in Table 18.

For gravity-fed systems, water is usually supplied from a publicly owned utility, via channels on the farm, to irrigation bays or furrows. Pressurised systems draw water from a range of sources including natural waterways, underground reserves and on-farm storage.

It is common for irrigation systems to be rated in terms of water efficiency, without regard for the circumstances in which they are used. For example, drip is frequently advocated as one of the most efficient irrigation systems.

Table 19 – Irrigation Systems Used for Victorian Agricultural Production [11]

General Type	Types of Irrigation Systems	Economics	Methods to Improve Water-use Efficiency	Comment
Gravity surface flooding systems.	Bay, hillside flooding, furrow.	Relatively low capital and energy costs, but can be particularly inefficient with respect to water use and lead to water-logging and rising water tables; restricted by soil type and topography.	Good design, land forming (laser grading), management and scheduling of water application to suit soil type; reuse of surface drainage water and drainage to groundwater.	Most common method in Victoria and the world.
Pressurised systems.	Fixed and movable sprinklers (often referred to as 'spray' irrigation – generally above the crop or 'overhead'), micro-sprinklers, drip (trickle), sub-surface drip.	Generally more costly to establish than flood systems; incur fuel costs for pumping; variable maintenance and labour costs; can be used on a wide range of soil types and topography; inefficient watering is possible, particularly with large overhead systems; some systems, particularly drip and micro-sprinklers, can be very efficient at placing water for optimum use by plants.	Good design, scheduling of water-application-matched system to soils, topography and plant requirements. Reuse of drainage water may be possible with some systems.	Use increasing since the 1950s for most vegetable crops.

Conversion from flood to spray irrigation is often encouraged, to increase water-application efficiency. However, the type of crop and production system, method of delivery of water and soil type and landform influence the efficiency and practicality of different systems. For example, fixed sprinklers and surface drippers are not practical for grazed pastures or many annual crops that are mechanically harvested.

For flood irrigation, rapid movement of water down the bay is necessary for even watering. This can only be achieved if there is a large volume of water available, and it generally cannot be provided directly through pipes at reasonable cost. Therefore, piping of water supply would require a change in water application method.

Sub-surface irrigation delivers water with minimal evaporation and need for flushing of salts accumulated by evaporation. However, it requires good soil structure, fairly sophisticated management including soil moisture monitoring and expensive equipment to deliver and drain water.

Above-crop sprinklers can easily produce uneven watering due to wind drift and water is lost through evaporation. Water delivery can be very uneven from large central pivot and boom spray systems due to poor system design, variability in application or because they are covering irregular terrain and soils.

Flood irrigation is widely believed to be very wasteful of water. It is generally wasteful compared with drip irrigation for trees and vines, especially where soil moisture monitoring is used to schedule irrigations. For pasture on Victorian dairy farms, the average water-use efficiency has been estimated as 40–50 per cent - that is, 50–60 per cent of water delivered to farms is not used by pasture but overflows the irrigation bays or drains past the root zone. However, there is considerable variation in the efficiency of flood irrigation. Modern technology to support scheduling of irrigation and reuse of drainage water can considerably improve efficiency. Other factors, such as channel maintenance and design, laser grading of bays, fertiliser use and grazing rotation of stock can also be critical to irrigation efficiency.

A recent study of water use on dairy farms in northern Victoria found that flood irrigation is the most efficient method of watering pastures for the majority of the region. This is partly because the soils in the locality are heavy (clays) with low permeability and the land is flat. Furthermore, any efficiencies that might be made on some sites by using pressurised systems will be more than off-set by the costs of fuel to provide the pressure.

In the Macalister Irrigation District, on the other hand, lateral (overhead) spray was shown to be more cost effective than flood irrigation where laser grading was used. Soils on the properties studied were permeable clays. The annual costs to run the spray system were approximately twice that of the flood system ($1,700 at 1993 prices for flood irrigation) on a property returning approximately $12,500 per year from 15 ha. However, establishing the flood irrigation system was considerably more expensive. The study concluded that the lateral spray system was more economic even with ongoing costs to provide pressurisation of water.

In summary, various studies demonstrate that the type of crop, size of the area being irrigated and other characteristics of the land and climate can affect the performance of any given irrigation system. Moreover, how the system is used is just as important as which system is used.

While dripper systems use the least water, much can also be done to improve the water-use efficiency of gravity-fed irrigation systems [17].

BENCHMARK ET REQUIREMENTS

Table 20 – Evapotranspiration Figures for the lower Murray* - Year 2004 [27]

