GLOBALIZATION AND WATER RESOURCES MANAGEMENT:
THE CHANGING VALUE OF WATER

AUGUST 6-8 AWRA/IWLRI-UNIVERSITY OF DUNDEE INTERNATIONAL SPECIALTY CONFERENCE 2001

ORD RIVER ALLOCATION PLANNING – ENVIRONMENTAL VALUATIONS, PAST, PRESENT AND FUTURE

Kerry Trayler and Russell King*

ABSTRACT: the Ord river is one of western Australia's major river systems. In the 1960s and 70s two dams were constructed across the Ord. Together these dams allowed the development of stage 1 (~13000ha) of the Ord irrigation project (oip) centred on the town of Kununurra and the generation of power from a hydroelectric station, below the Ord river dam. Stage 2 (~64000ha) irrigation developments are now proposed and combined water demands (Stage 1 & 2) total ~1200GL/annum. Since the conceptualisation of the OIP, the ecological and social values of the river system have gained importance via legislation. The requirement for an environmental water provision will halve the amount of water for irrigation expansion. This paper explores the environmental values of water in the Ord, from a pre and post dam perspective and details an approach being undertaken to assess changes to ecosystem function in relation to altered flow.
KEY TERMS: Allocation planning, environmental water requirements; environmental values; ecosystem function

INTRODUCTION

The Ord River, is situated in the east Kimberley region of Western Australia and has a catchment (at the site of the Ord River Dam) of 46,100 sq km, which extends into the Northern Territory. The catchment has a semi-arid to arid monsoonal climate with two distinct seasons: a warm, dry season; and a hot wet season occurring from November to April. Most of the annual rainfall is the result of the monsoonal depressions and tropical cyclones. Rainfall can be infrequent for the remainder of the year and consecutive dry months are common. The 650km long Ord is one of Western Australia's major river systems. It drains into the Cambridge Gulf near Wyndham and has a mean annual streamflow (at the river mouth) of 4500GL. The largest recorded flow was approximately 30800$m^3.sec^{-1}$ (1956).

The Water and Rivers Commission has overall responsibility for water resources of Western Australia and is the lead agency for their assessment, protection, planning and management. The Water and Rivers Commission is also responsible for licensing the diversion and use of water from any watercourse proclaimed under the Rights in Water and Irrigation Act, including the Ord River and its tributaries. The Commission does not, however, have singular authority or responsibility for management of the Ord River. There are many decision-makers with some control over activities on the Ord River and adjacent land, and there are community groups and individuals that have a strong interest in management of the river.

Ord River Irrigation Development

In the early 1960s, the Kununurra Diversion Dam (KDD) was constructed across the Ord to create Lake Kununurra. Subsequently, the Ord River Dam (ORD), which forms Lake Argyle was constructed in the early 1970s (Figure 1). Together the dams allowed the development of a major irrigation area (~13000ha) centred on Kununurra and the generation of power from a hydroelectric station, commissioned in 1996. Inflows to Lake Argyle occur as a result of markedly seasonal rainfall over the catchment and on the reservoir itself. There are minor abstractions of water directly from the Lake for mining purposes and for water supply to the Lake Argyle Tourist Village. Water is released from the Ord River Dam to meet the hydro power demands, to meet some in-stream (boating) demands below the Dam, and to maintain the water level in Lake Kununurra for irrigation purposes. Overflows from the Lake Argyle spillway join Stonewall Creek and flow back into the Ord River below Carlton Gorge.

* Respectively, Principal Environmental Officer; Senior Policy Officer. Water and Rivers Commission, 3 Plain St, Perth, Western Australia 6004. Phone: 61 8 9278 0300. Fax: 61 8 9278 0585. Email: kerry.trayler@wrc.wa.gov.au; russell.king@wrc.wa.gov.au

