QON 12 & 13 - Attachment B (part 2 of 2)

Connecting Rivers, Landscapes, People

2009/2010
Annual Watering Plan

Loddon River System

NORTH CENTRAL
Catchment Management Authority
Connecting Rivers, Landscapes, People

Document History

Version	Date Issued	Prepared By	Reviewed By	Date Endorsed
Version 1	7 July 2009	B. Velik-Lord	Loddon Environmental Water Advisory Group	10 July 2009
Version 2	15 July 2009	B. Velik-Lord	North Central CMA Natural Resource Management Committee	N/A
Version 3	17 July 2009	B. Velik-Lord	North Central CMA Board	22 July 2009
Version 4	4 August 2009	B. Velik-Lord	Minister for Environment and Climate Change	24 August 2009

Distribution

Version	Date	Issued To
Final	21 September 2009	Loddon Environmental Water Advisory Group

Document name: 2009/2010 Annual Watering Plan Loddon River System

Document Manager number: 30483

North Central Catchment Management Authority
PO Box 18
Huntly Vic 3551
T: 03 5440 1800
F: 03 5448 7148
E: info@nccma.vic.gov.au
www.nccma.vic.gov.au

The North Central Catchment Management Authority wishes to acknowledge the Victorian and Commonwealth governments for providing funding for this publication through the National Action Plan for Salinity and Water Quality.

Contents

Abbreviations

AWP – Annual Watering Plan

BE – Bulk Entitlement

CMA – Catchment Management Authority

DICP – Dry Inflow Contingency Plan

Environmental Reserve BE – Bulk Entitlement (Loddon River - Environmental Reserve) Order 2005

EOS – Environmental Operating Strategy

EPA – Environment Protection Agency

EWR – Environmental Water Reserve

G-MW – Goulburn-Murray Water

LEWAG – Loddon Environmental Water Advisory Group

LREFSP - Loddon River Environmental Flows Scientific Panel

LSWFA – Loddon System Withheld Flows Account

ML – Megalitres

QoR – Qualification of Rights

TAG – Technical Advisory Group

The White Paper – The Victorian Government's White Paper *Our Water Our Future,* Securing our Water Future Together

VWQMN – Victorian Water Quality Monitoring Network

1. Loddon River Catchment Overview

The Loddon River catchment covers approximately 1.5 million hectares or about 6.8% of the area of Victoria. The river rises on the northern slopes of the Great Dividing Range, south of Daylesford, before flowing 430 kilometres northward to join the Murray River (North Central CMA, 2005). The average annual rainfall varies from 1100mm in the southeast of the catchment (upper catchment area), to 400mm in the north of the catchment (lower catchment area). Small tributaries such as Bet Bet Creek and Birches Creek flow into the Loddon River in the upper area. The major towns of the Loddon Catchment include Bendigo, Swan Hill, Kerang, Castlemaine and Maryborough. Intensive horticulture occurs in the upper catchment and mixed farming and cereal growing dominates the mid and lower catchment (North Central CMA, 2005).

Three main streams of the upper catchment (Loddon River, Tullaroop Creek and Bet Bet Creek) all meet at Laanecoorie Reservoir, where the Loddon River then flows into a single thread toward Serpentine (Figure 1).

The Waranga Western Channel crosses the Loddon River basin, transporting water from the Goulburn System to the east of the catchment, through to Western Victoria (DSE, 2005a). There are 60 artificial water storages in the basin including the three main storages in the upper catchment (Cairn Curran Reservior, Tullaroop Reservoir, and Laanecoorie Reservoir). Cairn Curran and Tullaroop Reservoirs are the main storages that collect water from the upper parts of the catchment. Laanecoorie Reservoir is used as a re-regulating storage for releases from Cairn Curran and Tullaroop Reservoirs (North Central CMA, 2006). Since its construction, Laanecoorie Reservoir has lost more than 50% capacity due to siltation (LREFSP 2002a). This infrastructure is primarily used to control Loddon River flows for irrigation and domestic water supply, however it has also had a major influence on the river's natural flow regime (DSE, 2005b). The Loddon River is highly regulated with approximately 40% of stream flow diverted for consumptive uses (LREFSP 2002a).

In 2004 and 2005, Bulk Entitlements (BE) were established for the Loddon System. These BEs set out the water sharing rules for the Loddon System and under the Bulk Entitlement (Loddon River - Environmental Reserve) Order 2005 (the Environmental Reserve BE), an Environmental Water Reserve (EWR) was established. This allows for water provisions for use on the Loddon River between Cairn Curran Reservoir and Kerang Weir; and in Tullaroop Creek between Tullaroop Reservoir and Laanecoorie Reservoir (Victorian Government, 2005). These reaches are shown in Figure 1 and outlined in Table 1.

Table 1. ***Reaches of the Bulk Entitlement (Loddon River – Environmental Reserve) Order 2005***

Reach Number	Reach Location
Reach 1	Loddon River – Cairn Curran Reservoir to Laanecoorie Reservoir
Reach 2	Tullaroop Creek - Tullaroop Reservoir to Laanecoorie Reservoir
Reach 3a	Loddon River - Laanecoorie Reservoir to Serpentine Weir
Reach 3b	Loddon River - Serpentine Weir to Loddon Weir
Reach 4	Loddon River - Loddon Weir to Kerang Weir

The Loddon Environmental Reserve BE does not provide for:

- the upper reaches of the Loddon River system above Tullaroop and Cairn Curran Reservoirs, or
- the Loddon River downstream of Kerang Weir (Reach 5) as this is located within the Torrumbarry Irrigation Region.

Additionally, a provision of up to 2,000ML per year is provided for environmental use in the Boort District Wetlands. The Boort District Wetland group includes Lake Boort, Little Lake Boort, Lake Yando, Lake Leaghur, Lake Meran and Little Lake Meran as well as other priority wetlands in the region (Figure 1). These wetlands are considered to be bioregionally important. They represent depleted and threatened wetland types including shallow and deep freshwater marshes and provide important habitat for threatened flora and fauna for breeding, feeding and refuge.

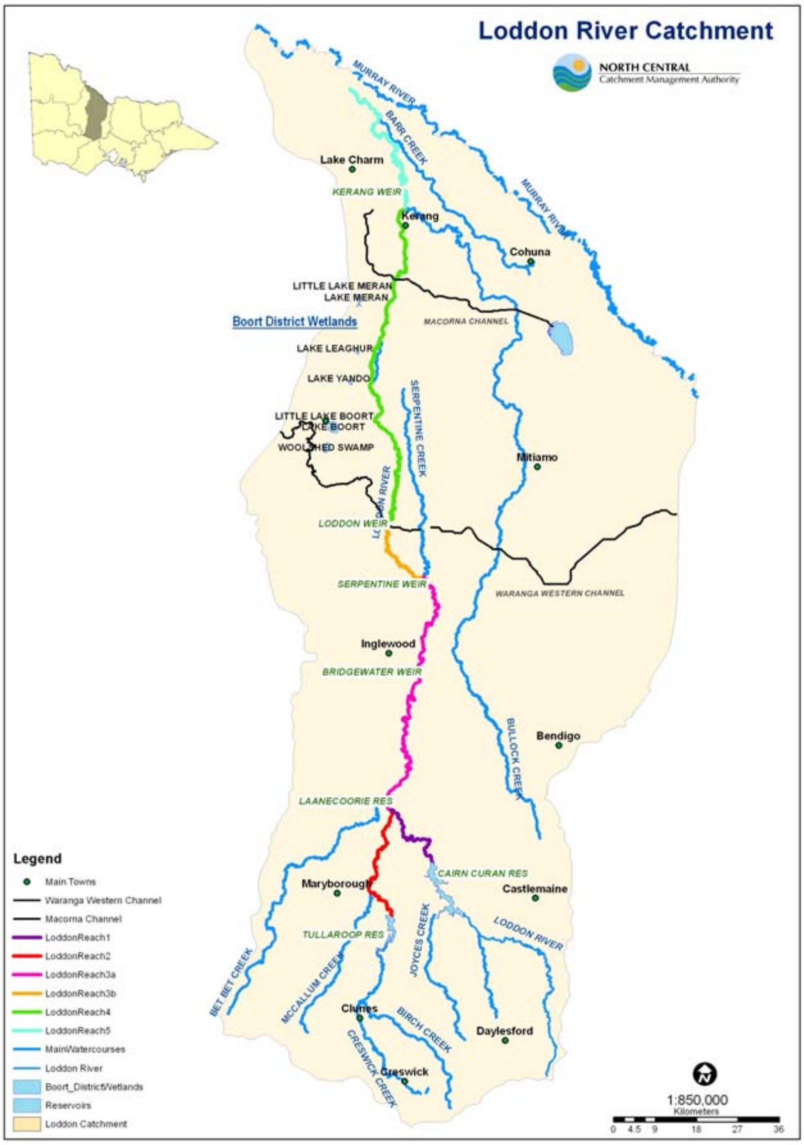


Figure 1. Loddon River Catchment

2. Background

This Annual Watering Plan documents how environmental water available for use in the Loddon System will be managed. The environmental water is available for use from the Bulk Entitlements for the Loddon System which provide the over-riding legal framework for management and use of water by all stakeholders (i.e. water authorities, irrigators and the environment) through the whole of the Loddon System.

Under extremely dry conditions, some provisions set out under the Bulk Entitlements are modified or suspended under a Declaration of Water Shortage and instigation of Temporary Qualification of Rights. The Loddon System has been under a Qualification of Rights over the past two seasons, with new Qualifications in operation for the 2009/10 season. These will be in operation until the Qualification of Rights is revoked; or until the 30th of June 2011, whichever is earlier.

The responsibility for the operational management of one of these Bulk Entitlements, Environmental Reserve BE has been delegated by the Minster for the Environment to the North Central CMA. As part of this responsibility, and as recommended in Appendix B of the Victorian Government's White Paper *Our Water Our Future* (the White Paper), the North Central CMA has developed an Environmental Operating Strategy (EOS) for the Environmental Reserve BE. The EOS (North Central CMA, 2006) outlines:

- the principles for the management of the Loddon Environmental Reserve BE
- the roles and responsibilities of key stakeholders
- the process for determining annual releases.

Each year the North Central CMA produces an Annual Watering Plan (AWP) (this Plan) in accordance with the principles and processes outlined in the EOS, and with the advice of Goulburn-Murray Water (G-MW) and other key stakeholders represented on the Loddon Environmental Water Advisory Group (LEWAG).

The AWP provides a transparent process for implementing environmental flow releases in the Loddon System (Loddon River and the Boort District Wetlands). The AWP is the tool through which the EWR is managed each year for this system. Decisions and priorities in the AWP have been based on a number of factors including:

- season review of the Loddon River and Boort District Wetlands from the previous year (July – June)
- water resource outlook for the next year (July – June)
- environmental needs and priorities for the Loddon River and Boort District Wetlands
- scenario planning (under five possible allocation levels)
- seasonally adaptive management program.

This AWP details the proposed management of the Loddon Environmental Reserve BE for the flow year from 1 July 2009 to 30 June 2010 and sees the fourth delivery season of the Environmental Reserve BE. This AWP (2009/10) is to remain in operation until such a time as the subsequent AWP (2010/11 season) has been endorsed by the Minister for Environment and Climate Change.

2a. Purpose

The purpose of the Annual Watering Plan is to:

- review the previous seasons usage of environmental water
- document the decision making process used to determine the distribution of environmental water

- identify and where possible, address issues or constraints which may affect the distribution of environmental water
- provide a communication forum between the North Central CMA, stakeholders and the local community of the Loddon River and Boort District Wetlands

While this document aims to provide a plan for the delivery of environmental water, it must be recognised that there are a number of uncertainties, particularly relating to climatic conditions which affect planning for the delivery of environmental water. In addition, system infrastructure, delivery and maintenance constraints may influence how environmental water can be distributed. For these reasons, environmental water must be delivered through an adaptive framework to provide the flexibility necessary for effective management.

2b. Underlying principles for environmental water reserve management

The North Central CMA has adopted nine principles for the management of the environmental water reserve which govern the operation of environmental flow releases. These principles are that:

- releases will be made to achieve maximum benefits with the goal of sustaining and where possible, restoring ecological processes and biodiversity of water dependant ecosystems
- the best regional environmental outcomes are sought through inter-agency and community cooperation
- the environmental contribution derived from natural and managed flows will be recognised in the development of the AWP
- all decisions are to be made on the best available science
- decisions are to be transparent, consistent with ecological objectives, accountable and in accordance with State and Federal law and policy
- the Environmental Reserve Manager (North Central CMA) must work closely with the Storage Operator (G-MW) to maximise environmental reserve benefits and consider opportunities for cost efficiencies
- monitoring, reporting and evaluation of the effectiveness of environmental flow releases will provide feedback for the continuous improvement in the use of environmental water
- delivery of the environmental flow allocation must occur in a flexible manner in response to changing conditions and in response to monitoring and an improved understanding of environmental water requirements
- community members are to be informed of improvements to the environment and engaged wherever possible in the process

2c. Loddon Environmental Water Advisory Group

To effectively manage the Environmental Water Reserve, the North Central CMA has established the Loddon Environmental Water Advisory Group (LEWAG).

The LEWAG provides advice at key decision points in the planning process to the North Central CMA on the best use of environmental water for the Loddon System, as defined by the Loddon System Bulk Entitlements (i.e. the Loddon River between Cairn Curran Reservoir and Kerang Weir, Tullaroop Creek between Tullaroop Reservoir and Laanecoorie Reservoir, and the Boort District Wetlands). It aims to ensure that environmental water is used effectively to maximise environmental benefits based on existing knowledge and in response to results of ongoing monitoring and research, ecological objectives, system constraints, previous usage and climatic conditions.

The LEWAG contains the following community and agency representatives:

- Environmental Water Reserve manager (North Central CMA)
- Storage Operator and Bulk Entitlement holder (Goulburn-Murray Water)
- Bulk Entitlement holder in Tullaroop System (Central Highlands Water)
- Northern Victoria CMA's Environmental Water Flows Coordinator
- Department of Sustainability and Environment
- Community representatives

The LEWAG meets at least twice a year. The first scheduled meeting in May provides an opportunity for the group to have input into the last season review and the preparation of the Annual Watering Plan. The North Central CMA then prepares a draft watering plan that is presented to the group at the June meeting for review. The group can be reconvened at other times should the need arise.

3. Environmental Water Reserve

3a. Environmental Water Reserve in the Loddon Catchment

During 2004 and 2005, five Bulk Entitlements relating to the Loddon Water System were gazetted by the Victorian Government:

1. Bulk Entitlement (Loddon System – Goulburn-Murray Water) Conversion Order 2005
2. Bulk Entitlement (Loddon System – Coliban Water) Conversion Order 2005
3. Bulk Entitlement (Loddon System – Environmental Reserve) Conversion Order 2005
4. Bulk Entitlement (Loddon System – Part Maryborough – Central Highlands Water) Conversion Order 2005
5. Bulk Entitlement (Creswick) Conversion Order 2004

This AWP deals with the management of the third of these Bulk Entitlements (Bulk Entitlement (Loddon System – Environmental Reserve) Conversion Order 2005). An Environmental Water Reserve (EWR) was established in order to manage environmental water under this Bulk Entitlement and was an objective of the Victorian Government White Paper *Securing Our Water Future Together* where the EWR set aside water to support the long term health of waterways.

The North Central CMA, as the caretaker for river health, has been delegated to manage this EWR and to advise the storage operator (G-MW), of the quantity and release pattern required to protect environmental values in the Loddon System.

The Environmental Reserve BE includes a number of provisions (Table 2) with allocations and natural flow affecting how these provisions are supplied as follows:

- minimum passing flows for the Loddon River over both the low flow and high flow period. Most flows have an “or natural” qualifier, meaning that a lower flow can be released if the natural flow is less than the specified flow (in all reaches except below Loddon Weir). The minimum passing flow over the high flow period may be reduced in response to low storage volumes for all reaches (refer to Appendix 1)
- river freshening flows for the Loddon River over the low flow period. These also have an “or natural” qualifier and are not provided in some reaches if the fresh does not occur naturally during the period (refer to Appendix 1)
- 2,000ML Wetland Entitlement for the Boort District Wetlands (available water is equal to the percentage allocation as Loddon entitlement holder’s licensed diverters)
- flexibility in managing unregulated water resources
- Deficit and Reimbursement Account – management of a water account to reimburse the accrued deficits of environmental minimum flows in the Loddon River Reaches
- Low Reliability Entitlement Allocation – certain rights to water have been converted to new entitlements, including the creation of a new low-reliability entitlement (‘sales’ water) to enhance the environmental reserve in the Loddon River and Boort District Wetlands.

Table 2. Environmental Water Reserve management under the *Bulk Entitlement (Loddon River – Environmental Reserve) Order 2005*

Bulk Entitlement (Loddon River – Environmental Reserve) Order 2005	
Loddon River Entitlement	**Minimum passing flows and river freshening flows**
Reach 1	Loddon River - Cairn Curran Reservoir to Laanecoorie Reservoir
Reach 2	Tullaroop Creek - Tullaroop Reservoir to Laanecoorie Reservoir
Reach 3a	Loddon River - Laanecoorie Reservoir to Serpentine Weir
Reach 3b	Loddon River - Serpentine Weir to Loddon Weir
Reach 4	Loddon River - Loddon Weir to Kerang Weir
Wetland Entitlement	Boort District Wetlands: Lake Yando, Lake Leaghur Lake Meran, Little Lake Meran, Lake Boort and Little Lake Boort (as Qualified)
Unregulated Water Resources	Loddon River Reaches and Boort District Wetlands
Accounting Procedures	Deficit and Reimbursement Account – Loddon River Loddon System Withheld Flows Account – Loddon River and Boort District Wetlands (set up under the Qualification of Rights)
Low Reliability Water Share (>100% allocation)	Loddon River Reaches and Boort District Wetlands

There are three water accounts which relate to the EWR in the Loddon System. These accounts are detailed below:

3a. i. Loddon System Withheld Flows Account

The Loddon Weir Withheld Flows Account (LWWFA) was established under the 2007 Qualification of Rights to record minimum flows which would otherwise be released below Loddon Weir. This account was set up by the storage operator (G-MW) and recorded the volumes of minimum flows which were not delivered due to the Qualifications from July 1 2008.

In the 2009 Qualification of Rights, this account has been renamed the Loddon System Withheld Flows Account (LSWFA) and records environmental flows which would otherwise be released throughout the Loddon System.

3a. ii. Deficit and Reimbursement Account

Under the Environmental Reserve BE, a Deficit and Reimbursement Account was set up to reimburse the accrued deficits of environmental minimum flows in the Loddon. In essence, flow volumes which should have been released as part of the operation of the Environmental Reserve BE, but were not (due to water shortage for example), are accrued in this account for use at a later date. There is a cap placed on this account at 25,000ML and the account is currently sitting at this level.

3a. iii. Boort District Wetland Entitlement

The Wetland Entitlement is a component of the Environmental Reserve BE for the Loddon System. Schedule 3 states that the wetland entitlement “shall be used to maximise the flora and fauna values within the Boort District Wetlands and supplied to wetlands on the principle of environmental water to the highest environmental use” (Bulk Entitlement (Loddon River – Environmental Reserve) Order 2005 pg. 2677). The wetlands in this category are Lake Meran, Little Lake Meran, Lake Boort, Lake Yando, Lake Leaghur or other priority wetlands in this region as opted by the Environmental Water Manager (Little Lake Boort has been added to these wetlands under the Qualification of Rights). Up to 2,000ML per annum is provided under the Environmental Reserve BE (including delivery losses incurred beyond the monitoring points) to water these wetlands. When G-MW is able to allocate the full licence volume or more to its licensed diverters (i.e. 100% HRWS allocation), the full wetland entitlement will also be allocated (i.e. 2,000ML). Conversely, where there is less than 100% irrigation allocation (e.g. 50%), the same allocation will be provided to the wetland entitlement (e.g. 50% of 2,000ML = 1,000ML). Up to 2,000ML can be carried over in this account for use in the following year.

3b. Environmental Priorities

3b. i. Loddon River - Objectives and Flow Components

In 2002 the Loddon River Environmental Flows Scientific Panel (LREFSP) was engaged to determine environmental flow objectives for the Loddon River (LREFSP, 2002). Specific flow components were developed for the river that aim to ensure biodiversity objectives are met. Table 3 shows each biodiversity objective and flow component required to target that objective.

Table 3. *Environmental Flow Objectives for the Loddon River study area (LRESFP, 2002a)*

Biodiversity Objective	Process		Draft Flow Objective	
			Flow Component	Timing
Restore or maintain River blackfish population	1a	Habitat availability	Low (depth >0.4 m)	All year
	1b	Breeding/Recruitment	Low	Spring
	1c	Movement	Low	All year
Restore or maintain native fish community (Murray cod, Golden perch and Silver perch)	2a	Available habitat and movement for all fish	All (depth > 0.5 m)	All year
	2b	Breeding cues for Murray cod	Freshes	Winter/Spring
	2c	Breeding cues for Golden perch	Freshes	Winter/Spring
	2d	Breeding cues for Silver perch	Freshes	Winter/Spring

Cont.

Biodiversity Objective	Process		Draft Flow Objective	
			Flow Component	Timing
Restore or maintain natural invertebrate community	3a	Disturbance	Cease-to-flow	Summer
	3b	Habitat maintenance	Freshes	Winter/Spring
	3c	Habitat availability	Low (depth >0.1 m)	Spring/Summer
Reinstate or maintain a mosaic of aquatic macrophytes	4a	Colonisation	Low	Spring
	4b	Disturbance	Low/Cease-to-flow	Summer
	4c	Habitat maintenance	Freshes	All year
Improve in-stream macrophyte habitat	4d	Colonisation/growth	Low	Spring/Summer
Improve submerged macrophyte habitat	4e	Colonisation/growth	Low (depth <0.3m)	Spring/Summer
Reinstate a mosaic of bank vegetation	5a	Colonisation/growth	All	Spring/Summer
	5b	Disturbance	Low/Cease-to-flow	Summer
	5c	Wetting	Freshes	Winter/Spring
Reverse terrestrialisation of bank/bench grasses	6	Disturbance	Freshes/High	Winter/Spring
Maintain red gum regeneration	7a	Wetting	Overbank	Spring
Restore or maintain floodplain/wetland processes	7b	Inundation	Overbank	Spring
Clean bed surface	8a	Disturbance	Freshes	Any time
Restore or maintain pools	8b	Scour	High	Any time
Restore or maintain runs	8c	Disturbance	Freshes/High	Any time
Re-shape in-channel forms to maintain physical habitat diversity and complexity	8d	Scour/deposition	Freshes/High	Any time
Scour silt on bed	8e	Scour	High/Overbank	Any time
Restore or maintain snag habitat	9	Submergence	Low	Any time
Entrain organic litter – carbon cycling	10	Disturbance	High	Winter

3b. ii. Boort District Wetlands

The Loddon Water System Bulk Entitlement process primarily focused on the Loddon River. Initially the prime motivating concern was improving fish habitat and meeting fish passage requirements. Maintenance of ecosystem processes, where wetlands are associated with river systems were incorporated into the Environmental Reserve BE via the establishment of the Wetland Entitlement. This entitlement is aimed at maximising the flora and fauna values of the Boort District Wetlands by supplying water that will result in the highest environmental gain for the wetlands.

Those wetlands considered part of the Boort District Wetlands under the Environmental Reserve BE and able to receive water from the Wetland Entitlement are: Lake Meran, Little Lake Meran, Lake Boort, Lake Yando, Lake Leaghur or other priority wetlands in the region as opted by the Environmental Water Manager.

In addition to these wetlands, an interim supply of up to 300ML was included in the Environmental Reserve BE in order to specifically supply Little Lake Boort until such a time as water savings from the Wimmera-Mallee Pipeline Project would be realised (Clause 2 of Schedule 3). This clause was suspended under the 2007 Qualification of Rights and will continue to be suspended under the 2009 Qualifications. However, also within the Qualification or Rights for the Loddon Water System, the Environmental Reserve BE has been amended to include Little Lake Boort as one of the wetlands of the Boort District Wetlands. In essence this means that under the Qualification of Rights, Little Lake Boort is to be prioritised for watering events along with all other Boort District Wetlands.

Table 4 shows the environmental water requirements of each of the Boort District Wetlands.

Table 4. *Environmental Water Requirements for Boort District Wetlands*

Wetland	Volume Required (ML)*	Historic Information	Existing Diversion Licenses (ML)	Environmental Watering Requirements**	Current Condition
Lake Meran	Top up flow events	Permanently full for most of the last 80 years – dried out in 2002	1,457	Can be filled using surplus Loddon River flows via Wandella Creek and Pickles Canal	Fringing Red gums on high ground stressed
Little Lake Meran (Area = 44ha)	1,014 - 1,764	Permanently full for most of the last 80 years – dried out in 1999	254	1,500 every 3-5 years (Fill early spring)	Fringing Red gums on high ground stressed
Lake Boort	Top up flow events (i.e. floods)	Permanently full for most of the last 80 years – dried out in 1999	74	Can be filled using surplus Loddon River flows via Kinypanial Creek (only in flood events)	Fringing Red gums on high ground stressed
Lake Yando (Area = 90ha)	755 - 967	Dry since 1998	120	427ML every 3-5 years (Fill early spring)	Vegetation stressed but remains healthy
Lake Leaghur (Area = 79ha)	806 – 1,138	Dry since 2002	170	664ML every 3-5 years (Fill early spring)	Vegetation stressed but remains healthy
Little Lake Boort	Maintain Environmental Level	Permanently filled for last 80 years and still retains water	0	Up to 600ML ever year	Lake holding water with aquatic plant regeneration occurring

*Volume Required: Minimum scenario (half filling + losses) to Fill scenario (fill + losses) (calculations estimated – assuming a porosity of 0.3).
**Applying an evaporation rate of 1.5m per year, water is expected to last for approximately 9 months in the Shallow freshwater marshes and one year in the Permanent freshwater systems.

There are currently no water operational plans that describe the watering requirements for the Boort District Wetlands. Although there is no definitive information quantifying the volumes and timing required there is information available on the wetland types and therefore the likely watering regimes required according to each wetland classification (Loddon Bulk Entitlement Project Group, 2005).

Wetlands within the Boort District Wetland group are classified as either shallow freshwater marshes or permanent open freshwater systems.

Shallow freshwater marshes include Lake Yando, Lake Leaghur and Lake Boort, and these *"tend to be less than half a metre deep and flooded for less than 1 year. Diverse vegetation like reeds (typha), red gum, open water, water couch, milfoils and water ribbons tend to provide habitat for lots of waterbirds, waterfowl and frogs"* (Heron and Joyce, 2008).

Permanent open freshwater systems of the Boort District Wetlands include Little Lake Boort, Lake Meran and Little Lake Meran. These wetlands *"are freshwater systems that usually hold water on a permanent basis. Some of these systems provide important habitat for large bodied native fish, waterbirds, colonial nesting breeding sites, waterfowl and tortoises"* (Heron and Joyce, 2008).

In the absence of detailed water operational plans, the selection of priority wetlands for environmental water is based on flooding history (wetting and drying cycles) and local knowledge of current wetland health and ecological requirements. Historical water events (both natural and through the use of environmental water) have been documented in Appendix 2 - Boort District Wetlands Flooding History.

All Boort District Wetlands would ecologically benefit from supply of water this season. The following priorities are based on ecological requirements and are driven by the volume of water available/allocation to the Loddon System. The priorities were agreed to by the LEWAG in May 2009.

3b. iii. Priority Wetlands

When sufficient water is available in the Loddon System for use in wetland watering, the priority wetlands to deliver water are as follows:

1. Lake Yando – River Red Gum woodland, groundlayer dominated by graminoids and shrubs (see Figure 2)
2. Lake Leaghur – River Red Gum woodland, groundlayer dominated by graminoids and shrubs
3. Little Lake Meran – Grassy/sedgy woodland, dominated by largely grass and herb life forms

However, if conditions remain dry and environmental water availability remains low, there is likely to be priority given to deliver a small amount of water to 'top up' Little Lake Boort (see Figure 3). This would follow on from watering events over the past two seasons which have maintained the lake as a drought refuge for birds.

Should unregulated flow (i.e. significant rainfall events) occur during the season, flows may be diverted from Loddon Weir to the Boort District Wetlands and the priority for filling these will be same as those detailed above. There may be some variation within the filling order depending on timing of flows, amount of water to be diverted and history of watering events through the 2009/10 season. Overall delivery of the EWR to the Boort District Wetlands requires room for flexibility as the volume of water available, and the ability to deliver the water has the potential to change significantly through the season.

Within these constraints, climatic conditions will also affect the ability to use the Wetland Entitlement to fill wetlands to a level adequate to achieve ecological outcomes. Climatic conditions will therefore significantly influence how the EWR can be delivered, and this will be adaptively managed through the season.

Where there is sufficient water volume but insufficient channel capacity or time to deliver to the first priority wetland, other priority wetlands or changes to the optimum delivery time may be considered. The time of year, individual wetland ecological requirements and the likelihood of higher priority wetlands having sufficient channel capacity and time for complete delivery will influence this decision.

The decision on volumes to be delivered is based on the known capacity of the wetland and is measured at the inlet to the wetland. It does not take into account losses due to evaporation and seepage within the wetland, or during delivery from the storages.

Water delivery to the Boort District Wetlands will be further explored under the scenario planning section of this Plan.

Figure 2. Lake Yando, June 23 2009.

Figure 3. Little Lake Boort, April 22 2009.

3c. Qualification of Rights

As described earlier, there are five Bulk Entitlements in operation in the Loddon System. These Bulk Entitlements specify the rights to water of each water authority and the environment, and water cannot be used from the system outside of the Bulk Entitlement provisions.

In extremely dry years, the Minister for Water has emergency powers to declare a water shortage and to qualify rights to water (under a Qualification of Rights). The Qualification of Rights changes the water sharing rules by suspending certain Bulk Entitlement requirements, with the aim of ensuring sufficient water is available to meet critical human needs. All Bulk Entitlement requirements not modified by the Qualification of Rights remain in place.

In light of the prolonged dry seasonal conditions across Victoria, the Bulk Entitlements for the Loddon System have been qualified over the past two seasons, and have been renewed for the 2009/10 season. Two Qualifications are now in operation:

1. Temporary Qualification of Rights in the Loddon Water System, July 2009
2. Temporary Qualification of Rights in Reach Two of the Loddon Water System, June 2009 (where 'Reach 2' is a reference to the reach of the Loddon System between Tullaroop Reservoir (inclusive) and Laanecoorie Reservoir (exclusive) also referred to as Tullaroop Creek).

Table 5 describes the key components of the 2009-2011 Qualification of Rights as it impacts on the Environmental Reserve BE, EWR flexibility under the Qualifications, and the expected impacts on environmental flows through the Loddon System.

Table 5. Key components of the 2009 Qualification of Rights and associated impacts on the Environmental Water Reserve

Allocation	Environmental Water Flexibility	Cairn Curran Reservoir to Laanecoorie Reservoir (Reach 1)	Tullaroop Creek (Reach 2)	Laanecoorie Reservoir to Serpentine Weir (Reach 3a)	Serpentine Weir to Loddon Weir (Reach 3b)	Loddon Weir to Kerang Weir (Reach 4)	Boort District Wetlands
0% Allocation	LSWFA - 600ML available and may be used in Boort District Wetlands (via water transfer)	No environmental flow provisions	Unlikely to be any environmental flow provisions	No environmental flow provisions	No environmental flow provisions	Continued cease to flow	0ML available directly from Wetland Entitlement (600ML available via transfer)
1% Allocation	LSWFA - 2,800ML available (incl. ability to transfer 2,000ML to Wetland Entitlement)	No environmental Flows	Dependent on Tullaroop Reservoir Storage Volume	No environmental Flows	No environmental Flows	Continued cease to flow	20ML available directly from Wetland Entitlement
5% Allocation	LSWFA - 2,800ML available (incl. ability to transfer 2,000ML to Wetland Entitlement) and 2009/10 flows withheld	Minimum passing flows can be restored (or stored in LSWFA)	Dependent on Tullaroop Reservoir Storage Volume	Minimum passing flows can be restored (or stored in LSWFA)	Minimum passing flows can be restored (or stored in LSWFA)	Minimum passing flows can be restored (or stored into the LSWFA account)	100-1000ML available directly from Wetland Entitlement
100% + Allocation	▪ LSWFA - 2,800ML and 2009/10 flows withheld (account accrual finished) ▪ 6,000ML of Deficit and Reimbursement account available at with further 19,000ML available when Cairn Curran storage volume is greater than 80GL ▪ Low reliability water share available 1% to 100% (up to 2,105ML)	Minimum passing flows and river freshening flows restored	Minimum passing flows and river freshening flows restored	Minimum passing flows and river freshening flows restored	Minimum passing flows and river freshening flows restored	Minimum passing flows and river freshening flows restored	2,000ML available directly from Wetland Entitlement

3d. Scientific Panel

In order to manage environmental water during drought in the Loddon System, additional information was obtained from a scientific panel who have experience in the Loddon River system (Cottingham et. al 2009). The focus of the options developed by this group relate to survival of critical ecological objectives during the dry period, rather than focusing on long term improvements in ecosystem health.

The primary objective for management of the Loddon System during drought is to maximise the chance of survival of aquatic biota by managing ecological risks while maximising water availability for essential consumptive purposes. Management will be undertaken in alignment with the following principles for drought response management in order to identify and manage ecological risks and maintain domestic and stock supply (Cottingham et. al 2009):

- A reduction in flow, or a cease-to-flow, will result in a decline in the availability of suitable habitat for many species as the river becomes a series of isolated pools.
- Consumptive demand and environmental benefit is provided by maintaining a continuous flow in the reaches upstream of Loddon Weir.
- Fish assemblages are most vulnerable as they rely on good quality water and flows for their survival, especially in the Loddon System where River blackfish and Silver perch occur. Fish, or more specifically the fish assemblages, may not have the ability to re-colonise to all locations after drought. The river systems have now been segmented by weirs and reservoirs which prevent fish passage if suitable conditions cannot be maintained for their survival. Re-stocking is not a viable option for all fish species.
- The macroinvertebrate populations will decline as water levels and available habitat decline. These provide an important food resource for fish and as such, flows may be targeted to ensure there are sufficient populations to provide food for fish. Their life histories are relatively short, and once suitable water conditions are present, re-colonisation from nearby areas is likely to occur fairly rapidly.
- Aquatic macrophytes (vegetation) are well adapted to surviving these conditions. Many aquatic plants have deep-rooted rhizomes that will enable them to survive dry conditions and provide a source for re-populating waterways, once water levels recover.
- The management of water quality to enhance the opportunity for survival of fish assemblages is critical.
- The risk of poor water quality is greater during the warmer months, and the maintenance of water quality within acceptable thresholds is easier during the cooler months.
- Cease to flow events are not desirable as a long term measure if they can be avoided. There is a lower risk of implementing cease-to-flow during cooler months. Cease to flow should only be used temporarily to maximise the availability of water over time, thereby increasing the chance of significant flora and fauna surviving in the hotter summer months.
- Complementary actions such as the management of diversions, angling pressure, stock access and protection of riparian vegetation should be undertaken to reduce stress on the systems and assist in future recovery.
- Using water judiciously – the chance of survival can be increased but cannot be guaranteed.

4. 2008/2009 Season Review

Rainfall-runoff conditions in the Loddon system remained very low at the end of the 2008/09 season. Over the past two years water storages on the Loddon have remained at between 1% and 3% capacity, with discharge from the storages also remaining low due to the 0% irrigation allocation observed in the 2008/09 season (Cottingham et. al 2009). In addition there have been no winter-spring flushes.

The continued dry conditions in observed in the 2008/09 season permitted the 2007/08 – 2008/09 Qualification of Rights to be maintained on the following Bulk Entitlements:

a. Bulk Entitlement (Loddon System – Part Maryborough – Central Highlands Water) Conversion Order 2005
b. Bulk Entitlement (Loddon System – Coliban Water) Conversion Order 2005
c. Bulk Entitlement (Loddon System – Environmental Reserve) Conversion Order 2005
d. Bulk Entitlement (Creswick) Conversion Order 2004
e. Bulk Entitlement (Loddon System – Goulburn-Murray Water) Conversion Order 2005

The Qualification of Rights in operation through this period were:

a. Temporary Qualification of Rights in the Loddon Water System, July 2007
b. Amendment to Temporary Qualification of Rights in the Loddon Water System, April 2008
c. Further Amendment to Temporary Qualification of Rights in the Loddon Water System, May 2008
d. Second Further Amendment to Temporary Qualification or Rights in the Loddon Water System, April 2009

There remained a zero percent allocation of High Reliability Water Shares (HRWS) in the Loddon System, with only minimal domestic and stock supply provided in the system. From an environmental water perspective, minimal water was available for use, with only two areas receiving environmental water:

- Tullaroop Creek (Reach 2) received a flow regime of 1ML/day with two freshes (for the first half of the season) followed by 1ML/day with 5ML/day intervals during the second half of the season to maintain regionally significant River blackfish populations
- 600ML (500ML was transferred from the LSWFA to the Wetland Entitlement, and 100ML from Little Lake Boort Committee of Management) was delivered to Little Lake Boort to maintain this lake as a drought refuge (see Figure 3)

4a. Water Resources

During the 2008/09 season the water held in Loddon Storages decreased significantly. The combined storage volume of Cairn Curran, Tullaroop and Laanecoorie Reservoirs begun the season (July 2008) at approximately 11,500ML (the combined capacity of these storages is 228,080ML). This volume was insufficient to enable any irrigation allocation to be made on the Loddon System and the 2007 Qualification of Rights remained in place.

By the end of the 2008/09 season (June 2009), the combined volume of water held in these storages dropped to approximately 5,900ML. Figure 4, Figure 5 and Figure 6 show the volume of water held in Cairn Curran Reservoir, Tullaroop Reservoir and Laanecoorie Reservoirs for the 2008/09 season.

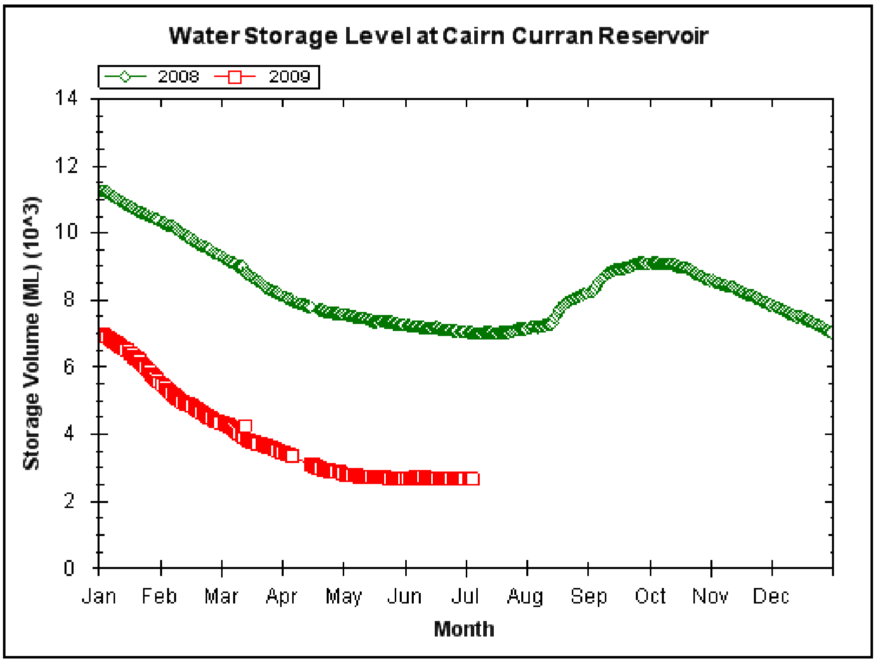


Figure 4. Storage volume of Cairn Curran Reservoir during 2008/09 (green represents 2008 and red represents 2009). Source (G-MW, www.g-mwater.com.au)

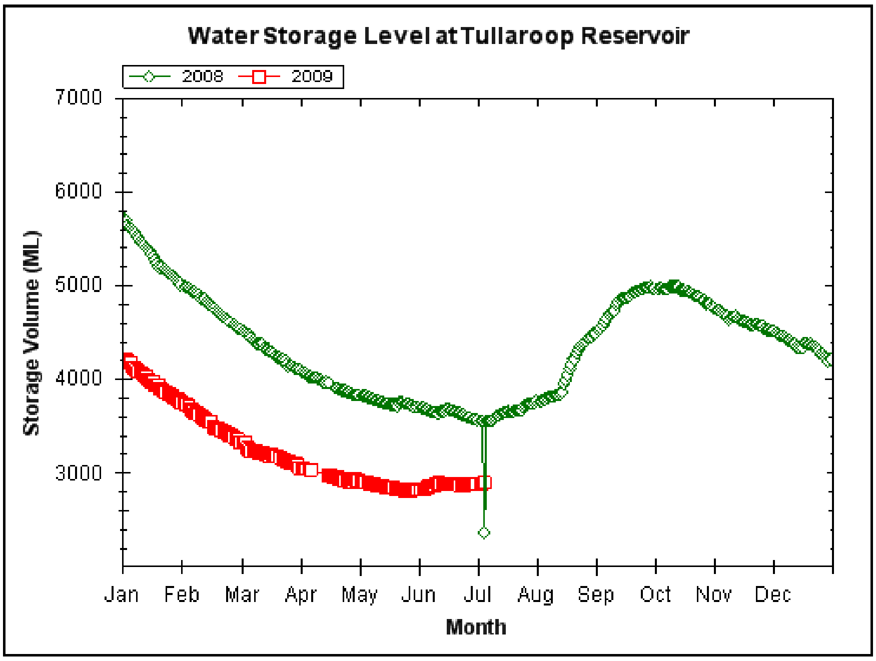


Figure 5. Storage volume of Tullaroop Reservoir during 2008/09 (green represents 2008 and red represents 2009). Source (G-MW, www.g-mwater.com.au)

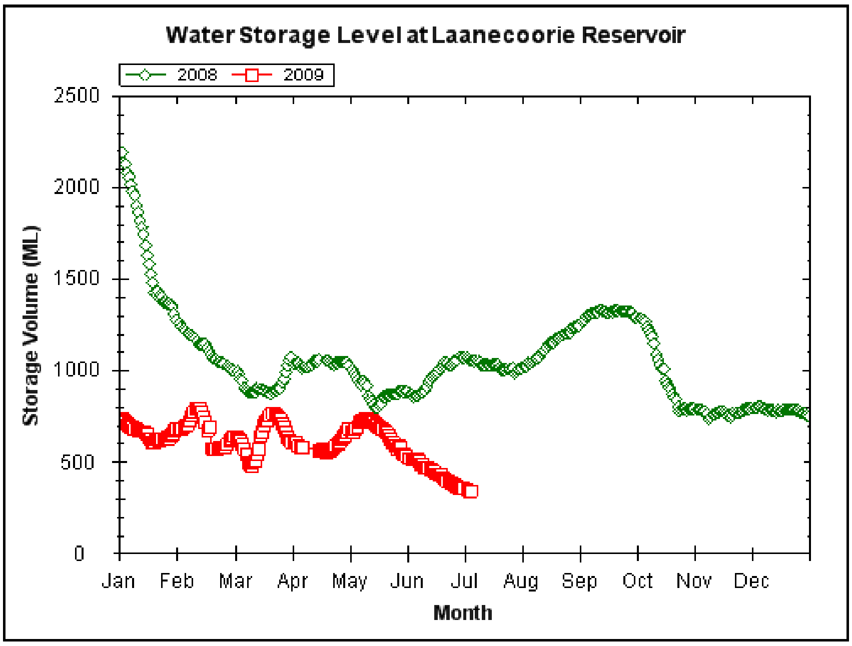


Figure 6. Storage volume of Laanecoorie Reservoir during 2008/09 (green represents 2008 and red represents 2009). Source (G-MW, www.g-mwater.com.au)

4b. Environmental Flow Review

The severe dry conditions experienced during 2008/09 and the subsequent Qualification of Rights of the Loddon System Bulk Entitlements resulted in minimal flows through most of the Loddon System. There were minimal flows specifically for environmental purposes administered in Reach 2 (Tullaroop Creek between Tullaroop Reservoir and Laanecoorie Reservoir) and a small volume of water was provided to Little Lake Boort to maintain a drought refuge.

Within the small amount of flexibility available during extremely dry years (as was observed during 2008/09), the management of the Loddon System EWR aims to focus on survival of priority species/ecosystems to:

a. Ensure (to the best ability), priority river assets during the dry seasons

b. Provide capacity for ecosystem recovery when conditions return to those similar to the long term average

The following sections outline the operations of the Loddon River and Boort District Wetlands from the 2008/09 season.

4b. i. Reach 1: Cairn Curran Reservoir to Laanecoorie Reservoir

Under the Qualification rules no environmental flow releases were administered in Reach 1, although some domestic and stock water was supplied, and water transfer releases (between Cairn Curran and Laanecoorie Reservoirs) were undertaken through the season.

Spot monitoring, undertaken by G-MW revealed dissolved oxygen levels between 8.4 and 12.7mg/L for the season with electrical conductivity (salinity) varying between 1,330 and 1,626µS/cm.

Figure 7 shows the flow releases from Cairn Curran Reservoir during the 2008/09 season.

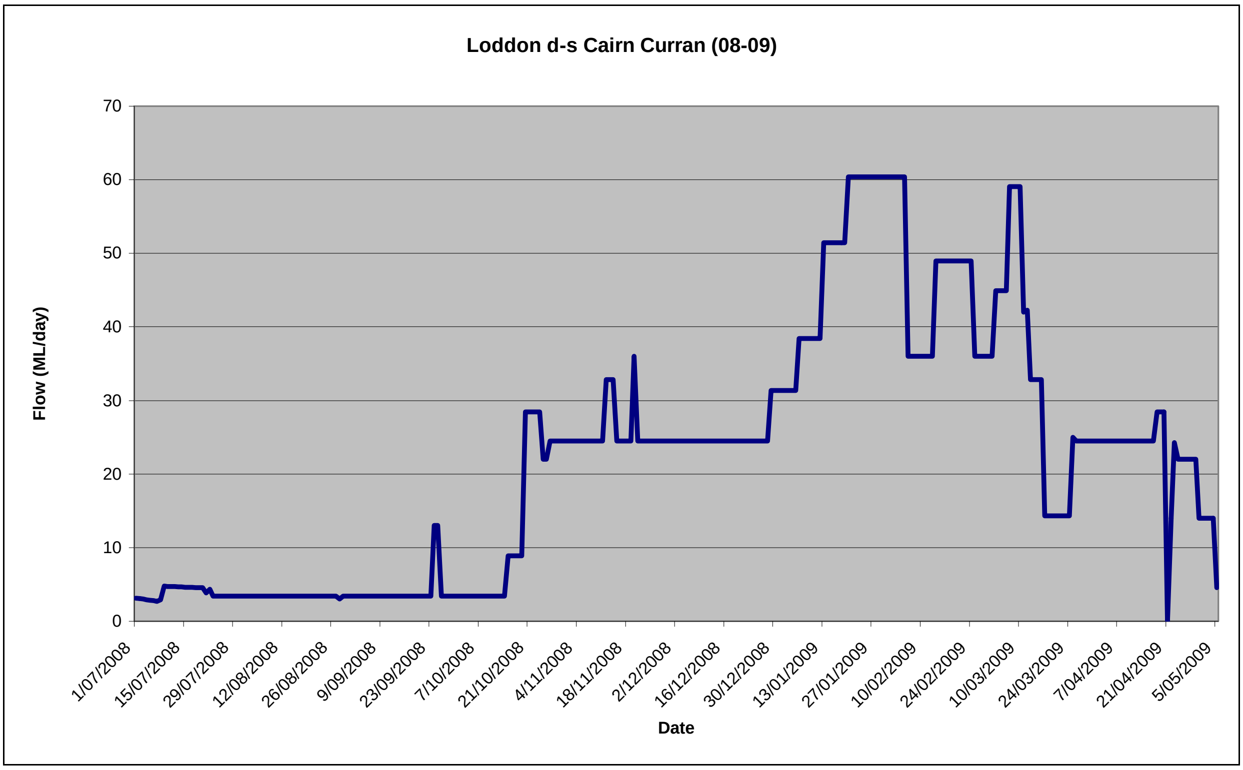


Figure 7. Flows downstream of Cairn Curran Reservoir (July 2008 – May 2009)

4b. ii. Reach 2: Tullaroop Reservoir to Laanecoorie Reservoir

The operation of Tullaroop Creek during 2008/09 has followed the Tullaroop Creek Adaptive Drought Management Program (April 2008 – October 2009) (North Central CMA 2008). The objective of the Adaptive Management Plan is to *"maximise the chance of survival of aquatic biota by managing ecological risks and maximising the water availability for the essential consumptive purposes of Maryborough."* (North Central CMA 2008, page 4).

During the first half of the 2008/09 season, Tullaroop Creek received a flow regime consisting of approximately 1ML/day with two freshes (one in September and one in November). This was modified during the second half of the season in order to maintain water quality and habitat in the wet section of river. The revises flow regime consisted of approximately 1ML/day with 5ML/day intervals. Figure 8 shows the flows released from Tullaroop Reservoir into Tullaroop Creek (Reach 2) through the 2008/09 season. Over the season approximately half of the creek length dried from Laanecoorie Reservoir back toward Tullaroop Reservoir. During summer, a prevalence of azolla sp. growth was observed around Mullins Road.

Spot monitoring, undertaken by G-MW and Thiess Services revealed dissolved oxygen levels between 2.9 and 12.1mg/L for the season with electrical conductivity (salinity) varying between 1,121 and 5,550µS/cm. pH varied between 7.6 and 9.0 over the season.

