Water Requirements of Viticulture Within The Blackwood Ground Water Area

As part of an economic study report

August 2003

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Contents

2. The Study

2.1 Introduction

This report details the water requirements of viticulture within the Blackwood Ground Water Area as part of an economic evaluation commissioned by the Waters and Rivers Commission. The current and potential water requirements of both wine and table grapes are examined.

The report is presented in four sections. The first section details current industry statistics on size. The second section details the area of land suitable for grape production within the ground water area. The third section details the outlook for the growth of the wine and table grape industries in 2005, 2010 and 2030 and respective water requirements. The data for this section is obtained through regional wine industry associations and nursery suppliers. In the final section future water use is estimated based on using three watering regimes and an assumption of a warming climate.

2.2 Peer Review

The report was undergone a peer review process which included inviting feedback from the Blackwood Valley Wine Industry Association, Geographe Vignerons Association, Wine Industry Association of Western Australia and Steve Partridge (ARM). Key industry people were involved in a review meeting. Those invited to participate were Albert Haak, Keith Scott, Sally Scott, Murray Edmonds, Andrew Hyatt, Sarah Dent, Dianna Fisher, Kristen Kennison and Bruce Pearse. In attendance at the meeting were Keith Scott, Sally Scott, Murray Edmonds, Nick Power, Murray Meaton, Jim Campbell-Clause and Ianto Ward.

2.3 The Study Area

The study area encompasses the Bunbury ground water area, the Busselton Capel ground water area and the Blackwood ground water areas (Figure 1). Three wine regions wholly or partly fall within the area including Blackwood Valley, Geographe and Margaret River.

The Margaret River wine region encompasses the Busselton and Augusta Margaret River shires areas that lie to the west of the 115 18E longitude parallel (Figure 2). The region includes the towns of Busselton, Dunsborough, Yallingup, Cowaramup, Margaret River, Karridale and Augusta.

The Blackwood Valley wine region is located south of Collie and South-East of Capel (Figure 3). It includes the towns of Nannup, Balingup, Greenbushes, Bridgetown and Boyup Brook.

The Geographe wine region is located to the north-east boundary of the Margaret River region, to the northern boundary of the Blackwood wine region and stretches as far east as Collie and north as Wagerup (Figure 4). It includes Bunbury and Harvey, Wokalup, Collie, Dardanup, Ferguson Valley, Capel, Boyanup, Donnybrook and Kirup.

We have drawn upon ABS data in this study. ABS data is collected by shire council boundaries however as these wine regions do not follow shire boundaries and do not coincide with ground water area boundaries the water use figures have been extrapolated. Wherever figures have been translated from ABS shire data to those of wine regions any assumptions have been stated.

FIGURE 1: Local Government boundaries, Ground Water sub-areas & Groundwater areas.