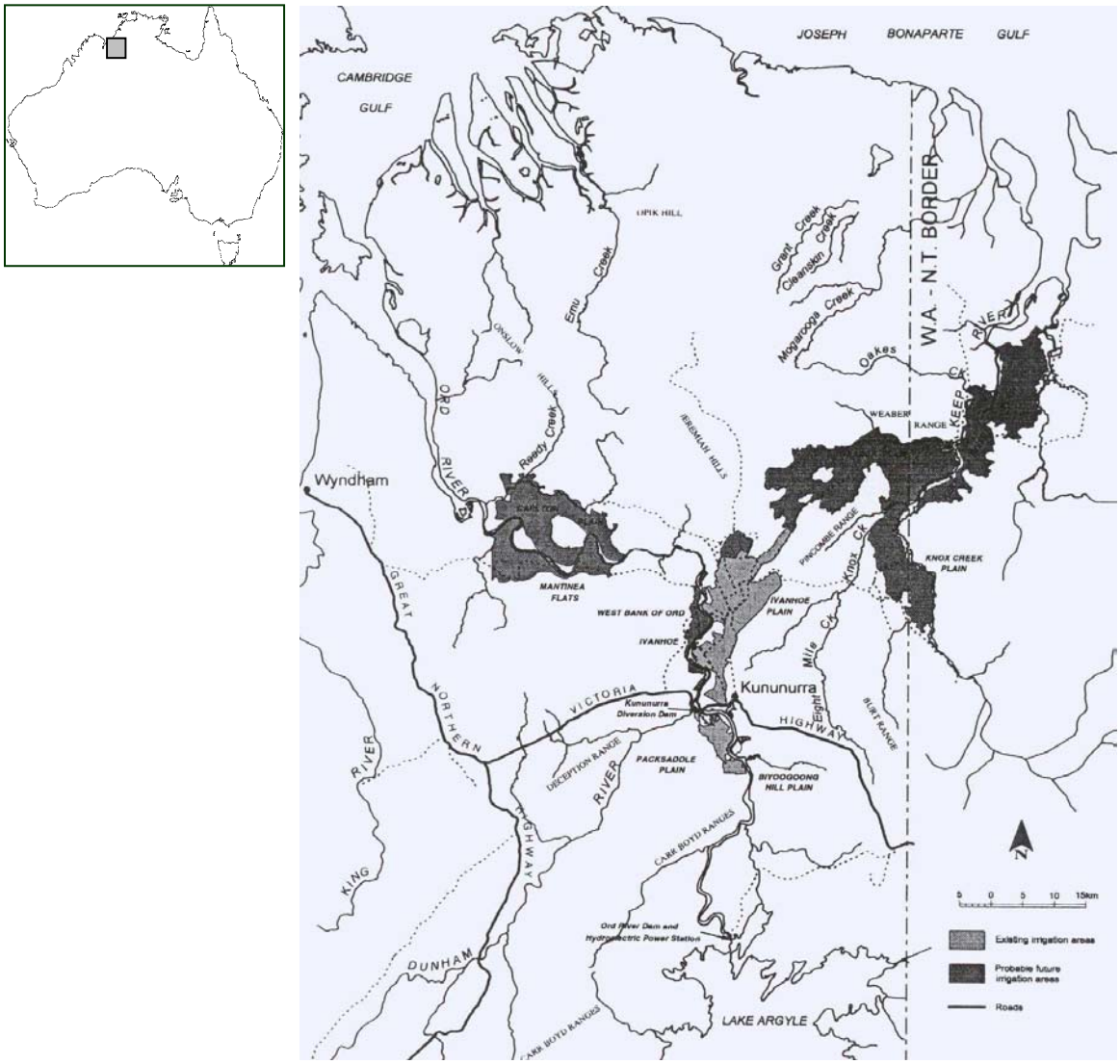

Figure 1: Location map of area downstream of the Ord River Dam

Lake Kununurra is the body of water which extends upstream from the Kununurra Diversion Dam to Carlton Gorge. Water levels within this Lake are maintained within a narrow range primarily to meet the needs for irrigation of the Packsaddle Plain and Ivanhoe Plain, but also in consideration of other factors including dam operating requirements and foreshore flooding considerations. Releases from the KDD are also made to meet the needs of irrigators pumping directly from the river and some in-stream requirements below the dam. The in-stream needs include provision for safe boating conditions and some control of water levels to allow stock watering on Carlton Hill Station. The Dunham River joins the Ord just downstream of the KDD.

There are proposals for the expansion of irrigation into the Weaber, Knox Creek and Keep River Plains east of the river (Figure 1). These areas would be supplied with water via from Lake Kununurra. There are also plans for irrigation development downstream of Lake Kununurra on Mantinea Flats, Carlton Plain and the West Bank of the Ord River downstream of the Dunham River. Collectively these are referred to as the Stage 2 developments. There are also plans to expand Stage 1 irrigation area. Existing irrigation demands utilize only a small proportion of the water resource in the Ord (300GL.year^{-1}; Table 1). Under the proposed expansion an additional 775GL.year^{-1} have been requested.