						Months						
Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	6.60	5.10	5.20	3.20	1.40	1.80	N/A	1.00	1.70	3.60	4.40	4.20
2	6.90	5.00	4.90	3.30	1.60	1.00	1.00	1.50	2.40	4.10	5.20	3.80
3	7.30	5.40	6.10	2.70	1.40	0.20	1.00	1.70	1.40	4.00	3.60	5.40
4	6.80	5.60	5.90	2.90	2.20	0.80	2.00	1.00	2.00	4.00	4.40	5.30
5	4.20	5.30	6.20	3.70	1.30	1.10	1.50	1.00	2.10	3.70	0.60	6.40
6	5.90	6.00	5.50	4.00	1.80	1.50	1.10	1.00	2.20	4.10	1.40	6.90
7	6.40	5.50	5.90	4.20	1.40	1.30	0.80	1.10	2.80	5.30	NA	2.30
8	3.80	4.90	4.10	3.50	1.90	1.40	0.80	1.50	0.80	5.80	2.70	1.90
9	4.90	6.00	5.50	3.50	1.80	1.60	0.90	2.00	1.50	NA	3.70	2.70
10	5.50	3.60	4.80	3.50	1.90	0.30	1.30	1.20	1.60	7.30	5.20	3.60
11	6.00	6.30	N/A	3.00	2.00	1.30	1.20	1.20	2.80	4.80	3.10	6.30
12	6.00	3.10	4.50	3.40	1.90	1.30	1.20	1.40	1.70	4.30	1.30	4.40
13	6.00	6.30	4.30	2.40	1.40	0.80	0.70	2.60	2.40	5.80	5.50	4.90
14	7.40	5.60	4.40	2.60	1.10	1.30	0.90	2.40	2.20	6.50	4.20	4.20
15	6.30	6.20	4.60	2.90	1.90	1.00	0.80	1.90	2.20	1.90	3.60	4.60
16	6.30	6.10	4.70	1.90	1.90	1.10	1.20	1.80	2.60	4.00	4.50	6.20
17	7.60	6.70	4.70	2.50	1.20	1.00	1.30	2.10	2.70	3.90	5.50	7.10
18	6.00	7.10	4.40	2.90	1.20	0.80	1.30	1.70	3.00	3.60	6.70	7.30
19	5.60	5.90	4.30	2.50	1.00	0.60	1.00	2.10	3.40	4.70	4.70	7.30
20	6.60	5.80	4.60	2.20	1.60	0.80	1.20	2.20	3.30	4.90	5.40	6.60
21	5.30	5.50	4.80	2.70	1.10	0.70	1.40	2.30	3.70	4.90	5.80	6.40
22	6.60	5.30	4.40	2.80	1.30	0.60	1.10	3.40	4.40	4.80	6.10	6.60
23	5.90	5.90	4.30	3.40	2.20	0.70	1.30	2.50	4.30	2.90	6.30	7.00
24	5.80	5.10	4.60	2.50	0.60	1.10	0.30	2.30	3.00	5.10	6.20	7.30
25	6.00	5.20	4.30	2.50	1.60	0.70	0.30	3.30	2.30	4.90	6.60	6.80
26	6.20	4.90	5.00	2.20	1.40	0.60	0.90	3.60	3.50	4.70	6.60	6.90
27	6.00	5.00	4.30	2.20	0.20	1.00	1.40	1.70	3.90	5.40	6.80	7.00
28	6.40	5.40	4.20	2.10	1.20	1.30	1.30	2.80	1.20	4.20	5.30	6.70
29	5.30	5.50	4.80	3.90	1.20	1.80	0.70	3.10	1.90	4.50	6.70	6.10
30	3.20		3.40	2.00	1.40	1.60	0.90	0.60	2.30	4.90	3.70	5.80
31	4.00		2.90		1.50		1.20	2.00		5.40		6.80
Total	182.80	159.30	141.60	87.10	45.60	31.10	32.00	60.00	75.30	138.00	135.80	174.80
Mean	5.90	5.49	4.72	2.90	1.47	1.04	1.07	1.94	2.51	4.60	4.68	5.64

* All figures are from the Nangiloc Colignan Weather Station (Sunraysia Rural Water Authority ET Figures)