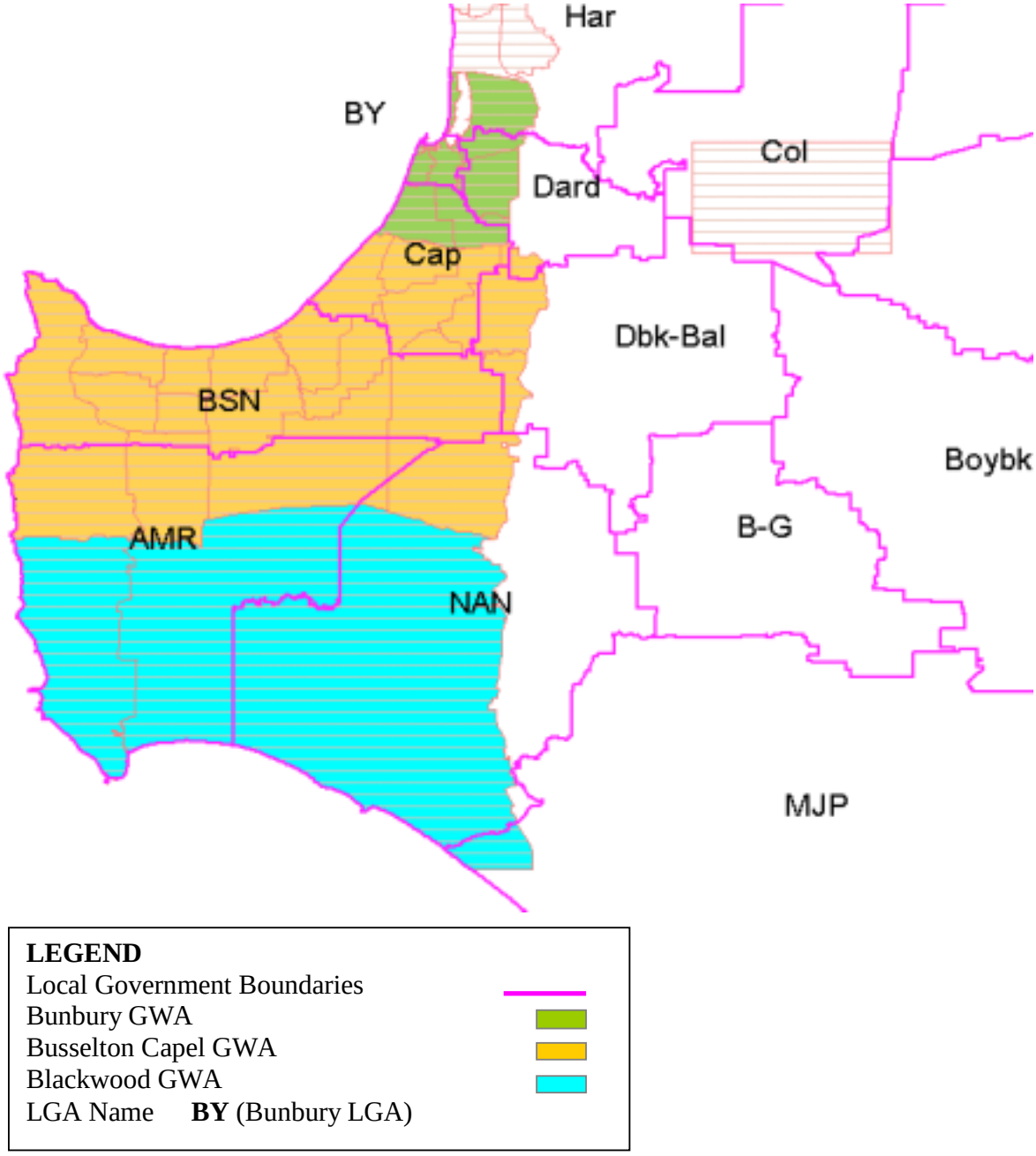

FIGURE 2: Margaret River wine region.

FIGURE 3: Blackwood Valley wine region.

FIGURE 4: Geographe wine region.

3. Method

3.1 Current industry statistics

The statistics detailing the size of the wine and table grape industries have been sourced from the Australian Bureau of Statistics. The ABS published information which was obtained from an Agricultural Census conducted at 30 June 2001 is contained in Table 1.

To provide up to date information on vineyard area, planting in spring 2001 and spring 2002 were estimated from rootling and cuttings sales in 2001 and 2002. These figures were supplied by two main nurseries (Viticlone and ARM) which supply to the area. Rootling and cutting numbers that have been sold for planting in spring 2003 have been included in water use calculations. An assumption of an additional 30% of rootling and cutting numbers has been made to account for supplies from other minor propagators. The growth in vineyard area over these years is displayed in Figure 5 of the results.

3.2 Potential water use – suitable land

The available amount of land that is suitable to produce grapes may present as a limiting factor to the growth of the industry over the next 30 years. This section details the area of land which has suitable characteristics for grape production.

The land characteristics which are required for successful vineyard planting are similar to other perennial horticultural crops. These characteristics are described in Tille and Lantzkes' land capability study for the Busselton, Margaret River, and Augusta area. Land characteristics which can be limiting factors to vineyard establishment are: wave erosion hazard, climatic zone, soil moisture availability, exposure to salt spray, soil fertility, water erosion hazard, flood hazard, slope stability, water supply, rooting conditions, wind exposure, wind erosion hazard, waterlogging, salinity and trafficability.

These land characteristics were used to classify the land areas within each of the shires in the south-west (Tille and Lantzke, 1990, 1996). The land capability classes used were:

- I Very high capability.
- II High capability.
- III Fair capability.
- IV Low capability.
- V Very low capability.

