SUSTAINABILITY OF IRRIGATION IN WESTERN AUSTRALIA

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ABSTRACT

Irrigation is a fundamentally-important industry in Australia. Despite being of high value, it places a big demand on the scant potable water resources of one of the driest continents on earth. In Australia, the irrigation industry has grown rapidly in the last decade and escalating growth is expected. However, it faces increasing challenges and must demonstrate sound environmental management including sustainable utilisation of water resources for a healthy survival. As competition for the diminishing supply of unallocated water from other users intensifies, the irrigation industry will receive greater scrutiny in review of any additional use of water - a community resource.

Depending on how irrigation systems are designed and managed, irrigation can have a significant 'environmental footprint'. With unallocated water becoming more limited and the cost of water to end-users increasing, the necessity to demonstrate water use efficiencies for existing and new developments may become a mandatory condition of use. Major change for the industry nationally may not occur without significant triggers. However, in Western Australia (WA) such triggers may already exist.

It has been predicted that in WA the greatest demand for more water will be for irrigation development. However, in the South West of WA, the current period of below average rainfall that is expected to intensify over the next 50 years due to climate change/ variability, could have a significant impact on water resources for the irrigation industry. Consequently, in addition to increased water use efficiency, the industry should intensify support for investigations in using alternative water supplies. An example is the possible use of treated wastewater in suitable areas on the Gnangara Groundwater Mound, an area which is currently experiencing environmental stress.

Implementation of initiatives by Government in partnership with the irrigation industry, as outlined in the WA State Water Strategy (Government of Western Australia 2003), will contribute significantly to sustainable water resource management of the irrigation industry.

Keywords *Western Australia, water resources, water allocation, sustainability, irrigation, Perth Basin*

Australian Irrigation

The total value of urban irrigation has not been quantified, however, agricultural irrigation has been estimated to return about $11 billion dollars or one-third of all agricultural revenue per year (Australian Academy of Technological Sciences and Engineering 1999). This high-value revenue is achieved on less than one percent of all agricultural land. However, production comes at a cost of high water consumption, with total water allocation to irrigation conservatively estimated at about 18,000 Gigalitres/year or about 75% of Australian water allocation (Commonwealth of Australia 2001). In Australia about 45% of irrigated land is in New South Wales, 27% in Victoria, nearly 20% in Queensland, 5% in South Australia and less than 3% in Western Australia and Tasmania (Australian Agricultural Assessment 2001).

Figure 1 shows water allocation for combined broad user groups for WA compared with Australia as a total.

Western Australian Irrigation

Water use per irrigated area in WA (~ 12 Megalitres /hectare) is almost double the national average (Commonwealth of Australia 2001). As the single largest water user group, nationally and within WA, the irrigation industry must improve its sustainability to continue growing. Although the irrigation industry in WA accounts for only about 2% (82,000 hectares) of total national area (~ 4,100,000 hectares) under irrigation, it faces some similar pressures that are likely to increase with the predicted industry growth potential.

In WA, irrigation (agricultural and urban (eg. Recreational) uses) accounts for about 36% (940,000 Megalitres) of all licensed surface water and groundwater allocation (Figure 2). Compared with other Australian States, WA relies heavily on groundwater resources for irrigation (490,000 Megalitres/ annum, 61,000 hectares) which supplies slightly more than that from surface water resources (450,000 Megalitres/ annum, 21,000 hectares). Irrigation is a high value industry where from a total area of about 82,000 hectares, or 3% of total WA land area, returns are more than $650 million dollars a year to WA with a value per hectare (/ha) more than three times the national average (Australian Academy of Technical Sciences and Engineering 1999).

The three largest irrigation schemes in WA and year 2001-02 agricultural statistics are the:
1. Ord Irrigation Area at Kununurra (extreme North East) utilising about 300,000 Megalitres/annum (Ml/a) - 11,500 ha;
2. Harvey-Waroona-Collie irrigation schemes (South West) about 94,000 Ml/a - 6,000 ha; and
3. Carnarvon irrigation scheme (Mid West Region) about 11,000 Ml/a- 1,000 ha.

The Ord and Harvey areas are supplied from surface water sources while Carnarvon is totally reliant on groundwater recharged from cyclonic activity.

Self-supply (ie. private) irrigation from surface water and groundwater abstraction is slightly greater (~ 55%) than that from scheme supply (~ 45%). However, private irrigation accounts for about 75% of the State's total irrigated area. The Megalitre: Hectare ratio of total allocation and irrigated area for scheme (21:1) versus private irrigation (9:1) suggests that scheme use is less efficient (ie. uses more water for the same area irrigated). However, this difference may be due to different water demands for different crops irrigated between scheme versus private irrigation (eg. sugar cane vs. recreational turf).

