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Water and Rivers Commission

Upper Canning/Southern Wungong Catchment Team

CITY OF GOSNELLS

WATER CORPORATION

Swan Avon INTEGRATED CATCHMENT MANAGEMENT

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Swan-Canning Cleanup Program

Implementing the Action Plan

August 2002

Swan-Canning Cleanup Program

Caring for the Canning

A plan to revitalise the Canning, Southern and Wungong rivers

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A supporting document to the
Swan-Canning Cleanup Program Action Plan

August 2002

Water and Rivers Commission

Acknowledgments

Author

Lucy Sands, Water and Rivers Commission

Working Group

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Special thanks go to the following people for providing comments and advice throughout the development of this plan: *Declan Morgan, Darryl Miller, Dr Andrew Storey, Dr Luke Pen, Dr Kerry Trayler, Bruce Greenop, Dr Tom Rose and Nina King.*

All photographs in this plan are by the author, unless otherwise stated.

Acronyms

AgWA	Agriculture Western Australia
BMPs	Best Management Practices
BOD	Biochemical Oxidation Demand
CCCG	Canning Catchment Coordinating Group
CoA	City of Armadale
CoC	City of Canning
CoG	City of Gosnells
COAG	Council of Australian Governments
DEP	Department of Environmental Protection
EP Act	Environmental Protection Act
EPA	Environmental Protection Authority
EPP	Environmental Protection Policy
EWPs	Environmental Water Provisions
ICM	Integrated Catchment Management
MfP	Ministry for Planning
PRI	Phosphorus Retention Index
RoB	Ribbons of Blue
RIWI Act	Rights In Water Irrigation Act
SCCP	Swan Canning Cleanup Programme
SRT	Swan River Trust
UCSWCT	Upper Canning Southern Wungong Catchment Team
W&RC or WRC	Water and Rivers Commission
WC	Water Corporation
WSUD	Water Sensitive Urban Design
WAMA	Western Australian Municipal Association
UWA	University of Western Australia

This plan is dedicated to Dr. Luke J. Pen

Luke's passion, knowledge and commitment to the Canning River has been the stimulus for much of the planning and restoration work done to improve the health of this and many other degraded waterways. Luke speaks the language of the general community and his enthusiasm and determination has, and always will be a great motivator to us all.

Contents

Executive summary

The Canning River and its tributaries are a natural asset of the southern suburbs of Perth. The Canning River System:

- provides drinking water to the Perth metropolitan area;
- is an important ecological corridor, providing habitat and refuge to aquatic and terrestrial life;
- provides recreational opportunities such as cycling, swimming, fishing, bushwalking and canoeing;
- has important cultural and spiritual significance to Aboriginal communities;
- has historical significance to people in the Canning Catchment;
- provides riparian land owners with a source of water; and
- flows into the Swan River Estuary, a scenic and recreational icon of Perth that also supports an important ecosystem.

As with many urban river systems, the Canning River System is showing signs of stress from this multitude of uses. Intense, often toxic algal blooms have been regularly recorded in the river system since 1994, an indication that it is under significant stress due to intense modification and poor land use management within the catchment.

The Swan-Canning Cleanup Program Action Plan recommended that a river management plan be developed and implemented for the Canning River System. The development of this plan commenced in July 1999. Soon after a Working Group of local stakeholders was established to assist in the development of the plan.

This plan has been prepared to complement an existing management framework for the Canning Catchment. It is a river management plan and as such focuses on the riparian zone, dealing with catchment issues where appropriate.

Section 1 of this plan outlines how the plan came about, how the plan relates to other existing projects in the catchment and how comment can be made on the plan. Section 2 is a detailed description of the river system. Section 3 describes in detail what is leading to the ecological and aesthetic decline of the Canning River System. It then outlines the desired objective in response to that problem and what needs to be done to achieve the objective.

The issues and objectives discussed in this plan have been summarised on page vi.

To achieve the vision of this plan, the Working Group developed a number of recommendations that will be implemented through seven management programs.

Each of the proposed recommendations have been assigned to an organisation that is considered to have key responsiblities in a particular area. It will be the responsibility of each of these organisations to facilitate the implementation of specific recommendations contained within the plan, in consultation with key stakeholders. In order for the plan to be successfully implemented it will require a coordinated approach with a number of organisations and groups working together in partnership to achieve the vision identified in the plan.

This plan is intended to guide certain aspects of river management in the Canning Catchment for the next five years. It is assumed after this time, that the recommended actions and management programs will need to be revisited by the major stakeholders operating in the catchment.

Issue	Objective
• Flow in the Canning River System has been significantly reduced. This has contributed to the degradation of ecological values, a loss of river power and flooding flows.	• Manage river flows so that the important ecological values of the river system are maintained, balancing the ecological requirements with the human demands for water.
• Meeting the ecological water requirements of the river alone will not improve the ecological health of the river. It is only one part of river restoration and management.	• Incorporate environmental water provisions (EWPs) into an overall river management program.
• The Kent Street Weir creates an impounded body of water upstream of the weir during summer. Low flow and insufficient mixing of the water column combined with high nutrient levels lead to conditions favourable to algal blooms.	• Prevent the conditions that lead to algal blooms upstream of the Kent Street Weir
• There has been a loss of social focus and importance of the Canning River System. Community awareness and knowledge of river management issues need to be raised to promote behavioural change and community participation in catchment and river management.	• For the broader community to be well informed about important river management issues and take action to protect and enhance the river system.
• The Canning River System is still highly utilised for private abstraction. Abstraction peaks during periods of low flow and over-abstraction can contribute to drought.	• Reduce the reliance on the river for abstraction and promote water conservation techniques.
• Nutrients from a variety of land uses are leaching in to the river, contributing to algal blooms. Improved management of nutrients, contaminants and water within each land use to reduce losses to surface water and groundwater is required to prevent contamination of the river system.	• Improve water quality entering the river by surface or groundwater by revising, developing and promoting best management practices and encourage the community to understand the link between human activity and the health of the river.
• Many tributaries have been modified into drainage networks. This has led to a loss of tributary habitat, biodiversity, landscape amenity, recreational opportunity, and ability to process nutrients. Drains can have ecological value and improve nutrient retention and processing functions if they are appropriately designed and maintained.	• Improve water quality entering the river by promoting best management practices and encourage the community to understand the link between human activity and the health of the river.
• Fringing vegetation has been lost through stock grazing, human development and the creation of drains.	• Re-establish river banks with fringing vegetation.
• River pools are an important summer refuge and habitat for aquatic and terrestrial flora and fauna. River pools have been lost due to sedimentation and modification of the flow regime.	• Re-establish deep river pools in the Canning River System.
• Urban development in the Canning Catchment is growing at a rapid rate. Development often results in increased nutrient export if best management practices are not incorporated into developments.	• Encourage the implementation of efficient best management practices in new developments and redevelopments to reduce nutrient and pollutant export.

Vision

To revitalise the Canning River System to a healthy ecosystem where algal blooms are kept to a minimum and a diverse range of aquatic life exists, and to ensure it is a resource that can be enjoyed and used responsibly by all people.

What is really meant by this vision?

The vision can also be described as the 'desired future state' for the Canning River System. Listed below is a detailed description of this desired future state.

Ecology

- Algal blooms are kept to a minimum in the Canning River System.
- The river corridor supports healthy populations of terrestrial and aquatic life.
- There is a diverse river environment that supports floodplains, pools and riffles.
- The river has stabilised banks that are vegetated with native species and free of weeds.
- The river has the capability to recover from disturbances.

Water quality

- Water entering and flowing down the Canning River System meets water quality guidelines.

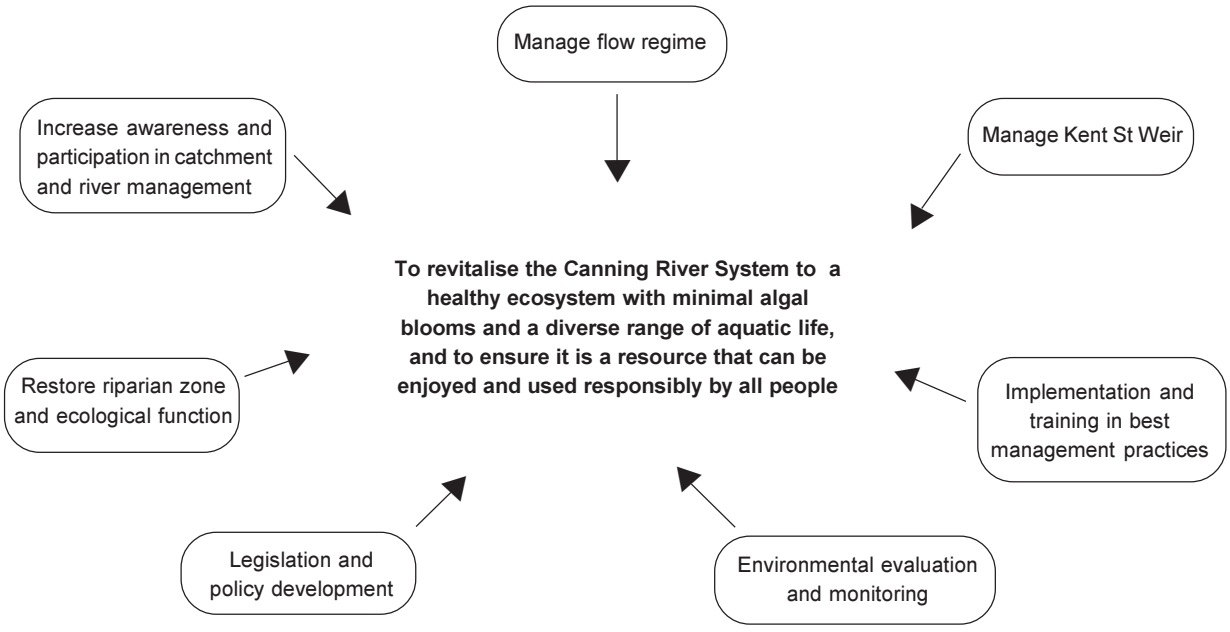
Human uses

- The river can meet the needs of abstraction rights and public water supply, whilst providing adequate water to the environmental values of the river.
- The river can provide a variety of environmentally acceptable recreational opportunities.

Community

- The river is socially important to the people of the Canning Catchment.
- The community are aware and involved in management of the river.

Management Programs



Section 1. Introduction

1.1 What are the issues?

The Canning and Southern Rivers and Wungong Brook (hereafter referred to as the Canning River System, see Map 1)) are a natural asset of the southern suburbs of Perth. The Canning River System:

- provides drinking water to the Perth metropolitan area
- is an important ecological corridor, providing habitat and refuge to aquatic and terrestrial life
- provides recreational opportunities such as cycling, swimming, fishing, bush walking and canoeing
- has important cultural and spiritual significance to Aboriginal communities
- has historical significance to people in the Canning Catchment
- provides riparian land owners with a source of water
- flows into the Swan River Estuary, a scenic and recreational icon of Perth that also supports an important ecosystem.

As with many urban river systems, the Canning River System is showing signs of stress from this multitude of uses. Intense, often toxic algal blooms have been regularly recorded in the river system since 1994, an indication that it is under significant stress due to intense modification and poor land use management within the catchment.

The major issues affecting the Canning River System identified by this plan include:

- Flow in the Canning River System has been significantly reduced. This has contributed to the degradation of ecological values, a loss of river power and flooding flows
- Meeting the ecological water requirements of the river alone will not improve the ecological health of the river. It is only one part of river restoration and management
- The Kent Street Weir creates an impounded body of water upstream of the weir during summer. Low flow and insufficient mixing of the water column leads to conditions favourable to algal blooms
- There has been a loss of social focus and importance of the Canning River System. Community awareness and knowledge of river management issues need to be raised to promote behavioural change and community participation in catchment and river management
- The Canning River System is still highly utilised for private abstraction. Abstraction peaks during periods of low flow and over-abstraction can contribute to drought
- Nutrient loss from a variety of land uses reach the river system, contributing to algal blooms. Improved nutrient, contaminant and water management within each land use is required to reduce losses to surface and shallow groundwater.
- Many tributaries have been modified into drainage networks. This has led to a loss of tributary habitat, biodiversity, landscape amenity, recreational opportunity, and ability to process nutrients. Drains can have ecological value and improve nutrient retention and processing functions if they are appropriately designed and maintained.
- Fringing vegetation has been lost through stock grazing, human development and the creation of drains.
- River pools are an important summer refuge and habitat for aquatic and terrestrial flora and fauna. River pools have been lost due to sedimentation and modification of the flow regime.
- Urban development in the Canning Catchment is growing at a rapid rate. Development often results in increased nutrient export if best management practices are not incorporated into developments.

***Toxic algal bloom in the Canning River near Kent Street Weir, 1998 (*Photo: B Boardman)**

It is evident that our behaviour and practices must change if the Canning River System is to continue to support a diversity of uses. The consequences of not acting are evident. The Canning River System will continue to decline, affecting the ecology of the river and those who use it. It is therefore the responsibility of everyone who lives, works or uses the Canning River and its catchment to halt the degradation and contribute to its revitalisation.

1.2 Vision for the Canning River System

The vision includes the thoughts and desires of the community and stakeholders in the Canning Catchment. It has been derived from workshops, community forums and other associated plans and projects.

To revitalise the Canning River System to a healthy ecosystem where algal blooms are kept to a minimum and a diverse range of aquatic life exists, and to ensure it is a resource that can be enjoyed and used responsibly by all people.

What is really meant by this vision?

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Ecology

- Algal blooms are kept to a minimum in the Canning River System
- The river supports healthy populations of terrestrial and aquatic life
- There is a diverse river environment that supports floodplains, pools and riffles
- The river has stabilised banks that are free of weeds and vegetated with native species
- The river has the capability to recover from disturbances

Water quality

- Water entering and flowing down the Canning River System meets water quality guidelines

Human uses

- The river can meet the needs of abstraction rights and public water supply, whilst providing adequate water to the environmental values of the river
- The river can provide a variety of environmentally acceptable recreational opportunities

Community

- The river is socially important to the people of the Canning Catchment
- The community are aware and involved in management of the river

1.3 Swan-Canning Cleanup Program and Integrated Catchment Management

The Swan-Canning Cleanup Program (SCCP) Action Plan was released in May 1999 and is administered by the Swan River Trust. The Water and Rivers Commission assists in the implementation of the SCCP Action Plan, along with other State and local government agencies. Contained within the Action Plan are forty-four (44) recommendations aimed at improving the health of the Swan-Canning River System.

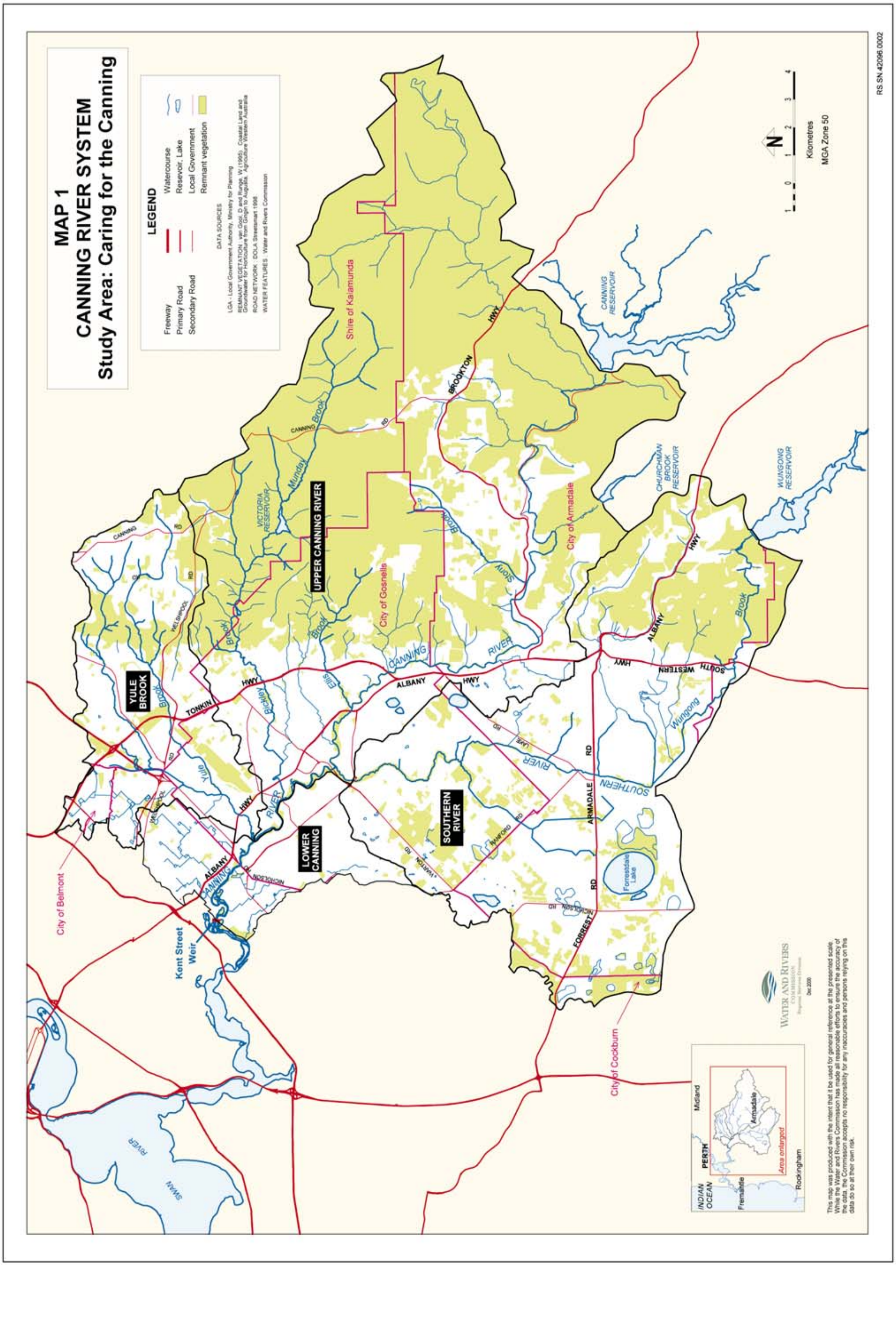
A key recommendation (No. 7.8) of the SCCP Action Plan was the development and implementation of a management plan for the Canning River. This recommendation has been partially fulfilled. Implementation will commence after the public consultation period.

This plan has been written so that it is consistent with the Environmental Protection (Swan and Canning Rivers) Policy Approval Order 1998. This Environmental Protection Policy (EPP) guides local and State government agencies in the management of the Swan and Canning Rivers, outlining measures that are required to achieve environmental quality objectives for the river system. This EPP will be reinforced by the Comprehensive Management Plan or *Riverplan* which is due to be released soon.

This plan is linked to other projects and programs being undertaken by State and local government and community groups in the Canning Catchment.

These include:

- *Upper Canning Southern Wungong Catchment Management Plan* (Everall, 1999)
- Canning River Oxygenation Trial (Kent Street Weir to Greenfield Street Footbridge)


MAP 1
CANNING RIVER SYSTEM
Study Area: Caring for the Canning
LEGEND
Freeway
Primary Road
Secondary Road
Watercourse
Reservoir, Lake
Local Government
Remnant vegetation
YULE BROOK
UPPER CANNING RIVER
LOWER CANNING
SOUTHERN RIVER
Shire of Kalamunda
City of Gosnells
City of Armadale
City of Belmont
City of Cockburn
Kent Street Weir
CANNING RESERVOIR
VICTORIA RESERVOIR
CHURCHMAN BROOK RESERVOIR
WUNGONG RESERVOIR
Forrestdale Lake
SWAN RIVER
Kilometres
MGA Zone 50
WATER AND RIVERS COMMISSION
RS SN 42096.0002

- Sediment Remediation Trial (Phoslock™) between Kent Street Weir and Nicholson Road, Cannington
- City of Canning Integrated Catchment Management Strategy
- Local Government Natural Resource Management Policy Development Project (Eastern Metropolitan Regional Council)
- Swan-Canning Industry Project
- Phosphorus Awareness Project

It is well documented that the ecological health of a river system is determined by activities in the catchment. In 1999, the *Upper Canning Southern Wungong Catchment Management Plan* was released by the Upper Canning Southern Wungong Catchment Team. The Catchment Plan covers the Cities of Armadale and Gosnells and has full support from both Councils. *Caring for the Canning* is designed to complement the *Upper Canning Southern Wungong Catchment Management Plan* by helping to achieve one of its goals - 'protecting and improving water quality in rivers'.

The Upper Canning Southern Wungong Catchment Team and Canning Catchment Coordinating Group have provided valuable input into the development of this plan. The implementation of this plan and the *Upper Canning Southern Wungong Catchment Management Plan* will coincide and in doing so will strengthen existing partnerships between all levels of government and the community. This will result in improved catchment and river management for the Canning River System.

1.4 Study area

The study area comprised the Canning River from the Canning Dam to the Kent Street Weir and the Southern River-Wungong Brook from the Wungong Dam to its confluence with the Canning River (Map 1).

The Canning River flows down from the Darling Scarp, onto the Swan Coastal Plain and then north-west to the Swan River Estuary. The Southern River-Wungong Brook also originates in the Scarp, flowing west onto the coastal plain and heading north to meet with the Canning River in Maddington.

The study area excludes the rivers above the Canning, Wungong and Churchmans Brook and Victoria Dams.

1.5 Development of this plan

In September 1999, a Working Group was established to discuss the objectives and formulate the recommendations for this plan. Each organisation involved in the preparation of the plan will participate in implementing the recommendations. Successful implementation of many of the recommendations will require a partnership approach from a few organisations.

The following organisations were represented on the Working Group:

Canning Catchment Coordinating Group
Upper Canning Southern Wungong Catchment Team
City of Gosnells
City of Canning
City of Armadale
Water Corporation
Water and Rivers Commission

Although not represented on the Working Group, the Swan River Trust, Agriculture Western Australia and the Canning Wungong Southern Rivers Advisory Committee provided input into the development of the plan.

1.6 How to use this plan

This plan is divided into 6 sections.

Section 1: Introduction

This section highlights the risks to the Canning River System and the vision for the river. It also describes how this plan is related to other projects under way in the Canning Catchment.

Section 2: River Description

This is an inventory of the Canning River System. It describes the current state of the river system, including infrastructure, biophysical characteristics, river functions and their importance.

Section 3: Revitalising the Canning River System

This section describes in detail what is leading to the ecological and aesthetic decline of the Canning River System. It then outlines the response required to alleviate these problems and specific actions to help accomplish this.

Section 4: Management Programs

This section groups the actions into specific management programs that all aim to achieve the vision of the plan.

Section 5: References

Section 6: Appendices

This is a collection of data that provides supporting information to the plan.

1.7 Implementation

The vision outlined in this plan is reflected in other plans and projects for the Canning Catchment. A number of these projects are already under way and are contributing to the achievement of this vision.

The actions listed in this plan will be implemented through seven management programs. These management programs will work towards the achievement of this vision.

1.8 How you can be involved

This plan has been written with input from a number of major stakeholders, including community catchment groups, sub-regional catchment groups, surface water users, local government authorities and State government agencies that operate in the Canning Catchment.