It is regarded that land area rated in Class I, II or III are fit to plant to viticulture.

Using the results of these classifications, a summary of the perennial horticulture capability for each shire in the south-west was detailed in 'Land Qualities for South-West WA', published by the Department of Agriculture – Western Australia. This summary is displayed in Table 5 of this report, where the land rated as class I, II or III has been totalled to provide a figure of the land area which is fit to plant to viticulture. This summary of class areas I, II and III exclude land area occupied by CALM. Using the results of these classifications, a summary of the perennial horticulture capability for each shire in the south-west was detailed in 'Land Qualities for South-West WA', published by the Department of Agriculture – Western Australia. This summary is displayed in Table 5 of this report, where the land rated as class I, II or III has been totalled to provide a figure of the land area which is fit to plant to viticulture. This summary of class areas I, II and III exclude land area occupied by CALM but does not exclude areas of remnant vegetation that may not be available for agricultural pursuits.

3.3 Present and Projected water use – future expansion of viticulture industry

The current volume of water used by the wine industry was extrapolated by combining the vineyard area in 2003, with a typical watering schedule for each wine region. These extrapolations are displayed in Figure 5. The vineyard area and water schedule for table grapes was supplied by Ian Cameron of the WA Agriculture Department and are displayed in the text below table 4.

In order to predict the water used by viticulture in the future, a projection of the future size of the industry is required. To do this several industry groups were consulted. Their views on the size of the industry are detailed in table 6.

Regional Wine Industry Associations

The respective associations from each region were contacted to complete a questionnaire on the future trends for viticulture area and water use. The three wine industry associations contacted for their opinions were; Blackwood Valley Wine Industry Association, Geographe Vignerons Association and Margaret River Wine Industry Association.

The questionnaire sent to the associations contained the questions:
1. What is the area of vineyards in the region in 2003:
3. What has been the trend in vineyard area (ha) from 1996 to 2003.
4. Projection of vineyard area in the region for the years 2005, 2010 and 2030.
5. Current water use by vineyards in the region.
6. Projection of water use (MegaLitres / ha) in 2005, 2010 and 2030.

3.4 Projection of water use – different levels of irrigation and climate change

The irrigation water requirement is likely to change in future years due to changes irrigation technology, changes in climate or where different wine styles are demanded.

At present some vineyards are watered with a full irrigation schedule. A full irrigation schedule is one where water is applied to avoid water stress and to maximise yield, but where vines are not over watered. This technique can achieve higher yields than other irrigation schedules although the desired quality may not be maximised and wine produced will mainly be basic quality. A typical water use figure for a full irrigation schedule in the south west is 2.6 (Donnybrook), 2.3 (Manjimup), 1.8 (Margaret-River) ML per hectare (see appendix).

In recent years there have been two significant advances in irrigation scheduling – regulated deficit irrigation (RDI) and partial root zone drying (PRD).

RDI is the control and management of water stress through irrigating at less than the full requirement of the vines and maintaining soil moisture at a relatively dry level. Using RDI can result in an improvement in quality as well as good yields. The aim is to maintain water stress within a desirable range through different growth stages so that the response of the vine can be harnessed to the benefit of the vineyard. Wine produced under a RDI regime will achieve premium, super premium, ultra premium or icon quality. RDI is the most common form of irrigation regime used in the study area. A typical water use figure for RDI in the study area is 1.8 (Donnybrook), 1.5 (Manjimup), 1.2 (Margaret River) ML per hectare (see appendix).

In PRD, water is applied alternatively to each side of the vine to create wet and dry regions in the root zone. This results in the vine responding to the dry side and reducing water use, vine size is restricted and fruit quality maximised. Wine produced under a PRD regime will be premium, super premium, ultra premium or icon quality. This technique results in half the normal volume (full irrigation) of water being used. PRD has not been adopted in Western Australia but is likely to in areas with low spring rainfall. A typical water use figure for PRD in the study area is between 0.9 to 1.8 ML per hectare.