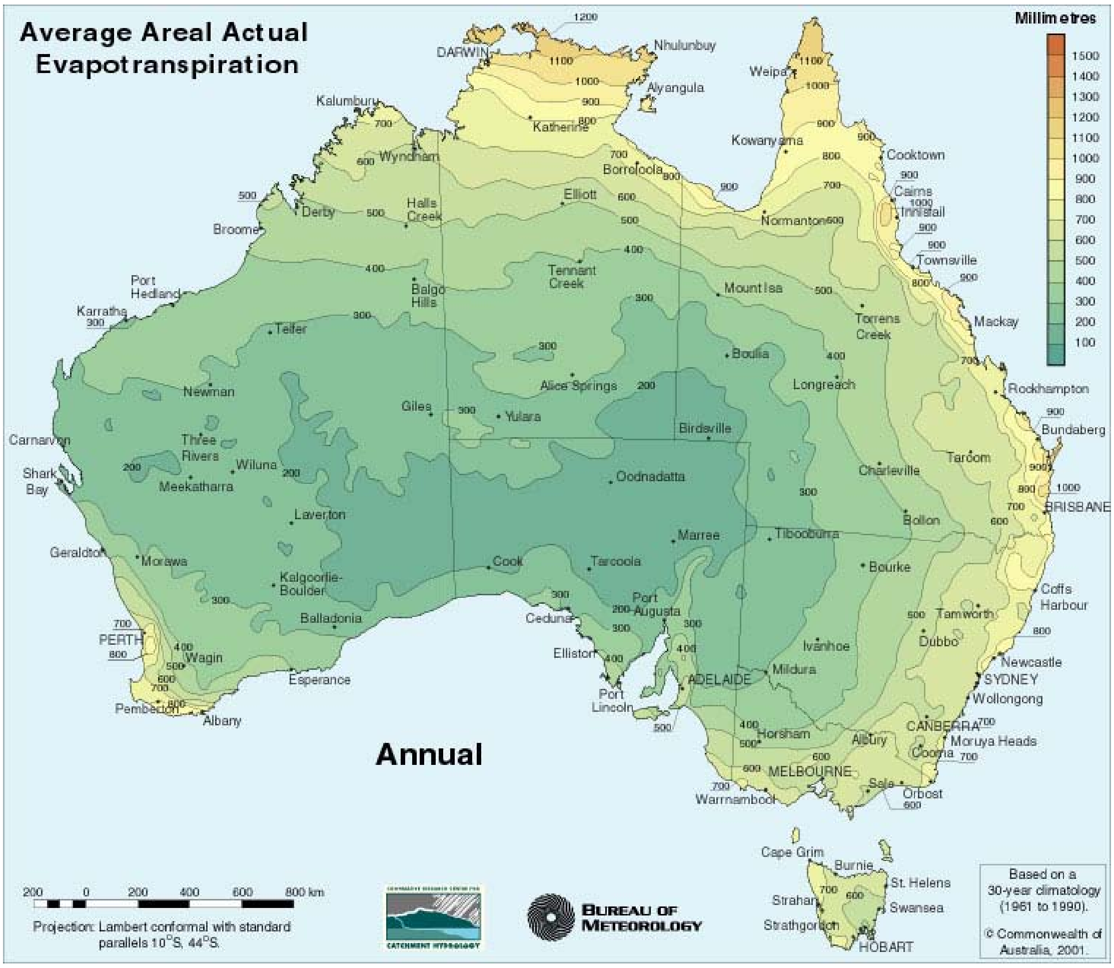


Figure 5 – Annual areal actual evapotranspiration [10]

Definition of evapotranspiration (ET) parameters

Areal actual ET is the ET that actually takes place, under the condition of existing water supply, from an area so large that the effects of any upwind boundary transitions are negligible and local variations are integrated to produce an areal average.

Areal potential ET is the ET that would take place, under the condition of unlimited water supply, from an area so large that the effects of any upwind boundary transitions are negligible and local variations are integrated to an areal average.

Point potential ET is the ET that would take place, under the condition of unlimited water supply, from an area so small that the local ET effects do not alter local airmass properties. It is assumed that latent and sensible heat transfers within the height of measurement are through convection only.

Table 19 – Annual evapotranspiration data from the main regions of Victoria [10].

	Regions Werribee[1]	Tatura[2]	Mildura[3]	Bairnsdale[4]	Geelong[5]	Horsham[6]
Jan	6.90	7.30	10.50	12.80	8.60	7.30
Feb	6.30	6.70	9.80	10.30	8.90	6.40
Mar	4.60	4.90	7.40	12.90	11.00	8.40
Apr	3.00	3.00	4.60	14.00	11.40	11.10
May	2.00	1.60	2.60	14.80	14.30	15.10
Jun	1.30	1.00	1.80	12.30	11.30	14.70
Jul	1.70	1.10	2.00	10.30	13.20	15.70
Aug	2.10	1.70	2.90	12.90	12.50	14.50
Sep	3.10	2.70	4.40	12.80	11.70	13.40
Oct	4.00	4.10	6.40	14.20	15.30	12.50
Nov	5.00	5.50	8.50	13.20	12.80	10.90
Dec	6.50	7.10	10.10	12.80	13.70	10.90
Annual Total (mm/day)	46.50	46.70	71.00	153.30	144.70	140.90
Annual Average (mm/day)	3.88	3.89	5.92	12.78	12.06	11.74
Number of years	8.30	32.30	37.30	12.60	6.50	45.40

1- Climate averages for Station: 087065 WERRIBEE RESEARCH FARM

Commenced: 1913; Last record: 1980; Latitude (deg S): -37.9000; Longitude (deg E): 144.6833; State: VIC

2- Climate averages for Station: 081049 TATURA INST SUSTAINABLE AG

Commenced: 1942; Last record : 2004; Latitude (deg S): -36.4378; Longitude (deg E): 145.2672; State: VIC

3- Climate averages for Station: 076031 MILDURA AIRPORT

Commenced: 1946; Last record: 2004; Latitude (deg S): -34.2306; Longitude (deg E): 142.0839; State: VIC

4- Climate averages for Station: 084108 BAIRNSDALE

Commenced: 1970; Last record: 1983; Latitude (deg S): -37.8333; Longitude (deg E): 147.6500; State: VIC

5- Climate averages for Station: 087025 GEELONG SEC

Commenced: 1870; Last record: 1970; Latitude (deg S): -38.1167; Longitude (deg E): 144.3667; State: VIC

6- Climate averages for Station: 079023 HORSHAM (POLKEMMET)

Commenced: 1873; Last record: 2004; Latitude (deg S): -36.6539; Longitude (deg E): 142.1036; State: VIC

USE OF SOIL MOISTURE MONITORING

Different soil moisture monitoring devices are used by growers, and measure either suction or volume of water in the soil.

Soil moisture suction is used as a measure of plant stress and is a handy tool for growers to use in scheduling their irrigations. Tensiometers and resistance blocks are used to measure soil moisture suction. On the other hand, there are growers using a range of other instruments that measure soil water content, including neutron probe, EnviroScan®, Gopher®, Time Domain Reflectometry (TDR), DRW Microlink® and Aquaflex.

Growers use soil moisture monitoring as a basis for irrigation scheduling as it can provide accurate information about the extraction of available water by the crop. These growers are aware of the importance of soil moisture monitoring, particularly in difficult soils such as Red Brown Earths, which require careful irrigation management.

Table 21 – The use of tools to schedule irrigation [31].

Tools used(b)	Number of Establishments
Evaporation figures or graphs	^787
Tensiometers	^845
Soil probes	^1,188
Government or commercial scheduling service	*363
Calendar or rotational scheduling	^1,812
Knowledge or observation	11,058
Other	^389

^ Estimate has a relative standard error of 10% to less than 25% and should be used with caution.

* Estimate has a relative standard error of 25% to 50% and should be used with caution.

(b) Agricultural establishments reporting more than one tool are shown against each tool reported.