This is the final version of the plan and if you would like to be involved in its implementation in any way, please contact the Project Manager:

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7 Ellam Street
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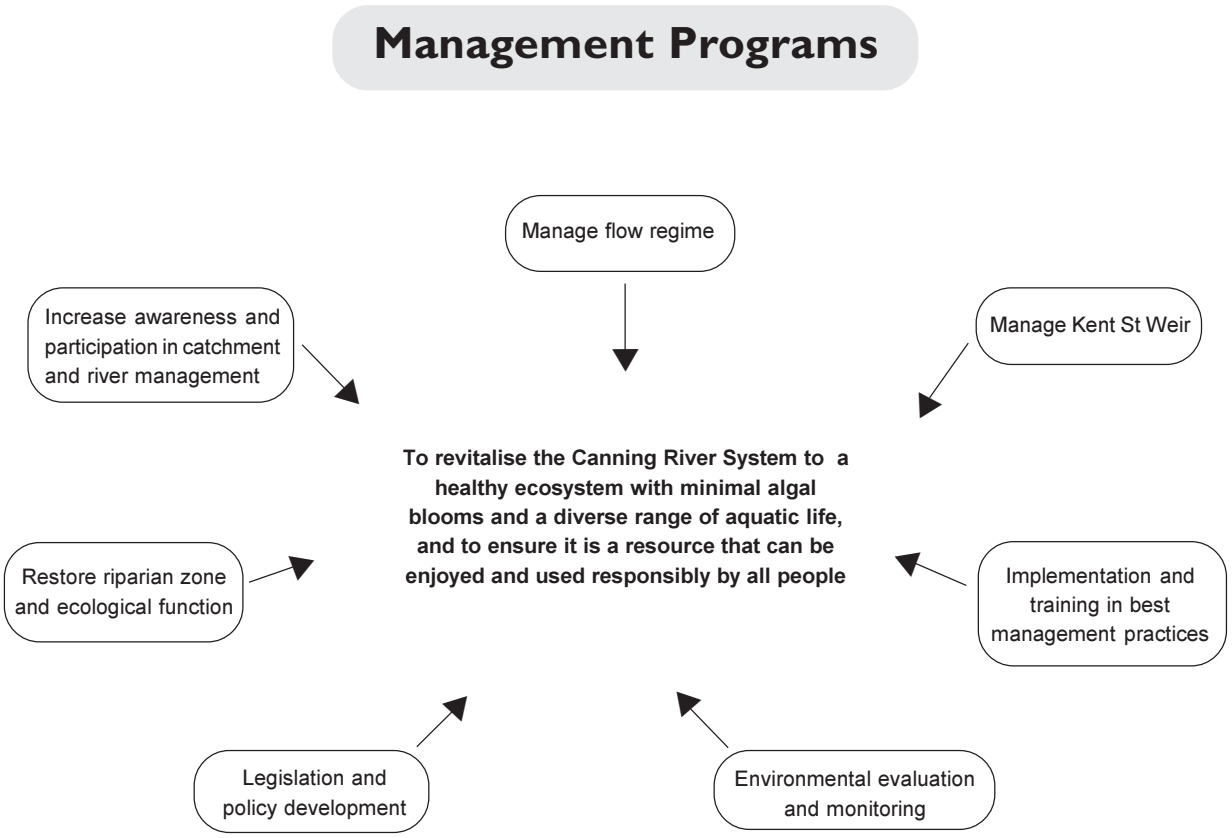


Section 2. River description and pressures on river function

2.1 Human development in the Canning Catchment

The Canning River has guided the pattern of urban development in the Canning Catchment over the past 170 years. During early European settlement, the land surrounding the Canning River was used for farming and horticulture. This has gradually been replaced by residential housing, however some pockets of farmland remain.

The Upper Canning Catchment and much of the Southern-Wungong Catchment is still largely rural or special rural, although the Ministry for Planning have recently prepared a draft structure plan for much of the Southern-Wungong Catchment which proposes large areas of urban development.

There are industrial areas throughout the Canning Catchment, with the largest being Kewdale-Welshpool. Smaller light industrial areas and commercial precincts are scattered around the catchment, adding to the diversity of land uses.

Human development has resulted in the replacement of native vegetation with impervious surfaces such as roads, car parks and roofs. To allow development to occur many drains have been constructed to minimise the threat of flooding. This has resulted in the modification of natural tributaries into drains and it has also altered the local hydrology. Consequently, there has been a loss of tributary habitat and ecological processing in these tributaries.

The input of nutrients to the river has increased due to fertiliser applications, septic tank leaching, industrial discharges, animal wastes and domestic detergents. The composition of organic matter entering the river system has also changed from eucalypts to more easily decomposed leaves, soft pasture plants and animal manure (SRT, 1999).

As the urban population increased in the 20th Century, so did the demand for potable water supplies. The Kent Street Weir was first built in 1926, supplying surrounding properties and villages with water for irrigation and domestic use. The population continued to increase and so the Canning Dam was constructed in 1940 and the Wungong Dam in 1976. Both are utilised for public water supply today. This has resulted in a dramatic reduction and alteration of flow to the river system.

2.2 Rainfall

In the Canning Catchment, 80% of the annual rainfall occurs between May and September, typical of a Mediterranean climate. The average annual rainfall is 1250 mm at Canning Dam. Figure 1 displays the annual rainfall variation from the average of 1250 mm from 1895 to 1999. Since 1975 the average annual rainfall has been well below the long-term average and this may be attributed to natural climatic variability.

2.3 Flow regime

2.3.1 Flow regime and its importance

Typically, the further a river is removed from its historic hydrology, the more the environment and its ecological value are affected (Storey *et al.*, 2000). A flow regime that has a predictable seasonal cycle is vital to aquatic life in a river system. Riverine plants and animals have evolved over thousands of years to cope with seasonal events such as winter flows and floods, low flows and drought. Human development of rivers and their catchments often results in unpredictable flow regimes.

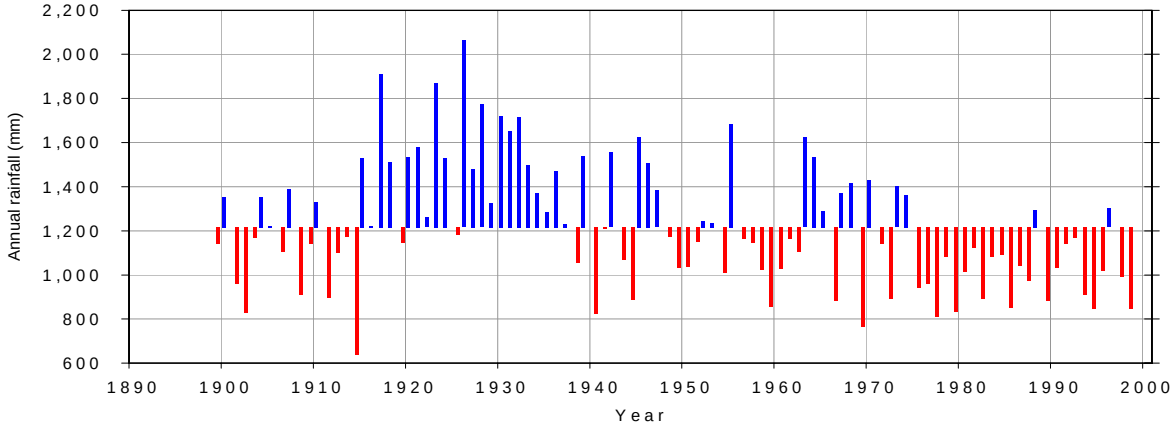
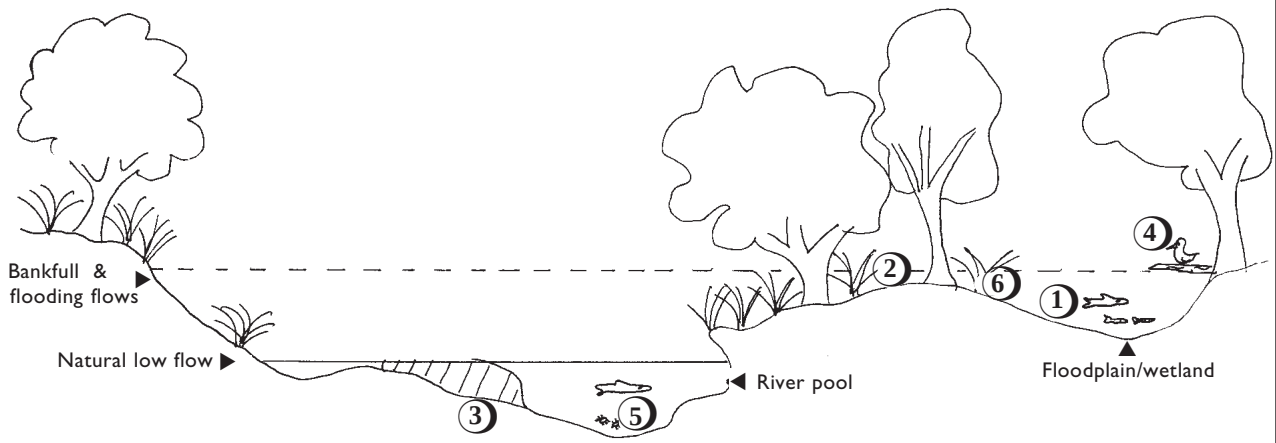


Figure 1: Average rainfall variation from mean (1250 mm) from 1900 to 1999

Rivers are important ecological corridors that are biologically diverse, supporting many different species of plants and animals. Each of these species is dependent on water in some way. Many species of fish require high flows to stimulate their breeding cycle. Others may need it so they can migrate to spawning areas. Flooded gums and other species of fringing vegetation consume water through their roots, however they also require floods to stimulate germination of their seed bank. Figure 2 illustrates the importance of seasonal high flow events to the ecology of lowland river systems.

Collectively the fauna, flora and water-dependent ecological processes present in a river system are referred to as its 'ecological values'. The Canning River System has been studied by a number groups and research scientists, so we have a good understanding of the ecological values of this river system.

There has also been a considerable amount of research conducted by research centres and universities Australia-wide that have determined the water requirements for a variety of ecological values of fresh water river systems. These research programs have examined the importance of seasonal flows, duration for which flows are required and the consequences of too much or too little water in a river system.



1 Higher water levels provide access to productive floodplains/wetlands that are important for fish spawning and foraging

2 Periodic flooding is required to stimulate germination of some native plants and to ensure seedlings survive

3 Sufficient flow is required to scour sediment deposits that have accumulated in river pools and riffles

4 Native waterbirds require sufficient water levels in associated wetlands for breeding and rely on river pools for summer refuge

5 Macroinvertebrates require sufficient and predictable flow to ensure survival

6 Periodic flooding is required to maintain riparian linkages (organic material from vegetation in riparian zone provides an important energy and nutrient source to the river channel)

Figure 2: Ecological water requirements of lowland reaches of the Canning River System

Table 1: Important ecological values of the Canning River System and their essential water requirements

Ecological value	Water requirements
Macroinvertebrates	• Permanent flow and predictable/seasonal flows are important so macroinvertebrates can synchronise their life cycles • Low flow leads to deoxygenation, accumulation of pollutants and desiccation which can alter macroinvertebrate populations and consequently riverine food webs
Fish	• Predictable flows are needed for fish to breed successfully • Sufficient water levels to maintain diversity of habitats and breeding grounds • Flows to discourage exotic Mosquitofish • Sufficient water level so fish can traverse natural obstacles during migration
Fringing vegetation	• Periodic flooding to disperse seed, stimulate germination and ensure seedlings survive • Recharge shallow groundwater tables that are important during periods of drought • Discourage and prevent weed growth
Channel maintenance	• Maintain channel width and depth and a diversity of habitats • Scouring out sediment from riffles and pools
Waterbirds	• Depend on flooding of shallow floodplain for breeding • River pools are an important summer refuge
Ecological processes and energy flows	• Periodic flooding to maintain riparian linkages (organic material from vegetation in riparian zone provides an important energy and nutrient source to the river channel)

Refer to Appendix 1 for a detailed description of water requirements for each identified ecological value.

2.3.2 Consequences of modifying natural flow regimes

Modifying a natural flow regime can affect the breeding success of aquatic organisms and in the long term it can significantly modify the ecology of the system and its capability to repair itself after disturbances.

The construction of water supply dams and private dams, diversion of springs, private on-stream abstraction, environmental releases and the installation of weirs have significantly modified the flow regime in the Canning River System. The river does not experience the same flow regime as it did prior to the construction of the Canning and Wungong Dams.

This modified flow regime, along with other disturbances that are unrelated to flow modification, have led to a decline in the ecological health of the river system. The ecological impacts of this modified flow regime are outlined below.

Table 2: Impacts of modified flows on the ecology of the Canning River System

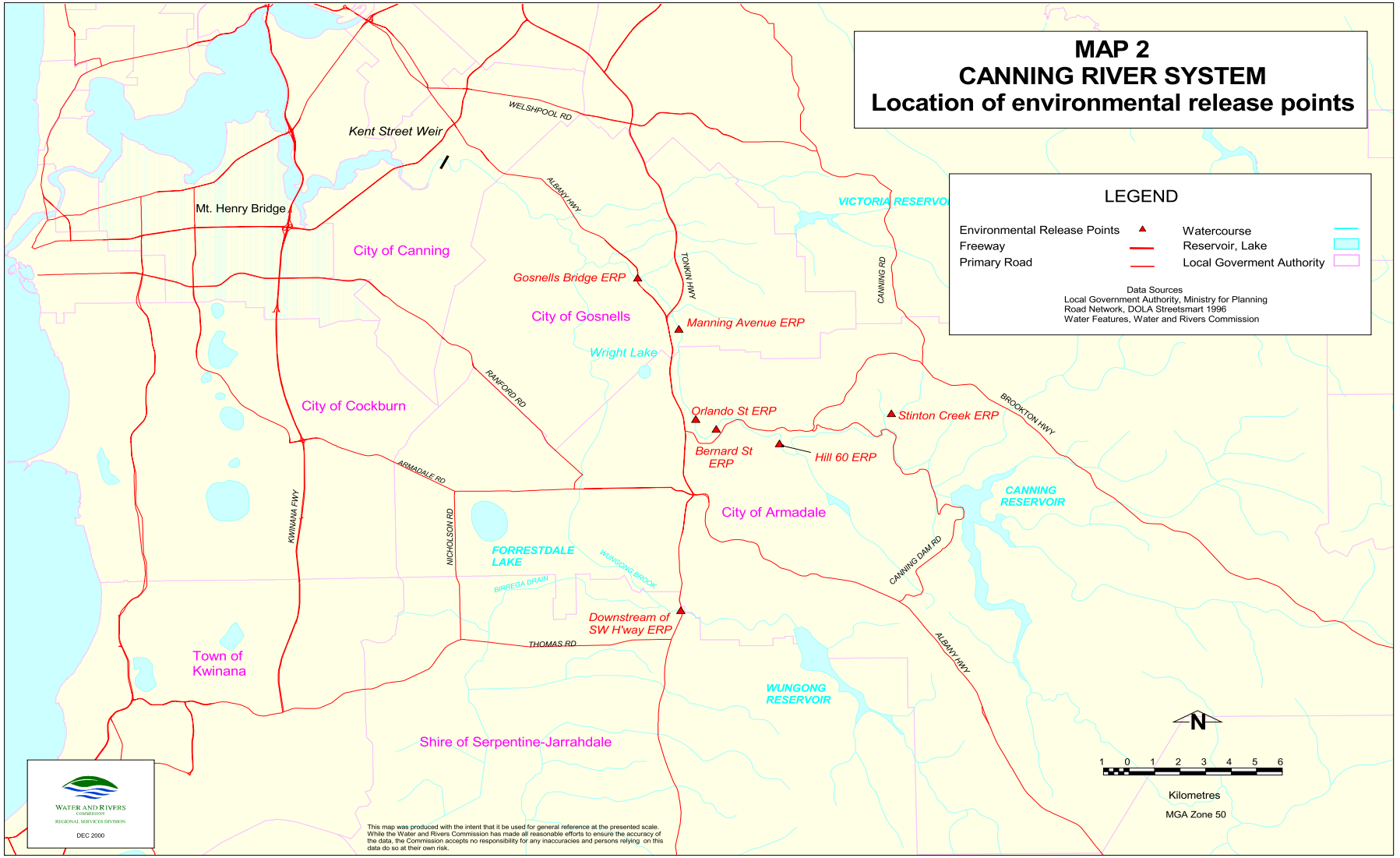
Impacts of modified flows on the ecology of the Canning River System	Resultant impacts (ecological and social)
Reduced scouring has altered the geomorphology of the river channel including the sedimentation of river pools in some parts of the river	• Loss of summer refuge for in-stream fauna • Restricted canoe access in some reaches
Reduced flow in spring may have reduced the breeding habitat necessary for certain species of native fresh water fish	• Affects breeding success and recruitment of native fresh water fish
Reduced flows and stagnant summer/autumn conditions have provided a suitable habitat for successful breeding of the introduced Mosquitofish	• Mosquitofish dominates the fish fauna of the river
Reduced flooding results in adverse impacts in the floodplain	• Reduced germination of fringing vegetation • Weed invasion • Loss of carbon energy and nutrient transfer from the floodplain to the river channel • Loss of important nursery grounds for juvenile/larval fish

2.3.3 Current management of the flow regime

When the Canning Dam was built, there was an undertaking to release summer flows into the rivers, primarily to protect riparian rights (W&RC, 1996).

Water is still released into the Canning River and also Southern River-Wungong Brook via riparian release points, also known as environmental release points (see Map 2). These release points are located where the Water Corporation's scheme water supply pipes (trunk mains) cross the river. The water released into the river is chlorinated scheme water, the impacts of which, if any, are being examined by the Water and Rivers Commission.

The release points are turned on in late spring when flows begin to recede and have primarily been used in the past to satisfy the irrigation demand along the river. Each release point is managed separately and turned on by the Water Corporation upon request by the Water and Rivers Commission.



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The environmental releases contribute significantly to summer and autumn flows, however the amount of groundwater recharge into the river that occurs during these seasons has not been quantified.

Water releases are maintained until autumn rains replenish the flow. They cease during large summer storm events, as experienced in January 2000, or when the closest upstream release point is providing adequate flow at that site.

It should be noted that since the decline in rainfall levels since 1975 and additional demand on dams to supply water to the growing Perth community, the Canning Dam has not overflowed into the Canning River since 1974 (see figure 14, Appendix 3). There is also a pumpback station that pumps water from upstream of the McNess Rd Bridge back into the Canning Dam. The headwaters of the Canning River now originate from small tributaries, many of which are regulated.

Table 3 lists the release points, approximate length of operation and estimated volumes released for the past three summers. It is important to note that these figures

Table 3: Estimated discharge volumes for 1997-2000

Release No.	Name/Location	Average period of operation	Volume Released (ML) 1997-1998	1998-1999	1999-2000
		Canning River			
1	Stinton Creek (Araluen Botanic Park), Roleystone	Oct-May	557.2	588.0	492.8
2	Hill 60, nr Stocker Rd, Roleystone	Nov-Apr	243.5	282.6	69.0
3	Bernard St, Kelmscott	Dec-Apr	0 *	0 *	168.0
4	Orlando St, Kelmscott	Dec-Apr	40.8	328.2	211.2
5	Manning Ave, Martin	Dec-Mar	11.2	0 *	84.0
6	Albany Highway bridge, Gosnells	Dec-Apr	19.5	43.8	79.0
Total			**872.2**	**1242.6**	**1104**
		Wungong Brook			
1	Main valve (east of SW highway), Wungong	Nov-May	786.6	693.7	498.3
2	South Western Highway, Wungong	n/a#	n/a#	n/a#	102.0
Total					**600.3**

* *These release points were under repair and turned off for this period.*

\# *The second release on Wungong Brook, South Western Highway, was not constructed until 1999.*

Environmental release point, Albany Highway Bridge, Gosnells

are only estimates, gauged on turns of the release valve. Water meters were installed on all release points in late 1999 to measure future release volumes, but the accuracy of these is currently in doubt.

2.4 Soils and nutrients

The eastern and western areas of the Canning Catchment differ greatly with respect to soils and landform. The Upper Canning and Yule Book Catchments are characterised by duplex Pinjarra Plain soils with steep shallow and duplex valley soils. These soils generally exhibit a high phosphorus retention index (PRI) with slow water infiltration properties. In contrast, the Southern Wungong and Lower Canning Catchments are relatively low lying with mostly low PRI Bassendean Sands where water can infiltrate quickly once wet.

The differences between the soils and landforms in these catchments influence the general patterns of nutrient, sediment and contaminant transport from these areas. This is exemplified by comparison of the Upper Canning and Southern Wungong Catchments.

Upper Canning River

Water in the Upper Canning River has low nutrient concentrations. This is due to a number of factors including soils with a high PRI and less urban and agricultural development in the upper catchment.

Seasonal water quality data in the Upper Canning River reveals that total phosphorus concentrations are low. However the majority of this is particulate phosphorus (Figure 3).

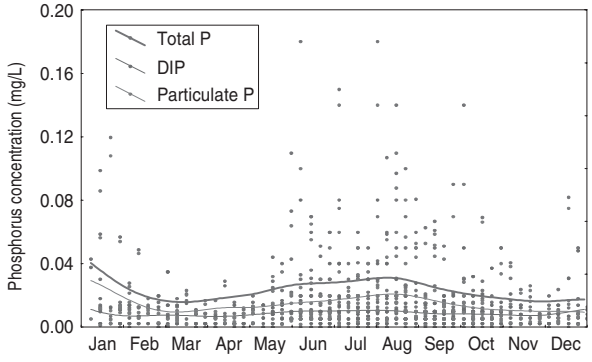


Figure 3 : Seasonal phosphorus concentrations (mg/L) in the Upper Canning River

Phosphorus tends to bind to soil that contains iron and aluminium oxides, such as the clays and laterites of the Upper Canning Catchment. If this soil erodes and is washed into the river, it contributes to the concentrations of particulate phosphorus.

If left unchecked, erosion of phosphorus-enriched surface soils can become a major source of particulate inputs of phosphorus to surface water and associated aquatic systems (Gerritse, 1999). High loads of organic matter, from animal manure and soft-leafed exotic trees, can also contribute to high concentrations of particulate phosphorus.

Seasonal data indicates that total nitrogen concentrations in the Upper Canning River are related to flow, peaking during the highest rainfall months. This seasonal pattern can also be related to the rise and fall of groundwater levels (W&RC, 2000). Figure 4 indicates that inorganic nitrogen is higher than the organic component of nitrogen. However, it is important to note that the land surrounding the Canning River monitoring site supports land uses such as orchards and market gardens, which typically have high fertiliser use, a source of inorganic nitrogen.

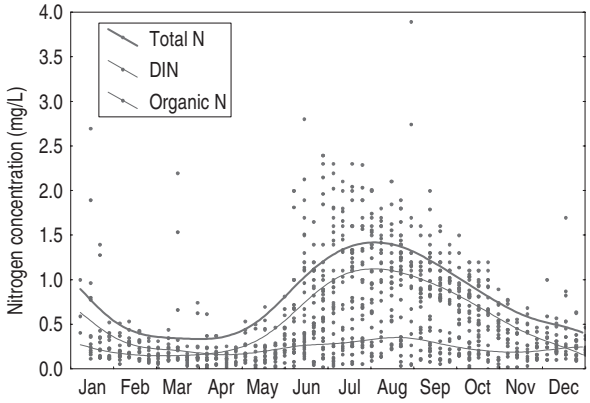


Figure 4: Seasonal nitrogen concentrations (mg/L) in the Upper Canning River

Southern-Wungong Catchment

The Southern-Wungong Catchment is one of the highest contributors of nutrients to the Swan-Canning Estuary. Peaks in total nitrogen and total phosphorus concentrations during July and August (see figures 5 and 6) suggest transport of these nutrients is coupled with seasonal flows and that the catchment typically has shallow groundwater levels. Inorganic phosphorus and nitrogen is readily leached

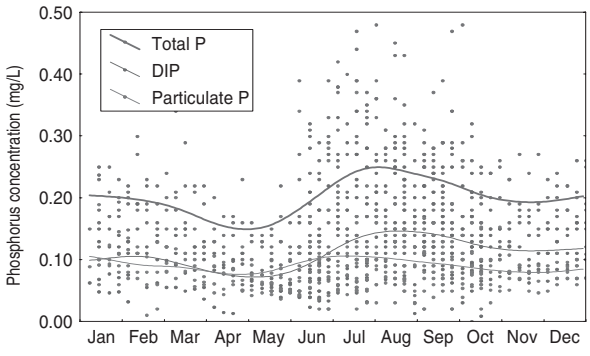


Figure 5: Seasonal phosphorus concentrations (mg/L) in the Southern River/Wungong Brook

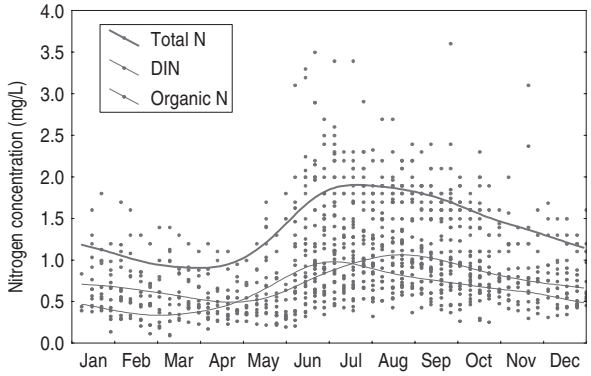


Figure 6: Seasonal nitrogen concentrations (mg/L) in the Southern River-Wungong Brook

from the low retention capacity, highly porous Bassendean sands and transport from these soils is further accelerated when groundwater levels rise close to the soil surface.