Sustainable Irrigation

Sustainable development is defined as *development that meets the needs of the present without compromising the ability of future generations to meet their own needs* (United Nation's World Commission on Environment and Development, 1987). The Government of WA supports sustainable (irrigation) practice involving the concept of the 'triple bottom line' – *simultaneous achievement of environmental, economic and social goals* (Government of WA 2002).

During the last decade, aspects of natural resource management within Australia have been approached, to a greater extent, in an integrated local and regional catchment context. Although national research agencies (eg. Land and Water Australia, Commonwealth Scientific and Industrial Research Organisation) have focused on areas of irrigation at a catchment scale, better integration is needed in practice – particularly in WA. The irrigation industry must demonstrate sound management of its 'environmental footprint' within local catchments to ensure continued community support. As competition intensifies with escalating demand from multiple uses of the State's finite water resources, the irrigation industry will become increasingly pressured to demonstrate sustainable best- practice. In local catchments where irrigation is not sustainable long-term (eg. due to rising salinity), the best use of the community water resource may be scrutinised. Therefore the irrigation industry must achieve and cohesively demonstrate to the community outcomes that support the 'triple- bottom- line' philosophy.

The relatively low cost of water in WA, particularly for self-supply irrigators, does not encourage good on-farm water resource management. Nevertheless, there appears to be a trend for adoption of more water efficient practices by irrigators in WA with a change from 48% to 35% for flood irrigation and 18% to 38% micro spray/ drip irrigation methods for years 1990 and 2000, respectively (Australian Bureau of Statistics 2003). As remaining unallocated water becomes scarcer with an increasing demand for water, the interrelationship between water use efficiency and sustainable best- practice (including economics) may improve. Limited water resources can promote water allocation to higher-value uses and more equitable use by all stakeholders (Alexander 2002). However, results in other Australian States suggest that economic efficiency does not necessarily relate to environmental effectiveness (Isaac 2003). In WA, it is too early to determine how the recently introduced ability to buy and sell water allocations (trading) will impact different water use sections of the irrigation industry and within other water usage groups.

Management of on- farm nutrient and sediment loads is a significant issue for the irrigation industry. Detrimental environmental impacts on a local and regional catchment scale may result from fertiliser application and other agricultural practices that contaminate waterways and groundwater aquifers. Tailwater recycling, common in the eastern states, has not been common practice in flood irrigation areas of WA. Only recently have specific nutrient discharge limits been set for large- scale developments in WA. However, this is likely to become a more standard condition in association with water allocation licences in the future and be an impetus to improvements in sustainable irrigation practice.

Rising water- tables on irrigated and non- irrigated farms can mobilise sub surface salts to the plant root zone and limit production. Nationally, irrigated areas account for 7% of all agricultural land showing signs of salinity (Australian Bureau of Statistics 2003). WA has the most farms and greatest land area with signs of salinity. WA also has the region most affected by salinity in Australia which is the Avon Region in the South West of the State. Although in the Avon Region most land area is not irrigated, nearly 9% of land that is irrigated is showing signs of salinity. Salinity management strategies on- farm and in a catchment context need to implemented to limit increasing salinity. About two- thirds of irrigators implementing strategies do so to improve farm sustainability (Australian Bureau of Statistics 2003). The main barriers to change are costs and lack of time to implement strategies.

The WA Government, in partnership with the community and irrigation industry, has defined several initiatives in the WA State Water Strategy (Government of Western Australia 2003) which will contribute to sustainable irrigation practice. These include; a review of many issues facing irrigation activities including efficiency gains, investigating means of increasing funding for water resource management activity (including irrigation), establishment of targets for water use efficiency improvements (eg. metering of use), development of water conservation plans linked to licensing (eg. demonstrated irrigation efficiency, best management practice), use of alternative water supply (eg. treated wastewater reuse) and working with local authorities to adhere to a daytime sprinkler ban and development of a Sustainable Water Management Program to address local water management issues.

Water Resource Management

Best practice water resource management is fundamental to sustainable irrigation in WA. However, management responsibility lies not only with regulatory powers of Government but also with representative industry associations and businesses as well as the irrigation end user.

The Water and Rivers Commission (the Commission) is the primary water resource management agency for the WA government. It is the Commission's responsibility to equitably share the State's water resources between ecological needs, social expectations and economic demands.

Under the *Rights in Water and Irrigation Act 1914* (amended 2000) and in reference to the *Environmental Protection Act 1986*, the Commission regulates groundwater abstraction from bores (wells) and water diverted from surface water resources through a system of water resource licensing. The Commission determines the level of sustainable abstraction from surface water and groundwater resources within defined water management units that are published in water resource management plans.

Through water resource licensing, the Commission allocates volumes of water for various public (eg. drinking water supply) and private use up to the sustainable abstraction limit (Water Authority 1990, Water and Rivers Commission 2000b). In addition to a water allocation, licences may stipulate conditions of use that must be adhered to by the licensee. Some conditions may need to be regularly reported to the Commission such as metering of use, water quality and water level monitoring (Water and Rivers Commission 1998a).