Global warming and climate change as a result of the enhanced greenhouse effect is likely to have a significant impact on viticulture in Australia. This fact is outlined in a report by Keith Jones 'The enhanced greenhouse effect and the Australian viticulture industry'. The CSIRO's predicts that Australian vines will be grown under much drier and warmer conditions this century. In 2030 the south-west region will be between 0.3 and 1.6 °C warmer than 2001 and receive somewhere between 4% more and 20% less rainfall than 2001 (Jones, K 2003). In this study the mid point of these predictions – a 1.0°C increase in temperature, will be used. In the results section we use this figure in conjunction with the isotherms for South Western Australia, described in Gladstones Viticulture and Environment. From these two publications a prediction of the increase water use requirements for viticulture as a result of climate change can be determined.

4. Results

4.1 Current industry statistics

The most current statistics on the size of the viticulture industry which have been published to date are from the Australian Bureau of statistics for 2001. The 2001 vineyard area in the four shires of Augusta Margaret River, Busselton, Capel and Nannup are displayed in Table 1. Current figures of vineyard area are then calculated using rootling and cutting sales from the nurseries.

The size of the wine industry in the study area as of the end of June 2001 was 4,220 hectares. A total of 25,500 tonnes of wine grapes were produced in 2001, it was higher in 2002 but similar in 2003. The table grape industry in all regions south of Harvey totalled an area of 150 hectares in the 2003 season (Cameron, pers. com). A total of 465 tonnes of table grapes were produced within the study area in 2003. This equated to a value of produce of $38.5 million of wine grape sales and $1.1 million of table grapes.

Table 1. Vineyard area (ha) in the Augusta-Margaret River, Busselton, Capel and Nannup shires from the 2001 ABS data.

Shire Name	Total Area (ha)
Augusta-Margaret River	1,968
Busselton	2,101
Capel	121
Nannup	30
TOTAL	**4,220 ha**

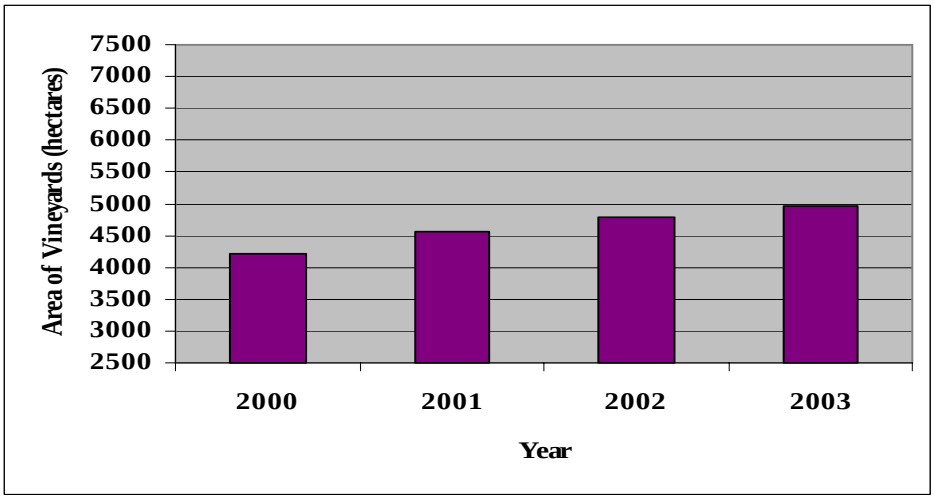

Figure 5. Area of wine grape vineyards in Capel, Augusta-Margaret River, Busselton and Nannup shires. The 2000 season was obtained by the 2001 ABS census data. Subsequent year's are derived from rootling supplies provided by ARM and Viticlone. An allowance of 30% was made for other propogators and it was assumed that the average planting density was 1667 vines per hectare.

The total area of wine grape vineyards at the end of 2001 was 4,552 hectares, which was an increase of 7.9% on the 4,220 in 2000. By the end of 2002 the vineyard area was 4,780 hectares, an increase of 5.4%. By the end of 2003, a total of 4,969 hectares of wine grape vineyards will be located within these four shires, an increase in 4.5% from 2002. This current growth figure of 4.5% will be used as a basis for predicting future growth as will be discussed in the following sections of this report.

4.2 Potential water use – suitable land

The land area which shows suitable characteristics for producing grapes in the four shires is as much as 94,070 hectares. When compared to a current planted area of 4,500 to 5,000 hectares it is clear the presence of suitable land will not be a limiting factor to the growth of the viticulture industries in the study area. Part of the 94 070 hectare is remnant vegetation and is not available for agricultural use.