2.5 Water quality

What is water quality?

Water quality is influenced by a range of factors including:

- Nutrient concentrations (including phosphorus and nitrogen)
- Dissolved oxygen concentrations
- Organic matter
- Heavy metals, herbicides and pesticides
- Light availability
- Pathogens and bacteria

Nutrients

Nutrients are essential for aquatic ecosystems. Once nutrients enter an ecosystem, they are naturally cycled throughout the food web. Nutrient cycling transfers compounds essential for growth from one habitat to another. However human activities generally deliver excess quantities of nutrients, especially nitrogen and phosphorus to the river system, which overwhelms this cycling process. The amount of available nutrients exceeds the ecosystem's capacity to recycle nutrients and hence they are available to nuisance algae.

Phosphorus and nitrogen are the two main nutrients of interest in an aquatic ecosystem. Algal growth is mostly determined by the biologically available dissolved fractions of nitrogen and phosphorus, however one nutrient may limit the growth of algae more than another and this is termed a 'limiting nutrient'.

Determining the limiting nutrient in a river is quite complex and is dependent upon a number of factors including the season. At this stage, there is uncertainty as to what the limiting nutrient is in the Canning River System. Until such time as this is confirmed, management efforts should aim at reducing the input of both nutrients.

Phosphorus

Phosphorus is present in waterways as:

- dissolved phosphate
- dissolved polyphosphate (commonly found in detergents)
- phosphorus in dissolved and particulate organic compounds
- phosphate attached to particles of sediment, clay and organic matter (Prosser *et. al.*, 1999).

When bottom waters and the sediment surface become anoxic (low in dissolved oxygen), sediments release phosphorus to the water column.

Nitrogen

In terrestrial and aquatic ecosystems nitrogen is most commonly present as ammonium nitrate and organic nitrogen. Unlike phosphorus, nitrate is not bound in soil and rapidly leaches to groundwater and surface water (Gerritse, 1999). Ammonium and nitrate are easily utilised for plant growth, including algal blooms.

Nitrogen does not often accumulate in excessive amounts due to a process called denitrification. Denitrification converts nitrates into nitrogen gas that escapes into the atmosphere. This natural cycling of nitrogen can prevent excessive build up. For denitrification to occur, nitrification must occur first and this requires oxygen. Low oxygen concentrations in bottom waters can therefore reduce the rate at which nitrogen can be removed from the river (SRT, 1999).

Dissolved oxygen concentrations

Oxygenation of the water column occurs at the surface. When the water flows over riffles, woody debris and granite outcrops the turbulent flow creates a larger surface area over which aeration can occur (Pen, 1999). In still water, such as that upstream of the Kent Street Weir, the surface waters are well oxygenated, however the bottom waters are not. For the entire water column to be oxygenated, sufficient mixing and turbulence is required. When there is insufficient mixing, any oxygen available at the bottom is quickly used up by the decomposition of organic matter.

Table 4: Common pollutants, possible sources and potential impact on waterways

Pollutant	Source	Impact on waterway
Organic nitrogen and phosphorus	• Leaves from soft-leafed exotic trees • Lawn clippings (blown in from adjacent parks) • Animal waste • Septic tank leaching/sewer overflows	• The system has difficulty processing excess nutrients so they are utilised by nuisance species for primary production
Inorganic nitrogen and phosphorus	• Fertiliser • Animal urea • Domestic detergents (car washing, scrubbing dirty floors) • Septic tank leaching/sewer overflows • Industrial effluent	
Sediment	• Disturbed and/or exposed soil • Pavement and vehicle wear • Organic matter (e.g. leaf litter, grass)	• Smothers important habitat • Lateral erosion of river channel
Heavy metals	• Vehicle wear • Spillage/illegal discharges • Underground fuel tank leakage • Atmospheric deposition • Industrial effluent	• Bioaccumulation • Some can kill organisms on contact
Gross pollutants	• Littering • Deciduous trees • Vehicle wear	• Visual pollution • Hazard to humans (broken glass, syringes) • Hazard to animals (fishing lines, plastic bags, bands, rope)
Pathogens and bacteria	• Animal faeces • Leaking sewerage/septic systems	• High biological oxygen demand (BOD) reducing dissolved oxygen concentrations in water column
Toxic chemicals	• Pesticides and herbicides • Illegal discharge • Leaking sewerage/septic systems	• Some can kill organisms on contact • Bioaccumulation

A lack of dissolved oxygen in the water column adversely affects in-stream organisms such as fish, macroinvertebrates and bottom dwelling organisms. Under low oxygen conditions, sediments release nutrients into the water column, which may fuel toxic algal blooms.

The Swan-Canning Cleanup Program's Canning River Oxygenation Trial aims to reduce the release of phosphorus and increase the rate of nitrogen removal from the system. Oxygenation also aids carbon removal and suppression of available phosphorus release from the sediments. In turn, this will reduce the nutrients available for nuisance algae. Detailed results of this trial are available from the Swan River Trust.

Organic matter

Organic matter is biodegradable material such as leaf litter, bark, weeds, faecal matter, decomposing algae and grass clippings. The widespread clearing of hard-leaved forests and woodlands and the establishment of pastures, annual crops and deciduous horticultural species, together with weed infestations along streams have produced a massive source of swiftly decaying, soft-leafed material (Pen, 1999). Organic matter is usually trapped and processed in fringing vegetation, however much of the river and network of drains leading into it are cleared, so a large amount of unprocessed organic matter enters the Canning River system.

Decaying organic matter has a high biological oxygen demand (BOD). The depletion of oxygen in the water column leads to a release of nutrients from the sediment and possibly algal blooms. This is of particular concern in the poorly mixed Kent Street Weir Pool. Small summer storms flush considerable quantities of organic matter sitting in drains into the Weir pool. To successfully reduce algal blooms it is important to reduce inputs of nutrients and unprocessed organic matter.

Heavy metals and pesticides

Heavy metals can come from a variety of human activities, including runoff from industrial activities, leaching of metals from waste disposal dumps, illegal discharges and tyre wear on vehicles. Pesticides, such as herbicides are used frequently to control weeds on rural and urban properties and along drains and waterways. Other pesticides are used to control invertebrate pests, including mosquitoes.

Both heavy metals and pesticides cause similar problems in waterways. Once ingested, the chemicals accumulate in animal tissue over many years and pass through food chains, causing long-term contamination of riverine foodwebs.

Light availability

Fringing vegetation influences the amount of light reaching the river and thus water temperature. High water temperatures can adversely affect the structure and dynamics of aquatic plant and animal communities.

Warm water temperatures can cause the following problems:

- increase in the breakdown of organic matter, which increases oxygen consumption,
- adverse impacts on the growth and metabolism of some aquatic species,
- thermal stratification, which leads to deoxygenation of bottom waters.

In slow flowing waters, such as the impoundment upstream of the Kent Street Weir, suspended sediment and silt settles to the bottom and light penetration is increased, providing conditions ideal for photosynthesis and thus algal blooms.

Pathogens and bacteria

Pathogens and bacteria may reach the Canning River System from agricultural and urban areas. Sources of pathogens are:

- human waste which enters nearby drains when septic tanks flood or fail,
- animal waste from domestic animals and livestock,
- animal waste from wildlife.

High levels of bacteria or pathogens are a health risk to people, wildlife and domestic animals. They also consume oxygen and generate offensive odours. Studies conducted by the Water and Rivers Commission show that pathogen concentrations are unacceptably high and need to be reduced if the river is going to be safe for high contact recreation.

2.6 Algal blooms and eutrophication

Human activity can lead to sudden increases in nutrient inputs and the rapid accumulation of phytoplankton growth, including toxic algal blooms (SRT, 1999). In recent years toxic algal blooms have occurred regularly in the area upstream of the Kent Street Weir. The most severe bloom was in 1994 when the river was closed to recreational use for several months.

The Swan River Trust began sampling for algal blooms in 1994. Table 5 lists algal blooms that have occurred in the Canning River since sampling began. Anecdotal evidence suggests blooms did occur in the river prior to 1994 but not as regularly.

Table 5: Algal blooms recorded by the Swan River Trust in the Canning River since 1994

Date	Location	Species
Jan-Mar 1994	Upstream Kent St Weir	Anabaena spp.
Feb-Mar 1994	Upstream Kent St Weir	Microcystis spp.
Feb-Apr 1994	Upstream Kent St Weir	Anabaena spp.
9 April 1996	Wharf St	Oscillatoria spp.
20 Jan 1997	Kent St Weir	Anabaena spp.
20 Jan 1997	Bacon to Wharf St	Anabaena spp.
29 Jan 1997	Kent St	Anabaena spp.
29 Jan 1997	Greenfield St	Anabaena spp.
3 Feb 1997	Bacon to Wharf St	Anabaena spp.
13 Jan 1998	Kent St Weir to Greenfield St	Anabaena spp.
20 Jan 1998	Kent St Weir to Greenfield St	Anabaena spp.
27 Jan 1998	Kent St Weir to Greenfield St	Anabaena spp.
3 Feb 1998	Kent St Weir to Mason's Landing	Anabaena spp.
17 Feb 1998	Kent St Weir to Mason's Landing	Anabaena spp.
24 Feb 1998	Bacon St	Anabaena spp.
3 Mar 1998	Wharf St	Anabaena spp.
10 Mar 1998	Ellison Drive	Anabaena spp.
12 May 1998	Wharf St	Microcystis spp.
12 Jan 1999	Wharf St	Anabaena spp.
19 Jan 1999	Kent St Weir	Anabaena spp.
9 Mar 1999	Kent St Weir	Anabaena spp.
Oct 1999	Roley Pool, Roleystone	Unidentified
9 Nov 1999	Bacon St	Unidentified
11 Jan 2000	Kent St Weir & Bacon St	Anabaena spp.
19 Dec 2000	Kent St Weir	Trachelomonas spp.
Feb 2001	Kent St Weir, Bacon St and Nicholson Rd	Anabaena spp.
13 Mar 2001	Kent St Weir	Carteria spp.
Mar 2002	Kent St Weir, Bacon St and Wharf St	Anabaena spp.
Apr 2002	Kent St Weir and Bacon St	Anabaena spp.

Although Anabaena and Microcystis are commonly referred to as blue-green algae, they are actually not algae but cyanobacteria (bacteria that photosynthesise). For the purposes of this report however, they will be referred to as algae.

Anabaena and Microcystis are the most common species found in the lower reaches of the Canning River, however other species are also washed in from the catchment. In 2000, a tropical species of cyanobacteria (*Cylindrospermopsis* cf. *raciborskii*) was found in a drain flowing into the Canning River. This was thought to have come from imported soil in a new residential estate.

The Canning River and its tributaries also experience excessive macrophyte growth of the aquatic weeds, *Salvinia* spp. and *Hydrocotyle ranunculoides*. In the early 1990s the area upstream of the Kent Street Weir was blanketed with *H. ranunculoides* in summer. The Swan River Trust implemented a weed control program, physically removing tonnes of this weed. In recent years the Trust has conducted follow-up spraying and removal which has kept this weed under control.

Nutrient enrichment is not the only cause of algal blooms and excessive macrophyte growth. The availability of light, fresh water, high water temperatures, lack of turbulence in the water column and store of nutrients in the sediments all influence the growth of algae and macrophytes.

The impoundment of the Canning River by the Kent Street Weir has resulted in a seasonal fresh water lagoon with large expanses of still water. This results in a long

Hydrocotyle ranunculoides blanketing the Canning River, 1992 (Photo: V Klemm)

The same site following removal of the weed (Photo: V Klemm)

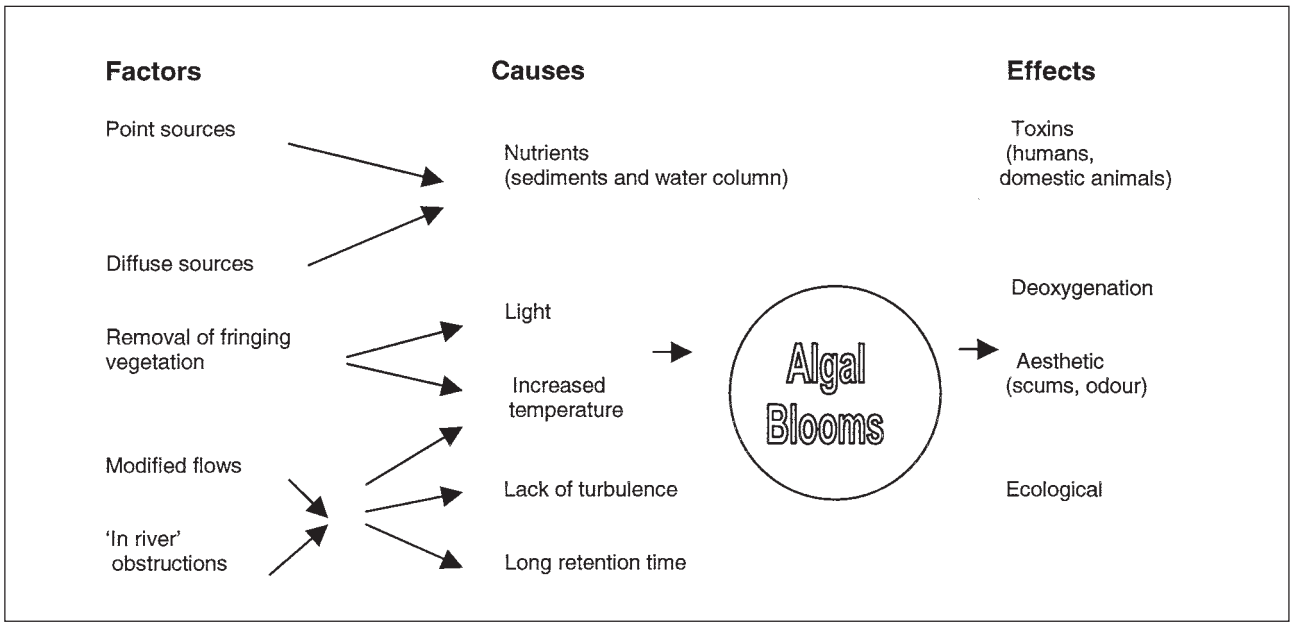


Figure 7: Conditions leading to algal blooms (derived from NSW Agriculture,1997)

retention time of water. The increased retention time and lack of shading of the river channel results in increased light penetration and high water temperatures. If there is insufficient light in the water column, nutrient enrichment will have little effect on algal growth (Bunn *et. al*., 1999).

The Canning River does not frequently experience saline stratification, as with the Swan River (saline water does at times flow over the weir and cause stratification). Although the river rarely experiences saline stratification it does experience thermal stratification. The lack of mixing between bottom and surface waters due to the impoundment of fresh water during summer results in warm water at the surface and cooler water on the bottom.

This lack of mixing prevents oxygen replenishment from surface to bottom. Any available oxygen left at the bottom is used up by the decomposition of organic matter, which can be built up after the collapse of previous algal blooms.

Small summer rainfall events deliver high organic loads and biological oxygen demand which can consume all the available oxygen. By this stage, the conditions are right for the sediments to release nutrients into the water column.

The excessive growth of algae and macrophytes can lead to the following problems:

Sign advising the public not to use the Canning River **(Photo: Phytoplankton Ecology Unit)**

- Excessive algal growth and subsequent reduced oxygen concentrations in the water column can cause the death of worms and other bottom dwelling invertebrates which are important prey for fish and other high-order predators like waterbirds.
- The frequency of algal blooms and their subsequent collapse has the potential to reduce biodiversity in parts of the river.
- Algal blooms have the potential to produce harmful toxins. These toxins can cause skin irritations in humans and harm domestic pets and livestock if they drink or wade in the water. This reduces the recreational amenity of the water.
- Excessive macrophyte growth can provide shade, bird feeding habitat, reduce water temperatures, add oxygen and are excellent for cyanobacteria control. However they consume oxygen rapidly when they decompose and limit the mixing of surface water and air when they completely blanket the surface. Excessive macrophyte growth can also block the river channel reducing recreational amenity.

2.7 Drainage networks

Drainage systems are developed to meet the community's need to minimise the threat of flooding. For many years, the main focus of drainage networks has been on hydraulic capacity and rapid transport of stormwater rather than water quality (EPA, 1998).

In the Canning River Catchment, minimal rainfall is experienced from November to April. This allows nutrients and pollutants to accumulate in the soil and on impervious surfaces and also accumulate in stagnant, low flow parts of the drainage system. When the first major rains occur, often referred to as the 'first flush', the accumulated pollutants are transported in a large pulse to the nearest drain or waterway. In Perth, the first flush effect is often compounded by soil with non-wetting properties, which may act as an impermeable surface during the first flush (W&RC, 1997a).

While the first flush from the catchment is an obvious problem, poor design and maintenance of the drainage systems results in an accumulation of nutrients and contaminants in the system that can contribute to the transport occurring during first flush events. This accumulated material aggravates eutrophication and pollution of the waterways between rainfall events.

Many of the natural tributaries in the Canning River Catchment have been modified into drains. This modification has involved the removal of fringing vegetation, alteration of the river bed and destruction of pools and riffles. This removes the tributaries' natural ability to slow down flow, settle out sediment and nutrients, as well as provide habitat for aquatic and terrestrial fauna.

The groundwater levels on the Swan Coastal Plain are frequently very close to the surface and the extensive network of drains often intercept the groundwater for most of the year. For example, the Southern River Catchment is made up of numerous seasonally inundated wetlands and damplands so the water level is at the surface or near the surface. When drains are constructed

in these areas to dry out the land for development, they often intercept and drain groundwater, even in summer. As a consequence, many of these drains flow year round, continuously transporting nutrients and pollutants to the Canning River System.

Contamination of shallow groundwater with nutrients or pollutants from historical and current land uses contributes substantially to many of the existing pollution problems in the drainage systems. Movement of contaminants by groundwater occurs slowly and seepage of contaminants into drains can be drawn out over many years resulting in chronic long-term impacts on the system.

Urban and rural drains that flow permanently through summer contribute to eutrophication of the river system. In summer they deliver stagnant, nutrient-rich, warm water that is rich in organic material to the river system. This water has a high biological oxygen demand, impacting on a system that is already under stress from low summer flows.

2.8 Taking surface water

The Canning River and its tributaries sustained Aboriginal communities long before European settlement. Land surrounding the Canning River was first developed by Europeans for farming in the 1800s. Ever since, the Canning River System has provided land owners abutting the river with fresh water to irrigate crops and pasture and the Perth metropolitan area with a public water supply.

Canning River

The Canning Dam was completed in 1940. Around this time, there was considerable concern amongst downstream land owners that the dam would reduce the quantity of water available for their use. The government of the day gave assurance that the summer flow into the Canning River would be released for the irrigation of existing commercial orchards and other agricultural pursuits (W&RC, 1996). As land use changed and the original lots were subdivided, additional demand was placed on the river system.

The Canning River was proclaimed under the *Rights in Water and Irrigation Act (1914)* in 1942, making non-riparian use subject to licensing. Later that year, the Canning River Irrigation Advisory Committee was established (W&RC, 1996). That Advisory Committee amalgamated with the Wungong Southern Rivers Irrigation Advisory Committee and is now referred to as the Canning Wungong Southern Rivers Advisory Committee. This Committee is made up of five local land owners and one Water Corporation representative.

In 1996 the Water and Rivers Commission produced an Interim Allocation Policy for the Canning River with advice from the Advisory Committee. This Interim Policy was developed to protect the ecological values of the river. It also outlined minimum flow requirements, although these were rough estimates and were to be followed up with a scientifically based ecological water requirements study, which has been done as part of this plan.

Bickley Brook, Kenwick. This is an example of a modified watercourse flowing into the Canning River

The Canning River Interim Allocation Policy (W&RC, 1996) outlines certain management principles that are currently used by the Advisory Committee when making licensing decisions. These are:

1. No additional water allocations will be made;
2. Water use is to be progressively reduced to a level that matches the availability;
3. Water users must adopt best practice water conservation and efficiency measures;
4. Pumping restrictions will be applied during periods of inadequate flow;
5. Individual pumping rates are to be limited to prevent an excessive reduction in the river flow.

There are 116 private licensed users on the Canning River. The majority of these are between Kelmscott and Gosnells. Of these 116 licensees, 59 also have a riparian right for domestic use. There are many more properties that abut the river and have a riparian right but not all of the owners of these properties exploit this right.

The quantity of water allocated to private licensed users is approximately 1.31 ML/yr. The total riparian use has been estimated in water use surveys conducted by the Water and Rivers Commission in recent years. Most water taken from the river is during summer when flows are at their lowest.

Southern River-Wungong Brook

The Southern River and Wungong Brook were proclaimed under the *Rights in Water and Irrigation Act (1914)* in 1976, shortly after the construction of the Wungong Dam earlier the same year. These rivers were actively licensed for a number of years, when upon advice from the Wungong Southern Rivers Irrigation Advisory Committee, licensing was suspended in 1985.

In February 2000, the Canning Wungong Southern Rivers Advisory Committee made a decision to resume licensing along the Southern River-Wungong Brook, in an effort to improve management of water resources along the river. The Advisory Committee has decided that before licences are reissued, a water use survey will be conducted along the entire length of the river. This will determine the total consumptive use.

Birrega Drain intercepts Wungong Brook downstream from the release point on Wungong Brook (see Map 2). There is a weir on Wungong Brook (500m downstream of the Perth-Bunbury railway line) that raises the water level and backs up water so it flows down Birrega Drain, which

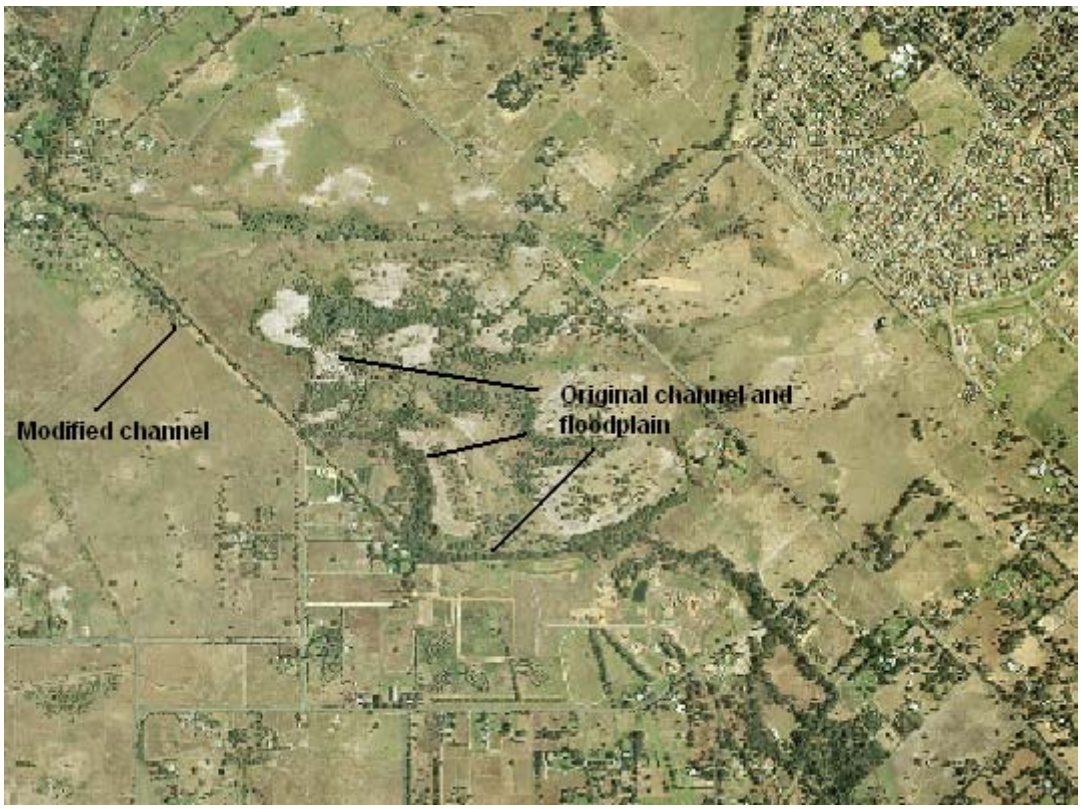


Figure 8: Aerial photograph, February 2000, illustrating the straightened, modified channel of Wungong Brook that drains water away from the original channel and floodplain

drains into the Peel-Harvey Catchment. There has been debate for many years as to whether the water released for Wungong Brook should be allowed to flow into Birrega Drain. The water released upstream is intended for Wungong Brook-Southern River.