The level of allocation within a water resource management unit, expressed as a percentage of the sustainable limit, defines the level at which the resource should be managed (Table 1).

Table 1. Resource categories for level of water allocation

Allocation as % of sustainable limit	0 – 30%	30 – 70%	70 – 100%	> 100%
Allocation category	C1	C2	C3	C4
Corresponding management response category	R1	R2	R3	R4

Source: Water & Rivers Commission 2000b

In areas with a low level of allocation (C1), the Commission employs a 'precautionary principle' in setting preliminary sustainable limits (Water and Rivers Commission 2002a). These limits are inherently conservative and are meant to be progressively refined from more detailed investigations as levels of allocation reach C3 category. Management Response Categories of R3/4 may involve detailed hydrogeological assessment and an evaluation of ecological water requirements to contribute to a determination of environmental water provisions also incorporating aspects of social and economic demands (Water and Rivers Commission 2000c).

Figure 3 shows the extent of groundwater allocation for combined aquifers in groundwater management units of the Perth Basin. From a total of 158 management units, 49 are at C3 and 13 are C4. Most C4 areas in the Perth region are currently at this level of (over) allocation due to temporary allocations to public water supply from groundwater resources as surface water storages are only at about 20% capacity, due to drought.

For WA as a whole, demand scenarios for 2020/21 (Water and Rivers Commission 2000a), indicate that an additional 24 Groundwater Management Units and two Surface Water Management Areas will have reached allocation category C3 (70 – 100% utilisation). However, some regional areas are already exceeding predicted values (West Pilbara, Murchison and Goldfields).

The need to adequately support increased management work required with R3 – R4 response categories is an important issue for WA, to ensure adequate protection of its most valuable natural resource – water and its dependent ecosystems.

Failure to do so may result in situations similar to some regions of eastern Australia where over-allocation of water resources (Commonwealth of Australia 2001) has required the 'claw-back' of water resource allocations with significant social and economic impact on the irrigation community.

WA is one of the few States in Australia that does not fund water resource management activity from a specific water resource management charge levied on users. In other States, water resource management funding is partly sourced from fees associated with water resource licensing and utilisation. The Commission is currently investigating options to help fund the additional work required to manage water resources in an environment of escalating demand (Government of Western Australia 2003). Already for specific proposals, the Commission may negotiate with a water resource licence applicant for the applicant to fund investigations specific to their proposed development. An example of this is circumstances where water service providers (ie. public water supplies) fund the investigation and reporting of ecological water requirements along a water course they propose to divert (dam) to enable the Commission to determine the environmental water provisions for the local catchment.

The WA State Water Strategy (Government of Western Australia 2003) presents a guide for management of a sustainable water future. The Commission is responsible for directing the implementation of many strategies including some with a focus on the irrigation industry. One such initiatives is the identification of opportunities for water use efficiency gains in the irrigation industry, costs associated with improving efficiency, pricing mechanisms, possible trade offs and identification and establishment of sustainable forms and locations for irrigated agriculture in the future. On the Gnangara Mound, an area with stressed water resources and environmental limitations, the State Water Strategy also proposes to establish a water use efficiency pilot program that focuses on distribution systems and water application efficiency.

In WA there is an increasing need to attract national research funding to support some State initiatives. For example, the issue of locations for sustainable irrigation areas in WA is being supported by the National Program for Sustainable Irrigation (Land and Water Australia) in funding irrigation research to develop a framework for future irrigation developments in northern Australia. The Program is also directly supporting another State Water Strategy initiative of investigating the potential for treated wastewater reuse in irrigated agriculture and water use efficiency investigation concerning evaluation of alternative methods to furrow irrigation in the South West of WA. The Strategy recognises the irrigation industry as an important WA industry but, as a high water consumer, its prosperous future depends on the widespread adoption of sustainable practices.

Perth Region

The State capital city, Perth and surrounding region, owes much of its prosperous development to access to good water supplies from local groundwater resources in coastal plain sediments as well as surface water resources held in dams in the nearby Darling Ranges (Water and Rivers Commission 1998b).

In this area, one of the most significant issues concerning the irrigation industry is its potential impact on the groundwater resources of the Gnangara Groundwater Mound (Figure 3B). The Mound is the largest and most important shallow groundwater resource in the Perth Region (Government of Western Australia 1996). The Mound is centred about 35 kilometres north of Perth City and covers an area of about 200 square kilometres. It stores about 25,000 Gigalitres of water with annual rainfall recharge of about 220 Gigalitres (Davidson 1995). The shallow (superficial aquifer) groundwater resources are underlain by semi-confined and confined resources (Leederville and Yarragadee aquifers).

Groundwater is drawn from the shallow aquifers primarily to satisfy demand from numerous small-scale private developments. Groundwater resources of the Gnangara Mound are also an essential source of public water supply for the Perth Region. The Mound supplied 95% (~ 147,000 Ml/a) of all WA public water supply sourced from groundwater in 2001/02. The Mound also accounts for 60% of the total public water supply to the Perth metropolitan area, including surface water sources.