Table 1: Annual components of water balance for Lake Argyle

Component	Amount (GL.year^{-1})
Inflow	3940
Rainfall	640
Lake evaporation	1750
Overflow	890
Releases	1950

Ord Allocation Planning

Since the initiation of the Ord Irrigation Project the ecological, recreational, social and cultural values of the river system have gained greater importance within the community and under the legal system, and economic values of the water resource beyond irrigation development have been recognised. The Water and Rivers Commission is responsible for developing a Water Allocation Plan. Under the Environmental Water Provisions Policy for Western Australia (WRC, 2000), the Commission must provide for the protection of water dependent ecosystems while allowing for the management of water resources for their sustainable use and development to meet the needs of current and future users.

It takes considerable time to develop a Water Allocation Plan for a system as complex as the Ord. There must be considerable scientific, technical and cultural investigation, detailed analysis, and extensive consultation before it can be finalised. Therefore, an Interim Allocation Plan is being prepared to facilitate planning of the Stage 2 irrigation developments and make initial provision for water dependant environments. The interim plan must take account of environmental, social and economic water requirements. Planning for the former is made difficult by the lack of information available on this river system and altered environmental values.

Impact of Irrigation Development: Altered Values

The KDD and ORD dams were constructed with little consideration for environment or social values. Their construction flooded vast areas of traditional Aboriginal lands, with subsequent loss of cultural value and had a profound affect on the hydrology and ecology of the Ord river. The river was markedly altered between the Carr Boyd Ranges and Bandicoot Bar creating Lakes Argyle and Kununnura. In addition, the extremely large flood storage capacity of Lake Argyle and its spillway characteristics mean that there is a greatly modified flood discharge pattern (Figure 2). The magnitude and frequency of high flow events have been severely limited. Large flood flows are discharged slowly over a period of many months rather than as the high energy, channel-forming flows that were previously experienced. Floodflows in the Lower Ord since construction of the dams have been dominated by flows from the Dunham River. This is despite the catchment area of the Dunham being less than 10% that of the Ord. There are now constant flows in the dry season so that the lower reaches of the river no longer dry out between pools. In effect, it has been transformed through regulation and the pattern of operation of the dams from a ‘dry tropics’ to a ‘wet tropics’ river.

Prior to the construction of the Ord River Dam, the river would flood downstream wetlands during the wet season of most years. The impact of the ORD has been to decrease the frequency and magnitude of high flow events in the lower Ord River, with a corresponding decrease in the extent and duration of floodplain inundation. The constant flows and the reduction in high flow scouring events post-regulation have reduced the frequency of germination events and stranded high bank vegetation. Floodplain wetlands are now more influenced by other short, seasonal creeks.

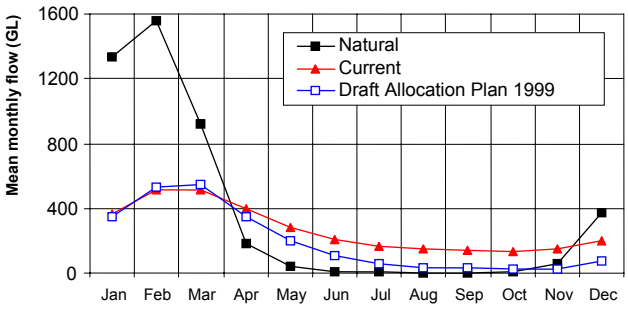

Figure 2: Monthly Flow Volume at Carlton Crossing under scenarios. Note the Draft Interim Water Allocation Plan (WRC 1999), the approach taken in determining environmental water requirements was a rule of thumb 20th percentile of the natural flows

The loss of the high magnitude floods means that there is greatly diminished stream power and so limited mobilisation of the coarser sediments (gravels, sands). Large sediment load is no longer delivered from upstream (only about 0.06% of the sediment that enters Lake Argyle is released). The relative importance of the sediment loads from the Dunham and other tributaries has increased. Channel surveys have shown extensive deposition of sediments in various parts of the channel, and especially an accretion of point bars and these forms appear to be closely linked to aquatic vegetation. The aquatic vegetation traps sediments and stabilises the depositional forms, which are in turn colonised by more substantial vegetation stands. The result is a gradual decrease in channel capacity, with on-going channel encroachment by first aquatic, and then riparian vegetation, and so a reduction in in-stream habitat area and diversity.