2.9 Fringing vegetation and weeds

Fringing vegetation is extremely valuable to ecosystem processes. The riparian zone of the Canning River System supports a higher diversity of flora and fauna than the adjoining land. Fringing vegetation provides the following benefits:

- provision of in-stream shade from the harsh summer sun
- provision of energy and nutrients to aquatic organisms
- the roots of fringing vegetation bind the soil and therefore stabilise the banks and prevent erosion
- provision of habitat and refuge for terrestrial flora and fauna
- branches break off and logs fall into the river channel, providing woody debris, an important habitat to aquatic organisms
- filters out sediment and nutrients passing from the land to the river. This is an important function when the adjoining land is cleared and supports human activity. The potential to remove pollutants before they enter the river can also occur via deep-rooted vegetation intercepting nutrient-enriched groundwater.

Although many acknowledge the importance of riparian land, human settlement along the Canning and Southern Rivers and Wungong Brook has resulted in its degradation. This has been caused by clearing, river training, modification of flows, uncontrolled stock access, fire and weed invasion.

Weed invasion is particularly bad along the Canning River. Nowhere else in the south-west do vines, tall grasses and woody weeds dominate the river valley to the extent and intensity that they do on this river (Pen, 1993, 1999). The worst instances of weed invasion are around Kelmscott and Gosnells where the middle and understorey is dominated by a wide range of woody and climbing weeds. This invasion of weeds threatens native plant communities and some local native fauna that depend on native vegetation for food and shelter.

Along most of the river system, grazing was uncontrolled for many years. When the river was fenced off, soft-leafed exotic weeds replaced the understorey and have increased the organic loads along the Canning and Southern Rivers. Much of Wungong Brook is still grazed, so exotic weeds have not had the opportunity to become established.

Much of the Wungong Brook-Southern River was modified into a straight trapezoidal drain many years ago.

Southern River, McNeill Road Bridge, 1999. This part of the river has been straightened and resembles little more than a drain with virtually no ecological value

The channel was excavated and levee banks created to improve drainage and open up the surrounding land to development. This occurred mostly between Rowley Road, Brookdale and Allen Road, Westfield. Figure 8 outlines sections of the original channel and associated floodplain, wetlands and sand dunes.

The modification of the Wungong Brook-Southern River has led to considerable problems. The channel has minimal fringing vegetation and is thus deprived of the benefits that fringing vegetation provide. There is virtually no woody debris and the banks are exposed to erosion or infested by weeds.

Storey (1998) conducted a fish and fish habitat survey of the Canning River and its tributaries. Out of 17 sites surveyed, McNeill Rd Bridge, Southern River (see photo below) was the only site in the main river channel where native species of fresh water fish were not observed. Only one single fish was found, that being the introduced Mosquitofish (*Gambusia halbrooki*) that prefers warmer waters. Local residents have now formed a catchment group for this part of Southern River, and are undertaking river restoration.

There has been some successful regeneration of native plant species along the lower reaches of the Canning River in Maddington. In all cases this is mainly due to the regeneration of *Eucalyptus rudis* and *Melaleuca raphiophylla* on farmland which has been less intensively used as the surrounding land has become urban (Pen, 1993).

2.10 Sedimentation

Erosion and sedimentation are natural riverine processes but poor land use management has resulted in excessive quantities of sediment entering the river channel through drains and tributaries. This has been coupled with a loss of scouring flows since the construction of the dams and climatic variability in the past 25 years. The river is therefore unable to scour all of the sediment under the current flow regime. Sediment deposits are an obstruction to flow and can modify the geomorphology of the river.

Fine sediments can be carried quickly downstream in suspension, whilst coarser sediments are typically rolled along the bed. As a result, coarse sediments can build up in the river causing large silt deposits (Pen, 1999).

Anecdotal evidence suggests a number of deep pools on the Canning River System have filled as a result of sedimentation. These pools provided an important summer refuge for in-stream fauna, particularly freshwater cobbler. Not only do sediment deposits fill deep pools, they also smother the river bed and woody debris, both important habitat types.

Some weeds are particularly good colonisers and take advantage of the opportunity that fresh sediment deposits provide. Depending on flow conditions, weeds can completely cover and consolidate sediment deposits within a few seasons, thereby stabilising them and making them harder to erode.

Large sediment deposit in a river pool, Kelmscott

Section 3. Revitalising the Canning River System

This section presents the main issues identified and dealt with by this plan. Under each issue an objective has been listed, as well as the response/s required to achieve the objective. Some of the responses have been carried out by this or other associated plans. Where further action is required to achieve the objective, recommendations have been listed. These recommendations are then repeated in Section 4 where all the recommendations are grouped under appropriate management programs for implementation.

3.1 Meeting the ecological water requirements

Issue:

Flow in the Canning River System has been significantly modified. This has contributed to the degradation of ecological values, a loss of river power and flooding flows.

Objective:

Manage river flows so that the important ecological values of the river system are maintained, balancing the ecological requirements with the human demands for water.

Response: what needs to be done to meet this objective?

- Identify ecological features and values of the river and their water requirements
- Develop environmental water provisions for the river
- Develop a formal water resource allocation plan for the Canning River System that allocates water to the ecological values, consumptive values and social values of the river

3.1.1 What are the ecological water requirements of the Canning River System?

Ecological water requirements (**EWRs**) are the water regimes needed to maintain the ecological values of water-dependent ecosystems at a low level of risk.

In October 1999 a study was commissioned to identify preliminary ecological water requirements for the ecological values (see Table 1. p8) of the Canning River System. The study was undertaken by the Aquatic Research Laboratory, University of Western Australia, on behalf of the Water and Rivers Commission.

The aim of the study was to estimate the flows required to enable the Canning, Southern and Wungong Rivers to function as an ecologically healthy system. The process used to identify the ecological water requirements is outlined in Appendix 2.

Once the water requirements of each ecological value were identified, these were pulled together to determine the monthly flow volumes suitable to all of these ecological values. This process was used for six sites on the Canning River System, mostly in the upstream sections.

The results of the study suggest that the Canning River was a permanently flowing waterway prior to regulation. Although the Canning River can never be returned to its pre-dam condition, it needs to be maintained as a permanent 'natural' system with water present and mostly flowing all year round, to maintain its important ecological values. The exception to this may be during periods of drought, as experienced in 2001/2002.

An important finding of the preliminary ecological water requirements study was that the Canning River System does not experience the seasonality of flows that it did prior to regulation. The current flow regime peaks in winter and gradually reduces during spring with low flows during summer. Prior to regulation, flows peaked in winter and then high flows would have been experienced again during spring. It is important that seasonality of flow is re-introduced to maintain the ecological values of the river system.

Figure 9 illustrates the differences in seasonality of flow and flow volumes in the Wungong Brook before and after the Wungong Dam was constructed. However, the period from 1977-1996 (post dam period) has also been the driest period on record with below average rainfall almost every year (see Figure 1).

The results of the preliminary ecological water requirements study are listed in appendix 3.

3.1.2 Developing environmental water provisions for the river

The ecological water requirements developed as part of this process are the 'first estimates' for the Canning River System. This needs to be confirmed through further research and trial releases, planning for this will commence in 2002. During this time, the social and consumptive water requirements of the river will also need to be determined. After this, the environmental water provisions will be identified.

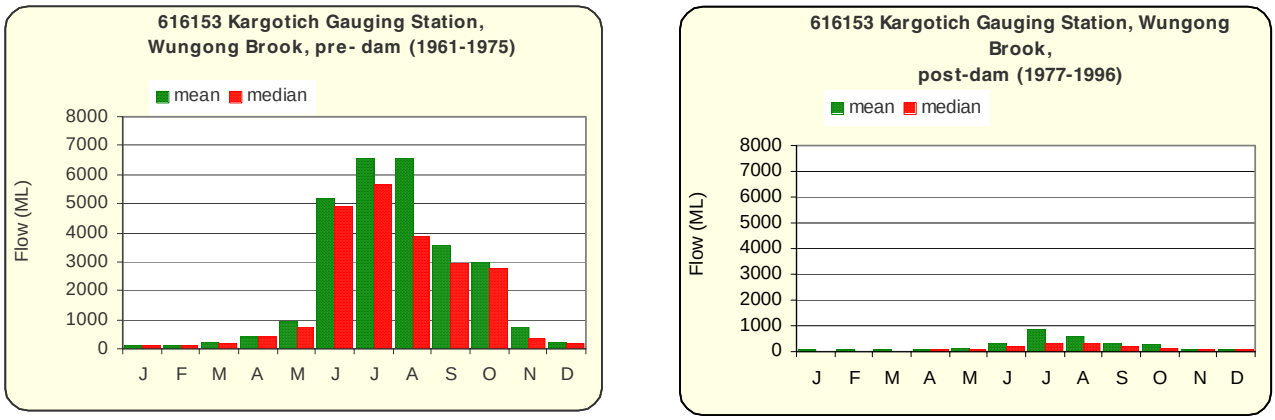


Figure 9: Mean and median annual flows recorded at Kargotich gauging station, Wungong Brook (S616153) pre and post dam construction

> **Environmental water provisions (EWPs)** are that part of the EWRs that can actually be met after consideration of social, consumptive and economic uses of water. EWPs are determined through a consultative water allocation planning and environmental assessment process (including EPA approval).

Environmental water provisions are the flow regimes that can be met after considering the ecological, social and consumptive uses of the river. The aim is to ensure that the important ecological values of the river system are maintained, whilst providing water for important human uses such as public water supply, recreation and private abstraction. This process requires consultation with the community and Water Corporation, experimentation with flows, monitoring and approval from the Environmental Protection Authority.

3.1.3 Trial release

The preliminary ecological water requirements developed as part of this study have been calculated using limited hydrological and ecological data. Simply maintaining the estimated flow volumes would not be a responsible management approach to achieving the objective of improving the ecological health of the river system.

To achieve a better understanding of the flow regime required to maintain the rivers' ecological values, a trial release program is proposed for the Canning River. This trial release program will aim to restore some of the seasonality and variability of flows that would have occurred prior to the construction of the dams and monitor the effects on the ecological values.

The preliminary ecological water requirements study estimated the flow required for the ecological values of the river, including the timing of these flows. One example is that native fish require increased flows during spring to ensure successful breeding. The trial release will release water into the river during spring to maintain the water levels required to assist fish reproduction. An essential part of this trial will be to conduct biological surveys to evaluate if the trial release is successful in achieving its aims (ie. an increase in fish spawning).

A major finding of the preliminary ecological water requirements study was that the Canning River System has very low channel 'roughness'. This means that the river has very few natural obstacles left in it that help to reduce the velocity of water and maintain water levels.

It is therefore recommended that a number of restoration techniques are applied prior to the commencement of the trial. This will help to slow the velocity of water and maintain the recommended water levels in some areas. For example, establishing woody debris in the river channel immediately upstream of a river pool will assist in reducing the velocity of flow upstream but will help to scour out the river pool. Recreating floodplains and/or wetlands (shallow, seasonally-flooded areas connected to the river at high water) in the lower reaches will improve habitat diversity for successful native fish reproduction.

However, restoration needs to be approached with caution. While impounding water is important to enable minor flows to sustain habitat and maintain permanent pools over summer, it will also encourage 'slow-water' exotic fish including, Mosquitofish, carp and goldfish. Some strong flows are needed to discourage these species. Making more of minor flows should not be seen as an alternative to the maintenance of reasonable flows over the summer / autumn period.

It is envisaged that the results of the trial release strategy will provide essential information required to develop the environmental water provisions.

3.1.4 Social uses of water

The social needs for water can include:

- water required for recreational and tourism activities
- water required to maintain Aboriginal and other Australian heritage features
- water to maintain landscape and aesthetic aspects and
- water to maintain educational and scientific aspects

To identify the social values of the Canning River System, the Water and Rivers Commission will consult with the local community through workshops and letter drops. Some of these issues have already been considered at the ecological water requirements workshop held in December 1999 at Kelmscott Hall (Appendix 4).

The workshop found that people were primarily concerned with:

- loss of flushing flows and resultant infilling of pools
- reduced populations of marron and freshwater cobbler
- continuing degradation of the river including weed invasion and sedimentation

When developing environmental water provisions, the primary consideration is usually given to the ecological values. However, there appears to be a strong social demand to improve the ecological health of the Canning River System. Recreational pursuits will also be considered when determining the social values of the rivers.

3.1.5 Consumptive uses of water

Consumptive use refers to water used for public water supply and private abstraction.

This includes the Canning and Wungong Dams that are used by the Water Corporation to supply the Perth metropolitan area with scheme water, private dams and springs and riparian and licensed surface water users that are located along the river system.

Consumptive use will be determined through consultation with the Canning Wungong Southern Rivers Advisory Committee, licensed surface water users, riparian users and the Water Corporation. It is acknowledged that consumptive use in the Canning River System is high and has contributed to the degradation of the ecological health of the river. Whilst developing the environmental water provisions, consideration will be given to the need for this high consumptive demand. However, it is possible that consumptive use will have to be reduced and/or efficiency of use increased. The Environmental Water Provisions Policy for Western Australia (W&RC, 2000) states that where environmental water provisions cannot be met in the short term 'a strategy will be developed in consultation with users and other stakeholders, to ensure such provisions are met within the minimum practicable time'.

3.1.6 Formal water resource allocation plan

The proposed environmental water provisions for the Canning River System will need to be approved by the appropriate Cabinet Ministers. The environmental water provisions will form part of a water resource allocation plan for the rivers, which shall replace the Canning River Interim Allocation Policy (W&RC, 1996). The water resource allocation plan will include guidelines for consumptive use, drought response strategies and the existing local rules as set by the Canning Wungong Southern Rivers Advisory Committee. It is expected that the water resource allocation plan will be complete by 2006.

3.1.7 Monitoring and revision of environmental water provisions

As previously stated, the ecological water requirements presented in this plan are the **first estimates** of what water levels and/or flows are required by the ecological values of the Canning River. They have been formulated with limited hydrological and ecological data. Monitoring is essential so river managers and the community can be confident that environmental water provisions (when set) are meeting their required objectives.

As outlined in Figure 10, environmental water provisions for the Canning will be regularly reviewed. The development of environmental water provisions is set to continue Australia-wide. This will result in more trial releases, further research and scientific developments.

The Canning River will be one of the first waterways in Western Australia to have environmental water provisions developed as part of an overall management plan. Therefore it is essential that environmental water provisions are considered in an adaptive context and reviewed in light of monitoring results and further research.

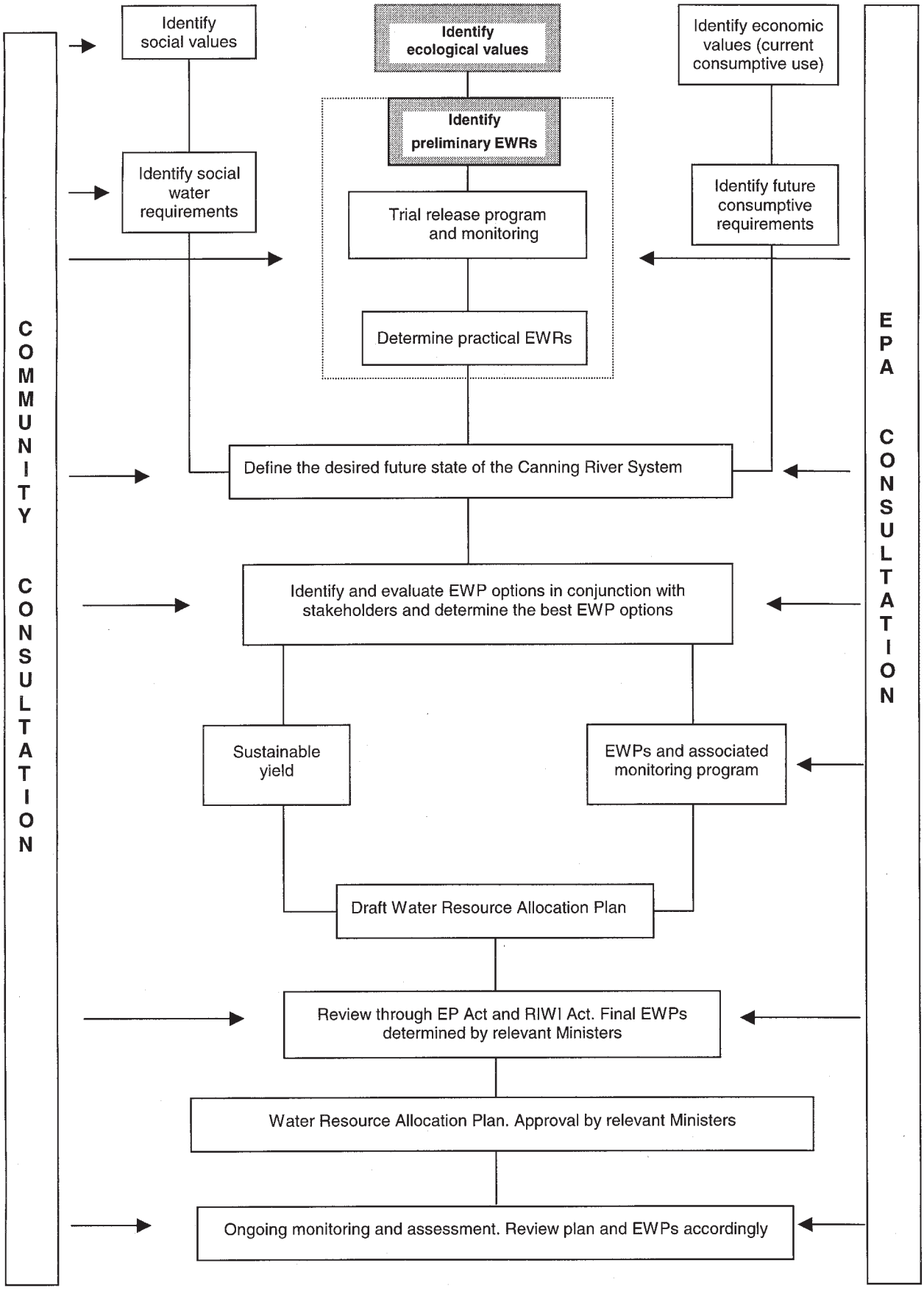


Figure 10: Proposed process for developing environmental water provisions in the Canning River System (shaded boxes indicated step is complete)

Section 3.1			
No.	**Recommendation**	**Proposed organisation**	**Partner**
A1	The Canning River System should be maintained as a relatively permanent flowing waterway and the quantity released from the environmental release points should never be less than historically released	W&RC	WC
A2	In consultation with stakeholders, develop and implement a trial release program in the Canning River System and report on the results of this trial release	W&RC	WC
A3	Conduct an appropriate sampling program to measure the effectiveness of the trial release program. This program should sample for the following parameters: • water quality • erosion and sedimentation downstream of environmental release points • aquatic invertebrates • fish species populations and structure This monitoring program can form part of the ecological health monitoring program outlined in recommendation C2	W&RC	WC
A4	Staff gauges (water level markers) need to be installed at certain locations along the river to calculate water levels and flow volumes during the trial release	W&RC	WC
A5	Determine Environmental Water Provisions (EWPs) for the Canning River System following the process outlined in Figure 10	W&RC	WC
A6	Incorporate the EWPs into a water resource allocation plan for the Canning River System	W&RC	
A7	Investigate the ability to provide a release from near the dam wall on Wungong Brook to maintain summer flows between the Wungong Dam and the release point at South Western Highway	W&RC	WC
A8	Investigate if additional environmental release points are required on the Canning, Southern and Wungong rivers to attain recommended EWPs in all parts of the system. Evaluate the cost of additional releases	W&RC	WC
A9	Review the EWPs as required, taking into account results of the monitoring program	W&RC	
A10	Investigate the need to retain the Weir approximately 500 m downstream of the Perth-Bunbury railway line on Wungong Brook	W&RC	

3.2 Environmental water provisions and river management

Issue:

Meeting the ecological water requirements of the river alone will not improve the ecological health of the river. It is only one part of river restoration and management.

Objective:

Incorporate environmental water provisions (EWPs) into an overall river management program.

Response: what needs to be done to meet this objective?

- Raise awareness of what EWPs are and what they can achieve
- Work with catchment groups to ensure EWPs and river restoration projects complement each other

Many people attribute the degradation of the Canning River System to low flows, heavy abstraction and loss of flooding flows in winter. There is no doubt that the modified flow regime has caused significant ecological problems in the river, but degradation can also be attributed

to land use practices and human activity within the catchment that are relatively distinct from the modified flow regime.

To improve the ecological health of the Canning River System it is vital that water is formally allocated to the ecological values of the river. However this is only one part of effective river restoration and management. Environmental water provisions need to form part of an overall river management program that requires commitment from all levels of government, business and the community.

To improve the ecological health of the Canning River System it will require a more natural flow regime. The Canning River and its tributaries have had large quantities of woody debris, boulders and aquatic plants removed and much of the fringing vegetation has been cleared and replaced with weeds. River pools have also been filled due to sediment coming in from human activity in the catchment. The channel also has been incised (eroded down) in sections due to more rapid runoff from the urbanised catchment.

As a result, water flowing down the Canning River and its tributaries does not have the natural obstacles usually present to slow flow down and raise the water level. Consequently, even during high rainfall events the river cannot reach its 'bankfull' level which is important to its ecological values.

Figure 11 illustrates the differences in flow and water levels between a cleared river channel and a vegetated river channel with woody debris present. Contrary to some beliefs, woody debris does not increase flood risk when placed correctly.

It is evident that a large amount of river restoration is required to complement the development of environmental water provisions in the Canning River System. One cannot occur without the other, it must be acknowledged that they are intrinsically intertwined.

The following areas will need concentrated efforts from all people in the Canning Catchment to ensure that the Canning River System can be revitalised to an ecologically healthy system. The task is too great for one group, organisation, State or local government to undertake. It must be done as a partnership approach.

Catchment management

- water quality protection
- adoption and development of best management practices (BMPs) in land use management
- land use planning and development that acknowledges environmental constraints

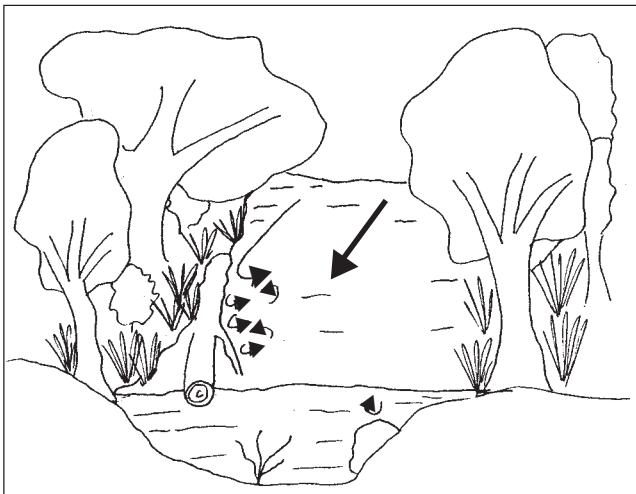
Riparian Management

- riparian revegetation
- replacement of in-stream habitat (i.e. woody debris, boulders, native aquatic plants)
- channel stability (re-establishment of sedges and rushes, tree planting)
- controlling livestock access
- prevention of further losses from new developments

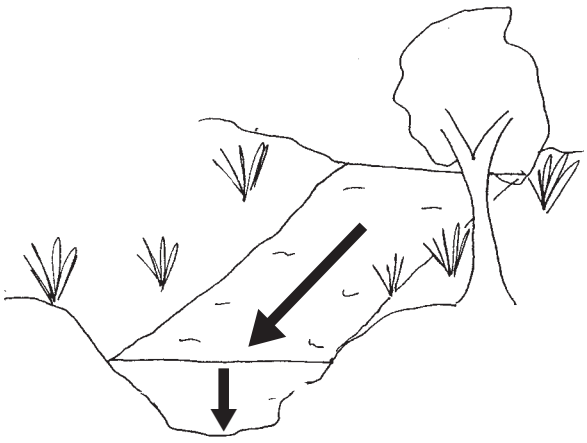
Sampling for fish, Southern River **(Photo: A Storey)**

Section 3.2			
No.	**Recommendation**	**Proposed organisation**	**Partner**
A11	Increase public awareness that developing environmental water provisions forms one part of an overall river restoration program	W&RC	Community groups

Uncontrolled livestock access and the resultant loss of fringing vegetation and erosion on a South West waterway. Note in the background the fenced off, vegetated area. **(Photo: H Bucktin)**



A) Woody debris and fringing vegetation provide natural obstacles in the river channel, slowing the velocity of flow and providing a variety of instream flow conditions



B) A cleared river channel has a high velocity of flow, contributing to erosion and incision of the river channel

Figure 11: Differences in flow and water levels between a cleared river channel and a vegetated river channel

3.3 Managing the Kent Street Weir impoundment

Issue

The Kent Street Weir creates an impounded body of water upstream of the Weir during summer. Low flow and insufficient mixing of the water column combined with high nutrient levels leads to conditions favourable to algal blooms.