Pressures on the groundwater resources of the Gnangara Mound are intense. Besides being a relatively inexpensive source for water to satisfy nearby urban demand for public water supply, it is also heavily utilised from abstraction by private licensed groundwater bores in addition to unlicensed garden bores. Unlicensed garden bore abstraction is estimated to be over 100,000 Ml/a for the total Perth Region.

Allocation Category units for the Gnangara Mound comprise (15) C1 & C2, (25) C3, and (6) C4 (Figure 3B). For the Perth Basin, eight out of nine management units that would change from C3 to C4 if applications for additional water were granted (pending) are on the Gnangara Mound. Although additional allocation would not likely be approved, it demonstrates the high demand and limited extent of unallocated groundwater resources remaining on the Mound. These are also areas for potential water trading.

However, in some local areas abstraction from shallow groundwater is likely to be partly responsible for declining water tables that are breaching recommended minimum levels in some wetlands (Environmental Protection Policy for the Crown Land of the Gnangara Mound 1992) (Water and Rivers Commission 2002b). Some of the confined aquifers are also experiencing declining hydraulic heads (0.3 meters/year) which is evident over much of the Perth Region (Davidson, 1995). For the confined aquifer systems, the Commission has adopted a policy to limit additional abstraction (Water and Rivers Commission 2000).

Much of the Gnangara Mound's natural environment places a significant demand on groundwater resources for its survival (Water and Rivers Commission 1997). This demand includes access to shallow groundwater resources which have hydraulic connections to many natural wetlands that support diverse flora and fauna ecosystems (Arnold and Wallis, 1987). Unique fauna associated with cave systems on the western side of the Gnangara Mound are believed to be partly dependent on groundwater flow for survival (Water and Rivers Commission 2002c). Groundwater levels in the caves are declining possible due to reduced rainfall recharge (drought), public and private groundwater abstraction, and land management activities (eg. pine plantations) (Western Australian Planning Commission 2001).

Management of land use on the Gnangara Mound is critical for the protection of the groundwater resource that supports multiple uses. Priority beneficial use of the resource over much of the Mound includes maintenance of select wetlands and flora (Environmental Protection Policy for the Crown Land of the Gnangara Mound 1992) and as a primary source area for public water supply (Government of Western Australia 1996). Greater management of private abstraction (mostly irrigation) is necessary (Government of Western Australia 2003) and the Commission is responsible for implementing water use efficiency initiatives with assistance from the WA Department of Agriculture. Depleted groundwater resources being experienced in association with the current drought in the South West of WA, together with priority beneficial use of groundwater in some areas for the environment and public water supply, intensifies the position that irrigation on the Gnangara Mound is likely to be increasingly scrutinised for sustainable practice.

The permeable nature of the soils across much of the Gnangara Mound (and coastal plain) increases the risk of contamination of groundwater resources from some landuse practices. Irrigation water leaching beyond the plant root zone and reaching the watertable may be enriched with nutrients from fertilisers for agricultural and other uses. In the Wanneroo area, some shallow wells on horticultural properties are recycling nutrient enriched groundwater that has also been detected in some nearby residential bores. The Commission requires water chemistry monitoring from some horticultural developments to assess and manage the environmental impact of irrigation (Water and Rivers Commission 1998a).

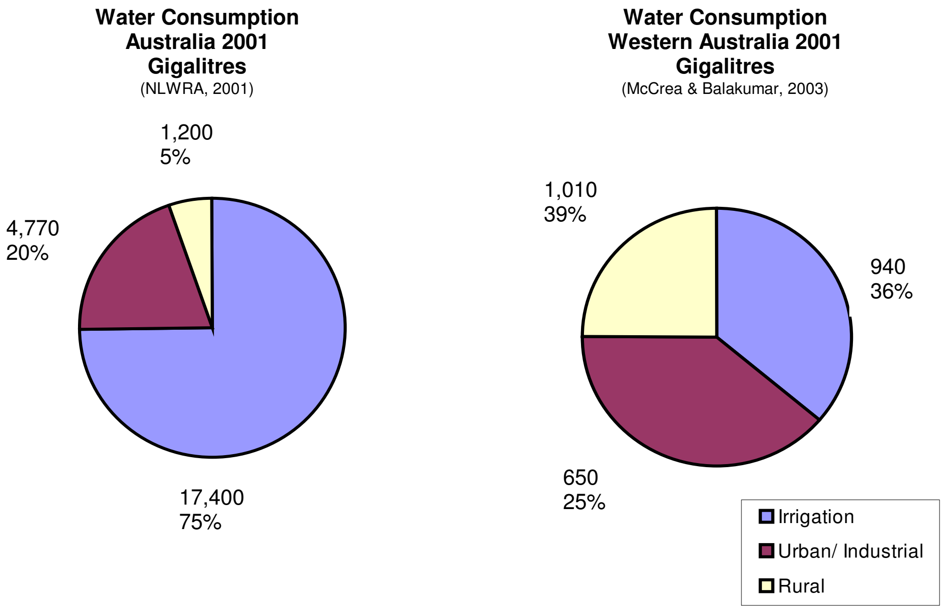

Figure 1. Comparison of water consumption for Australia and Western Australia in broad use categories.