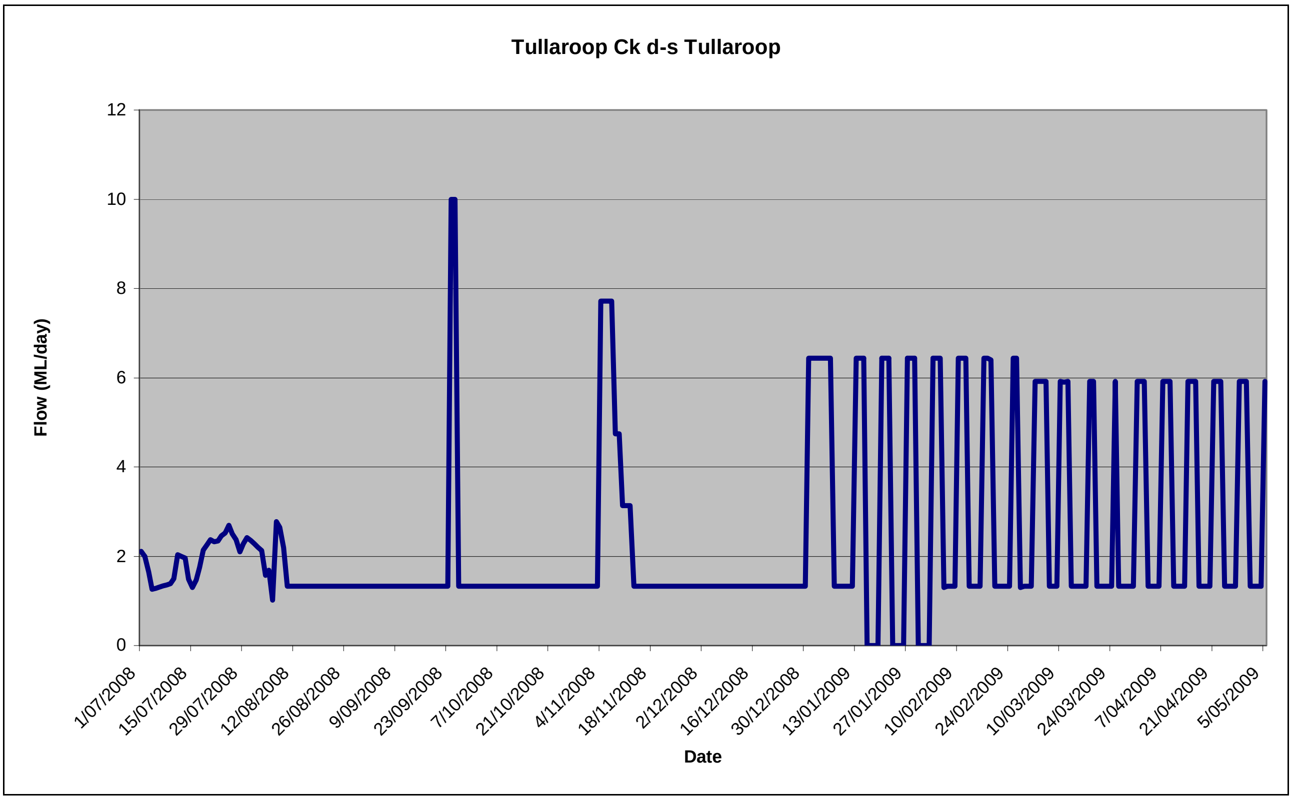


Figure 8. Flows released from Tullaroop Reservior into Tullaroop Creek (July 2008 – May 2009)

4b. iii. Reach 3a: Laanecoorie Reservoir to Serpentine Weir

Under the Qualification rules no environmental flow releases were administered in this reach, although some water releases occurred for stock and domestic proposes. The river maintained water between Laanecoorie and Bridgewater, however there were areas where stock were able to cross the river. At five spot monitoring sites dissolved oxygen levels were above 4mg/L (between 4.5 and 11.3mg/L) and salinity levels between 1,832 and 4,410µS/cm (monitoring was undertaken by G-MW).

Figure 9 shows the flows released from Lannecoorie Reservoir for the 2008/09 season.

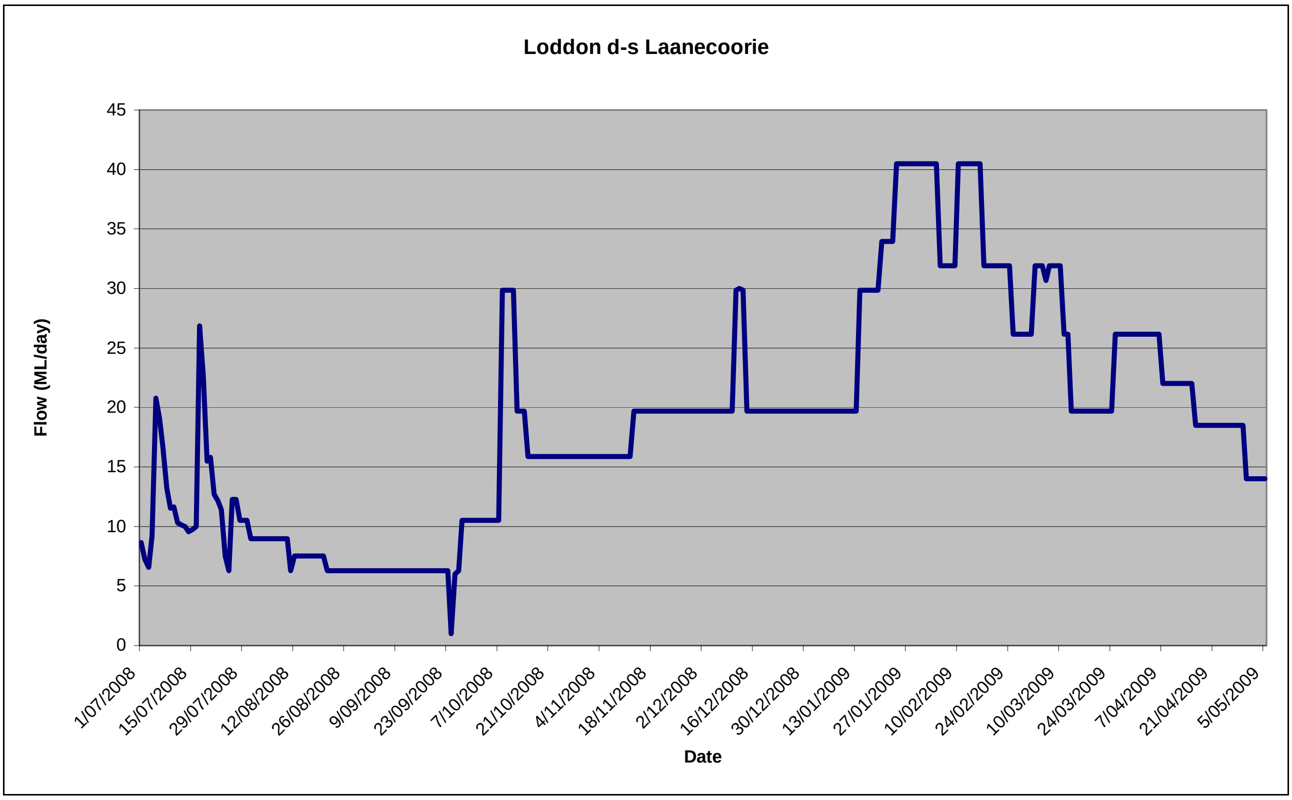


Figure 9. Flow downstream of Laanecoorie Reservoir (July 2008 – May 2009)

4b. iv. Reach 3b: Serpentine Weir to Loddon Weir

Under the Qualification of Rights, no environmental flow releases were administered in this reach, although some domestic and stock flows occurred. Only minimal irrigation diversion occurred in the reach which may be due to the poor water quality of the water in the reach.

The G-MW spot monitoring site downstream of Serpentine Weir revealed dissolved oxygen levels dropping to 2.62mg/L in February 2009 while being above 4mg/L for the other times sampled through the season. Salinity levels were between 3,220 and 4,120µS/cm in the 2008/09 season.

This reach is at higher risk of ceasing to flow than the upper reaches, placing higher risk to water quality over the warmer months. In some places along this reach the river had ceased to flow through the whole river profile.

A fish death event occurred downstream of Serpentine Weir in March 2009 after water overtopped Serpentine Weir. Water quality data from the continuous monitoring probe in the Loddon River at Serpentine Weir is provided for this period in Figure 10. Of note in this graph is the dissolved oxygen concentration which dropped below 2mg/L six times in the weeks preceding the fish death event which was reported on March 16 2009. The water level recorded by the monitoring probe reached its maximum height on March 11 after which the water level receded, indicating an overtopping event. During this time the dissolved oxygen concentration dropped to 0.5mg/L and remained low for a number of hours (unlike the previous low dissolved oxygen events).

Figure 11 shows the flows downstream of Serpentine Weir for the 2008/09 season.

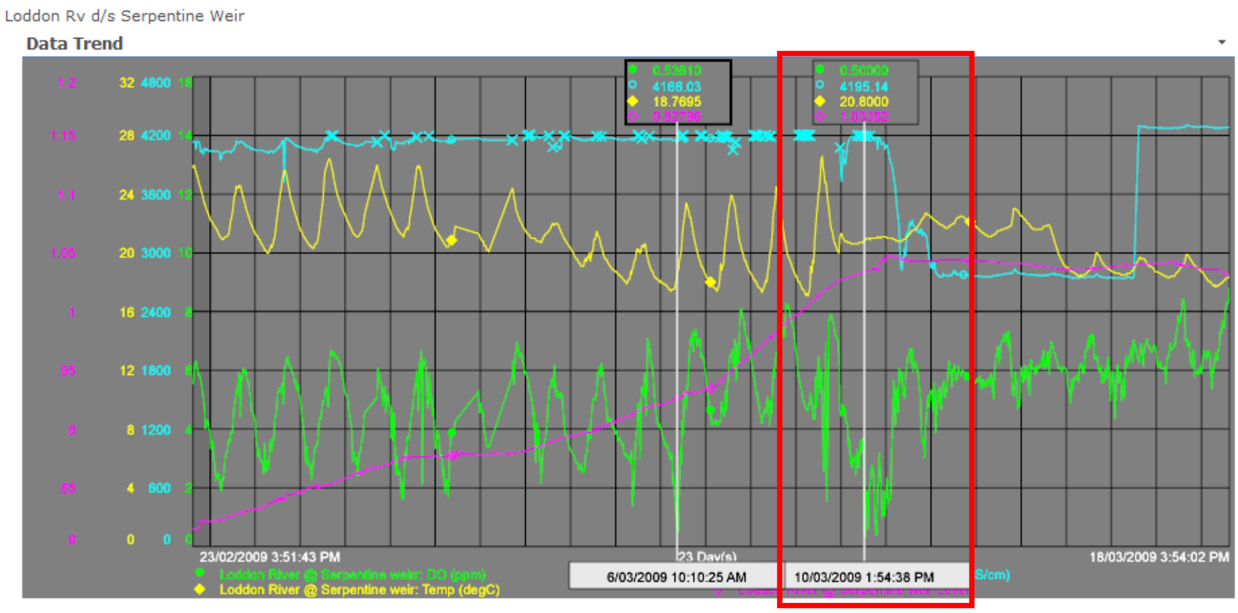


Figure 10. Real-time water quality monitoring from the Loddon River, downstream of Serpentine Weir between February 23 and March 18 2009 (fish death event is highlighted in red). The green line denotes dissolved oxygen concentration, purple line denotes Serpentine Weir level, blue line denotes salinity and yellow line denotes temperature.

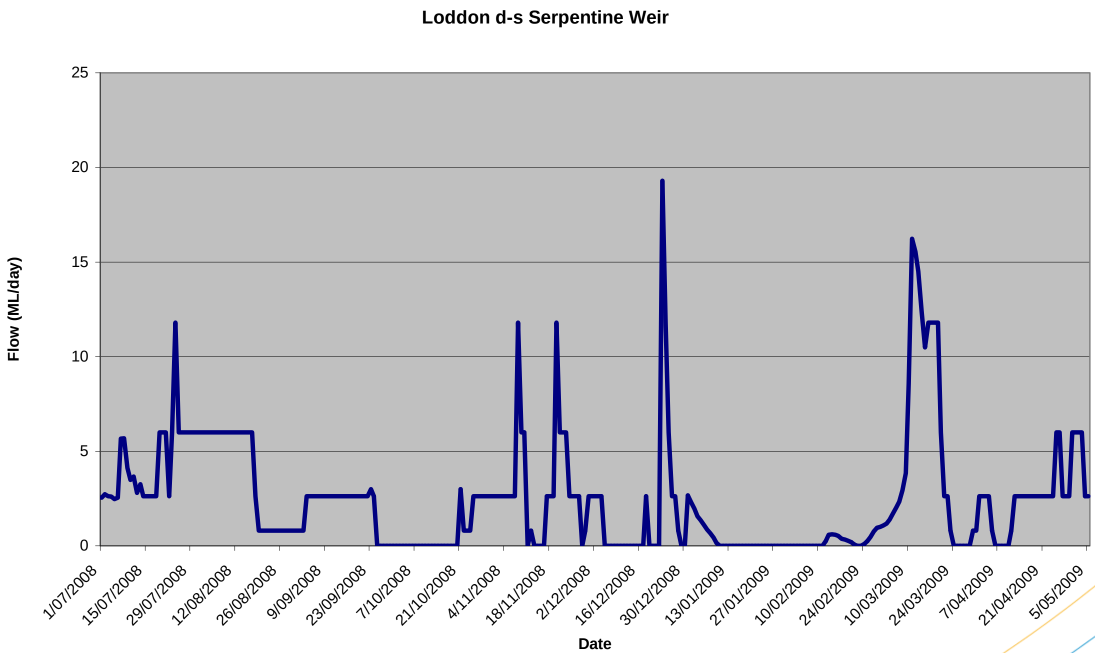


Figure 11. Flows in Loddon River downstream of Serpentine Weir between July 2008 and May 2009.

4b. v. Reach 4: Loddon Weir to Kerang Weir

There were no irrigation allocations or environmental flow releases in this reach in the 2008/09 season (Figure 13 shows the flows observed in the Loddon River, downstream of Loddon Weir). Very minimal flows occurred into this reach (peaking at 0.5ML/day for one day in September 2008) and from an environmental perspective, an objective of this season was to keep this reach as dry as possible. The majority of the length of this reach remained dry for the whole year, with only the river immediately below Loddon Weir wet.

One issue observed during the season was the risk of Acid Sulphate Soils (ASS) forming at sites within the reach, and as such, CSIRO undertook a detailed assessment for current and potential impacts of ASS in the reach. This assessment followed on from preliminary assessments undertaken by CMA staff following observations from both staff and community members highlighting the poor state of soils in some locations.

The spot monitoring at six sites in this reach undertaken by G-MW revealed that where water was flowing in the reach, dissolved oxygen levels were between 5.1 and 12.2mg/L between July and November 2008. Salinity levels were between 561 and 2,624µS/cm during this time. Of interest for this reach is that the pH of the water at Borung-Fernihurst Road dropped to 3.3 in late September 2008. This site is in close proximity to where detailed assessments into the prevalence and risks posed by Acid Sulphate Soils in this reach were conducted by CSIRO in December 2008.

CSIRO (2009) investigated a stretch of river approximately 12km downstream of Loddon Weir and found that soils were slightly to moderately acidic. Where pooled surface waters were in contact with sulphuric soil materials and predominantly derived from surface runoff, the water was found to be acidic to very acidic. Therefore, CSIRO (2009) concluded that the risk of soil acidification and subsequent metal materialisation is considered to be high and the risk of forming monosulphidic black ooze (MBO) upon flooding under stagnant or low flow conditions was likely to be high. The result of these preliminary findings warrant further investigation to be undertaken in this reach in order to understand how to manage this issue into the future. North Central CMA is currently in the process of obtaining further expert advise into how management of these soils should be undertaken into the future.

An emerging issue also faced in this reach relates to the germination of Red Gum saplings on the highly silted bed of the river channel (see Figure 12). This growth has been observed over the past two years, however in the area near Yando it has been observed that the growth has stalled and the saplings have begun thinning naturally. The initial growth of these saplings was observed in response to the cease to flow conditions and peak rainfall event in late December of 2007 and at the time exposed cracks up to 1.5 metres deep were also observed. These cracks still remain in the reach.

There has been significantly more fencing undertaken in this reach over the past year than in previous years (both through incentives provided by the North Central CMA, and by individual landholders), and this may be due to the need to manage stock while the river is dry and forming no barrier to movement. Without grazing in the riparian zone, community members have noticed a considerable improvement of grasses and organic material remaining on site in this reach.

Figure 12. Red Gum germination in Reach 4 of the Loddon River.

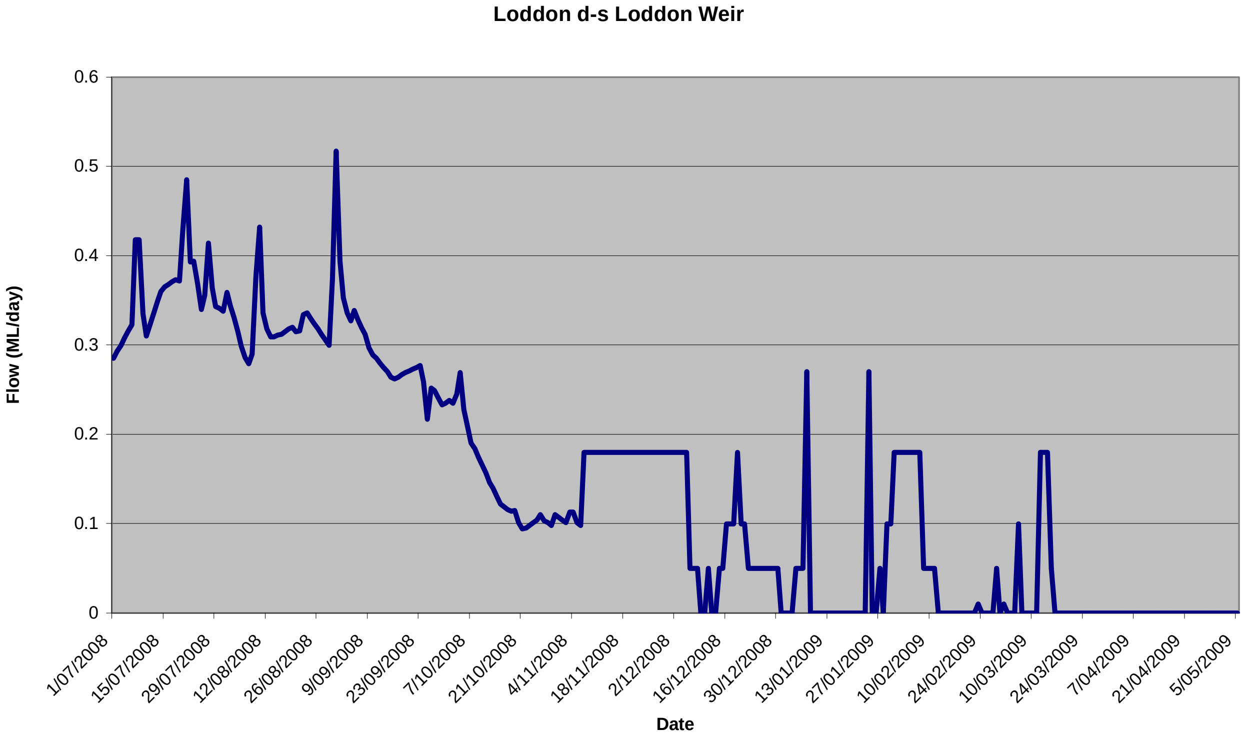


Figure 13. Flows downstream of Loddon Weir between July 2008 and May 2009.

4b. vi. Boort District Wetlands

At the beginning of the 2008/09 season the only wetland of the Boort District Wetland group which held water was Little Lake Boort. All other wetlands (Lake Boort, Lake Yando, Lake Leaghur, Lake Meran and Little Make Meran) remained dry.

Following a review of best possible environmental outcomes available to each wetland in light of the continuing drought conditions, it was decided that Little Lake Boort was best placed to provide continuing drought refuge for the Loddon system. Water was therefore provided to maintain Little Lake Boort throughout the 2008/09 season (set out in the Amendment to the Temporary Qualification of Rights in the Loddon Water System (May 2008), and the Second Further Amendment to the Temporary Qualification of Rights in the Loddon Water System (April, 2009)) via a transfer of water from the LSWFA to the Boort District Wetland Entitlement. Over the season a total of 500ML was delivered from this entitlement and in addition to this water, the Committee of Management for Little Lake Boort delivered 100ML to the lake from a purchased water right, making a total of 600ML delivered (see Figure 3).

A number of bird species were observed inhabiting the lake during the season. Species recoded by a local community member during the 2008/09 season included:

- Australian Pelican
- Australian Shellduck
- Australian Wood Duck
- Black Duck
- Black Fronted Dotterel
- Black Swan
- Black Tailed Native Hen
- Black Winged Stilt
- Dusky Moorhen
- Eurasian Coot
- Great Cormorant
- Great Egret
- Horary Headed Grebe
- Little Pied Cormorant
- Masked Lapwing
- Purple Swamphen
- Royal Spoonbill
- Straw Necked Ibis
- Teal Duck
- Whiskered Tern
- White Faced Heron
- White Ibis
- Yellow Billed Spoonbill

4d. Research and On-Ground Works

Some key research and on-ground works undertaken in the Loddon system during the 2008/09 season included:

- Acid Sulphate Soils: identification and preliminary investigation in Reach 4 of the Loddon River (between Loddon Weir and Kerang Weir), and subsequent Acid Sulphate Soil Assessment of the Lower Loddon River and Burnt Creek, Central Victoria (CSIRO, 2009)
- Lake Yando channel outfall upgrade: North Central CMA and G-MW jointly undertook planning and implementation of an upgrade to the delivery capacity to Lake Yando. This upgrade increased the channel outfall capacity to the wetland from 6ML/day to 35Ml/day, resulting in a decrease of minimum filling duration of the wetland from 72 days to 12 days.
- Loddon Stressed River Restoration Project:
    - Revision of Loddon River Restoration Plan to fill knowledge gaps
    - Development of a Community Engagement Plan to renew community enthusiasm

- Development and implementation of a Monitoring, Evaluation, Review and Improvement (MERI) Plan to build on work site monitoring
- Continuation of works to improve native fish habitat and migratory opportunities
- On-ground works component has delivered 25km of fencing the main stem of the Loddon and important tributaries; established eight off-stream watering points; 17ha of revegetation (direct seeding and tubestock); and 1ha of willow management.

5. 2009/10 Scenario Planning

5a. Water Resources

The availability of irrigation allocations for the 2008/09 season in the Loddon system will rely entirely on inflows from winter and spring rainfalls. July, August, September and October are usually the peak inflow months, therefore there is potential for an irrigation allocation to be made in the Loddon System so long as the system receives substantial inflows which will ensure that water can be supplied for essential human needs.

The current combined volume of water in the three Loddon storages (Cairn Curran, Tullaroop and Laanecoorie Reservoirs) is approximately 6,000ML (as at June 2009). The combined total capacity of these storages is 228,020ML.

As at the June 2009, the balances of the environmental water accounts on the Loddon System are as follows:

- Loddon System Withheld Flows Account: ~ 2,800ML
- Deficit and Reimbursement Account: 25,000ML (account cap has been reached)
- Boort District Wetland Entitlement: 0ML (Entitlement availability is reliant on irrigation allocation being made).

Whilst the accounts described above are provided for use in the Loddon System for environmental purposes, the water ‘contained’ in them is not always available for immediate use. Certain trigger levels must be reached before water in the accounts becomes available for use (e.g. no water held in the Deficit and Reimbursement Account will become available for environmental use until a 100% irrigation allocation is made in the Loddon System). This will be explored further in the following sections under the scenario planning for 2009/10. Consideration also needs to be given to where the water is held in storage. For example, environmental water in the Loddon System Withheld Flows Account is held in Cairn Curran Reservoir and as such may not be easily available for use in the area around Serpentine and Loddon Weirs.

As at July 1 2009, total water resources held in Loddon storages were as follows:

- Cairn Curran Reservoir (Figure 14) – 2,665ML (2% capacity)
- Tullaroop Reservoir – 2,886ML (4% capacity)
- Laanecoorie Reservoir – 345ML (4% capacity)

Without significant inflows into the system over the winter/spring of 2009, it is likely that these water resources will be insufficient to provide any irrigation allocation at the start of the 2009/10 irrigation season.

Figure 14. Cairn Curran Reservoir, May 27 2009

5b. G-MW Dry Inflow Contingency Planning

Goulburn-Murray Water has developed four scenarios which are based on annual volumes and an assessment of the possible Loddon System operations and likely recipients under continued dry conditions in 2009/10 (G-MW, 2009). This planning resulted in a Dry Inflow Contingency Plan (DICP) containing four forecast scenarios likely to impact on G-MW's water operations (repeat of 2006/07 inflows, 99% probability of exceedance inflows (POE), 95% POE and 90% POE). POE represents the percentage of years that the inflow volumes to the Loddon System would be exceeded based on the historic record of inflows to the system.

The DICP is formulated to plan for the worst case scenarios in the coming season to ensure that the water corporations have made adequate planning provisions. The scenarios were developed in January 2009 and are based upon 118 years of inflow statistics held by G-MW. It does not imply the probabilities of each scenario occurring, and does not account for the seasonal variation of inflows and demands.

These inflow scenarios have been used as a base from which to plan environmental water use in the 2009/10 season in the following sections.

5c. Reach-by-reach scenario planning

The overall aim of the Annual Watering Plan is to ensure that the Environmental Water Reserve for the 2009/2010 season is adequately planned, covering a range of possibilities from drought conditions through to a year with an irrigation allocation of greater than 100%. The scenarios define how environmental water will be managed under specific water resource availability possibilities and highlights how management should change as more water comes available. Five scenarios have been developed for planning purposes under the following headings:

- Scenario 1 – Drought (Repeat of 2006/07)
- Scenario 2 – Very Dry
- Scenario 3 – Dry
- Scenario 4 – Return to 100% Allocation
- Scenario 5 - Wet

As the season unfolds, the availability of environmental water is not directly correlated to inflow. Due to the Qualification of Rights, environmental water becomes available at set trigger points, resulting in step changes for water availability. The scenarios are not intended to be prescriptive, rather they set broad management principals and targets to guide environmental water management as the season unfolds.

With Loddon System water storages at extremely low levels, the river flows in 2009/10 are predominantly dependent on rainfall and associated inflows in the coming winter/spring. As a result, conditions will change over time and environmental flow management will need to respond to what actually happens in the system. An adaptive approach to the use of the Environmental Water Reserve for the Loddon River and Boort District Wetlands has therefore been incorporated into this plan.

To plan for the range of possible climatic conditions in the Loddon River and Boort District Wetlands, five system scenarios have been developed. These scenarios are based on the four scenarios developed as part of the Northern Victorian Dry Inflow Contingency Planning scenarios (DICP) (G-MW 2009), with one additional scenario included which describes responses to higher inflow rates.

A scientific panel was convened to provide guidance on how to best manage the environmental impacts of the drought through the use of environmental water in the Loddon River catchment. The specific role of this group, and key findings were provided earlier in this document (refer to section 3d).

The environmental water availability for each of the three environmental accounts/entitlements currently in operation in the Loddon System are shown in Figure 15, Figure 16 and Figure 17. These are used in planning for environmental water use in the Loddon System. The possible management of unregulated flows (e.g. from rainfall events) in the Loddon River is also planned

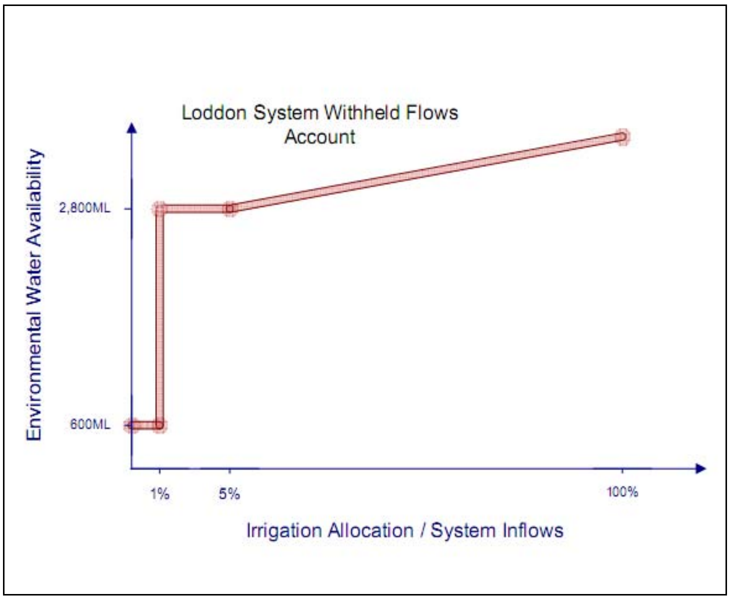


Figure 15. Environmental water availability in the LSWFA according to irrigation allocation on the Loddon System

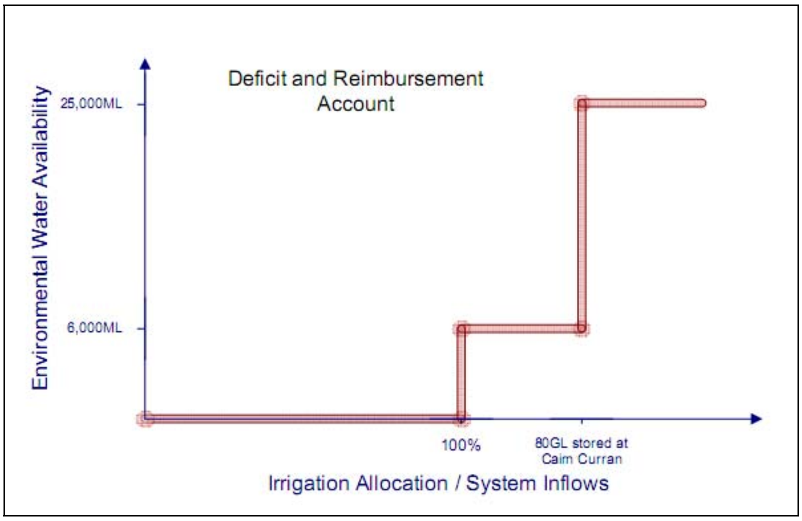


Figure 16. Environmental water availability in the Deficit and Reimbursement Account according to irrigation allocation and system inflows on the Loddon System

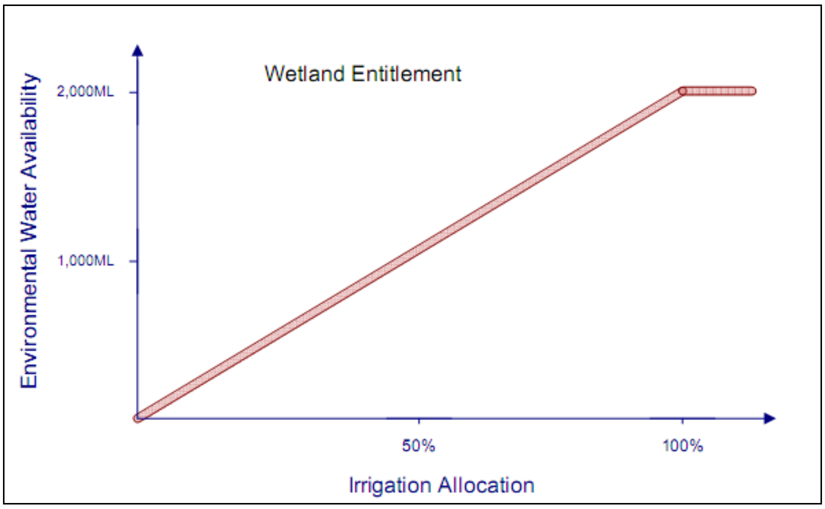


Figure 17. Environmental water availability in the Wetland Entitlement according to irrigation allocation on the Loddon System

This scenario planning explicitly acknowledges the ambiguity and uncertainty in the water resource outlook for the Loddon System. These scenarios are not predictions. Rather, they represent a plausible range of possible futures.

5c. i. Scenario 1 – Drought (Repeat of 2006/07)

This scenario is based on the inflow volumes received in the Loddon River catchment during the 2006/07 season, added to the volumes of water currently in storage. 2006/07 was the driest inflow season on record and as such, provides some guidance on what may be expected in the worst case scenario.

Under this scenario there will be no irrigation allocation provided to irrigators in the Loddon system. The 2009/10 – 2010/11 Qualification of Rights will be in operation and there will be minimal environmental water available for use. 600ML is available from the Loddon System Withheld Flow Account. This water is held in Cairn Curran Reservoir and can only be used in the Loddon River between Cairn Curran and Laanecoorie Reservoirs, and between Laanecoorie Reservoir and Bridgewater. There is opportunity to transfer this water into the Wetland Entitlement for use in Boort District Wetland, however this could only be done if the Loddon River is sufficiently wet to allow the transfer of water through to Loddon Weir without significant losses being incurred.

The water available under this scenario is insufficient to maintain any river flows for the whole year. The priority water supply objective is to supply the towns of Bridgewater, Inglewood, Dunolly and Laanecoorie. These are all supplied from the river in the reach between Laanecoorie and Bridgewater. Intermittent releases from Laanecoorie Reservoir would be made over the year to keep Bridgewater Weir pool topped up.

The result of this will be that Reach 1 (Cairn Curran to Laanecoorie Reservoirs) will be used as a transport route to move water between the two reservoirs, in essence providing a low flow to the reach during September/October, with no flow for the remainder of the year.

Approximately half of Reach 3a (Laanecoorie Reservoir to Serpentine Weir) will contain water (from Laanecoorie Reservoir to Bridgewater Weir) in order to supply Bridgewater township. There will be periods of no flow, with occasional low flow releases filling pools along the river. The remainder of this reach (below Bridgewater Weir) will have no flow, and the pools will dry over the season.

While the river operation will not explicitly target environmental values in the upper section of Reach 3a, it aligns with environmental priorities for the river under a continuing drought scenario. Reach 3a contains some of the highest environmental values along the Loddon River, and will have the most flow of any reach. More importantly, the scientific panel discussed the need to maintain large, deep pools of water during drought. These areas provide the best habitat in the river for flora and fauna species to seek refuge while other areas of the river dry out. Through the maintenance of Bridgewater weir pool to enable water extraction for town supply, this weir pool will contain water for the whole season which will additionally maintain this area for drought refuge (see Figure 18).

Reach 3b (from Serpentine Weir to Loddon Weir) will have no flow through the season. However, the weir pool of Loddon Weir will be maintained by water moving though the landscape from the Goulburn River in the east, though Loddon Weir and out to the Boort Irrigation Area to the west via the Waranga Western Channel. Water contained in the Loddon Weir pool will therefore not be Loddon water as such, but Goulburn water.

Reach 4 of the Loddon River (Loddon Weir to Kerang Weir) will remain dry under this scenario. This is consistent with the desired management of the newly identified problem of acid sulphate soils identified in this reach. While more knowledge about how to manage these soils is required, management in the immediate future is focused on keeping the soils dry, or submerging them for an extended period of time (preferably two years).

If a significant rainfall event occurs in the 2009/10 season and provides unregulated flows over a short-term period in the river (particularly if they threaten to overtop Loddon Weir), there will be a need to divert water from the river system to ensure Reach 4 remains dry. These unregulated flows should be diverted for use in the Boort District Wetlands and depending on the volume, timing and previous watering of each wetland, will follow the Boort District Wetland prioritisation as discussed in Section 3.

The preferred use of the 600ML of water available from the LSWFA under this scenario is to water a wetland in the Boort District Wetland group if water can be transferred from Cairn Curran/Laanecoorie Reservoir. If not, the water will be used to support flows in Reach 3a (Laanecoorie Reservoir to Serpentine Weir). In particular, the water will be used to minimise water quality problems where this is possible.

Reach 2 (Tullaroop Creek) will be operated as per the Tullaroop Creek Adaptive Drought Management Program (North Central CMA 2008). Under this scenario, water will be provided to ensure critical human uses are met, and it is unlikely that there will be a significant volume of water available to specifically target environmental values for the whole season. Under the Tullaroop Creek Qualification of Rights, there may be some water available for the reach from carryover water from the previous Qualification period (2007/08 – 2008/09) but this volume is likely to be minimal. So long as the total volume of water in storage is less than 10,000ML and an irrigation allocation will not be made, the entitlement of the environment to environmental flows remains suspended. Another trigger level enabling some use of water in the reach will be met on November 1 2009 so long as certain storage levels in Tullaroop Reservoir are reached. These levels will not be reached under this scenario.

Table 6 shows the river system operations and environmental water use expected under Scenario 1 while Table 11 shows overall system operations (under all scenarios) and Table 12 shows Boort District Wetland prioritisation.

Figure 18. Bridgewater Weir pool, May 27 2009

Table 6. Loddon System operations under Scenario 1 – Drought

Loddon System Reach	REACH 1: Cairn Curran to Laanecoorie Reservoir	REACH 2: Tullaroop to Laanecoorie Reservoir	REACH 3a: Laanecoorie Reservoir to Serpentine Weir	REACH 3b: Serpentine Weir to Loddon Weir	REACH 4: Loddon Weir to Kerang Weir	Boort District Wetlands
Key Reach Characteristics	Channel in-filled, lack of pools and some bank notching. Little instream woody habitat and five native fish species expected (incl. historical records of River blackfish)	Complex morphology present in reach with high levels of instream woody habitat. Four native fish species expected (incl. River blackfish)	Channel unstable and high levels of instream woody habitat. Four native fish species expected (incl. past distribution of Silver perch). Drought refuge provided by Bridgewater and Serpentine Weir pools.	Moderate reversal of seasonal flows and unnatural cease to flow periods. Aggradation of the channel and moderate woody habitat instream. Four native fish species expected (incl. past distribution of Silver perch). Drought refuge provided by Loddon Weir pool.	Risk of Acid Sulphate Soils in reach and flows reduced all year. Excessive siltation and growth of instream vegetation (phragmites, cumbungi and River Red Gum). Moderate – high instream woody habitat. Potential for high native fish diversity.	Little Lake Boort (priority drought refuge in absence of other flooded areas). Lake Yando (Priority 1). Lake Leaghur (Priority 2). Little Lake Meran (Priority 3). Lake Mean (use water to top up after flood event). Lake Boort (use water to top up after flood event).
Environmental Water Flexibility	600ML of Loddon System Withheld Flows Account available (however may not be able to utilise in the system) Deficit and Reimbursement Account unavailable Wetland Entitlement unavailable Minor unregulated flows at Loddon Weir Environmental releases from Tullaroop Reservoir until October 31, 2009					
Reach Operations	Transfer of water from Cairn Curran to Laanecoorie via Reach 1	Water provided to supply Maryborough for some of season	River operated between Laanecoorie Reservoir and Bridgewater Weir (no water below Bridgewater)	No river operation	No river operation	Possibility of transferring 600ML from LSWFA to Wetland Entitlement for wetland delivery (if water can be transferred to Loddon Weir) Harvest unregulated flows for wetland use
Environmental Water Use	No environmental water available	Minimal environmental water to maintain values after October 31	If unable to supply wetland from Boort District Wetlands, add flow to reach to management water quality and maintain habitat	No environmental water available	Reach to be kept dry (divert any unregulated flows to Boort District Wetlands)	

5c. ii. Scenario 2 – Very Dry

The main difference between this scenario and Scenario 1 is that there is slightly more water available in the system for use by towns, irrigators and the environment, and assumes that a 1% allocation is available in the Loddon System. At a 1% HRWS allocation in the Loddon system, the total volume of the Loddon Weir/System Withheld Flows Account (LW/SWFA) as at July 1, 2009 becomes available for use for environmental purposes (approximately 2,800ML).

It is unlikely that water will be transported on mass from Cairn Curran to Laanecoorie under this scenario which will mean there will be a low, steady flow through Reach 1 (Cairn Curran to Laanecoorie Reservoir) throughout the season. This reach is not as high priority as other reaches in the system from an environmental perspective so environmental releases will not be targeted in this reach.

Reach 3a will receive a steady low flow throughout the season with the aim of providing water through the whole reach between Laanecoorie Reservoir and Serpentine Weir. This will provide water to both Bridgwater and Serpentine Weir pools, increasing the available habitat for flora and fauna species.

Reach 3b (Serpentine Weir to Loddon Weir) will also receive an intermittent and very low base flow through the whole reach to provide water between Serpentine Weir and Loddon Weir.

At this stage there will be river flow from Cairn Curran Reservoir to Loddon Weir. Reach 4 (Loddon Weir to Kerang Weir) will still remain dry under this scenario. Once again there will be a need to manage any unregulated flows resulting from rainfall events to ensure Reach 4 remains dry, and these flows will likely be directed to the Boort District Wetlands.

There is an option under the Qualification of Rights which will allow up to 2,000ML of water to be transferred from the LSWFA into the Wetland Entitlement account. This means that up to 2,000ML (plus any unregulated flows) could be available for use in any of the Boort District Wetlands over the season (according to the wetland prioritisation). This clause has been included in the current Qualification of Rights due to the need to keep Reach 4 dry under this scenario, and the priority of providing water to the Boort District Wetlands.

In addition, when an allocation occurs on the Loddon System, water becomes available for use from the Wetland Entitlement. A total of 2,000ML is contained in this entitlement which becomes available at 100% allocation. At a 1% allocation 20ML is available for use.

With some baseflow being provided from Cairn Curran to Loddon Weir, the next environmental objectives are to maintain water quality and provide a September/October fresh in Reach 3a to clean accumulated sediment from the bed and improve macroinvertebrate habitat. Water from the LSWFA can be used to provide a fresh through these reaches of at least 52ML/day for 13 days (plus flows rising and falling) which would require approximately 650ML. Some of this water would continue to flow through to Loddon Weir and could be used to for a wetland watering event.

If this water delivery is undertaken, there would be approximately 1,000ML remaining in the LSWFA which would be used to manage any water quality issues in the river during summer, and approximately another 1,000ML will be available to transfer to the Wetland Entitlement in order to water Boort District Wetlands (according to wetland priorities).

Management of water held in the LSWFA will be dependent on the timing of inflows into the Loddon System, and therefore, when the 1% allocation is made. Freshes and wetland watering events would ideally be made in winter/spring of the 2009/10 season and any water remaining in the LSWFA at the end of the 2009/10 season would be reserved for use in 2010/11.

Reach 2 (Tullaroop Creek) will again be operated as per the Adaptive Drought Management Program. There will be slightly more water available for use in the creek under this scenario, which will be managed as per the Program.

Table 7 shows river system operations and environmental water use expected under Scenario 2 while Table 11 shows overall system operations (under all scenarios) and Table 12 shows Boort District Wetland prioritisation.

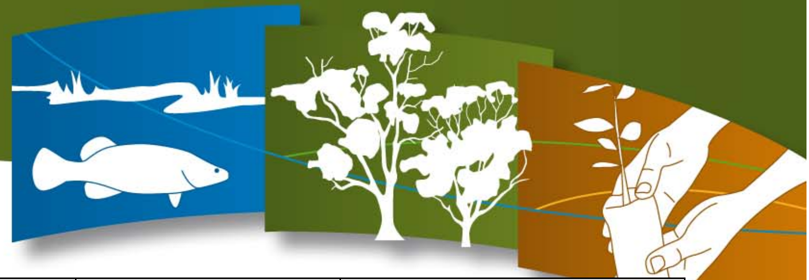


Table 7. Loddon System operations under Scenario 2 – Very Dry

Loddon System Reach	REACH 1: Cairn Curran to Laanecoorie Reservoir	REACH 2: Tullaroop to Laanecoorie Reservoir	REACH 3a: Laanecoorie Reservoir to Serpentine Weir	REACH 3b: Serpentine Weir to Loddon Weir	REACH 4: Loddon Weir to Kerang Weir	Boort District Wetlands
Key Reach Characteristics	Channel in-filled, lack of pools and some bank notching. Little instream woody habitat and five native fish species expected (incl. historical records of River blackfish)	Complex morphology present in reach with high levels of instream woody habitat. Four native fish species expected (incl. River blackfish)	Channel unstable and high levels of instream woody habitat. Four native fish species expected (incl. past distribution of Silver perch). Drought refuge provided by Bridgewater and Serpentine Weir pools.	Moderate reversal of seasonal flows and unnatural cease to flow periods. Aggradation of the channel and moderate woody habitat instream. Four native fish species expected (incl. past distribution of Silver perch). Drought refuge provided by Loddon Weir pool.	Risk of Acid Sulphate Soils in reach and flows reduced all year. Excessive siltation and growth of instream vegetation (phragmites, cumbungi and River Red Gum). Moderate – high instream woody habitat. Potential for high native fish diversity	Lake Yando (Priority 1). Lake Leaghur (Priority 2). Little Lake Meran (Priority 3). Lake Mean (use water to top up after flood event). Lake Boort (use water to top up after flood event). Little Lake Boort (drought refuge in absence of other flooded areas).
Environmental Water Flexibility	2,800ML of Loddon System Withheld Flows Account available (able to transfer up to 2,000ML into Wetland Entitlement)					
	Deficit and Reimbursement Account unavailable					
	20ML (1%) of Wetland Entitlement available					
	Small unregulated flows at Loddon Weir					
	Environmental releases from Tullaroop Reservoir for the whole season					
Reach Operations	Steady low flows provided throughout season	Steady very low flows provided throughout the season	Steady low flows provided throughout season	Steady very low flows provided throughout season	No river operation	Some water transferred from LSWFA to Wetland Entitlement and unregulated flows diverted to wetlands according to priorities (Table 12)
Environmental Water Use	No environmental water allocated to reach	Environmental water managed as per Adaptive Drought Management Program	Provide fresh(es) and hold water to respond to water quality issues	No environmental water allocated specifically to reach (however water from Reach 3a and wetland water flow through reach)	Reach to be kept dry (divert any unregulated flows to Boort District Wetlands)	

5c. iii. Scenario 3 – Dry

Under this scenario there is likely to be at least a 5% HRWS allocation for the Loddon System. The total volume of the LSWFA is available for use in the system (approximately 2,800ML). In addition to this volume, the 2009/10 flows withheld will be accounted for and available for use.

As in Scenario 2, there will be uninterrupted flows between Cairn Curran Reservoir and Loddon Weir. The priority for environmental water once the whole of this river length contains a baseflow will be to add freshes to Reach 3a (Laanecoorie Reservoir to Serpentine Weir). The target of these freshes will be to remove accumulated sediments and biofilms in order to improve the habitat and abundance of macroinvertebrates in this reach. The reason for targeting this component of the reach habitat is to ensure that adequate food is available for fish populations, with an attempt to improve the survival and condition of individuals in the reach.

If further water is available for use in the system, the next priority will be to provide freshes to Reach 3b (Serpentine Weir to Loddon Weir) with a similar objective to that described in Reach 3a (Laanecoorie Reservoir to Serpentine Weir).

Once again, as overall inflows to the system are relatively low, there will be a need to maintain the dry condition of Reach 4 (Loddon Weir to Kerang Weir) under this scenario, as was discussed in the previous scenarios.

With increasing irrigation allocation, there will be an increase in the water available for use from the wetland entitlement. Under a 5% irrigation allocation, 100ML becomes available and up to 2,000ML will again be able to be transferred from the LSWFA into the Wetland Entitlement. However, it is unlikely that the full amount will be transferred as there will be freshes provided in Reach 3a, with water provided for these events also originating from the LSWFA.

Depending on the timing of the 5% allocation being made in winter/spring, at least one fresh would be provided in Reach 3a (~650ML) which may be increased to provide a reasonable flow rate through Reach 3b. Approximately 1,000ML would be reserved to manage any water quality problems with another 1,000ML available for transfer into the Wetland Entitlement and use in the Boort District Wetlands. The remaining LSWFA water will be reserved for 2010/11.

Reach 2 (Tullaroop Creek) will again be operated as per the Adaptive Drought Management Program. There will be slightly more water available for use in the creek under this scenario, which will be managed as per the Program.

Table 8 shows river system operations and environmental water use expected under Scenario 3 while Table 11 shows overall system operations (under all scenarios) and Table 12 shows Boort District Wetland prioritisation.

Table 8. Loddon System operations under Scenario 3 – Dry

Loddon System Reach	REACH 1: Cairn Curran to Laanecoorie Reservoir	REACH 2: Tullaroop to Laanecoorie Reservoir	REACH 3a: Laanecoorie Reservoir to Serpentine Weir	REACH 3b: Serpentine Weir to Loddon Weir	REACH 4: Loddon Weir to Kerang Weir	Boort District Wetlands
Key Reach Characteristics	Channel in-filled, lack of pools and some bank notching. Little instream woody habitat and five native fish species expected (incl. historical records of River blackfish)	Complex morphology present in reach with high levels of instream woody habitat. Four native fish species expected (incl. River blackfish)	Channel unstable and high levels of instream woody habitat. Four native fish species expected (incl. past distribution of Silver perch). Drought refuge provided by Bridgewater and Serpentine Weir pools.	Moderate reversal of seasonal flows and unnatural cease to flow periods. Aggradation of the channel and moderate woody habitat instream. Four native fish species expected (incl. past distribution of Silver perch). Drought refuge provided by Loddon Weir pool.	Risk of Acid Sulphate Soils in reach and flows reduced all year. Excessive siltation and growth of instream vegetation (phragmites, cumbungi and River Red Gum). Moderate – high instream woody habitat. Potential for high native fish diversity	Lake Yando (Priority 1). Lake Leaghur (Priority 2). Little Lake Meran (Priority 3). Lake Mean (use water to top up after flood event). Lake Boort (use water to top up after flood event). Little Lake Boort (drought refuge in absence of other flooded areas).
Environmental Water Flexibility	2,800ML plus accrual of the volume of minimum flows withheld after 1 July 2009 (able to transfer up to 2,000ML into Wetland Entitlement)					
	Deficit and Reimbursement Account unavailable					
	100ML (5%) of Wetland Entitlement available					
	Small unregulated flows at Loddon Weir					
	Environmental releases from Tullaroop Reservoir for whole season					
Reach Operations	Steady low flows provided throughout season including some domestic and stock and irrigation flows provided for in spring, summer and autumn	Steady low flows provided throughout season including some domestic and stock and irrigation flows provided for in spring, summer and autumn	Some domestic and stock and irrigation flows provided for in spring, summer and autumn	Steady low flows provided throughout season	No river operation	Use of water from Wetland Entitlement as well as some water transferred from LSWFA to Wetland Entitlement and unregulated flows diverted to wetlands according to priorities (Table 12)
Environmental Water Use	No environmental water allocated to reach	Environmental water managed as per Adaptive Drought Management Program	Use of environmental water to provide freshes to reach	Potential to use some environmental water to provide freshes	Reach to be kept dry (divert any unregulated flows to Boort District Wetlands)	

5c. iv. Scenario 4 – Return to 100% Allocation

This scenario begins where good inflows are recorded in the system. Under this scenario there will be a HRWS irrigation allocation of 100% however it would still be a much drier year than a 'historically average year'.

6,000ML of water from the Deficit and Reimbursement Account becomes available for use under this scenario (when irrigation allocation reaches 100%). This water can be carried over for use in 2010/11. There would be significant inflows into the Loddon System, including significant unregulated flows at Loddon Weir.

The total volume of the LSWFA will be available for use in the Loddon System (2,800ML plus withheld passing flows recorded until the 100% allocation was declared). There is a possibility that once sufficient inflows are received in the Loddon System and water held in storage is deemed to be sufficient to meet on-going demand, the Minister for Water could revoke the Qualification of Rights. This would not happen until this scenario is reached and from an environmental water perspective, there would be a need to utilise as much water from the LSWFA as soon as practical as this account was set up under the Qualification of Rights and cannot be guaranteed once the Qualification expires (or is revoked).

Minimum passing flows and some river freshening flows will be provided for the river between Cairn Curran and Loddon Weir under this scenario after the 100% allocation has been declared, in accordance with those described in the Loddon System Bulk Entitlement.

Significant summer/autumn flows will occur in order to deliver irrigation entitlements and these would be adequate to meet environmental needs through Reach 1, 3a, and 3b (Cairn Curran Reservoir through to Loddon Weir), and there would be some winter/spring freshes. However, these freshes may not be large, and a release of LSWFA water may be required to provide desired fresh characteristics to target macroinvertebrate habitat.

In Reach 4 (Loddon Weir to Kerang Weir), the management objective at the start of the year will be to keep the reach dry. However, unregulated flows may exceed the ability to divert them, and some flow into Reach 4 could start to occur. At around 100% allocation, the management objective for Reach 4 changes from actively keeping it dry, to providing the normal environmental flow regime over the remaining 2009/10 season and for the full 2010/2011 season. If it is clear that the 100% allocation is going to be reached, the LSWFA water may be used before the 100% allocation is reached to start the normal flow regime earlier. The 6,000ML of water held in the Deficit and Reimbursement Account is to be reserved for use in 2010/11, ensuring that at least one year of minimum passing flows can be provided regardless of inflows into the Loddon System in the 2010/11 season.

At 100% irrigation allocation, 100% of the Wetland Entitlement will become available for use in the Boort District Wetlands (2,000ML). This entitlement can also be carried over for use in 2010/11, but the carryover volume is not available until the 2010/11 allocation also reaches 100%. Some unregulated flows at Loddon Weir would be diverted before the 100% allocation was reached, and transfer of LSWFA water into the Wetland Entitlement would again be available. Hence watering of several wetlands (according to wetland priorities) would occur under this scenario.