Objective

Prevent the conditions that lead to algal blooms upstream of the Kent Street Weir.

Response: what needs to be done to meet this objective ?

- Identify the best option to improve water quality, maintain recreational amenity and maintain the ecological values upstream and downstream of the Weir

The Kent Street Weir has altered the natural hydrological regime of the Canning River in that area. There was some discussion in the *Swan-Canning Cleanup Program Action Plan* (SRT, 1999) of the effect the Kent Street Weir has on water quality, and the plan listed options to improve the management of the Weir. This section evaluates the options for the Weir in two separate sections, one for the Kent Street Weir structure and one for additional options to improve water quality.

3.1.1 Options for the Kent Street Weir Structure

The Kent St Weir consists of a permanent concrete sill, with concrete pylons that support both a walk/cycle way and wooden boards that impound fresh water in summer. The Weir was not originally designed to take the extra weight of the walk/cycle way, which were added after its construction. The concrete sill acts as an underwater barrier year-round, preventing the mixing of water. The weir boards are inserted and removed by hand each year by Swan River Trust staff.

The Kent St Weir has historical significance but suffers from structural problems that may limit its safety and longevity. In 1999, the concrete pylons of the Weir structure were reinforced to improve the safety of workers who install and remove the weir boards. It is uncertain how long this work has extended the life of the Weir.

The removal of the Weir would have a number of serious ecological and social consequences. Replacement or repair would be expensive, but would reduce the risk of injury to Swan River Trust staff.

Kent Street Weir, Cannington

Three possible options for improving the Weir structure are presented below. Issues associated with the timing of these works are not addressed here.

Option 1

Removal of the Kent Street Weir

There has been considerable discussion amongst the community as to what the removal of the Kent Street Weir involves. Some perceive it to mean complete removal of the Weir, including the walk/cycle way. Others understand that removing the Weir involves permanent removal of the weir boards only, which are used to impound fresh water during summer and autumn.

In any case, both options have similar disadvantages. Removing the entire structure would be met with community resistance, as it is an important social feature of the Canning River and is heritage listed due to its historical associations.

Removing the bottom section of the Weir will require removal of part of the heritage-listed structure. This would require consultation with the Heritage Council of Western Australia and the local community.

Permanently removing the weir boards has social ramifications. If the weir boards were not in place over summer, the river channel would narrow and make it difficult for canoeing and other recreational pursuits. It would also affect the aesthetic appeal of the Kent Street Weir Park in summer.

Reverting back to an estuarine condition has ecological problems. The freshwater impoundment upstream of the Weir acts as a summer refuge for waterbirds, turtles and supports native macrophytes and aquatic weeds. The intrusion of saline water upstream of the Weir during summer could lead to the death of freshwater species, although many native species of aquatic flora and fauna can tolerate saline intrusion.

A serious consideration is that salt water intrusion would provide salt-marsh mosquitoes with a suitable habitat to breed. This would cause significant problems in the residential areas surrounding the river.

Removing the weir boards would not necessarily prevent algal blooms upstream of the Weir. The area would be subject to tidal influences and therefore saline stratification. This would restrict the mixing of bottom waters and lead to conditions that would promote algal blooms of brackish-water tolerant species such as the blue-green *Nodularia* spp. (SRT, 1999).

Option 2

Replace the Kent Street Weir and supplement summer flow with water from environmental release points

Advantages	Disadvantages
• No need to manually remove/ replace weir boards • Reduces ongoing maintenance costs of installing and replacing weir boards • Channel width maintained • Disrupts the water column, preventing anoxic conditions • Easier manipulation of the Weir • Prevents saline intrusion upstream of the Weir	• High infrastructure costs • Increased flushing of nutrients and organic matter into lower reaches • Removal of part of the historic structure • Large pulses of frewshwater may increase stratification in lower estuary

This option maintains the Weir in its current location but removes the weir boards, pylons and concrete sill, and replaces them with a hydraulically controlled weir system. This option includes the retention of the walk/cycle way.

Replacing the bottom section of the Weir would solve the problems associated with a deteriorating structure. Removing the weir boards and replacing them with a hydraulically controlled system would remove the need for manual insertion and removal of the weir boards at the beginning and end of each summer.

The hydraulic weir structure could also be manipulated to improve mixing in the Weir pool during summer. The Weir would remain closed until there was a sufficient build up of water from a storm event or environmental releases. The Weir could then be opened on a low tide, flushing the Weir pool while preventing saline water intruding upstream.

This strategy could be coupled with an increase in river flow at critical times to either increase mixing of the water

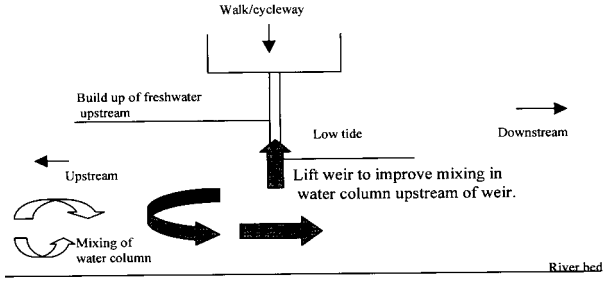


Figure 12: Diagrammatical presentation of Option 2 – Installing an hydraulically-controlled weir system to enable improved mixing of the water column

column or to break up any bloom formations that have occurred. The only way to artificially increase flow in the Canning River System is by discharging water from the environmental release points, which are fed from the scheme supply and have a limited capacity (see Section 2.3.3). The Weir manipulation/water release strategy depends on having adequate flow available from the release points to replace the water lost during manipulation of the Weir. It is uncertain whether the water currently discharged from the release points is sufficient for these purposes (see p 9).

Option 3

Modify central weir boards and supplement summer flow with water from environmental release points

Advantages	Disadvantages
• Disrupts water column and flushes out algal blooms • No need to manually remove/ replace weir boards • Channel width maintained • Prevents saline water intrusion upstream of the Weir • Provides means of manipulating Weir so that it could be used as a tool to improve water quality in the Kent St Weir pool	• Large pulses of freshwater may increase stratification in lower estuary • Increased flushing of nutrients and organic matter into lower reaches • High infrastructure costs • Retention of lower part of the Weir (concrete sill) will prevent complete mixing • Does not address the structural problems of the Weir

The aim of this option is the same as option 2; to increase mixing and prevent conditions conducive to algal blooms from occurring. The main difference is that in this option only the central weir boards would be modified and the bottom section of the Weir would be retained. A major disadvantage of this option is the uncertainty about the life expectancy of the Weir. To spend money on a deteriorating structure could be viewed as a band-aid solution and uneconomical.

Summary

There is a desire to remove the weir boards permanently and revert back to the natural hydrological regime that existed before the Weir was constructed. However, the Canning Catchment has been intensively developed and the Canning River and its tributaries have been regulated through the construction of water supply dams and private dams, so the flow regime from the catchment has been significantly altered. The rock bar at Fremantle has also been removed, which has increased tidal flushing of the Swan-Canning Estuary. Thus the natural hydrological regime could never be fully restored.

Removing the Weir permanently would cause saline stratification in the area upstream of the Weir. This would restrict the water column from mixing and it is likely algal blooms in this area would persist.

Option 3 is not a long-term solution considering the structural problems associated with the concrete pylons of the Weir. There was discussion in the SCCP Action Plan (1999) of constructing a new structure next to or near the Kent Street Weir to manipulate flow. This would be an expensive option as the Kent Street Weir would still require upgrading to eliminate the structural problems.

Option 2 appears to be the most viable, long-term solution for the Kent Street Weir. The costs associated with replacing the bottom section of the Weir are high but will lead to improved management of the water quality and hydrology of that section of river. The walk and cycle way would still remain.

If the bottom section of the Weir is reconstructed it should be designed to flush bottom or surface waters. Releasing bottom water will prevent conditions favourable to blooms and remove the anoxic waters often present in the Weir pool. The ability to release surface water would also be advantageous when a bloom is present. Algal blooms accumulate near the surface and will often die on contact with saline water. One concern is that when algal blooms die out, they consume oxygen as they decompose. The Canning Estuary downstream of the Kent Street Weir is tidal and is flushed more efficiently than the Weir pool. However, the ecological impacts of flushing an algal bloom and/or organic loads downstream need to be determined by the Swan River Trust and approved by the Environmental Protection Authority.

The ability to manipulate the weir boards to improve flushing and oxygenation of the water column will be dependent upon having a sufficient water level upstream of the Weir. This relates directly to the development of environmental water provisions (EWPs) for the Canning River System (see Section 3.1.2). If the agreed EWPs result in increased summer flow in the Canning River, this may achieve the water levels and mixing required to flush the Weir pool. It is evident that more work on EWRs and EWPs for the Weir pool are required. Modelling of the Weir pool may be able to predict the magnitude of flow required to achieve certain outcomes.

3.3.2 Additional options for preventing algal blooms, improving ecosystem function and resilience

During summer, conditions in the Kent St Weir pool support the formation of potentially toxic cyanobacterial blooms, which threaten ecosystem function and human amenity. Also common are anoxia and high nutrient levels that, in addition to creating conditions that are conducive to algal blooms, limit the ecological function and aesthetic value of the river.

The Swan Canning Cleanup Program has supported trials of oxygenation and sediment remediation that aim to lower nutrient levels and anoxia in the Weir pool. These intervention techniques are intended to be used until improved catchment management practices make them redundant.

Option 4

The continuation of oxygenation and sediment remediation programs in the Kent St Weir Pool

The Canning River Oxygenation Project currently operates from Kent St Weir to Greenfield bridge in summer. The 2001/02 summer is the last year of approved funding, but there is potential for the project to be extended for another two years.

Three Phoslock™ trials have been conducted on the Kent St Weir pool. Funding for these trials has been sought on an individual basis, as this product is still being developed.

The advantages and disadvantages of continuing oxygenation in the Kent St Weir Pool

Advantages	Disadvantages
• Drastically improves dissolved oxygen concentrations. This leads to reductions in nutrient concentrations and therefore assists limitation of algal blooms in the Kent St Weir pool	• High annual cost
• Increases the resilience of the system to stresses by restoring dissolved oxygen concentrations after rainfall and other high BOD loading events	• Increase in dissolved oxygen is temporary. Although the process results in permanent removal of nitrogen and organic carbon, phosphorus release is only temporarily suppressed. Treatment would be required each summer
• Increases population of aquatic fauna. Studies have demonstrated increases in freshwater prawns, fish and aquatic invertebrates in oxygenated areas compared to untreated areas	• Algal blooms have occurred while oxygenation was in progress so it won't prevent algal blooms. The blooms that have occurred during oxygenation have been generally limited in duration (up to 6 weeks), so while oxygenation may be limiting the bloom, a direct link hasn't been confirmed.
• Improves aesthetics and conditions for aquatic life by reducing odours resulting from hydrogen sulphide, ammonium nitrate and methane production	• Oxygenation requires infrastructure to be in place year round. Therefore, even if oxygenation is required one summer, maintenance and depreciation costs to infrastructure will still apply year-round
• Oxygenation equipment already in place, experience gained with its operation means that the service can be delivered efficiently when required.	
• Easily reversible, little chance of negative consequences	

The advantages and disadvantages of continuing sediment remediation treatment in the Kent St Weir Pool

Advantages	Disadvantages
• Very effective at removing dissolved phosphorus from the water column when it is applied and then forming a layer that prevents release of phosphorus from the sediment into the water column. This capability should assist the limitation of algal blooms in the Kent St Weir pool.	• High cost per application
• Permanent removal of phosphorus from the system	• No direct link yet shown in field studies between application of Phoslock™ and reduction in algal growthin the Canning River. However field trials in the Vasse River have shown that the application of Phoslock™ can limit the duration of an algal bloom.
• Does not require any permanent infrastructure on site	

Option 5

Combination of oxygenation and sediment remediation programs (Option 4) and flow modification techniques

The option offers greater flexibility to deal with the different conditions that may cause algal blooms but is also likely to be more expensive than using only one technique.

It is evident that without a change in management approach, the conditions in the Kent Street Weir pool are not expected to improve and frequent algal blooms will persist. Any option for the Kent Street Weir should focus on reducing the frequency and intensity of algal blooms. Increased flow has proved to be very important in managing cyanobacterial blooms elsewhere (Webster and Jones *et al*., 1996) and if available could also be effective in the Kent St Weir Pool.

Oxygenation has shown that it can increase dissolved oxygen concentrations, reduce nutrient levels, increase the resilience of the ecosystem and increase numbers of freshwater prawns and macroinvertebrates. Although it won't prevent cyanobacterial blooms, there have been no extended blooms when oxygenation has been in place. The main disadvantage of oxygenation is the high annual cost, and the fact that its effect is only a temporary one.

Trials have shown that Phoslock™ is extremely effective at reducing dissolved phosphorus concentrations under both oxygenated and anoxic conditions. A fine layer of Phoslock™ in the sediment will persistently reduce dissolved phosphorus in the water column for extended periods of time, but large summer rainfall events may reduce the length of time for which the treatment is effective. Recent field trials in the Vasse River have confirmed that Phoslock™ can limit the duration of an algal bloom, but trials in the Canning River have not yet shown such a link.

The water quality component of the modelling required to determined the flow required in Options 2 and 3 may be useful in predicting the need for intervention techniques if a new Weir is installed and modified flow regime decided upon. Until such time, it is insufficient to let water quality suffer. The oxygenation and sediment remediation programs should continue until a decision is made for the Weir and flow regime.

Section 3.3			
No.	**Recommendation**	**Proposed organisation**	**Partner**
B1	Retain the function of the Kent Street Weir to maintain • ecological values • social values, including access across the river • amenity		
B2	Obtain an engineering estimate of the structural integrity and life expectancy of the Weir and ability to withstand high flows and floods	W&RC/ SRT	
B3	Conduct a feasibility study on what the impacts would be if a toxic algal bloom and/or high organic loads were released into the Canning River Estuary	W&RC/ SRT	
B4	Establish a water quality monitoring site immediately downstream of the Kent Street Weir	W&RC/ SRT	
B5	Continue the oxygenation and sediment remediation programs in the Kent Street Weir pool (subject to funding) until the feasibility of modifying the Weir has been determined.	W&RC/ SRT	
B6	Conduct research into ecological water requirements for a site in the Kent Street Weir pool.	W&RC/ SRT	

3.4 Social importance and community involvement

Issue:

There has been a loss of social focus and importance of the Canning River System.

Community awareness and knowledge of river management issues need to be raised to promote behavioural change and community participation in catchment and river management.

Objective:

For the broader community to be well informed about important river management issues and take action to protect and enhance the river system.

Response: what needs to be done to meet this objective?

- Improve the social importance and cultural connection of the community and the river
- Increase community participation in river management and monitoring programs

Many people claim that the social focus of the Canning River System has changed. The Canning River System is a significant element in the landscape for Nyungar communities who lived along the river or on flat land adjacent to it (SRT, 1997). The Canning River, like most waterways, has a special spiritual significance to Nyungars.

The Canning River divided an area peopled by two Aboriginal tribes – the Beeloo and the Beelair. From the Canning River to the hills was the territory of Munday, the leader of Beeloo; while across the Canning to the sea, was the land belonging to Midgegooroo and his famous son, Yagan. A wide range of food was gathered by the Canning River natives, including the fruit, nuts and roots of trees and plants, grubs, reptiles, birds and eggs; animals, both large and small; cobbler and mullet trapped in small weirs, and gilgies dug from the mud of the swamps.

The Canning River, like many waterways, has special spiritual significance to the Nyungar people. Not only did it supply food, but guidance and strength. The Aborigine used the waters of the Canning River to cleanse and connect their babies to the spiritual guidance of these waters (McCormack, 2002). European settlement has resulted in significant degradation of the Canning River system. Restoration of the river should also acknowledge the spiritual importance of this waterway to the Aboriginal people.

The river was also an important cultural icon during European settlement. It was one of the only sources of fresh water for early settlers and was used as an important means of transport. Children once learnt to swim in the Canning River at the base of Wharf Street, Cannington (Richards, 1991).

One look at the Swan River reveals its social importance to the people of Perth, with surrounding property values reaching millions of dollars. However, inappropriate planning along the Canning, Southern and Wungong Rivers has led to properties backing onto to the river instead of facing it. This has resulted in the Canning River System being treated more as a drain than a precious asset to the South-East Corridor.

There are ways of improving the amenity and encouraging community ownership of the Canning River System. The river runs through some of the hottest suburbs in Perth so there is a potential to increase recreational use in certain reaches of the river during summer. This may include swimming, water playgrounds, interactive fountains, cycling, guided riverwalks and canoeing, but should avoid activities that degrade amenity by reducing water quality or degrade fringing vegetation.

To assist in re-establishing the cultural connection with the Canning River System, the general public should be encouraged to participate in river management projects or monitoring programs. With some training, community members can participate in monitoring and sampling programs. This enables people to understand more about how the river ecosystem functions and how best to manage it.

It is recommended that an ecological health monitoring program be established in the Canning River Catchment. Monitoring ecological health can include the following parameters:

- status of fringing vegetation, erosion and shade
- species diversity and abundance of aquatic life (including macroinvertebrates, fish, frogs, birds, mammals and reptiles)
- water quality

Biological parameters often have more meaning to the general community than water quality concentrations.

Ecological surveys will be required as part of the trial release program proposed for the Canning River System (Section 3.1.3). It is envisaged that the community can become involved in this survey work and this can then be expanded into a monitoring program for the catchment. This information can be reported to the wider community, with the aim of raising awareness and encouraging action.

Section 3.4			
No.	**Recommendation**	**Proposed organisation**	**Partner**
C1	Improve the social focus of the Canning River System by encouraging appropriate community events, facilities and recreational opportunities along the banks of the river	W&RC, CoA, CoG, CoC	UCSW CT, CCCG
C2	Develop and implement an ecological health monitoring program that includes: • community involvement in sampling • sampling of biological indicators • a suite of indicators that best monitor the ecological status and/or changes of the catchment • publication of these results in an public awareness campaign (refer to recommendation E1)	W&RC (Ribbons of Blue)	UCSW CT
C3	Support community projects that are designed to achieve on-ground management and community participation in river management	W&RC, SRT	CoA, CoG, CoC, Community groups
C4	Ensure key stakeholder groups are involved or advised in implementing the plan and other initiatives on the river	W&RC, SRT	

Student from Leeming Senior High School monitoring macroinvertebrates in Booragoon Lake during Ribbons of Blue 'Snapshot' 1999 **(Photo: F Davies)**

3.5 Surface water allocation and management

Issue

The Canning River System is still highly utilised for private abstraction. Abstraction peaks during periods of low flow and over-abstraction can contribute to drought.

Objective

Reduce the reliance on the river for abstraction and promote water conservation techniques.

Response: what needs to be done to meet this objective?

- Promote water conservation techniques and principles
- Encourage land owners to investigate other potential sources of water

Riparian and licensed surface water users who pump water from the river are often blamed for causing the problems associated with low flows. The majority of land owners use this resource responsibly, however the cumulative abstraction from the river during summer does reduce flow significantly.

During February to March 2000, the Water and Rivers Commission conducted a water use survey of the north-eastern bank of the Canning River, between Kent Street Weir and Canning Dam. The results of the survey indicated that the majority of land owners on this side of the river are either under-utilising their allocation or make no use of it at all. The Water and Rivers Commission is in the process of reviewing these licences with the land owners, and reducing their licensed allocation where appropriate.

Historically, many springs in the upper reaches of the Canning River Catchment flowed into the river. The majority of these springs have been diverted into private dams for irrigation purposes. Cumulatively this has reduced the flow in the Canning River.

Water conservation

Land owners connected to the Water Corporation's scheme supply are urged to be 'WaterWise'. The WaterWise program encourages people to recognise that we live in a dry climate where water is a precious resource. The Water Corporation encourages scheme users to adopt water conservation principles such as planting native species and irrigating between 6pm and 9am.

Similarly, it is recommended that riparian land owners conserve water by following these principles. Surface water is a precious commodity that riparian land owners and licensees are sharing with the environment and the community. Where possible, surface water users should only pump from the river from 6pm and 9am when evaporation rates are low. Surface water should not be used in a wasteful manner. Restricting the area to be irrigated, planting native species and irrigating once every couple of days instead of every day will reduce water use from the river.

Water reforms and environmental water provisions

The Council of Australian Governments (COAG) Water Law Reform Framework Agreement requires that the environment be formally recognised as a legitimate water user in the water allocation planning process. As stated in Section 3.1, environmental water provisions (EWPs) will be determined for the Canning River System. Ecological, economic and social values of the river system will be considered when developing EWPs.

The water law reforms that were introduced to Parliament in 1999, propose to establish water resource management committees. It is envisaged that these committees will replace the existing Canning Wungong Southern Rivers Advisory Committee. Under the proposed reforms, the water resource management committees will develop local rules and policies that will be incorporated into a water resource allocation plan (recommendation A6).

This may include rules on sharing water during periods of drought, controlling activities that impact on the watercourse (i.e. dams) and managing the flow of water to protect the use of streams for recreational activities (W&RC, 1998).

The water resource allocation plan will also include environmental water provisions (EWPs) for the Canning River System. The EWPs will specify how the water will be allocated and managed to meet various needs, including public water supply, private abstraction and water required by the ecological values of the river (ecological water requirements).

Riparian right

The quantity of water and it's use for properties connected to natural waterways and thus have a riparian right is open to interpretation. The *Rights in Water and Irrigation*

Act (1914) states that landowners with a riparian right may take water free of charge for domestic use for their family and to water stock.

If the freehold title for a property was granted before 1914, the *Rights in Water and Irrigation Act (1914)* states that those lots have a further right to take water for a garden not exceeding 2.0 Ha associated with the dwellings.

However, the Canning River Interim Allocation Policy recommended that all riparian landowners limit irrigation to 0.2 hectares (half an acre) to assist in reducing water use on the Canning River.

During the Canning River water use survey (Allen, unpub.) the majority of land owners who were using in excess of their riparian right were unaware of the restrictions imposed by the Canning River Interim Allocation Policy (W&RC, 1996).

There is clearly a need to clarify if the properties concerned were alienated from the Crown before or after 1914 (Allen, unpub) and for the Water and Rivers Commission to publicise the meaning of 'riparian right' and its entitlement to water.

3.6 Reducing nutrient export

Issue:

Nutrients from a variety of land uses are leaching in to the river, contributing to algal blooms. Improved management of nutrients, contaminants and water within each land use to reduce losses to surface water and groundwater is required to prevent contamination of the river system.

Objective

Improve water quality entering the river from surface or groundwater by revising, developing and promoting best management practices and encourage the community to understand the link between human activity and the health of the river.

Response: what needs to be done to meet this objective?

- Promote the use of best management practices for all land uses with an updated emphasis on source control of contaminants
- Support existing projects that aim to raise awareness of what individuals and business can do to reduce nutrient losses, reinforcing the link between actions and impact on the river system

The Canning River Catchment supports a variety of different land uses and a large population. Nutrient and pollutant loss from the catchment will depend upon how the land is managed. There are many simple techniques land owners can use to reduce nutrient and pollutant loss from their properties.