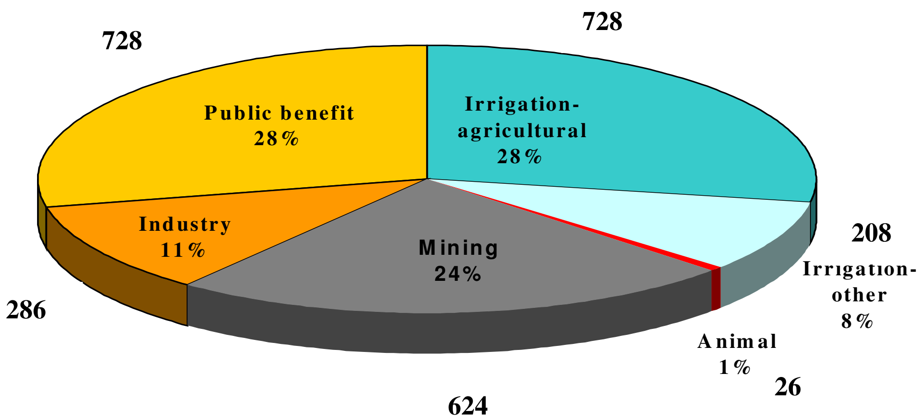

Figure 2 . Groundwater and surface water allocations (Gigalitres) to water use groups in Western Australia 2002 (McCrea and Balakumar 2003).