The channel deposition processes and stable flows have encouraged the development of wide beds of emergent and submerged macrophytes in most shallow areas. The deposition of fine sediments has lead to in-filling of benthic interstices within the sand and gravel, and that the deeper pools which once provided dry season refugia are now shallower and filled with fine sediment. Except for short spells during and after rainfall events, the water is now relatively clear most of the time. The implications of these changes to the invertebrate and fish fauna are likely to have been profound. The aquatic fauna are likely to have been greatly affected by the reduced frequency, extent and duration of inundation of the lower floodplain inundation and the deposition of fine sediment. Loss of habitat diversity, reduced species diversity, carrying capacity and population size is the likely result.

Today's Values and Interim Allocation Planning

The effect of the dams construction is not all negative, Lakes Kununurra and Argyle now provides permanent water and are valuable dry season refuges for waterbirds. The lakes are listed under the International Ramsar Convention. Lake Argyle also supports a large freshwater crocodile population. Downstream on the Ord River Floodplain, an area of extensive tidal mudflats and mangroves, seasonal wetlands and permanent waterholes (~116000ha) is also Ramsar protected. The area is ranked as one of the five most important wetlands in Western Australia for migratory shorebirds.

Constant flows and reduced magnitude floods have encouraged the development of a more stable, dense band of riparian vegetation approximately 15m wide along the waters edge within the main river channel. Thickets of paperbark saplings and species that once occurred in isolated sheltered sites form tall woodlands in these areas. These new riparian zones provide important fauna habitat.

The presence of the dams and the permanent water had significant impacts on recreation and tourism in the region, worth ~$40M annually. Lake Argyle is a major attraction for visitors and tour boats operate between the KDD and the ORD, as well as on Lake Argyle itself. Barramundi fishing charters are popular below the KDD and there are commercial fishing and aquaculture operations on Lake Argyle.

When the Water and Rivers Commission (WRC) first undertook the development of a Draft Interim Water Allocation Plan (WRC, 1999), the approach taken in determining Environmental Water Requirements (EWRs) was

a rule of thumb 20th percentile of the natural flows (Figure 2). Little ecological data was available to justify a more sophisticated approach. In keeping with the precautionary principle, ~265GL remained unallocated. Priority for this water was given to meet revised Environmental Water Provisions (EWPs) when adequate data on riverine ecology became available and a dry season EWP (to mitigate irrigation return) was foreshadowed (WRC, 1999). Despite this, public comments on the draft plan considered that the Commission had not adequately protected the environmental values that had arisen in the 30 years of post-dam operation. Strategic advice from the Environmental Protection Authority (EPA) recommended that the Commission review the interim EWPs and that maintenance of the riverine environmental values established since the construction of the ORD be the basis of that review. The EPA also recommended that the Commission seek advice from a panel with expert knowledge of tropical river ecosystems and undertake further community consultation.

The Commission subsequently established a Scientific Panel to provide advice on the water-dependent ecosystems and their water requirements. The Panel identified important physical and biological attributes of the Ord River system and the water regime dependency of those attributes. The Panel also described each attribute in terms of the pre and post dam hydrology. Attributes included: hydrology; water quality; channel dynamics and sediment; riparian and aquatic vegetation; fish assemblages; ecological processes; mangrove communities; waterbirds and invertebrates. These attributes and potential risks associated with changes from the current flow regimes are shown in Table 2.

The Panel emphasised the limitations imposed by the minimal ecological data. Within that constraint, they identified the maintenance of an adequate dry season flow as the key consideration in determining the interim EWRs. They made a number of recommendations (WRC, 2000), including:

- Dry season water levels and flows should be maintained at current or possibly slightly lower levels. The level to which flows could be lowered would be dependent on assessment of impacts on habitat and water quality.
- Flows could be allowed to gradually decline towards the end of the dry season, but not to the extent where the river recedes to isolated pools – a flow must be maintained.
- To maintain present ecological processes, waterbird and aquatic invertebrate values of the Lower Ord floodplain, there should be no significant diminution in the existing frequency and size of flood events.