Table 5. Area of land suitable for viticultural production.

Shire	Area Suitable for Viticulture Class I, II and III (ha).	Total Area of Shire
Augusta-Margaret River	23,040	224,760
Busselton	32,780	145,520
Capel	19,960	55,730
Nannup	18,290	293,480
TOTAL	**94,070 ha**	**719,490 ha**

Source: Agriculture Western Australia, (2001). Land Qualities for south west Western Australia.

4.3 Projected water use – future expansion of the viticulture industry

The most up to date information projecting the future size of the wine industry was obtained from several sources - the Blackwood Valley wine industry, a report to the Geographe Vignerons Association, the 2001 ABS data and rootling and cutting sales of nurseries.

The Blackwood Valley Wine Industry Association were the source for the projection of vineyard area in their region. The Blackwood Valley region received 7 responses out of its 31 members. The Blackwood Valley figure of 500 hectares is an estimate of the area of vineyards in the region in 2003. The responses from the members indicated the area of vineyards would increase by 30 % by 2010 and double by 2030 (table 6).

The current vineyard area for the Geographe region was sourced from the "Final report for Geographe Vigneron's Association by the Centre for Regional Development and Research survey, May 2002. Most (87.5%) of association members participated in the survey. The vineyard area for Geographe in 2003 is 909 ha. The current growth rate of 4.5% from section 4.1 was extrapolated to project the future vineyard area of the region.

The current vineyard area in the Margaret River wine region (4,818 ha) was calculated from deducting the vineyard areas in Capel (121 ha) and Nannup (30 ha) from the total vineyard area for the four shires (4,969 ha) (Figure 5). The Margaret River wine industry association have not kept complete data on vineyard areas or tonnages for the region to date. Again the growth rate of 4.5% per annum (see section 4.1) was used to project the future vineyard area of the region (table 6).

The total area of wine grape vineyards currently in the three regions is estimated to be 5,779 hectares. In two years, by the end of 2005, it is estimated the vineyard area in the three wine regions will have increased to 6,824 hectares. In seven years, by the end of 2010, it is estimated the vineyard area in the three wine regions will be 8,444 hectares. In the long range forecast for 2030, it is estimated the vineyard area in the three wine regions will be 19,796 hectares.

Table 6. Projection of vineyard area (ha) in each wine region in the years 2005, 2010 and 2030.

Wine Region	2003	2005	2010	2030
Blackwood Valley	500 BVWIA	570 BVWIA	650 BVWIA	1,000 BVWIA
Geographe	909 GVAR	993 4.5% p/a	1,237 4.5% p/a	2,983 4.5% p/a
Margaret River	4,818 NURS	5,261 4.5% p/a	6,557 4.5% p/a	15,813 4.5% p/a
TOTAL	**5,779 ha**	**6,824 ha**	**8,444 ha**	**19,796 ha**

Source:
4.5% – Based on the 4.5% growth rate in the year 2003 (shown in figure 5).
BVWIA – Blackwood Valley Wine Industry Association
NURS – The current vineyard area in the Margaret River wine region (4,818 ha) was calculated from deducting the vineyard areas in Capel (121 ha) and Nannup (30 ha) from the total vineyard area for the four shires (4,969 ha) (Figure 5).
GVAR – Final report for Geographe Vigneron's Association by the Centre for Regional Development and Research survey, May 2002

By 2005 the table grape industry in the south west will be 10% less than now. By 2010 it will grow to be 10% bigger than at present with the adoption of new varieties. In 2030 it may be 20% bigger than now or 25% smaller than now if the new varieties are not successful. If Chile and South Africa are allowed to sell grapes in Australia, it is expected plantings in the south west will drop considerably and the table grape industry will be concentrated more in the northern regions and away from the south west. As there are so many unknowns, the 30 year projection is of very limited value (Cameron, pers. comm.).

Table 10. Prediction of the future table grape vineyard area (ha).

Table Grapes	2005	2010	2030
South west	135 ha	165 ha	180 ha

Source: Cameron, I, personal communication.