Best management practices (BMPs) are specific for each type of land use or development. It is a generic term that refers to the techniques and practices land owners or managers can use to prevent pollution. For example, BMPs for mechanical workshops may include bunding oil and fuel, appropriate storage and recycling of liquid waste and appropriate storage and recycling of car batteries.

Section 3.5			
No.	**Recommendation**	**Proposed organisation**	**Partner**
D1	Require land owners to evaluate what best management practices they could use before being re-issued licences on the Wungong Brook-Southern River	W&RC	
D2	Include water efficiency conditions on Surface Water Licences when licences are re-issued	W&RC	
D3	Develop a long-term incentive scheme that encourages riparian and licensed users to use water from the main scheme supply	W&RC	WC
D4	Clearly define the riparian right entitlement and promote this through a leaflet for riparian land owners that includes best management practices for irrigation and up to date information on licensing and water reforms	W&RC	

BMPs for agricultural/horticultural activities may include fertiliser management, planting of windbreaks and soil amendment.

Provision of information is an important aspect of water quality protection. It is important that this information is widely available to residents, industries, commercial ventures and developers. Many people realise the need to protect our waterways but may be unaware of the contribution they make to river degradation or what they can do to prevent it.

A number of projects are under way in the Canning Catchment that aim to provide relevant information to land and business owners so they can make an informed decision about their actions.

One of these projects is the Swan-Canning Industry Project. This project aims to promote BMPs that can be used by industry in order to prevent pollution of nearby drains and waterways. A core component of this is professional training for small business owners and local government officers. This training highlights the risks various chemicals have on the environment and how they should be stored, used and disposed of to prevent pollution.

To reduce the loss of nutrients from farm land in the Swan-Canning Catchment, Agriculture Western Australia are training farmers and small property owners how to design and implement their own farm plan. Not only will this reduce nutrient and possibly sediment loss from individual properties but it will also save the land owner money in fertiliser costs and erosion control.

In residential areas, many people do not realise that they may contribute to the pollution of the river. Diffuse pollution is the main source of nutrients and pollutants in the Canning River System. Over-fertilised lawns, overflowing septic tanks, domestic detergents from household cleaners and animal waste all contribute to the pollution of the river.

Feeding bread to waterbirds is perceived to be a harmless and enjoyable activity by many, however it does have serious adverse consequences. There is 1-2 grams of phosphorus in one slice of bread, which could provide enough phosphorus for a small lake (swimming pool size) to become nutrient rich. This combined with the additional organic matter provided by the bread can lead to algal blooms. Waterbirds can also become dependant on bread as a food source.

A number of projects have been set up by concerned residents that aim to raise the awareness of water quality protection in the general community.

The Yellow Fish Road Program is a stormwater drain awareness program that paints yellow fish above roadside drain inlets, encouraging local residents to establish the connection between the stormwater system and our rivers.

Light industry spill kit, used for containing chemical spills

The Phosphorus Awareness Project was established in the Canning Catchment and aims to protect water quality by promoting appropriate use of products containing phosphrous to prevent it from entering waterways. This project targets community, schools, local government and industries.

Best management practices for public land

Local parks and public open space are highly visual and are often seen as setting an example to the local community of how land should be managed. Over-watering and over-fertilising is costly and sets a poor example. The assessment and application of nutrients in their correct amounts can reduce nutrient runoff greatly.

Soil and leaf tissue analysis determines the amount of fertiliser required for optimum plant growth. This reduces the amount of wasted fertiliser that would otherwise runoff or infiltrate to the nearest drain or waterway. This technique is currently used by some land owners and local government authorities in the Canning Catchment.

Deciduous trees are ideal for certain gardens, allowing sunlight into buildings during winter and providing shade in summer. However if they are planted in locations where their leaves can make their way into drains and rivers they can cause problems. When the leaves decompose in water they consume oxygen and add to the nutrient loading in the river.

Best management practices for public land need to focus on greater implementation of non-structural pollutant management such as management of garden wastes (including grass clippings), soil movement from building sites or road works, street sweeping, timing and rates of fertiliser and water applications. Use of these on public land to set an example needs to be highlighted to the general public through signage or some other communication campaign.

Section 3.6			
No.	**Recommendation**	**Proposed organisation**	**Partner**
E1	Trial a 'clean up our river' campaign in the Canning Catchment. Begin with promotional material in the local papers. This should include: • best management practices for a variety of land uses • ecological status report (refer to recommendation C2) • facts about river systems including historical information • a survey of community attitudes at the commencement and finish of the campaign	W&RC	UCSW CT, CCCG
E2	Promote the Swan River Action Program (Adult Awareness Program) in the Canning Catchment	SRT	UCSW, CT CCCG
E3	Support effective existing and new community projects that effectively target nutrient problems in addition to improving ecological and aesthetic values	W&RC, WC	
E4	Distribute small property manual 'The land is in your hands' to all ratepayers in special rural and rural areas	AgWA, W&RC	CoA, CoG, CoC
E5	Actively encourage participation in Agriculture WA property management workshops to promote BMPs for small landholdings	AgWA	W&RC, SRT, UCSW, CT
E6	Develop and promote a user-friendly chart that recommends the most effective types of fertilisers and mulches to use in in the Canning Catchment, based on soil types	W&RC	CCCG AgWA
E7	Hold a training course for retail nursery staff to promote the guide outlined in recommendation E6	W&RC	
E8	Support the following recommendations of the Swan-Canning Industry Project: • develop a framework to facilitate local government management of local light industry pollution issues • promote best management practice in pollution prevention as the preferred approach to managing environmental risks • increase industry participation in the adoption of simplified environmental management systems as part of their operational processes	SRT	CoA, CoG, CoC
E9	Develop and adopt a drainage and nutrient management plan or guidelines for all grassed public open space areas as a joint Council initiative. Where new areas of grassed public open space are being created, provide developers with these guidelines	CoA, CoC, CoG	
E10	Promote the use of local native species in landscaping the land managed or to be managed by local government	CoA, CoG, CoC	
E11	Adopt and implement a policy of cleaning up leaves dropped by deciduous trees before they enter stormwater systems connected to the river and its tributaries	CoA, CoC, CoG	
E12	Erect signs at local waterbodies where feeding of bread to waterbirds is common practice and is possibly leading to algal blooms	CoA, CoC, CoG	
E13	Support a research project to draw together information on the impact of deciduous leaf fall on waterways	W&RC	

3.7 Drainage management

Issue:

Many tributaries have been modified into drainage networks. This has led to a loss of tributary habitat, biodiversity, landscape amenity, recreational opportunity, and ability to process nutrients. Drains can have ecological value and improve nutrient retention and processing functions if they are appropriately designed and maintained.

Objective:

Improve the ecological value, recreational opportunity and aesthetics of modified waterways and drains.

Response: what needs to be done to meet this objective?

- Where possible, return modified watercourses to natural streamlines
- Identify sub-catchments that contribute high pollutant concentrations and determine effective treatments that can be used to reduce these concentrations

Natural streamlines

Although we may not be able to return many of these modified watercourses back to their natural form, they can be modified to create a system that supports aquatic life and improves the quality of water entering the Canning River, whilst still maintaining the function of conveyance.

Turning a drain (or modified watercourse) into a 'natural streamline' is a simple process whereby weeds are removed and native fringing vegetation is reintroduced. This has a multitude of benefits including:

- an increase in stream cover and lower water temperatures, hence less algal growth
- increase in nutrient uptake by fringing vegetation
- trapping of sediments by sedges and rushes
- provision of wildlife habitat
- reduction in velocity/erosive capacity of water
- bank stabilisation

In addition to nutrient and sediment removal, natural streamlines have the potential to increase biological diversity, ecological structure, conservation values and aesthetic values of unsightly drains.

There seems to be a negative stigma attached to the word 'drain'. Many people believe that if a modified watercourse is referred to as a drain then the local community will treat it with less respect and a place to dump waste. The local community should be informed that these modified watercourses are connected to the Canning River System and have biological importance.

Drain retro-fitting

Existing drainage systems are not designed to improve water quality. Drains transport poor quality water from a combination of surface runoff and seepage from ground-water.

Menzies Drain, Cannington: an example of a drain being modified into a 'natural streamline' **Photo: R Paice**

Section 3.7			
F1	Establish a 'natural streamline' demonstration site upstream of Kent Street Weir and assess the effectiveness of streamlining drains in urban catchments	W&RC	UCSW CT,
F2	Support a student project at a Western Australia University to monitor and report on the water quality and ecological health at this demonstration site and existing natural streamline sites in the Canning Catchment, including Bannister Creek and Southernwood Creek	W&RC	CCCG
F3	Implement the principles of natural streamlines where appropriate as opposed to piping open drains	CoA, CoG, CoC	
F4	Identify drainage sub-catchments that contribute significant pollutant loads to the main river channel based on: • land use and land capability • modelling, Geographic Information System (GIS) • snapshot sampling • known erosion points	CoA, CoG, CoC	W&RC WC
F5	Map local government drainage networks starting with priority sub-catchments	CoA, CoG, CoC	
F6	Using literature on the most recent collaborative approach to urban water management and design in the Canning Catchment and the results from recommendations F4, develop a summary document that outlines: • priority drainage sub-catchments for retro-fitting • effective treatments to use in retro-fitting taking the physical characteristics of the Canning Catchment into account • costs associated with retro-fitting options • problems posed by contaminated groundwater that is intercepted by drains	W&RC	CoA, CoG, CoC WC
F7	Engage Keep Australia Beautiful to conduct and annual litter audit of priority sub-catchments on Tidy WA Day by: • noting and analysing litter and debris entering the stormwater system • publicising the results though recommendation E1	W&RC	
F8	Conduct a survey of local drainage maintenance and determine where maintenance practices, particularly sediment removal may require upgrading/revision	CoA, CoG, CoC	
F9	Ensure dry street sweeping is conducted in preference to wet street sweeping. Street sweeping should be encouraged to occur in priority sub-catchments prior to the first flush to remove pollutant build up and prevent litter and debris from entering the waterways	CoA, CoG, CoC	
F10	Review design guidelines for new Water Corporation drains to ensure they are consistent with the latest collaborative research and literature on urban stormwater management	WC	
F11	Investigate the cost effectiveness of structural drainage controls	W&RC	

Retro-fitting includes implementation of a treatment train approach involving a combination of modifications. This may include changes to the inlets of drainage systems to include litter and sediment traps through to modifications of open drainage systems and compensating basins to improve nutrient retention and processing. This approach spreads the control and treatment of contaminant movement to rivers across the whole drainage system, from the source to the main drain outlet, rather than concentrated end-of-pipe treatment of contaminants.

Drainage improvement strategies identified in the Mills St Main Drain (Canning Plains) retro-fitting project in Wilson and Cannington will be readily adaptable to the surrounding urban drainage systems to reduce nutrient export. Any modifications to drains need to be undertaken as an coordinated partnership between community groups, local government and government agencies.

Improvement strategies must include an integrated broad-scale approach working at a range of levels from source to river. These should include at-source controls to minimise nutrient accumulation and movement to localised ground or surface waters through to structural improvements in the drainage system from the point of entry at street level to improving the nutrient retention and processing capacity of the main drains and compensating basins. Consideration of any BMP's need to take into account and target the chronic problems arising from continual seepage of contaminated groundwater into drainage systems.

Prioritisation of drain retro-fitting should be undertaken by identification of drains and sub-drainage systems where concentrations of pollutants are greatest. These are the waterways where there are greatest opportunities for immediate success from retro-fitting, provide greatest community feedback to support other contaminant reduction activities and will have greatest impact on local conditions.

The cost of some of these treatments may be high, but if they are designed and maintained properly, they may significantly improve the water quality entering the Canning River System. This can be weighed up against the cost that the community must absorb with continuous poor water quality and frequent algal blooms in the river system itself.

Tree planting, Todd Place, Huntingdale

3.8 River restoration and rehabilitating fringing vegetation

Issue:

Fringing vegetation has been lost through weed invasion, stock grazing, human development and the creation of drains.

Objective:

Re-establish river banks with fringing vegetation.

Response: what needs to be done to meet this objective?

- Support community groups and local government authorities in river restoration
- Hold training courses for interested members of the community
- Prioritise weed removal and revegetation and restoration works

Fringing vegetation discourages algal growth, increases nutrient uptake, provides woody debris to the river channel, increases biodiversity and reduces water temperature. It is essential that river restoration focuses on replacing native fringing vegetation along the Canning, Southern and Wungong Rivers. This will be especially beneficial for the Southern River, which was largely denuded of fringing vegetation in its middle reaches.

River restoration is an evolving art that involves much more than planting trees. It requires careful planning, including:

- recognition of site characteristics and hydrological zone
- consideration of channel form
- site stabilisation
- weed removal and control
- consideration of regional stream ecology
- appropriate plant species selection
- stock and people control
- maintenance (ie. weeds)
- monitoring and evaluation

Section 3.8

No.	Recommendation	Proposed organisation	Partner
G1	Encourage and support each local government authority in acquiring skills in river restoration and revegetation techniques	W&RC	SRT
G2	Request that Job Description Forms for Horticultural Officers and/or Parks and Gardens staff include rehabilitation skills and an interest in environmental issues as desirable criteria	CoA, CoG, CoC	
G3	Include Horticultural Officers, Parks and Garden staff and/or Environmental Officers from each LGA on the Swan Catchment Centre's 'Environmental Educators Network' list, so that they are informed of upcoming events and training workshops on natural resource management	W&RC	
G4	Provide support and coaching to new and existing community volunteer groups. Assist groups in acquiring the technical skills and confidence they require to initiate and/or participate in river restoration works	W&RC	
G5	Organise a property planning course for riparian land owners that focuses on riparian management issues including: • weed control and disposal techniques • river restoration principles • erosion control	AgWA	UCSW CT, W&RC
G6	Support community projects that aim to re-establish woody debris in the rivers	W&RC	UCSW CT
G7	Using the results of the foreshore assessment surveys; • prioritise revegetation and weed removal works • develop a revegetation strategy for these priority areas • organise and conduct on-ground works	W&RC	UCSW CT

Aquatic and terrestrial weeds are particularly bad in the Canning River and can seriously inhibit restoration works. The issue of weed removal and management needs to be dealt with strategically and as a collaborative approach between landholders, community groups, State and local government.

The Cities of Armadale and Gosnells are developing a Regional Weeds Strategy and are also working in partnership with the Upper Canning Southern Wungong Catchment Team in developing Weed Management and Rehabilitation Workplans. The City of Canning includes much of the Canning River Regional Park, where the Department of Conservation and Land Management has prepared a weed management plan.

Since river restoration is an evolving discipline, it is recommended that groups and individuals liaise with officers experienced in river restoration techniques prior to commencing large projects. There may also be some approvals that need to be obtained from the Swan River Trust or under the Aboriginal Heritage Act when planning a project.

Training and recruitment of people willing to be involved in river restoration is important to guarantee its success. Currently there is a small, highly skilled group of people involved in river restoration and burnout is a serious issue. Recruitment of new people into river restoration is required to sustain it in the long term.

3.9 Restoring river pools

Issue:

River pools are an important summer refuge and habitat for aquatic and terrestrial flora and fauna. River pools have been lost due to sedimentation and modification of the flow regime.

Objective:

Re-establish deep river pools in the Canning River System.

Response: what needs to be done to meet this objective?

- Map the location of river pools that have been filled through the process of sedimentation
- Determine the most appropriate method of removing sediment deposits from river pools

Preventing erosion is the best cure for sedimentation in rivers. Many of the sediment deposits in the Canning River System are a result of human development, including roads, subdivisions and stormwater drains.

The City of Armadale have released an '*Erosion Prevention and Sediment Control Manual'* that focuses on how to prevent erosion from earth disturbing activities by taking into account the local conditions of the Upper Canning Catchment.

Lloyd (1997) found that much could be done to reduce erosion in the Canning Catchment. The impacts that erosion can cause are not well understood and even where erosion control measures are used, they are often inadequate (Lloyd, 1997). The cost of erosion control is often minimal and can be incorporated into the costs of new developments (ie. meshing around building developments).

There has been some discussion of what to do with the existing sediment deposits in river pools. The current flow in the river is inadequate to enable natural flushing of pools. To re-establish pools river restoration is required.

The installation of woody debris above river pools may increase the velocity of water and scouring of pools and is being considered as part of the trial release program proposed for the Canning River (see Section 3.1.3). Removing sediment may be another option, but this requires careful consideration.

Any attempt at sediment removal should be careful not to trigger an erosion event or cause down-cutting of the river channel. However, sediment removal may have a place in river restoration if carefully planned and may enable us to understand the rate of sedimentation in the Canning River System.

Section 3.9			
No.	**Recommendation**	**Proposed organisation**	**Partner**
H1	Map sedimentation and erosion 'hot spots' in the main river channel of the Canning, Southern and Wungong Rivers. Identify tributaries that contribute/have the potential to contribute high sediment loads to the rivers	W&RC	
H2	Establish a strategy for removing a sediment deposit from river pools in the main river channel of the Canning, Southern and Wungong rivers	W&RC	UCSW CT

3.10 Incorporation of principles of best management practices and water sensitive urban design into all developments

Issue:

Urban development in the Canning Catchment is growing at a rapid rate and redevelopment does not incorporate best management practices which results in nutrient export. Development often results in increased nutrient export if best management practices are not incorporated into developments.

Objective:

Achieve widespread implementation of best management practices and water sensitive urban design for all scales of urban development to reduce nutrient and pollutant export to the Canning River System .

Response: what needs to be done to meet this objective?

- Undertake professional training in new urban water management technologies
- WSUD principles (new and revised) need to be incorporated as requirements for all new developments as well as re-development and smaller scale works.

The Southern River-Forrestdale-Brookdale-Wungong District Structure Plan, prepared by the WAPC, provides a guide to the future development and management of key environmental issues for Southern River in the City of Gosnells and Forrestdale, Brookdale and Wungong in the City of Armadale.

As part of its implementation, the Structure Plan highlighted the importance for an Urban Water Management Strategy (UWMS) to be developed for the area prior to major development in order to address issues of water and nutrient management at a catchment scale.

The aim of the UWMS is to develop a water management strategy for the Structure Plan Area which demonstrates how existing land uses can be managed and how the development of land can be undertaken while ensuring that adverse impacts on wetlands, hydrology and the Swan-Canning system will not occur.

EPA Bulletin 987 also highlighted the need for a UWMS for the area. The Bulletin prepared under Section 16(j) of the Environmental Protection Act raised environmental concerns related to the groundwater and surface water management for the development, and required the following issues to be satisfactorily resolved before the Structure Plan was finalised:

1. Demonstration that the proposed landuse changes can be managed to meet the objectives and targets for the Swan-Canning system
2. Demonstration that the landuse changes can be managed to avoid adverse impacts on wetlands, watercourses and the Swan-Canning system due to changes in hydrology
3. The satisfactory completion of an overall drainage, nutrient and hydrological strategy for the area and establishment of acceptable implementation mechanisms
4. Finalisation and agreement on Bushplan site boundaries

The implementation of the UWMS will be important in terms of influencing stormwater design and management in the Perth metropolitan area and reducing the export of pollutants into the Swan-Canning River system.

Urban development in the Perth metropolitan area is growing at a rapid rate. Urban development has historically resulted in excess nutrients, sediment and pollutants entering aquatic systems.

All land use planners, developers, engineers and consultants need to understand and be able to incorporate the principles of WSUD into new developments. This will go a long way to ensuring that there is improved drainage design and maintenance to assist in protecting water quality.

Legislation and policy

Education and training is a key element in protecting water quality in our waterways. However, a mix of regulatory and non-regulatory mechanisms is likely to be required to achieve an improvement in water quality in the Canning River System.

There are acts, policies and regulations surrounding waterway management and water quality protection in Western Australia but most are site specific, dealing with gazetted rivers or areas of significant interest. The Canning River system does have related legislation including the *Environmental Protection (Swan and Canning Rivers) Policy Approval Order 1998, Rights in Water and Irrigation Act 1914* and much of it is also under the Swan River Trust management area which is administered by the *Swan River Trust Act 1988.*

There is no legislation dealing principally with stormwater quality management or that requires developers or local governments to comply with water sensitive urban design criteria (W&RC, 1997b).

The current philosophy of water quality protection allows a substance to enter a waterbody, as long as the concentrations of the pollutant fall within the range of contaminant acceptability (i.e. ANZECC guidelines, 1992).

These guidelines for acceptable limits of pollutants may not consider the multiple stresses of each system. The Water & Rivers Commission is in a process of developing a holistic approach to water quality management with the Water Corporation, Department of Planning and Infrastructure and Local Government.

Section 3.10			
No.	**Recommendation**	**Proposed organisation**	**Partner**
I1	Organise catchment based workshops on urban water management that are consistent with the principles of the Southern River/Forrestdale/ Brookdale/Wungong Structure Plan Urban Water Management Strategy, Canning Plains Catchment Management Plan and Upper Canning Southern Wungong Catchment Management Plan.	W&RC	CoA, CoG, COC
I2	Work with professional organisations to ensure that continuing professional development includes an understanding of water quality management issues.	W&RC	
I3	Once the 'Managing Urban Stormwater Quality' manual has been revised arrange for the information to be included in the curriculum for all planning, engineering, environmental science and landscape architect courses at Western Australian Universities	W&RC	
I4	Update and improve existing design principles in 'A Manual for Managing Urban Stormwater Quality in Western Australia' and place on WRC website	W&RC	
I5	Establish an inter-agency Stormwater Working Group that focuses on integrated management of water quality from source to river. This committee should: • set policy • ensure inter-agency consultation • develop design criteria for drainage networks • determine water quality criteria for new and existing drainage networks • determine how to effectively enforce the water quality criteria	W&RC	WC, WAMA, MfP, DEP
I6	The Water and Rivers Commission will assist the Department of Planning and Infrastructure in developing a Statement of Planning and Policy that recognises and adopts WSUD.	W&RC	
I7	Councils to include a provision in Town Planning Schemes that requires the developer to demonstrate that the principles of water sensitive urban design (WSUD) have been incorporated into the drainage design	CoA, CoG, CoC	
I8	Require new developments to include integrated treatment trains and source control rather than isolated BMPs as conditions of approval	CoA, CoG, CoC	
I9	When revising Town Planning Schemes ensure future land uses are compatible with the Environmental Protection (Swan and Canning rivers) Policy Approval Order 1998 and SCCP water quality management objectives	CoA, CoG, CoC	

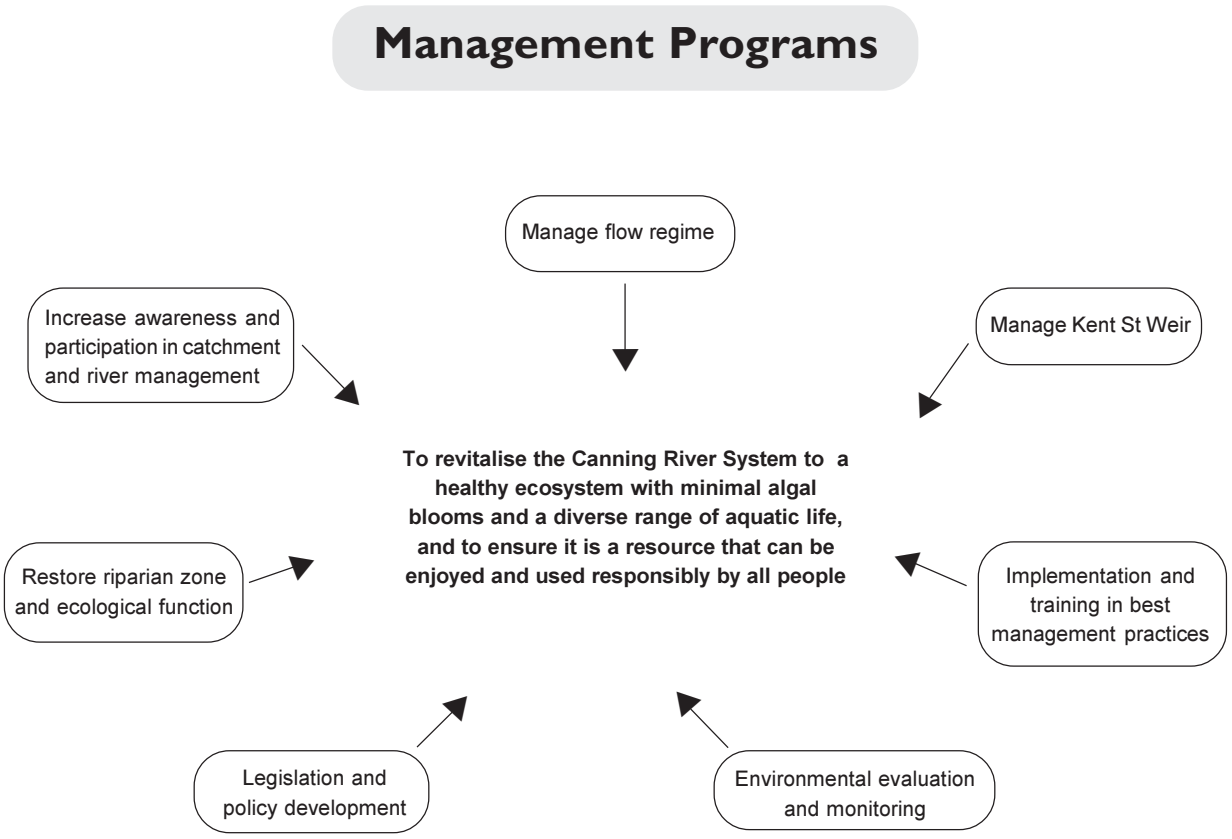
Section 4. Management programs

The recommendations listed in Section 3 have been grouped into seven management programs, that aim to achieve the vision of this plan. Grouping the recommendations into defined management programs will assist in their implementation by focusing the recommendation on a desired outcome.