Under Recommendation 1, the Panel suggested that cross-sectional surveys of wetted perimeter might be used to estimate change in habitat in relation to discharge and river height (Figure 3). This information, together with hydrological analyses, water quality data and information on social and economic values provides the basis for derivation of interim EWPs (Table 3). Because these provisions have been developed with limited understanding of the Ord riverine ecosystem, they remain interim and precautionary. A revised Interim Water Allocation Plan is in preparation with the intention to facilitate irrigation development planning, but without unacceptable risk of environmental damage or over-allocation. The plan will remain interim until a final allocation plan is developed in ~2003.

Table 2: Summary of potential impacts of future changes to the water regime

Attribute	Likely impact of potential flow modifications (compared with the current scenario)	Key considerations
Channel dynamics and sedimentation	Probably insignificant compared to impact of dams but may exacerbate channel narrowing and pool infilling	Assumptions based on limited investigations. Impacts of 1999/2000 wet season floods need assessment and determination of potential for active channel management. Relationship between deposition and encroachment of vegetation needs further clarification. Catchment and floodplain management should be considered.
Aquatic and riparian vegetation	Probably benign if dry season flows do not become 'no flow', but a shift in communities is likely. Potential for further encroachment of emergent macrophytes into shallower parts of channel will increase the rate of channel infill	Relationship between sedimentation and vegetation establishment needs to be confirmed. Increased nutrient concentrations in lower flows could also increase macrophyte growth.
Mangroves	Impacts likely to be benign.	
Invertebrates	Low dry season flows could increase species diversity, but loss of wetted area and shallow instream habitat could reduce abundance.	Relationship between discharge levels and wetted area/shallow instream habitat areas needs to be confirmed to allow assessment of significance of lower dry season flows.
Fish assemblages	Potentially significant. Less wetted area will mean reduced habitat for fish. Proportion of channel covered by macrophytes/ epiphytes may increase – high respiration may result in anoxia and fish kills if there are no flow periods. Dry season no flow periods with isolated pools would be potentially catastrophic for fish.	Relationship between discharge levels and wetted area/shallow instream habitat areas needs to be confirmed to allow assessment of significance of lower dry season flows.
Waterbirds	Potentially benign if flood frequency and area of inundation remains unchanged. Rates of change of water levels in Lakes Argyle and Lake Kununurra need to be maintained near current.	Management of water levels in Lake Kununurra should be reviewed to meet downstream management requirements but protect Jacana nesting requirements.
Crocodiles	Likely to be benign.	Impact on nesting site availability may need review.
River processes	Depends on impact of reduced dry season flows on habitat and energy inputs. Sufficient flows are required to maintain pool levels that can "buffer" the effects of high oxygen consumption by plants and animals.	Relationship between dry season water level and habitat needs better definition. Relative importance of shallow margins and of deeper water needs to be determined.
Water quality	Potentially highly significant. Lower flows could increase concentrations if nutrient and pesticide inputs remain unchanged. High sediment levels create a sink for nutrients that may be released as sediments are exposed by low water. Isolated pools with no flow periods potentially catastrophic.	The level of low flows which may be acceptable - while maintaining water quality - needs to be determined. The potential for mitigation through catchment management needs to be addressed.

Table 3: Summary of changes in Ord River flows just d/s of the Dunham River

Scenario	Annual Flow *			Wet Flows (November to Mar)			Driest 5 months	
	Median (GL)	% of Post Dam	% of Natural Flows	Median (GL)	% of Post Dam	% of Natural Flows	Median m^3/sec	Minimum m^3/sec
Proposed flows under a revised interim allocation plan	1915	68	53	829	59	26	45	35
Post Dam flows (1974/5 to 99/2000)	2832	100	79	1410	100	44	50	38
Natural Flows Prior to Dams	3564	126		3229	229		0.8	0

* Based on simulated results over 86 years from April 1905 to 1991

Future Values: Further Investigation and the Final Allocation Plan

An Holistic Approach to determining the EWRs of the Lower Ord River will be applied to the development of the final Allocation Plan. This approach evolved from South African, Building Block Method (King and Louw, 1996) and subsequent Australian research on environmental flows. The aim of the Holistic Approach (Arthington, 1998) is to assess water requirements of a complete ecosystem including source area, river channel, riparian zone, floodplain, groundwater, estuary and rare / endangered species. This approach assumes that if certain essential features of a rivers natural flow can be identified and adequately incorporated into the modified and regulated flow regime, then the biotic and functional integrity of the system should be maintained (Arthington, 1998). Further, it recognizes that some features of the flow regime are more important than others in maintaining the system. The Holistic Approach requires an understanding of the ecological processes governing the functioning of the river, its floodplain, wetlands and estuary.