Under this scenario, Reach 2 (Tullaroop Creek) will be managed as per the provisions under the Loddon System Bulk Entitlement. It is likely that normal flows as well as river freshening flows will be provided throughout the reach.

Table 9 shows river system operations and environmental water use expected under Scenario 4 while Table 11 shows overall system operations (under all scenarios) and Table 12 shows Boort District Wetland prioritisation.

Table 9. Loddon System operations under Scenario 4 – Return to 100% Allocation

Loddon System Reach	REACH 1: Cairn Curran to Laanecoorie Reservoir	REACH 2: Tullaroop to Laanecoorie Reservoir	REACH 3a: Laanecoorie Reservoir to Serpentine Weir	REACH 3b: Serpentine Weir to Loddon Weir	REACH 4: Loddon Weir to Kerang Weir	Boort District Wetlands
Key Reach Characteristics	Channel in-filled, lack of pools and some bank notching. Little instream woody habitat and five native fish species expected (incl. historical records of River blackfish)	Complex morphology present in reach with high levels of instream woody habitat. Four native fish species expected (incl. River blackfish)	Channel unstable and high levels of instream woody habitat. Four native fish species expected (incl. past distribution of Silver perch). Drought refuge provided by Bridgewater and Serpentine Weir pools.	Moderate reversal of seasonal flows and unnatural cease to flow periods. Aggradation of the channel and moderate woody habitat instream. Four native fish species expected (incl. past distribution of Silver perch). Drought refuge provided by Loddon Weir pool.	Risk of Acid Sulphate Soils in reach and flows reduced all year. Excessive siltation and growth of instream vegetation (phragmites, cumbungi and River Red Gum). Moderate – high instream woody habitat. Potential for high native fish diversity	Lake Yando (Priority 1). Lake Leaghur (Priority 2). Little Lake Meran (Priority 3). Lake Mean (use water to top up after flood event). Lake Boort (use water to top up after flood event). Little Lake Boort (drought refuge in absence of other flooded areas).
Environmental Water Flexibility	BE flows restored and Loddon System Withheld flows account available					
	6,000ML of Deficit and Reimbursement Account available					
	2,000ML (100%) of Wetland Entitlement available					
	Significant unregulated flows at Loddon Weir					
Reach Operations	Significant irrigation flows	Significant irrigation flows	Significant irrigation flows	Some domestic and stock and irrigation flows	No river operation	
Environmental Water Use	Minimum passing flows and river freshening flows restored	Return to BE (minimum passing and river freshening flows restored)	Minimum passing flows and river freshening flows restored (may also need to provide winter/spring fresh from LSWFA)	Minimum passing flows and river freshening flows restored	Reach to be kept dry (divert any unregulated flows to Boort District Wetlands) until 100% allocation declared	Wetlands to receive unregulated flows, wetland water, and some LSWFA water to water wetlands according to priorities (Table 12)

5c. v. Scenario 5 – Wet

This scenario will occur if the Low Reliability Water Share (LRWS) allocation in the Loddon System is greater than 0%. It will also involve substantial unregulated flows occurring at Loddon Weir.

At this point everything remains similar to Scenario 4, however it is likely that there will be sufficient inflows and volumes in storage to guarantee an allocation of close to 100% in the 2010/11 season. There will also be confidence in the ability to provide minimum passing flows in Reach 4 (Loddon Weir to Kerang Weir) for the 2010/11 season.

Under this scenario it is likely that at least 80GL of water will be in storage in Cairn Curran Reservoir and as such, a further 19,000ML will be available for use from the Deficit and Reimbursement Account (the full 25,000ML will be available for use in the system). This water will be used to provide flushes in Reach 4, with a view to eventually provided a bankfull flow in the 2010/11 season.

It is likely that at least three wetlands of the Boort District Wetland group will be watered in 2009/10, with some water reserved in order to provide follow-up watering in 2010/11.

As discussed under Scenario 4, there may be a need to use utilise the water contained in the LSWFA relatively quickly if the Minister for Water revokes the Qualification of Rights for the Loddon Water System (meaning that this account will no longer be in operation).

In addition to the HRWS, there will be allocations made to Low Reliability Water Shareholders (LRWS) of between 1% and 100% (up to 2,105ML) in the Loddon System.

Reach 2 (Tullaroop Creek) will be managed in the same way as under Scenario 4. The provisions under the Loddon System Bulk Entitlement will be restored and it is likely that low flows as well as river freshening flows will be provided throughout the reach.

Table 10 shows river system operations and environmental water use expected under Scenario 5 while Table 11 shows overall system operations (under all scenarios) and Table 12 shows Boort District Wetland prioritisation.

Table 10. Loddon System operations under Scenario 5 – Wet

Loddon System Reach	REACH 1: Cairn Curran to Laanecoorie Reservoir	REACH 2: Tullaroop to Laanecoorie Reservoir	REACH 3a: Laanecoorie Reservoir to Serpentine Weir	REACH 3b: Serpentine Weir to Loddon Weir	REACH 4: Loddon Weir to Kerang Weir	Boort District Wetlands
Key Reach Characteristics	Channel in-filled, lack of pools and some bank notching. Little instream woody habitat and five native fish species expected (incl. historical records of River blackfish)	Complex morphology present in reach with high levels of instream woody habitat. Four native fish species expected (incl. River blackfish)	Channel unstable and high levels of instream woody habitat. Four native fish species expected (incl. past distribution of Silver perch). Drought refuge provided by Bridgewater and Serpentine Weir pools.	Moderate reversal of seasonal flows and unnatural cease to flow periods. Aggradation of the channel and moderate woody habitat instream. Four native fish species expected (incl. past distribution of Silver perch). Drought refuge provided by Loddon Weir pool.	Risk of Acid Sulphate Soils in reach and flows reduced all year. Excessive siltation and growth of instream vegetation (phragmites, cumbungi and River Red Gum). Moderate – high instream woody habitat. Potential for high native fish diversity	Lake Yando (Priority 1). Lake Leaghur (Priority 2). Little Lake Meran (Priority 3). Lake Mean (use water to top up after flood event). Lake Boort (use water to top up after flood event). Little Lake Boort (drought refuge in absence of other flooded areas).
Environmental Water Flexibility	BE flows restored and Loddon System Withheld flows account available 25,000ML of Deficit and Reimbursement account available 2,000ML (100%) of Wetland Entitlement available Some of the 2,105ML Loddon System Low Reliability Water Shares Unregulated flows at Loddon Weir					
Reach Operations	High domestic and stock and irrigation flows	High domestic and stock and irrigation flows	High domestic and stock and irrigation flows	High domestic and stock and irrigation flows	River not operated for consumptive purposes	Wetlands to receive water according to priorities (Table 12)
Environmental Water Use	Minimum passing flows and river freshening flows as per BE	Minimum passing and river freshening flows as per BE	Minimum passing flows and river freshening flows as per BE	Minimum passing flows and river freshening flows as per BE	Steady low flows provided during season (and adaptive management to occur in response to ASS)	

Table 11. Scenario description according to reach.

LODDON RIVER REACH	SCENARIO 1 DROUGHT	SCENARIO 2 VERY DRY	SCENARIO 3 DRY	SCENARIO 4 RETURN TO 100% Allocation	SCENARIO 5 WET
Irrigation Allocation (Assumed Trigger)	**0% HRWS allocation**	**1% HRWS allocation**	**5% HRWS allocation**	**100% HRWS allocation**	**Greater than 0% LRWS allocation**
Environmental Water Flexibility	600ML of Loddon System Withheld Flows Account available (however may not be able to utilise in the system)	2,800ML of Loddon System Withheld Flows Account available (able to transfer up to 2,000ML into Wetland Entitlement)	2,800ML plus accrual of the volume of minimum flows withheld after 1 July 2009 (able to transfer up to 2,000ML into Wetland Entitlement)	BE flows restored Loddon System Withheld flows account available	BE flows restored Loddon System Withheld flows account available
	Deficit and Reimbursement Account unavailable	Deficit and Reimbursement Account unavailable	Deficit and Reimbursement Account unavailable	6,000ML of Deficit and Reimbursement Account available	25,000ML of Deficit and Reimbursement account available
	Wetland Entitlement unavailable	20ML (1%) of Wetland Entitlement available	100ML (5%) of Wetland Entitlement available	2,000ML (100%) of Wetland Entitlement available	2,000ML (100%) of Wetland Entitlement available
	Minor unregulated flows at Loddon Weir	Small unregulated flows at Loddon Weir	Small unregulated flows at Loddon Weir	Significant unregulated flows at Loddon Weir	Some of the 2,105ML Loddon System Low Reliability Water Shares
	Environmental releases from Tullaroop Reservoir until October 31, 2009	Environmental releases from Tullaroop Reservoir for the whole season	Environmental releases from Tullaroop Reservoir for whole season		Unregulated flows at Loddon Weir
REACH 1: Cairn Curran to Laanecoorie Reservoir	Transfer of water from Cairn Curran to Laanecoorie via Reach 1	Steady low flows provided throughout season	Steady low flows provided throughout season including some domestic and stock and irrigation flows provided for in spring, summer and autumn	Significant irrigation flows	High domestic and stock and irrigation flows
	No environmental water available	No environmental water allocated to reach	No environmental water allocated to reach	Minimum passing flows and river freshening flows restored	Minimum passing flows and river freshening flows as per BE
REACH 2: Tullaroop to Laanecoorie Reservoir	Water provided to supply Maryborough for some of season	Steady very low flows provided throughout the season	Steady low flows provided throughout season including some domestic and stock and irrigation flows provided for in spring, summer and autumn	Significant irrigation flows	High domestic and stock and irrigation flows
	Minimal environmental water to maintain values after October 31	Environmental water managed as per Adaptive Drought Management Program	Environmental water managed as per Adaptive Drought Management Program	Return to BE (minimum passing and river freshening flows restored)	Minimum passing and river freshening flows as per BE
REACH 3a: Laanecoorie Reservoir to Serpentine Weir	River operated between Laanecoorie Reservoir and Bridgewater Weir (no water below Bridgewater)	Steady low flows provided throughout season	Some domestic and stock and irrigation flows provided for in spring, summer and autumn	Significant irrigation flows	High domestic and stock and irrigation flows
	If unable to supply wetland from Boort District Wetlands, add flow to reach to management water quality and maintain habitat	Provide fresh(es) and hold water to respond to water quality issues	Use of environmental water to provide freshes to reach	Minimum passing flows and river freshening flows restored (may also need to provide winter/spring fresh from LSWFA)	Minimum passing flows and river freshening flows as per BE
REACH 3b: Serpentine Weir to Loddon Weir	No river operation	Steady very low flows provided throughout season	Steady low flows provided throughout season	Some domestic and stock and irrigation flows	High domestic and stock and irrigation flows
	No environmental water available	No environmental water allocated specifically to reach (however water from Reach 3a and wetland water flow through reach)	Potential to use some environmental water to provide freshes	Minimum passing flows and river freshening flows restored	Minimum passing flows and river freshening flows as per BE
REACH 4: Loddon Weir to Kerang Weir	No river operation	No river operation	No river operation	No river operation	River not operated for consumptive purposes
	Reach to be kept dry (divert any unregulated flows to Boort District Wetlands)	Reach to be kept dry (divert any unregulated flows to Boort District Wetlands)	Reach to be kept dry (divert any unregulated flows to Boort District Wetlands)	Reach to be kept dry (divert any unregulated flows to Boort District Wetlands) until 100% allocation declared. Then normal environmental flows provided, and water from Deficit and Reimbursement Account reserved to provide normal flows in 2010/11	Steady low flows provided during season (and adaptive management to occur in response to ASS)
Boort District Wetlands	Possibility of transferring 600ML from LSWFA to Wetland Entitlement for wetland delivery (if water can be transferred to Loddon Weir) Harvest unregulated flows for wetland use	Some water transferred from LSWFA to Wetland Entitlement and unregulated flows diverted to wetlands according to priorities (Table 12)	Use of water from Wetland Entitlement as well as some water transferred from LSWFA to Wetland Entitlement and unregulated flows diverted to wetlands according to priorities (Table 12)	Wetlands to receive unregulated flows, wetland water, and some LSWFA water to water wetlands according to priorities (Table 12)	Wetlands to receive water according to priorities (Table 12)

Table 12. Boort District Wetland Prioritisation

WETLAND	Conservation Status	Rarity of Wetland Type (Bioregional significance – maximum score of 5)	Primary Usage of Wetland (current land status)	Required Hydrological Water Regime	Volume to adequately fill wetland (not including 'wetting up losses')	Timing (delivery and management regime)	Current Condition	Last watering event	Current Vegetation Condition	Additional management planning programs and works	Connection to floodplain	Ecological Prioritisation	Constraints to delivery of water
Lake Yando Shallow Freshwater Marsh	4 - High Bioregional Important Wetland	4	Wildlife Reserve Parks Victoria (PV)	Winter filling, dry in summer (Temporary – water for 6-8 months)	**427ML**	Late Winter / Spring or Autumn prime	DRY	1996	Vegetation stressed but remains healthy (resilience)	▪ Removed grazing ▪ Lowered full supply level ▪ Installed outlet structure	▪ Receives flood water from Venables Creek and in larger floods (rare) receives water from Kinypanial Creek via Lake Boort and Lake Lyndger. ▪ Gauge installed ▪ Water Supply: unregulated	Priority 1	▪ Diversion licences on lake need to be managed
Lake Leaghur Shallow Open Freshwater Marsh	4 - High Bioregional Important Wetland	5	Water Reserve G-MW/DSE	Winter filling, dry in summer (Temporary – water for 6-8 months)	**664ML**	Late Winter / Spring or Autumn prime	DRY (small leak from outfall channel)	2001	Vegetation stressed but remains healthy (resilience)	▪ Full supply level lowered ▪ Outlet structure installed	▪ Receives flood water from Venables Creek and Wandella Creek ▪ Gauge installed. ▪ Water Supply: regulated, fresh supply, non-irrigation.	Priority 2	▪ Delivery is restricted in the channel (outfall = 60ML/day) ▪ Diversion licences on lake need to be managed
Little Lake Meran Permanent Lake	3 - Moderate Bioregional Important Wetland	3	Water Reserve PV/G-MW	Water all year except during extreme drought (now)	**1,500ML**	Late Winter / Spring or Autumn prime	DRY Historically a permanent lake but likely to return to a seasonal/ ephemeral wetland	Dry since 1999	Fringing Red gums on high ground stressed Good variety of regeneration into the bed	▪ Groundwater bore network installed	▪ Cut off from Loddon Floodplain	Priority 3	▪ Delivery capacity available in channel during peak time equal to the outlet capacity - 20ML/d, allowing water to be delivered at any time of the year. ▪ Diversion licences on lake need to be managed
Lake Meran Permanent Open Freshwater	4 – High Bioregional Important Wetland	4	Lake Reserve Shire/DSE Committee of Management	Water all year except during drought	**9,400ML**	Late Winter / Spring or Autumn prime	DRY	1996 (Dry since 2002)	Fringing Red gums on high ground stressed Good variety of regeneration into the bed Athel Pine in bed of wetland	▪ Realignment of G-MW channel outfall (2004). ▪ Lake Meran: Fenced/protected 1/3 lake ▪ Grazing licences rationalised	▪ Receives water from Venables/Wandella Creek system ▪ Gauge installed. ▪ Water Supply - unregulated.	Top up flows after a Loddon Flood	▪ Insufficient WE volume to fill Lake Meran (top up) ▪ Diversion licences on lake need to be managed
Lake Boort Shallow Open Freshwater Marsh	4 – High Bioregional Important Wetland	4	Lake Reserve PV/G-MW	Winter filling, dry in summer (Temporary – water for 6-8 months)	**5,817ML**	Late Winter / Spring or Autumn prime	DRY	1996 (Dry since 1998)	Fringing Red gums on high ground stressed Good variety of regeneration into the bed	▪ Upgrade G-MW inlet ▪ Archaeological survey (PV) ▪ Biological control – Bridal Creeper	▪ Loddon River Floodwater via Kinypanial Creek, and off the Dryland Korong Vale and Wedderburn Catchments ▪ Gauge installed. ▪ Water Supply: unregulated.	Top up flows after a Loddon Flood	▪ Insufficient WE volume to fill ▪ Channel delivery capacity during peak is 0ML/d ▪ Diversion licences on lake need to be managed
Little Lake Boort Shallow Permanent Open Freshwater	4 – High Bioregional Important Wetland	5	Lake Reserve Loddon Shire/DSE Committee of Management	Permanent	**600ML**	Autumn prime to maintain drought refuge status	Winter Minimum Level (LLB Flushing Strategy)	April 2009	Lake holding water Aquatic plant regeneration	▪ Flushing channel and flushing pump installed (2004) ▪ Gauges installed	▪ Cut off from Loddon Floodplain	Drought Refuge in absence of other flooded areas	▪ Channel delivery capacity during peak is 0ML/d

6. Delivering the Environmental Water Reserve

6a. Managing Environmental Water through the Season

Table 11 shows overall system operations (under all scenarios) and Table 12 shows Boort District Wetland prioritisation.

The 2009/10 season will start under extremely dry conditions, with only 600ML of water from the LSWFA available and no river flow. As such, there are likely to be no environmental flow management decisions able to be made during the first two months of the season. Any unregulated flows arriving at Loddon Weir should be diverted to the first Boort wetland on the priority list, to keep the Loddon River below Loddon Weir dry.

By September/October 2009, inflows received in the Loddon System and the seasonal outlook will guide whether to transfer the 600ML of LSWFA water to the Wetland Entitlement for use in Boort District Wetlands, or whether this water will be used to provide a spring flush in Reach 3a.

Should an allocation of 100% HRWS be made on the Loddon System, flow diverting and harvesting at Loddon Weir for use in the Boort District Wetlands will stop and minimum passing flows will be reinstated below Loddon Weir. Unregulated flows escaping over Loddon Weir before this allocation level is reached will result in careful consideration as to whether the use LSWFA water should be used to continue these flows.

Should the Loddon System receive large inflow volumes during the season, the environmental value of using this water in the Boort District Wetlands during autumn (i.e. autumn watering events) will need to be determined and priorities set accordingly.

6b. Costs

The Environmental Water Manager does not have to make any payment for headworks costs relating to the Environmental Reserve BE. However, any additional delivery costs relating to the supply of the wetland entitlement where it is delivered through channel infrastructure will require payment.

6c. Notice Required

A notice period of 4 - 7 days is the agreed notice required for environmental water orders from Loddon storages to the Loddon River and the Boort District Wetlands.

If channel capacity and maintenance constraints are foreseen G-MW in making environmental water available, the Environmental Water Manager will be advised accordingly.

6d. Travel Time and Channel Capacity

Release from Cairn Curran and Tullaroop Reservoirs on the Loddon System may take up to 5-6 days to reach Loddon Weir, however this will be influenced by existing conditions in the channel and seasonal conditions.

The Environmental Reserve Bulk Entitlement (Schedule 3, clause 3.1) states that the wetland entitlement "*shall be supplied only when there is spare channel capacity available after meeting all the consumptive demands supplied from the system waterway*". Therefore the intended delivery times to wetlands in this AWP may change subject to consumptive demand.

Table 13 documents the minimum times that it could take to deliver enough water to fill (not taking into account evaporation or seepage) each of the key wetlands during both extremes of channel capacity - peak and off-peak (i.e. no other channel use therefore limited only by outfall capacity). These times are based on the maximum possible access to channel capacity. At different times during the year, available capacity will be less than those detailed in Table 13.

Table 13. ***Minimum days to fill the key wetlands during peak and off-peak (not taking into account evaporation or seepage).***

Wetland	ML	Delivery Capacity During Peak (ML/d)	Outfall Delivery Capacity (ML/d)	Min. Days to Deliver to Full (During Peak)	Min. Days to Deliver to Full (During Off-Peak)
Lake Yando	427	0	35	n/a	12
Lake Leaghur	664	0	60	n/a	11
Lake Meran	9,400	20	60	470	157
Little Lake Boort	300	0	80	n/a	4
Lake Boort	5,817	0	80	n/a	73
Little Lake Meran	1,500	20	20	75	75

7. Communication

It is important that the North Central CMA, as the manager of the Environmental Water Reserve, ensure all stakeholders are kept informed of its operational activities in relation to the release of water for environmental purposes through factual and prompt information.

The following primary and secondary audiences have been identified as requiring factual and prompt communication engagement.

- Primary audience - Bulk Entitlement holders and storage operators (Goulburn-Murray Water and Central Highlands Water) are to be informed of the North Central CMA's management of the Environmental Water Reserve and to ensure that consistent messages are delivered to the target audiences.
- Primary audience - Loddon Environmental Water Advisory Group. Members of this group assisted in the development of the Annual Watering Plan and are key community representatives in the Loddon System. They will be informed of the North Central CMA's management of the Environmental Water Reserve.
- Primary audience - diversion licence holders, farmers, irrigators, landholders etc. Individuals within this group have an entitlement to water to carry out their business activities and need to be informed of the North Central CMA's management of water for the river.
- Primary audience - the general community who use the water for recreational and social purposes. It is important this group are made aware of the role and functions of the North Central CMA as manager of the Environmental Water Reserve.
- Secondary audience – other stakeholders (DSE and DPI etc). Although already informed, they are an important group because the North Central CMA's activities require their input and support. They require continuing engagement with up to date information.

7a. Communication delivery channels

The delivery of our key messages will be via:

- Media releases - wherever practical these are to be joint releases with input from the North Central CMA and Goulburn-Murray Water. A media release should precede any environmental flow release.
- Advertising - to minimise the potential for key messages to be lost when media outlets editorialise media releases, paid advertisements are to be considered to supplement the release. This ensures balance is provided in the North Central CMA's community engagement of any environmental flow release.
- North Central CMA Website - all current and future proposed environmental flows will be displayed on the website and updated on a fortnightly basis. All media releases are also to be displayed.
- Community consultation – a copy of any media release is to be provided to any interested Loddon Environmental Water Advisory Group members to ensure they are informed and have up to date information that can be passed on to their local networks.

8. References

CSIRO, 2009. Acid Sulphate Soil Assessment of the Lower Loddon River and Burnt Creek, Central Victoria, Draft Report Version 1.4 (14/04/2009). CSIRO Land and Water Science Report 18/09

Department of Natural Resources and Environment (DNRE), 2002. Healthy Rivers, Healthy Communities & Regional Growth – Victorian River Health Strategy (RHS), East Melbourne, Victoria. Environment Australia (undated) National River Health Program.

Department of Sustainability and Environment (DSE), 2005a. State Water Report 2003-2004. A statement of Victorian water resources, Victorian Government, East Melbourne.

Department of Sustainability and Environment (DSE), 2004. Victorian Government White Paper, Our Water Our Future. Victorian Government, East Melbourne.

G-MW (2008) Goulburn-Murray Water Announces Water Allocations, Media Release, 1st July 2008.

G-MW (Unpub.) G-MW Allocation Forecasts. 1st July 2009.

Heron, S and Joyce, A., 2008. Northern Region Sustainable Water Strategy – Impact of water availability on significant wetlands. Report prepared for Department of Sustainability and Environment, Melbourne.

Humphries, P., 2006. (Unpub). Loddon-Campaspe Drought Response Options – Environmental Flow Management, prepared for the North Central CMA, Huntly, Victoria.

Loddon Environmental Water Advisory Group (2008) Meetings held on 3rd June and 15th July 2008, North Central Catchment Management Authority, Huntly, Victoria.

Loddon Bulk Entitlement Project Group (undated) Options for supply to Wetlands Issues Paper - Draft

Loddon River Environmental Flows Scientific Panel, 2002a. Environmental Flow Determination of the Loddon River Catchment: Final report. Unpublished Report to the North Central Catchment Management Authority and Department of Natural Resources and Environment.

Loddon River Environmental Flows Scientific Panel, 2002b. Environmental Flow Determination of the Loddon River Catchment: Issues paper. Unpublished Report to the North Central Catchment Management Authority and Department of Natural Resources and Environment.

Loddon River Environmental Flows Scientific Panel, 2005. Review of the Environmental Implications of the Draft Loddon River Bulk Entitlement. Unpub.

North Central CMA, 2008. Adaptive Management Program Tullaroop Creek 2008-2009. Huntly, Victoria

North Central CMA, 2007. Loddon River Annual Watering Plan 2007/08. Huntly, Victoria.

North Central CMA, 2007. Loddon Stressed Rivers Restoration Program, Case Study Review. Huntly, Victoria.

North Central CMA, 2006. Waterways of the North Central Region Catchment and Waterway Descriptions, Huntly, Victoria.

North Central CMA, 2006. Loddon River Environmental Operating Strategy, Huntly, Victoria

North Central CMA, 2005. North Central River Health Strategy, Huntly, Victoria

North Central CMA, 2003. Loddon Stressed Rivers Restoration Project, Huntly, Victoria.

Victorian Government, 2005.Bulk Entitlement (Loddon River – Environmental Reserve) Order, Victorian Government Gazette, Water Act 1989, Melbourne.

9. Appendix 1: Environmental Reserve Bulk Entitlement

Environmental Flow Schedule – Environmental Reserve BE

Reach	River Section	Storage Volume	ML/day	Type	Ecological Objective	Notes	Timing	Duration (days)	Frequency (per year)
1	**Loddon River** Cairn Curran Reservoir to Laanecoorie Reservoir	Not applicable	20 or natural	PF		Whichever is less	Nov to April	Continuous	
		>60,000 Combined storage volume of Cairn Curran and Tullaroop	35 or natural	PF		Whichever is less	May to Oct	Continuous	
		< or = 60,000 Combined storage volume of Cairn Curran and Tullaroop	20 or natural	PF		Whichever is less	May to Oct	Continuous	
		Not applicable	35	**Fresh**	Temporary movement of large fish, cleans biofilms, and entrains litter	Inclusive of minimum flow- this flow won't be provided if inflows are less	Nov to April	7	3
2	**Tullaroop Creek** Tullaroop Reservoir to Laanecoorie Reservoir	Not applicable	10 or natural	PF			Nov to April	Continuous	
			13.5	**Fresh**	Clean biofilms and stream bed	Inclusive of the 10 if natural flow is higher–this flow won't be provided if inflows are less	Nov to April	7	4
3a	**Loddon River** Laanecoorie Reservoir to Serpentine Weir	Not applicable	15 or natural	PF		Whichever is less	Nov to July	Continuous	
		>60,000 Combined storage volume of Cairn Curran and Tullaroop	52 or natural	PF		Whichever is less	Aug to Oct	Continuous	
		< or = 60,000 (Combined storage volume of Cairn Curran and Tullaroop)	15 or natural	PF		Whichever is less	Aug to Oct	Continuous	
		Not applicable	52	**Fresh**	Golden perch upstream movement to spawn	Inclusive of minimum flow- flow won't be provided if inflows are less	Nov to April	13	3

Cont.

Reach	River Section	Storage Volume	ML/day	Type	Ecological Objective	Notes	Timing	Duration (days)	Frequency (per year)
3b	**Loddon River** Serpentine Weir to Loddon Weir	Not applicable	19 or natural	PF		Whichever is less	Nov to April	Continuous	
		>60,000 (Combined storage volume of Cairn Curran and Tullaroop)	61 or natural	PF		Whichever is less	May to Oct		
		< or = 60,000 (Combined storage volume of Cairn Curran and Tullaroop)	19 or natural	PF		Whichever is less	May to Oct		
		Not applicable	61	**Fresh**	Golden perch upstream movement to spawn	Inclusive of minimum flow	Nov to April	11	3
4	**Loddon River** Loddon Weir to Kerang Weir	Not applicable	7-12 or natural (+ loss)	PF		Varied as slow rise and fall where possible	Nov to April		
		>60,000 (Combined storage volume of Cairn Curran and Tullaroop)	61 or natural	PF		Whichever is less, plus a flow equal to the loss	May to Oct		
		< or = 60,000 (Combined storage volume of Cairn Curran and Tullaroop)	10 or natural	PF		Whichever is less, plus a flow equal to the loss	May to Oct		
		Not applicable	50	**Fresh**	Attractant flow for Golden perch	Inclusive of minimum flow (+ loss)	Jan to Feb	14	1

10. Appendix 2: Boort District Wetlands Flooding History

Wetland	Total Volume (ML)	Supply Channel Number	Outfall capacity (ML/d)	Spare channel capacity during peak	Diversion licences (ML)	1990 (Jul-Dec)	1991 (Jan-Jun)	1991 (Jul-Dec)	1992 (Jan-Jun)	1992 (Jul-Dec)	1993 (Jan-Jun)	1993 (Jul-Dec)	1994 (Jan-Jun)	1994 (Jul-Dec)	1995 (Jan-Jun)	1995 (Jul-Dec)	1996 (Jan-Jun)	1996 (Jul-Dec)	1997 (Jan-Jun)	1997 (Jul-Dec)
Priority sites																				
Lake Boort	5,817	3	up to 80	0	74	Wetland full	Wetland half full	Wetland full	Wetland full	Wetland flooded	Wetland full	Wetland flooded	Wetland full	Wetland full	Wetland full	Wetland flooded	Wetland half full	Wetland flooded	Wetland half full	Wetland half full
Lake Yando	427	2/2	35	0	120	Wetland half full	Wetland dry	Wetland half full	Wetland half full	Wetland flooded	Wetland half full	Wetland flooded	Wetland half full	Wetland full	Wetland half full	Wetland flooded	Wetland full	Wetland flooded	Wetland half full	Wetland less than half full
Lake Leaghur	664	2/2	60	0	170	Wetland full	Wetland full	Wetland full	Wetland full	Wetland full	Wetland full	Wetland flooded	Wetland full	Wetland full	Wetland half full	Wetland flooded	Wetland full	Wetland flooded	Wetland half full	Wetland half full
Lake Meran	9,400	2	60	20	1457	Wetland full	Wetland full	Wetland flooded	Wetland full	Wetland flooded	Wetland full	Wetland full	Wetland full	Wetland full	Wetland half full	Wetland full	Wetland full	Wetland flooded	Wetland full	Wetland half full
Little Lake Meran	1,500	8/2	20	20	254	Wetland full	Wetland full	Wetland flooded	Wetland full	Wetland full	Wetland flooded	Wetland full	Wetland full	Wetland full	Wetland flooded	Wetland full	Wetland full	Wetland flooded	Wetland full	Wetland full
Secondary priority sites																				
Little Lake Boort	1,000	3	up to 80	0	0	Wetland full	Wetland full	Wetland full	Wetland full	Wetland full	Wetland full	Wetland half full	Wetland full	Wetland full	Wetland full	Wetland full	Wetland half full	Wetland full	Wetland full	Wetland full

Wetland	1998 (Jan-Jun)	1998 (Jul-Dec)	1999 (Jan-Jun)	1999 (Jul-Dec)	2000 (Jan-Jun)	2000 (Jul-Dec)	2001 (Jan-Jun)	2001 (Jul-Dec)	2002 (Jan-Jun)	2002 (Jul-Dec)	2003 (Jan-Jun)	2003 (Jul-Dec)	2004 (Jan-Jun)	2004 (Jul-Dec)	2005 (Jan-Jun)	2005 (Jul-Dec)	2006 (Jan-Jun)	2006 (Jul-Dec)	2007 (Jan-Jun)	2008 (Jul-Dec)	2009 (Jan-Jun)
Priority sites																					
Lake Boort	Wetland less than half full	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry
Lake Yando	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry
Lake Leaghur	Wetland less than half full	Wetland less than half full	Wetland less than half full	Wetland less than half full	Wetland less than half full	Wetland less than half full	Wetland less than half full	Wetland less than half full	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry
Lake Meran	Wetland half full	Wetland half full	Wetland less than half full	Wetland less than half full	Wetland less than half full	Wetland less than half full	Wetland less than half full	Wetland less than half full	Wetland less than half full	Wetland less than half full	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry
Little Lake Meran	Wetland half full	Wetland half full	Wetland less than half full	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry	Wetland dry
Secondary priority sites																					
Little Lake Boort	Wetland full	Wetland full	Wetland full	Wetland full	Wetland full	Wetland full	Wetland full	Wetland half full	Wetland less than half full	Wetland less than half full	Wetland less than half full	Wetland less than half full	Wetland less than half full	Wetland less than half full	Wetland less than half full	Wetland less than half full	Wetland full	Wetland half full	Wetland full	Wetland half full	Wetland half full

Environmental Watering Plan for the Macquarie Valley 2008/09

Environmental water releases in 2007/08

Two environmental water releases were made from Burrendong Dam in 2007/08. Heavy rainfall triggered the initial release of 12,952 ML of carryover account water commencing on the 4th January 2008. The delivery rate at Marebone Weir was 1200-1300 ML/d with water being directed to the southern and northern marsh. As a result of in-situ rainfall (270+ mm on 23rd December) and the first environmental release a colony of ~2000 egrets and cormorants established in the Northern Nature Reserve. The delivery of water to the marshes ceased at the beginning of February as the environmental account was drawn down to zero. However, a series of rainfall events in the marsh and several small tributary events were sufficient to sustain the bird colony throughout February.

A 5% allocation announcement was made on the 19th February and a second environmental release commenced flowing into the marshes on the 6th of March; taking sixteen days to travel between Burrendong Dam and Marebone Weir. The target delivery rate during the second release was 250 ML/d at Marebone with flows being directed down the Bulgeraga Creek to the Northern Marsh, with the express intent to maintain water under the breeding colony and in adjacent foraging areas for as long as possible. The second delivery totalled ~8700 ML and inflows to the marshes ceased on the 15th of April.

The combination of rainfall and environmental water releases resulted in inundation of between 6000 and 10000 hectares for a period of up to 4½ months over summer. The wet conditions over the mild summer resulted in good vegetation responses and the egret and cormorant colony was considered a successful breeding event with >90% fledging success, although the fate of juveniles after dispersal from the breeding site is not known.

Current condition of water dependent assets

Asset	Last watering [1]	Condition
Southern Nature Reserve	February 2008 (<10%, 30 days)	Poor; some good response in northern boundary area.
Northern Nature Reserve	April 2008 (<30%, 120 days)	Varies from good in wetter areas to large areas of dead red gum woodland in driest areas
Wilgara Ramsar site (Gum Cowal/Terrigal Creek system)	December 2007 (rainfall only)	Moderate
Monkey Swamp	February 2008 (<5%, <30 days)	Poor; critical reduction in extent and condition of water couch
Monkeygar Wetlands	April 2008 (>80%, 90 days)	Generally good although noticeable reduction in water couch area on margins.
Mole Marsh	April 2008 (>90%, 90 days)	Generally good although noticeable reduction in water couch area on margins.
Northern Marsh (north of NR)	January 2006 (<5%, rainfall only)	Critical – extensive areas of dead or stressed red gums has not been

		well watered since 2000
Buckiinguy Swamp	April 2008 (>80%, 60 days)	Generally good although noticeable reduction in water couch area on margins.
Long Plain Cowal	December 2007 (rainfall only)	Reasonable

[1] By any means – natural or managed

Water Management Arrangements for 2008/09

The Water Sharing Plan remains suspended under a Severe Water Shortage Order (WMA section 60). At the beginning of June 2008 there was sufficient water in storage to secure essential town water, domestic and high security supplies for two years. Therefore it is assumed that allocations to the environment will be in accordance with typical resource assessment procedures even while the WSP remains suspended. In addition it is anticipated that with the WSP suspended it will be possible to manage all environmental water as "active" account water.

Should drought conditions re-emerge during the year which results in critically low inflows to the major storages a return to drought contingency management (limiting environmental water availability) is possible. While the WSP remains suspended the EFRG will continue to advise the Minister on the management of environmental water as it becomes available: this includes the management of tributary events where a proportion of flows is available to the environment.

Volumes of environmental water available

The balance of the environmental water account is zero ML. The environment is entitled to a share of tributary flows in excess of that required to meet stock and domestic and town water supply requirements.

The water levels in the supply dams at the beginning of June 2008 are:

Windamere = 24% or 89,021 ML
Burrendong = 18.1% or 242,813 ML

Account	Maximum	Available 01/07/08
Planned Environmental Water	160,000 ML	0 ML
Carryover of PEW	0 ML	0 ML
Adaptive Environmental Water	13,852 ML	0 ML
Carryover of AEW	0 ML	0 ML
Supplementary Access	320 ML	0 ML

Likely environmental watering conditions

Estimated water availability for 2007/08

The following resource assessment scenarios provided by State Water are based on historical statistical inflows to Burrendong and Windamere Dams.

1. **Under drought conditions:** the 2008/09 allocation is likely to be at 0% [0 ML] until the end of October 2008 and remain at 0% [0 ML] by the end of January 2009. This is likely in 100% of years.
2. **Under dry conditions:** the 2008/09 allocation is likely to be at 6% [9600 ML] until the end of October 2008 and at 16% [25,600 ML] by the end of January 2009. This is likely in 70% of years.
3. **Under median conditions:** the 2008/09 allocation is likely to be at 31% [49,600 ML] until the end of October 2008 and at 54% [86,400 ML] by the end of January 2009. This is likely in 50% of years.
4. **Under wet conditions:** the 2008/09 allocation is likely to be at 63% [100,800 ML] until the end of October 2008 and at 92% [147,200 ML] by the end of January 2009. This is likely in 30% of years.

Water purchased for the environment will be managed in conjunction with planned environmental water. Water entitlement purchased for the environment as at 3rd June 2008 is 13,852 ML, by the end of June there may be 29,886 ML of general security adaptive environmental water entitlement held on the Macquarie. There is an additional 320 ML of Supplementary Water entitlement, which has been purchased in the Macquarie: this is expected to increase to 1257 ML by the end of June 2008.

Climate indicators forecast generally neutral to dry conditions (meaning scenarios 2&3 are more likely than 1 or 4) as we move into 2008/09.

Objectives for environmental water use for 2008/09

Macquarie and Effluent Creeks

Release of water from Burrendong

The Environmental Flows Reference Group (EFRG) considered the available water scenarios and climate indicators and agreed that environmental water management in the Macquarie in 2008/09 would most likely continue to focus on relieving drought conditions in the marshes. Clause 22(e) of the WSP allows releases of environmental water to be made at any time of year to alleviate severe drought conditions. Should climate alter markedly during the year management guidelines will be reviewed, however it is envisaged that the availability of increased volumes of water will generally not alter the primary objective to alleviate drought conditions. The EFRG has recommended the following thresholds to guide management of environmental flows in 2008/09. These thresholds have been set to trigger an assessment of the advisability of making a release and should not be interpreted to automatically trigger a release from Burrendong Dam. Recommendations to make a release must consider the on-ground conditions and forecast water availability at the time the nominated thresholds are reached.

1. Minimum of 40,000 ML (rainfall, trib flows, account water and purchased water) is required before considering the possibility of

releasing water from Burrendong Dam in an 'event-style' release pattern.
2. Minimum of 6000 ML (available in account and purchased water) is required before considering the possibility of releasing water from Burrendong Dam in a 'base-flow' release pattern.

Objectives

The first threshold is based on event-style management aimed at providing sufficient water to the core areas of the marsh to maintain habitat in semi-permanent wetland areas potentially in the southern, northern and eastern marsh, although the actual areas targeted will be determined by the specific circumstances of any triggering event.

The second threshold is based on reinstatement of base flows to the marshes aimed at maintaining soil moisture levels above critical levels in those parts of the marsh that benefited from environmental flows and seasonal rainfall (Summer-Autumn) in 2007/08. It was further recommended that this threshold might become redundant if not triggered before soil moisture levels fell in the target areas.

Tributary flows

Additional water for the environment arises from tributary flows in response to rainfall events. Tributary flows are divided into two categories:

1. Flows less than 5000 ML/d in excess of requirements at Warren and
2. Flows greater than 5000 ML/d in excess of requirements at Warren.

State Water typically use tributary flows to satisfy extractive needs where possible. Dam releases augment tributary flows to deliver stock, domestic, town water and irrigation supplies. Tributary flows in excess of extractive needs are generally available to the environment. Under the Water Sharing Plan tributary events that exceed 5000 ML/d at Warren are declared Supplementary events and water is made available to holders of Supplementary Water Access Licences.

Water from the tributaries in excess of requirements flow through to the Macquarie Marshes or if the peak of the event is large enough into floodplain creeks or onto the floodplain itself. State Water can exert some control over where excess tributary flows are directed. The EFRG has considered a means of prioritising areas to benefit from tributary flows should they occur (Appendix 1).

As government holds supplementary water licences on behalf of the environment, some consideration has been given to the management of such licences when supplementary events are declared. It is recommended that the environmental water manager place an order for the environment's share of all such events with consideration being given to supplying the available water to system targets identified by the procedures documented in Appendix 1.

Cudgegong

While Windamere remains below 110,000 ML (33%) in storage environmental releases are prohibited. At the commencement of the water year Windamere stands at 24% or 89,100 ML.

The EFRG has previously agreed that unless there is a compelling reason to alter them, the arrangements for environmental releases from Windamere should ensure that releases are made as frequently as possible. The default position described by the Water Sharing Plan imposes a target range of 150-1500 ML/d, which may be made at any time of year. The EFRG has proposed no alteration to the default position for the 2008/09 water year.

Risks and mitigating strategies

Risk	Rating	Response
Unpredictable weather – turns drier than expected	Medium (possible and moderate)	Review asset condition and future priorities for watering
Unpredictable weather – turns wetter than expected	High (possible and major)	Additional wetting opportunities possible – continually assess volumes available
Flow management is uncoordinated	Medium (possible and moderate)	Regular communication with EFRGG, DWE and State Water
Estimated flow target volumes are substantially wrong	Medium (unlikely and moderate)	Monitor flow delivery daily and seek adjustments; revise targets accordingly
Unforeseen physical impediments to flow delivery	Medium (rare and major)	Early communication with State Water; alert DWE compliance if obstructions identified; targeted surveillance is planned
Insufficient water available to complete colonial waterbird breeding, if initiated	High (likely and severe)	Early identification of breeding events and assessment of likely outcomes; reconsider flow rates and targets to improve likelihood of success; consider the purchase of temporary water allocations to complete event; manage expectations with comprehensive and regular communication
Germination and spread of Lippia	High (likely and moderate)	Limited opportunity; seek voluntary de-stocking to encourage native plant competition
Future watering opportunities compromised by full use of ECA during this water year	Medium (possible and minor)	Document trade-offs associated and discuss further with EFRG

Monitoring, reporting and revising

Monitoring as per RiverBank monitoring strategy for adaptive environmental water, and IMEF program for key wetland sites.

Reporting to

- Director, Water for the Environment, DECC: monthly update on conditions (climate, available environmental water) and weekly update during flow delivery events.
- EFRG: weekly/fortnightly update on conditions and flow delivery details. EFRG to be consulted if triggers for changes to this plan occur.
- Central West CMA: through EFRG representatives
- Macquarie Customer Services Committee: regular update at meetings.
- Broader community: update in E-water newsletter; press releases.

This plan is to be **revised** when conditions dictate. Triggers for revision will be sustained catchment or localised rainfall that produces significant flows in tributaries. Good communication with State Water and local community representatives will help clarify the timing and scale of revision.

Primary responsibility for identifying and reporting opportunities for revisions to this plan rests with DECC Senior Wetlands and Rivers Conservation Officer.

Prepared by: Debbie Love in consultation with Mike Maher

Position: SWaRCO North-West Branch, EPRG; SWaRCO, Water for the Environment Branch, CCPPG

Date: 31 July 2008

Approved by: Derek Rutherford

Signature:

Position: Director, Water for the Environment Branch, CCPPG

Date:

Appendix 1

SYSTEM TARGETS ARE NOT DEFINED BY ENVIRONMENTAL NEED: THEY MERELY REFLECT THE AREAS TO WHICH WATER CAN BE DIVERTED USING EXISTING INFRASTRUCTURE.

Environmental priorities will be assessed when environmental water becomes available (either as tributary flow or if there is improvement in water availability conditions) on the basis of the following principles[1]:

- State of long-lived, water-dependent vegetation;
- Waterbird breeding event;
- Crucial habitat maintenance (eg. Refugia);
- Opportunity to establish a useful connection for in-stream biota;
- Threatened species and communities (Appendix A,B and C);
- Ramsar sites;
- Time since last watered.

Table 1 will be used to document the assessment of environmental priorities on a case-by-case basis. Alongside an assessment of environmental priority, we need to consider the volume of water (and the rate and duration of an event) required to meet an environmental need. This is a difficult task as under the extremely dry circumstances experienced in the valley any volume of water that is not extracted from the river system has environmental value. With this in mind, this paper identifies the amount of water required to achieve an end-of-system flow in riparian systems and an approximate volume required to inundate floodplain environments (Table 2).

THIS DOES NOT IMPLY THAT AN END-OF-SYSTEM FLOW MEETS ENVIRONMENTAL NEED: RATHER IT MERELY PROVIDES A BENCHMARK AGAINST WHICH AVAILABLE VOLUMES MIGHT BE EVALUATED.

State Water has indicated that tributary events up to 250 ML/d will most likely be fully committed for domestic supplies. State Water will make an assessment of tributary inflows if and when they occur and will advise the EFRG of the likely rate and duration of flow

[1] These principles are not in order of importance nor are they intended to be prescriptive.

available for environmental purposes. The nature of tributary flows dictates that the EFRG will generally have between 3-5 days to advise State Water of preferred management of the environmental share.

The task for decision-makers will be to assess the areas to which water can be delivered against the environmental priorities.

Decisions will necessarily need to be made out-of-session and within a limited timeframe on a case-by-case basis. The decisions are complex and require trade-offs that may be contentious in the broader community. The EFRG has recommended that the operational sub-group of Rob McCutcheon (CMA), Debbie Love (DECC) and Sam Davis (DPI- Fisheries) will be responsible for assessing environmental priorities in conjunction with State Water on a case-by-case basis. It is anticipated that this sub-group will make recommendations to the Minister/DECC as it has in previous management of environmental flows.

Table 1: Criteria for assessment of environmental priorities

System	Vegetation	Crucial Habitat	Waterbirds	Connectivity	Threatened Species	Ramsar	Time since watered
Beleringar Creek (top end via River)						×	Nov 2005 Molong flood
Lower Beleringar Creek (via Albert priest channel)						×	Nov 2005 Molong flood June 2007
Ewenmar Creek						×	Nov 2005 Molong flood June 2007
Gunningbar Creek						×	June 2007 Regulated
Bogan River: Nyngan – G'ingbar confluence						×	Jan 2007 Surplus, APC & rainfall
Lower Bogan River ds G'ingbar confluence						×	March 2007 Surplus, APC & rainfall
Duck Creek						×	June 2007 Regulated

System	Vegetation	Crucial Habitat	Waterbirds	Connectivity	Threatened Species	Ramsar	Time since watered
Upper Crooked Creek						×	June 2007 Regulated
Lower Crooked Creek (via Mumblebone Channel)						×	2000 Flood
Marra Creek (via Marebone Weir)						×	May 2006 Replenish't
Macquarie River (between Warren & Marebone Weirs)						×	June 2007 Regulated T'bragar flow
Gum Cowal/Terrigal (via Marebone Break)						✓	Dec 2005 EF June 2007 T'bragar flow
Southern Marsh (via Macquarie River)						✓	Jan 2006 EF June 2007 T'bragar flow
Milmiland Creek						×	Jan 2006 EF June 2007 T'bragar flow
Lower Marra Creek (via Milmiland Creek)						×	Jan 2006 Environment flow
Northern Marsh (Western side)						✓	Jan 2007 S&D June 2007 T'bragar flow
Northern Marsh (Eastern side)						✓	Feb 2006 EF June 2007 T'bragar flow
Lower Macquarie via North Marsh						✓	Feb 2006 EF
Lower Macquarie River (via NMBC)						×	Feb 2006 EF

*Systems listed in order of location of off-take point from most upstream to furthest downstream

Table 2: Estimated end of system flow requirements and operational constraints assumed to support recommendations for management of environmental water

System	Water required for EOS flow		System constraints	Other
	Rate (ML/d)	Duration (d)		
Beleringar Creek (top end via River)			Needs >7000 ML/d at Gin Gin	Nov 2005 tributary flow probably did not fill entire section. Regulator illegally opened for period in June 2007 and several hundred megalitres diverted.
Lower Beleringar Creek (via Albert priest channel)	70	10	Albert Priest channel likely to be fully utilised for Nyngan town water supply	
Ewenmar Creek	80	10	Needs >4500 ML/d at Gin Gin via Reddenville	S&D replenishment normally pumped
Gunningbar Creek (incl. Duck and Crooked to Mumblebone Dam)	80-90	21		Target for domestic supply. Total reqd. into G'bar @ Warren would be ~250. (APC-80, Duck+Crooked+G'bar 90, Target for L.Bogan –80).
Bogan River: Nyngan – G'ingbar confluence	60-80	12-16	Albert Priest channel likely to be fully utilised for Nyngan town water supply	~1000 ML needed in total, the rate required varies
Lower Bogan River ds G'ingbar confluence	50-80	50-80	Would also deliver water to G'ingbar, Duck and Crooked Creek	Target for domestic supply ~4000 ML needed in total
Duck Creek	See Gunningbar			This section cannot be targeted separate to Gunningbar etc
Upper Crooked Creek	See Gunningbar			This section cannot be targeted separate to Gunningbar etc
Lower Crooked Creek below Mumblebone Dam (via Mumblebone Channel)			Total of 10,000 ML did not reach EOS	Usually requires large flood to run naturally.
Marra Creek (via Marebone Weir)including Lower Marra Creek	250	50-60	River between Warren and Marebone would need to be running and Marebone Weir would need to be full	Target for domestic supply. ~9000 ML needed in total

System	Water required for EOS flow		System constraints	Other
	Rate (ML/d)	Duration (d)		
Macquarie River (between Warren & Marebone Weirs)			Minimum estimate 800-1500 ML to re-wet river section between Warren and Marebone.	The area downstream of Marebone Weir will be isolated from regulated flow. All targets downstream of Warren have added consideration of re-establishing flow between Warren and Marebone Weirs.
Gum Cowal/Terrigal (via Marebone Break)	450	20	Channel capacity of Marebone Break ~500 ML/d	~9000 ML in total to wet whole system.
Southern Marsh (via Macquarie River)	1000-1500	60	Figures based on inflows during Nov-Dec 2005 environmental flow to provide equivalent inundation and spread	~60-90 GL required in Macquarie River downstream of Marebone Weir.
Milmiland Creek			This section does not receive replenishments. Operation of structure is guided by license conditions – administered by DWE.	Set to commence to flow when 500 ML/d at Oxley gauge unless period of 230 days without flow, when commence to flow might be reset to 100 ML/d at the written request of landholders. There is no requirement for this to close down once flows reach the Marra Creek.
Lower Marra Creek (via Milmiland Creek)		Long duration		Long duration is required to deliver water to the lower Marra (estimated 4000-5000 ML required in total).
Northern Marsh (via Southern Marsh)	750	65	Figures based on inflows during Nov-Dec 2005 environmental flow to provide equivalent inundation and spread	~50 GL required downstream of Pillicawarrina. Peak rate in 05/06 EF event was 1300 ML/d at Pillicawarrina.
Northern Marsh (via Bulgeraga Creek)	300 (max rate downstream of Bifurcation)	160	Flows in excess of 300 ML/d in the Bulgeraga Creek downstream of the Bifurcation are likely to result in scouring of the channel bed	160 days required at max rate of 300 ML/d to deliver 50GL (2005/06 EF event) but inflow rates might not result in same level of inundation and spread.