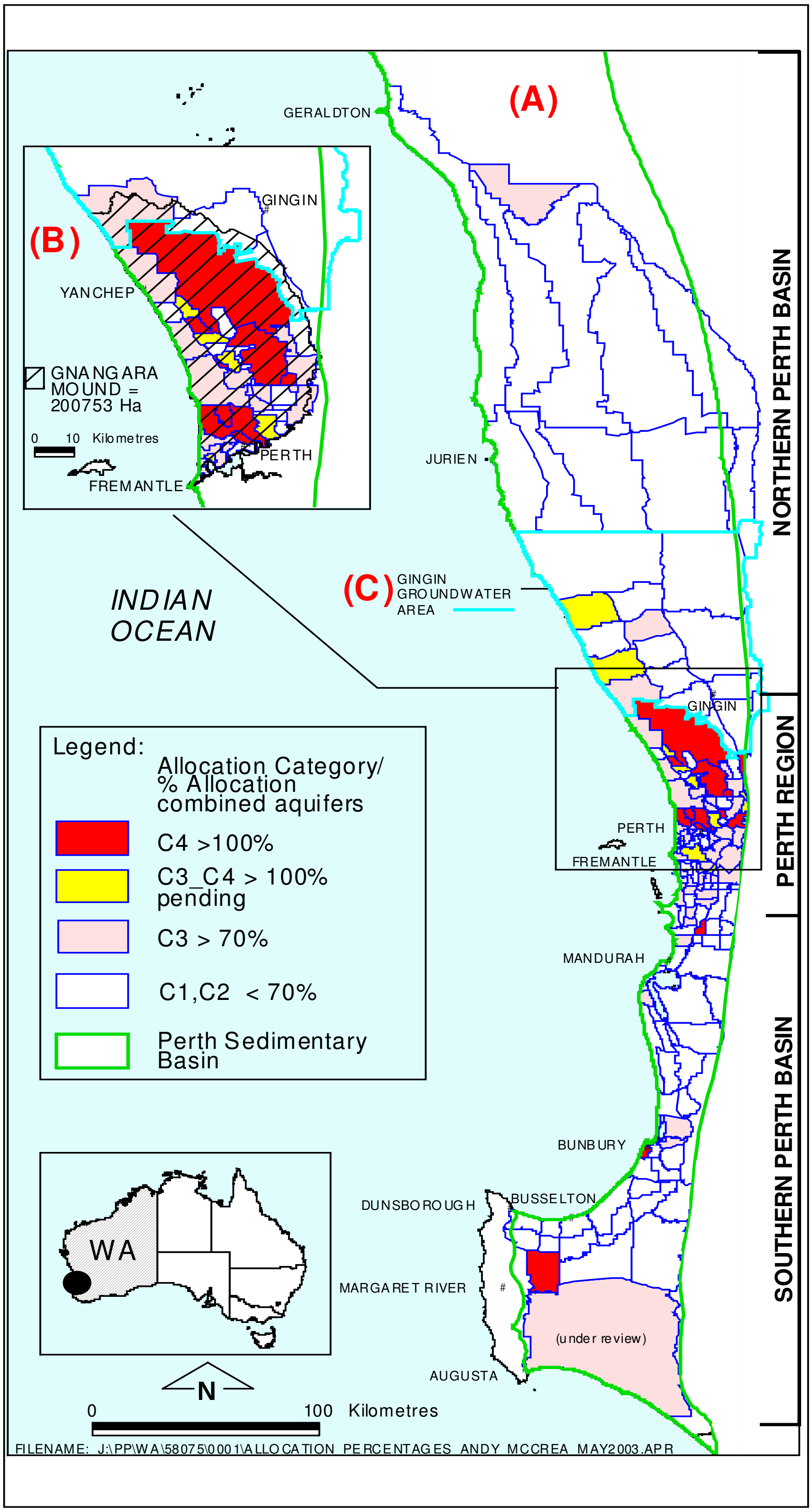

Figure 3. Extent of groundwater allocation for **combined aquifers** in groundwater management units of the Perth Basin, Western Australia.

Note: management units exceeding 100% allocation may not be causing environmental stress (refer to text).

Sustainable irrigation must comply with water quality protection of the groundwater resource. The Commission manages landuses in declared public water source protection areas (eg. parts of the Gnangara Mound) through a policy of catchment protection involving Priority 1, 2, and 3 source protection areas (Water and Rivers Commission 2003). In Priority 1 areas, activities must comply with an undeveloped catchment, Priority 2 source protection areas recognise existing landuse and manages development to limits where risks to pollution are not increased, and for Priority 3 areas landuse values predominate over water protection.

More than 320,000 Ml/a of groundwater is allocated from the Gnangara Mound (Table 2). Groundwater abstraction for public benefit represents the largest single use category on the Gnangara Mound (54%). Public water supply accounts for most of the public benefit usage and for 46% of all groundwater allocation on the Mound. The remaining 8 % of public benefit includes uses such as fire fighting, backup supply and road construction. Allocation for irrigation purposes (agricultural plus other) is the second largest usage group accounting for 35% of licensed groundwater use. Most irrigation is for agricultural purposes (21%) and the remainder (14%) mostly for recreation and aesthetic use (ie. urban). This latter usage would be significantly larger if the volume of public water (scheme) supply used for garden irrigation was considered (70,000 Ml Perth Region) in addition to the volume of groundwater (104,000 Ml Perth Region) abstracted from unlicensed bores to irrigate domestic gardens (Water and Rivers Commission 2001). Industry and commercial interests represent 11% of the total groundwater allocated from the Gnangara Mound.

There are over 8,500 groundwater licensees on the Gnangara Mound. More than two-thirds of all licensees draw groundwater for irrigation purposes. The number of licensees is about equally divided between recreation plus aesthetic and agricultural licences. There are about 11,500 ha irrigated on the Mound with slightly more agricultural area irrigated than for recreational and aesthetic purposes.

Details of proposed use from the Mound (Table 2) provide a general indication of where additional demand for groundwater resources may exist in the future. It appears that demand for additional groundwater allocation for agricultural irrigation is likely to be strong followed to a lesser degree by industrial and commercial development and irrigation for recreational and aesthetic purposes.

Table 2. Existing and Proposed Groundwater Licence Data (Megalitres/annum) for Usage Categories on the Gnangara Mound (2002)

	IRRIGATION		NON-IRRIGATION		
	Irrigation: Agricultural	Irrigation: Urban	Industry & Commercial	Public Benefit & Scheme supply*	TOTAL
Year 2002 1. Allocation	**66,458**	**45,679**	**36,335**	**173,862**	**322,334**
%	21	14	11	54 (*46)	
Subtotal	112,137 Ml / 35%		210,197 Ml / 65%		
2. Licence no.	**2,813**	**3,244**	**901**	**1,564**	**8,522**
%	33	38	11	18	
Subtotal	6,057 lic. / 71%		2,465 lic. / 29%		
3. Hectares	**6,301**	**5,261**	**n/a**	**n/a**	**11,562**
%	55	45			
Subtotal	11,562 ha / 100%		n/a		
Proposed 1. Allocation	**7,364**	**3,569**	**4,760**	**(0)**	**15,693**
%	47	23	30	0	
Subtotal	10,933 Ml / 70%		4,760 Ml / 30%		
2. Licence no.	**57**	**40**	**19**	**18**	**134**
%	43	30	14	13	
Subtotal	97 lic. / 73%		37 lic. / 27%		
3. Hectares	**520.85**	**101.9**	**n/a**	**n/a**	**622.75**
%	84	16			
Subtotal	622.75 ha / 100%		n/a		

*147,501 Megalitres / annum public water (scheme) supply. n/a = not applicable. Ml = Megalitres. ha = hectares. lic = licence

Gingin Groundwater Area

The Gingin Groundwater Area, part of the Northern Perth Basin (Figure 3C), is a good example of the rapidly escalating irrigation development in the Perth Basin. The total groundwater allocation was about 117,700 Ml in 2002 (Figure 4). More than 80% of total groundwater allocation in 2002 was for agricultural irrigation. The groundwater allocation to this area is nearly 13% of all groundwater allocated for irrigation purposes in WA. Reasons for this rapid growth in irrigation in the Gingin Groundwater Area include the relatively close proximity to Perth and the diminishing potential for new developments in the Perth region where much rural land is being zoned residential for urban expansion. In addition, generally the Gingin Groundwater Area has less environmental constraints to agricultural irrigation than in the Perth region (eg. Gnangara Mound).