Each of the proposed recommendations have been assigned against an organisation that is considered to have key responsiblities in a particular area. It will be the responsibility of each of these organisations to facilitate the implementation of specific recommendations contained within the plan, in consultation with key stakeholders. In order for the plan to be successfully implemented it will require a coordinated approach with a number of organisations and groups working together in partnership to achieve the vision identified in the plan.

This section also outlines how the recommendation may be implemented and any costs associated with implementing the recommendation.

This plan is intended to guide certain aspects of river management in the Canning Catchment for the next five years. It is assumed that after this time the recommended actions and management programs will need to be revisited by the major stakeholders operating in the catchment at that time.



No.	Recommendation	Comments	Proposed organisation	Partner/s	Associated costs
MANAGEMENT PROGRAM 1 — *Manage the flow regime*					
A1	The Canning River System should be maintained as a relatively permanent flowing waterway and the quantity released from the environmental release points should never be less than historically released		W&RC	WC	
A2	In consultation with stakeholders, develop and implement a trial release program in the Canning River System during 2001-2002 and report on the results of this trial release		W&RC	WC	Salary costs
A4	Staff gauges (water level markers) need to be installed at certain locations along the river to calculate water levels and flow volumes during the trial release			W&RC	WC
A5	Determine Environmental Water Provisions (EWPs) for the Canning River System following the process outlined in Figure 10		W&RC	WC	Salary costs
A6	Incorporate the EWPs into a water resource allocation plan for the Canning River System		W&RC		Salary costs
A7	Investigate the ability to provide a release from near the dam wall on Wungong Brook to maintain summer flows between the Wungong Dam and the release point at South Western Highway		W&RC	WC	Salary costs
A8	Investigate if additional environmental release points are required on the Canning, Southern or Wungong rivers to attain recommended EWPs in all parts of the system. Evaluate the cost of additional releases		W&RC	WC	Salary costs
A9	Review the EWPs as required, taking into account results of the monitoring program		W&RC		
A10	Investigate the need to retain the Weir approximately 500 m downstream of the Perth-Bunbury railway line on Wungong Brook		W&RC		
D3	Develop a long-term incentive scheme that encourages riparian and licensed users to use water from the main scheme supply		W&RC	WC	
MANAGEMENT PROGRAM 2 — *Manage the Kent Street Weir*					
B1	Retain the function of the Kent Street Weir to maintain • ecological values • social values, including access along the river • amenity				
B2	Obtain an engineering estimate of the structural integrity and life expectancy of the weir and ability to withstand high flows and floods		W&RC/SRT		Consultant engineer
B3	Conduct a feasibility study on what the impacts would be if a toxic algal bloom and/or high organic loads were released into the lower Canning River		W&RC/SRT		

No.	Recommendation	Comments	Proposed organisation	Partner/s	Associated costs
MANAGEMENT PROGRAM 2 — *Manage the Kent Street Weir (continued)*					
B4	Establish a water quality monitoring site immediately downstream of the Kent Street Weir		W&RC/SRT		Water quality analysis
B5	Continue the oxygenation and sediment remediation programs in the Kent Street Weir pool (subject to funding until the feasibility of modifying the Weir has been determined				
B6	Conduct research into ecological water requirements for a site in the Kent Street Weir pool				
MANAGEMENT PROGRAM 3 — *Implementation and training of best management practices*					
E5	Actively encourage participation in Agriculture WA property management workshops to promote BMPs for small landholdings		AgWA	W&RC, SRT, UCSWCT	
E7	Hold a training course for retail nursery staff to promote the guide outlined in recommendation E6	Liaise with TAFE to incorporate training into an existing unit. Negotiate with TAFE to obtain accreditation	W&RC		Salary costs
E8	Support the following recommendations of the Swan-Canning Industry Project: • develop a framework to facilitate local government management of local light industry pollution issues • promote best management practice in pollution prevention as the preferred approach to managing environmental risks • increase industry participation in the adoption of simplified environmental management systems as part of their operational processes		W&RC	SRT,CoA, CoG,CoC	Salary costs, training courses,
E9	Develop and adopt a drainage and nutrient management plan or guidelines for all grassed public open space areas as a joint Council initiative. Where new areas of grassed public open space are being created, provide developers with these guidelines		CoA, CoG, CoC		Salary costs
E10	Promote the use of local native species in landscaping the land managed or to be managed by local government		CoA, CoG, CoC		Salary costs
E11	Adopt and implement a policy of cleaning up leaves dropped by deciduous trees before they enter stormwater systems connected to the river and its tributaries	Also prevents the blocking of gutters	CoA, CoG, CoC		Salary costs
D1	Require land owners to evaluate what best management practices they could use before being re-issued licenses on the Wungong Brook-Southern River		W&RC		Salary costs
D2	Include water efficiency conditions on Surface Water Licences when licences are re-issued		W&RC		Salary costs

No.	Recommendation	Comments	Proposed organisation	Partner/s	Associated costs
MANAGEMENT PROGRAM 3 — *Implementation and training of best management practices (cont.)*					
F6	Using literature on the most recent collaborative approach to urban water management and design in the Canning Catchment and the results from recommendation F4, develop a summary document that outlines: • priority drainage sub-catchments for retro-fitting • effective treatments to use in retro-fitting taking the physical characteristics of the Canning Catchment into account • costs associated with retro-fitting options • problems posed by contaminated groundwater that is intercepted by drains		W&RC	CoA, CoG,	Salary costs Investigate CoC funding opportunities
F8	Conduct a survey of local drainage maintenance and determine where maintenance practices, particularly sediment removal may require upgrading/revision		CoA, CoG, CoC		Salary costs
F9	Ensure dry street sweeping is conducted in preference to wet street sweeping. Street sweeping should be encouraged to occur in priority sub-catchments prior to the first winter season flush to remove pollutant build up and prevent litter and debris from entering the waterways		CoA, CoG, CoC		
F10	Review design guidelines for new Water Corporation drains to ensure they are consistent with the latest collaborative research and literature on Urban Stormwater Management	This review should include batter slopes to reduce the erosion and slumping currently occurring	WC		Salary costs
F11	Investigate the cost effectiveness of structural drainage controls		W&RC		
G1	Encourage and support each local government authority in acquiring skills in river restoration and revegetation techniques		W&RC	SRT	
G4	Provide support and coaching to new and existing community volunteer groups. Assist groups in acquiring the technical skills and confidence they require to initiate and/or participate in river restoration works	Implement through workshops and hands-on training days	W&RC		Salary costs, workshops
G5	Organise a property planning course for riparian land owners that focuses on riparian management issues including: • weed control and disposal techniques • river restoration principles • erosion control		AgWA	UCSWCT, W&RC	Salary costs, workshops

No.	Recommendation	Comments	Proposed organisation	Partner/s	Associated costs
MANAGEMENT PROGRAM 3 — *Implementation and training of best management practices (cont.)*					
I1	Organise catchment based workshops on urban water management that are consistent with the principles of the Souther River/ Forresdale/Brookdale/Wungong Strucutre Plan Urban Water Management Strategy, Canning Plains Catchment Management Pland and Upper Canning Southern Wungong Catchment Management Plan		W&RC	CoA,CoG, CoC	Salary costs, consultants (subsidise with minimal fee for attending workshop) Investigate funding opportunities
I2	Work with professional organisations to ensure that continuing professional development includes an understanding of water quality management issues		W&RC		
I3	Once the 'Managing Urban Stormwater Quality' manual has been revised arrange for the information to be included in the curriculum for all planning, engineering, environmental science and landscape architect courses at WA Universities		W&RC		Salary costs
MANAGEMENT PROGRAM 4 — *Environmental evaluation and monitoring*					
A3	Conduct an appropriate sampling program to measure the effectiveness of the trial release program. This program should sample for the following parameters: • water quality • erosion and sedimentation downstream of environmental release points • aquatic invertebrates • fish species populations and structure This monitoring program can form part of the ecological health monitoring program outlined in recommendation C2	Seek external research grant	W&RC	WC	Salary costs Consultants Investigate funding opportunities
E13	Support a research project to draw together information on the impact of deciduous leaf fall on waterways		W&RC		
F2	Support a student project at a WA University to monitor and report on the water quality and ecological health at this demonstration site and existing natural streamline sites in the Canning Catchment, including Bannister Creek and Southernwood Creek		W&RC	CCCG	Salary costs (support)
F4	Identify drainage sub-catchments that contribute significant pollutant loads to the main river channel based on: • land use and land capability • modelling, Geographic Information System (GIS) • snapshot sampling • known erosion points	Involve a WA University. Identify and appropriately deal with any pollution point sources whilst obtaining this information	CoA,CoG, CoC	W&RC WC	Salary costs, sampling

No.	Recommendation	Comments	Proposed organisation	Partner/s	Associated costs
MANAGEMENT PROGRAM 4 — *Environmental evaluation and monitoring (continued)*					
C2	Develop and implement an ecological health monitoring program that includes: • community involvement in sampling • sampling of biological indicators • a suite of indicators that best monitor the ecological status and/or changes of the catchment • publication of these results in an public awareness campaign (refer to recommendation E1)	Links to sampling program required for trial release program (Recommendation A3) Involve community in survey sampling	W&RC (Ribbons of Blue)	UCSWCT	Seek funding grant
H1	Map sedimentation and erosion 'hot spots' in the main river channel of the Canning, Southern and Wungong Rivers. Identify tributaries that contribute/have the potential to contribute high sediment loads to the rivers	River survey - identify origin of sediment where possible	W&RC		Salary costs
F5	Map local government drainage networks starting with priority sub-catchments		CoA,CoG, CoC		Salary costs
MANAGEMENT PROGRAM 5 — *Restore riparian zone*					
F1	Establish a 'natural streamline' demonstration site upstream of Kent Street Weir and assess the effectiveness of streamlining drains in urban catchments	Select a highly visual drain	W&RC WC	UCSWCT,	Salary costs, seek funding grant
F3	Implement the principles of natural streamlines where appropriate as opposed to piping open drains		W&RC	UCSWCT	
G6	Support community projects that aim to re-establish woody debris in the rivers				
G7	Using the results of the foreshore assessment surveys; • prioritise revegetation and weed removal works • develop a revegetation strategy for these priority areas • organise and conduct on-ground works		W&RC	USCWCT	Investigate funding opportunities
H2	Establish a strategy for removing a sediment deposit from river pools in the main river channel of the Canning, Southern and Wungong rivers		W&RC	UCSWCT	Investigate funding opportunities
MANAGEMENT PROGRAM 6 — *Increase awareness and participation in catchment and river management*					
A11	Increase public awareness that developing environmental water provisions forms one part of an overall river restoration program		W&RC	Community group	Salary costs

No.	Recommendation	Comments	Proposed organisation	Partner/s	Associated costs
MANAGEMENT PROGRAM 6 — *Increase awareness and participation in catchment and river management (continued)*					
E1	Trial a 'clean up our river' campaign in the Canning Catchment. Begin with promotional material in the local papers. This should include: • best management practices for a variety of landuses • ecological status report (refer to recommendation C2) • facts about river systems including historical information • a survey of community attitudes at the commencement and finish of the campaign	Survey can link into existing SCCP survey	W&RC	UCSWCT, CCCG	Salary costs, advertising, consultant to conduct survey
E2	Promote the Swan River Action Program (Adult Awareness Program) in the Canning Catchment		SRT	UCSWCT, CCCG	
E3	Support existing and new community projects that effectively target nutrient problems in addition to improving ecological and aesthetic values		W&RC, WC		Salary costs (support)
E4	Distribute small property manual 'The land is in your hands' to all ratepayers in special rural and rural areas	Make copies available at saddlery stores, stockfeeders, real estate agents, newsagents	AgWA, W&RC	CoA, CoG, CoC	AgWA to supply 5000 copies, Project Officer to distribute
E6	Develop and promote a user-friendly chart that recommends the most effective types of fertilisers and mulches to use in the Canning Catchment, based on soil types	Work with Nursery Industry Association so that guide is available in local nurseries and retail outlets. Develop guide with TAFE colleges	W&RC	CCCG AgWA	Salary costs, printing
E12	Erect signs at waterbodies where feeding of bread to waterbirds is common practice and is possibly leading to algal blooms		CoA, CoC, CoG		
D4	Clearly define the riparian right entitlement and promote this through a leaflet for riparian land owners that includes best management practices for irrigation and up to date information on licensing and water reforms		W&RC		Salary costs, printing
F7	Engage Keep Australia Beautiful to conduct an annual litter audit of priority sub-catchments on Tidy WA Day by: • noting and analysing litter and debris entering the stormwater system • publicising the results though recommendation E1		W&RC		

No.	Recommendation	Comments	Proposed organisation	Partner/s	Associated costs
MANAGEMENT PROGRAM 6 — *Increase awareness and participation in catchment and river management (continued)*					
C1	Improve the social focus of the Canning River System by encouraging appropriate community events, facilities and recreational opportunities along the banks of the river	First initiative - Canning River Festival	W&RC, CoG, CoC	UCSWCT, CCCG	
C3	Support community projects that are designed to achieve on-ground management and community participation in river management	Including local Indigenous groups	W&RC, SRT		
C4	Ensure key stakeholder groups are involved or advised in implementing the plan and other initiatives on the river		W&RC, SRT		
G2	Request that Job Description Forms for Horticultural Officers and/or Parks and Gardens staff include rehabilitation skills and an interest in environmental issues as desirable criteria		CoA, CoG CoC		
G3	Include Horticultural Officers, Parks and Garden staff and/or Environmental Officers from each LGA on the Swan Catchment Centre's 'Environmental Educators Network' list, so that they are informed of upcoming events and training workshops on natural resource management		W&RC		
I4	Update and improve existing design principles in 'A Manual for Managing Urban Stormwater Quality in Western Australia' and place on W&RC website	Interactive website	W&RC		
MANAGEMENT PROGRAM 7 — *Legislation and policy development*					
I5	Establish an inter-agency Stormwater Working Group that focuses on integrated management of water quality from source to river. This committee should: • set policy • ensure interagency consultation • develop design criteria for drainage networks • determine water quality criteria for new and existing drainage networks • determine how to effectively enforce the water quality criteria		W&RC	WC, WAMA, MfP, DEP	Salary costs
I6	The Water and Rivers Commission will assist the Department of Planning and Infrastructure in developing a Statement of Planning Policy that recognises and adopts WSUD		MfP		Salary costs
I7	Councils to include a provision in Town Planning Schemes that requires the developer to demonstrate that the principles of water sensitive urban design (WSUD) have been incorporated into the drainage design		CoA, CoG, CoC		Salary costs

No.	Recommendation	Comments	Proposed organisation	Partner/s	Associated costs
MANAGEMENT PROGRAM 7 — *Legislation and policy development (continued)*					
I8	Require new developments to include integrated treatment trains and source control rather than isolated BMPs as conditions of approval		CoA, CoG, CoC		Salary costs
I9	When revising Town Planning Schemes ensure future land uses are compatible with the Environmental Protection (Swan and Canning rivers) Policy Approval Order 1998 and SCCP water quality management objectives		CoA, CoG, CoC		

Stormwater detention basin

Section 5. References

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Section 6. Appendices

Appendix 1
Water requirements of individual ecological values

Ecological water requirements of macroinvertebrates

Macroinvertebrates are an important component of the river's ecological structure. They break down organic matter and debris, consume algae and are a food source for other organisms.

Many species of macroinvertebrates have life cycles that are dependent on either oxygen-rich water in riffles and/or flows at certain times of the year. There are two main features of flow regimes that influence macroinvertebrate community structure: seasonality and predicability/persistence.

- Seasonality is important because low flows in summer result in higher water temperatures that are needed for reproduction and growth of macroinvertebrates (Humphries *et al*,. 1998). However the problems associated with low flow or no flow include desiccation, de-oxygenation of the water column and accumulation of leaf leachates and pollutants that may have an adverse impact on macroinvertebrates (Storey *et al.*, 2000).
- Predicability/persistence is important, as some species are susceptible to high and variable flows. These species can synchronise their life cycles so that the sensitive life stages (e.g. the larvae of crustaceans or pupating life stages) occur during the dry season. As a consequence unusually high flow volumes during the summer may adversely affect these particular species (Storey *et al.*, 2000).

Riffle zones are important to macroinvertebrate communities. To maintain macroinvertebrate communities in the Canning River, flow needs to be maintained over the top of these riffles.

Ecological water requirements of fish

Previous studies have found seven native species and five introduced species of fish in the Canning River System. For all native species found in the Canning River System, there is a need for permanent water.

Summary of freshwater fish found in the Canning River System (Storey *et al.*, 2000)

Species	Recorded in 2001	Previously recorded
Galaxias occidentalis (Western minnow)	✔	✔
Edelia vittata (Western pygmy perch)	✔	✔
Bostockia porosa (Nightfish)	✔	✔
Tandanus bostocki Freshwater cobbler	✔	✔
Pseudogobius olorum (Swan River goby, Blue spot goby)	✔	✔
Afurcagobius suppositus (Big headed goby)	✔	✔
Leptatherina wallacei (Swan River hardyhead)	✔	✔
**Gambusia holbrooki* (Mosquitofish)	✔	✔
**Phalloceros caudimaculatus* (One-spot livebearer)	✔	✔
**Oncorhynchus mykiss* (Rainbow trout)		✔
**Salmo trutta* (Brown trout)		✔
**Carassius auratus* (Goldfish)	✔	✔

** Introduced species*

Each species has its own requirements for flow and/or water levels to assist with breeding, migration and habitat. Knowing the species present in the Canning makes it easier to determine the flow/water levels required and the timing of these.

Species found in the Canning River System require sufficient water levels/flows.

Predictable winter/spring flooding must be maintained to ensure breeding success and strong recruitment in western minnow, pygmy perch and nightfish (Storey *et al.*, 2000).

Western minnow, pygmy perch and nightfish need fringing vegetation to be flooded so they can spawn. They also require the stimulus of fast flowing waters in tributaries for successful spawning. If water levels fall too soon or fluctuate greatly, eggs laid in inundated areas may be stranded and desiccate. Flooded vegetation and shallow, flooded off-river areas also provide sheltered nursery areas for growing juveniles.

Sufficient water levels to maintain diversity of habitats and migration upstream or downstream

There are obstacles present in the Canning River System, such as 'V notch' weirs that obstruct the migration of fish. Water levels need to be sufficient in spring to flood these obstacles and allow migratory fish to traverse them. The other option is to install broad-crested weirs or 'fish ladders' that still measure flow but allow migration of aquatic fauna.

Predictable flow pattern for the maintenance of Freshwater Cobbler 'nests' and recruitment of estuarine species

Freshwater Cobbler build 'nests' in pools or areas with slow flow for the female to lay her eggs. Unseasonal or unpredictable high flows during the breeding months of November to January can dislodge these 'nests' and affect breeding success of the Cobbler. Very low flows can also cause harm by exposing these 'nests', leading to desiccation (Allen, 1989).

Estuarine species are also influenced by river flow. Unpredictable or unseasonal flow will lead to a reduction in suitable habitat for juveniles of migratory marine species such as the commercially fished sea and yelloweye mullet, perth herring, western school prawn and crabs.

Flows to discourage the recruitment of introduced Mosquitofish.

Pusey *et al.* (1989) noted that natural winter flows in unregulated systems reduced the population density of Mosquitofish to low levels. The Mosquitofish is a poor swimmer and large flushing winter flows may have the potential to affect the successful recruitment of this aquatic pest.

During spring increased flows are required for:
- fish migration (drowning out of obstructions)
- flooding of fringing vegetation to allow some species to attach eggs, and
- to flood shallow off-river areas to allow them to be used as nursery areas for larval/juvenile species' (Storey *et al.,* 2000).

Ecological water requirements of fringing vegetation

The ecological water requirements of fringing vegetation are the conditions necessary to maintain the health and vigour of plant species and enable them to regenerate (Pen, 1999) and the water levels required to recharge isolated shallow aquifers in the floodplain.

Most species of fringing vegetation are not as susceptible to low flows as macroinvertebrates and fish. However they do need sufficient flow to keep the riparian zone moist. The other aspect of flow that is important to fringing vegetation is flooding (inundation). Many fringing species require inundation of the floodplain to stimulate germination and ensure seedling survival. A lack of floodplain flows over a number of years can lead to a loss of seedling recruitment and opens up the understorey to weed invasion. It is evident that this has occurred in several areas of the Canning River.

Ecological water requirements for channel maintenance

In-stream flows influence channel form and morphology by scouring out river pools, scouring sediment from riffles and maintaining stream width and depth. Erratic and high winter flows are often required to maintain existing (or active) channel dimensions, and prevent the accumulation of sediment on productive organic debris in river pools (Storey *et al.,* 2000).

The construction of Canning Dam and the diversion of many scarp tributaries that once flowed into the Canning River System has dramatically reduced river power (Storey *et al.,* 2000) and therefore the magnitude of in-stream scouring.

Ecological water requirements of waterbirds

Permanent pools in coastal plain reaches of the Canning River provide refuges for waterbirds, particularly in the summer months (Storey *et al.,* 2000), providing a suitable habitat and food source. Many waterbirds are opportunistic breeders that depend on flooding of shallow floodplains and wetlands for a certain duration within which to complete their breeding cycle (Good, date unknown).

Ecological water requirements for ecological processes and energy flows

High flows are important to ecosystem functioning (e.g. primary production, nutrient spiralling and decomposition). Without high flow or flood events, the productivity of a river system will be affected.

The floodplain is an important source of carbon (leaf litter, debris, terrestrial insects) nutrients and energy to river systems. It is important that the floodplain is inundated to maintain riparian linkage to the river channel.

Appendix 2
Process used to identify Ecological Water Requirements (EWRs) of the Canning River System

To identify the ecological water requirements the following process was used:

1. Community/stakeholder workshop (December 1999) and consultation with catchment groups to assist in identifying the important ecological values of the river system.
2. Analysis of flow data to determine historical flow rates in comparison to the existing flow rates.
3. Selection of sites (four on the Canning, one on the Southern River and one on Wungong Brook) to conduct field surveys.
4. A survey of channel dimensions and flow rates at selected sites.
5. Qualitative field and literature surveys of fish and macroinvertebrate fauna to determine species presence in the Canning River System.
6. Qualitative field survey of fringing vegetation using the rapid assessment methodology of Pen and Scott (1995).
7. Using the above information, determination of the monthly flows or water levels estimated to maintain the identified ecological values (see Table 1) at a low level of risk (minimum water requirements).

To determine the flow regime needed to maintain these ecological values, the 'holistic approach' developed by Davies *et al.* (1998), was used.