System	Water required for EOS flow		System constraints	Other
	Rate (ML/d)	Duration (d)		
Lower Macquarie via North Marsh			SWC would not normally deliver via this route. However, if the NMBC and Duck Swamp are dry and the Bora system is wet it might be equally efficient to put water through the Northern Marsh.	Some indication might be possible from flows entering the system following the Talbragar flow of June 2007.
Lower Macquarie River (via NMBC)	130	60		Target for domestic supply

Environmental Watering Plan for the Macquarie Valley 2009/10

Environmental water releases in 2008/09

There were no environmental water releases in 2008/09. At the commencement of the water year there was no water available in the environmental account. A total of 10% Available Water Determination (AWD) was made available between November 2008 and March 2009, providing just over 19,000 ML in the environmental account; made up of 16,000 ML of environmental water allowance (EWA) and 3,178 ML of NSW adaptive environmental water (AEW).

	AWD (%)	carryover	EWA	Usage	EWA account
Jul-08	0	0	0	0	0
Aug-08	0		0	0	0
Sep-08	0		0	0	0
Oct-08	0		0	0	0
Nov-08	1		1,600	0	1600
Dec-08	7		11,200	0	12800
Jan-09	0		0	0	12800
Feb-09	1		1,600	0	14400
Mar-09	1		1,600	0	16000
Apr-09	0		0	0	16000
May-09	0		0	0	16000
Jun-09					16000

No releases were made during the year as there were no rainfall or tributary events sufficiently large to supplement the water available from environmental accounts.

Current condition of water dependent assets

Asset	Last watering[1]	Condition[2]
Southern Nature Reserve	March 2008 (<10%, < 90 days)	The entire southern section of the MMNR has been invaded by chenopods. Remnant areas of river red gum and common reed are also affected. Remnant areas showed some response to water in 2008.
Northern Nature Reserve	April 2008 (<30%, 120 days; + 20%, <30 days) May 2009 (<5%, 60 days)	Varies from very good in wetter areas of reed and red gum woodland to large areas of dead red gum woodland and dead reed bed in driest areas. Large areas of the northern reserve are affected by chenopod invasion.
Gum Cowal / Terrigal Creek system	December 2007 (rainfall only)	Extensive areas of couch have been replaced by chenopod dominated grasslands. The red gum forest and woodland appears to be in good condition, though recent mapping shows chenopods in the understorey. This area benefited from summer rainfall which improved tree health markedly.
Monkey Swamp	February 2008 (60%, <120 days)	There has been a critical reduction in extent and condition of water couch and common reeds at this site. There are still extensive areas of mixed marsh vegetation and river red gum though chenopods have invaded these areas.
Monkeygar Wetlands	April 2008 (>80%, 120 days)	There has been a marked decrease in the area of common reed bed and a contraction of water couch area. There has been chenopod invasion of mixed marsh areas.
Mole Marsh	April 2008 (>90%, <90 days)	There has been a major reduction in area of mixed marsh/grassland on Mole Marsh and invasion of chenopods into previously wet areas and under red gum forests.
Northern Marsh (north of NR)	December 2007 (<5%, rainfall only)	The invasion of chenopods is extensive in this area of the marsh with roly poly and buck bush dominated groundcover in previously productive river red gum and coolabah woodlands and water couch and mixed marsh grasslands. Extensive areas of red gum forest are in very poor condition or dead.
Buckiinguy Swamp	April 2008 (60%, <90 days)	Extensive areas of water couch have been replaced by mixed marsh with co-dominant chenopods, while the central reed bed has also contracted in area and height.
Long Plain Cowal	December 2007 (rainfall only)	Extensive increase in chenopod dominance in grassland areas as well as areas previously mapped as wetland vegetation.

[1] Percentage areas are relative to maximum flooded extent of asset, which is similar in extent to the 2000 flood.
[2] These descriptions are based on 2008/2009 vegetation mapping and provide a comparison with mapping from 1991.

Water Management Arrangements for 2009/10

The Water Sharing Plan remains suspended under a Severe Water Shortage Order (WMA section 60). On the 1st July 2009 the Minister for Water announced a 0% Available Water Determination and 100% access to carryover water in 2009/10.

It is assumed that allocations to the environment will be in accordance with typical resource assessment procedures even while the WSP remains suspended. In addition it is anticipated that with the WSP suspended it will be possible to manage all environmental water as "active" account water.

Should drought conditions re-emerge during the year which results in critically low inflows to the major storages a return to drought contingency management (limiting environmental water availability) is unlikely with the current storage levels and forecast demand. While the WSP remains suspended the EFRG will continue to advise the Minister on the management of environmental water as it becomes available: this includes the management of tributary events where a proportion of flows is available to the environment.

Volume of environmental water available

The balance of the environmental water account is 19,178 ML; made up of 16,000 ML of environmental water allowance and 3,178 ML of adaptive environmental water. The environment is also entitled to a share of tributary flows in excess of that required to meet stock and domestic and town water supply requirements. The water levels in the supply dams at the beginning of July 2009 are:

Windamere = 22.3% or 82,812 ML
Burrendong = 19.0% or 252,238 ML

Account	Maximum	Available 01/07/09
Planned Environmental Water (PEW)	160,000 ML	0 ML
Carryover of PEW	-	16,000 ML
Adaptive Environmental Water	34,228 ML	0 ML
Carryover of AEW	-	3,178 ML
Supplementary Access*	1,339 ML	1,339 ML

* Availability depends on declaration of a Supplementary event.

In addition to Planned Environmental Water and state-owned AEW the Commonwealth Environmental Water Holder (CEWH) will have up to 44.8 GL♦ of general security entitlement in 2009/10.

Likely environmental watering conditions

Estimated water availability for 2009/10

The following resource assessment scenarios provided by State Water are based on historical statistical inflows to Burrendong and Windamere Dams.

1. **Under drought conditions:** the 2009/10 allocation is likely to be at 0% [0 ML] until the end of October 2009 and remain at 0% [0 ML] by the end of January 2010. This is likely in 100% of years. With the addition of carryover, under the drought scenario a volume of 19,178 ML will be available.

		State		Commonwealth		Carryover	TOTAL	
drought	probability	Oct	Jan	Oct	Jan		Oct	Jan
[0,0]	100%	0	0	0	0	19,178	19,178	19,178

2. **Under dry conditions:** the 2009/10 allocation is likely to be at 2% [3885 ML] until the end of October 2009 and at 13% [25,250 ML] by the end of January 20010. This is likely in 70% of years. If the environmental water holdings of the Commonwealth were contributed, available water would increase to 4781 ML at the end of October and 31,074 ML at the end of January. With the addition of carryover, available water under the dry scenario will increase to 23,959 ML in October and 50,252 ML in January.

		State		Commonwealth		Carryover	TOTAL	
dry	probability	Oct	Jan	Oct	Jan		Oct	Jan
[2, 13]	70%	3,885	25,250	896	5,824	19,178	23,959	50,252

♦ Information on water purchases made by the Commonwealth is available from: http://www.environment.gov.au/water/policy-programs/entitlement-purchasing/2008-09.html

3. **Under median conditions:** the 2009/10 allocation is likely to be at 25% [48,557 ML] until the end of October 2009 and at 44% [85,460 ML] by the end of January 2010. This is likely in 50% of years. If the environmental water holdings of the Commonwealth were contributed, available water would increase to 59,757 ML at the end of October and 105,172 ML at the end of January. With the addition of carryover, available water under the median scenario will increase to 78,935 ML in October and 124,350 ML in January.

		State		Commonwealth		Carryover	TOTAL	
median	**probability**	**Oct**	**Jan**	**Oct**	**Jan**		**Oct**	**Jan**
[25, 44]	50%	48,557	85,460	11,200	19,712	19,178	78,935	124,350

4. **Under wet conditions:** the 2009/10 allocation is likely to be at 58% [112,652 ML] until the end of October 2009 and at 85% [165,094 ML] by the end of January 2010. This is likely in 30% of years. If the environmental water holdings of the Commonwealth were contributed, available water would increase to 138,636 ML at the end of October and 203,174 ML at the end of January. With the addition of carryover, available water under the wet scenario will increase to 157,814 ML in October and 222,352 ML in January.

		State		Commonwealth		Carryover	TOTAL	
wet	**probability**	**Oct**	**Jan**	**Oct**	**Jan**		**Oct**	**Jan**
[58, 85]	30%	112,652	165,094	25,984	38,080	19,178	157,814	222,352

5. **Under very wet conditions:** There is a 10% chance of Burrendong Dam spilling before October 2009; which should provide a 100% allocation and 194,228 ML from the State-owned water and potentially an additional 44,800 ML from Commonwealth sources. With the addition of carryover, available water under the very wet scenario will increase to 258,206 ML in October and 258,206 ML in January.

		State		Commonwealth		Carryover	TOTAL	
Very wet	**probability**	**Oct**	**Jan**	**Oct**	**Jan**		**Oct**	**Jan**
[100, 100]	10%	194,228	194,228	44,800	44,800	19,178	258,206	258,206

Water purchased for the environment will be managed in conjunction with planned environmental water. Water entitlement purchased for the environment as at 26th June 2009 is 34,228 ML. There is an additional 1,339 ML of Supplementary Water entitlement that has been purchased in the Macquarie by NSW and the CEWH also holds additional supplementary entitlement.

Climate indicators forecast generally neutral to dry conditions (meaning scenarios 2&3 are more likely than 1 or 4) as we move into 2009/10. Scenario 5 is unlikely.

Objectives for environmental water use for 2009/10

Macquarie and Effluent Creeks

The following table links water availability scenarios and ecological objectives with management objectives, actions and targets.

scenario♦	ecological objective	management objective WSP	management action♥	estimated wetland target♣	estimated in-channel target
drought [0,0] 100%	avoid damage	relief of severe, unnaturally prolonged drought where habitat maintenance of semi-permanent wetland is considered critical	inundation of priority, good condition semi-permanent wetland and refugia	up to 7000 ha: 5000 NM; 600 ha SM; 1500 ha EM. Minimum 3 months	200-300 ML/d at Marebone Weir
dry [2, 13] 70%	ensure capacity for recovery	habitat maintenance of semi-permanent wetland; small-scale recruitment of fish or waterbirds; fish dispersal	inundation of priority, good condition semi-permanent wetland and refugia; increased duration; connectivity	up to 7000 ha: 5000 NM; 600 ha SM; 1500 ha EM. Minimum 5 months	200-500 ML/d at Marebone Weir
median [25, 44] 50%	maintain ecological health and resilience	habitat maintenance of semi-permanent wetland; small-scale recruitment of fish or waterbirds; fish dispersal	inundation of priority, good and fair condition semi-permanent wetland; connectivity	up to 23000 ha: 15000 NM; 4000 ha SM; 4500 ha EM. Minimum 5 months	500-1500 ML/d at Marebone Weir
wet [58, 85] 30%	improve and extend healthy and resilient ecosystems	habitat maintenance of semi-permanent wetland; medium-scale recruitment of fish or waterbirds; fish dispersal	inundation of priority, good and fair condition, semi-permanent wetland; increased duration; connectivity and in-channel targets	up to 23000 ha: 15000 NM; 4000 ha SM; 4500 ha EM. Minimum 7 months	500-2500 ML/d at Marebone Weir
v.wet [100, 100] 10%	improve and extend healthy and resilient ecosystems	habitat maintenance of semi-permanent wetland; large-scale recruitment of fish or waterbirds; fish dispersal	inundation of priority, good, fair and poor condition, semi-permanent wetland; connectivity and in-channel targets	at least 49000 ha: 35000 NM; 9200 SM; 5500 ha EM. Minimum 7 months	1500-5000 ML/d at Marebone Weir

♦ scenario name (drought, dry etc); likely allocation at October and January respectively [x,y]; statistical probability of condition occurring

♥ good, fair and poor condition wetland is generally defined as: good quality wetland has vegetation in good condition relative to the 1990 mapping; fair quality wetland has experienced a reduction in vegetation health relative to the 1990 mapping but has not undergone major change; poor quality wetland has experienced a major change in vegetation health, type or extent relative to 1990 mapping. NB: the definition of semi-permanent wetland is given in the Water Sharing Plan as River red gum, water couch and common reed communities.

♣ Estimated areas of wetland in the given health category. These estimates are based on mapped areas of vegetation changes and the inundation frequency over 30 years. These are coarse estimates made for environmental water management purposes. Additional work will be undertaken to determine these areas with greater accuracy.

Release of water from Burrendong
The Environmental Flows Reference Group (EFRG) considered the available water scenarios and climate indicators and agreed that environmental water management in the Macquarie in 2009/10 would most likely continue to focus on relieving drought conditions in the marshes. Clause (15)(22)(e) of the WSP allows releases of environmental water to be made at any time of year to alleviate severe drought conditions. Should climate alter markedly during the year management guidelines will be reviewed, however it is envisaged that the availability of increased volumes of water will generally not alter the primary objective to alleviate drought conditions. The EFRG has recommended the following thresholds to guide management of environmental flows in 2009/10.

These thresholds have been set to trigger an assessment of the advisability of making a release and should not be interpreted to automatically trigger a release from Burrendong Dam. Recommendations to make a release must consider the on-ground conditions and forecast water availability at the time the nominated thresholds are reached.

1. Minimum of 30,000 ML (rainfall, tributary flows, environmental water allowance and purchased water) is required before considering the possibility of releasing water from Burrendong Dam in an 'event-style' release pattern before the end of July 2009.
2. If a volume of 30,000 ML (rainfall, tributary flows, environmental water allowance and purchased water) has not become available by the end of July the EFRG will consider a release of the available volume (min = 19,178 ML) to take advantage of cool winter-spring conditions.

Post-July decisions regarding releases will consider the effectiveness of available water volumes in reducing the effects of drought in light of conditions encountered.

Objectives
These thresholds are based on event-style management aimed at providing sufficient water to a targeted core area of the marsh for a minimum period of 3 months to prevent damage to semi-permanent wetland areas in the southern, northern or eastern marsh, although the actual area/s targeted will be determined by the specific circumstances of any triggering event.

Tributary flows

Additional water for the environment arises from tributary flows in response to rainfall events. Tributary flows are divided into two categories:

1. Flows less than 5000 ML/d in excess of requirements at Warren and
2. Flows greater than 5000 ML/d in excess of requirements at Warren.

State Water typically use tributary flows to satisfy extractive needs where possible. Dam releases augment tributary flows to deliver stock, domestic, town water and irrigation supplies. Tributary flows in excess of extractive needs are generally available to the environment. Under the Water Sharing Plan tributary events that exceed 5000 ML/d at Warren are declared Supplementary events and water is made available to holders of Supplementary Water Access Licences.

Water from the tributaries in excess of requirements flow through to the Macquarie Marshes or if the peak of the event is large enough into floodplain creeks or onto the floodplain itself. State Water can exert some control over where excess tributary flows are directed. The EFRG has considered a means of prioritising areas to benefit from tributary flows should they occur.

As government holds supplementary water licences on behalf of the environment, some consideration has been given to the management of such licences when supplementary events are declared. It is recommended that the environmental water manager consider placing an order for the environment's share of all such events with a view to achieving identified targets.

Cudgegong

While Windamere remains below 110,000 ML (33%) in storage environmental releases are prohibited. At the commencement of the water year Windamere stands at 22.3% or 82,976 ML.

The EFRG has previously agreed that unless there is a compelling reason to alter them, the arrangements for environmental releases from Windamere should ensure that releases are made as frequently as possible. The default position described by the Water Sharing Plan imposes a target range of 150-1500 ML/d, which may be made at any time of year. The EFRG has proposed no alteration to the default position for the 2009/10 water year.

Risks and mitigating strategies

Risk	Rating	Response
Decision-making phase		
Priority-setting overlooks critical ecological needs	High (unlikely and major) Severe environmental damage	EMP and priority setting frameworks developed by DECC and EFRG used to systematically examine priorities
Water requirements to meet ecological objectives are under/over-estimated	Moderate (possible and moderate) Contained environmental impact	Document outcomes to inform future decision-making; liaise with SWC to ensure real-time management can be responsive to unintended outcomes
Future watering opportunities compromised	Moderate (possible and minor) Some environmental impact	Document trade-offs associated with decisions
Water delivery phase		
Unforeseen physical impediments to water delivery	Moderate (rare and major) severe environmental impact	Early communication with State Water; alert DWE compliance if obstructions identified; targeted surveillance is planned
Unforeseen operational impediments to water delivery (channel capacity/valve capacity sharing)	Moderate (rare and major) severe environmental damage	Early communication with State Water; request DWE ruling with respect to channel capacity sharing arrangements
Estimated flow target volumes or rates are substantially inaccurate	Moderate (possible and moderate) Contained environmental impact	Monitor flow delivery daily and seek adjustments; revise targets accordingly
Gauging station failure or inaccuracy	Moderate (possible and moderate) Contained environmental impact	Forewarn hydrometric suppliers of likely release and request confirmation that stations are active and accurate (particularly if access during release may be difficult); negotiate alternate accounting procedures with State Water and DWE as required
Errors or omissions in accounting methods	Low (unlikely and minor) Some environmental impact	Weekly audit of accounts compared to delivery strategy in consultation with State Water and DWE
Water delivery options impeded by construction of Marebone fishway	Moderate (unlikely and major) Severe environmental damage	Request State Water and DPI to ensure contingency arrangements for delivery of environmental water during construction of fishway
Unintended ecological outcomes (eg. insufficient water available to complete colonial waterbird breeding, if initiated; germination and spread of weeds; germination of dense eucalypts)	High (possible and major) Severe environmental damage	Early identification of water requirements and assessment of likely outcomes; reconsider flow rates and targets to improve likelihood of success; consider the purchase of temporary water allocations to complete event/avoid negative outcome; manage expectations with comprehensive and regular communication

Monitoring, reporting and revising

Monitoring will be conducted as per the RiverBank monitoring strategy for adaptive environmental water, and IMEF program for key wetland sites.

Minimum monitoring includes satellite imagery analysis to measure extent of inundation; analysis of available hydrographic data at Marebone, Gum Cowal, Oxley, Pillicawarrina and Miltara and Bell's Bridge; airborne surveillance to check water delivery and diversions and activity at colonial bird breeding sites; weekly or fortnightly on-ground inspection of wetland areas to ground-truth inundation areas, duration of inundation and photographic evidence of response. Additional monitoring tailored to the specific objectives of the release may be required, eg. Inspection of progress of waterbird breeding, observation/measurement of area wetted in target areas, duration of connectivity and monitoring of fish movement, but will ultimately be dependent on objectives of the release and the availability of resources.

Reporting to

- Director, Water for the Environment, DECCW: monthly update on conditions (climate, available environmental water) and weekly update during flow delivery events.
- EFRG: weekly/fortnightly update on conditions and flow delivery details. EFRG to be consulted if triggers for changes to this plan occur.
- Central West CMA: through EFRG representatives
- Macquarie Customer Services Committee: regular update at meetings.
- Broader community: update in E-water newsletter; press releases.

This plan is to be **revised** when conditions dictate. Triggers for revision will be sustained catchment or localised rainfall that produces significant flows in tributaries. Good communication with State Water and local community representatives will help clarify the timing and scale of revision.

Primary responsibility for identifying and reporting opportunities for revisions to this plan rests with DECC Senior Wetlands and Rivers Conservation Officer.

Prepared by: Debbie Love in consultation with the Environmental Flows Reference Group

Position: SWaRCO North-West Branch, Environment Protection and Regulation Group
Department of Environment, Climate Change and Water

Date:

Approved by: Derek Rutherford

Signature:

Position: Director, Water for the Environment, Climate Change, Policy and Programs Group
Department of Environment, Climate Change and Water

Date: 17/8/09

Appendix 1

Environmental priorities will be assessed when environmental water becomes available (either as tributary flow or if there is improvement in water availability conditions) on the basis of the following principles[3]:

- State of long-lived, water-dependent vegetation;
- Waterbird breeding event;
- Crucial habitat maintenance (eg. Refugia);
- Opportunity to establish a useful connection for in-stream biota;
- Threatened species and communities;
- Ramsar sites;
- Time since last watered.

Table 1 will be used to document the assessment of environmental priorities on a case-by-case basis. Alongside an assessment of environmental priority, we need to consider the volume of water (and the rate and duration of an event) required to meet an environmental need. The EFRG has developed tools to assist in this assessment, though they are not reproduced herein.

[3] These principles are not in order of importance nor are they intended to be prescriptive.

Table 1: Criteria for assessment of environmental priorities

Asset	Last watering	Condition	vegetation	Crucial habitat	Waterbirds	connectivity	Threatened species/EEC[∂]	Ramsar
Southern Nature Reserve	February 2008 (<10%, < 30 days)	The entire southern section of the MMNR has been invaded by chenopods. Remnant areas of river red gum and common reed are also affected. Remnant areas showed some response to water in 2008.	Reed RRG		Wader foraging	✓	5	6287
Northern Nature Reserve	April 2008 (<30%, 120 days) May 2009 (<5%, 60 days)	Varies from very good in wetter areas of reed and red gum woodland to large areas of dead red gum woodland and dead reed bed in driest areas. Large areas of the northern reserve are affected by chenopod invasion.	Reed RRG Couch Coolabah Lignum	✓	Egrets herons Waders Foraging Ibis	✓	15	11255
Gum Cowal / Terrigal Creek system	December 2007 (rainfall only)	Extensive areas of couch have been replaced by chenopod dominated grasslands. The red gum forest and woodland appears to be in good condition, though recent mapping shows chenopods in the understorey. This area benefited from summer rainfall which improved tree health markedly.	RRG Lignum Couch cooba	✓	Egrets Herons Pied heron Ibis foraging	✓	7	549
Monkey Swamp	February 2008 (<5%, <30 days)	There has been a critical reduction in extent and condition of water couch and common reeds at this site. There are still extensive areas of mixed marsh vegetation and river red gum though	Couch Mixed marsh		Waders Foraging		2	0

[∂] This is to be updated before finalisation. Currently reflects number of threatened fauna species recorded in each of these areas. I also intend to add threatened fauna and endangered ecological communities. We will have more detailed information to reference in decision making but this I think will serve for this planning purpose.

Asset	Last watering	Condition	vegetation	Crucial habitat	Waterbirds	connectivity	Threatened species/EEC[a]	Ramsar
		chenopods have invaded these areas.						
Monkeygar Wetlands	April 2008 (>80%, 120 days)	There has been a marked decrease in the area of common reed bed and a contraction of water couch area. There has been chenopod invasion of mixed marsh areas.	Reed	✓	Ibis Magpie Geese		10	0
Mole Marsh	April 2008 (>90%, <30 days)	There has been a major reduction in area of mixed marsh/grassland on Mole Marsh and invasion of chenopods into previously wet areas and under red gum forests.	Couch Mixed marsh		Waders foraging		8	0
Northern Marsh (north of NR)	December 2007 (<5%, rainfall only)	The invasion of chenopods is extensive in this area of the marsh with roly poly and buckbush dominated groundcover in previously productive river red gum and coolabah woodlands and water couch and mixed marsh grasslands. Extensive areas of red gum forest are in very poor condition or dead.	RRG Reed Coolabah Cooba Lignum couch	✓	Egrets Herons Ibis	✓	11	0
Buckiinguy Swamp	April 2008 (50%, <30 days)	Extensive areas of water couch have been replaced by mixed marsh with co-dominant chenopods, while the central reed bed has also contracted in area and height.	Reed couch RRG		Foraging Brolgas		5	0
Long Plain Cowal	December 2007 (rainfall only)	Extensive increase in chenopod dominance in grassland areas as well as areas previously mapped as wetland vegetation.	Lignum Cooba		ibis		6	0

Threatened species	northern nature reserve	southern nature reserve	Gum Cowal/Terrigal	Monkey Swamp	Monkeygar wetlands	Northern Marsh areas	Mole Marsh	Buckiinguy Swamp	Long-Plain Cowal	Marebone area	Pillicawarrina
Australasian bittern	✓	✓	✓		✓	✓	✓	✓			
Australian bustard							✓		✓		
barking owl	✓		✓		✓	✓	✓	✓	✓		
black-breasted buzzard	✓										
black-necked stork		✓					✓				
black-tailed godwit	✓										
blue-billed duck	✓	✓			✓	✓					✓
brolga	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
brown treecreeper	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
bush-stone curlew	✓										
cotton pygmy goose					✓						
freckled duck	✓				✓	✓					✓
grey-crowned babbler			✓		✓	✓	✓	✓	✓		✓
hooded robin	✓					✓					
koala	✓										
magpie goose	✓		✓		✓	✓	✓		✓		✓
Major Mitchell's cockatoo						✓					
painted snipe					✓						
Sloane's froglet											✓
stripe-faced dunnart			✓								
superb parrot	✓					✓					
yellow-bellied sheath-tail bat	✓										
Spiny mint-bush	✓										

Endangered ecological communities (TSC Act)

1. Brigalow
2. Coolibah-black box woodland
3. Myall woodland

Endangered ecological communities (FM Act)

1. Darling River Endangered ecological community – this includes all species of native invertebrates and fish in all channels within the Marsh area and downstream of both Windamere and Burrendong Dams

Environmental Watering Plan for the Macquarie Valley 2010/11

Environmental water releases in 2009/10

At the commencement of the water year there was 10% of carryover water available in the environmental account. A total of 0% Available Water Determination (AWD) was made available in 2008/09. There was an environmental water release of 19,283 ML in 2009/10; made up of 16,000 ML of environmental water allowance (EWA) and 3,196 ML of NSW adaptive environmental water (AEW) and 87 ML of CEWH adaptive environmental water (CEWH).

		EWA			AEW			CEWH			Account
	AWD (%)	C/over	credit	Usage	C/over	credit	Usage	C/over	credit	Usage	Balance (ML)
July 2009	0	16000	0	0	3196	0	0	87	0	0	19,283
August 2009	0		0	1232		0	0		0	0	18,051
September 2009	0		0	6395		0	0		0	0	11,656
October 2009	0		0	8125		0	0		0	0	3531
November 2009	0		0	248		0	3196		0	87	0
December 2009	0		0			0			0		0
January 2010	0		0			0			0		0
February 2010	0		0			0			0		0
March 2010	0		0			0			0		0
April 2010	0		0			0			0		0
May 2010	0		0			0			0		0
June 2010	0		0			0			0		0

In addition there were two supplementary access events which were declared during the 2009/10 water year in which the environment ordered water to be delivered to the Macquarie Marshes against Supplementary Water Access accounts. The first of the events saw 1000 ML of Supplementary water delivered at Marebone over 2 days between the 2nd January and the 4th January 2010 (565.5 ML CEWH & 434.5 ML Riverbank) directed into the Gum Cowal along with 6867 ML of Stock and Domestic Replenishment. The second of these events was delivered at Marebone on the 22nd February and saw 500 ML (280.1 ML CEWH & 219.9 ML Riverbank) also delivered to Gum Cowal along with 2134 ML of operational surplus.

From Marebone (but not inc). to Buckingong (includes oxley waterhole).

Recent also useful – what is ecologically relevant?

Current condition of water dependent assets

Asset	Last watering[1]	Condition[2]
South Macquarie	'05/06 environmental flow watered Mundooie area	Riparian vegetation in this zone is in generally good condition. There are large areas of floodplain vegetation in very poor condition, which appears to be related to flood protection works associated with cultivation in some instances.
Bulgeraga Floodplain	Small areas of floodplain woodland in '01.	Woody vegetation in this zone is generally restricted to the riparian zone. There is a small area of floodplain woodland in the middle reaches of the zone that is in a very poor condition.
The Jungle & Back Swamp	Small areas wet in 05/06, 30% of area in 2001.	The woody vegetation in this zone is in quite good condition with only small patches of stressed vegetation, possibly related to flood protection works associated with cultivated areas.
Old Macquarie	October 2009 in channel SNR section.	Riparian vegetation retains some vigour, floodplain vegetation through SNR, Willie and Maxwellton is in very poor condition with a majority of dead trees.
Southern Nature Reserve	August 2010 (<10%, ~90 days)	The entire southern section of the MMNR has been invaded by chenopods. Remnant areas of river red gum and common reed are also affected. Remnant areas showed some response to water in 2008.
North Marsh	March 2010 (<20%, 90 days)	Varies from very good in wetter areas of reed and red gum woodland to large areas of dead red gum woodland and dead reed bed in driest areas. Large areas of the northern reserve are affected by chenopod invasion.
Gum Cowal / Terrigal Creek system	February 2010 (in-channel, 60 days)	Extensive areas of couch have been replaced by chenopod dominated grasslands. The red gum forest and woodland appears to be in good condition, though recent mapping shows chenopods in the understorey. This area benefited from summer rainfall which improved tree health markedly.
Monkey Swamp	February 2010 (<10%, <30 days)	There has been a critical reduction in extent and condition of water couch and common reeds at this site. There are still extensive areas of mixed marsh vegetation and river red gum though chenopods have invaded these areas.
Monkeygar Wetlands	April 2010 (>90%, 180 days)	There has been a marked decrease in the area of common reed bed and a contraction of water couch area. There has been chenopod invasion of mixed marsh areas. 2009/10 watering has improved condition of reed bed and surrounding couch fields.

[1] Percentage areas are relative to maximum flooded extent of asset, which is similar in extent to the 2000 flood.

[2] These descriptions are based on 2008/2009 vegetation mapping and provide a comparison with mapping from 1991.

Mole Marsh	April 2010 (~25%, 120 days)	There has been a major reduction in area of mixed marsh/grassland on Mole Marsh and invasion of chenopods into previously wet areas and under red gum forests. 2009/10 watering has improved condition of couch fields and small reed bed.
Buckiinguy Swamp	June 2010 (60%, >180 days)	Extensive areas of water couch have been replaced by mixed marsh with co-dominant chenopods, while the central reed bed has also contracted in area and height. 2009/10 watering has improved condition of couch fields, mixed marsh (spike rush) and reed bed has been observed to expand in some zones.
Long Plain Cowal	April 2000 (~20%, ~90 days)	Extensive increase in chenopod dominance in grassland areas as well as areas previously mapped as wetland vegetation. Significant areas of red gum in very poor condition.

Water Management Arrangements for 2010/11
The Water Sharing Plan remains suspended under a Severe Water Shortage Order (WMA section 60). On the 1st July 2010 the Minister for Water announced a 0% Available Water Determination and 100% access to carryover water in 2009/10. ?

It is assumed that allocations to the environment will be in accordance with typical resource assessment procedures even while the WSP remains suspended. In addition it is anticipated that with the WSP suspended it will be possible to manage all environmental water as "active" account water.

With the current storage levels and forecast demands should drought conditions re-emerge during the year resulting in critically low inflows to the major storages, a return to drought contingency management (limiting access to carryover) is possible. While the WSP remains suspended the EFRG will continue to advise the Minister on the management of environmental water as it becomes available: this includes the management of tributary events where a proportion of flows is available to the environment.

Volume of environmental water available

The balance of the environmental water account is 0 ML; with zero account balances in all three holdings (EWA, AEW and CEWH). The environment is entitled to a share of tributary flows in excess of that required to meet stock and domestic and town water supply requirements. The water levels in the supply dams at the beginning of July 2010 are:

Windamere = 17.6% or 65,666 ML
Burrendong = 12.3% or 175,543 ML

Account	Maximum	Available 01/07/10
Planned Environmental Water (PEW)	160,000 ML	0 ML
Carryover of PEW	-	0 ML
Adaptive Environmental Water	46,066 ML	0 ML
Carryover of AEW	-	0 ML
Supplementary Access*	1,442 ML	1,442 ML

In addition to Planned Environmental Water and state-owned AEW the Commonwealth Environmental Water Holder (CEWH♦) will have up to 57,631 ML of general security entitlement and 1888 ML of Supplementary Access shares in 2010/11. — check ✓

Likely environmental watering conditions

Water purchased for the environment (by NSW) will be managed in conjunction with planned environmental water. Water entitlement purchased for the environment as at 17th June 2010 is 46,066 ML. There is an additional 1,442 ML of Supplementary Water entitlement that has been purchased in the Macquarie by NSW and the CEWH also holds additional entitlement. → Note separate approval process for CEWH

Climate indicators forecast generally neutral to dry conditions (meaning scenarios 2&3 are more likely than 1 or 4) as we move into 2010/11, although models also predict an increased chance of a La Nina developing in the second half of 2010, which may see an increase in the likelihood of above median rainfall. → Recent predictions haven't been as positive

Estimated water availability for 2010/11

The following resource assessment scenarios provided by State Water are based on historical statistical inflows to Burrendong and Windamere Dams.

---

* Availability depends on declaration of a Supplementary event.

♦ Information on water purchases made by the Commonwealth is available from: http://www.environment.gov.au/water/policy-programs/entitlement-purchasing/2008-09.html

CHEW Water Register

1. **Under drought conditions:** the 2010/11 allocation is likely to be at 0% [0 ML] until the end of October 2010 and remain at 0% [0 ML] by the end of January 2011. This is likely in 100% of years. With no carryover, under the drought scenario a volume of 0 ML will be available.

		State		Commonwealth		Carryover	TOTAL	
drought	probability	Oct	Jan	Oct	Jan		Oct	Jan
[0,0]	100%	0	0	0	0	0	0	0

2. **Under dry conditions:** the 2010/11 allocation is likely to be at 1% [2061 ML] until the end of October 2010 and at 13% [26,789 ML] by the end of January 2011. This is likely in 70% of years. If the environmental water holdings of the Commonwealth were to be made available water available this would increase to 2637 ML at the end of October and 34281 ML at the end of January.

		State		Commonwealth		Carryover	TOTAL	
dry	probability	Oct	Jan	Oct	Jan		Oct	Jan
[1, 13]	70%	2060.6	26,788.6	576.3	7492.0	0	2636.9	34,280.6

3. **Under median conditions:** the 2010/11 allocation is likely to be at 23% [47,395 ML] until the end of October 2010 and at 43% [88,608 ML] by the end of January 2011. This is likely in 50% of years. If the environmental water holdings of the Commonwealth were to be made available water available would increase to 60,650 ML at the end of October and 113,390 ML at the end of January.

		State		Commonwealth		Carryover	TOTAL	
median	probability	Oct	Jan	Oct	Jan		Oct	Jan
[23, 43]	50%	47,395.2	88,608.4	13,255.1	24,781.3	0	60,650.3	113,389.7

4. **Under wet conditions:** the 2010/11 allocation is likely to be at 57% [117,458 ML] until the end of October 2010 and at 83% [171,458 ML] by the end of January 2011. This is likely in 30% of years. If the environmental water holdings of the Commonwealth were to be made available water available would increase to 150,307 ML at the end of October and 208,869 ML at the end of January.

wet	probability	State Oct	State Jan	Commonwealth Oct	Commonwealth Jan	Carryover	TOTAL Oct	TOTAL Jan
[57, 83]	30%	117,457.6	171,034.8	32,849.7	47,833.7	0	150,307.3	218,868.5

5. **Under very wet conditions:** There is less than 10% chance of Burrendong Dam spilling before October 2010; which should provide a 100% allocation and 206,066 ML from the State-owned water and potentially an additional 57,361 ML from Commonwealth sources.

Very wet	probability	State Oct	State Jan	Commonwealth Oct	Commonwealth Jan	Carryover	TOTAL Oct	TOTAL Jan
[100, 100]	<10%	206,066	206,066	57,361	57,361	0	263,427	263,427

Objectives for environmental water use for 2010/11

Macquarie and Effluent Creeks

The following table links water availability scenarios and ecological objectives with management objectives, actions and targets.

scenario[♦]	ecological objective	management objective WSP	management action[♥]	estimated wetland target[♠]	estimated in-channel target
Drought 0-25 GL	avoid damage	relief of severe, unnaturally prolonged drought where habitat maintenance of semi-permanent wetland is considered critical	inundation of priority, good condition semi-permanent wetland and refugia	2400 hectares Minimum 3 months	200-300 ML/d at Marebone Weir
Dry 26-59 GL	ensure capacity for recovery	habitat maintenance of semi-permanent wetland, small-scale recruitment of fish or waterbirds; fish dispersal	inundation of priority, good condition semi-permanent wetland and refugia; increased duration; connectivity	4000 hectares Minimum 3 months	200-500 ML/d at Marebone Weir
Median 60-149 GL	maintain ecological health and resilience	habitat maintenance of semi-permanent wetland; small-scale recruitment of fish or waterbirds; fish dispersal	inundation of priority, good and fair condition semi-permanent wetland; connectivity	9000 hectares Minimum 3 months	500-1500 ML/d at Marebone Weir
Wet 150-219 GL	improve and extend healthy and resilient ecosystems	habitat maintenance of semi-permanent wetland; medium-scale recruitment of fish or waterbirds; fish dispersal	inundation of priority, good and fair condition, semi-permanent wetland; increased duration; connectivity and in-channel targets	19,000 hectares Minimum 3 months	1000-2000 ML/d at Marebone Weir
Very wet 220-263 GL	Improve, extend and restore healthy and resilient ecosystems	habitat maintenance of semi-permanent wetland; large-scale recruitment of fish or waterbirds; fish dispersal	inundation of priority, good, fair and poor condition, semi-permanent wetland; connectivity and in-channel targets	50,000 hectares Minimum 4 months	2000-3000 ML/d at Marebone Weir

+ Carryover

potentially available * in CEWH.

Release of water from Burrendong

♦ scenario name (drought, dry etc); likely allocation at October and January respectively [x,y]; statistical probability of condition occurring

♥ good, fair and poor condition wetland is generally defined as: good quality wetland has vegetation in good condition relative to the 1990 mapping; fair quality wetland has experienced a reduction in vegetation health relative to the 1990 mapping but has not undergone major change; poor quality wetland has experienced a major change in vegetation health, type or extent relative to 1990 mapping. NB: the definition of semi-permanent wetland is given in the Water Sharing Plan as River red gum, water couch and common reed communities.

♠ See more detailed explanation in Appendix 1.

The Environmental Flows Reference Group (EFRG) considered the available water scenarios and climate indicators and agreed that environmental water management in the Macquarie in 2010/11 would most likely continue to focus on relieving drought conditions in the marshes. Clause (15)(22)(e) of the WSP allows releases of environmental water to be made at any time of year to alleviate severe drought conditions. Should climate alter markedly during the year management guidelines will be reviewed, however it is envisaged that the availability of increased volumes of water will generally not alter the primary objective to alleviate drought conditions. The EFRG has recommended the following thresholds to guide management of environmental flows in 2010/11.

These thresholds have been set to trigger an assessment of the advisability of making a release and should not be interpreted to automatically trigger a release from Burrendong Dam. Recommendations to make a release must consider the on-ground conditions and forecast water availability at the time the nominated thresholds are reached.

1. Minimum of x ML (rainfall, tributary flows, environmental water allowance and purchased water) is required before considering the possibility of releasing water from Burrendong Dam in an 'event-style' release pattern before the end of July 2010.
2. If a volume of x ML (rainfall, tributary flows, environmental water allowance and purchased water) has not become available by the end of July the EFRG will consider a release of the available volume to take advantage of critical growth periods for target vegetation.

Post-July decisions regarding releases will consider the effectiveness of available water volumes in reducing the effects of drought in light of conditions encountered.

Objectives

These thresholds are based on event-style management aimed at providing sufficient water to a targeted area of the marsh for a minimum period of 3 months to prevent damage to semi-permanent wetland areas in the southern, northern or eastern marsh, although the actual area/s targeted will be determined by the specific circumstances of any triggering event.

Tributary flows

Additional water for the environment arises from tributary flows in response to rainfall events. Tributary flows are divided into two categories:

1. Flows less than 5000 ML/d in excess of requirements at Warren and
2. Flows greater than 5000 ML/d in excess of requirements at Warren.

State Water typically use tributary flows to satisfy extractive needs where possible. Dam releases augment tributary flows to deliver stock, domestic, town water and irrigation supplies. Tributary flows in excess of extractive needs are generally available to the environment. Under the Water Sharing Plan tributary events that exceed 5000 ML/d at Warren are declared Supplementary events and water is made available to holders of Supplementary Water Access Licences.

Water from the tributaries in excess of requirements flow through to the Macquarie Marshes or if the peak of the event is large enough into floodplain creeks or onto the floodplain itself. State Water can exert some control over where excess tributary flows are directed. The EFRG has considered a means of prioritising areas to benefit from tributary flows should they occur.

As government holds supplementary water licences on behalf of the environment, some consideration has been given to the management of such licences when supplementary events are declared. It is recommended that the environmental water manager consider placing an order for the environment's share of all such events with a view to achieving identified targets.

Cudgegong

While Windamere remains below 110,000 ML (33%) in storage environmental releases are prohibited. At the commencement of the water year Windamere stands at 17.6% or 65,666 ML.

The EFRG has previously agreed that unless there is a compelling reason to alter them, the arrangements for environmental releases from Windamere should ensure that releases are made as frequently as possible. The default position described by the Water Sharing Plan imposes a target range of 150-1500 ML/d, which may be made at any time of year. The EFRG has proposed no alteration to the default position for the 2010/11 water year.

Risks and mitigating strategies

Risk	Rating	Response
Decision-making phase		
Priority-setting overlooks critical ecological needs	High (unlikely and major) Severe environmental damage	EMP and priority setting frameworks developed by DECC and EFRG used to systematically examine priorities
Water requirements to meet ecological objectives are under/over-estimated	Moderate (possible and moderate) Contained environmental impact	Document outcomes to inform future decision-making; liaise with SWC to ensure real-time management can be responsive to unintended outcomes
Future watering opportunities compromised	Moderate (possible and minor) Some environmental impact	Document trade-offs associated with decisions
Water delivery phase		
Unforeseen physical impediments to water delivery	Moderate (rare and major) severe environmental impact	Early communication with State Water; alert NOW compliance if obstructions identified; targeted surveillance is planned
Unforeseen operational impediments to water delivery (channel capacity/valve capacity sharing)	Moderate (rare and major) severe environmental damage	Early communication with State Water; request NOW ruling with respect to channel capacity sharing arrangements
Estimated flow target volumes or rates are substantially inaccurate	Moderate (possible and moderate) Contained environmental impact	Monitor flow delivery daily and seek adjustments; revise targets accordingly
Gauging station failure or inaccuracy	Moderate (possible and moderate) Contained environmental impact	Forewarn hydrometric suppliers of likely release and request confirmation that stations are active and accurate (particularly if access during release may be difficult); negotiate alternate accounting procedures with State Water and NOW as required
Errors or omissions in accounting methods	Low (unlikely and minor) Some environmental impact	Weekly audit of accounts compared to delivery strategy in consultation with State Water and NOW
Unintended ecological outcomes (eg. insufficient water available to complete colonial waterbird breeding, if initiated; germination and spread of weeds; germination of dense eucalypts)	High (possible and major) Severe environmental damage	Early identification of water requirements and assessment of likely outcomes; reconsider flow rates and targets to improve likelihood of success; consider the purchase of temporary water allocations to complete event/avoid negative outcome; manage expectations with comprehensive and regular communication

Monitoring, reporting and revising

Monitoring will be conducted as per the RiverBank monitoring strategy for adaptive environmental water, and IMEF program for key wetland sites.

Minimum monitoring includes satellite imagery analysis to measure extent of inundation; analysis of available hydrographic data at Marebone, Gum Cowal, Oxley, Pillicawarrina (Macquarie River and Bulgeraga Creek) and Miltara and Bell's Bridge; airborne surveillance to check water delivery and diversions and activity at colonial bird breeding sites; fortnightly on-ground inspection of wetland areas to ground-truth inundation areas, duration of inundation and photographic evidence of response. Additional monitoring tailored to the specific objectives of the release may be required, eg. Inspection of progress of waterbird breeding, observation/measurement of area wetted in target areas, duration of connectivity and monitoring of fish movement, but will ultimately be dependent on objectives of the release and the availability of resources.

Reporting to

- Director, Water for the Environment, DECCW: monthly update on conditions (climate, available environmental water) and weekly update during flow delivery events.
- Commonwealth Environmental Water Holder: through updates to EFRG. → at least same for us when Cwth water used. – STET – OK.
- EFRG: weekly/fortnightly update on conditions and flow delivery details. EFRG to be consulted if triggers for changes to this plan occur.
- Central West CMA: through EFRG representatives.
- Macquarie Customer Services Committee: regular update at meetings.
- Broader community: update in E-water newsletter; press releases.

This plan is to be **revised** when conditions dictate. Triggers for revision will be sustained catchment or localised rainfall that produces significant flows in tributaries. Good communication with State Water and local community representatives will help clarify the timing and scale of revision.

Primary responsibility for identifying and reporting opportunities for revisions to this plan rests with DECC Senior Wetlands and Rivers Conservation Officer - Macquarie.

Prepared by: Debbie Love in consultation with the Environmental Flows Reference Group
Position: SWaRCO North-West Branch, EPRG;
Date:

Approved by: Derek Rutherford
Signature:
Position: Director, Water for the Environment Branch, CCPPG
Date:

Appendix 1

Water availability scenario	• Management action • Descriptive target
Drought 3 months 0 -25 GL	**inundation of priority, good condition semi-permanent wetland and refugia** East Marsh – no targets South Marsh – Buckiinguy Swamp, Monkeygar Wetlands, Mole Marsh North Marsh – Bora woodland, reed bed
Dry 3 months 26-59 GL	**inundation of priority, good condition semi-permanent wetland and refugia; increased duration; connectivity** East Marsh – in-channel to Terrigal confluence South Marsh – Buckiinguy Swamp, Monkeygar Wetlands, Mole Marsh North Marsh – Bora woodland, reed bed
Median 3 months 60-149 GL	**inundation of priority, good and fair condition semi-permanent wetland; connectivity** East Marsh – in-channel to Marthaguy confluence + floodplain couch areas South Marsh – Buckiinguy Swamp, Monkeygar Wetlands, Mole Marsh, Monkey Swamp North Marsh – Bora woodland, reed bed, P block, Hunt's, Bluelight, Ginghet, Zoo Paddock
Wet 3 months 150-219 GL	**inundation of priority, good and fair condition, semi-permanent wetland; increased duration; connectivity** East Marsh – in-channel to Marthaguy confluence + floodplain couch areas (including restoration) South Marsh – Buckiinguy Swamp, Monkeygar Wetlands, Mole Marsh, Monkey Swamp, South Macquarie, SNR (lagoons) North Marsh – Bora woodland, reed bed, P block, Hunt's, Bluelight, Ginghet, Zoo Paddock
Very wet 4 months 220-263 GL	**inundation of priority, good, fair and poor condition, semi-permanent wetland; connectivity and in-channel targets** East Marsh – in-channel to Marthaguy confluence + floodplain couch areas (including restoration) + floodplain RRG South Marsh – Buckiinguy Swamp, Monkeygar Wetlands, Mole Marsh, Monkey Swamp, South Macquarie, SNR (lagoons) + floodplain RRG North Marsh – Bora woodland, reed bed, P block, Hunt's, Bluelight, Ginghet, Zoo Paddock, poor condition RRG

Appendix 2

Environmental priorities will be assessed when environmental water becomes available (either as tributary flow or if there is improvement in water availability conditions) on the basis of the following principles[3]:

- State of long-lived, water-dependent vegetation;
- Waterbird breeding event;
- Crucial habitat maintenance (eg. Refugia);
- Opportunity to establish a useful connection for in-stream biota;
- Threatened species and communities;
- Ramsar sites;
- Time since last watered.

Table 1 will be used to document the assessment of environmental priorities on a case-by-case basis. Alongside an assessment of environmental priority, we need to consider the volume of water (and the rate and duration of an event) required to meet an environmental need. The EFRG has developed tools to assist in this assessment, though they are not reproduced herein.

[3] These principles are not in order of importance nor are they intended to be prescriptive.

Table 1: Criteria for assessment of environmental priorities

Asset	Last watering	Condition	vegetation*	Crucial habitat	Waterbirds	connectivity	Threatened species/EEC	Ramsar
South Macquarie	'05/06 environmental flow watered Mundooie area	Riparian vegetation in this zone is in generally good condition. There are large areas of floodplain vegetation in very poor condition, which appears to be related to flood protection works associated with cultivation in some instances.	252 ha couch 4051 ha RRG 79 ha Coolabah 363 ha lignum		Foraging	✓	tbd	0
Bulgeraga Floodplain	Small areas of floodplain woodland in '01.	Woody vegetation in this zone is generally restricted to the riparian zone. There is a small area of floodplain woodland in the middle reaches of the zone that is in a very poor condition.	2984 ha RRG 2013 ha black box 153 ha cooba			✓	tbd	0
The Jungle & Back Swamp	Small areas wet in 05/06. 30% of area in 2001.	The woody vegetation in this zone is in quite good condition with only small patches of stressed vegetation, possibly related to flood protection works associated with cultivated areas.	2817 ha RRG 62 ha Coolabah 750 ha cooba			✓	tbd	0
Old Macquarie	October 2009 in channel SNR section.	Riparian vegetation retains some vigour, floodplain vegetation through SNR, Willie and Maxwellton is in very poor condition with a majority of dead trees.	[illegible]70 ha RRG				tbd	0
Southern Nature Reserve	August 2010 (<10%, ~90 days)	The entire southern section of the MMNR has been invaded by chenopods. Remnant areas of river red gum and common reed are also affected. Remnant areas showed some response to water in 2008.	56 ha reed 252 ha couch 4 ha RRG	✓	Wader foraging	✓	5	6287

* area in hectares based on 2008 mapping

Asset	Last watering	Condition	vegetation*	Crucial habitat	Waterbirds	connectivity	Threatened species/EEC	Ramsar
Northern Marsh	March 2010 (<20%, 90 days)	Varies from very good in wetter areas of reed and red gum woodland to large areas of dead red gum woodland and dead reed bed in driest areas. The invasion of chenopods is extensive in this area of the marsh with roly poly and buckbush dominated groundcover in previously productive river red gum and coolabah woodlands and water couch and mixed marsh grasslands.	1821 ha reed 670 ha Couch 10876 ha RRG 3813 ha Coolabah 326 ha Lignum	✓	Egrets herons Waders Foraging Ibis	✓	15	11255
Gum Cowal / Terrigal Creek system	February 2010 (in-channel, 60 days)	Extensive areas of couch have been replaced by chenopod dominated grasslands. The red gum forest and woodland appears to be in good condition, though recent mapping shows chenopods in the understorey. This area benefited from summer rainfall which improved tree health markedly.	48 ha Couch 5938 ha RRG 3615 ha Black Box 444 ha Lignum	✓	Egrets Herons Pied heron Ibis foraging	✓	7	549
Monkey Swamp	February 2010 (<10%, <30 days)	There has been a critical reduction in extent and condition of water couch and common reeds at this site. There are still extensive areas of mixed marsh vegetation and river red gum though chenopods have invaded these areas.	2109 ha Couch 315 ha Coolabah 20 ha lignum		Waders Foraging		2	0
Monkeygar Wetlands	April 2010 (>90%, 180 days)	There has been a marked decrease in the area of common reed bed and a contraction of water couch area. There has been chenopod invasion of mixed marsh areas.	326 ha reed 471 ha Couch 450 ha RRG 149 ha Coolabah 9 ha cooba	✓	Ibis Magpie Geese		10	0

Asset	Last watering	Condition	vegetation*	Crucial habitat	Waterbirds	connectivity	Threatened species/EEC	Ramsar
Mole Marsh	April 2010 (~25%, 120 days)	There has been a major reduction in area of mixed marsh/grassland on Mole Marsh and invasion of chenopods into previously wet areas and under red gum forests.	20 ha reed 555 ha Couch 129 ha RRG 37 ha Coolabah 3 ha lignum		Waders foraging		8	0
Buckiinguy Swamp	June 2010 (60%, >180 days)	Extensive areas of water couch have been replaced by mixed marsh with co-dominant chenopods, while the central reed bed has also contracted in area and height.	81 ha reed 666 ha Couch 987 ha RRG 35 ha Coolabah		Foraging Brolgas		5	0
Long Plain Cowal	April 2000 (~20%, ~90 days)	Extensive increase in chenopod dominance in grassland areas as well as areas previously mapped as wetland vegetation.	3998 ha RRG 5062 ha black box 104 ha Lignum		ibis		6	0

Threatened species ← Water-dependent?	northern nature reserve	southern nature reserve	Gum Cowal/Terrigal	Monkey Swamp	Monkeygar wetlands	Northern Marsh areas	Mole Marsh	Buckiinguy Swamp	Long-Plain Cowal	Marebone area	Pillicawarrina
Australasian bittern	✓	✓	✓		✓	✓	✓	✓			
Australian bustard							✓		✓		
barking owl	✓		✓		✓	✓	✓	✓	✓		
black-breasted buzzard	✓										
black-necked stork		✓					✓				
black-tailed godwit	✓										
blue-billed duck	✓	✓			✓	✓					✓
brolga	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
brown treecreeper	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
bush-stone curlew	✓										
cotton pygmy goose					✓						
freckled duck	✓				✓	✓					✓
grey-crowned babbler			✓		✓	✓	✓	✓	✓		✓
hooded robin	✓					✓					
koala	✓										
magpie goose	✓		✓		✓	✓	✓		✓		✓
Major Mitchell's cockatoo						✓					
painted snipe					✓						
Sloane's froglet											✓
stripe-faced dunnart			✓								
superb parrot	✓					✓					
yellow-bellied sheath-tail bat	✓										

Endangered ecological communities (TSC Act)

1. Brigalow
2. Coolibah-black box woodland
3. Myall woodland

Endangered ecological communities (FM Act)

1. Darling River Endangered ecological community – this includes all species of native invertebrates and fish in all channels within the Marsh area and downstream of both Windamere and Burrendong Dams

Spiny mint-bush	✓

Environmental Watering Plan for the Murrumbidgee Valley 2008/09

Environmental water releases in 2007/08

The Murrumbidgee Regulated Water Sharing Plan remained suspended for the whole of 2007/08. In November the Minister for Water approved the use of up to 10 GL of Environmental Water Allowance (EWA) to assist the survival of endangered Southern Bell Frog (*Litoria raniformis*) populations in "Lowbidgee" wetlands. Several small surplus flow events were identified by State Water and a total of 8,915 ML was diverted into prioritised Lowbidgee wetlands inundating approximately 1,500 ha. Overall the wetland watering project was successful in promoting the survival and recruitment of *L. raniformis*. Monitoring of the response to the flooding indicates that "The long-term persistence of this species depends on regular flooding events to promote recruitment. At this stage annual flooding over a number of years may be required in order to re-establish population numbers"(Wassens et al, 2008- draft)

The EWA volume used was deducted from the recognised volume of EWA (113GL) nominally held in Burrinjuck Dam.