USE OF WEATHER BASED SYSTEMS FOR SCHEDULING

DPI has produced a number of publications (Agnotes, a grower's guide, production manuals etc) which describe the use of weather based systems for irrigation scheduling. Two weather-based scheduling systems are used by growers, in measuring the amount of water lost from a crop. These are based on:

1. Evaporation from an open water surface

2. Historical climate data such as relative humidity, temperature, wind speed and sunshine hours.

Pan evaporation is the simplest and most commonly used method for calculating crop water use. Some growers use a Class A pan. Crop water use is generally less than open pan evaporation, and the difference is known as the crop factor, so that *Crop Water Use (mm) = Crop Factor x Pan Evaporation (mm)* [24].

SECTION 4 – VICTORIAN VEGETABLE GROWING REGIONS BY CATCHMENT

TOTAL CATCHMENT WATER USED FOR VEGETABLE CROPS

Table 22 – Total water used for vegetable crops [31]

	Agricultural establishments	Agricultural Establishments Irrigating	Area of agricultural land '000 ha	Area irrigated 000 ha	Volume applied ML	Application rate ML/ha	Average water allocation/farm ML
Vegetables for human consumption	1,048	928	27	25	78,956	3.2	25.76
Vegetables for seed	166	83	^2	^1	^2,972	2.2	^6.02
Total	1,214	1011	29	26	81,928	na	na

^ Estimate has a relative standard error of 10% to less than 25% and should be used with caution.

AVERAGE WATER ALLOCATION/FARM (TYPE, HIGH/LOW SECURITY)

Seasonal water allocations are regularly reviewed and updates announced based on storage volumes. In recent years many Victorian water distribution utilities have had to reduce water allocation due to prolonged drought conditions. Example reports follow:

Report 8/05: End of August 2005, DPI, Victoria

Northern Victoria - Goulburn Murray Water

- Updated seasonal irrigation allocations were announced on 1 September. Inflows resulting from the rainfall of July–August have increased water availability in most of the supply systems.
- There is still insufficient water in Lake Eppalock to enable an allocation for irrigation entitlements in Campaspe system. The recent strong inflows to Murray system storages have increased the reserve for next season's Murray system allocations.
- Goulburn system: 63% of water right and licence volume (increase of 56% since last month)
  - Murray system: 100% of water right and licence volume (increase of 18% since last month)
  - Campaspe system: 0% of water right and licence volume (no change)
  - Loddon system: 33% of licence volume (increase of 32% since last month)
  - Bullarook Ck system:
  Newlyn Reservoir 148% of licence volume (48% increase)
  Hepburns Lagoon 148% of licence volume (79% increase)
  - Broken system: 170% of licence volume (92% increase).
- The seasonally adjusted outlook for the February 2006 allocation has improved for most systems. However, future allocations will be largely influenced by inflows in the remaining winter/spring months.

- – In the Goulburn there are 8 chances in 10 of the allocation being 100% of water right and licensed volume (was 5 chances in 10 last month), and less than 1 chance in 10 of any sales water being available. In Loddon system, there are 5 chances in 10 of the allocation being 100% of water right and licensed volume.
  – In the Murray system, there 3 chances in 10 the chances of receiving any sales allocation by 15 February 2006.
  – In the Broken system it has reached the maximum sales allocation.
  – In the Campaspe system, there is 1 chance in 10 of the allocation being 100% of water right and licensed volume or better (same as last month), and less than 1 chance in 10 of some sales water being available.
- The next allocation announcement is scheduled for 15 September.

Grampians Wimmera Mallee Water

- Storages in the Wimmera Mallee domestic and stock supply system finished the month at 8.6% of capacity (compared with 13.5% at the same time last year).
- Available water under the Wimmera Glenelg Bulk Entitlement (BE) is 100,000 ML. Any water above this volume is being directed to the reserve for next year, which to date stands at a volume of 10,390 ML.
- Irrigation supply is at 2,110 ML (which is around 8% of allocation). While allocations on the Wimmera Mallee system are still very low, it is an improvement on the zero irrigation allocation in the Wimmera Mallee system experienced for the past two years.
- The 2005/06 summer domestic and stock channel run will provide one dam for each 400 hectares a significant increase in restrictions from 2004/05 summer.
- Supply-by-agreement customers' allocation remains at 40%. This low allocation is causing significant hardship to these enterprises and there is considerable interest in the purchase of temporary entitlement, with demand well in excess of any volume that may be available.
- Allocations are expected to be updated in mid September 2005

- The outlook for the 2005/06 season (commencing 1 November 2005) is dependent on spring rainfall. However, if the dry conditions persist, there is a chance the current level of restrictions will increase.

Southern Rural Water

- Lake Glenmaggie, the principal source of water for Thomson-Macalister Irrigation District, is now at 87.2% of capacity. The irrigation season opened on 15 August with an allocation of 55% and this subsequently increased to 80%. The further outlook for the 2005/06 irrigation season is totally dependent on inflows in spring. As Glenmaggie is an annual storage there is high probability that it will fill before the end of October.
- Allocations for irrigators in the Werribee system (Werribee and Bacchus Marsh irrigation districts and the Werribee River) increased to 60% of water right, a significant improvement on last year's opening allocation of 5%. SRW's share of Werribee Basin storages is 37.3%. It is possible allocations will reach 100% this season, but further increases in allocation are dependent on inflows in winter/spring.
- Water levels in the Deutgam Groundwater Management Area have substantially recovered. The allocation in this area remains at 60% of licensed volume.
- Rosslynne Reservoir remains low at 15% of capacity. The allocation for SRW diverters on Jacksons Creek is currently 15%. With inflows well below average the outlook for SRW diverters on Jacksons Creek is for another season with a very low allocation.
- Water availability on the Latrobe system remains good, with Blue Rock Lake being at 91.1% of capacity. Southern Rural Water has announced an allocation of 100% of license volume 15.