4.4 Projection of water use – different levels of irrigation

At present most vineyards use an RDI schedule. If this was to continue to 2005 the industry across the three wine regions would use 9,127 ML, in 2010 11,265 ML and in 2030 26,145 ML (Table 13). The use of a full irrigation schedule allows higher yields. It is unlikely to be used in future in these regions but if it were it would require 14,003 ML in 2005, 17,300 ML in 2010 and 40,301 ML in 2030.

At present PRD is not widely used being an unproven technique in the loval environment. It is likely however that PRD or PRD in combination will be utilised more in the future. If PRD was used alone it would require 6,77 ML in 2005, 8,35 ML in 2010 and 19,410 ML in 2030.

Water use of table grapes varies from 4.0 ML to 5.5 ML per hectare depending on variety (Cameron, pers comm.) This equates to a total demand of up to 825 ML for the 150 ha currently planted in the study area.

Table 11. Prediction of Total Water Use Requirement for table grapes in the south west in 2005, 2010 and 2030 (ML per ha)

Table Grapes	2003	2005	2010	2030
South west	825 ML	743 ML	908 ML	990 ML

Source: Cameron, I, personal communication.

Table 12. Typical water use figures (ML per ha) for RDI and a full irrigation schedule.

Wine Region	PRD	RDI	Full Irrigation
Blackwood Valley	1.3	1.8	2.5
Geographe	1.3	1.8	2.6
Margaret River	0.9	1.2	1.9

Source: Campbell-Clause, J.

Table 13. Total Water Use Requirement for each wine region in 2005, 2010 and 2030 (ML per ha) and irrigated using a PRD, RDI, a full irrigation schedule and a rise in temperature of 1.0°C by 2030 combined with a full irrigation schedule.

2003

Wine Region	PRD	RDI	Full
Blackwood Valley	650	900	1,250
Geographe	1,182	1,636	2,363
Margaret River	4,472	5,963	9,441
TOTAL	**6,304 ML**	**8,499 ML**	**13,055 ML**

2005

Wine Region	PRD	RDI	Full
Blackwood Valley	741	1,026	1,425
Geographe	1,291	1,787	2,582
Margaret River	4,735	6,313	9,996
TOTAL	**6,767 ML**	**9,127 ML**	**14,003 ML**

2010

Wine Region	PRD	RDI	Full
Blackwood Valley	845	1,170	1,625
Geographe	1,608	2,227	3,216
Margaret River	5,901	7,868	12,458
TOTAL	**8,354 ML**	**11,265 ML**	**17,300 ML**

2030

Wine Region	PRD	RDI	Full	full with climate change
Blackwood Valley	1,300	1,800	2,500	2,725
Geographe	3,878	5,369	7,756	8,454
Margaret River	14,232	18,976	30,045	32,749
TOTAL	**19,410 ML**	**26,145 ML**	**40,301 ML**	**43,928 ML**

Assuming that by the year 2030 the majority of vineyards will be irrigating to a full irrigation schedule the total water use in the three wine regions would be 40,301 ML.

As climate change studies (Jones, K 2003) predict, the water use requirements would increase. Calculating how much evaporation would increase as a result of increased temperatures is not straightforward. There are other factors besides temperature which influence evaporation - such as wind velocity and relative humidity. To obtain a projection of the effects of increase in the temperature on evaporation CSIRO's "ozclim" climate prediction program can be used. If the temperature of the region increased by 1.0°C the evaporation rate for the regions involved in our study would increase by between 2% and 9% (Foster, I pers. comm.). The evaporation rate is directly related to the calculation of water use; hence the water use would increase by between 2% to 9%.

As a result of climate change an increase in temperature of 1.0°C by 2030 would result in the water use increasing up to as much as 43,928 ML per annum for the three wine regions discussed in this report. This figure is for the three wine regions using a full irrigation watering schedule.

5. Summary

In Australia the greatest unexploited potential for producing high quality wines lies in the south-western and southern regions of Western Australia. Nowhere else in Australia combines, to the same degree, a climate conducive to reliable high quality, adequate to very good water supplies, suitable soils and topography for medium to large scale viticulture, and ample land still available at reasonable cost. Combined with continuing freedom from significant vine diseases, these factors give conditions for viticultural investment possibly unmatched in the world (Gladstones 1997).

The Western Australian Wine industry accounts for about 3.5% of the Australian Wine Industry by volume but because of a strong commitment to the premium and ultra premium market, Western Australia represents at least 10% of the total value.