Current condition of water dependent assets

Asset[1]	Last watering[2]	Condition
Core SBF wetlands - North Yanga	Summer 2008	Good
Core SBF wetlands – Nimmie-Caira	Summer 2008	Good
Remainder of North Yanga Redgum forest	Summer 2005	Good
South Yanga Red Gum forest	2000	Critical
Black Swamp	1993	Poor
Mid-Murrumbidgee Wetlands - DIWA	2000	Poor-Critical
Dams to Narrandera Wetlands	Spring 2005 or 2000	Good -Poor
Carrathool to Maude Weir Wetlands	1996 or 2000	Poor-Critical
Fivebough Swamp (Ramsar)	EWA 2005, other 2008	Poor
Tuckerbil Swamp (Ramsar)	EWA 2005 then dry	Good

[1] Identified in RiverBank Water Use Plan, Yanga National Park wetland management plan or Murrumbidgee Regulated Water Sharing Plan

[2] By any means – natural or managed

Volumes of environmental water available

Account	Maximum limit (ML)	Available 01/07/08 (ML)
EWA (payback of suspended account water)	104,000	Surplus flow dependant
Translucency	26,328 (State Water Figure)	Nil, while WSP suspended
Other EWA *	SW to confirm	Nil, while WSP suspended
AEWL and other DECC licenses (includes Yanga)	Allocation dependant ie includes supplementary access licences	482.5
Commonwealth EWH	?	Allocation dependant

*the volume of EWA accrued prior to the WSP being suspended and after the September 2006 DNR Resource Assessment quoted the "recognised volume" of 113GL.

Likely environmental watering scenarios

- Burrinjuck Dam is expected to be at about 42% capacity (433,000 ML) and Blowering Dam 36% (605,000 ML) as at 01/07/08.
- The repayment of "loaned EWA" to a storage account will occur once GS reaches 20% with storage inflows shared 1:1 with GS users until full repayment has occurred.
- The WSP will not be turned back on until the EWA is repaid in full and all HS needs are fully accounted for.
- DWE have agreed to the continuation of the EWA substitution arrangements, so until 20% GS is announced the availability of EWA is entirely dependant on rainfall/tributary flows and State Waters re-regulation capacity along the river.
- Presently all weir pools are partially or completely empty and there is approximately 75% of full re-regulation potential, so a significant rainfall event would be needed for surplus water to become available.
- Average rainfall for the next 2 months is most likely required to generate surplus flows.
- Presently close to average rainfall conditions are predicted for the Murrumbidgee Catchment during July and August, however above average rainfall is forecast for September and October.
- The Murrumbidgee Environmental Water Allowance Reference Group (EWARG) has not met for nearly 2 years. However, it is likely that DECC will soon re-convene the group.
- In summary, for the 3 month period up to the 1st October 2008:
  - Low probability of WSP being switched back on
  - Low probability of GS allocation reaching the 20% payback trigger
  - Moderate probability of EWA water (surplus flows) becoming available

Objectives for environmental water use for 2008/09

A. **Under average to slightly wet conditions** (in order of priority assuming progressive increases in environmental water availability)

1. To flood key SBF wetlands in the Lowbidgee (Yanga National Park and Maude systems)
<u>Reason</u>: *recent population crash of this endangered species. Flooding is essential to provide drought refuge and breeding habitat for the recovering population. Requires delivery of approximately 10 GL and could be achieved using small to moderate surpluses under EWA payback arrangements.*

2a. To flood the southern section of red gum forest in Yanga National Park (South of Tala Lake) using the channel systems from Maude Weir for greatest efficiency.
<u>Reason</u>: *forest condition currently critical and declining. Flooding is essential to retain some of the river red gums alive and provide best chance of preventing loss of ecological character. Requires delivery of approximately 50-60 GL and could be achieved using moderate surpluses under EWA payback arrangements*

2b. To flood sections of privately owned red gum forest in the Lowbidgee from both Redbank and Maude Weirs. Target sites would be prioritised for watering using an independent assessment program which would inform the Murrumbidgee EWARG or DECC decision making process.

<u>Reason</u>: *forest condition currently critical and declining. Flooding is essential to retain some of the river red gums alive and provide best chance of preventing loss of*

ecological character. Requires delivery of approximately 50-60 GL and could be achieved using moderate surpluses under EWA payback arrangements

3. To flood the Northern Section of red gum forest in Yanga National Park (above Tala Lake)
   Reason: *condition good (compared with the southern section). Flooding would allow for Southern Bell Frog dispersal into historical habitat, waterbird breeding in significant rookery and wetland areas including Piggery Lake and maintenance of red gum forest health. Requires delivery of approximately 60 GL and could be achieved using moderate surpluses under EWA payback arrangements.*

4. To inundate the Nimmie-Caira system of Lowbidgee wetlands creating and sustaining a waterbird breeding event of a similar extent to that of 2005 (30,000 pairs, mainly Ibis and Cormorants)

Reason: *condition good, but waterbird numbers are declining nationally and this would boost numbers of a variety of species affected by a series of very dry years. Requires delivery of approximately 60-70 GL and could be achieved using moderate surpluses under EWA payback arrangements.*

5. Use infrastructure to flood prioritised mid-catchment wetlands in the Murrumbidgee Irrigation Area eg. Coonancoocabil Swamps and MIA State Forest wetlands.

Reason: *condition varies from good to poor, up to 8 years since last flooding, create drought refuge and potential habitat for threatened waterbird species, could be achieved using small surpluses under EWA payback arrangements. Requires delivery of approximately 0.2-10 GL and could be achieved using moderate surpluses under EWA payback arrangement. This would be a substitute for filling river fed wetlands with large scale dam releases, and would be attempted if piggybacking opportunities (option 6. below) did not arise or stand alone releases were not possible.*

B. Under very wet conditions
Above plus:

6. To piggyback EWA releases onto significant tributary fresh/s inundating the majority of river fed wetlands from Gundagai to Maude Weir.

Reason: *condition currently critical and declining (condition gets progressively worse as you move downstream). Flooding is essential to retain live fringing river red gum, aquatic plant seed-bank and ecological character. Some sites have not filled in 12 years Requires delivery of approximately 45,000 ML/Day or greater @ Wagga for 2-3 days (See the Murrumbidgee Environmental Water Delivery Guidelines DNR 2006)*

7. To maintain and complete any colonial waterbird breeding event initiated by flood or environmental flows.

Reason: *waterbird numbers are declining nationally and this would boost numbers of a variety of species affected by a series of very dry years*

8. To inundate the Lowbidgee wetlands and red gum forest north of Redbank Weir to Balranald.

Reason: *condition currently poor and declining. Flooding is essential to retain live river red gum aquatic plant seed-bank and ecological character. Significant waterbird breeding sites are located in this system. Some sites have not filled* *in 8 years. Requires delivery of approximately 100 GL and would require access to sustained periods of surplus flows*

9. To inundate extensive areas of the Yanga Nature Reserve (potentially via the Abercrombie System) and other significant wetlands located outside of the Lowbidgee Flood control and Irrigation district (LCID)

Reason: *condition currently critical and declining. Flooding is essential to retain live river red gum, black box, river cooba, aquatic plant seed-bank and ecological character. Some sites have not filled in 12 years. Requires delivery of approximately 100 GL and would require access to sustained periods of surplus flows*

10. To ensure the "Junction wetlands" below the Lowbidgee are satisfactorily watered by managing high Murrumbidgee flows to co-inside with high Murray Flows. This may involve a period of reduced diversions into the Lowbidgee to create higher downstream river heights

Reason: *condition critical and this system cannot be watered without high rivers (ie no weirs for diversions) Flooding is essential to retain live river red gums, aquatic plant seed-bank and ecological character. Some sections have not filled for 12 years. Requires the delivery of approximately 5,000 ML/Day or greater @ d/s of Redbank Weir for several weeks plus a Murray River flow u/s of the junction of >10,000ML/day for the same period*

C. Under dry conditions

11. Use limited surplus flows, as identified by State Water, to inundate central deeper areas of the Twin Bridges Wetlands in Yanga National Park. (highest priority SBF wetlands identified by CSU.)

If surplus flows do not arise or are insufficient, use Adaptive Environmental Water to inundate key SBF wetlands in Yanga and other areas of the Lowbidgee eg Eulimbah Swamp and Coates Swamp.

Reason: *preserve the Southern bell frog population in their priority habitat areas and provide for limited recruitment. Requires the delivery of approximately 1-5 GL and could be achieved using small surpluses under EWA payback arrangements.*

D. Other opportunities

12. Under dry conditions in the catchment of Fivebough Swamp (MI drainage network around Leeton) there could be a need to provide environmental water to this site. Alternatively, under wet conditions if the site was partially flooded already, the complete flooding with environmental water could be requested to provide maximum inundation. The later also applies to Tuckerbil Swamp. (See Management Plans)

Reason: *Ramsar sites, condition currently poor due to no major flood of entire swamp basin for many years, would provide habitat for JAMBA- CAMBA bird species and preserve ecological character. Requires the delivery of approximately 0.5 GL for Fivebough and 0.4GL for Tuckerbil Swamp.*

13. Under very wet conditions environmental water may be requested by the Murray Wetlands Working Group (MWWG) for the flooding of Black Swamp (Murrumbidgee Catchment Wetland, MWWG rehabilitation project site)

Reason: *DIWA site, condition currently poor due to no flooding since 1993, significant waterbird breeding site. Flooding is essential to retain live fringing Black Box trees. Requires the delivery of approximately 1.5 GL via the Coleambally Outfall Drain*

14. To pump water into between 1 and 3 high conservation value, nationally significant mid-Murrumbidgee wetlands (DIWA) identified under the Integrated Monitoring of Environmental Flows (IMEF) Program
Reason: This would be primarily to preserve the highly diverse aquatic plant seed-bank at the targeted sites, which have not been inundated for 8 years. It would enable the later, natural or managed, dispersal of aquatic plants throughout the other Murrumbidgee wetlands. This would require between 1-3 GL of water depending on the number of sites and is a current DWE/MWWG "Caring for Country" project submission.

Risks and mitigating strategies

Risk	Rating	Response
Unpredictable weather – turns drier than expected	High (likely & major)	Review asset condition and future priorities for watering.
Unpredictable weather – turns wetter than expected	Medium (unlikely & major)	Additional wetting options possible – continually assess volumes available
Flow management is uncoordinated	Medium (possible & moderate)	Establish EWARG; early communication with State Water and CSC
Water use and works approvals not linked to licences	High (possible & major)	Confirm status with DWE; seek discretionary one-off approval if necessary
Estimated flow target volumes are substantially wrong	Medium (unlikely & moderate)	Monitor flow delivery daily and seek adjustments; revise targets for future attempts
Unforeseen physical impediments to flow delivery	Medium (rare & major)	Early communication with Lowbidgee Landholders and State Water; alert DWE if illegal obstructions identified
Water use plan not amended in time to take advantage of other opportunities	Medium (possible & moderate)	Seek urgent approval from DWE
Insufficient water available to complete colonial waterbird breeding, if initiated	Medium (unlikely & severe)	"Borrow" of EWA 2 ahead of later accrual; purchase GS allocation
Murrumbidgee water resources used to supply traditional Murray requirements resulting in Murrumbidgee EWA reduction or loss of surplus flow arrangements etc	Medium (unlikely & major)	Review asset condition and future priorities for watering, arrange "payback' conditions

Monitoring, reporting and revising

Monitoring as per Rivers Environmental Restoration SPII, RiverBank monitoring plan for adaptive environmental water, and IMEF wetland monitoring program -DWE.

Reporting to

- Director, Water for the Environment, DECC – monthly update on conditions (climate, available environmental water) and weekly update during flow delivery events.
- Environmental Water Allowance Reference Group when formed – monthly update on conditions and weekly update during flow delivery events.
- Murrumbidgee Customer Services Committee – regular update at meetings.
- Broader community – updates in Riverbank Newsletter.

This plan is to be **revised** when conditions dictate. Triggers will be sustained catchment or localised rainfall that produces significant flows into storages or tributaries. Good communication with PWG, State Water, DWE staff and Lowbidgee landholders will help clarify the timing and scale of revision.

Prepared by: James Maguire (in consultation with Justen Simpson)

Position: Senior Wetlands and Rivers Conservation Officer, South; Principal Project officer Water, Water for the Environment
Date: 15th July 2008

Approved by: Derek Rutherford

Position: Director Water for the Environment

Sign:

Date: 23/9/08

Environmental Watering Plan for the Murrumbidgee Valley 2010/11

Summary of Environmental water releases in 2009/10

The Murrumbidgee Regulated Water Sharing Plan remained suspended for the entire water year. Over spring and summer 2,400 ML of Environmental Water Allowance (EWA) was used to assist the endangered Southern Bell Frog (*Litoria raniformis*) populations in key "Lowbidgee" wetlands.

Approximately 700 ML of EWA was diverted into key Southern Bell Frog (SBF) wetlands in the Nimmie-Caira system during November in conjunction with a 6,000 ML Stock and Domestic diversion. Some recruitment was detected by the Charles Sturt University (CSU) monitoring program, but it appears to have been a less successful watering than in the previous year.

Approximately 1700 ML of EWA was also used, along with a 1661 ML of DECCW licence water and 7096 ML of Commonwealth environmental water, to flood a wetland system known as the Twin Bridges–Piggery Lake complex, situated in the north of Yanga National Park.

The initial use of this licence water was to support breeding populations of the SBF, however towards the end of this watering program the watering focus shifted to maintaining suitable water levels in and around a significant waterbird rookery which established in the top end of this complex.

Ongoing DECCW and CSU monitoring had shown that SBF populations had moved into former habitat areas further south in Yanga National Park eg Piggery and Little Piggery Lakes. To get water to these more distant areas, larger volumes of water were required than in the previous few years of managing for the SBF recovery.

Dense aquatic plant growth greatly limited both the maximum diversion rates out of the Redbank Weir pool (to less than 50% of State Water estimates) and the passage of water south into Piggery Lake. However, after diverting all the available licence water, the Piggery Lake system received its required replenishment flow and renewed SBF calling was subsequently recorded.

Soon after these SBF diversions were completed, routine DECCW waterbird monitoring detected a newly established Great Egret and Cormorant rookery in the top end of the wetland complex in an area known as "Top Narockwell Swamp".

Further Commonwealth environmental water, which became available with progressive allocation increases, was used to sustain this rookery to completion over a period of 3 months. Four fortnightly "top up" flows, ranging from approximately 400 to 800 ML, were delivered to the site to maintain the desired water levels in both forage and nesting sites.

Approximately 200 Great Egrets and similar numbers of cormorants successfully nested and fledged their young at this rookery site.

This was the first usage of Commonwealth environmental water in the Murrumbidgee Catchment and its availability was crucial to maintaining the necessary hydrology in the Yanga wetlands for both the SBF and the waterbird rookery sites.

In March a significant rainfall event in the Wagga area flooded tributaries including Tarcutta and Kyeamba Creeks and resulted in a period of supplementary access being declared along the Murrumbidgee River.

The Commonwealth Environmental Water Holder (CEWH) transferred water to a DECCW supplementary licence and a combined event share based on the total holding was calculated by State Water. This volume (approximately 2GL) was ordered to the Glen Dee Regulator (SW structure) on the North Redbank Channel and supplied to the bottom end wetland systems starting with wetlands on the property "Murrundi". Along with the supplementary licence water, approximately 1GL of the "lowbidgee share" was also delivered to this same system and the resulting inundation extended down to the property "Moola".

As the watering was nearing completion 5 GL of additional EWA was made available by NOW out of a SW identified surplus flow (scheduled weir pool drainage). The 5GL was supplied to the same wetland system and extended the inundation right to the bottom end properties "Baupie" and the Balranald Shire Common (which is managed by Balranald Shire Council as an ecotourism site, complete with bird hides and walkways). This watering event created a wetland complex approximately 15 km long and covering approximately 2.5 - 3,000 ha of river red gum forest and associated wetlands.

In May Nap Nap Swamp was inundated via Nimmie Creek and the northern Levee bank breached allowing water to flow through into Nap Nap Lignum Swamp and then into Waugorah Creek. When water had passed through the Nap Nap boundary into the Creek sections in "Mungery" flows were stopped thru Nap Nap and instead diverted further down Nimmie Creek through the "White Elephant" Channel. Water flowed for the length of Waugorah Creek and flooded into North Stallion Swamp in Yanga National Park before overflowing back into the permanent section of Waugorah Creek which had just been topped up with stock and domestic flows. For Waugorah Creek and Stallion Swamp this was the first time these areas had been flooded in at least 10 years. 3.8 GL of allocation purchased by DECCW was contributed to this event along with 7 GL of EWA.

Maude Weir Lagoon was filled in December with approx 30 ML of EWA and topped up with approximately 3ML of EWA in both December and May. The survival of stocked native fish at this site is being monitored and their passage back to the river channel will be actively facilitated in spring 2010.

Fivebough Swamp, just north of Leeton, (RAMSAR site) was inundated with 1003 ML of EWA in May. The site was filled to its highest level in over 10 years. Early waterbird monitoring detected 23 Brolgas foraging at the site.

In Late April the CEWH approved the transfer of 40 GL to DECCW accounts for the watering of Yanga National Park. This water was diverted into Yanga almost entirely via the two northern regulators (1AS and 1ES) with just over 37 GL delivered through the top end and the residual delivered along with approximately 35 GL of EWA via the Maude Channel systems. EWA flows via the Maude system commenced on the third of June and were gradually ramped up to a maximum of approximately 950 ML/day using the North and South Caira Channels. By the 4th of July Tala Lake had filled to a level where it was overflowing down Tala and Woolshed Creeks into the southern section of Yanga National Park. By early August water had spread through the southern sections of Yanga National Park inundating forest and wetland systems down to the Devils Creek regulator just north of Yanga Lake. It was estimated that the area inundated within Yanga would be approximately 16,000ha. This is the largest flood event for Yanga National Park in at least 10 years.

Volumes of environmental water available

Account	Maximum limit (ML)	Available 03/08/10 (ML)
EWA	Potentially up to 200,000. Linked to dam inflows and translucent under-releases, as per new EWA accrual rules	Approx 59,000 available but committed (see EWA tracking and accrual table)
CEWH - General Security	52,891[2]	Dependent on allocations and other priorities in the southern connected Murray system[3]
CEWH - Supplementary	20,820	Dependent on access announcements[3]
Lowbidgee Access	200,000	5,000 just used in Yanga, and 2,500 in North Redbank
DECCW General Security	13,498	2,645
DECCW Supplementary	5,679	Dependent on access announcements

1. With the WSP still inactivated and the 75 GL of loaned EWA having been repaid on the 1st of March 2010. NOW have agreed to make a percentage of overall resource improvement available as additional EWA
2. This figure includes only water held in the Murrumbidgee. Note the Commonwealth environmental water holdings include water throughout the southern connected Murray system. Water from outside the Murrumbidgee could be traded in to provide water for Murrumbidgee assets. Likewise, Commonwealth water in the Murrubmodgee could be traded out to provide for priorities in other parts of the southern connected Murray system.
3. Decisions on the use of Commonwealth environmental water are made by the Commonwealth Environmental Water Holder after assessment against publicly available criteria and following advice from the Environmental Water Scientific Advisory Committee and input from the States and other stakeholders such as Environmental Water Advisory Groups.

Likely environmental watering scenarios

- Burrinjuck Dam is at 53 % of capacity (542 GL) and Blowering Dam 54% (897 GL) as at 03/08/10.
- NOW have agreed that EWA volumes will accumulate in callable accounts based on dam inflows and translucent under-releases in the 2010/2011 season (see July MoU from Derek Everson)
- With the High Security allocations increasing to 80% (2nd August announcement) the June/July EWA has been made fully available (48GL) and further EWA is now accumulating daily
- The mid catchment is currently very wet and any rainfall events from now until October will create tributary inflows and potential opportunities for piggybacking EWA releases from dams onto high tributary flows

- Presently most of the Murrumbidgee Weir pools are full following the July supplementary access event. So a significant rainfall event would likely result in further supplementary and lowbidgee access flows becoming available.
- Presently average to below average rainfall conditions are predicted for the upper catchment (above dams) from August to November inclusive http://www.eldersweather.com.au/raindeciles.jsp?lc=n07&dc=disableCookies
- The Murrumbidgee Environmental Water Reference Group (EWAG) was informally reconvened by DECCW and held meetings on the 5th of November 2009 and 24th March 2010.
- In summary, for the 4 month period up to the 1st of November 2010
  - ➢ Continued ongoing access to EWA is assured, however the volumes are depéndant on the upcoming weather conditions and dam inflows
  - ➢ High probability of supplementary access becoming available
  - ➢ High probability of Lowbidgee gaining access to surplus flows, which will contribute to achieving environmental watering targets
  - ➢ High probability of piggybacking opportunities arising which will be suitable for the release of EWA
  - ➢ Medium probability of WSP being switched back on within this period

Objectives for environmental water use for 2010/11

A. **<u>Under dry conditions (unlikely scenario given rainfall forecasts)</u>**

1. **Retain some of the EWA and during late spring and summer use whatever water is available to fill the highest priority Southern Bell Frog (SBF) wetlands as identified during the ongoing CSU/DECCW frog monitoring program. If these key sites are already catered for, then water other wetlands which are considered to be important for the population maintenance/expansion of this threatened species.**
   At least one top-up flow will be required, to produce the necessary hydrology for the SBF tadpoles lifecycle (minimum of four months inundation)

<u>Reason</u>: preserve the Southern Bell Frog populations in their priority habitat areas and provide for limited recruitment. Requires the delivery of approximately 5-10 GL.

Note: If surplus flows come about outside of the SBF breeding season it is recommended that sites are selected using another criteria

<u>B. Under average to slightly wet conditions</u>

1. **Provide maintenance flows to key waterbird rookeries which may establish in Yanga National Park. The known rookeries are mostly located in the northern section of the park which would be watered with the Yanga and Waugorah Regulators (1AS and 1ES). If rookeries were to establish in the Southern section of Yanga it would be most efficient to use the channel systems from Maude Weir (if available) to speed up water delivery. (Note the complete watering of Yanga National Park has just been completed)**
   <u>Reason</u>: maintain waterbird breeding event through to completion

2. Flood prioritised sections of privately owned red gum forest and lignum creeks/swamps in the Lowbidgee from both Redbank and Maude Weirs.
<u>Reason</u>: *red gum forest and lignum condition currently critical in parts, but good in other sections watered in June 2009. Flooding is essential to retain some of the river red gums alive and provide best chance of preventing loss of ecological character. Requires delivery of up to 50 GL*
Note 1 : The Federal Department of the Environment, Water, Heritage and the Arts have prioritised several Lowbidgee wetland sites in the North Redbank system as targets for their Spring 2010 watering program. However, provision of this water will require a decision by the CEWH and is contingent on the availability of water from spring allocations and other critical priorities in the southern connected Murray system.
Should the planned waterings proceed, DECCW would aim to match the Commonwealth environmental water at least 1:1 with EWA. This would create a significant wetland complex and may trigger a waterbird breeding events in several known rookery sites.
Note 2:- The Murrumbidgee CMA has entered into PVP Ecotender arrangements with several landholders in the Lowbidgee to manage grazing and exclude logging in RRG forest areas. Ecotender or similar conservation arrangements may result in the relevant wetlands becoming high priority sites for environmental watering.

3. To inundate the key rookeries and other wetlands of the Nimmie-Caira system creating and sustaining a waterbird breeding event of a similar extent to that of 2005 (30,000 pairs, mainly Ibis and Cormorants)
<u>Reason</u>: *condition good, but waterbird numbers are declining nationally and this would boost numbers of a variety of species affected by a series of very dry years. Requires delivery of approximately 30-50 GL. This would also be likely to create large scale SBF recruitment and dispersal to former habitat areas*

4. Inundate all the wetlands and red gum forest of the North Redbank System down to Balranald (picking up the sites which were not watered previously and creating one large connected complex, relates to point 2 above)
<u>Reason</u>: *condition currently poor and declining. Flooding is essential to retain live river red gum, aquatic plant seed-bank and ecological character. Significant waterbird breeding sites are located in this system. Some sites have not filled in over 5 years. Requires delivery of up to 80 GL and would most likely be achieved in combination with periods of "lowbidgee access"*

5 Use irrigation infrastructure to flood prioritised mid-catchment wetlands in the Murrumbidgee Irrigation Area (MIA) eg. Coonancoocabil Swamps, MIA National Park wetlands, Barrenbox Swamp and lower Mirrool Creek
<u>Reason</u>: *condition varies from good to poor, over 10 years since some of these sites were last flooded would, create drought refuge and potential habitat for threatened waterbird species.*
<u>**Note**</u>: *These MIA wetlands may offen be more logistically suited to receiving Supplementary licence water than Lowbidgee sites (due to system delivery constraints and flow sharing arrangements). In spring and Autumn in particular the MIA delivery system may be available to deliver licence water to these sites, whilst supplying irrigation flows without exceeding capacity.*

Note: The operational protocol for the Coonancoocabil Swamps states that the swamp regulators may be opened to flood the sites with Surplus flows (during announced supplementary events) or during periods of environmental releases. The site manager should be aware of such events and ready to operate the regulators.

C. Under wet to very wet conditions

1. Piggyback EWA releases onto significant tributary fresh/s inundating the majority of river fed wetlands from Gundagai to Maude Weir.

Reason: *condition currently critical and declining (condition gets progressively worse heading west along the river). Flooding is essential to retain live fringing river red gum, aquatic plant seed-bank and ecological character. Some sites have not filled in 12 years Requires delivery of approximately 35,- 45,000 ML/Day or greater @ Wagga for 2-3 days (See the Murrumbidgee Environmental Water Delivery Guidelines DNR 2006)*

2. Maintain and complete any colonial waterbird breeding event initiated by natural flood event or environmental flows.

Reason: *waterbird numbers are declining nationally and this would boost numbers of a variety of species whose numbers have been affected by a series of very dry years. This could require anything between 2-50 GL depending on a number of variables including site location, size and "delivery losses".*

3. Inundate extensive areas of the Yanga Nature Reserve and other significant wetlands located outside of the Lowbidgee Flood Control and Irrigation District (LFCID) eg Yanga Lake and Paika Lake

Reason: *condition currently critical and declining. Flooding is essential to retain live river red gum, black box, river cooba, aquatic plant seed-bank and ecological character. Requires delivery of up to 100 GL and would most likely only be achieved in conjunction with significant periods of Lowbidgee surplus flow access. Would require use of lowbidgee infrastructure which may be already fully utilised during the desired diversion period. May require MoUs and other landholder agreements to use private structures and flood private land.*

D. Other potential watering opportunities

1. **Fill Tuckerbil Swamp and top up Fivebough Swamp. (Note: Fivebough Swamp watering completed May 2010)**

(Note: Fivebough Swamp was watered in May 2010, Tuckerbil Swamp is currently dry however the Fivebough and Tuckerbil Wetland Management Trust (FTWMT) may request water in Spring)

Reason: *Ramsar sites managed by the FTWMT, watering provides habitat for JAMBA-CAMBA bird species and maintains ecological character. A Fivebough top up to maintain bird breeding would only require approx 200 ML. Filling Tuckerbil Swamp would require the delivery of approximately 0.5 GL*

Note: as there is no metering at this site currently, it is recommended that a number of flow gaugings are undertaken during all future diversions as a compliance measure. This will ensure that the volume diverted is at least similar to that ordered for the site. In the long term, sites of this significance should have flow metering stations installed.

2. Pump water into 1 to 3 high conservation value, nationally significant mid-Murrumbidgee wetlands (DIWA). These sites have been identified under the Integrated Monitoring of Environmental Flows (IMEF) Program eg. McKenna's, Sunshower and Yarradda Lagoons.

Reason: *This would be primarily to preserve the highly diverse aquatic plant seed-bank at the targeted sites, which have not been inundated for 9 years. It would enable the later, natural or managed, dispersal of aquatic plants throughout the other Murrumbidgee wetlands. This would require between 1-3 GL of water depending on the number of sites.*

Note: Although highly desirable, this watering project would be dependant on enhanced staffing (from internal or external sources), for the necessary project management and monitoring required.

3. Divert water to Wanganella Swamp.
Reason: Wanganella Swamp is a nationally significant site (DIWA) and due to the drought and water savings measures has remained dry since 2007. Previously the site was watered annually in association with irrigation flows down the Billabong/Forest Creek system.
Up until 2007 the swamp was an annual Brolga breeding site and historically a breeding site for the Australasian Bittern. It provided habitat for a number of threatened waterbirds including the Freckled Duck, Blue Billed Duck, Australian Painted Snipe and other JAMBA - CAMBA bird species.

Note: this site is actually located in the Murray Catchment but is supplied water from the Murrumbidgee regulated system. A water supply agreement needs to be reached between various agencies/groups and it is likely watering of this site will not involve Murrumbidgee environmental water resources.

4. Pump water into selected Lower Murrumbidgee wetlands (Balranald pumpers).
Reason: This would be primarily to preserve the aquatic plant seed-bank within a selection of these sites. Logistically only something in the range of 1-4 sites could be achieved using an estimated 1-2 GL

Note: This would be dependant on enhanced staffing (from internal or external ources) for the necessary project management (approvals etc) and monitoring required. Watering applications were received from the Balranald pumpers last season. Some sites are likely to receive water via Lowbidgee, Supplementary and EWA diversions in April and Spring watering events eg "Baupie"

5. Ensure the "Junction wetlands" below the Lowbidgee are satisfactorily watered. This would involve managing high Murrumbidgee flows to co-inside with high Murray Flows. This could require a period of reduced diversions into the Lowbidgee to create higher downstream river heights. Ideally this could be achieved by running licence allocation down the Murrumbidgee system to target the lower icon sites while the Murray River was already predicted to be above the 10,000ML/day level for some period.
Reason: the condition of these wetlands is critical and this system cannot be watered without high rivers (ie no weirs for diversions) Flooding is essential to retain live river red gums, aquatic plant seed-bank and ecological character. Some sections have not filled for 12 years. Requires the delivery of approximately 5,000 ML/Day or greater @ d/s of Redbank Weir for several weeks plus a Murray River flow u/s of the junction of >10,000ML/day for the same period

Note: To allow for a significant benefit in this junction wetland system there would have to be a substantial period of nil or reduced diversions into lowbidgee. The result of this period of reduced diversions (lowbidgee sites going without water) needs to be weighed up against the possible benefits to be achieved in the junction wetlands system.

Unless surplus flow is not diverted into Lowbidgee (eg because Murray allocation is low and water can be re-regulated in Lake Victoria) it is unlikely that the river system can be managed for providing benefits to the Junction wetlands except during flood years.

Table 1.) Other Potential Watering sites to be considered under suitable conditions

Wetland Name	Location	Size (ha)	ML (est)	Justification	Comments
Tuckerbil Swamp	Leeton	300?	400	RAMSAR, JAMBA, CAMBA	Water supplied in 2005, not currently requested, see F&TS management plan
Turkey Flats Swamp (SF)	Yanco	250?	500	DIWA,Rehabilitation site	Needs MoU with MI to run escape flows, channel flow constraints, no metering
Yanco Ag High Lagoon & MIA Forest (SF)	Yanco	80		DIWA	Was watered in 2005 and can be flooded currently, but control regulator not in place to allow a full forest flooding.
Campbells Swamp (Reserve)	Griffith		235	Migratory waterbird habitat	**Recommended,** (just recently watered no site assessment as yet)
Nericon Swamp (Reserve)	Griffith		230	Migratory waterbird habitat	**Recommended,** (just recently watered)
Wetland cell of Barrenbox Swamp	Griffith			Waterbird habitat, site rehabilitation	MI have verbally expressed interest in watering this site
Lower Mirool Creek and wetlands	Griffith		5,000	DIWA	The water saving project modifications to Barrenbox swamp will reduce the frequency of releases into this system
30 Mile gums (TSR)	Hay		30	Site profile and cultural significance	Potential ICAL site, strong HSC and community support **(Recommended and watered)**
Maude Weir Lagoon	Maude	3	5	Native fish nursery project	**Recommended,** SW estimate sufficient due to very small volume, no gauging

Where would Toogimbie Indigenous Protected Area fit into this prioritisation? any thought?

Note: Further sites may be added to this table as submissions are received via EWAG members, landholders etc. Sites which are likely to be actively watered on an ongoing basis into the future, will have further information collated and be included to sections 1-5 above in future versions of this document.

Supplementary event management

Any of the above listed sites may be prioritised for watering, often at short notice, during a supplementary event (surplus flows in the river). However many sites do not currently have the necessary work approvals to allow for the taking of licence water nor the required standard of metering to enable ordered flows to be measured and then debited from the related licence.

It is the responsibility of the proponent or site manager to ensure that these two requirements are covered and that DECCW is made aware of the work approvals as part of any watering submission. This way DECCW can have any likely work approvals linked to an appropriate licence prior to the event being declared.

Risks and mitigating strategies

Risk	Rating	Response
Unpredictable weather – turns drier than expected	High (likely & major)	Review asset condition and future priorities for watering.
Unpredictable weather – turns wetter than expected	Medium (unlikely & major)	Additional watering options possible – continually assess volumes available
Flow management is uncoordinated	Medium (possible & moderate)	Establish EWAG; early communication with State Water, LBG Landholders and other stakeholders
Water use and works approvals not linked to licences	High (possible & major)	Confirm status with NOW seek discretionary one-off approval if necessary
Estimated flow target volumes are substantially wrong	Medium (unlikely & moderate)	Monitor flow delivery daily and seek adjustments; revise targets for future attempts
Adverse water quality impacts aquatic (inc threatened fish) species	Medium (possible and moderate)	Monitor diversion targets for blackwater or other critical water quality issues and manage to minimise impacts on threatened fish species (eg control return flows to river)
Unforeseen physical impediments to flow delivery	Medium (rare & major)	Early communication with Lowbidgee Landholders and State Water; alert NOW if illegal obstructions identified
Water use plan not amended in time to take advantage of other opportunities	Medium (possible & moderate)	Seek urgent approval from NOW
Insufficient water available to complete colonial waterbird breeding, if initiated	Medium (unlikely & severe)	Transfer in CEWH or DECCW water from other valleys. "Borrow" of EWA 2 ahead of later accrual; purchase GS allocation
Murrumbidgee water resources used to supply traditional Murray requirements resulting in Murrumbidgee EWA reduction or loss of surplus flow arrangements etc	Medium (unlikely & major)	Review asset condition and future priorities for watering, arrange "payback" conditions

Monitoring, reporting and revising

Monitoring as per Rivers Environmental Restoration SPII, RiverBank monitoring plan for adaptive environmental water, and IMEF style wetland monitoring program for mid and lower murrumbidgee wetlands – DECCW may have to find funding for external contractors due to the envisaged "gap year" in RERP funding. WftE branch are currently investigating options for the retention of key staff during the 2010/11 year to continue monitoring at least within the Lowbidgee.

Currently there are limited resources available for monitoring of wetlands outside of the key sites in the Lowbidgee (eg Mid-Murrumbidgee, Yanco Creek or Mirool Creek wetlands) and monitoring may be limited to flow surveillance and measurement, estimation of inundation area, and photo points or other observational monitoring.

This limited monitoring situation is something which needs to reviewed. particularly in light of the increasing availability of Commonwealth Government water.

Reporting to

- Director, Waters, Wetlands and Coast, DECCW – monthly update on conditions (climate, available environmental water) and weekly update during flow delivery events.
- Environmental Water Advisory Group (EWAG) – Twice yearly meetings to discuss watering priorities and monthly updates during flow delivery events.
- Murrumbidgee Customer Services Committee – regular updates at meetings.
- DEWHA – as per specified arrangements pre watering event
- Broader community – updates in Riverbank and Water for the Environment Newsletters.

This plan is to be **revised** when conditions dictate. Triggers will be sustained catchment or localised rainfall that produces significant flows into storages or tributaries.
Good communication with stakeholders, in particular, EWAG members, State Water, NOW, and Lowbidgee landholders, will help clarify the timing and scale of revision.

Prepared by: James Maguire, in consultation with Justen Simpson
Position: Senior Wetlands and Rivers Conservation Officer, Environment Protection and Regulation Group;
& Manager of Environmental Water Delivery, Waters Wetlands and Coast Division
Date: 03 August 2010

Approved by: Derek Rutherford

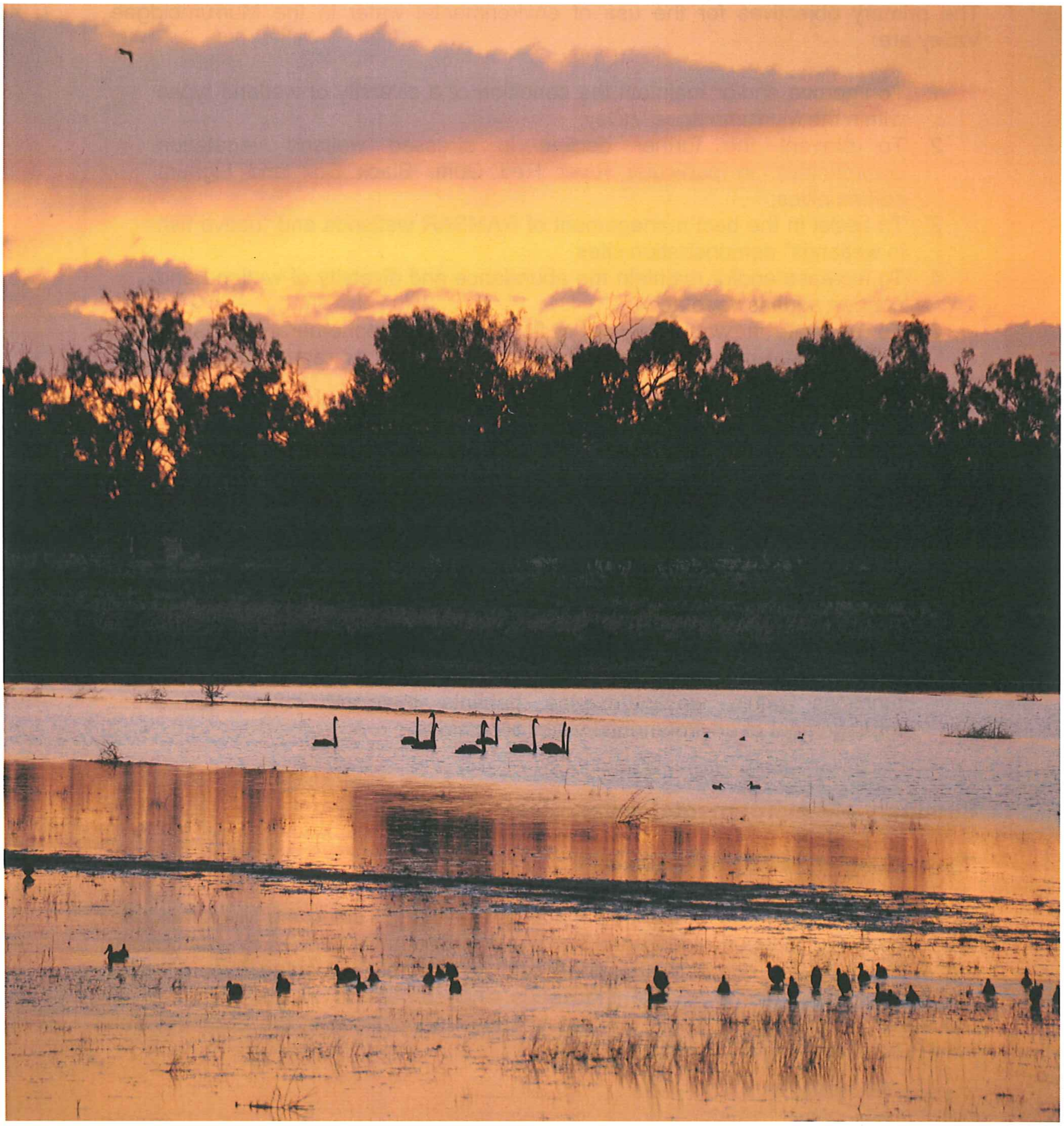
Position: Divisional Director Waters, Wetlands and Coast

Sign:

Date: 25/8/10

Environmental Watering Plan for the Murrumbidgee Valley 2011/2012

Paika Lake – James Maguire



Introduction

The 2010/11 water year saw a dramatic improvement in water resource availability and several significant flooding events in the Murrumbidgee Valley, however the Murrumbidgee Regulated Water Sharing Plan (WSP) remained suspended for the entire year. Despite this, environmental water accrual rules were followed as per the intentions of the WSP and numerous large scale watering events were completed. The WSP is scheduled to be reinstated on the 1st July 2011.

Primary Objectives for Environmental Water Use 2011/12

The primary objectives for the use of environmental water in the Murrumbidgee Valley are:

1. To improve and/or maintain the condition of a diversity of wetland types within the Murrumbidgee Valley;
2. To prevent the further decline in stressed wetland vegetation communities, in particular River Red Gum, Black Box and Lignum communities;
3. To assist in the best management of RAMSAR wetlands and "native fish in wetlands" demonstration sites
4. To increase and/or maintain the abundance and diversity of wetland and riparian aquatic vegetation
5. To reinstate a wetting/drying cycle for natural ephemeral floodplain wetlands that have been negatively impacted by river regulation and/or severe drought conditions;
6. To provide habitat for wetland-dependant fauna including endangered species such as the Southern Bell Frog (Litoria raniformis) and Fishing Bat (Myotis macropus);
7. To trigger/and or maintain colonial waterbird breeding events primarily in the Lowbidgee wetlands
8. To compliment naturally occurring high river flows (or if necessary create high flows) that provide a benefit to wetland/floodplain dependant fauna and flora communities by increasing duration and/or extent of inundation;
9. To minimise the adverse impacts that altered flow rates may have on in-stream fauna, in particular native fish populations, and;
10. To assist in furthering the understanding of biological processes and functions within wetland/riverine habitats that will inform future management of environmental water allocations.

Summary of Environmental water releases in 2010/11

Background - Lowbidgee Wetlands

The Nationally significant Lowbidgee wetlands are located along the Murrumbidgee River floodplain between Maude and Balranald in South Western NSW. Historically this wetland system regularly supported colonial waterbird breeding events which numbered in the many tens of thousands and sometimes in the hundreds of thousands. It was also home to the largest known populations of the Southern Bell Frog (*Litoria raniformis*) in NSW.

During the decade of drought between 2001 and 2010, condition of the Lowbidgee wetlands declined dramatically. Some sections of red gum forest and black box woodland died, waterbird numbers declined and the Southern Bell Frog population crashed to a critically low level. During this time the small available volumes of NSW and Commonwealth environmental water were used to maintain river red gum forest health in prioritised areas (particularly around known waterbird rookery areas) and to maintain key habitat areas for the survival and recruitment of the Southern Bell Frog.

Summary - Lowbidgee wetland watering

As the drought came to an end in the 2010/11 water year, the most significant ever recorded volumes of both NSW and Commonwealth environmental water were diverted into the Lowbidgee wetland systems. Water was diverted to some lignum and black box dominated areas which hadn't seen flooding for over two decades eg Fiddlers Creek through into the Yanga Nature Reserve. Similarly some red gum forested areas were flooded which hadn't been watered in ten years eg South Yanga NP and the upper sections of Uara and Waugorah Creeks.

These environmental flows and the subsequent over-bank floods of late 2010 revived the vegetation, triggered and sustained numerous significant waterbird breeding events and enabled a patchy and partial recovery of the Southern Bell Frog populations.

Yanga National Park

The collective environmental diversions coming from the North (top end of Yanga) and West (Nimmie–Caira (NC)) and the Uara Creek "Fingerboards" return flows combined to completely flood the southern section of the National Park and fill Yanga Lake by early November.

This environmental watering was the most comprehensive since at least 2000. It demonstrated that the southern section of Yanga National Park can be rapidly watered using the NC channels. Additionally, it showed that Yanga Lake can be filled in the same way if significant volumes are diverted down the NC channels for several months.

North Redbank

Approximately 7,000 ML of EWA and 2,000 ML of Commonwealth environmental water licence water was diverted into the North Redbank wetland system during winter and spring of 2010 in amongst ongoing Lowbidgee surplus flow access). Significantly more water than this had been committed by both NSW Office of Environment and Heritage (OEH) and the Commonwealth Environmental Water Holder (CEWH), however it was not needed, with the Lowbidgee diversions eventually inundating the whole floodplain.

Highlights in this system included the new OEH funded infrastructure, which enabled water to be delivered through "Baupie" and into the southern section of the Balranald Shire Common wetlands. These common wetlands had not been watered for over a decade.

Another highlight was the large egret and heron rookery which established at Steam Engine Swamp on the property "Paika East". This rookery was larger than any previously recorded event, containing thousands of Egrets, Heron and Cormorants.

Nimmie-Caira Wetlands

The Nimmie–Caira wetlands, including known rookeries and flood-ways, were inundated with approximately 50,000 ML of EWA during late winter and spring of 2010.

Highlights of these watering events include the establishment of two large Ibis rookeries at Telephone Bank Swamp and Eulimbah Swamp and a smaller rookery at Nap Nap Swamp.

The two large Ibis rookeries contained an estimated 30,000 pairs of Ibis. These rookeries were intensively monitored by researchers from NSW University, who documented four major egg laying events during the season and high reproductive success (report pending). At these rookeries, there was also a good species diversity of other waterbirds breeding including Freckled Ducks and other threatened species observed such as Australasian Bitterns (calling) and Blue-billed Ducks (pers comm Kate Brandis).

Another highlight was the re-colonisation of several wetlands with the Southern Bell Frog eg Nap Nap Swamp and Suicide Swamp. This was promising news for the recovery of this threatened species, however recruitment appears to have been limited (Thomas et al March 2011 CAP Report).

Fiddlers Creek to Yanga Nature Reserve

During September and early October, 15,360ML was diverted down the South Caira Channel and out of the “Warwagae” offtake regulator. This diversion was successful in inundating the lower third of Fiddlers Creek, which is sparsely vegetated with Lignum. and continued well into the Yanga Nature reserve, that is pre-dominantly Black Box woodland. The flows travelled the length of the Nature Reserve through the deeper runners or creek lines, but did not flood out to give good coverage of the reserve on the whole.

Paika Lake

At the time of writing of this plan water had just commenced filling Paika Lake. This is the first time the lake has been filled for approximately 100 years. Significant investment in infrastructure by OEH was necessary to enable water to be diverted to the Lake. The Lake is under transition from a dry system which had power lines running through the middle of its bed and was opportunistically cropped and grazed, to a highly managed aquatic reserve ecosystem. The landholders are developing Property Vegetation Plans (PVPs) which will see cropping excluded and grazing used selectively as a management tool.

Approximately 16,000 ML has been allocated to the filling of Paika Lake and the adjacent “Charax Swamp” which is a shallow Black Box wetland. The delivery path from the North Redbank Channel to Paika Lake also involves the watering of a significant area of red gum forest and several kilometres of creek line on “Narwie”, so a diverse range of wetland habitats are being created as part of this project. It is estimated this watering action may take up to 3 months to achieve a full level in the lake.

Background - Mid-Murrumbidgee floodplain wetlands

The mid-Murrumbidgee wetlands are located on the Murrumbidgee River floodplain between Gundagai and Maude and include the sub reach, Wagga to Carrathool, which is listed in the Directory of Important Wetlands Australia (DIWA)
The mid-Murrumbidgee wetlands are on the whole reliant on rainfall derived high river events or large scale environmental water releases to achieve their filling. As such, following the prolonged drought, most of these wetlands had remained dry for 5-10 years and for the sites with higher commence to fill levels even up to 14 years.

Some of these wetlands were studied under the IMEF program between 1999 and 2005. These selected study sites were highly diverse in their aquatic macro-invertebrate assemblages and many were covered with an abundant variety of aquatic vegetation (Hardwick *et al.* 2001 – the ASM paper).

As the drought came to an end in late winter of the 2010/11 water year, 47,000 ML of Environmental Water Allowance (EWA) was released from Burrinjuck Dam to coincide with a tributary rainfall event ("piggyback flow"). The resultant flow remained below minor flood level but was significant enough to fill many hundreds of wetlands and flood thousands of hectares of fringing river red gum forest right along the river system. This was the most significant wetland filling event since at least 1996 (pre-environmental flows) and the most effective ever use of EWA in piggybacking fashion.

Several larger flood events followed in the months after the EWA release, with the largest event in December, being classified as a major to moderate flood in the upper and mid river reaches. At the time of writing this plan the mid-Murrumbidgee wetlands are still partially full following the successive connections in the 2010/11 year.

Ongoing environmental monitoring has indicated that despite a good response in the health of the fringing red gums, the aquatic plants assemblages have not responded well in most wetlands. Some of the best vegetated sites historically are now virtually devoid of aquatic plants (see historical and current pictures below)

Mckennas Lagoon January 2001, showing abundant aquatic vegetation, dominated by Tall Spikerush (*Eleocharis sphacelata*) and Spiny Mudgrass (*Pseudoraphis spinescens)*

McKennas Lagoon March 2011, devoid of any aquatic plant life.