Table 23 – Average water allocation/farm by districts [31]

Districts	Agricultural establishments no.	Agricultural establishments irrigating no.	Area of agricultural land '000 ha	Area irrigated 000 ha	Volume applied ML	Application rate ML/ha(b)	Average water allocation/farm ML
Gippsland	3,343	*681	477	*12	*30,422	2.5	9.10
East Gippsland	2,364	^1,058	^1,433	^76	^255,338	3.4	108.01
Ovens-Murray	2,132	^792	710	^17	^60,073	3.6	28.18
Goulburn	5,781	3,302	1,636	209	947,408	4.5	163.88
Loddon	2,035	726	1,034	^55	^166,719	3.0	81.93
Mallee	4,097	2,748	2,599	142	731,131	5.1	178.46
Wimmera	2,806	*196	2,466	*17	*65,712	3.9	23.42
Central Highlands	1,971	^353	759	^8	^22,536	2.9	11.43
Western District	4,305	^731	1,617	*28	*109,282	3.8	25.38
Barwon	1,785	*227	467	*3	*7,430	2.5	4.16
Melbourne	2,594	1,189	217	26	^68,305	2.6	26.33
Total	33,212	12,005	13,413	593	2,464,357	4.2	74.20

AVERAGE ALLOCATION % / FARM OVER LAST 10 YEARS

Table 24 – Area Irrigated Victoria - Aggregation of SLA to AWRC River Basin [5]

Basin	Area Irrigated 1983/84 (ha)	Area Irrigated 1992/93 (ha)	Area Irrigated 1996/97 (ha)	Change in Area Irrigated 1992/93 - 1996/97 (%)
VIC	554,992	581,418	546,068	-0.06
East Gippsland (Vic)	338	316	283	-0.11
Snowy River (Vic)	511	478	430	-0.10
Tambo River	662	675	703	0.04
Mitchell River (Vic)	9,202	9,246	8,798	-0.05
Thomson River	20,242	21,708	21,390	-0.01
Latrobe River	11,826	10,408	10,320	-0.01
South Gippsland	8,885	11,722	9,744	-0.17
Bunyip River	8,081	6,762	7,842	0.16
Yarra River	3,330	2,650	3,114	0.18
Maribyrnong River	240	595	240	-0.60
Werribee River	4,164	3,630	5,469	0.51
Moorabool River	4,166	3,347	1,990	-0.41
Barwon River	2,566	2,734	1,998	-0.27
Lake Corangamite	2,010	3,373	1,880	-0.44
Otway Coast	2,088	2,493	1,678	-0.33
Hopkins River	4,114	7,691	2,851	-0.63
Portland Coast	2,173	2,965	2,416	-0.18
Glenelg River (Vic)	1,709	8,376	1,947	-0.77
Millicent Coast (Vic)	1,112	7,402	2,270	-0.69
Upper Murray River (Vic)	1,287	2,122	2,824	0.33
Kiewa River	784	714	982	0.38
Ovens River	7,886	8,131	7,977	-0.02
Broken River	62,848	63,369	64,895	0.02
Goulburn River	103,698	104,290	100,402	-0.04
Campaspe River	21,570	21,269	20,477	-0.04
Loddon River	145,105	141,804	134,759	-0.05
Avoca River	60,237	60,217	60,567	0.01
Murray (Vic)	42,295	44,976	48,994	0.09
Mallee (Vic)	12,723	13,055	13,233	0.01
Wimmera - Avon Rivers	7,590	13,541	4,205	-0.69

AVERAGE ALLOCATION OVER LAST 3 YEARS (DROUGHT AFFECTED)

Victorian irrigators on 10, 262 establishments, were allocated 2,417,086 ML of their total entitlement of 2,825,506 ML in 2002/03 [31].

CROP TYPES/FARM

Table 25 – Land use for horticulture in Victorian irrigation areas

Irrigation District Region	Crop type
SOUTHERN RURAL	
Metropolitan (Werribee, Bacchus Marsh & Cranbourne)	Mainly vegetables, some fruit
Gippsland	Mixed farms, vegetables
East Gippsland	Mixed farms, vegetables
Barwon, Western District & South of Central Highlights	Vegetables
GOULBURN MURRAY	
Goulburn & Loddon Campaspe	Vegetables, fruit, Mixed farm
Ovens Murray	Fruit, vegetables
WIMMERA MALLEE & SUNRAYSIA	
Mallee, Wimmera & North of Central Highlights	Mixed Fruit and vegetables

Table 26 – Some crops commonly used in Victoria as green manures and their planting season [29]

	Summer	Autumn	Winter	Spring
Legumes				Yes
cow pea (slow)				
cow pea	Yes			
faba bean		Yes	Yes	
field pea		Yes	Yes	Yes
lupin				Yes
lupin (fast)		Yes		
vetch	Yes			Yes
Non-legumes				
barley	Yes	Yes	Yes	
canola		Yes	Yes	Yes
Italian ryegrass	Yes	Yes	Yes	Yes
Japanese millet	Yes			Yes
mustard (slow)				Yes
mustard	Yes			
oat (slow)	Yes			
oat		Yes		
oat (fast)			Yes	
rye corn		Yes		
sorghum (slow)				Yes
sorghum	Yes			