This approach focuses on determining the flow regime required to maintain the ecological processes of the river, rather than protecting a few important species. The aim of establishing EWRs for the Canning River System is to enhance the key ecological values to enable the river to function as an ecologically healthy system.

After determining the water requirements of each ecological value, channel surveys are undertaken. The channel surveys reveal the dimensions of the river channel and the quantity of water required to meet the EWRs (i.e. inundate the floodplain, scour out sediment and maintain channel width and depth).

Channel surveys were conducted at the following locations:

Canning River

- Orlando Street, Kelmscott (Canning River Release No. 4)
- Harry Hunter Drive, Gosnells (WRC gauging station S616027)
- Manning Avenue, Martin (Canning River Release No. 5)
- Albany Highway Bridge, Gosnells (Canning River Release No. 6)

Southern Wungong

- South Western Highway Bridge, Wungong (Wungong Brook Release No. 2)
- Anaconda Drive, Gosnells (WRC gauging station S616092)

Appendix 3
Results of the preliminary Ecological Water Requirements study for the Canning River System

Included in this appendix are the predicted flow calculations required to sustain the ecological values of the Canning River System. The reader should be mindful that these figures are based on limited hydrological and ecological data. It is not proposed that these flow volumes will be released into the river system. The actual future flow regime requires further research and consideration of the social, consumptive and economic uses of the river. This will be determined through the environmental water provisions development process (see section 3.1.2).

To determine the preliminary ecological water requirements (EWRs) for the Canning River system the consultant (Aquatic Research Laboratory, University of WA) identified important water dependent ecological values of the river and their water requirements.

Table 1: Important ecological values of the Canning River System and their essential water requirements

Ecological value	Water requirements
Macroinvertebrates	• Permanent flow and predictable/seasonal flows are important so macroinvertebrates can synchronise their life cycles • Low flow leads to deoxygenation, accumulation of pollutants and desiccation which can alter macroinvertebrate populations and consequently riverine food webs
Fish	• Predictable flows are needed for fish to breed successfully • Sufficient water levels to maintain diversity of habitats and breeding grounds • Flows to discourage exotic Mosquitofish • Sufficient water level so fish can traverse natural obstacles during migration
Fringing vegetation	• Periodic flooding to disperse seed, stimulate germination and ensure seedlings survive • Recharge shallow groundwater tables that are important during periods of drought • Discourage and prevent weed growth
Channel maintenance	• Maintain channel width and depth and a diversity of habitats • Scouring out sediment from riffles and pools
Waterbirds	• Depend on flooding of shallow floodplain for breeding • River pools are an important summer refuge
Ecological processes and energy flows	• Periodic flooding to maintain riparian linkages (organic material from vegetation in riparian zone provides an important energy and nutrient source to the river channel)

Once these were determined, channel surveys of the hydraulic geometry (shape) were undertaken, followed by an analysis of the current and historic flow records. This information was processed using the holistic methodology framework, adopted nationally to determine specific flow volumes required to meet the monthly EWRs.

The monthly flow requirements for each ecological value are presented in Tables 6-11. Proposed monthly flows are for each of the six sites (Figure 13).

Canning River

- Orlando Street, Kelmscott (near environmental release point No.4)
- Harry Hunter Drive, Martin (near Water and Rivers Commission gauging station No. S616027)
- Manning Avenue, Gosnells (near environmental release point No.5) and;
- Albany Highway, Gosnells (near environmental release point No. 6).

Southern-Wungong

- South-West Highway, Wungong (environmental release point No.1)
- Anaconda Drive, Huntingdale (Water and Rivers Commission gauging station No. S616092)

As discussed in Section 2.2, the Perth region has experienced a reduction in rainfall since 1975. This has reduced stream flows, particularly in the upper catchment. The amount of water entering the Canning Dam has significantly decreased due to this reduction in rainfall and this has effected the discharge into the river below the dam. Between 1938 and 1975, the Canning Dam overflowed on 19 occasions (see figure 14), but it has failed to overtop since 1975. This is predominantly due to the decreased catchment yield as a result of less rainfall, although increased rates of abstraction from the dam to supply the growing Perth community also plays an important role.

However, with increasing distance downstream, these reduced flows are counteracted by the effects of catchment clearing and urbanisation (which increase the proportion of rainfall resulting in run-off and the speed in which it enters the river system). Increased and more rapid run-off often results in channel widening and incision, whereby the bed of the river is degraded.

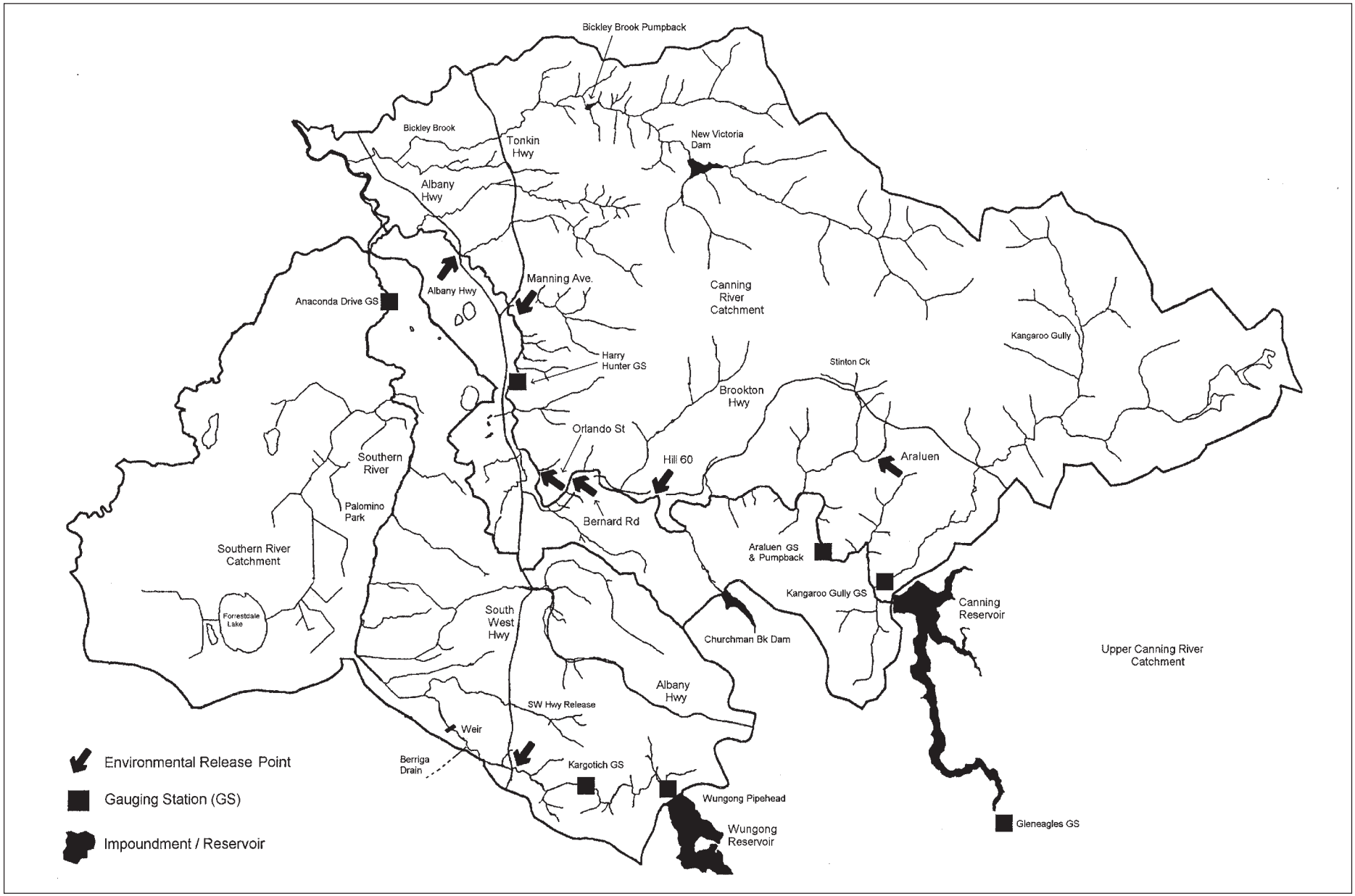

Figure 13: Map of the Canning River System indicating environmental release points, current gauging stations and significant reservoirs

The reduction in rainfall and change in run-off has implications for calculating EWRs. The influence of reduced rainfall on the lower Canning River system is difficult to determine because of the absence of long-term historic flow data. The only reliable data for the Canning River on the coastal plain is Harry Hunter gauging station (S616027), however the record for this station is from 1975 onwards, coinciding with the lower rainfall period.

To deal with this issue, the Water and Rivers Commission have modelled the expected pre-dam flow at Harry Hunter station for 'average climatic conditions' (using rainfall period 1962 to 1995) and 'dry period conditions' (1975 to 1995) using the following information;

- relationships between rainfall
- dam inflows
- current flow at Harry Hunter station
- percent of catchment cleared between the dam and Harry Hunter station (~20%) and; estimated environmental releases

Modelling indicates that the current drier climatic regime would result in approximately a 19% and a 41% reduction in mean monthly flows for summer and winter respectively on the coastal plain if the system had not been regulated. Therefore, in acknowledgement that the river would be subjected to lower flows because of the reduced rainfall, EWRs for 'average climatic condition' and 'dry period condition' have been developed.

Tables 6-11 outline the preliminary ecological water requirements for the six sites surveyed on the Canning, Southern and Wungong Rivers.

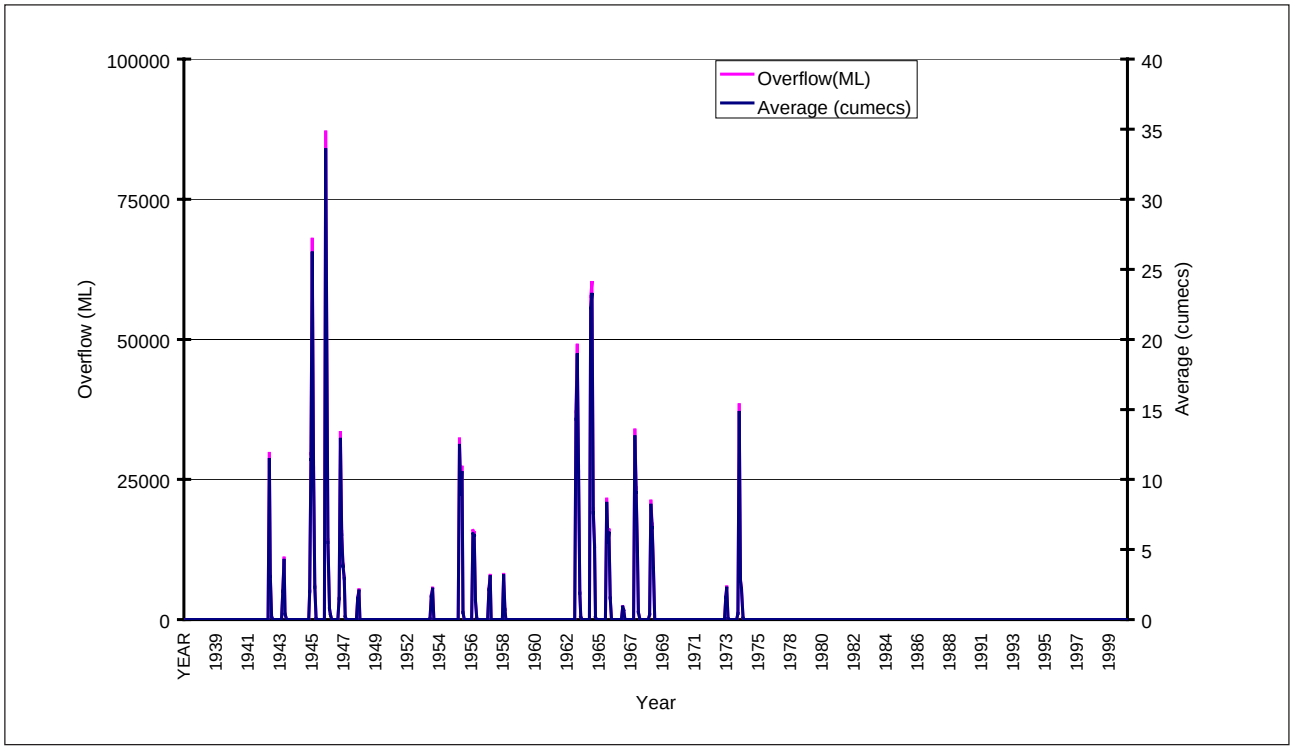

Figure 14: Overflow events at the Canning Dam from 1938 to 2000

Table 6: Preliminary ecological water requirements estimated for Canning River at Orlando Road, Kelmscott; near environmental release point No. 4

				Monthly flow (ML) to maintain the following water dependent ecosystems:									
Month	Modelled pre-dam flows at Harry Hunter (average climatic conditions)	Modelled pre-dam flows at Harry Hunter (dry period conditions)	Existing flows at S616027 Harry Hunter (median ML)	Fish passage	Macro-Invertebrates	Pools	Channel form	Waterfowl	Energy flows	Riparian Vegetation	Seasonal adjustment	TOTAL EWR for Average Climatic condition	TOTAL EWR for Dry period condition
January	620	510	149		309	274		274	309			309	254
February	510	410	161		279	248		248	279			279	224
March	470	390	210		309				309			309	257
April	460	500	309		299				299			299	325
May	910	770	684		912				912			912	772
June	6520	3150	1965		882				882		2108	2108	1019
July	15960	8960	3070		912		3668		912	3921		3921	2201
August	17740	10980	3208		882				882		3149	3149	1950
September	10850	7430	1886	2640	882				882			2640	1808
October	6050	3590	1084	2555	309			274	309			2555	1517
November	1630	1080	467		299	265		283	299			299	198
December	660	390	151		309	274		294	309			309	183

TOTALS: Existing median annual flows at Harry Hunter = 14,027ML
Proposed median annual flows at Orlando Rd release point 4 = 17,089 ML (wet) / 10,707 ML (dry)

1. Baseflows are to maintain flow in riffles of at least 5cm in depth. This will support macroinvertebrate communities and ensure baseflow conditions for native fish.
2. Increased flows are required during August, September and October to enable the migration of native fish (*i.e.* these higher flows will "drown-out and inundate streamside vegetation where some species (*e.g. Galaxias*) attach eggs.
3. Increased flows for July are to coincide with seasonally-elevated water levels causing a flushing flow and inundating riparian vegetation.
4. Seasonal adjustments are to ensure EWRs mimic the historic flow regime.

Table 7: Preliminary ecological water requirements estimated for Canning River at Harry Hunter Gauging Station, Martin; WRC S616027

				Monthly flow (ML) to maintain the following water dependent ecosystems:									
Month	Modelled pre-dam flows at Harry Hunter (average climatic conditions)	Modelled pre-dam flows at Harry Hunter (dry period conditions)	Existing flows at S616027 Harry Hunter (median ML)	Fish passage	Macro-Invertebrates	Pools	Channel form	Waterfowl	Energy flows	Riparian Vegetation	Seasonal adjustment	TOTAL EWR for Average Climatic condition	TOTAL EWR for Dry period condition
January	620	510	149		468	421		421	468			468	385
February	510	410	161		423	380		380	423			423	340
March	470	390	210		468				468			468	388
April	460	500	309		453				453			453	492
May	910	770	684		1124				1124			1124	951
June	6520	3150	1965		1124				1124		2340	2340	1131
July	15960	8960	3070		1124		4245		1124	4436		4436	2490
August	17740	10980	3208		1124				1124		4089	4089	2531
September	10850	7430	1886	3063	1088				1088			3063	2097
October	6050	3590	1084	2965	468			421	468			2965	1760
November	1630	1080	467		453	407		407	453			453	300
December	660	390	151		468	421		421	468			468	276

TOTALS: Existing median annual flows at Harry Hunter Dve = 14,027.04 ML
Proposed median annual flows at Harry Hunter Dve = 20,748 ML (wet) / 13,141 ML (dry)

Table 8: Preliminary ecological water requirements estimated for Canning River at Manning Avenue, near environmental release point No. 5

				Monthly flow (ML) to maintain the following water dependent ecosystems:									
Month	Modelled pre-dam flows at Harry Hunter (average climatic conditions)	Modelled pre-dam flows at Harry Hunter (dry period conditions)	Existing flows at S616027 Harry Hunter (median ML)	Fish passage	Macro-Invertebrates	Pools	Channel form	Waterfowl	Energy flows	Riparian Vegetation	Seasonal adjustment	TOTAL EWR for Average Climatic condition	TOTAL EWR for Dry period condition
January	620	510	149		461	420		420	461			461	380
February	510	410	161		416	379		379	416			416	335
March	470	390	210		461				461			461	383
April	460	500	309		446				446			446	485
May	910	770	684		1096				1096			1096	927
June	6520	3150	1965		1060				1060		2256	2256	1090
July	15960	8960	3070		1096		4137		1096	4479		4479	2515
August	17740	10980	3208		1096				1096		3615	3615	2237
September	10850	7430	1886	3357	1096				1096			3357	2299
October	6050	3590	1084	3249	461			420	461			3249	1928
November	1630	1080	467		446	406		406	446			446	296
December	660	390	151		461	420		420	461			461	273

TOTALS: Existing median annual flows at Harry Hunter Dve = 14,027.04 ML
Proposed median annual flows at Manning Ave release point 5= 20,745 ML (wet) / 13,147 ML (dry)

Table 9: Preliminary ecological water requirements estimated for Canning River at Albany Highway, Gosnells; near environmental release point No. 6

				Monthly flow (ML) to maintain the following water dependent ecosystems:									
Month	Modelled pre-dam flows at Harry Hunter (average climatic conditions)	Modelled pre-dam flows at Harry Hunter (dry period conditions)	Existing flows at S616027 Harry Hunter (median ML)	Fish passage	Macro-Invertebrates	Pools	Channel form	Waterfowl	Energy flows	Riparian Vegetation	Seasonal adjustment	TOTAL EWR for Average Climatic condition	TOTAL EWR for Dry period condition
January	620	510	149		355	300		300	309			355	292
February	510	410	161		280	271		271	280			280	225
March	470	390	210		309				309			309	257
April	460	500	309		299				299			299	325
May	910	770	684		902				902			902	763
June	6520	3150	1965		872				872		2444	2444	1181
July	15960	8960	3070		902		3540		902	4018		4018	2256
August	17740	10980	3208		902				902		3580	3580	2216
September	10850	7430	1886	4266	902				902			4266	2922
October	6050	3590	1084	4128	309			300	309			4128	2450
November	1630	1080	467		299	291		291	299			299	198
December	660	390	151		309	300		300	309			309	183

TOTALS: Existing median annual flows at Harry Hunter Dve = 14,027.04 ML
Proposed median annual flows at Albany Hwy release point 6= 21,189 ML (wet) / 13,268 ML (dry)

Table 10: Preliminary ecological water requirements estimated for Wungong Brook at South-west Highway, Wungong; near environmental release point No. 1

			Monthly flow (ML) to maintain the following water dependent ecosystems:						
Month	Historic flows at S616153 Kargotich Weir (median ML)	Existing flows at S616153 Kargotich Weir (median ML)	Fish passage	Macro-invertebrates	Channel form	Riparian vegetation	Seasonal adjustment	TOTAL EWR for Average Climatic condition	TOTAL EWR for Dry period condition
January	95	29		25				25	21
February	109	32		22				22	18
March	168	30		25				25	21
April	409	35		24				24	26
May	756	70		25				25	21
June	4876	218		24			89	89	43
July	5662	361		25	356	366		366	205
August	3880	344		25			283	283	175
September	2929	210	267	25				267	183
October	2743	132	276	25				276	164
November	363	74		24			90	90	59
December	162	50		25				25	15

TOTALS: Existing median annual flows at Kargotich Weir = 1,718 ML
Proposed median annual flows at South-west Hwy = 1517 ML (wet) / 951 ML (dry)
Median historic flows at Kargotich Weir = 26,958 ML

Table 11: Preliminary ecological water requirements estimated for Southern River at Anaconda Drive Gauging Station (near Fremantle Road), Huntingdale; WRC S616092

				Monthly flow (ML) to maintain the following water dependent ecosystems:						
Month	Historic flows at S616153 Kargotich Weir (median ML)	Existing flows at S616153 Kargotich Weir (median ML)	Existing flows at S616092 Anaconda Dve (median ML)	Fish passage	Macro-invertebrates	Channel form	Riparian vegetation	Seasonal adjustment	TOTAL EWR for Average Climatic condition	TOTAL EWR for Dry period condition
January	95	29	133		34			76	76	63
February	109	32	89		31			92	92	74
March	168	30	239		34			210	210	174
April	409	35	394		33			452	452	491
May	756	70	501		34			606	606	513
June	4876	218	1543		33			847	847	409
July	5662	361	1142		34			1256	1256	705
August	3880	344	2645		34	1854	1927		1927	1193
September	2929	210	2488	1243	33				1243	851
October	2743	132	831	1284	34				1284	762
November	363	74	213		33			612	612	405
December	162	50	267		34			198	198	117

TOTALS: Existing median annual flows at Anaconda Dve = 11,688 ML
Proposed median annual flows at Anaconda Dve = 8803 ML (wet) / 5757 ML (dry)
Median historic flows at Kargotich Rd = 26,958 ML

Appendix 4
Ecological Water Requirements Workshop
Held at Kelmscott Hall
9th December, 1999 (7:30pm to 9:30pm)

Workshop coordinated by Lucy Sands (Water and Rivers Commission) and Drs Andrew Storey & Peter Davies (Department of Zoology, UWA)

The aim of the workshop was to inform the public of this plan and a specific aspect of that plan, the study on ecological water requirements (EWRs). The workshop was attended by approximately 25 people, mostly riparian landowners.

As part of this workshop, participants were asked to express their main concerns for the river, and to list what they believed to be important values of the river system (Part A).

Issues listed related to EWRs, EWPs and general catchment management. Participants were then asked to vote on what they considered to be the most important issue (Part B).

Part A. Issues raised at EWR's workshop for the Canning River System

- Drains – there is a lack of infiltration at source and dispersal of runoff
- Sediment in pools, need to identify sources (i.e. drains, agriculture, urban developments, industry)
- Too much water too fast
- What fringing vegetation needs to be put back after weed removal?
- Exotic fish species - first half of century it was goldfish now its Koi who are eating juvenile crustaceans
- No big marron or freshwater cobbler in river
- Weeds need to be removed i.e. arum lily, blackberry, watsonia
- Diversion of Kangaroo Gully has removed/reduced pools and reduced floodplain flows. This has reduced habitat diversity
- Tributaries and creeks have been engineered into drains
- Waterbird breeding – low flows have resulted in deaths at certain times of year
- Pollution and poor water quality from industrial areas
- Channel choked by sediment and weeds – channel difficult to access
- Protection of existing natural vegetation
- Leaching from sanitary disposal site- point source pollution
- Declining recreational opportunities/amenity
- Loss of social focus
- Historically there was more water in the river for recreation
- Roley Pool – sedimentation
- Natural springs have been lost to private abstraction
- Loss of flushing flows
- In-stream habitat – logs causing pools and habitat
- There is increased incision of the river channel
- Costs – who is going to pay for restoration and cleaning it up?
- Conflicts over river front access and ownership
- Weirs/barriers – to flow and fish
- Private abstraction – some inappropriate management practices, inefficient use of water
- Security in future land uses and riparian rights
- Illegal abstraction
- Evaporation from private dams – not shaded, this water used to flow down shaded channel

Part B. Issues voted-on by workshop participants

Issue	Votes
Weeds need to be removed i.e. arum lily, blackberry, watsonia	9
Security in future land uses and riparian rights	7
No big marron or freshwater cobbler in river	6
Sediment in pools, need to identify sources (ie. drains, agriculture, urban developments, industry?)	6
Private abstraction – some inappropriate management practices, inefficient use of water	6
Channel choked by sediment and weeds – channel difficult to access	3
Natural springs have been lost to private abstraction	2
Loss of flushing flows	2
Illegal abstraction	2
Drains – there is a lack of infiltration at source and dispersal of runoff	1
Tributaries and creeks have been engineered into drains	1
Waterbird breeding – low flows have resulted in deaths at certain times of year	1
Pollution and poor water quality from industrial areas	1
Costs – who is going to pay for restoration and cleaning up?	1