Mid-Murrumbidgee Piggybacking release

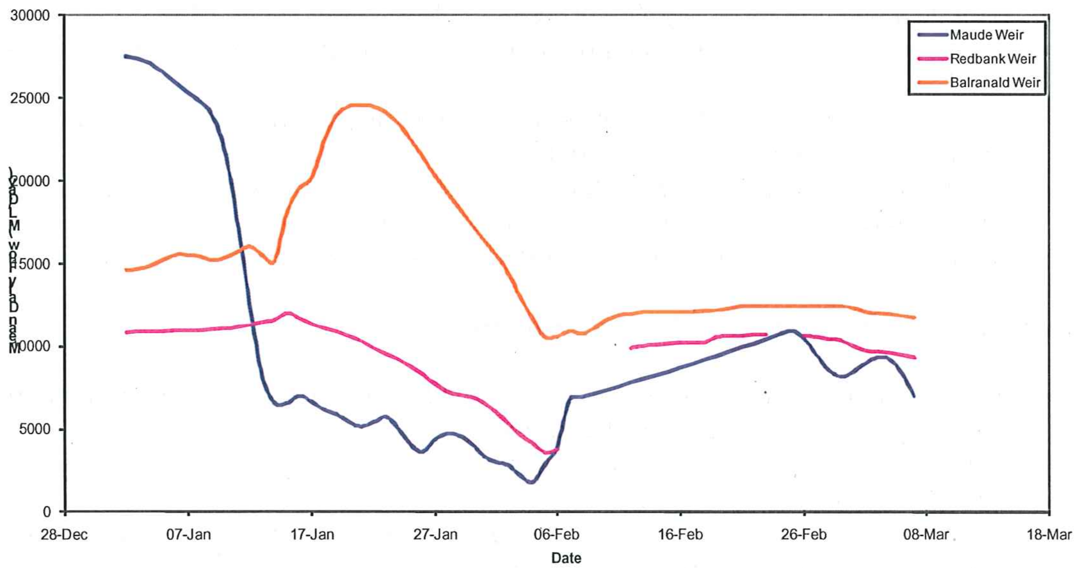
- On the 5th September the decision was made by the Murrumbidgee Technical Advisory Group (TAG) to maintain flows at Gundagai above 30,000ML/d.
- Murrumbidgee River at Gundagai peaked on 6th September at 43,000ML/d (5.72m) unassisted by Dam releases.
- Piggyback release of Environmental Water Allowance (EWA) from Burrinjuck Dam pushed the flow at Gundagai to 46,000ML/d (5.95m). This was 230mm above the natural peak and 150mm below the minor flood level of 6.1m.
- Environmental releases of 47 GL over 3 days (peak release of 20,000ML/d) were used to sustain the peak at Gundagai. Flow at Gundagai stayed above 30,000ML/d for 3 days and 18 hours.
- Flow at Wagga peaked at 52,000ML/d (6.95m), below minor flood level of 7.3m and stayed above 40,000ML/d for 4 days and 7 hours.
- Flow at Darlington Point peaked at 26,600ML/d (5.39m), below minor flood level of 5.5m. Flow at Darlington Point stayed above 24,000ML/d for 4 days and 6 hours.
- 47 GL EWA releases extended duration of high flows through Wagga significantly and inundated wetlands down the whole system to the Murray Junction.
- The flow was the most significant wetland filling event since 1996.
- It was also the most significant piggybacking event ever, largely due to size of the base flow volume.
- Significant River Red Gum forest inundation documented from a flyover in Darlington Point to Yanco river reach.
- Sat image analysis (NOW/OEH) of this same "indicator reach" has shown that 90% of the available wetlands filled during this flow event
- State Water (SW) management of event exceeded OEH expectations.

Lower Murrumbidgee blackwater dilution flows

- During spring and summer of 2010, successive floods culminated in the December moderate to major flood event.
- Areas of the wider floodplain inundated for the first time in 20 years, reconnection of full wetlands.
- Vast areas of organic material inundated and high carbon return flows back to the river channel, particularly d/s of Redbank Weir.
- DO levels in the main channel dropped to below 1mg/L which is a critical level for fish.
- Between Xmas and New Year hundreds of fish deaths were reported by Balranald locals.
- The reports were mostly very large Murray Cod collectively in the hundreds ranging from 5-50 pounds.
- Golden Perch and Carp were also recorded during OEH, SW and Fisheries field inspections in the following weeks.
- The fish deaths corresponded to a period of recession between the medium and larger flood.
- Location d/s of Maude although Hay was apparently affected but reports were too late and no evidence was gathered.
- Standard river operation practices (re EoSF/gains) and a sharp rise in irrigation demand were likely to cause a rapid recession in river levels d/s of Hay following the major peak passage.

- The looming larger potential fish death event was flagged by OEH and EWA releases were recommended with support by NSW I&I (Fisheries) and NOW.
- EWAG supported the provision of 30,000 ML to maintain base flows d/s of Maude and dilute low DO flows coming off the floodplain (17,115 ML SW confirmed usage).
- EWA releases on top of base river flows commenced 25/01/11.
- CEWH committed a further 61,000 ML on 05/02/11 (actual usage as confirmed by State water 57,751 ML).
- Flow range of 4 - 5,000 ML/day requested of SW for d/s of Maude Weir.
- Stream capacity between Maude and Redbank is reduced to 9,000ML/day in some sections.
- Flows were reduced in line with increases in WQ and reductions in floodplain return flows.
- Flows were completed in late March.
- Monitoring revealed that the intervention was successful in increasing DO in the river to above lethal levels, however there was evidence that fish deaths had already occurred before the intervention (NoW, in prep). See below graph provided by NOW.

Mean Daily Flow Lower Murrumbidgee River January-March 2011



Volumes of environmental water likely to be available in 2011/12

Account	Maximum limit (ML)	Available 01/07/11 (ML) (assuming 95% HS and 35% GS starting allocations)
EWA	150,000	54,000
CEWH High Security	0.1	0.1
CEWH - Supplementary	Potentially 20,820	Event triggered
OEH Supplementary	5,679	Event triggered
Lowbidgee Access	Potentially 200,000	Event triggered
OEH General Security	21,535	7,537
CEWH General Security	71 GL (Bidgee) 587 GL (Southern Connected Basin)	25 GL (Bidgee) 205 GL (Southern Connected Basin)

Current Conditions (June 2011)

- Burrinjuck Dam is at 87.8% of capacity (903,451 GL) and Blowering Dam 96.7% (1,579,883 GL) as at 29/06/11.
- NOW have announced that the Murrumbidgee Regulated Water Sharing Plan (WSP) will be re-activated at the commencement of the new water year (1 July 2011).
- Presently most of the Murrumbidgee weir pools are reasonably full and there is a supplementary access declaration valid until the 7th of June which is likely to be extended until the end of the water year.
- Presently the long range weather forecast for the catchment downstream of the dams is for near normal (3 months) to below normal (1 month) rainfall for period of July to October.
- The long range weather forecast for the catchment of the storages is very similar.
- Given the condition of the upper catchment following significant summer and autumn rains, even average rainfall is likely to lead to significant dam inflows
- The Murrumbidgee Environmental Water Reference Group (EWAG) has been reconvened by OEH and held meetings on the 24th March 2010 and 18th of May 2011. During Summer of 2011 a number of phone meetings were also held to discuss black-water dilution flows.
- In summary, for the 4 month period up to the 1st of October 2011
  - High probability of EWA 1 (50 GL) becoming available when General Security allocations exceed 60% (plus carryover)
  - High probability of Supplementary Access being declared
  - High probability of Lowbidgee gaining access to surplus flows, which will contribute to achieving environmental watering targets.
  - High probability of piggybacking opportunities arising which will be suitable for the release of EWA.
  - High probability of dams spilling

Objectives for environmental water use for 2011/12

A. <u>Under dry conditions</u>

Water options under this scenario have not been considered due to carryover dam volumes, catchment conditions, rainfall forecasts and likely commencing allocations levels

B. Under average to slightly wet conditions

1. **Flood the southern section of Yanga National Park in late spring (South of and including Tala Lake) using the channel systems from Maude Weir if available, (ideal timing late June to early November)**
   Reason: forest condition currently stable but poor to average in many sections. Flooding of this system 2 years in a row will build on the response from 2010 flows and ensure a long term benefit to forest health. Requires delivery of approximately 20-30 GL.

Note: This will be a follow up watering, back to back with several flood events from last year. An assessment will be carried out prior to any watering to gauge the potential risk of over watering this system and the likelihood of any associated tree loss and aquatic vegetation decline.

This system will still be partially wetted (in late Spring 2011) due to residual flow drainage from the summer floods, hence the conservative volume estimate.
The well watered top end of Yanga is being managed to achieve a drying phase, unless over-bank flows preclude this objective from being achieved.
This watering action would require the usage of the South Caira channel for approximately 3-4 weeks.

This opportunistic channel usage was discussed at the 18th May EWAG meeting and thought to be unlikely (due to conflicting use and weed control goals) but not out of the question. The Nimmie-Caira landholders need to agree to make the channel available or to potentially share usage for a longer period than the 3-4 weeks
Later access to significant periods of surplus flows or Lowbidgee access may enable diversions into Yanga Lake to take place.

2. **Flood privately owned sections of Fiddlers Creek through to the Yanga Nature Reserve (ideal timing late June to early November)**
   Reason: Black box woodland condition is stable following record summer rainfall and inundation of lower lying sections with environmental diversions in 2010, however this Nature Reserve system and the adjacent delivery system wetlands would benefit greatly in the long term from a good follow up inundation . Requires delivery of approximately 30-40 GL.

Note: This watering action would require the usage of the South Caira channel for approximately 4-6 weeks. This Lowbidgee infrastructure may be already fully utilised during the desired diversion period
However, opportunistic channel usage was discussed at the 18th May EWAG meeting and thought to be unlikely (due to conflicting use and weed control goals) but not out of the question. The Nimmie-Caira landholders need to agree to make the channel available or to potentially share usage for a longer period.

3. **With landholder support, flood selected sections of the North Redbank wetland system which are likely to benefit from back to back inundation events (without becoming over-watered.) This would only be attempted in late spring once the wetlands had dried out at least partially. The action would require landholders support and in some cases group support due to connectivity between adjacent holdings.**
   Reason: Similarly to South Yanga, many sections of the North Redbank system had been greatly under-watered prior to last year. Flooding of this system 2 years in a row will build on the response from 2010 flows and ensure a long term benefit to forest health. Requires delivery of approximately 20-30 GL.

Note: This will be a follow up watering, back to back with several flood events from last year. An assessment will be carried out prior to any watering to gauge the potential risk of over watering this system and the likelihood of any associated tree loss and aquatic vegetation decline.

The "Wynburn" and "Baupie" escapes can be used to actively drain these wetland complexes should over-watering occur and there is a risk to vegetation health/cover.

4. **Divert water down Uara Creek and through the "Fingerboards" Creek section in Yanga National Park (ideal timing August to October)**

Reason: Similarly to South Yanga National Park, Uara Creek had been dry for the decade prior to last years event and it is generally thought that it would benefit from back to back watering.

Note: This action will need the private landholders support regarding flooding the upper section of Uara Creek. The Nimmie-Caira landholders also need to agree to make the South Caira channel available or to potentially share channel usage for a period while these diversion are carried out.

This will be a follow up watering, back to back with a sustained environmental diversion during last year. An assessment will be carried out prior to any watering to gauge the potential risk of over watering this system and the likelihood of any associated die off in the lower lying black box trees.

5. **Continue to water black box depressions north of Paika Lake which can be targeted using the Paika Lake bypass channel (ideal timing August to October)**
   Reason: These Black Box swamps were dependant on significant Murrumbidgee flood events for filling. Like Paika Lake they have been isolated from the historically connected North Redbank forest system for a century and the fringing trees have been surviving on rainfall only. By diverting more water into or past Charax Swamp, several other unnamed Black Box Swamp areas can be watered. This may use between 500 and 5,000 ML depending on the number of swamps targeted.

Note: This watering action would likely require some earthworks or regulating structures to enable the targeted delivery of flows. Ongoing use of the North Redbank channel as well as the continued flooding of forest and creek sections in Narwie and Paika Creek is necessary for this action to be achieved. Late August or September would be the ideal timing for this action ie just after the Paika Lake watering is completed.

C. Under very wet conditions

1. **Piggyback environmental releases onto significant tributary fresh/s inundating the majority of river fed wetlands from Gundagai to the Murray River junction. (ideal timing late June to early November)**

   Reason: Despite the highly successful piggybacking event of August 2010 and the later successive floods which refilled the Mid-Murrumbidgee wetlands numerous times, the response of most wetlands in terms of aquatic plants in particular has been very poor. While environmental accounts hold sufficient volumes and base flow triggers are reached, this watering objective needs to be one of the highest priorities to facilitate the long term recovery of these wetlands. It should be noted that the vast majority of these wetlands do not have the infrastructure needed to deliver water to them without creating a high river event. Requires delivery of between 30- 45,000 ML/Day @ Wagga for 2-3 days.
   Note: at the time of writing this plan, a “standalone” river release of approximately 160 GL is underway. The releases will be made over a 10 day period, with the primary objective being the replenishment of the majority of the Mid-Murrumbidgee wetlands. A substantial percentage of the volume released will flow through into the Murray system. A follow-up release during

spring may be beneficial to support bird breeding and maximise duration for aquatic plant response. Detailed on-ground monitoring being carried out by Charles Sturt University and OEH will help inform this decision. A summary of this stand alone release event will be included in future revisions of this plan.

2. **Maintain and complete any colonial waterbird breeding event initiated by natural flood event or environmental flows (likely timing November to March)**
   This relates primarily to the Lowbidgee floodplain where the delivery infrastructure exists to supply maintenance flows to rookery areas.
   Reason: waterbird numbers are declining nationally and this would boost a variety of species whose numbers have been affected by a series of very dry years. This could require anything between 2-50 GL depending on a number of variables including site location, size and "delivery losses".

D. Other potential watering opportunities

1. **Blackwater dilution flows (likely timing Summer and early Autumn)**
   Remain alert to the potential need for in stream flows to provide a natural recession and/or additional dilution following any flood event which inundates the floodplain. The risk has been lessened following last years events but is still a possibility especially for late spring or summer high flow events.

2. **Ensure the "Junction wetlands" below the Lowbidgee are satisfactorily watered.** This involves managing high Murrumbidgee flows to coincide with high Murray flows. This could require a period of reduced diversions into the Lowbidgee to create higher downstream river heights. This can be achieved by running environmental water down the Murrumbidgee system in a large stand alone release (eg June/July 2011 event) which is effectively quarantined and therefore not subject to erosion by Supplementary water users. Alternatively, depending on the timing, volume, peak height and antecedent river/wetland conditions a significant piggybacked release may get down to the lower Murrumbidgee system at the required level, despite supplementary and/or Lowbidgee use. In all instances the Murray River would need to be above, or forecast to exceed, the 10,000ML/day level at Barham for some period to make such a watering action successful.
   Reason: the condition of these wetlands is stable but poor and this system cannot be watered without high rivers (ie no weirs for diversions.) Flooding is essential to retain live river red gums, aquatic plant seed-bank and ecological character. Some sections had not filled for 12 years, prior to last years prolonged flood event. Requires the delivery of approximately 5,000 ML/Day or greater at d/s of Redbank Weir for several weeks plus a Murray River flow of >10,000ML/day at Barham for the same period.

Note: Often to allow for a significant benefit in this junction wetland system there would have to be a substantial period of nil or reduced diversions into Lowbidgee. The result of this period of reduced diversions (Lowbidgee sites going without water) needs to be weighed up against the possible benefits to be achieved in the junction wetlands system.

Unless Lowbidgee landholders were willing to forgo access to specific surplus flow events (potentially under some loan/payback arrangement) it is unlikely that the river system can be managed for providing benefits to the Junction wetlands except during very wet years

Table 1 - Other Potential Watering sites to be considered under suitable conditions

Site Name	Location	Size (ha)	ML (est)	Justification	Comments
Tuckerbil Swamp	Leeton	300?	400	Ramsar, JAMBA, CAMBA	EWA last supplied in 2005, request from FTMC expected this year. **Recommended**
Turkey Flats Swamp (MIA National park)	Yanco	250?	500	DIWA, NP and Rehabilitation site	River release may fill, if not following works filling with EWA via MI may be attempted.
Yanco Ag High Lagoon (MIA National Park)	Yanco	80	320	DIWA, NP and Rehabilitation site	Was watered in 2005 and can be flooded currently, but control regulator not in place to allow forest flooding
Coonancoocabil Lagoon (MIA National Park)	Yanco	80	400	Native Fish in wetlands demonstration site. Highly managed conservation area within National Park	**Recommended**. Following a complete drying to control carp, the project steering committee may request water for this lagoon as part of a long term management objective
Almond Rd Black Box egret rookery	Leeton	2	6	Waterbird rookery	**Recommended**
Campbells Swamp (Reserve)	Griffith		235	Migratory waterbird habitat	**Watered last year**
Nericon Swamp (Reserve)	Griffith		230	Migratory waterbird habitat	**Watered last year**
Wetland cell of Barrenbox Swamp	Griffith			Waterbird habitat, site rehabilitation	**Watered last year**, MI have not requested water at this stage
Lower Mirool Creek floodplain and wetlands	Griffith		5,000	DIWA	**Not recommended.** Summer rainfall had filled all system wetlands and commenced flows in the lower flood plain. Alligator weed issues need addressing
30 Mile gums (TSR)	Hay		30	Site profile and cultural significance	Strong support from Hay Shire Council and local indigenous community. **(Not recommended Watered, last year)**
Maude Weir Lagoon	Maude	3	5	Native fish nursery project	**Recommended if filling is managed to facilitate native fish movement and followed by drying cycle to control carp.**

Murrumbidgee River channel	Downstram of Burrinjuck and Blowering Dams	All areas		Populations of threatened fish species,. endangered aquatic ecological community.	Introduce flow variability (small in-channel rises and slow recession) that has been removed/attenuated by flow regulation. eg increase base flow by 50-200% over 1 to 2 days and reduce back over 8 to 10 days.
Murrumjbidgee River channel	River channel Berembed weir to Gogeldrie weir			Populations of threatened fish species, endangered aquatic ecological community.	Introduce flow variability (small in-channel rises and slow recession) that has been removed/attenuated by flow regulation. eg increase base flow by 50-200% over 1 to 2 days and reduce back over 8 to 10 days.
Murrumbidgee River channel	Gogeldrie weir to Murray confluence			Populations of threatened fish species, endangered aquatic ecological community.	Introduce flow variability (small in-channel rises and slow recession) that has been removed/attenuated by flow regulation. eg increase base flow by 50-200% over 1 to 2 days and reduce back over 8 to 10 days.
Yanco & Colombo Creeks	Yanco weir to Billabong Creek confluences			Populations of threatened fish species, endangered aquatic ecological community.	Introduce flow variability (small in-channel rises and slow recession) that has been removed/attenuated by flow regulation. eg increase base flow by 50-200% over 1 to 2 days and reduce back over 8 to 10 days.
Murrumbidgee channel weirs	Berembed, Yanco, Gogeldrie, Hay, Maude, Redbank, Balranald			Populations of threatened fish species, endangered aquatic ecological community.	Reduce rates of rall downstream of weirs to mimic natural recession rates and provide ample opportunity for fish to vacate off stream habitats. Manage for fish passage, maintain contingency for maintaining flows at critical instream breeding times?

Note: Further sites will be added to this table as submissions are received via EWAG members, landholders etc. Sites which are likely to be actively watered on an ongoing basis into the future will have further information collated and be included to sections A to D above in future versions of this document.

Supplementary Event Management

Any of the above listed sites may be prioritised for watering, often at short notice, during a supplementary event (surplus flows in the river). However many sites do not currently have the necessary work approvals to allow for the taking of licence water nor the required standard of metering to enable ordered flows to be measured and then debited from the related licence.

It is the responsibility of the proponent or site manager to ensure that these two requirements are covered and that OEH is made aware of the work approvals as part of any watering submission. This way OEH can have any likely work approvals linked to an appropriate licence prior to the event being declared.

Risks and Mitigating Strategies

Risk	Rating	Response
Unpredictable weather – turns drier than expected	High (likely & major)	Review asset condition and future priorities for watering.
Unpredictable weather – turns wetter than expected	Medium (unlikely & major)	Additional watering options possible – continually assess volumes available
Flow management is uncoordinated	Medium (possible & moderate)	Establish EWAG; early communication with State Water, LBG Landholders and other stakeholders
Water use and works approvals not linked to licences	High (possible & major)	Confirm status with NOW seek discretionary one-off approval if necessary
Estimated flow target volumes are substantially wrong	Medium (unlikely & moderate)	Monitor flow delivery daily and seek adjustments; revise targets for future attempts
Unforeseen physical impediments to flow delivery	Medium (rare & major)	Early communication with Lowbidgee Landholders and State Water; alert NOW if illegal obstructions identified
Water use plan not amended in time to take advantage of other opportunities	Medium (possible & moderate)	Seek urgent approval from NOW
Insufficient water available to complete colonial waterbird breeding, if initiated	Medium (unlikely & severe)	Transfer in CEWH or OEH water from other valleys. "Borrow" of EWA 2 ahead of later accrual; purchase GS allocation
Murrumbidgee water resources used to supply traditional Murray requirements resulting in Murrumbidgee EWA reduction or loss of surplus flow arrangements etc	Medium (unlikely & major)	Review asset condition and future priorities for watering, arrange "payback' conditions

Monitoring, Reporting and Revising

Monitoring – Mid-Murrumbidgee

"Mid-Murrumbidgee ecosystem response monitoring - wetland and in river".
This new project will be carried out by CSU with assistance from OEH. The project is funded by SEWPC and will include a number of historical IMEF wetland sites

OBJECTIVES

1) Quantify the rate of recovery of frog communities and aquatic and riparian plant communities by comparing the baseline pre-drying (1998-2005), immediately after natural flood events (2010/2011) and following the delivery of environmental water in mid 2011

2) Describe temporal changes to tadpole and small bodied fishes communities following wetland flooding

3) Quantify the exchange of dissolved organic carbon (DOC) and particulate organic carbon (POC) between riverine and wetland systems

4) Assess the changes in biofilm biomass and diversity and abundance and diversity of aquatic macroinvertebrates in reaches downstream of Burrinjuck and Blowering dams in response to the flow pulse.

5) To generate knowledge to assist environmental water managers and dam operators better predict future ecological responses to large releases of environmental water from dams.

Monitoring – Lowbidgee

The recent intensity of the Lowbidgee wetland monitoring will be reduced this year with the wind up of the Catchment Action NSW funded monitoring program led by Jenifer Spencer (OEH) in co-operation with Dr Skye Wassens (CSU)

Five newly purchased remote monitoring cameras will be deployed into priority Lowbidgee wetlands to take times lapse photographs and record frog/bird calls. These cameras enable the production of a small "movie" which tracks the changes in the wetland enables a waterbird and frog surveys to be compiled.
Photo-points will be established at all other major watering sites.
Opportunistic waterbird surveys will be conducted by SWARCO during wetland inspections.

Satelite imagery will be analysed quarterly to access inundation extent and vegetation response. This quarterly time frame will aid in regular reporting on watering events.

Reporting to

- Divisional Director, Water Wetlands and Coast – monthly update on conditions (climate, available environmental water) and weekly update during flow delivery events.
- Environmental Water Advisory Group (EWAG) – Twice yearly meetings to discuss watering priorities and monthly updates during flow delivery events.
- Murrumbidgee Customer Services Committee – regular updates at meetings.
- SEWPC – as per specified arrangements pre watering event
- Broader community – updates in Riverbank and Water for the Environment Newsletters.

Revising

This plan is to be revised when water availability conditions change significantly. Triggers will be catchment or localised rainfall that produces significant flows into storages or tributaries.

Effective communication with stakeholders, in particular, EWAG members, State Water, NOW, and Lowbidgee landholders, will help clarify the timing and scale of revision.

Prepared by: James Maguire in consultation with Justen Simpson

Position: Senior Wetlands and Rivers Conservation Officer, LAHPS, South;
& Manager of Environmental Water Delivery, Water for the Environment

Date: 16th June 2010

Approved by: Derek Rutherford

Position: Divisional Director, Water Wetlands and Coast

Sign:

Date: 16/8/11

GWYDIR

ECAOAC

Gwydir Environmental Watering Plan 2010/11 water year

Environmental water releases - 2009/10 water year (1st July –30th June)

Outcomes from the 2009/2010 Season

1. River Flows & Distribution

The 09/10 water year was characterised by a single natural ‘Supplementary’ flow event in the Gwydir River system, occurring briefly in early January 2010 and totalling 14,202 ML @ Pallamallawa (03/01/2010 to 07/01/2010).

November & December 2009 suffered an extended period of $40^{o}C$+ daily temperatures and a lack of seasonal rainfall events and river flows. The Gwydir River system (incl. Mehi River and Mallowa Creek) had dried down to a series of low level pools, prompting DECCW (as the environmental water manager) and local State Water staff to consider the potential for fish kills and the need to protect priority river reaches from further decline.

Immediately prior to Christmas 2009 the Gwydir River system (Incl. Mehi River) was restarted by the River Operator (State Water) via small stock and domestic and limited irrigation deliveries.

In early January, cyclonic activity resulted in rainfall (70 mm) being received across the lower wetland areas, with more significant falls (140 mm) in the upper tributaries. This rainfall activity and subsequent river flows resulted in the announcement of a single ‘Supplementary Flow’ event in the system for the period.

The calculated environmental share from the total amount of 14,202 ML was to be 7,689 ML (5,189 ML Env. Share + 2,500 ML 3T Rule). In accordance with current rostering/sharing arrangements in the Gwydir, State Water delivered approximately 3,000 ML of the Gwydir River flow (env. share) into the Mehi River system. Approximately 350 ML of this volume were subsequently delivered into the Mallowa Creek system (10/01/2010 to 15/01/2010). The remaining volume (2,650 ML) flowed downstream along the Mehi River, filling waterholes and assisted the carriage of irrigation water to the downstream extraction points. This volume was not expected to have reached the Barwon River @ Collarenebri, due to the dry state along its length of the receiving Mehi River system.

The remaining environmental volume delivered to the downstream Yarraman gauge was 4,660 ML (2,160 ML + 2,500 ML). A total of 2,928 ML was delivered into the Gingham system, leaving a remaining total of 1732 ML into the Lower Gwydir system. However, only approximately 730 ML entered the wetlands leaving an unaccounted loss of approximately 1,000ML.

A smaller release totalling 70 ML was made to the ‘Whittakers Lagoon’, in early January 2010, from water held under license by NSW Government (RiverBank AEWL). This release was the second stage of the restoration program for this isolated wetland remnant. The ecological response at the site to date has been positive (increasing abundance and cover of native aquatic macrophytes; increased water bird diversity, waterbird breeding).

Table 1: Summary of Gwydir flow events and distribution between wetland assets

Event	Total Env. vol (ML)	ECA	AEWL	Lower Gwydir (ML)	Gingham (ML)	Mehi (ML)	Mallowa Crk (ML)	Other
Jan 2010	70	0	70					Whittakers Lagoon
04/1/- 9/1/10	7689			1731	2928	3000		
10/1–15/1/10							350	
Unexpl. Loss				Approx 1000				
Total Recv'd	6659			731	2928	2650	350	

2. Inundation Outcome

The total wetland area inundated as a result of this single natural 'Supplementary Flow' event was approximately 1,370 hectares located:

- 980 Hectares in both the Upper Gingham Watercourse (Tyreel and Raft downstream to Tillaloo) and downstream core wetlands areas below 'Westholme';
- 250 Hectares across the Lower Gwydir Wetlands;
- 120 Hectares Mallowa Creek.

Note: Due to the brief nature of the flow event and state of the receiving environment, no aerial assessment was made, post the event. A conservative figure of 3 ML per Hectare was used to calculate the area of inundation. Wetland areas below the Gingham Bridge are unlikely to have been inundated. It is unknown at this time which environmental assets were inundated in the Mallowa Creek system.

All of the above wetland systems were inundated for only a very brief period. The inundation was mostly shallow and insufficient to generate significant wetland response. The response was also mostly restricted to the lowest features within the wetland areas and along channel systems.

In contrast an additional 20 hectares at Whittakers Lagoon were inundated with good wetland vegetation and other ecological responses (waterbird feeding and breeding habitat) as a result of this season's (70ML) water delivery.

Substantial follow-up rainfall was received after this initial New Year event, however no further river flows resulted. Whilst the combined rainfall (320mm) for the period (Jan-May 2010) did stimulate vegetative growth across the wetland, Marsh Club-rush of the L.G Big Leather wetlands did not set seed. Field assessments were undertaken in early April 2010 and observed moderate end of season growth and development across most other sedgeland plant species. Seeding of these other species was observed but limited in extent.

3. Management Implications

There was no evident explanation for the losses from the early January 2010 'Supplementary Flow' distribution into the Lower Gwydir (LG) system. However, following a review of pre-flow conditions and flow records in cooperation with State Water, and assuming 20% loss of flow)to evaporation, waterholes, soil moisture, etc), an environmental water loss of approximately 1,000 ML was agreed (see Attachment A).

In brief, the conditions immediately prior and during the January 2010 flow event were as follows:

- A base flow had occurred along the entire length of the LG for at least two weeks prior;
- Substantial rainfall (70-140mm) received across the LG catchment (Xmas – New Year);
- The total daily flow was within channel capacity during the flow period;
- All flows were within the capacity of all river gauges;
- All river gauges appear to have been reading correctly over the period of the flow event.

Irrigation meter readings have shown a small (100 ML) discrepancy across the Lower Gwydir system during the event. Compliance inspections by NSW Office of Water, after the issue was highlighted, failed to determine a likely cause.

DECCW will liaise with the NSW Office of Water with regard to the repayment of the agreed 1,000 ML loss volume to the Lower Gwydir wetlands during a subsequent flow event.

In addition, discussion with State Water has highlighted the need for the consideration of 'Critical Environmental Needs' at the time of flow within the future rostering decisions of 'Supplementary Access' in the Gwydir.

4. State of water dependent assets at July 2010

Asset	Last watering	08/09 Condition	Current Condition
Lower Gwydir Wetlands system	ECA & natural flows Jan & Feb 2009 ; 320mm local rainfall Jan – May 2010	**MODERATE**	**MODERATE** (surviving on rainfall and sub-soil moisture from 09)
Wondoona Waterhole – End of system target for Lower Gwydir Wetlands	Natural flow Feb 09 and 320mm local rainfall Jan – May 2010	**MODERATE**	**MODERATE (**rainfall insufficient to re-fill WH)
Gingham Watercourse Wetlands system	Natural flows Jan & Feb 2009; ECA – Feb 09; 320 mm local rainfall Jan – May 2010	**MODERATE**	**MODERATE** (surviving on rainfall and sub-soil moisture from 09)
'Old Dromana' Ramsar site	Natural flows Jan & Feb 2009; ECA – Feb 09; 320 mm local rainfall Jan – May 2010	**MODERATE - GOOD**	**MODERATE to GOOD** (surviving on rainfall and sub-soil moisture from 09)
'Goddard's Lease' Ramsar site	Natural flows Jan & Feb 2009; ECA – Feb 09; 320 mm local rainfall Jan – May 2010	**MODERATE**	**MODERATE** (surviving on rainfall and sub-soil moisture from 09)
'Crinolyn' Ramsar site	Natural flows Jan & Feb 2009; ECA – Feb 09; 320 mm local rainfall Jan – May 2010	**POOR - MODERATE**	**POOR – MODERATE** (surviving on rainfall and little sub-soil moisture from 09)
'Windella' Ramsar site	Natural flows Jan & Feb 2009; ECA – Feb 09; 320 mm local rainfall Jan – May 2010	**POOR**	**POOR** (surviving on rainfall and little sub-soil moisture from 09)
Known colonial waterbird breeding sites – Gingham Wetlands	Natural flows Jan & Feb 2009; ECA – Feb 09; 320 mm local rainfall Jan – May 2010	**MODERATE**	**MODERATE (**Lignum stands on Lynworth flowered and in good condition; Yarrol – Cleared 06 but watered in '09
Potential colonial waterbird breeding sites – Gingham Wetlands	Natural flows Jan & Feb 2009; ECA – Feb 09; 320 mm local rainfall Jan – May 2010	**MODERATE - GOOD**	**MODERATE (**Lignum stands on Munwonga and Glendara flowered and in good condition; Boyanga – moderate condition)
Waterbird feeding areas – Gingham & Lower Gwydir Wetlands	ECA and natural flow Feb '09; local rainfall Jan – May 2010	**MODERATE**	**MODERATE** (surviving on rainfall and sub-soil moisture from 09)
Marsh Club-rush reed-bed stands ('Old Dromana' & 'Belmont')	Natural flow Feb 2009; ECA – Feb 09; 320 mm local rainfall Jan – May 2010	**MODERATE - GOOD**	**MODERATE** (surviving on rainfall and sub-soil moisture from 09)
Whittakers Lagoon Mehi River Floodplain	70 ML delivered Jan 2010 and 320 mm ocal rainfall Jan – May 2010 ; 90 ML delivered Nov '08 and 460 mm local rainfall Dec '08	**MODERATE**	**MODERATE** (Lagoon filled / good ecological response; ½ level retained over winter period)

	– April '09		
Connected lagoon system of Talmoi, Baroona & Tillaloo Gingham Wetlands System	Natural flow – Feb 09; 320 mm local rainfall Jan – May 2010	**MODERATE**	**MODERATE** (rainfall only)
Glendara Lignum stand & small Lagoon & Pear Paddock lagoon Gingham Wetlands system	Natural flow – Feb 09; local rainfall Jan – May 2010	**MODERATE - GOOD**	**MODERATE** (rainfall only)
Gwydir River benches – Copeton to Gravesend	ECA and natural flow – Feb 09; 320 mm local rainfall Jan – May 2010	**MODERATE**	**MODERATE** (rainfall only)
Water Hyacinth – flows to assist control strategies	ECA and natural flow – Feb 09; 320 mm local rainfall Jan – May 2010		Gingham WH free of hyacinth at this time

Volumes of environmental water available at July 2010

Account	Entitlements (ML)	Available 3/7/10 (ML)
Supplementary flow events	Environment share as per WSP	Event based determinations
Environmental Contingency Allowance	45,000 ML and may store up to a maximum of 90,000 ML	17,300 (15,000 held in reserve for waterbird breeding
DECCW AEWL (RiverBank, WRP, RERP) -General Security	17,092	1,394
DECCW AEWL- Supplementary	441	(availability is subject to announcement of a Supplementary event)
Commonwealth Environmental Water Holdings- General Security	84,632	0
Commonwealth Environmental Water Holdings-Supplementary	19,100	(availability is subject to announcement of a Supplementary event)

Please Note:
The Commonwealth Environmental Water Holder/ings (CEWH) volumes are as according to the CEWH holdings website, http://www.environment.gov.au/water/policy-programs/cewh/holdings.html

"It should be noted that a separate review and approval process is undertaken by the CEWH prior to the use of any CEWH holdings. Priority given to watering actions by the CEWH is based on an assessment of environmental benefits against publicly available criteria and after receiving advice from the Environmental Water Scientific Advisory Committee (which has also agreed to the assessment criteria), as well as input from state governments and others. The criteria are available at: www.environment.gov.au/water/policy-programs/cewh."

River allocation forecasts (provided by State Water July 2010)

The following table shows predicted Available Water Determinations (AWD) for General Security Access Licences within the Gwydir Regulated River Water Source as a percentage of full entitlement using historical inflow sequences into Copeton Dam and down-stream tributaries.

The forecast takes into account the current water delivery position including current account balances and expected deliveries and losses throughout the forecast period.

Each forecast AWD is reliant on inflows equal to or exceeding the relevant percentile inflows for the entire forecast period.

The 6 month and 3 month AWD forecasts are not cumulative.

	Minimum inflows (drought of record)	80th percentile inflows	50th percentile inflows	20th percentile inflows
3 month forecast to 1 October 2010	0 %	0 %	0 %	9.9 %
6 month forecast to 1 January 2011	0 %	0 %	4.5 %	27.8 %

For **Water Delivery Announcements** and State Water Media Releases go to:
http://www.statewater.com.au/whanew/mediareleases.htm
For **Available Water Determinations** and Office of Water Media Releases go to:
http://www.water.nsw.gov.au/Water-management/Water-availability/Waterallocations/Available-water-determinations/default.aspx

Forecast for Gwydir Valley
In general, there is a low likelihood of any meaningful water availability from General Security Accounts, held for environmental purpose this 2010/11 Water Year. A total 75 GL of inflow is required into Copeton Dam before an AWD into General Security Accounts can be announced. The Copeton Dam is currently @ 7 % capacity and falling.

The ECA Account is currently @ 17.3 GL, 15 GL of which is generally held as a bird breeding contingency volume.
Therefore 2.3 GL may currently be used for general environmental requirements.

State Water is currently operating under extreme water conservation management principles, ie. only high security and essential supplies delivered from the dam..

On a positive note, indicators suggest together with the Southern Oscillation Index (SOI) which has been consistently positive since April, that there are developing stages of a La Niña event in 2010.

In summary:

- Low probability of full ECA (45,000ML)
- Low probability of 30,000 ML ECA and 2,000 ML AEWL by end of 2010/11
- Moderate probability of 25,000 ML ECA and 1,200 ML AEWL by end of 2010/11
- Moderate to High probability of supplementary flow event by end of 2010

Objectives for environmental water use for 2010/11

A. Under average (expected) conditions
Under Median conditions the 10/11 allocation is unlikely to increase by October 2010 and is likely to increase to 4.5% by January 2011. This is possible in 50% of years.

Moderate probability of 25,000 ML ECA and 1,200 ML AEWL by end of 2010/11

Moderate to High probability of supplementary flow event by end of 2010

1. In combination with tributary flows, to wet as much of the Gingham wetlands above the Gingham Bridge as possible, including the "Goddard's Lease" Ramsar site.

   Reason: A wetting event following the 2008/09/10 events and 2010 (320mm) rainfall will further improve the viability of core wetland communities, and allow further testing of the effectiveness of structural improvements designed to increase extent of flooding. In order to achieve the required duration of inundation events, ECA flows must be timed in combination with significant natural flows in the system ie. at least 10,000 ML as the wetlands share of a 'Supplementary Flow' event into the Gingham watercourse.

2. In combination with tributary flows, to inundate as much of the Lower Gwydir wetlands as possible, with the focus on "Old Dromana" Ramsar site, the Marsh Club-rush reed-bed & Wondoona Waterhole in the Lower Gwydir system.

   Reason: A wetting event following the 2008/09/10 events and 2010 (320mm) rainfall will further improve the viability of core wetland communities, and allow further testing of the effectiveness of structural improvements designed to increase extent of flooding. The Marsh Club-rush community is the largest remaining in NSW. Wondoona Waterhole is the end of the Lower Gwydir wetlands system target. In order to achieve the required duration of inundation events, ECA flows must be timed in combination with significant natural flows in the system ie. at least 10,000 ML as the wetlands share of a 'Supplementary Flow' event to the Lower Gwydir System.

3. Specifically targeted flows are not expected to be required for the integrated Water Hyacinth control program in 2010/2011, but should be provided for within this plan in case they are required at short notice.

   Reason: The integrated Water Hyacinth control program does not require wetting to germinate hyacinth in 2010/11, however it may in future watering plans. It is important to retain a source of biological control agents within the Gwydir Wetlands. Approximately 100 ML of ECA water is set aside annually to maintain nursery habitat but may not necessarily be used during the water year.

4. To maintain water levels in the Gingham and Boyanga Waterholes, in the Gingham system, as they are significant components and refuge for fish and waterbirds within the Gingham Wetlands system.

   Reason: The waterholes are an integrated part of the Gingham Wetlands system and act as refuge sites during extended dry periods.

5. To refill Whittakers Lagoon for a period of approximately six months between September 2010 and March 2011.

   Reason: Whittakers Lagoon is typical of many wetland assets now isolated from all but exceptional floods. Its location provides an opportunity to demonstrate the recovery potential of this wetland type. RiverBank AEWL allocations of approximately 90 - 120 ML will be used for the watering. . More than one delivery may be used. This watering is expected to enhance the ecological responses observed during the 2008/9 & 09/10 waterings, particularly those of the aquatic plants. A small delivery during this water year may complete the restoration program for this hydrologic cycle.

6. During the water year, determine the feasibility of inundating the lagoon systems of Talmoi, Baroona & Tillaloo & Pear Paddock lagoon for a period of approximately 4 - 6 months between September 2010 and March 2011.

   Reason: These systems of interconnected Lagoons and Waterholes are now isolated from all but floods and larger, extended duration flows, such as occurred early '09. Specific releases to these sites may be made during this water year, if they prove feasible to deliver water to achieve the desired wetland outcomes of life cycle completion and support of fundamental wetland ecological processes.

7. During the water year, seek to identify and demonstrate feasibility of water delivery to any other significant Lagoons or Waterholes that may require inundation to protect, enhance or restore their wetland values.

   Reason: There may be other significant Lagoons or Waterholes that are now isolated from all but exceptional floods.

B. Under wet to very wet conditions
Under wet conditions the 10/11 allocation is likely to increase by up to 9.9% by October 2010 and is likely to increase by up to 27.8% by January 2011. This is likely in 20% of years.

In addition to objectives 1 to 7 above:

8. To wet more than 80% of the "Crinolyn" and "Windella" Ramsar sites along the Gingham Watercourse for at least 60+ days. A total flood volume of 100,000 ML @ Yarraman Bridge Moree is expected to inundate these lower Ramsar sites, at the required depth & duration to restore their ecological values.

   Reason: Due to their location further down the Gingham Watercourse, larger volumes of water are required to wet these sites for sufficiently long to provide significant ecological responses. Both are in urgent need of watering to re-establish the ecological character for which they were listed as Ramsar sites in the late 1990s.

9. To support the successful completion of a colonial waterbird breeding event that initiates from tributary flows. Currently a 15,000 ML reserve is kept in the ECA account for such contingencies. With recent installation of various structures and resulting efficiencies, this reserve may be reduced in the future.

   Reason: Colonial waterbirds breed when very wet conditions occur. At a continental scale, such opportunities have drastically reduced in frequency. Each event therefore has great significance. In the Gwydir Wetlands opportunities are usually provided by flood level flows in the tributaries downstream of Copeton Dam. Hence there is usually some warning as to their likelihood, providing opportunities to survey known sites regularly to detect breeding.

Note*: Wet to very wet conditions will provide the opportunities for the frequency and duration of wetland inundation, achieved under A. Average conditions 1-7, to be extended in the priority areas. Gains in wetland restoration will be achieved via a greater water availability held in all Environmental Accounts in Copeton Dam and by deliveries to a receiving environment that is already in a wetted state.*

C. Under drought & dry conditions
Under Drought conditions the 2010/11 allocation in not likely to increase by October 2009 or increase by January 2010. This relates to the possibility in 80% of years.

Low probability of full ECA (45,000ML)
Low probability of 30,000 ML ECA and 2,000 ML AEWL by end of 2010/11

10. To maintain core wetland areas in Lower Gwydir and Gingham Watercourses, particularly the "Old Dromana" and "Goddard's Lease" Ramsar sites, by delivering sufficient water for long enough to allow wetland biota to complete lifecycles.

    Reason: Refuge areas for plant and animal species are critical for re-colonisation when wetter conditions resume. Almost annual flooding of these refuge areas provides the best opportunities to maintain community viability. Without any further allocation announcements, the ECA account should still retain sufficient water to achieve this. It is important, and a requirement of the Water Sharing Plan, that environmental benefits be maximised from ECA water. Leaving it unused does not do this.

D. Under extreme and extended dry conditions
Under these dry conditions, water availability will be restricted to the remaining volumes held in environmental accounts. Under these extreme conditions an environmental release to maintain the

downstream wetlands areas is not anticipated unless substantial natural inflows were to be received.
Note: The Gwydir ECAOAC may consider and advise on the reduction from the agreed bird breeding (15,000 ML) volume, held in the ECA account to a new volume (10,000 ML). Consideration may then be given for the released 5,000 ML to be utilised for critical environmental needs either river or wetland in nature.

11. The provision of a very low flow, directed to priority river reaches, before conditions reach a critical level, will assist the continual survival of native fish populations. These actions will also support the ecological recovery of the river system, through repopulation of native species from refuge pools, when river flows return to the system.

    Reasons: *River systems, upstream of the Gwydir Wetlands, may cease to flow and dry down to a series of pools during these periods. River pools act as refuge for native fish populations which will repopulate the river systems when flows return. Conditions within these pools can quickly change during periods of extended high daily temperatures, resulting in reduced Dissolved Oxygen (DO) levels and increased evaporation rates. Native fish populations within refuge pools will succumb when conditions reach critical levels. A critical level will be reached when either/or, DO Levels in the remaining water(refuge) body are reduced to 5.0 milligrams per litre (mg L) or less and water levels in the refuge are minimal, so as to restrict fish movement within the pool.*

    River Sampling Points - (Advice provided by Dr Glenn Wilson – Independent Scientist UNE)
    Gingham Watercourse @ Willowlee;
    Lower Gwydir Channel @ Brageen Crossing;
    Mehi River @ Downstream Combadello Weir to the locality of Ketah Weir.

    Note: Regular monitoring for DO and water level reductions, within refuge pools, in the priority reaches, is required during these extreme conditions. Water delivery should be commenced before critical levels are reached.

E. Other opportunities

No other opportunities are likely during 2010/11. Efforts continue to identify other small wetlands capable of being watered.

Risks and mitigating strategies

Risk	Rating	Response
Unpredictable weather – turns drier than expected	Medium (possible and moderate)	Review asset condition and future priorities for watering
Unpredictable weather – turns wetter than expected	High (possible and major) Opportunity for broader & sustained wetland inundations & bird breeding events. GS accounts fill = increased access to GS water volumes to sustain events.	Additional wetting opportunities possible – continually assess volumes available
Flow management is uncoordinated	Medium (unlikely and moderate)	Regular communication with ECAOAC, State Water and CSC
Loss of a large volume of Environmental Water ie. 1000 ML + from a 'Supplementary Flow' event. *Note: The likelihood of water loss is related to the degree of pressure for water at the time of each flow in*	High (Given the experience of the 2009/10 Water Year) Most likely Lower Gwydir system.	An extensive, effective and suitably funded compliance response. Undertaken during the flow event to identify all reasons for water loss. High resolution imagery flights ie. Quickbird or IKONOS or worldview products, during the event.

the system.		
Estimated flow target volumes are substantially wrong	Medium (unlikely and moderate)	Monitor flow delivery daily and seek adjustments; revise targets accordingly
Poor water quality impacts on native fish, inc threatened species	Medium (unlikely and moderate)	Communication with State Water and I&I if river flow and meteorological conditions are adverse.
Unforeseen physical impediments to flow delivery	Medium (rare and major)	Early communication with State Water and community reps; alert NSW Office of Water (NOW) if obstructions identified
Insufficient water available to complete colonial waterbird breeding, if initiated	High (unlikely and severe)	Reserve 15,000 ML of ECA; reassess minimum volume required to sustain a breeding event
Larger germination and spread of water hyacinth	High (likely and major)	Adhere to Integrated Water Hyacinth Control protocols; maintain spray equipment for quick response
Germination and spread of Lippia	High (likely and moderate)	Limited opportunity; seek voluntary de-stocking to encourage native plant competition
Future watering opportunities compromised by full use of ECA during this water year	Medium (possible and minor)	Document trade-offs associated and discuss further with ECAOAC
Flooding of commercial crops	Medium (unlikely and major)	Implement approved communication strategy

Monitoring, reporting and revising

Monitoring as per RiverBank monitoring strategy for adaptive environmental water, and IMEF program for key wetland sites, subject to resources. Specifically, a combination of desktop and ground assessments will be used and include the following components.

1. State Water will provide their report on the flow (as per previously agreed table format);
2. DECCW will audit river gauge info., delivery of flows, both supplementary and environmental share;
3. DECCW will follow-up with a field visit to map inundation extent using ATV and GPS;
4. DECCW will create a map of inundation for the Big Leather Ramsar site and across the property Old Dromana;
5. DECCW will also include inundation extent for Goddards Lease Ramsar site and selected locations in the Gingham;
6. DECCW will provide the results of the above in condensed report form to CEWH within four weeks of water delivery.
7. 3-6 are dependant on suitable access to the site for ground mapping.

Reporting to

- Director Waters, Wetlands and Coast DECCW: monthly update on conditions (climate, available environmental water) and weekly update during flow delivery events.
- Commonwealth Environmental Water Holder

- ECAOAC: monthly update on conditions and weekly update during flow delivery events. ECAOAC to be consulted when triggers for changes to this plan occur.
- Border Rivers – Gwydir CMA: through ECAOAC representative
- Gwydir Customer Services Committee: regular update at meetings.
- Broader community: update in E-water newsletter.

This plan is to be **revised** when conditions dictate. Triggers for revision will be sustained catchment or localised rainfall that produces significant flows in tributaries. Good communication with State Water and local community representatives will help clarify the timing and scale of revision.

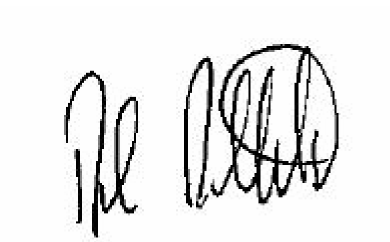
Primary responsibility for identifying and reporting opportunities for revisions to this plan rests with Daryl Albertson, DECCW Senior Wetlands and Rivers Conservation Officer.

Prepared by: Daryl Albertson and in consultation with the Gwydir Environment Contingency Allowance Operations Advisory Committee (ECAOC).