Fast = faster maturing varieties

Slow = slower maturing varieties

WATER ALLOCATION FOR VEGETABLES COMPARED WITH OTHER CROPS

Table 27 – Water usage by enterprise type [31]

Crop	Area irrigated 000 ha	Volume applied ML
Vegetables for human consumption	25	3.20
Vegetables for seed	1	0.12
Fruit trees, nut trees, plantation or berry fruits (e)	39	7.01
Grapevines	35	8.34
Nurseries, cut flowers or cultivated turf	3	0.43
Other broad-acre crops (d)	8	0.71
Cereal crops not for grain or seed	5	0.69
Cereal crops for grain or seed (b)	27	2.08
Cereal crops cut for hay	13	1.59
Pasture for hay and silage	57	8.31
Pasture for grazing	368	65.39
Pasture for seed production	np	Np

(b) Excludes rice

(d) Excludes sugar cane and cotton

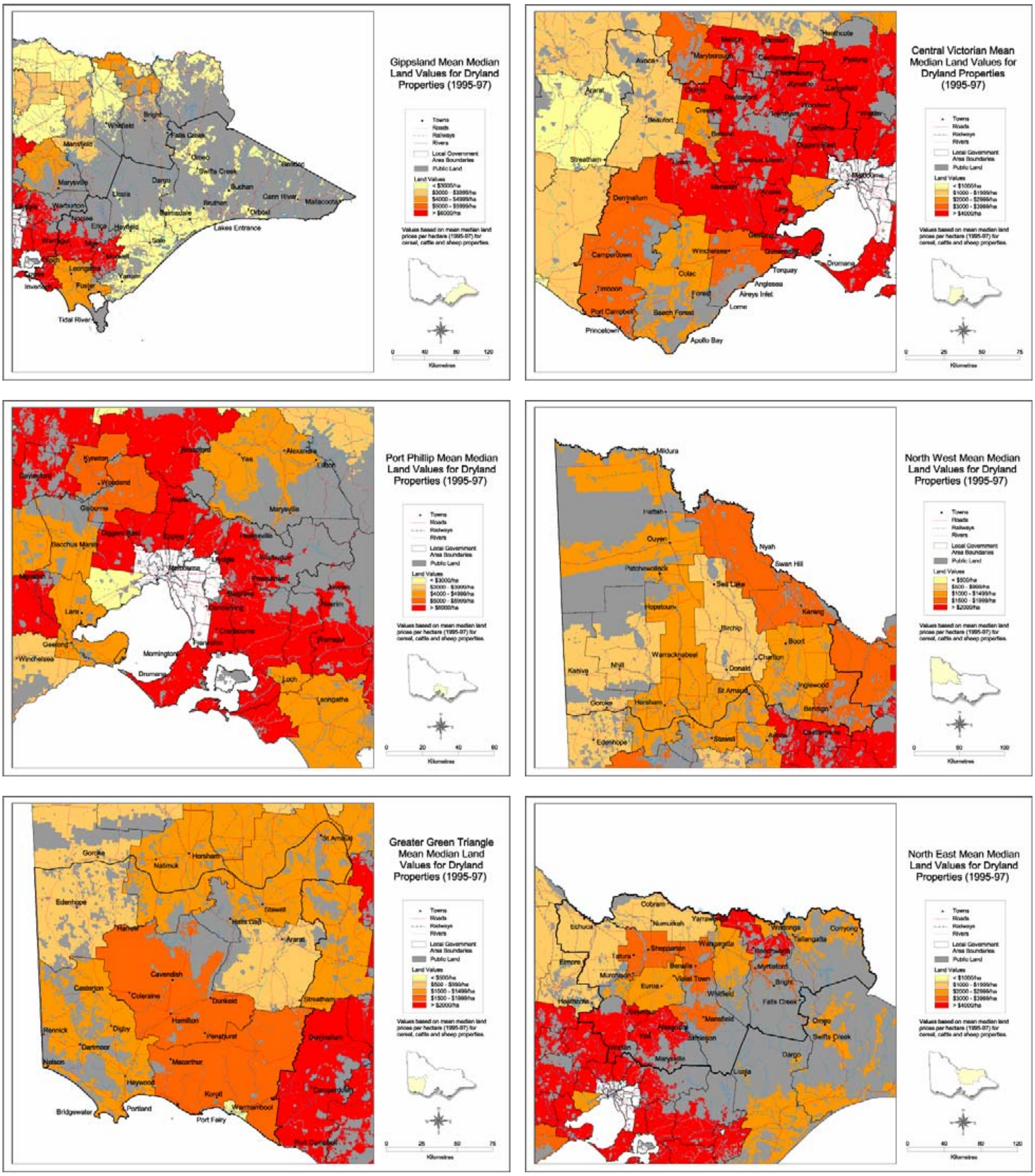
(e) Excludes grapevines

ADOPTION OF NEW TECHNOLOGIES ON VICTORIAN FARMS OVER THE PAST 5 YEARS

Table 28 – Changes to irrigation practices, past 5 years to 30 June 2003 [31]

Changes	Number of Establishments
Total irrigating	12,005
Made no changes	3,470
Intending to make one or more changes	8,535
Type of change(b)	
More efficient irrigation application techniques	5,272
More efficient irrigation scheduling	4,185
Piping or covered open channels to reduce water loss	^1125
Levee banks and/or drains	^1,281
Laser-level	2,989
Irrigation water re-use or recycling	2,167
On-farm soil moisture monitoring	^1,179
Document farm water plan	^845
Other	^786

(b) Agricultural establishments reporting more than one change are shown against each change report.