In 1997 and 2002, groundwater allocations increased by a total of about 49,500 Megalitres. This was a 42% increase in groundwater allocation and was mostly accounted for by significant areas of olive grove establishments, which totalled new allocations of about 30,000 Megalitres (Figure 5, fruit, berry, nut and oil). The area irrigated in Gingin Groundwater Area for years 1997 and 2002 increased 57% from 4,783 to 11,133 hectares which compares to an increase of 25% for total land irrigated in WA and nationally for years 1990 and 2000 (Australian Bureau of Statistics 2003).

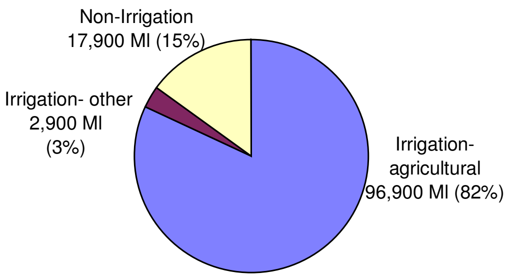

Figure 4. Irrigation versus non-irrigation groundwater allocation in Gingin Groundwater Area 2002 (Megalitres/annum).

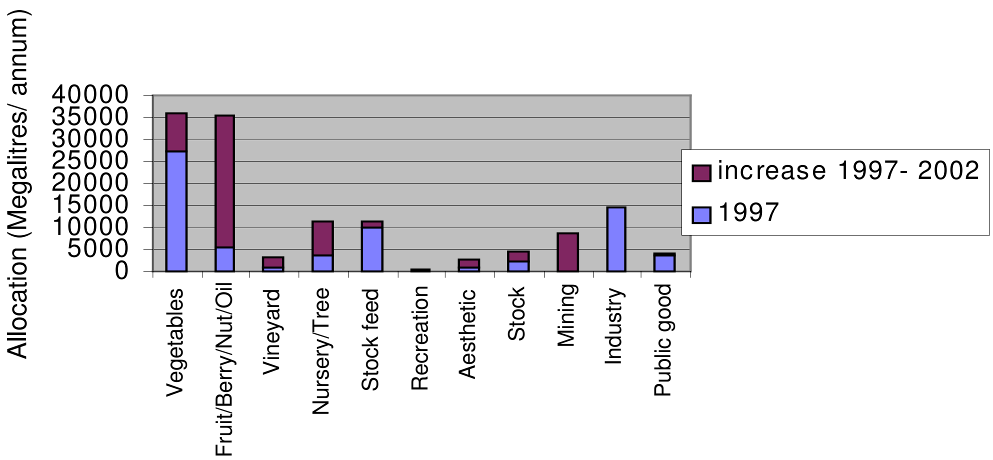

Figure 5. Gingin Groundwater Area. Increase (total 49,527 Megalitres) in groundwater allocation to usage categories for years 1997 and 2002.

Climate

Some surface water catchments in the South West of WA have experienced a 30% reduction in mean annual stream flows over the last 30 years due to an extended period of reduced rainfall (Ruprecht and Rodgers 1999). Whether this represents long-term climate change, possibly due to an increase in emissions of greenhouse gases, or a natural component of climate variability is uncertain. However, climate change predictions suggest that Mediterranean climate regions (eg. South West WA) will potentially be areas of reduced water availability (IPCC 2001). In addition to reduced rainfall, the South West of WA is predicted to get warmer and consequently have increased rates of evapotranspiration.

Climate change/variability is a significant issue to the Australian economy where agricultural exports account for a quarter of Australia's total merchandise (Australian Greenhouse Office

2003). Adaptation to climate variability has been a practice with Australian agriculture where experiences of droughts and floods are not uncommon.

Although agricultural practice (eg. land clearing) is a major contributor to greenhouse (WA Department of Agriculture 2002), the impact from irrigated agriculture is likely to be minimal due to the relatively small land area involved. Of more concern to irrigation is the potential impact from climate change/variability on the industry (David Ugalde, Australian Greenhouse Office, Canberra, personal communication) and its ability to adapt to this factor – both positive (opportunity) and negative (threat). For example, a warmer climate could have detrimental impact on the chill factor necessary for setting stone fruit but enable planting of crops in areas that previously were limiting due to the risk of frost. Reduced rainfall may limit leaching of salts from the plant root zone but have environmental benefits in limiting contribution to receiving water bodies (eg. Estuaries).