Position: SWaRCO North-West Branch, EPRG

Date: 30 July 2010

Approved by: **Derek Rutherford**



Signature: Date: 17 August 2010

Position: **Divisional Director Waters, Wetlands and Coasts**

Department of Environment, Climate Change and Water

Attachment A

Gwydir Valley Supplementary Event 3rd January 2010	
Event Volume Calculations	**ML**
Gwydir Inflow @ Pallamallawa 03/01/2010 to 07/01/2010	**14202**
Trib inflow Tareelaroi to Combadello (03/01/2010 to 06/01/2010)	**537**
Trib inflow Glendello to Clarendon (04/01/2010 to 06.01/2010)	**1433**
Total Flow	**16172**
Total Available Share	
Total Flow Volume	16172
3T Rule (5 days)	2500
D/S Orders/Requirements	1324
Available flow to be shared	12348
50% Consumptive share	**6174**
Volume Announced	**6054**
Total Supplementary extracted	**5431**
Over Pumping debited to other accounts	138
Total Pumping	5569

Gwydir Inflow	**ML**
Pallamallawa inflow (03/01/2010 to 07/01/2010)	14202
3T Rule	2500
D/S Orders	764
Total to be shared from Gwydir flow	10938
Share	**5469**
Flow Delivered to Yarraman (04/01/2010 to 08/01/2010)	7223
Orders and Supplementary pumping D/S of Yarraman	2563
3 T Rule	2500
Environmental share of Supplementary event delivered to Yarraman - (less 3 T Rule volume)	**2160**
Specific information	
Gingham Diversion Measured at Teralba from 5/01/2010 to 9/01/2010	2928
D/S Tyreel (LG) total Flow 4/01/2010 to 8/01/2010	3849
Millewa Flow from 07/01/2010 12/01/2010	731

Appendix 1

	B	C	D	E	F
1	**STATE WATER**				
2	**June 2010**				
3	**GWYDIR RESOURCE ASSESSMENT**				
4	**Previous Assessment date:**	**31-May-2010**			
5	**Current Assessment date:**	**30-June-2010**			**GL**
6	**Storage volume**				99.77
7	Dead storage			19.00	80.77
8	Storage Loss Committed (projected 2 years)			11.70	69.07
9					
10	**Essential Supplies**				
11	Brought forward			45.29	
12	Used and associated loss since last assessment			-1.16	
13	Allocation Assignments from High Security to General Security			-4.43	
14	Transfer to General Security delivery loss account			-1.33	
15	Current balance			38.36	30.71
16					
17	**Environmental Contingency Allowance (ECA)**				
18	Brought forward			17.30	
19	Orders from assessment period			0.00	
20	Current balance			17.30	13.41
21					
22	**General Security Irrigation**				
23	Brought forward			7.65	
24	Orders from assessment period			-1.02	
25	Allocation Assignments from High Security to Low Security			4.43	
26	Current balance			11.07	2.34
27					
28	**Delivery Loss**				
29	Brought forward			0.00	
30	Losses since last assessment			0.00	
31	Credit from Essential Supplies (for Allocation Assignments to GS)			1.33	
32	Current balance			1.33	1.01
33					
34	**Apparent Losses since last assessment**			**0.00**	
35	Essential Supply Loss	53%		0.00	
36	General Security + ECA Loss	47%		0.00	
37					
38	**Resources available for sharing**				**1.01**
39					
40	**New balances**	**Limit**	**Commitments**		**Balance**
41			**Current**	**Additional**	
42		GL	GL	GL	GL
43	Storage Loss	11.58	11.70	**-0.12**	11.58
44	Essential Supplies	111.00	38.36	**1.13**	39.49
45	Delivery Loss	256.28	0.00	**0.00**	1.33
46	ECA	90.00	17.30	**0.00**	17.30
47	General Security Irrigation	764.25	11.07	**0.00**	11.07
48	Uncommitted resources	-	2.34	**-2.34**	0.00
49	**Total**	**-**	**80.77**	**-1.33**	80.77
52	**Recommendations (General Security)**				
53	**Incremental Increase CREDITED**	**0.00**	**GL**		
54	**Available Water Determination**	**0.0000**	**ML per unit share**		
55					
56					
57					
58					
59	Recommended by:			1 Jul, 2010	
60	Craig Cahill, Water Delivery Manager North, State Water				
61					
62	Approved by:			1 Jul, 2010	
63	Peter Christmas, Director, Water Management & Implementation				

Appendix 2

For information on likely weather conditions over next 3 months see
http://www.bom.gov.au/climate/enso/

6 Monthly rainfall totals for Murray Darling Basin

About the map

Map: Rainfall Totals | B / W

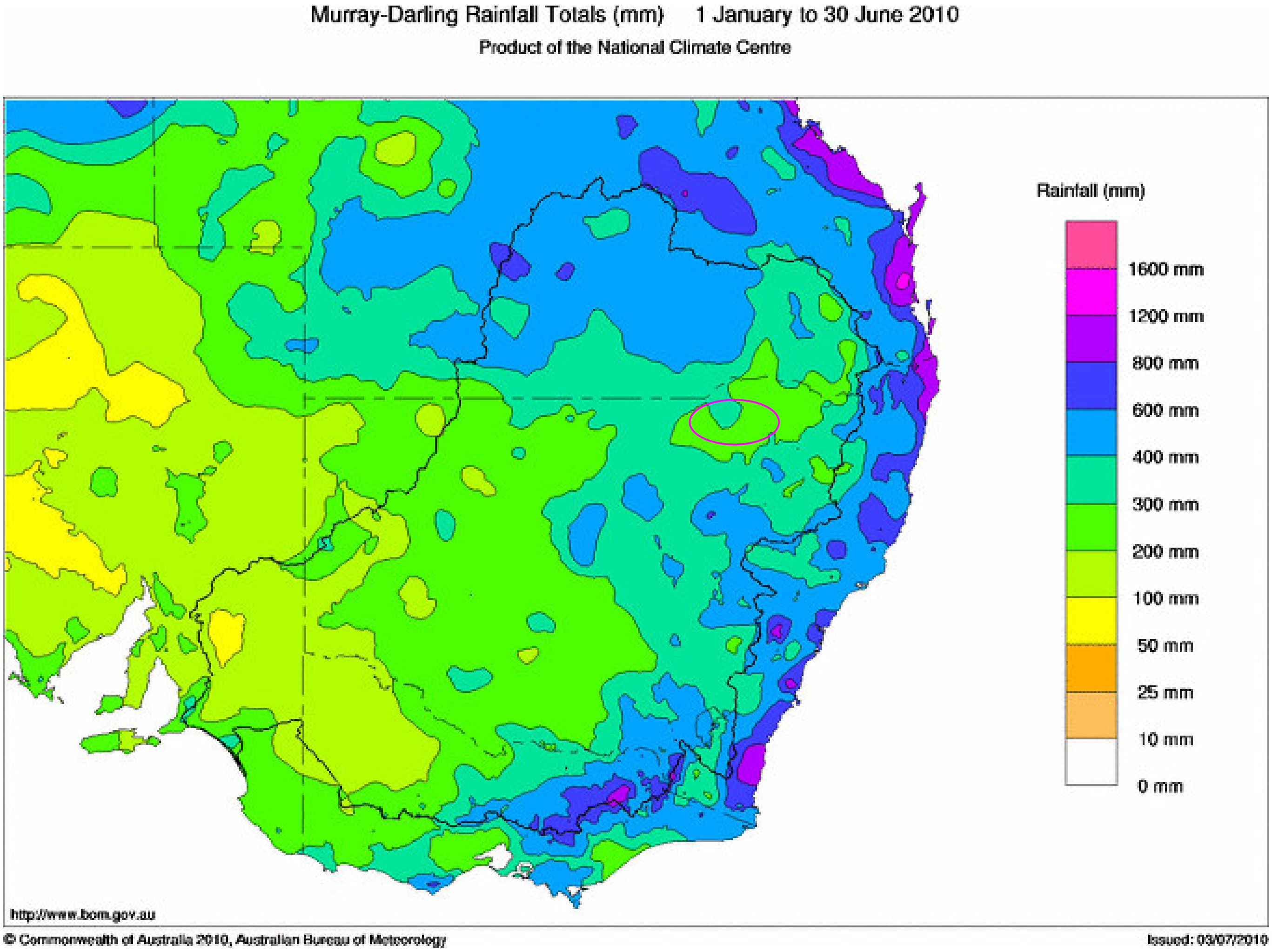
Period: 6 months | SHORTER | LONGER

Area: Murray Darling Basin | EARLIER | LATER

Zoom out

Print GIF | PDF

Archive Colour maps



Appendix 3
DECC Environmental Water entitlements at
http://www.environment.nsw.gov.au/environmentalwater/achievements.htm

Appendix 4
Commonwealth Environmental Water entitlements at
http://www.environment.gov.au/water/policy-programs/entitlement-purchasing/2008-09.html

Gwydir Environmental Watering Plan 2011 / 2012 water year

Environmental water releases – 2011 / 2012 water year (1st July –30th June)

Outcomes from the 2010 & 2011 Season

1. River Flows & Distribution

During the season, the Gwydir Catchment was one of the few catchments in NSW that did not experience any substantial flooding. The extended period (7 Months) of low flow water, delivered to the wetlands, under the Gwydir Water Sharing Plan Low Flow Rule (500 ML per day), proved very beneficial in providing a continuous filling of the wetlands, without significant broadscale flooding.

The 2010/2011 wetland growing season unfolded well due to late winter rains in July 2010 and continued to improve with regular rainfall and subsequent river flows through till January 20th 2011.

In August 2010 the Commonwealth Water Holder (CWH) took advantage of downstream natural river flows, delivering 3056 ML to the wetlands via their Supplementary Water License. This initial water delivery, in combination with local rainfall and natural flows, assisted to prime the core wetland areas of the system. Post flow monitoring indicated a soil store of 1.00-1.5 metres across many areas of inundation.

At a meeting of the Gwydir ECAOAC (8th Dec 2010) the committee discussed and supported the notion of working towards achieving 6-8 months of continual wetland inundation across a large area of the Gwydir Wetlands. This duration of watering is required to support the ecological processes that underpin the completion of life cycles for many wetland species. In addition, restoration of this complex wetland system could not commence without this type of large scale watering event, an event of the type that had not occurred since the late 1990s.

Natural river (low) flows to the wetlands ceased on the 20th January 2011. In order to clearly achieve the ‘Whole of Season’ watering goal, an additional 20,000 ML was delivered from the range of environmental water reserves (5 GL ECA + 5GL AEW + 10 GL CWH) during late January through March 2011. Ultimately the Gwydir ECAOAC ‘Whole of Season’ watering goal was achieved for the 2010/2011 wetland growing season, with post seasonal monitoring (March 2011) showing abundant wetland response across the range ecological species, all but colonial waterbird populations and/or breeding events.

Water delivery: During the season, the total flows measured at upstream Pallamallawa gauge was 546,283 ML. In total 141,000 ML was delivered to the Gwydir Wetlands, including ordered environmental water above: Gingham @ Teralba gauge received 86,000 ML; Lower Gwydir @ Millewa gauge received 55, 000 ML. These total volumes include the initial August 2010(3056 ML) Supplementary delivery and the 20,000 ML ordered water delivery, from the variety of entitlements, made post 20th January till mid March 2011.

Table 1: Summary of Gwydir flow events and distribution between wetland assets

Event	Total Env. vol (ML)	ECA (ML)	AEWL (ML)	CWH (ML) GS + Supp	Lower Gwydir (ML)	Gingham (ML)	Mehi System (ML)	Other
Dec. 2010	70	0	70		N/A	N/A		Whittakers Lagoon
July 2010 – March 2011	140,650	4,657	5,000	13,056	55,000	85,657		
as above	67,000						67,000	

2. Inundation Outcome

On the 30th March 2011 an aerial survey was undertaken enabling the mapping and calculation of inundation extent as follows: Approximately, 10,000 hectares of remnant wetlands and watercourse vegetation was inundated by seasons end. The Gingham - 5500 Hectares & Lower Gwydir 4500 Hectares. This outcome indicates an inundation rate of approximately 10 – 14 ML per hectare for a period of 6 to 8 months.

The Gwydir Ramsar sites located on 'Old Dromana', Goddards Lease, Windella & Crinolyn received good watering throughout the season. In particular, 'Old Dromana' and 'Windella' showed remnant water and substantial vegetation growth during the mapping survey.

It should be noted that in areas of exposed cultivation, a dry surface soil layer will mask any indication of previous inundation. At the time of the March 2011 mapping flight, many areas of cultivation at the periphery of the wetlands were observed as dry soil. There is therefore the potential for the final inundated area to be greater (>10,000 hect.) and may increase the total by up to 20% (12,500 hect).

Ecological response: Daily temperatures remained cooler during the early months of the season(Aug-Nov 2010), assisting in providing conditions for exceptional wetland vegetation growth. Periphery 'Coolibah' woodlands, Lignum and Cooba stands received good inundation over the season. The Marsh Club Rush(EEC) stand flowered on mass early in the season(Oct 2010), which had not been occurred to the extent observed since late 1990s.

The recently released Gwydir Wetlands Adaptive Environmental Management Plan(AEMP) indicates (pg 19) that the remaining area of semi permanent wetland vegetation (SPWV), in Gingham & Lower Gwydir Wetlands system as mapped in 2008, is likely to be 6829 Hectares (Bowen & Simpson 2010). The AEMP indicates (pg 41) a duration of inundation for this particular core wetland vegetation community of at least 6 months. The AEMP also indicates a duration of inundation for Lignum shrubland (associated with river cooba and coolibah) ie. inner floodplain, of at least 3 months between September and March. Given the outcome of this seasons watering, the SPWV and inner floodplain vegetation within the 10,000 hectare area of inundation did receive the required watering duration this season.

The use of the variety of entitlement water for environmental purpose has ultimately enhanced the overall outcome of this season watering event. The small (3056 ML) August 2010, Supplementary Water delivery, helped to build soil moisture across the core areas, which in turn, assisted additional natural flows to distribute water further across the wetlands. The 20 GL delivery, made at seasons end, ensured that the 'Whole of Season' watering goal was sufficiently met, substantially benefiting the Gwydir Wetlands system.

3. Management Implications

The 2010/11 season provided an extended low flow sequence which enabled a number of water delivery and management assumption to be checked and confirmed. In addition, observing how the whole system filled and emptied over the course of a season has been invaluable to the water managers. The development of the Gwydir Long Term Watering Pan will ultimately benefit by last seasons observations, calculations and flow management validation.

The undertaking of aerial inundation mapping at the end of the season (March) fails to capture the state of inundation at any other point in time. Knowled€ge and understanding of wetland inundation would be greatly improved with the inclusion of a mid season mapping flight. In addition, the use of time series satellite imagery would also greatly assist in the development of seasonal inundation extent across the whole Gwydir wetland & floodplain system. Cultivated areas at the periphery of the wetlands, that are regularly inundated in the process of wetland watering, would be more clearly highlighted.

The property 'Glendara is the location of significant wetland assets in the Gingham System. Water flows to this site have been minimal in recent history, a result of the draining effects of the adjoining S&D channel. This site has benefited greatly during the season due to the works associated with the RERP funded Stock & Domestic Restoration Project. Flows entered the site throughout the 8 months of watering providing 10-14 ML per hectare of inundation.

The historical colonial bird breeding sites located on the properties 'Yarrol' & 'Lynworth' in the Gingham watercourse wetlands system also benefited greatly due to the works associated with the RERP funded Stock & Domestic Restoration Project. Water flows entered the site throughout the 8 months of watering providing 10-14 ML per hectare of inundation.

Table 2: State of water dependent assets at April 2011

Asset	Last substantial watering	09/10 Condition	Current 10/11 Condition
Lower Gwydir Wetlands system	ECA & natural flows Nov 2008 - Feb 2009. Total 20 GL - 2729 Hect. @ 7 ML per Hect. Moderate watering	Minimal flows; (<2GL) limited ecological response; 320mm local rainfall Jan – May 2010.	Well watered: 6-8 months inundation across 4500+ Hect; Extensive ecological response. (55 GL *incl. 11.5 GL E. Water* @ 10-14 ML per Hect.)
Wondoona Waterhole – End of system target for Lower Gwydir Wetlands	ECA & natural flows Nov 08 - Feb 2009. Filled although for minimal duration.	Minimal flows; limited ecological response; 320mm local rainfall Jan – May 2010	Well watered: 6-8 months inundation; Extensive ecological response. Filled and holding.
Gingham Watercourse Wetlands system	ECA & natural flows Nov 2008 - Feb 2009. (total 24.8 GL - 2706 Hect. @ 9 ML per hect.) Moderate watering	Minimal flows; (<3 GL) limited ecological response; 320mm local rainfall Jan – May 2010.	Well watered: 6-8 months inundation across 5500+ hectares; Extensive ecological response. (86 GL *incl. 11.5 GL E.Water* @ 10-14 ML per hect.) S&D channel restoration works improved watering extent.
'Old Dromana' Ramsar site	ECA & natural flows Nov 2008 - Feb 2009. Well watered	Minimal flows; limited ecological response; 320mm local rainfall Jan – May 2010	Well watered: 6-8 months inundation; Extensive ecological response. 10-14 ML per Hectare.
'Goddard's Lease' Ramsar site	ECA & natural flows Nov 2008 - Feb 2009. Well watered	Minimal flows; limited ecological response; 320mm local rainfall Jan – May 2010	Well watered: 6-8 months inundation. Extensive ecological response. 10-14 ML per Hectare
'Crinolyn' Ramsar site	ECA & natural flows Nov 2008 - Feb 2009. Moderate watering	Minimal flows; limited ecological response; 320mm local rainfall	Well watered: At least 6 months inundation. Extensive ecological response. 5-10 ML per Hectare

		Jan – May 2010	
'Windella' Ramsar site	ECA & natural flows Nov 2008 - Feb 2009. Minimal watering	Minimal flows; limited ecological response; 320mm local rainfall Jan – May 2010	Well watered: At least 6 months inundation. Extensive ecological response. 5- 10 ML per Hectare
Known colonial waterbird breeding sites – Gingham Wetlands	ECA & natural flows Nov 2008 - Feb 2009. Moderate watering	Minimal flows; limited ecological response; 320mm local rainfall Jan – May 2010	Well watered: 6-8 months inundation. Extensive ecological response. S&D channel restoration works improved watering extent. 10-14 ML per Hectare.
Potential colonial waterbird breeding sites – Gingham Wetlands	ECA & natural flows Nov 2008 - Feb 2009. Moderate Watering	Minimal flows; limited ecological response; 320mm local rainfall Jan – May 2010	Well watered: 6-8 months inundation Extensive ecological response. S&D channel restoration works improved watering extent.
Waterbird feeding areas – Gingham & Lower Gwydir Wetlands	ECA & natural flows Nov 2008 - Feb 2009. Moderate Watering	Minimal flows; limited ecological response; 320mm local rainfall Jan – May 2010	Well watered: 6-8 months inundation. Extensive ecological response. 10-14 ML per Hectare.
Marsh Club-rush reed-bed stands ('Old Dromana' & 'Belmont')	ECA & natural flows Nov 2008 - Feb 2009. Moderate Watering	Minimal flows; limited ecological response; 320mm local rainfall Jan – May 2010	Well watered: 6-8 months inundation. Extensive ecological response. Mass flower/seeding this season. Observed area increase.
Whittakers Lagoon Mehi River Floodplain	90 ML delivered Dec 2009 1st delivery in restoration project.	70 ML delivered Jan 2010. 2nd delivery.	70 ML delivered Dec 2010. ¾ full & holding. 3rd & final delivery in restoration project.
Small remnant Wetlands Areas – Upper Gingham Assoc. with channel flows ie. paddock titled 'Jackson' on 'The Gully' (approx. 250 + Hectares)	ECA & natural flows Nov 2008 - Feb 2009. Well watered	Minimal flows; limited ecological response; 320mm local rainfall Jan – May 2010	Well watered: 6-8 months inundation. Extensive ecological response. 10-14 ML per Hectare
Glendara Lignum stand & small Lagoon & Pear Paddock lagoon Gingham Wetlands system	ECA & natural flows Jan & Feb 2009. Limited watering.	Minimal flows; limited ecological response; 320mm local rainfall Jan – May 2010	Well watered: 6-8 months inundation Extensive ecological response. S&D channel restoration works improved watering extent. 10-14 ML per Hectare.
Gwydir River benches – Copeton to Gravesend	ECA & natural flows Nov 2008 - Feb 2009. Many sites watered.	Minimal flows; limited ecological response; 320mm local rainfall Jan – May 2010	Well watered higher in the system.
Water Hyacinth – flows to assist control strategies	ECA and natural flow – Nov 2008 – Feb 2009; 320 mm local rainfall Jan – May 2010	Limited WH growth	Limited WH growth at this time. Active spraying has achieved good results this season. MPSC working well with landholders.

Table 3: Volumes of environmental water available at June 2011

Account	Entitlements (ML)	Available 30/4/2011 (ML)	AWD Forecast to September 2011 (14.4% - Median Conditions) (ML)
Supplementary flow events	Environment share as per WSP	Event based determinations	-
Environmental Contingency Allowance	45,000 ML and may store up to 90,000 ML	49,000 (15,000 held in reserve for waterbird breeding	56,056
DECCW AEWL (RiverBank, WRP, RERP) -General Security	17,092	10,259.9 ML	11,737.3
DECCW AEWL- Supplementary	441	441 (availability is subject to announcement of a Supplementary event and until end of water year)	-
Commonwealth Environmental Water Holdings- General Security	89,525	63,634.6 ML	72,798
Commonwealth Environmental Water Holdings-Supplementary	19,100	16,044 (availability is subject to announcement of a Supplementary event and until end of water year)	-

Please Note:
The Commonwealth Environmental Water Holder/ings (CEWH) volumes are as according to the CEWH holdings website, http://www.environment.gov.au/water/policy-programs/cewh/holdings.html

"It should be noted that a separate review and approval process is undertaken by the CEWH prior to the use of any CEWH holdings. Priority given to watering actions by the CEWH is based on an assessment of environmental benefits against publicly available criteria and after receiving advice from the Environmental Water Scientific Advisory Committee (which has also agreed to the assessment criteria), as well as input from state governments and others. The criteria are available at: www.environment.gov.au/water/policy-programs/cewh."

River allocation forecasts (provided by State Water March 2011)

The following table shows predicted Available Water Determinations (AWD) for General Security Access Licences within the Gwydir Regulated River Water Source as a percentage of unit shares using historical inflow sequences into Copeton Dam and downstream tributaries.

The forecast takes into account the current water delivery position including current account balances and expected deliveries and losses throughout the forecast period. Each forecast AWD is reliant on inflows equal to or exceeding the relevant percentile inflows for the entire forecast period.

Table 4: The 6 month and 3 month AWD forecasts are not cumulative.

	Minimum inflows (drought of record)	80th percentile inflows	50th percentile inflows	20th percentile inflows
3 month forecast to June 2011	No increase	0.0 %	2.2 %	15.1 %
6 month forecast to September 2011	No increase	1.0 %	14.4 %	38.7 %

For **Water Delivery Announcements** and State Water Media Releases go to:
http://www.statewater.com.au/whanew/mediareleases.htm
For **Available Water Determinations** and Office of Water Media Releases go to:
http://www.water.nsw.gov.au/Water-management/Water-availability/Waterallocations/Available-water-determinations/default.aspx

Forecast for Gwydir Valley

The ECA Account is currently @ 49 GL, 15 GL of which is generally held as a bird breeding contingency volume. Therefore 34 GL may currently be used for general environmental requirements. ECA can hold a maximum of 90 GL. Good rainfall and dam inflows over the recent season has turned the water availability in the Gwydir around. General Security and ECA accounts (Table 3) have meaningful water in which to use in the 2011/2012 water year and wetland growing season.

Computer Models: All leading international climate models surveyed by the Bureau predict ENSO conditions within the neutral range over the southern hemisphere winter. The majority of models indicate neutral conditions can be expected to persist into the southern hemisphere spring.

In summary:

- Good water reserves held in upstream dam accounts;
- Moderate probability of supplementary flow event by end(Dec) 2011

Objectives for environmental water use for 2011/12

A. Under average (expected) conditions

Under Median conditions the 11/12 allocations are likely to increase by 14.5% by September 2011. This is possible in 50% of years.

Moderate probability of 56,105 ML ECA, 11,746.5 ML AEWL and 72,861 ML COMMWATER by September 2011. Moderate to High probability of supplementary flow event by end of 2011.

1. In combination with tributary flows, to wet as much of the Gingham wetlands above the Gingham Bridge as possible, including the “Goddard’s Lease” Ramsar site.

   Reason: A wetting event following the previous 2010/11 season will further improve the viability of core wetland communities and more importantly continue the restoration of these iconic wetland areas. In order to achieve the required duration and extent of inundation events, deliveries must take advantage of any significant natural flows in the system when they occur. Substantial ‘Environmental Water’ reserves are now available to achieve significant ecological response which will ultimately support and build upon the extensive ecological response of the 2010/11 growing season.

2. In combination with tributary flows, to inundate as much of the Lower Gwydir wetlands as possible, with the focus on “Old Dromana” Ramsar site, the Marsh Club-rush reed-bed & Wondoona Waterhole in the Lower Gwydir system.

   Reason: : A wetting event following the previous 2010/11 season will further improve the viability of core wetland communities and more importantly continue the restoration of these iconic wetland areas. In order to achieve the required duration and extent of inundation events, deliveries must take advantage of any significant natural flows in the system when they occur. Substantial ‘Environmental Water’ reserves are now available to achieve significant ecological response which will ultimately support and build upon the extensive ecological response of the 2010/11 growing season.

3. Specifically targeted flows are not expected to be required for the integrated Water Hyacinth control program in 2011/12, but should be provided for within this plan in case they are required at short notice.

   Reason: The integrated Water Hyacinth control program does not require wetting to germinate hyacinth in 2011/12, however it may in future watering plans.

4. To maintain water levels in the Gingham and Boyanga Waterholes, in the Gingham system, as they are significant components and refuge for fish and waterbirds within the Gingham Wetlands system.

   <u>Reason</u>: The waterholes are an integrated part of the Gingham Wetlands system and act as refugia sites during extended dry periods. The continual draining of the waterholes has now ceased as a result of the RERP funded Stock & Domestic Restoration Project. Their water holding capacity has been increased which in turn has decreased the frequency of drying thereby extending the potential for refugia at these sites. These sites are not expected to be watering separately from the wider wetland system during these 'average' water availability conditions.

5. To refill Whittakers Lagoon for a period of approximately six months between September 2010 and March 2011.

   <u>Reason</u>: Whittakers Lagoon is typical of many small wetland assets, now isolated from all but exceptional floods. Its location and proximity to Moree and main highway provides an opportunity to demonstrate the recovery potential of this wetland type. RiverBank AEWL allocations have been be used consecutively (2009, 10 & 11) for the watering. This sequence of watering has completed the restoration program for this site. Local Pest & Livestock Authority have now fenced off the site from grazing and will manage it for conservation into the future. Further water deliveries are expected to mirror natural flow events in the Mehi River system and utilise the small (441 ML) Riverbank held supplementary water license to support the longer term condition at the site.

6. During the water year, determine the feasibility of inundating the lagoon systems of Talmoi, Baroona & Tillaloo & Pear Paddock lagoon for a period of approximately 4 - 6 months between September 2010 and March 2011.

   <u>Reason</u>: These systems of interconnected Lagoons and Waterholes are now isolated from all but floods and larger, extended duration flows, such as occurred early '09. Specific releases to these sites may be made during this water year, if they prove feasible to deliver water to achieve the desired wetland outcomes of life cycle completion and support of fundamental wetland ecological processes. Natural flows during 2010/11 season have also shown that higher volume events are needed to water these assets.

7. During the water year, seek to identify and demonstrate feasibility of water delivery to any other significant Lagoons or Waterholes that may require inundation to protect, enhance or restore their wetland values.

   <u>Reason</u>: There may be other significant Lagoons or Waterholes that are now isolated from all but exceptional floods.

B. Under wet to very wet conditions

Under wet conditions the 11/12 allocations are likely to increase by up to 39% by September 2011. This is likely in 20% of years.

In addition to objectives 1 to 7 above:

8. To wet more than 80% of the "Crinolyn" and "Windella" Ramsar sites along the Gingham Watercourse for at least 60+ days. A total flood volume of 100,000 ML @ Yarraman Bridge Moree is expected to inundate these lower Ramsar sites, at the required depth & duration to restore their ecological values.

   <u>Reason</u>: Due to their location further west of the Gingham Watercourse, larger volumes of water are required to wet these sites for sufficiently long to provide significant ecological responses. The 2010/11 water season did inundate these downstream areas for the required period and extent. The total flow volume of last season was 141,000 ML.

9. To support the successful completion of a colonial waterbird breeding event that initiates from tributary flows. Currently a 15,000 ML reserve is kept in the ECA account for such contingencies. With recent installation of various structures and resulting efficiencies, this reserve may be reduced in the future.

   <u>Reason</u>: Colonial waterbirds breed when very wet conditions occur. At a continental scale, such opportunities have drastically reduced in frequency. Each event therefore has great significance. In the Gwydir Wetlands opportunities are usually provided by flood level flows in the tributaries downstream of Copeton Dam. Hence there is usually some warning as to their likelihood, providing opportunities to survey known sites regularly to detect breeding.

Note*: Wet to very wet conditions will provide the opportunities for the frequency and duration of wetland inundation, achieved under A. Average conditions 1-7, to be extended in the priority areas. Gains in wetland restoration will be achieved via a greater water availability held in all Environmental Accounts in Copeton Dam and by deliveries to a receiving environment that is already in a wetted state.*

C. Under drought & dry conditions

Under Drought conditions the 2011/12 allocation in not likely to increase by September 2011 or increase by January 2012. This relates to the possibility in 80% of years.

The ECA Account is currently @ 49 GL, 15 GL of which is generally held as a bird breeding contingency volume. Therefore 34 GL in addition to Riverbank (WAL 10,250 ML) & Commwater (63,634 ML) may be used in this water year for environmental requirements.

10. To maintain core wetland areas in Lower Gwydir and Gingham Watercourses, particularly the “Old Dromana” and “Goddard’s Lease” Ramsar sites, by delivering sufficient water for long enough to allow wetland biota to complete lifecycles.

   <u>Reason</u>: Refuge areas for plant and animal species are critical for re-colonisation when wetter conditions resume. Almost annual flooding of these refuge areas provides the best opportunities to maintain community viability. Without any further allocation announcements, the ECA account should still retain sufficient water to achieve this. It is important, and a requirement of the Water Sharing Plan, that environmental benefits be maximised from ECA water. Leaving it unused does not do this.

D. Under extreme and extended dry conditions

Under these dry conditions, water availability will be restricted to the remaining volumes held in environmental accounts. Under these extreme conditions an environmental release to maintain the downstream wetlands areas is not anticipated unless substantial natural inflows were to be received.

Note: The Gwydir ECAOAC may consider and advise on the reduction from the agreed bird breeding (15,000 ML) volume, held in the ECA account to a new volume (10,000 ML). Consideration may then be given for the released 5,000 ML to be utilised for critical environmental needs either river or wetland in nature.

11. The provision of a very low flow, directed to priority river reaches, before conditions reach a critical level, will assist the continual survival of native fish populations. These actions will also support the ecological recovery of the river system, through repopulation of native species from refuge pools, when river flows return to the system.

   ***Reasons:** River systems, upstream of the Gwydir Wetlands, may cease to flow and dry down to a series of pools during these periods. River pools act as refuge for native fish populations which will repopulate the river systems when flows return. Conditions within these pools can quickly change during periods of extended high daily temperatures, resulting in reduced Dissolved Oxygen (DO) levels and increased evaporation rates. Native fish populations within refuge pools will succumb when conditions reach critical levels. A critical level will be reached when either/or, DO Levels in the remaining water(refuge) body are reduced to 5.0 milligrams per litre (mg L) or less and water levels in the refuge are minimal, so as to restrict fish movement within the pool.*

River Sampling Points - (Advice provided by Dr Glenn Wilson – Independent Scientist UNE)
Gingham Watercourse @ Willowlee;
Lower Gwydir Channel @ Brageen Crossing;
Mehi River @ Downstream Combadello Weir to the locality of Ketah Weir.

Note: Regular monitoring for DO and water level reductions, within refuge pools, in the priority reaches, is required during these extreme conditions. Water delivery should be commenced before critical levels are reached.

E. Other opportunities

No other opportunities are likely during 2011/12.

Efforts continue to identify and acknowledge other small wetlands capable of being watered. Additional work is required to duly consider aquatic riverine assets in the system ie. associated rivers & stream.

Risks and mitigating strategies

Risk	Rating	Response
Unpredictable weather – turns drier than expected	Moderate to Low (possible but expected to be low)	Review asset condition and future priorities for watering
Unpredictable weather – turns wetter than expected	High (possible and major) Opportunity for broader & sustained wetland inundations & bird breeding events. GS accounts fill = increased access to GS water volumes to sustain events.	Additional wetting opportunities possible – continually assess volumes available
Flow management is uncoordinated	Medium (unlikely and moderate)	Regular communication with ECAOAC, State Water and CSC
Loss of a large volume of Environmental Water ie. 1000 ML + from a 'Supplementary Flow' event. *Note: The likelihood of water loss is related to the degree of pressure for water at the time of each flow in the system.*	High (Given the experience of the 2009/10 Water Year) Most likely Lower Gwydir system.	An extensive, effective and suitably funded compliance response. Undertaken during the flow event to identify all reasons for water loss. High resolution imagery flights ie. Quickbird or IKONOS or worldview products, during the event.
Estimated flow target volumes are substantially wrong	Medium (unlikely and moderate)	Monitor flow delivery daily and seek adjustments; revise targets accordingly
Poor water quality impacts on native fish, inc threatened species	Medium (unlikely and moderate)	Communication with State Water and I&I if river flow and meteorological conditions are adverse.
Unforeseen physical impediments to flow delivery	Medium (rare and major)	Early communication with State Water and community reps; alert NSW Office of Water (NOW) if obstructions identified
Insufficient water available to complete colonial waterbird breeding, if initiated	High (unlikely and severe)	Reserve 15,000 ML of ECA; reassess minimum volume required to sustain a breeding event
Larger germination and spread of water hyacinth	High (likely and major)	Adhere to Integrated Water Hyacinth Control protocols; maintain spray equipment for quick

		response
Germination and spread of Lippia	High (likely and moderate)	Limited opportunity; seek voluntary de-stocking to encourage native plant competition. Continual inundation may assist 'Lippia' suppression.
Future watering opportunities compromised by full use of ECA during this water year	Medium (possible and minor)	Document trade-offs associated and discuss further with ECAOAC
Flooding of commercial crops	Medium (unlikely and major)	Implement approved communication strategy

Monitoring, reporting and revising

Monitoring as per RiverBank monitoring strategy for adaptive environmental water, and IMEF program for key wetland sites, subject to resources. Specifically, a combination of desktop and ground assessments will be used and include the following components.

1. State Water will report on the distribution of announced Supplementary Flow events, post the event (as per previously agreed table format);
2. State Water will demonstrate to OE&H, the delivery of all Ordered Environmental Water by the provision of flow records for downstream river monitoring gauges ie. Teralba (Gingham) & Millewa (L.Gwydir) post the event;
3. OE&H will undertake regular audits of water distribution and river gauge information in relation to Supplementary Flow Events, WSP Environmental Water Share & all Ordered Water deliveries;
4. OE&H will prepare regular water delivery sitreps during the periods of all Ordered Water deliveries;
5. OE&H will undertake both pre season and post seasonal ecological monitoring at key sites across the Gwydir Wetland system;
6. In combination with post seasonal ecological monitoring, OE&H will create a map of inundation extent for the Gwydir Wetland system(Gingham & Lower Gwydir);
7. The map in (6) will also include the inundation extent for the four sites listed under the Gwydir Ramsar Agreement being Big Leather, Goddards Lease, Windella & Crinolyn);
8. OE&H will provide the record of seasonal flows, inundation extent and ecological monitoring in the form of the Gwydir Annual Report;
9. 4 is dependant on suitable access to the site for monitoring purposes.

Reporting to

- Director Waters, Wetlands and Coast OE&H: monthly update on conditions (climate, available environmental water) and weekly update during flow delivery events.
- Commonwealth Environmental Water Holder
- ECAOAC: monthly update on conditions and weekly update during flow delivery events. ECAOAC to be consulted when triggers for changes to this plan occur.
- Border Rivers – Gwydir CMA: through ECAOAC representative
- Gwydir Customer Services Committee: regular update at meetings.
- Broader community: update in E-water newsletter.

This plan is to be **revised** when conditions dictate. Triggers for revision will be sustained catchment or localised rainfall that produces significant flows in tributaries. Good communication with State Water and local community representatives will help clarify the timing and scale of revision.

Primary responsibility for identifying and reporting opportunities for revisions to this plan rests with Daryl Albertson, DECCW Senior Wetlands and Rivers Conservation Officer.

Prepared by: Daryl Albertson and in consultation with the Gwydir Environment Contingency Allowance Operations Advisory Committee (ECAOC).

Position: SWaRCO North-West Branch, EPRG

Date: June 2011

Approved by: **Derek Rutherford**

Signature: Date:

Position: **Divisional Director Waters, Wetlands and Coasts**

Office of Environment & Heritage

Attachment A: Supplementary Flow Events 1-7

Gwydir Valley Supplementary Event 1 - August 2010

Event Volume Calculations	**ML**
Gwydir inflow @ Gravesend 31/07/2010 to 30/09/2010	**150373**
Tycannah Creek inflow 25/08/2010 to 13/09/2010	**2988**
Gil Gil inflow 24/09/2010 to 29/09/2010	**2182**
Total Flow	**155543**

Total Available Share	
Total Flow Volume	155543
3T Rule (62 days*)	30550
D/S Orders/Requirements	7650
Available flow to be shared	117343
50% Consumptive share	**58671.5**
Volume Announced	**58653**
Total Supplementary extracted	**57456**
Over Pumping debited to other accounts	0
Total Pumping	57456
Percentage announced	49.98%

Gwydir Inflow	**ML**
Gwydir inflow @ Gravesend 31/07/2010 to 30/09/2010	150373
3T Rule	30550
D/S Orders	7650
Total to be shared from Gwydir flow	112173
Share	**56087**
Flow Delivered to Yarraman (02/08/2010 to 02/10/2010)	75921
Orders and Supplementary pumping D/S of Yarraman	8637
3 T Rule	30550
Environmental share of Supplementary event delivered to Yarraman - (less 3 T Rule volume)	**36734**
Specific information	
Gingham Diversion Measured at Tyreel from 02/08/2010 to 2/10/2010	36864
D/S Tyreel (LG) total Flow 02/08/2010 to 02/10/2010	36550
Millewa Flow from 04/08/2010 04/10/2010	14752

Gwydir Valley Supplementary Event 2 - October 2010

Event Volume Calculations	ML
Gwydir inflow @ Gravesend 16/10/2010 to 31/10/2010	**87358**
Total Flow	**87358**

Total Available Share	
Total Flow Volume	87358
3T Rule (16 days*)	8000
D/S Orders/Requirements	550
Available flow to be shared	78808
50% Consumptive share	**39404**
Volume Announced	**38020**
Total Supplementary extracted	**36245**
Over Pumping debited to other accounts	0
Total Pumping	36245
Percentage announced	48.24%

Gwydir Inflow	ML
Gwydir inflow @ Gravesend 31/07/2010 to 30/09/2010	87358
3T Rule	8000
D/S Orders	550
Total to be shared from Gwydir flow	78808
Share	**39404**
Flow Delivered to Yarraman (17/10/2010 to 01/11/2010)	34954
Orders and Supplementary pumping D/S of Yarraman	4239
3 T Rule	8000
Environmental share of Supplementary event delivered to Yarraman - (less 3 T Rule volume)	**22715**
Specific information	
Gingham Diversion Measured at Tyreel from 07/10/2010 to 1/11/2010	28050

D/S Tyreel (LG) total Flow 17/10/2010 to 01/11/2010	8576
Millewa Flow from 19/09/2010 3/11/2010	3592

Gwydir Valley Supplementary Event 3 November 2010	
Event Volume Calculations	**ML**
Gwydir inflow @ Gravesend 14/11/2010 to 16/11/2010	**2909**
Total Flow	**2909**
Total Available Share	
Total Flow Volume	2909
3T Rule (3 days*)	1396
D/S Orders/Requirements	180
Available flow to be shared	1333
50% Consumptive share	**667**
Volume Announced	**544**
Total Supplementary extracted	**542**
Over Pumping debited to other accounts	0
Total Pumping	542
Percentage announced	40.81%
Gwydir Inflow	**ML**
Gwydir inflow @ Gravesend 14/11/2010 to 16/11/2010	2909
3T Rule	1396
D/S Orders	180
Total to be shared from Gwydir flow	1333
Share	**667**
Flow Delivered to Yarraman (16/11/2010 to 18/11/2010)	1448
Orders and Supplementary pumping D/S of Yarraman	0
3 T Rule	1396
Environmental share of Supplementary event delivered to Yarraman - (less 3 T Rule volume)	**52**
Specific information	
Gingham Diversion Measured at Tyreel from 16/11/2010 to 18/11/2010	749
D/S Tyreel (LG) total Flow 16/10/2010 to 18/11/2010	775

Millewa Flow from 18/11/2010 20/11/2010	678

Gwydir Valley Supplementary Event 4 November 2010	
Event Volume Calculations	**ML**
Gwydir @ Gravesend 18/11/2010 to 28/11/2010	**32855**
Total Flow	**32855**
Total Available Share	**ML**
Total Flow Volume	32855
3T Rule (11 days)	5367
D/S Orders/Requirements (riparian flows)	660
Available flow to be shared	26828
50% Consumptive share	**13414**
Volume Announced	**13339**
Total Supplementary extracted	**13097**
Over Pumping debited to other accounts	0
Total Pumping	13097
Percentage announced	49.72%
Gwydir Inflow	**ML**
Gwydir @ Gravesend 18/11/2010 to 28/11/2010	32855
3T Rule	5367
D/S Orders	660
Total to be shared from Gwydir flow	26828
Share	**13414**
Flow Delivered to Yarraman (19/11/2010 to 30/11/2010)	9803
Orders and Supplementary pumping D/S of Yarraman	0
3 T Rule	5367
Environmental share of Supplementary event delivered to Yarraman - (less 3 T Rule volume)	**4436**
Specific information	
Gingham Diversion Measured at Tyreel from 19/11/2010 to 29/11/2010	8044
D/S Tyreel (LG) total Flow 19/11/2010 to 29/11/2010	5061
Millewa Flow from 21/11/2010 01/12/2010	3424

Gwydir Valley Supplementary Event 5 - December 2010	
Event Volume Calculations	**ML**
Gwydir @ Gravesend 3/12/2010 25/12/2010	**61858**
Moomin Creek Inflow	**2800**
Total Flow	**64658**
Total Available Share	**ML**
Total Flow Volume	64658
3T Rule (23 days)	11434
D/S Orders/Requirements (riparian flows)	2475
Available flow to be shared	50749
50% Consumptive share	**25375**
Volume Announced	**25032**
Total Supplementary extracted	**24398**
Over Pumping debited to other accounts	0
Total Pumping	24398
Percentage announced	49.33%
Gwydir Inflow	**ML**
Gwydir @ Gravesend 3/12/2010 25/12/2010	61858
3T Rule	11434
D/S Orders	2475
Total to be shared from Gwydir flow	47949
Share	**23975**
Flow Delivered to Yarraman (4/12/2010 to 26/12/2010)	24638
Orders and Supplementary pumping D/S of Yarraman	2385
3 T Rule	11434
Environmental share of Supplementary event delivered to Yarraman - (less 3 T Rule volume)	**10819**
Specific information	
Gingham Diversion Measured at Tyreel from 4/12/2010 to 26/12/2010	13199
D/S Tyreel (LG) total Flow 4/12/2010 to 26/12/2010	13749
Millewa Flow from 6/12/2010 to 28/12/2010	7804

Gwydir Valley Supplementary Event 6 - January 2011	
Event Volume Calculations	**ML**
Gwydir @ Gravesend 7/01/2011 to 12/01/2011	**15859**
Total Flow	**15859**
Total Available Share	**ML**
Total Flow Volume	15859
3T Rule (6 days)	3000
D/S Orders/Requirements (riparian flows)	8806
Fill Tareelaroi weir	400
Available flow to be shared	3653
50% Consumptive share	**1827**
Volume Announced	**1819**
Total Supplementary extracted	**1571**
Over Pumping debited to other accounts	0
Total Pumping	1570.9
Percentage announced	49.79%
Gwydir Inflow	**ML**
Gwydir @ Gravesend 7/01/2011 12/01/2011	15859
3T Rule	3000
D/S Orders	7166
Fill Tareelaroi weir	400
Total to be shared from Gwydir flow	5293
Share	**2647**
Flow Delivered to Yarraman (8/01/2011 to 13/01/2011)	3256
Orders and Supplementary pumping D/S of Yarraman	50
3 T Rule	3000
Environmental share of Supplementary event delivered to Yarraman - (less 3 T Rule volume)	**206**
Specific information	
Gingham Diversion Measured at Tyreel from 08/01/2011 to 13/01/2011	1334
D/S Tyreel (LG) total Flow 08/01/2011 to 13/01/2011	1679

Millewa Flow from 10/01/2011 to 15/01/2011	1184

Gwydir Valley Supplementary Event 7 - January 2011

Event Volume Calculations	**ML**
Gwydir @ Gravesend 13/01/2011 to 14/01/2011	**8926**
Gil Gil Creek @ Boolataroo 11/01/2011 to 1501/2011	**286**
Total Flow	**9212**

Total Available Share	**ML**
Total Flow Volume	9212
3T Rule (2 days)	1000
D/S Orders/Requirements (riparian flows)	1594
Fill Tareelaroi weir	850
Available flow to be shared	5768
50% Consumptive share	**2884**
Volume Announced	**2782**
Total Supplementary extracted	**2568**
Over Pumping debited to other accounts	0
Total Pumping	2568
Percentage announced	48.23%

Gwydir Inflow	**ML**
Gwydir @ Gravesend 13/01/2011 14/01/2011	8926
3T Rule	1000
D/S Orders	1594
Fill Tareelaroi weir	850
Total to be shared from Gwydir flow	5482
Share	**2741**
Flow Delivered to Yarraman 14/01/2011 to 15/01/2011	1678
Orders and Supplementary pumping D/S of Yarraman	265
3 T Rule	1000
Environmental share of Supplementary event delivered to Yarraman - (less 3 T Rule volume)	**413**
Specific information	
Gingham Diversion Measured at Tyreel from 14/01/2011 to 15/01/2011	1066
D/S Tyreel (LG) total Flow 14/01/2011 to 15/01/2011	948
Millewa Flow from 16/01/2011 to 17/01/2011	388

Appendix 1

	B	C	D	E	F
1	**STATE WATER**				
2	**End 30 April 2011**				
3	GWYDIR RESOURCE ASSESSMENT				
4	**Previous Assessment date:**	**31-March 2011**			
5	**Current Assessment date:**	**30-April -2011**			**GL**
6	**Storage volume**				671.98
7	Dead storage			19.00	652.98
8	Storage Loss Committed (projected 2 years)			45.94	607.04
9					
10	**Essential Supplies**				
11	Brought forward			110.64	
12	Used and associated loss since last assessment			-2.37	
13	Allocation Assignments from High Security to General Security			0.00	
14	Transfer to General Security delivery loss account			0.00	
15	Current balance			108.27	498.77
16					
17	**Environmental Contingency Allowance (ECA)**				
18	Brought forward			49.61	
19	Orders from assessment period			0.00	
20	Current balance			49.61	49.61
21					
22	**General Security Irrigation**				
23	Brought forward			332.35	
24	Orders from assessment period			0.00	
25	Allocation Assignments from High Security to Low Security			0.00	
26	Current balance			332.35	116.81
27					
28	**Delivery Loss**				
29	Brought forward			114.60	
30	Losses since last assessment			0.00	
31	Credit from Essential Supplies (for Allocation Assignments to GS)			0.00	
32	Current balance			114.60	2.21
33					
34	**Apparent Losses since last assessment**			**0.56**	
35	Essential Supply Loss	100%		0.56	
36	General Security + ECA Loss	0%		0.00	
37					
38	**Resources available for sharing**				**2.21**
39					
40	**New balances**	**Limit**	**Commitments**		**Balance**
41			**Current**	**Additional**	
42		GL	GL	GL	GL
43	Storage Loss	145.93	45.94	**-0.01**	**45.93**
44	Essential Supplies	111.00	108.27	**2.22**	**110.49**
45	Delivery Loss	256.28	.114.60	**0.00**	**114.60**
46	ECA	90.00	49.61	**0.00**	**49.61**
47	General Security Irrigation	764.25	332.35	**0.00**	**332.35**
48	Uncommitted resources	-	2.21	**-2.21**	**0.00**
49	**Total**	**-**	**652.98**	**0.00**	**652.98**
50 51					
52	**Recommendations (General Security)**				
53	**Incremental Increase CREDITED**	**0.00**	**GL**		
54	**Available Water Determination**	**0.0000**	**ML per unit share**		
55					
56					
57					
58					
59	Recommended by:			2 May, 2011	
60	Craig Cahill, Water Delivery Manager North, State Water				
61					
62	Approved by:			4 May, 2011	
63	Paul Simpson, Manager Surface Water Management				

Appendix 2

For information on likely weather conditions over next 3 months see
http://www.bom.gov.au/climate/enso/

Rainfall Outlook: Winter (Jun-Aug)

About Rainfall Outlook

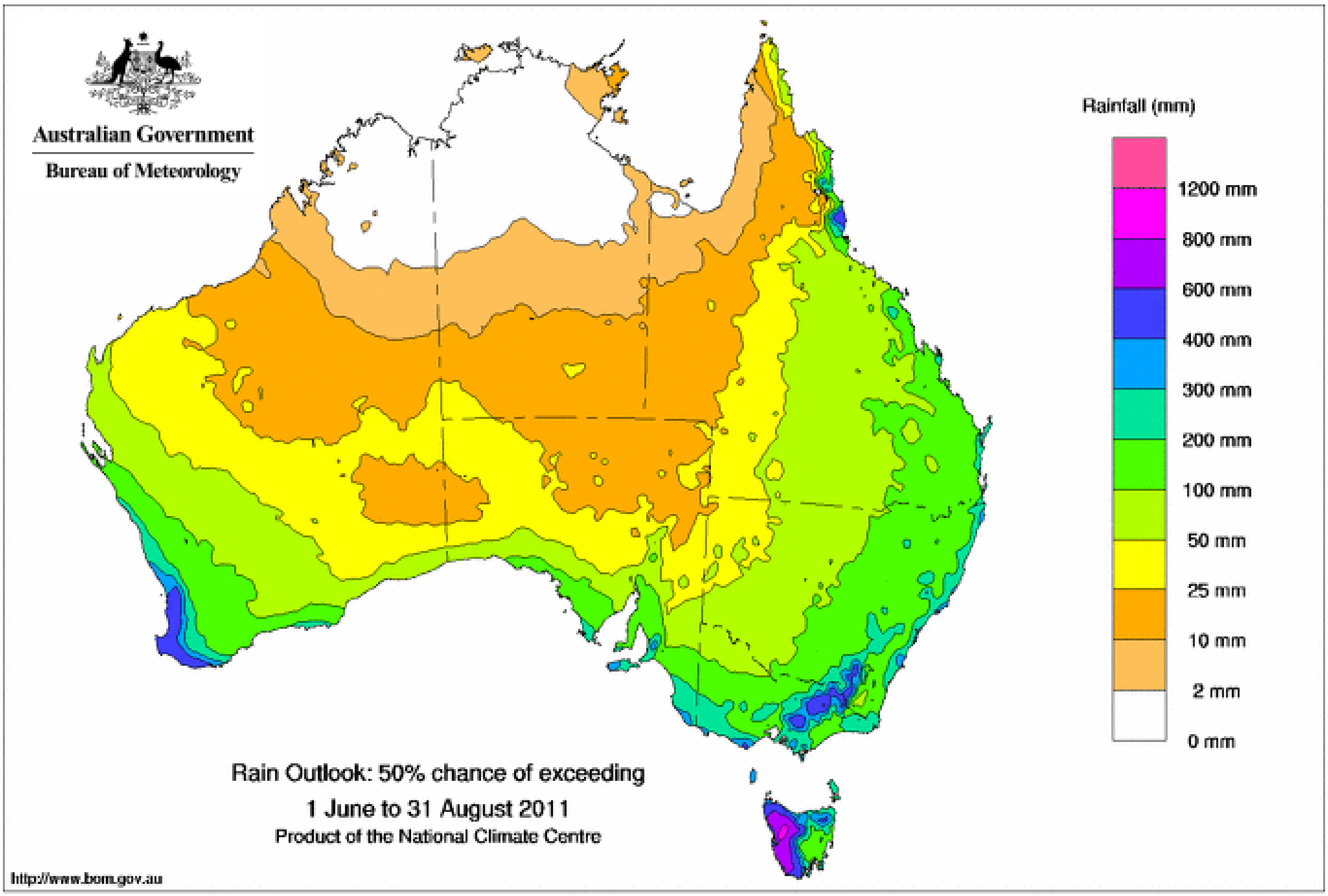
Rainfall outlooks for the coming season are derived from the Bureau's official seasonal climate outlook model. Consult the seasonal outlook verification information for areas of greatest skill.