Figures 6 – Median land values by district for dryland properties 1995–97 [16]

LAND VALUE

Table 29 – Land values by districts (DPI) 16.

Region	Land Value
Port Philip Region	The outer areas of metropolitan Melbourne contain the most expensive dryland agricultural properties in Victoria, averaging median values of more than $6,000 per hectare. The least expensive areas in the region lie to the west, where dryland agricultural properties average median prices are less than $3,000 per hectare.
North West Region	Some dryland agricultural properties in the North West region are priced lower than $1,000 per hectare, however, the majority of local government areas have mean median property values ranging between $1,000 and $1,999 per hectare.
Central Victorian Farm Plantations Region	Throughout the CVFP region, mean median values for dryland agricultural properties range from $2,000 per hectare in the far north-west to over $4, 000 per hectare throughout most of the northern section of the region. Other dryland properties are generally priced somewhere in between these values.
Greater Green Triangle Region	Mean median dryland property values vary significantly in the Greater Green Triangle region. Some, around Warrnambool, are priced lower than $500 per hectare while others in the north-east and north-west average $1,000 per hectare. However, the majority of the region which falls within Victoria have mean median property values ranging between $1,000 and $1,499 per hectare.
North East Region	Mean median land values for dryland agricultural properties in the North East region vary from between $1,000 – $1,999 per hectare in the North East, to over $4,000 per hectare in the far north-east. Other parts of this region which are not occupied by public land have average median values somewhere between $2,000 – $3,999 per hectare.
Gippsland Region	The Gippsland region is mostly crown land, so there are few dryland agricultural properties available, except for patches of East Gippsland, priced between $2,000 – $2,999. The same mean median value is applicable throughout much of the southern part of Gippsland, while West Gippsland properties are greater than $4,000 per hectare and some average more than $6,000 per hectare, thus are comparable to the Melbourne metropolitan area.

THE NUMBER OF GROWERS WHO HAVE COMPLETED IRRIGATION TRAINING

It is estimated that less than 30% of Victorian vegetable growers have participated in formal irrigation training, although figures vary between industry sectors and regions. Rates are higher in the north of the state, where irrigation becomes more critical to crop performance (e.g. the processing tomato industry). More sophisticated irrigation systems also require a higher level of training. Most growers have attended field days, where topics relating to irrigation are discussed. Growers look to government agencies (DPI and water providers), irrigation equipment suppliers, consultants and other farmers for advice on their irrigation practices.

CHANGES TO MANAGEMENT OF THE FARM BUSINESS

Table 30 – Changes to management of farm businesses, percentage of total respondents, 2001–02 [7]

Changes	Victoria %	Australia %
Financial management	18	19
General business management	12	14
Marketing	9	12
Production management	15	18
People management	6	6
Natural resource management:		
Combating salinity on property	6	6
Improving water quality	6	8
Improve general land use and use of soil	19	24
Managing nature conservation on property	8	12
No change	40	36

Preliminary estimates from the 2001–02 Agricultural Survey provide information on the operation and management of Australian farm businesses. This includes details relating to knowledge of, and participation in, further training and education programs.

These estimates show that 64% of respondents indicated some change to farm business management practices during the year ended 30 June 2002. The main changes made were related to improving general land use and use of soil (24%), financial management (19%) and production management (18%).

The results indicate that 40% of respondents attended a demonstration site or field day, 25% participated in workshops or short courses, 16% attended a conference and 12% engaged a consultant. While 9% of respondents attended a TAFE course, only 1% attended a university course. Around 32% of respondents reported they did not participate in any courses.

OTHER INITIATIVES

Stressed Rivers Program: The Stressed Rivers Program aims to restore those aspects of the flow regime that are of greatest benefit to habitats and to undertake other work to improve habitats. However, at present only 35 river reaches have been identified as stressed under the program – rather fewer than the 65 per cent that are considered to be in poor condition.

The Snowy River is conspicuous by its absence from the program, although the Snowy River Inquiry indicated that much of the river could certainly be described as stressed. Inter-governmental agreement has been required to address the problems of the Snowy River. The Goulburn River is not included either, although it is one of the most stressed rivers in the State. The Goulburn was excluded because its main physical feature, the Eildon Dam, cannot be removed. Practicability of relieving stress in rivers was one of the criteria for choosing rivers for the program.

Improving the condition of stressed rivers appears to be feasible, and is likely to produce benefits beyond the river itself. However, reversing the impacts of past mistakes on these rivers will involve considerable commitment and resources.

River flows are vital to the restoration of stressed rivers. Provisions for these can be included in Streamflow Management Plans. These are currently being co-ordinated with the Stressed Rivers Program through the River Health Program.

The Farm Dams (Irrigation) Review: Recent studies have shown that dams can reduce the annual run-off from the catchment by twice the volume of the holding capacity of the dams. The cumulative effect of large private dams or thousands of small dams can be substantial.

It was found that farmers in the upper river catchments felt aggrieved that their traditional 'right' to build dams was under threat while irrigators lower in the catchment were concerned that the proliferation of dams in the upper catchment would deplete their supplies.

The Government confirmed the principles of:

a. The total water resources of a catchment should be included within the water allocation regime;

b. Water-resource management issues involve the total catchment and require a partnership between the community and Government;

c. Allocation mechanisms should be simple, efficient and equitable;

d. As the value of water to the community increases, so should the management effort to allocate and protect the water resources;

e. All water users should share in the cost of managing the water resources of a catchment.