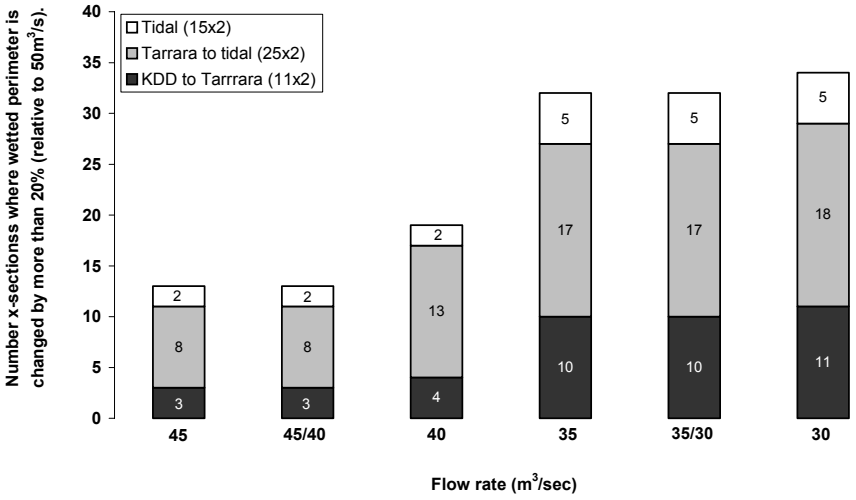

Figure 3: Changes (>20%) in wetted perimeter. Note that changes of more than 20% are considered to be significant. Wetted perimeter changes are used as an estimate of change in fish and invertebrate habitat

Very little is known of the ways in which flows in the large floodplain river systems of Western Australia influence ecological processes and how this energy is distributed through food webs. Therefore, an investigation is underway to determine the ecological processes and energy base of the ecosystem in the regulated Ord system and nearby unregulated floodplain rivers (Keep, Dunham and Pentecost Rivers). The phenology and distribution of riparian and floodplain production and how this is influenced by flow is also being assessed. Flow requirements based on productivity processes and a range of other water dependent features will be determined using the Holistic Method and expressed in the context of historic flows. The study is a collaborative project involving three universities (University of Western Australia, Edith Cowan University and Griffith University), the Water and Rivers Commission and Environment Australia under the Environmental Flows Initiative. The information obtained will underpin the determination of EWRs for the Lower Ord River.

Other studies are being undertaken and that will also contribute to the final Ord River Water Allocation plan and subsequent review. One project will determine fish and invertebrate composition, abundance and biomass in relation to available habitat and flow in the Lower Ord. This will support the early wetted perimeter work used to estimate changes in habitat. Another project being undertaken by the University of Western Australia and the CRC for the Management of Tropical Savannas is examining the potential for changes in flow regime to impact on the channel morphology and distribution of riparian vegetation.

The Water and Rivers Commission is also consulting local Aboriginal groups to determine past and present day cultural values associated with the Lower Ord. Aboriginal people attach great importance to the Ord River and associated environments, floodplains and wetlands and these values, together with what is already known of the social and economic values of the system will also influence the final Allocation Plan.

ACKNOWLEDGMENTS

A number of individuals contributed to the information contained in this document. These include Paula Deegan, Ian Loh, Simon Rodgers and members of the Scientific Panel.

REFERENCES

Arthington, A.H. (1998). Comparative Evaluation of Environmental Flow Assessment Techniques: Review of Holistic Methodologies. LWRRDC Occasional Paper 26/98.

King, J.M. and Louw, D. (1996). Development and use of the Building Block Methodology for assessing in-stream flow requiremnts in South Africa. In: “Proceedings of LWRRDC and MDBC Workshop on In-stream Flow Methodologies”: Cooma, ACT.

Water and Rivers Commission (1999). Draft Interim Water Allocation Plan. Ord River, Western Australia. Water Resource Allocation and Planning Series. WRAP2. May 2000.

Water and Rivers Commission (2000). Ord River Scientific Panel Report. Recommendations for Estimation of Interim Ecological Water Requirements for the Ord River. June 2000.