Like the Australian industry the Western Australian wine industry has expanded rapidly in recent years. In June 1998, Western Australia had 4534 hectares under vines, three years later that was nearly 11000 hectares or 140% growth in 3 years. This increased area under vine has resulted in greater production (approximately 65 000t in 2003). With domestic sales increasing only marginally, exports (nationally and internationally) are required to soak up the extra production.

Excessive production has softened grape prices particularly of red varieties. Demand and prices are still strong for premium white varieties particularly chardonnay and sauvignon blanc. Weather conditions across much of Australia resulted in a smaller national grape crush in 2002 and more so in 2003. This has resulted in most vineyards in the south west finding a market for their fruit.

A good crop nationally and a strengthening local currency will further soften prices and reduce Australia's market competitiveness. The Winemakers' Federation of Australia

outlook is a short term oversupply, with oversupply less likely in the medium term. They see global prospects still sound however they also see an imbalance between market growth and new entrants. An oversupply would eventuate only if international demand declined and/or our market competitiveness weakened.

The local industry will grow in response to market forces. Unprecedented growth in the late nineties and the increase in production that we are now experiencing has seen supply exceed demand for some red varieties but not for some white varieties. The industry will continue to grow particularly in the Margaret River region due to its strengthening worldwide reputation for quality.

Strong demand for land will continue in the traditional Margaret River area from Cowaramup through to Witchcliffe. This demand will come from both viticulture and tourism enterprises with land uses such as golf courses also likely to be popular in the future. Surface and groundwater limitations in this area appear likely to be a constraint on development. The high value of the land for viticulture and tourism enterprises will at some time justify a reticulated water supply system from sources outside the area. Such water could be obtained from the Yarragadee Formation. Such a water supply would ease future pressures on town water supplies for Margaret River and allow some of the urban growth to be met from Yarragadee sources.

Another growth area could be around Karridale. With land prices lower than the northern Margaret River region the soils and slopes of the Blackwood tributaries are attractive to viticulture. Further from the Margaret River region, there is interest in large blocks of plantings on the Abba flood plain situated between Busselton and Bunbury. The soil types on the flood plain are consistent and land prices are lower than Margaret River.

Outside the Margaret River wine area, the Blackwood region and the Geographe region are projected to grow at slower rates.

Irrigation technology has developed rapidly with the introduction of drip irrigation in the eighties. Soil moisture monitoring devices are now used a standard operating procedure together with defined irrigation scheduling strategies. In the late eighties the Department of Agriculture worked closely with the table grape and wine grape industries to develop irrigation strategies for the production of high quality grapes. A very high level of adoption of RDI schedule was achieved by wine grape growers in the south west. This has resulted in high water use efficiency.

The industry nationally promotes irrigation research through the GWRDC and through the CRCV. The trialing of PRD has been effective and is expected to become widely adopted in South Australia and in other states when further trial work is complete and some component technology is developed to allow its easy adoption. It is likely to be adopted in Western Australia in sites with low spring rainfall where the wet and dry side of the vine can be achieved early in the growing season. Widespread adoption is unlikely in Western Australia because RDI is used so effectively and we are achieving high water use efficiency figures.

It is likely that more soil and plant water use sensors will be developed that will assist with irrigation scheduling and improve water use efficiency further

It is predicted that the reliance on ground water will continue to increase if rainfall levels decline as the climate prediction models suggest or environmental and social issues restrict the volumes of catchment water allocated for use on vineyards.

The water requirements detailed in this report are a total water requirement and no break up of surface and ground water sources has been estimated. At present in the south west all of the water used in viticulture is collected on site as either surface or ground water. There are no examples to date of water being piped in from other sources, however this method could be used to supplement limited water supplies. There are several examples of this method being used in wine growing regions on the east coast of Australia.

If the climate warms by 1.0°C water use will increase to 28,885 ML in 2030.