In addition, the Government added that:

A sound, well-regulated system [for water allocation and management] is needed that provides security for existing users and opportunity for future development. Further development of water trading will enable water to move equitably to enterprises that provide the best economic return [17].

The White Paper [37]***:*** The Victorian Government released a White Paper titled 'Securing our Water Future Together' in June 2004, as an integrated, innovative water strategy. It comprised seven chapters describing future plans for allocation and pricing, and addressing issues of environmental use, as well as smarter use for both agricultural and urban purposes.

The white paper was framed around five fundamental principles:

1: The management of water will be based on an understanding that a healthy economy and society is dependent on a healthy environment

2: The Government will maintain overall stewardship of all water resources irrespective of source, on behalf of all Victorians.

3: Water authorities will be retained in public ownership.

4: Users of the services our water systems provide should, wherever practical, pay the full cost, including infrastructure, delivery and environmental cost associated with that service.

5: The water sector, charged with managing our water systems, will be capable, innovative and accountable to the Victorian community.

REFERENCES

1. Australian Bureau of Statistics (2001) Farm gate value of vegetable crop production, ABS Census, HAL Vegetable Production Statistics for Victoria.
2. Australian Bureau of Statistics (2002). Percentage area of 10 major vegetable crops. Census, 2001.
3. Australian Bureau of Statistics (2003). Agricultural Survey Data for 2002–03. 001 ABS. Produced for DPI Victoria.
4. Australian Bureau of Statistics (2002). Total area, yield and average yield for major Victorian vegetable crops. ABS Census 2001.
5. Australian Bureau of Statistics (1997). Total area irrigated VABS AgStat 97, 93 784. http://audit.ea.gov.au/ANRA/agriculture/agriculture_frame.cfm?region_type=VIC&region_code=VIC&info=irri_extent
6. Australian Bureau of Statistics (2002). Gross returns per ML for main Victorian vegetable crops. ABS Census 2001.
7. Australian Bureau of Statistics (2002). Farm Business Operations and Management, Australia. 7111.0.55.001 Agricultural Survey:
8. Australian Bureau of Statistics (2004). Agricultural Survey Data for 2002–03.
9. Bureau of Meteorology (2005). Average Annual Rainfall of Victoria, Commonwealth of Australia.
10. Bureau of Meteorology (2005). Annual Areal Actual Evapo-transpiration: http://www.bom.gov.au/cgi-bin/climate/cgi_bin_scripts/evapotrans/et_map_script.cgi
11. Cornish JG, Murphy JP and Fowler CA. (1990), Irrigation for Profit: Water Force Victoria, Irrigation Association of Australia, Numurkah, Victoria.
12. Department of Primary industries (2005). Victorian Vegetable Industry. Information Brochure, Victoria.
13. DNRE & ERNST & YOUNG (2001). Vegetable Benchmarking Study, Seven Vegetables Report.
14. Department of Primary Industries (2005). Resources On-line, Rainfall. http://www.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/water-streports-rainfall
15. DPI Victorian Resources On-line (2005). Water allocation update. Report 8/05. http://www.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/water-streports-irrig-allocns
16. Department of Primary Industries (2005). Resources On-line, Land values by districts. http://www.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/private-regional
17. Environment and Natural Resources Committee (2001). Inquiry into the Allocation of Water Resources for Agricultural and Environmental Purposes, State Government, Victoria.
18. Giddings J (Ed). (2004). Drip irrigation a grape grower's guide. NSW Agriculture.
19. Goulburn Murray Water Authority: http://www.g-mwater.com.au
20. Holmes R. (2001). Statistics showing production and estimated wash water use 2000/2001, DPI Knoxfield, Victoria (Unpublished).
21. Loddon Murray Region Horticulture Gross Margins 2005–06, Catchment and Agriculture Services, Department of Primary Industries, Echuca, Victoria, 20005.
22. Madge D and Jaeger C. (2003). Organic Farming: Green manures for vegetable cropping. Agnote No AG1084, Department of primary industries, Victoria.
23. Marr P (Ed). (2002). Irrigation for horticulture in the Mallee. NSW Agriculture.
24. Qassim A and Ashcroft B. (2001). Irrigation scheduling for vegetable crops, DPI Agnotes, AG0787, Tatura, Victoria.

25. Sarquis A.V. (1981). Economic Impacts of Agricultural Production and Processing in Stanislaus County. University of California Cooperative Extension, Stanislaus County

26. Southern Rural Water Authority: http://www.srw.com.au/welcome.html

27. Sunraysia Rural Water Authority web page (2004). Evapotranspiration Figures - Year 2004 from the Nangiloc Colignan Weather Station.

28. Sunraysia Rural Water Authority: http://www.srwa.org.au/

29. Sutherland J and Piggott T. (1980). Green manure crops for vegetable production. Agriculture Note, Agdex 207/537, ISSN 0155 0217, Department of Primary Industries, Victoria..

30. Top BM. (2002). Economic Evaluation of Vegetable Crop Production in the Goulburn Valley, Masters Thesis, University of Melbourne

31. Trewin D. (2005). Water Use on Australian Farms, 2002/03, ABS 4618.0. Australian Bureau of Statistics.

32. Victorian Regions: http://www.atv.org.au/Regions.htm

33. Victorian Year Book (2000). Rainfall in districts of Victoria: cited from Bureau of Meteorology.

34. Water Allocation Report (August 2005). DPI, Victoria http://www.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/water-streports-irrig-allocns

35. Watermove: www.watermove.com.au

36. Wimmera Mallee Water Authority: http://www.wmwater.org.au/

37. The White Paper: http://www.dse.vic.gov.au/DSE/wcmn202.nsf/