There has been limited study of the potential impact of climate change on specific agricultural crops except wheat (Australian Greenhouse Office 2003). However, widescale impact on irrigated agriculture may be significant and in the Murray-Darling Basin which accounts for 70% of all water usage in Australia, the impact may be as much as $1 billion in net present value terms (Australian Greenhouse Office, 2003).

By year 2070, research by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Bureau of Meteorology (Indian Ocean Climate Initiative), predict climate change/ variability in the South West of WA with significant impacts on biodiversity, agriculture, infrastructure, fire risk, and water supplies (IPCC 2001). Water resources are highly vulnerable (Jones and Pittock 2002) with competition for water supply likely to increase between agricultural, urban, and environmental allocations (Australian Greenhouse Office, 2002). The impact of reduced rainfall and warmer temperatures (greater evapotranspiration) on groundwater aquifer recharge has not been as well quantified. Fortunately in WA, conservative rainfall recharge values (precautionary principle) has been used for the establishment of groundwater allocation limits and the fact that actual usage is often less than licensed allocation, reduces the possibility that groundwater abstraction is stressing aquifer systems in periods of reduced rainfall. Because of this reason, management units in Figure 3 showing overallocation (C4), may not be causing environmental stress.

Collaboration between government, industry, regional communities and research institutions are needed to develop cost effective adaptation strategies for climate change. Several adaptation options are given by the Australian Greenhouse Office (2002) and for the irrigation industry, include improved water use efficiency and irrigation management.

Challenges

The irrigation industry, Government resource management agencies and the community will be facing a lot of additional future challenges including:

- How to resource the greater costs of water resource management required in an environment of increasing water demand.
- The ability to adapt and modify operations for a prosperous irrigation future.
- The need to define, integrate and manage irrigation activity at the catchment scale.
- How to manage water resources in a period of climate variability. This may involve greater use of environmental risk assessment protocol for irrigation development (Hart 2000, Lund and McCrea 2002).
- Stronger representation from across all sections of irrigators in a single unified professional body that is able to contribute to development and promotion of industry best management practice, Government policy and effectively demonstrate a sustainable irrigation industry to the general community.

- Wide community support, including that from indigenous groups will be needed for large- scale irrigation development in an environment of increased scrutiny of sustainable irrigation practice.
- Northern parts of Australia (WA) are likely to be targeted for greater irrigation development (eg. Ord Stage 2) and long-term planning addressing unique sustainability issues is required.
- Development of Government policy enabling allocation of water of different quality to different uses (eg. treated wastewater for irrigated agriculture).
- Widespread adoption of best management practice from agricultural and urban irrigation use. (eg. the current day time sprinkler bans for unlicensed garden bore abstraction in WA and proposed for licensed local government abstraction ie. irrigation of recreational facilities, parks and gardens).
- Mechanisms for change in the irrigation industry to more water efficient technology/ practice must be supported by research and education (eg. WaterWise on the Farm, Government of WA 2003),
- Temporary or permanent trading of water allocations will become increasingly widespread and require a new level of consumer knowledge and skill to support sound on-farm water management decisions.

Conclusion

There are major challenges ahead for the irrigation industry and State water resource managers in Western Australia. Changes are needed to promote sustainable practice and better enable future development in the industry. Formulation and compliance with policy, in such areas as water use efficiency, needs to be achieved from a collaborative approach between Government and industry representatives. Use of alternative water sources (treated wastewater and stormwater) may make a significant contribution to support sustainable practice, particularly for management areas at or approaching full allocation.

Predictions are that the demand for irrigation water in WA will increase at an even greater pace than is currently being experienced (Water and Rivers Commission 2000a).

It is important for the irrigation industry to be unified and pro-active in adoption and demonstration of sustainable practice because it already has the single greatest allocation of water resource in the State and this is predicted to increase. As resources become more limiting, community expectations reflected through Government policy, may intensify requirements for industry compliance to sustainable practices.

Community expectations for improved environmental maintenance may become increasingly difficult to satisfy if lower than average rainfall continues in the South West of WA and growth projections for the industry materialise. The long- term implications for the irrigation industry need to be addressed.

Water resources in many management units on the Gnangara Groundwater Mound have reached near to full allocation. A major challenge in the immediate term is to improve environmental maintenance in some areas of the Mound. This will require concessions between end-users including water allocations to public water supply, private abstraction (eg. irrigation) and environmental demands.

Better integrated natural resource management and planning is needed at a catchment scale incorporating the irrigation industry and the community in relation to existing and proposed areas of irrigation development.

It is important to continue support for irrigation education programs and research, particularly those that involve implementation of components of the WA State Water Strategy (Government of Western Australia 2003). In addition, WA's continued involvement in a national irrigation research and development program supports sustainability of the irrigation industry.

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