The potential for further growth in the future is unlimited with land being highly suitable and available in abundance. Water use per hectare will improve slightly with improved technology. Water requirement in 2003 is about 8,611 ML in the ground water area for the 5,779 hectares planted. In 2005 the water requirement for the estimated 6,824 hectares in the ground water area is expected to be in 9,244 ML. In 2010 the water requirement for the estimated 8,444 hectares in the ground water area is expected to be in 11,412 ML. In 2030 the water requirement in the ground water area is expected to be in 39,232 ML for the 19,796 hectares expected to be in production by 2030

In addition to the quantity of water used on the vineyard, mention should be made of the water required by the winery to process the grapes. This figure has not been included in this report on viticulture.

For table grapes, the water requirement in 2003 is about 825 ML in the ground water area for the 150 hectares planted. In 2005 the water requirement for the estimated 135 hectares in the ground water area is expected to be 908 ML. In 2010 the water requirement for the estimated 165 hectares in the ground water area is expected to be in 908 ML. In 2030 the water requirement in the ground water area is expected to be in 990 ML for the 180 hectares is anticipated to be in production.

6. Contacts

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7. Web site addresses

www.agric.wa.gov.au
www.winewa.asn.au
www.dlgrd.wa.gov.au
www.wrc.wa.gov.au
www.awbc.com.au
www.winetitles.com.au

8. Appendies

Donnybrook RDI

Month	Evap	Cfactor	Irrig KL/ha	Meg
Jan	221	25	552.5	0.5525
Feb	187	20	374	0.374
Mar	150	20	300	0.3
Apr	84	10	84	0.084
May	63	0	0	0
Jun	47	0	0	0
Jul	50	0	0	0
Aug	63	0	0	0
Sep	73	0	0	0
Oct	109	0	0	0
Nov	149	10	149	0.149
Dec	203	15	304.5	0.3045
Total			1764	**1.764**

Donnybrook Full Irrigation

Month	Evap	Cfactor	Irrig KL/ha	Meg
Jan	221	25	552.5	0.5525
Feb	187	30	561	0.561
Mar	150	30	450	0.45
Apr	84	10	84	0.084
May	63	0	0	0
Jun	47	0	0	0
Jul	50	0	0	0
Aug	63	0	0	0
Sep	73	0	0	0
Oct	109	10	109	0.109
Nov	149	20	298	0.298
Dec	203	25	507.5	0.5075
Total			2562	**2.562**

Manjimup RDI

Month	Evap	Cfactor	Irrig KL/ha	Meg
Jan	211	20	422	0.422
Feb	173	25	432.5	0.4325
Mar	149	20	298	0.298
Apr	86	10	86	0.086
May	66	0	0	0
Jun	47	0	0	0
Jul	56	0	0	0
Aug	59	0	0	0
Sep	77	0	0	0
Oct	101	0	0	0
Nov	143	5	71.5	0.0715
Dec	199	10	199	0.199
Total			1509	**1.509**

Manjimup Full Irrigation

Month	Evap	Cfactor	Irrig KL/ha	Meg
Jan	211	25	527.5	0.5275
Feb	173	30	519	0.519
Mar	149	30	447	0.447
Apr	86	20	172	0.172
May	66	0	0	0
Jun	47	0	0	0
Jul	56	0	0	0
Aug	59	0	0	0
Sep	77	0	0	0
Oct	101	5	50.5	0.0505
Nov	143	15	214.5	0.2145
Dec	199	20	398	0.398
Total			2328.5	**2.3285**

Marg River RDI

Month	Evap	Cfactor	Irrig KL/ha	Meg
Jan	159	20	318	0.318
Feb	157	25	392.5	0.3925
Mar	69	20	138	0.138
Apr	57	10	57	0.057
May	53	0	0	0
Jun	47	0	0	0
Jul	49	0	0	0
Aug	49	0	0	0
Sep	53	0	0	0
Oct	77	0	0	0
Nov	129	5	64.5	0.0645
Dec	171	15	256.5	0.2565
Total			1226.5	**1.2265**

Marg River Full Irrigation

Month	Evap	Cfactor	Irrig KL/ha	Meg
Jan	159	25	397.5	0.3975
Feb	157	30	471	0.471
Mar	69	30	207	0.207
Apr	57	15	85.5	0.0855
May	53	0	0	0
Jun	47	0	0	0
Jul	49	0	0	0
Aug	49	0	0	0
Sep	53	0	0	0
Oct	77	10	77	0.077
Nov	129	20	258	0.258
Dec	171	20	342	0.342
Total			1838	**1.838**

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