Map or Table View

Outlook scenarios Chance of at least Table Above median outlook : Report

Chance of Exceeding

75 % 50 % 25 %



 Issued: 23/05/2011

Product Code: IDCKWSSR00

Appendix 3

DECC Environmental Water entitlements at
http://www.environment.nsw.gov.au/environmentalwater/achievements.htm

Appendix 4

Commonwealth Environmental Water entitlements at
http://www.environment.gov.au/water/policy-programs/entitlement-purchasing/2008-09.html

NSW GOVERNMENT | Environment, Climate Change & Water

Australian Government
Water for the Future

Gwydir Wetlands
Adaptive Environmental Management Plan

Synthesis of information projects and actions

Environment, Climate Change & Water
NSW Government

Australian Government
Water for the Future

Gwydir Wetlands
Adaptive Environmental Management Plan

Synthesis of information projects and actions

Cover photographs
Top: magpie geese, Gingham wetlands – Daryl Albertson. Bottom left: water couch-spike rush wetlands at Glendarra, Gingham Watercourse – Daryl Albertson. Bottom centre left: coolibah, Mehi River – Shannon Simpson. Bottom centre right: cumbungi, Gwydir Wetlands – Sharon Bowen. Bottom right: flooded woodland near Gingham Channel – Tracy Fulford.

NSW Wetland Recovery Program website: www.wetlandrecovery.nsw.gov.au

Published by:

Department of Environment, Climate Change and Water NSW
59–61 Goulburn Street
PO Box A290
Sydney South 1232
Phone: (02) 9995 5000 (switchboard)
Phone: 131 555 (environment information and publications requests)
Phone: 1300 361 967 (national parks information and publications requests)
Fax: (02) 9995 5999
TTY: (02) 9211 4723
Email: info@environment.nsw.gov.au
Website: www.environment.nsw.gov.au

ISBN 978 1 74293 088 6
DECCW 2011/0027
February 2011
Printed on recycled paper

Contents

Summary

The extensive Gwydir Wetlands lie on the lower Gwydir River in north-western NSW. Just east of Moree, the Gwydir floodplain begins to broaden, forming an inland delta so wide it merges with the floodplains of the Barwon/Macintyre valley to the north and the Namoi valley to the south. As the river branches repeatedly and channels decrease in capacity, floodwaters from the upper catchment spill frequently onto the floodplain, creating a patchwork of flood-dependent wetlands. These provide habitat for waterbirds, fishes, frogs, reptiles and invertebrates.

The whole of the lower Gwydir floodplain is a wetland ecosystem, but at its heart is the complex of semi-permanent wetlands known as the Gingham and Lower Gwydir (Big Leather) watercourses. These wetlands are renowned for the huge flocks of waterbirds that congregate to breed when large floods flow down the river. The surrounding floodplain wetlands and woodlands, including the Mallowa Creek wetlands, are important feeding grounds for breeding waterbirds. Myall woodlands and woodland birds are also important elements of the floodplain ecology.

The Gamilaroi people were the first owners of the lands of the lower Gwydir valley. They retain strong cultural and spiritual ties to the Gwydir Wetlands despite being physically displaced by non-Aboriginal settlement and the policies of past colonial and state governments. Both archaeological evidence and oral histories provide information about Aboriginal occupation and use of the wetlands up to recent times.

The patterns of water flows that once sustained the wetlands have been profoundly altered since settlement by non-indigenous Australians. Even before the advent of large-scale river regulation, land holders changed the river to suit their needs by cutting or enlarging channels to re-direct flows. Extensive catchment clearing around the turn of the twentieth century created conditions that led to the formation of the Gwydir Raft, a mass of timber and sediment that clogs about 15 kilometres of the channel of the lower Gwydir River west of Moree.

The Raft effectively dams the river, creating the Gwydir Pool and redirecting flows towards the Gingham Watercourse. Construction of a weir and regulator at Tyreel has allowed some measure of control over the direction of flows, ensuring that the Lower Gwydir (Big Leather) Watercourse receives water for stock and domestic use, and environmental flows.

The completion of Copeton Dam in the 1970s – and the weirs and regulators subsequently constructed to control releases from the dam – has substantially affected the seasonality and distribution of river flows. Whereas previously water mainly flowed straight down the Gwydir River into the wetlands, much of the flow is now diverted into the Mehi River and Carole Creek systems to supply irrigators. Flows in these systems reach the Barwon River much more frequently than before river regulation, when most high flows and floods were dissipated in the Gingham and Big Leather watercourses.

Most of the floodplain is privately owned and used for agriculture. There have been dramatic changes in the last few decades as land holders have adapted to changing economic forces. While sheep and cattle grazing were once the dominant land uses, the major changes in water distribution and flooding from the late 1970s encouraged both the rapid development of irrigated agriculture and a switch from grazing of native pastures to improved pasture and dryland cropping. These changes have greatly reduced the former extent of wetland vegetation and floodplain woodlands.

Invasive exotic plants have also had a major impact on the wetlands. Water hyacinth, an aquatic weed, is firmly established in Gingham Watercourse. Control programs have aimed to limit the weed's impact in the wetlands and prevent it from escaping downstream into the Barwon–Darling system. The initial outbreak of water hyacinth in the 1970s was regarded as so serious that measures were taken to drain the wetlands to kill the plants. While this approach reduced the extent of the infestation, it has had long-term consequences for the functioning of the wetlands.

Lippia is adapted to more terrestrial conditions on the floodplain but is quite tolerant of flooding. Current water and grazing regimes have allowed it to spread and displace native groundcover species, particularly water couch. Lippia is already widespread in the Murray–Darling Basin and remains difficult to control despite intensive research into eradication methods.

The Gwydir Wetlands Adaptive Environmental Management Plan (AEMP):

- describes the ecological assets and values of the Gwydir Wetlands and the values that the wetlands hold for Aboriginal people
- describes the ways in which the wetlands have changed since settlement by non-indigenous Australians
- provides maps and data showing changes in land use and vegetation cover from 1996–2008
- summarises what is currently known about the water needs of wetland plant communities and waterbirds
- explains how much water is held for environmental purposes and who controls it
- considers how much of the wetlands can be adequately watered under several scenarios of water availability
- explains ways in which management decisions will be made and the actions needed to restore and maintain critical ecological functions and habitats in the wetlands.

Water is the key to restoring the resilience of the wetlands. Ongoing development of river flow and flood models and decision support software will assist in maximising the benefits from the use of environmental water in the Gwydir Wetlands.

Acronyms and abbreviations

AEMP	adaptive environmental management plan
ARI	average recurrence interval
AWD	available water determination
BRG CMA	Border Rivers–Gwydir Catchment Management Authority
CAMBA	China–Australia Migratory Bird Agreement
CAP	catchment action plan
CEWH	Commonwealth Environmental Water Holder
CMA	catchment management authority
CRC	cooperative research centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAA	Department of Aboriginal Affairs
DECCW	Department of Environment, Climate Change and Water
DSEWPC	Department of Sustainability, Environment, Water, Population and Communities (formerly the Department of Environment, Water, Heritage and the Arts)
DIPNR	Department of Infrastructure, Planning and Natural Resources
DNR	Department of Natural Resources
DWR	Department of Water Resources
ECA	environmental contingency allowance
ECAOAC	Environmental Contingency Allowance Operations and Advisory Committee
EEC	endangered ecological community
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
FM Act	*Fisheries Management Act 1994*
Gwydir WSP	*Water Sharing Plan for the Gwydir Regulated River Water Source*
I&I NSW	Industry & Investment NSW (formerly Department of Primary Industries)
IMEF	Integrated Monitoring of Environmental Flows program
JAMBA	Japan–Australia Migratory Bird Agreement
LHPA	Livestock Health and Pest Authority (formerly Rural Lands Protection Board)
LPMA	Land and Property Management Authority (NSW)
LGA	local government area
MDBA	Murray–Darling Basin Authority
nd	no date

NOW	NSW Office of Water
NPWS	National Parks and Wildlife Service
NSW VCA	New South Wales Vegetation Classification and Assessment Database
POEO Act	*Protection of the Environment Operations Act 1997*
RERP	Rivers Environmental Restoration Program
ROKAMBA	Republic of Korea–Australia Migratory Bird Agreement
State Water	State Water Corporation
TSC Act	*Threatened Species Conservation Act 1995*
UNE	University of New England
UNSW	University of New South Wales
WRC	Water Resources Commission
WRP	Wetland Recovery Program
WSP	water sharing plan

1 Introduction

1.1 The purpose of the Gwydir Wetlands Adaptive Environmental Management Plan

The condition of the Gwydir Wetlands has been declining for many years. If this trend is not reversed, the wetlands will cease to exist as a large, diverse and complex ecosystem. The Gwydir Wetlands Adaptive Environmental Management Plan (AEMP) demonstrates that managers now possess much of the knowledge needed to begin restoring the wetlands' ecological resilience.

The AEMP recommends various actions and strategies to improve the condition of the wetlands. It is a guide for adaptively managing a highly modified ecosystem to achieve realistic objectives. It is not a guide to returning the wetlands to a past condition or to managing them to maintain a fixed state.

1.2 The context for the AEMP

There are many important policies, Acts and programs that support and complement the AEMP at international, national, state and regional levels. Internationally, the Ramsar Convention (*The Convention on Wetlands of International Importance, especially as Waterfowl Habitat)* provides a global framework for the conservation and wise use of wetlands and their resources (Ramsar Convention 1987). In the Gwydir Wetlands, parts of four properties totalling 823 hectares are listed as a 'wetland of international importance' under the Ramsar Convention. When Ramsar listing occurred in 1999, most of the relevant land in these properties was privately-owned, although there was a small area of Crown land. One property, 'Old Dromana', has recently been purchased by the NSW Government, with funding provided by the Australian Government, and will be managed for conservation purposes.

In designating wetlands as Ramsar sites, countries agree to manage and monitor the listed sites with the aim of preventing adverse changes in their ecological character, which is described at the time of listing (Department of the Environment, Water, Heritage and the Arts 2009a).

Although there are separate management planning processes for Ramsar sites, one of the AEMP's objectives is to consider the requirements of these internationally recognised wetlands.

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) gives legislative recognition to the Ramsar Convention under Australian law. It also provides for the national listing of threatened species and ecological communities. The EPBC Act gives the Australian Government certain powers to protect Ramsar sites, threatened species and endangered ecological communities.

Regarding the Murray–Darling Basin, the Commonwealth *Water Act 2007* provides for the Murray Darling Basin Authority (MDBA) to develop a Basin Plan which will establish Sustainable Diversion Limits for each of the Basin's water sources, including the Gwydir River. The Basin Plan will include an Environmental Watering Plan to coordinate the management of environmental water.

The Water Act also established the Commonwealth Environmental Water Holder (CEWH) to manage the Commonwealth's environmental water holdings to protect or restore the environmental assets of the Basin to give effect to international agreements. The CEWH makes decisions after receiving advice from an Environmental Water Scientific Advisory Committee, as well as input from state governments and others, and must operate in accordance with the Basin Plan.

At state level, the *Water Sharing Plan for the Gwydir Regulated River Water Source* (Gwydir WSP) (NSW Government 2003) is a legal instrument made under the *Water Management Act 2000* that directs how the available water in Gwydir River is to be shared, including the provision of water for the environment.

Other NSW Acts that assist in protecting the wetlands include the:

- *Native Vegetation Act 2003* which signalled an end to broadscale clearing. This Act is important for conserving vegetation throughout the Gwydir floodplains, including the wetland vegetation described in this AEMP.
- *Threatened Species Conservation Act 1995* (TSC Act), which aims to protect threatened species, populations and ecological communities and their habitats in NSW.
- *Fisheries Management Act 1994* (FM Act), which applies to aquatic species, aiming to conserve threatened species, populations and ecological communities of fish and marine vegetation.

Regionally, the Border Rivers–Gwydir Catchment Action Plan (Border Rivers–Gwydir CAP) identifies broad catchment targets for natural resource management. Proposed actions in the AEMP complement these targets, and the Border Rivers–Gwydir Catchment Management Authority (BRG CMA) will help the Department of Environment, Climate Change and Water (DECCW) to annually review the implementation of the AEMP.

Floodplain management plans are an important tool for managing floodplains in NSW. The *Lower Gingham Watercourse Floodplain Management Plan* (Department of Natural Resources 2006) applies to the floodplains adjoining the western part of the Gingham Watercourse, and provides a statutory framework for managing floodplain structures that affect the distribution of floodwaters in that area.

The Gwydir Wetlands lie within the area of Moree Plains Shire Council, which is responsible for developing and implementing noxious weed control programs. The council's most important role in relation to this plan is in assisting land holders to control infestations of water hyacinth.

The NSW and Australian governments funded the NSW Wetland Recovery Program (WRP) to halt the decline of the Gwydir Wetlands and Macquarie Marshes by restoring and protecting critical ecological functions and habitats. One component of the WRP is the development of this AEMP. The NSW RiverBank Program and the Rivers Environmental Restoration Program (RERP), funded by the NSW and Australian governments, are also supporting the restoration of the Gwydir Wetlands and Macquarie Marshes, as well as wetlands in the Lachlan and Murrumbidgee valleys and the Narran Lakes. These programs include significant resource planning, water and wetland purchases, research, infrastructure development and land management actions.

The AEMP is not a statutory document, and will need support from NSW and Australian governments, and local communities, for its implementation. DECCW is the lead government agency for implementing the AEMP. The Border Rivers–Gwydir Catchment Action Plan will take account of much of the information and many of the recommendations in the AEMP.

1.3 Gwydir River

Gwydir River is a large river system in the Murray–Darling Basin (Figure 1), with a catchment of about 26,000 square kilometres. The river begins west of Armidale and flows about 300 kilometres west to Pallamallawa where it begins to form a wide, flat floodplain that stretches to the Barwon River. West of Moree, the floodplain occupies the width of the valley, forming part of the Darling Riverine Plains. The northern and southern boundaries of the Gwydir catchment in this region are arbitrarily defined, as floodwaters occasionally flow to or from the adjoining Border Rivers (Barwon/Macintyre) and Namoi River catchments (Pietsch 2006).

Copeton Dam is the valley's major water storage facility, with a capacity of 1,364,000 megalitres (Department of Water Resources nd). The main tributaries of Gwydir River downstream of Copeton Dam are Horton River, and Myall, Mosquito, Warialda, and MacIntyre creeks. Halls, Tycannah and Gurley creeks flow into Mehi River and Moomin Creek south-west of Moree.

Average rainfall in the Gwydir Valley ranges from 980 millimetres over the north-eastern margin to about 480 millimetres around the western extremity. There are two wet periods, from November–March and June–July, while the rest of the year is relatively dry (Water Resources Commission 1980).

Almost the entire runoff for the catchment is generated above Pallamallawa, with the western floodplains contributing almost no runoff due to low slopes, absorbent soils and a high evaporation rate. About 6% of the average flow at Pallamallawa is carried across the floodplain to Barwon River by the two largest distributaries, Mehi River and Carole-Gil Gill Creek (Pietsch 2006).

Pietsch (2006) provides a detailed description of the geomorphology and hydrology of the western part of the Gwydir Valley, which he calls the 'Gwydir fan-plain'. The following details are taken mainly from that work, which makes extensive use of early survey plans and other historical records to evaluate changes in the river channels.

Within-channel flow across the Gwydir fan-plain is carried by Gwydir River and its three main effluent streams (streams that flow out of a major river): Mehi River, Moomin Creek and Carole Creek. Mehi River is the first to branch off from the south bank of Gwydir River, about 20 kilometres east of Moree. Carole Creek branches off from the north bank of Gwydir River about 25 kilometres further west. Moomin Creek diverges from Mehi River and takes a wide arc to the south before rejoining the river near Collarenebri.

In addition to in-channel flow, it is normal for water to flow through shallow depressions in the floodplain known as 'watercourses', such as the well-known Gingham and Big Leather watercourses. Survey plans of these features drawn in the early twentieth century depicted chains of 'swamps' (meaning wetlands without open water) that connected occasional waterholes, with only rare stretches of formed channels. Since that time, artificial channels have been cut along both watercourses. While these channels assisted the delivery of low-flow stock and domestic allocations, they reduced the watering of previously naturally irrigated prime wetland pastures (Pietsch 2006).

Of the main channels, Gwydir River has its bed at the lowest elevation and carries most of the coarse bedload sediment in the system (Pietsch 2006). Without the weirs that raise water levels at the off-takes to the Mehi River, Moomin Creek and Carole Creek, these streams would only commence to flow during high flows in Gwydir River (Pietsch 2006). The flow capacities of all these channels are reduced in the downstream direction. Although Gwydir River is the main stream, it has the greatest contraction in capacity, due in part to the natural diversion of high flows into effluent streams and watercourses.

Figure 1 Location of the Gwydir River catchment in the Murray–Darling Basin.

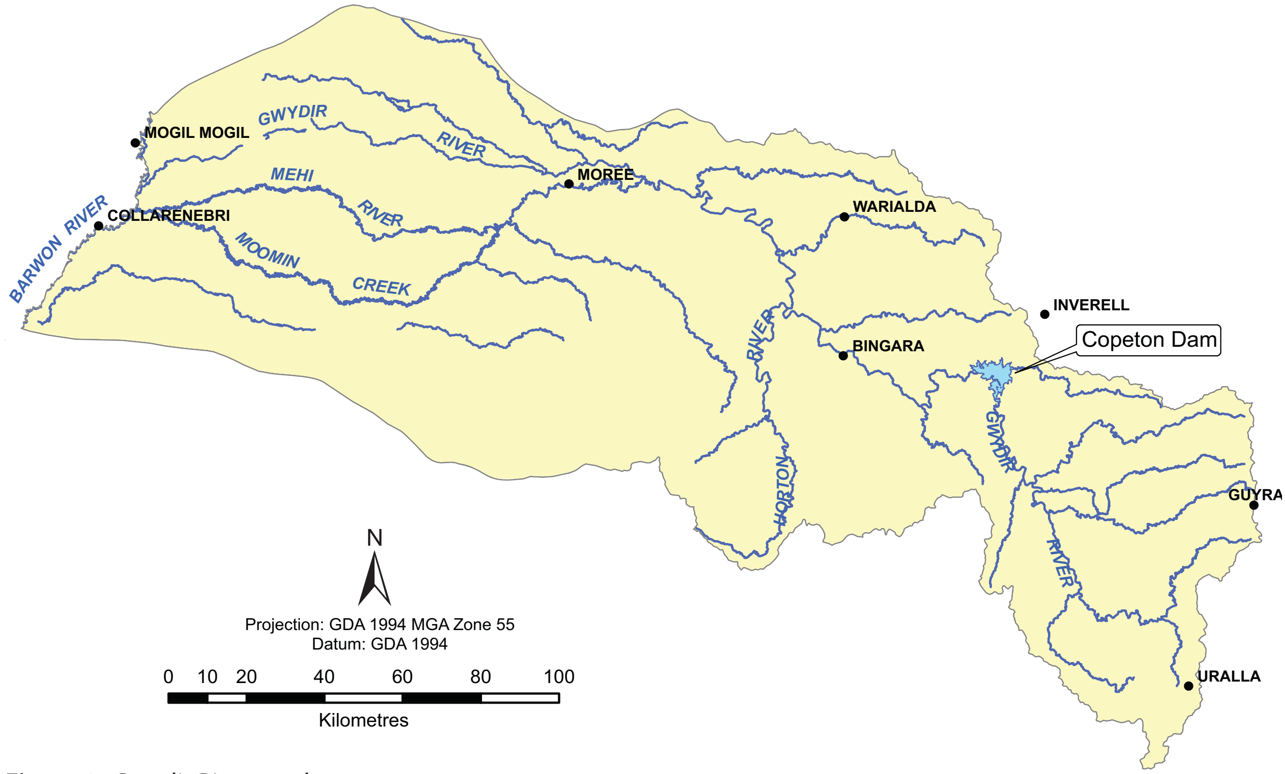


Figure 2 Gwydir River catchment.

An important feature of the lower Gwydir River is the Raft, an accumulation of woody debris and silt that clogs the channel for over 15 kilometres. Pietsch (2006) and Blandford et al (1977) provide the most details on the origin and development of the Raft, although they contradict each other in some respects. However, the effect of the Raft on water distribution in the Gwydir Wetlands is not disputed.

The Raft began to develop in either the 1870s or the early 1900s. It commenced at a point about 7 kilometres above Brageen Crossing, from where it progressed upstream (Pietsch 2006). It is believed that the widespread clearing of trees in the upper catchment resulted in masses of logs and branches being carried downstream periodically by large floods. From 1946–1955, the Raft advanced upstream 3.6 kilometres. The 1971 flood caused it to grow by 365 metres in length, while the 1976 flood caused it to extend another 60 metres. Each growth phase caused changes in the hydrologic behaviour of this section of the floodplain (Blandford et al 1977).

Silt and other debris are trapped in the mass of woody debris, and the course of much of the former channel is now buried and largely obscured. The head of the Raft has stabilised about 20 kilometres west of Moree, where it partly dams Gwydir River, creating Gwydir Pool (Pietsch 2006).

The Raft is now over 15 kilometres long (Pietsch 2006). Its blocking effect has increased the proportion of flows entering Gingham Watercourse (Blandford et al 1977). This has created an overflow area at the eastern end of Gingham Watercourse, where about 2,000 hectares of mixed coolibah and river red gum forests and woodlands have developed since the 1950s (McCosker & Duggin 1993).

The early activities of non-indigenous Australians had other important impacts on the distribution of flows across the floodplain. Pietsch (2006) describes several instances of channel works designed to redistribute natural river flows, including:

- A channel was cut to bypass the lower reaches of the Goonal Anabranch sometime after 1908, which was successful in increasing flows into the Big Leather Watercourse.
- Works undertaken between 1903 and 1936 reduced the height of the Mehi River off-take from about 3.4 metres above the bed of the Gwydir River to about 1.1 metres. This equates to a four-fold increase in flow duration, from less than 5% before cutting to more than 20% afterwards.
- A small, high-level channel was cut before the 1920s to create an off-take from Gwydir River to Carole Creek (previously there was no direct connection). The connecting channel was enlarged in the 1940s.
- A channel was cut in the 1890s from the northern end of Carole Creek, where it dissipated in a flood-out, to direct flows into Gil Gil Creek.
- The off-take of Moomin Creek from Mehi River was modified in the early twentieth century to increase flows down this creek.

Photo 1 Gwydir Raft (Photo: Neal Foster).

The most far reaching change in the Gwydir River system came with the construction of Copeton Dam, and the downstream weirs and regulators that allow much of the flows to be diverted into the Mehi River and Carole Creek systems.

Currently, river flows are managed by State Water according to the rules set out in the Gwydir WSP (NSW Government 2003). Within the regulated section, State Water supplies water ordered by licence holders. The regulated parts of the Gwydir Water Management Area include Gwydir River from Copeton Dam to the Raft, part of the lower Gwydir River (called Lower Gwydir Watercourse in this AEMP), Mehi River and Moomin Creek to the south, and Carole Creek and part of Gil Gil Creek to the north (Department of Infrastructure, Planning and Natural Resources 2004).

All other rivers and creeks that flow into the main river (tributaries) or flow from it (effluents) are unregulated rivers for the purposes of water supply management ,and water availability is generally subject to natural river flows. Some of the effluents receive replenishment flows to satisfy the water requirements of domestic and stock water users.

1.4 Gwydir Wetlands

For the purpose of this AEMP, 'wetland' has the same meaning as the Ramsar Convention definition:

> … areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres.
>
> (Ramsar Convention 1987)

Under this definition, virtually the entire Lower Gwydir floodplain (Figure 3) may be regarded as a wetland ecosystem. Gwydir Wetlands consist of a mosaic of wetland types, ranging from semi-permanent marshes and waterholes to floodplain woodlands only inundated by large floods (Australian Nature Conservation Agency 1996, Torrible et al 2008). Although these wetlands are highly modified by agricultural development and water management, they retain high ecological and cultural values, as described in the following sections.

The core wetland areas include waterholes and semi-permanent wetland vegetation typified by marsh club-rush (also known as sag) and water couch which is inundated frequently by overbank flooding from many small channels. River cooba and lignum shrublands are common in and around the margins of the core wetlands. Coolibah woodlands fringe the core wetland areas and form extensive woodlands on less frequently flooded parts of the floodplain (Keyte 1994, Bowen & Simpson 2010).

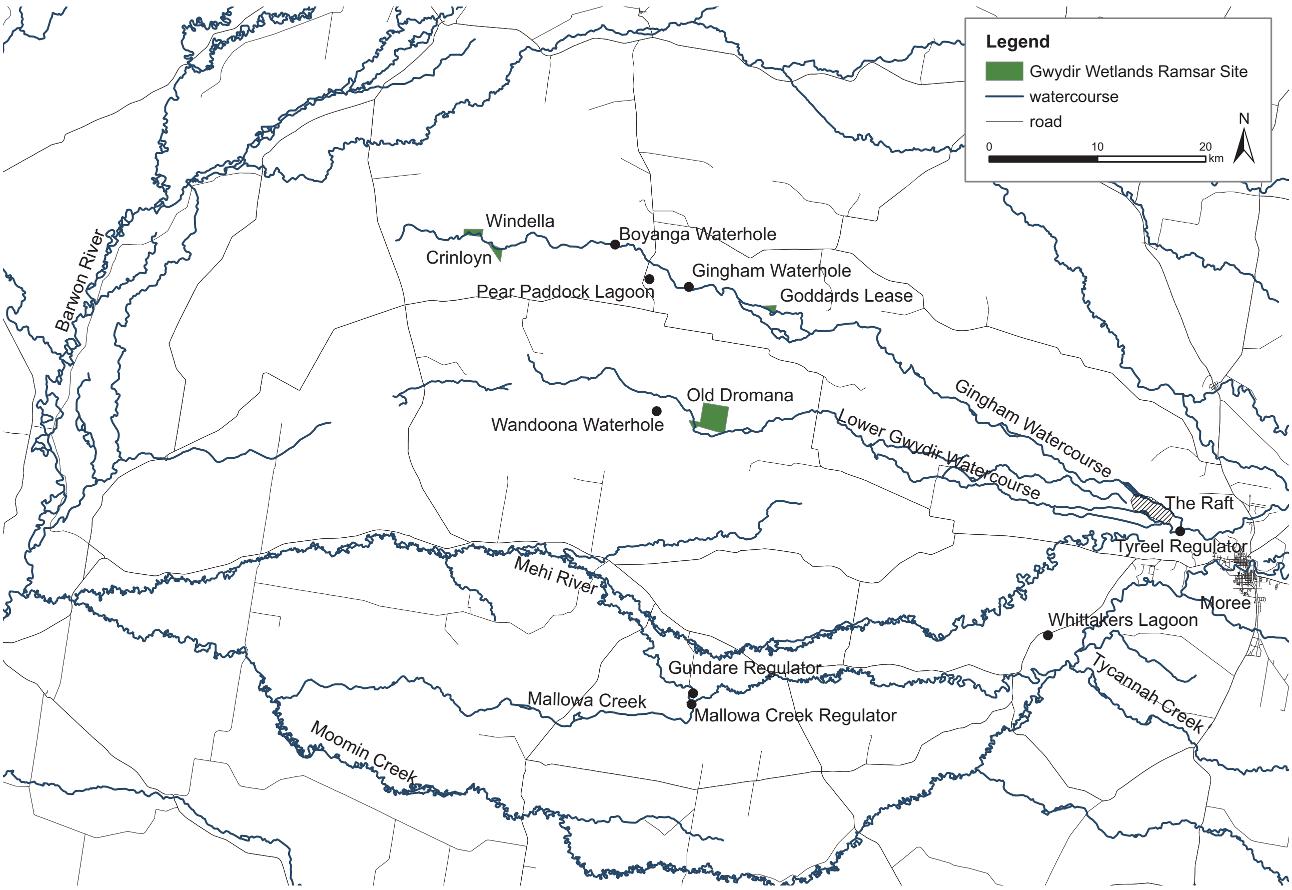


Figure 3 The Lower Gwydir floodplain, which is the region covered by this AEMP, showing key locations and features.

Gwydir Wetlands are known as a major centre for waterbird breeding in Australia (Morse 1922, McCosker 1996), and provide habitat for hundreds of animal and plant species. In 1921, part of the wetlands was proclaimed as a bird and wildlife sanctuary (Keyte 1994). The floodplain wetlands provide habitat for migratory birds listed under international agreements that Australia has made with Japan, China and the Republic of Korea (JAMBA, CAMBA and ROKAMBA respectively).

The values of the wetlands are now recognised at all levels of government in Australia, and internationally through the Ramsar Convention. The wetlands are included in the *Directory of important wetlands in Australia* (Australian Nature Conservation Agency 1996).

1.5 Ecological systems and processes

Ecosystems comprise both organisms and their non-living environments, and include humans if they are present (Barnhart 1986, Meffe et al 2002).

The Gwydir Wetlands ecosystem includes the plants, animals and places occurring there, and processes that form the wetlands such as flooding, drying and nutrient cycling. Managing the wetlands requires also considering the processes in the whole Gwydir catchment and the hydrology and geomorphology of the river and floodplain.

A river's natural flow regime is driven by climate and runoff from the upstream catchment, and its main components are the size, frequency, duration, timing and rate of change of flows (Poff et al 1997, Puckridge et al 1998). This flow regime is the key driver of ecological systems in rivers and wetlands. High flows generate floods in Gwydir Wetlands, and the extent, frequency, duration and depth of flooding determine the distribution, type and vigour of wetland vegetation.

Like most other major rivers in the Murray–Darling Basin, Gwydir River is highly regulated (Mussared 1997, Young 2001). The resulting changes to the natural flow regime have severely affected the structure and functioning of the wetlands.

1.6 Aboriginal cultural values

Gwydir Wetlands are part of the traditional country of the Gamilaroi people. They provided an important and rich asset, complementing the resources of the plains and ranges. The specific places in the wetlands, and the plants and animals that the wetlands supported, were important in Aboriginal culture.

Aboriginal cultural values are related to the history of Aboriginal interaction with Gwydir Wetlands, and to the values, interests and aspirations of contemporary Aboriginal communities that have a custodial relationship with them. The Aboriginal ethos of 'caring for Country' can assist the sustainable management of wetlands through its emphasis on the connections between people and the natural world and the sense of responsibility to care for the natural world.

The three main elements of protecting and strengthening cultural values in Gwydir Wetlands are:

1. acknowledging Aboriginal connections to Country
2. protecting Country by maintaining the health of Gwydir Wetlands, protecting sites of Aboriginal cultural heritage, and protecting plants and animals that have cultural values
3. improving access for Aboriginal people to Country for cultural activities, facilitating working on Country, and increasing participation in managing the environment.

1.7 Economic systems

This section gives an overview of the economy of the Gwydir catchment (see Figure 2 for a map of the catchment) including a general description of key industry sectors. It should not be interpreted as a comparison of the relative economic value of these sectors in the Lower Gwydir floodplain because the available data apply to different areas.

The economy of the Gwydir catchment is highly reliant on agriculture, including cropping and livestock farming. The catchment has a number of small urban centres and rural settlements (Argent et al 2007).

Consistent with regional areas across Australia, the catchment's population has declined steadily over the past decade and youth out-migration has led to a higher rate of ageing of the population than is the average in NSW. Economic indicators show a stronger dependence on agriculture for employment, higher rates of unemployment and lower income levels than the state average (AgEconPlus 2007, Argent et al 2007). However, these trends are not uniform across the catchment. The western catchment communities rely more on agriculture than the larger population centres in the east (Argent et al 2007).

1.7.1 Agriculture and other industries

Total agricultural output for the Gwydir catchment was worth $755 million in 2005–06, which was 8.3% of the estimated value of NSW agricultural production. Crops accounted for 73% of the value of agricultural production, while livestock slaughtering and livestock products accounted for 22% and 5% respectively (Australian Bureau of Statistics 2010).[1] Agriculture covers 83.1% of the land area of the catchment (Australian Bureau of Statistics et al 2009, p. 131).

The agriculture, forestry and fishing sector is the largest employer in the Gwydir catchment. These rural industries accounted for 28.9% of total employment in 2006, declining from 32.1% in 1996. Other major sources of employment in 2006 were the retail trade sector (9.3%), education and training sector (8.5%), health care and social assistance sector (8.3%), public administration and safety sector (6.2%) and construction sector (5.7%) (Australian Bureau of Statistics 1996, 2006b).

1.7.2 The irrigation industry

Irrigated agriculture covers up to 5% of the area of the catchment (Australian Bureau of Statistics et al 2009, p. 131) but contributes 30–40% of the total value of agricultural production depending on the conditions of the year. The gross value of irrigated agriculture in the Gwydir catchment in 2005–06 was approximately $154 million (Marsden Jacob Associates 2010).

Cotton is the dominant irrigated crop by area and value. The area of irrigated farming fluctuates annually, primarily in relation to water availability (Hassall & Associates 2007).

1. The statistics in this section are for the Guyra, Gwydir, Moree Plains and Uralla local government areas (LGAs). These areas are different to the official Gwydir catchment area because the LGA boundaries do not match the official catchment boundaries. These LGAs were selected in the AgEconPlus (2007) consultants' report because more than half their areas were contained in the official Gwydir catchment boundaries.

1.7.3 Cotton production

Photo 2 Irrigated cotton and associated floodplain works in the upper Gingham Watercourse (Photo: Neal Foster).

Cotton production is highly concentrated in the catchment, with 95% of the area under production in 2005–06 located in the Moree Plains local government area (AgEconPlus 2007). In 2005–06, approximately 77,500 hectares were planted for cotton, of which approximately 90% was irrigated (Australian Cottongrower 2009). In 2005–06, the cotton crop had a value of approximately $162 million, with irrigated cotton accounting for approximately 95% of this value (Marsden Jacob Associates 2010, AgEconPlus 2007).

The irrigated cotton industry grew significantly during the 1980s and 1990s, but recent seasonal conditions and commodity prices have combined to lessen the momentum of that growth (Hassall & Associates 2007). Cotton planting fluctuates depending on seasonal conditions and availability of water. In 1998–99 and 2000–01 approximately 110,000 hectares were planted, although only approximately 30,000 hectares were planted in 2003–04 and 2008–09 (Australian Cottongrower 2009).

Cotton processing also contributes to the regional economy. Nine cotton gins operate in the Gwydir catchment, and each is reported to employ an average of 25 people in the cotton ginning season, which lasts three months each year (AgEconPlus 2007).

Cotton could be replaced with other crops if prices change significantly. To date, there is little evidence to suggest a long-term change in the cropping patterns in the catchment. The high variability of rainfall and river flows mean that annual crops such as cotton are likely to continue to be an important component of future cropping strategies (Hassall & Associates 2007).

Despite this, the recent dry period has exposed many irrigators to other cropping options at a time of low water availability and high prices for feed grains. This type of shift depends on many factors such as commodity prices, management expertise, and infrastructure and equipment exchangeability (Hassall & Associates 2007).

1.7.4 The grazing industry

Most agricultural land in the Gwydir catchment is used for livestock grazing. Livestock slaughtering and livestock products in the catchment were worth $233 million in 2005–06. Cattle and calves provided the largest contribution to livestock slaughtering ($142 million) followed by sheep and lambs ($20 million). Wool provided by far the largest contribution to livestock products ($34 million) (Australian Bureau of Statistics 2006a).[2]

2. This comprises the Guyra, Gwydir, Moree Plains and Uralla LGAs.

2 The ecological assets and values of the Gwydir Wetlands

The ecological assets and values described in this section have been identified through studies that have collated existing information and gathered new data about the flora and fauna of the Gwydir Wetlands. The results of these studies are reported in Bowen & Simpson 2010, Spencer 2010, Spencer et al 2010, Wilson et al 2009 and Torrible et al 2008.

The selected ecological assets that are listed below serve as indicators for the health of the whole ecosystem. When wetlands and waterbirds are flourishing, it is because ecological functions and processes are intact. To stabilise and eventually improve the condition of the wetlands under both existing and projected climatic conditions, the sensible base to work from is their existing condition. The studies will help to establish benchmarks from which future changes in condition of the wetlands can be monitored.

The animals, plants, and ecosystems described here also hold important Aboriginal cultural values, which are described in section 6.

The ecological assets and values defined in this AEMP are:

- **waterbirds and waterbird habitat** – the wetlands are renowned for large-scale waterbird breeding with many tens of thousands of birds breeding throughout the area
- **wetland vegetation** – the character of the wetlands derives from the presence of varied associations of water couch, marsh club-rush, lignum, river cooba, coolibah, black box and river red gum
- **species and communities of special significance** – these include the aquatic ecological community, fish, reptiles, frogs, woodland birds and myall woodland.

Water management is treated separately, in section 3. Water drives ecological processes of the wetlands, as well as supporting the agricultural and social systems of the Gwydir Valley.

Photo 3 Brolgas (Photo: Daryl Albertson).

2.1 Waterbirds and waterbird habitat

Gwydir Wetlands are recognised as a refuge for waterbirds in dry times, and for supporting some of the largest waterbird breeding colonies recorded in Australia. There have been 75 waterbird species recorded in Gwydir Wetlands – 65 species on the Ramsar-listed property 'Old Dromana' alone. They include species listed as threatened both in NSW and nationally, and species listed on the JAMBA, CAMBA and ROKAMBA migratory bird agreements (see table 1 for full names of these agreements) (Spencer 2010).

Table 1 Migratory bird species recorded in the Gwydir Wetlands listed under international agreements (from Spencer 2010).
Note: fork-tailed swift and white-throated needletail are species of swift that are not regarded as waterbirds.

Common name	Listed under JAMBA (J), CAMBA(C), ROKAMBA (R)
Australian painted snipe	C
Caspian tern	C
Cattle egret	J C
Common greenshank	J C R
Common sandpiper	J C R
Common tern	J C R
Fork-tailed swift	J R
Glossy ibis	C
Great egret	J C
Latham's snipe	J C R
Little curlew	J C R
Marsh sandpiper	J C R
Oriental plover	J R
Ruff	J C R
Sharp-tailed sandpiper	J C R
White-bellied sea-eagle	C
White-throated needletail	C R
White-winged black tern	J C R

JAMBA = Japan–Australia Migratory Bird Agreement
CAMBA = China–Australia Migratory Bird Agreement
ROKAMBA = Republic of Korea–Australia Migratory Bird Agreement

There is much available information about the required habitats, nesting materials and feeding areas of breeding waterbirds in the wetlands. Waterbird habitat includes preferred locations and vegetation for shelter and nest sites, the water needed to flood breeding sites and feeding areas, and the availability of preferred food items. Differences in flow size, timing and duration of flooding are known to encourage different-sized breeding events.

Photo 4 Intermediate egrets (Photo: Neal Foster).

The key waterbird breeding habitats in Gwydir Wetlands are floodplain waterholes, in-channel lagoons and floodplain wetlands with sedgelands, stands of cumbungi, lignum, belah, coolibah and river red gum. Feeding habitats include floodplain waterholes, in-channel lagoons and floodplain areas with freshwater meadows, sedgelands and stands of cumbungi (Spencer et al 2010).

Colonially nesting species are prominent among the waterbirds that breed in Gwydir Wetlands. Great egret, intermediate egret, little egret, Nankeen night heron, glossy ibis, Australian white ibis, straw-necked ibis, little pied cormorant and little black cormorant breed in the largest numbers. Records of major breeding events date back to the 1920s, when Gwydir Wetlands were thought to hold 'the largest heronry in NSW' with 'hundreds of thousands of birds breeding there' (Morse 1922).

Large-scale waterbird breeding in Gwydir Wetlands is an indicator that the ecological system is functioning well. To breed successfully, colonially nesting waterbirds need flooding of sufficient volume and duration to inundate colony sites and feeding areas for at least 4–5 months between August and April (Marchant & Higgins 1990, 1993). These flows are also critical for maintaining wetland vegetation, and for enabling aquatic invertebrates to complete their lifecycles (Jenkins & Wolfenden 2006). Although smaller flows do not generally support successful colonially nesting waterbird breeding, they do enable other flood-dependent waterbird species to breed (Marchant & Higgins 1990, Spencer 2010).

2.2 Wetland vegetation

Gwydir Wetlands provide important refuges for native plants and animals in a highly developed agricultural region (Bowen & Simpson 2010). The vegetation communities on the floodplains are very fragmented and poorly conserved in NSW. Some are listed as endangered ecological communities (EECs) under the TSC Act or threatened ecological communities under the EPBC Act (Benson et al 2006, Keith 2004, Keith et al 2009).

In addition to these legislative listings, vegetation communities in NSW are being systematically classified and their conservation status is being assessed under the New South Wales Vegetation Classification and Assessment Database Project (NSW VCA) being conducted by DECCW (Benson 2006). Descriptions of the communities found in the Western Plains region (which includes Gwydir Wetlands) have been published (Benson et al 2006).

Several studies have reported reductions in the extent and condition of both semi-permanent wetland and floodplain vegetation communities of Gwydir Wetlands since the regulation of Gwydir River in the 1970s. These changes have been attributed to reduced inundation of the floodplain which has reduced the productivity of floodplain pastures and encouraged changes in land use from grazing to cropping (Bennett & Green 1993, McCosker & Duggin 1993, Keyte 1994, Bowen & Simpson 2010).

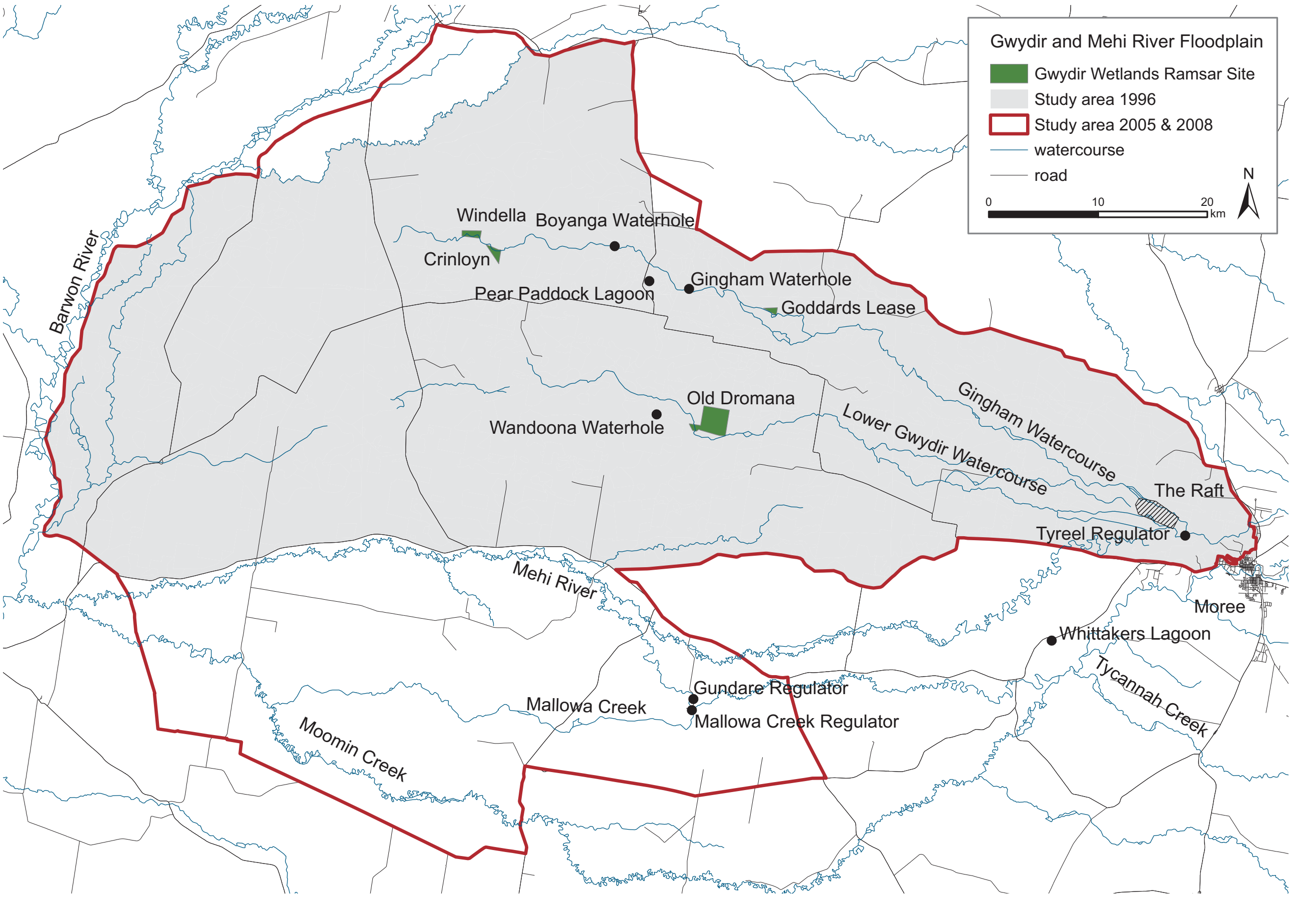


Figure 4 Boundaries of vegetation maps for 1996, 2005 and 2008.

The **condition** of vegetation communities is a measure of the species composition and vigour of native plants compared to a **reference condition**, which is based either on sites which have not been significantly affected by human activities, or a **hypothetical condition** that would be expected in the absence of human-mediated stressors such as changes to water quantity and quality and fire regimes, physical habitat structure, grazing pressure and the impacts of weeds and pest animals.

Bowen and Simpson (2009) mapped the vegetation communities in Gwydir Wetlands in 2008, and used maps of vegetation in 1996 and 2005 by McCosker (1997, 2007) to measure changes in extent. Figure 4 shows the areas covered by these mapping projects, and Figures 5 and 6 show the changes between 1996 and 2008.

At higher elevations, the floodplain supports a variety of woodland and grassland communities classified as 'dryland floodplain vegetation' (e.g. poplar box and belah woodlands, native millet and windmill grass). These are shown on the maps but are not considered as assets, apart from the myall woodland described in section 2.3.6.
Wetland vegetation in the study area is classified into two groups:

- **semi-permanent wetland vegetation** – communities that depend on frequent flooding to maintain their structural integrity and condition
- **floodplain wetland vegetation** – communities whose dominant overstorey species require flooding at some stage for regeneration, can tolerate prolonged flooding for several months and can survive dry periods lasting for several years.

2.2.1 Semi-permanent wetland vegetation

In Gwydir Wetlands, areas of semi-permanent wetland vegetation large enough to be mapped only occur in the Gingham and Lower Gwydir watercourses (see Figure 7). The total extent of these communities (water couch–spike rush, marsh club-rush and cumbungi) has declined by an estimated 76% since the regulation of Gwydir River in the 1970s (Bowen & Simpson 2010). Figures 5 and 6 and Table 2 show the changes from 1996–2008, which amount to a reduction of 51% in area over this period.

Water couch grassland, water couch–spike rush meadows

Extensive water couch grasslands have been previously mapped in Gwydir Wetlands (McCosker & Duggin 1993, Keyte 1994). Most no longer receive the flows they need, and have declined in area and condition or have disappeared entirely (Bowen & Simpson 2010).

Water couch generally needs to be flooded in spring or summer at least once a year to maintain vigorous growth and compete successfully with other species (Bennett & Green 1993, Roberts & Marston 2000). Flooding may continue for 4–6 months or longer, or can occur in separate, shorter events. Water couch can recover from a one- to three-year dry spell but cannot tolerate extended or frequently repeated dry periods. When water couch is dry, it does not tolerate grazing well, and when it is underwater, it does not tolerate persistent grazing. However, according to recent research, under suitable flow conditions, grazing can help maintain water couch's dominance in grassy wetland communities (Wilson et al 2008, P Berney pers comm 2009).

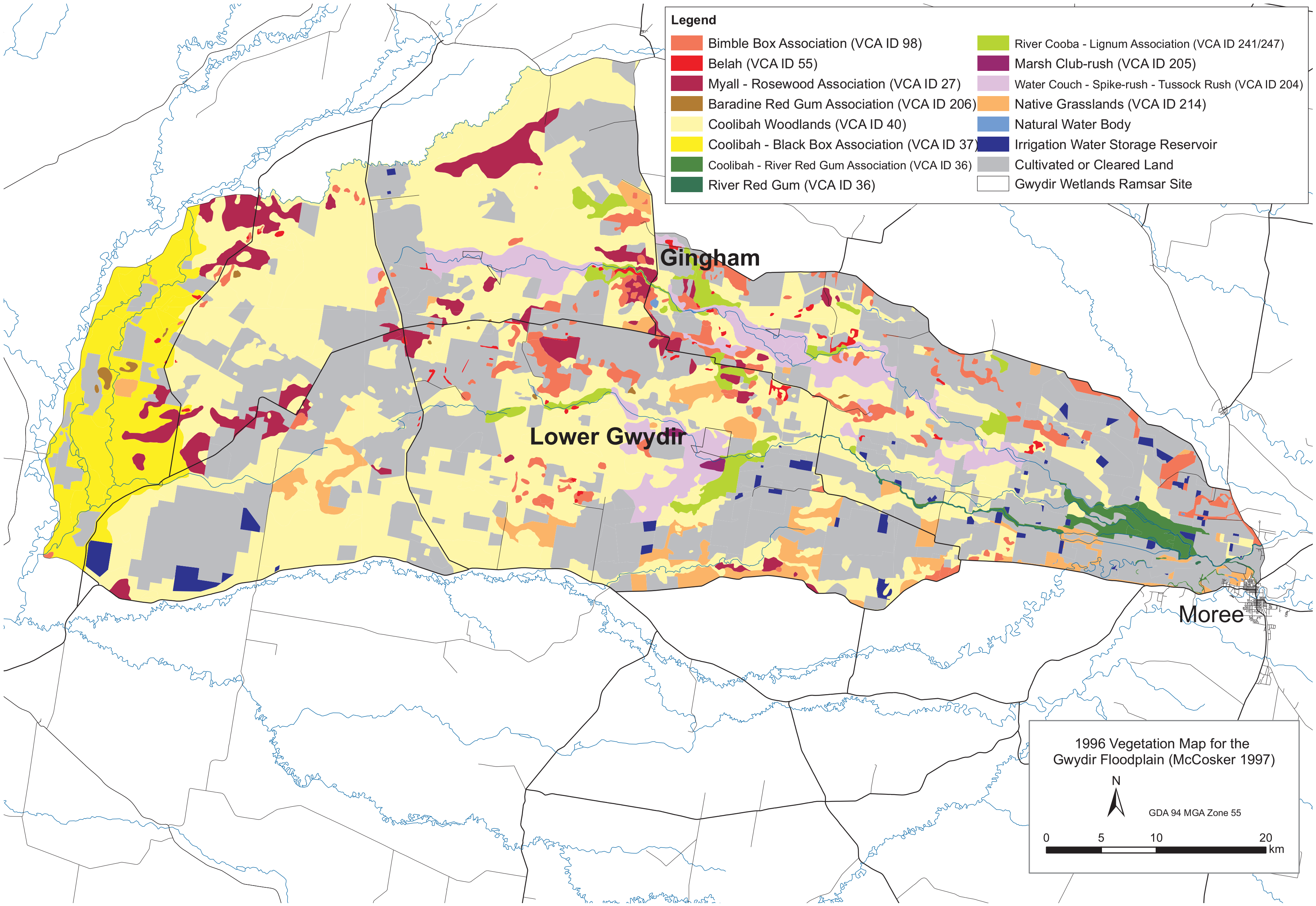


Figure 5 Vegetation of the Gwydir Wetlands and floodplain 1996 (McCosker 1997).

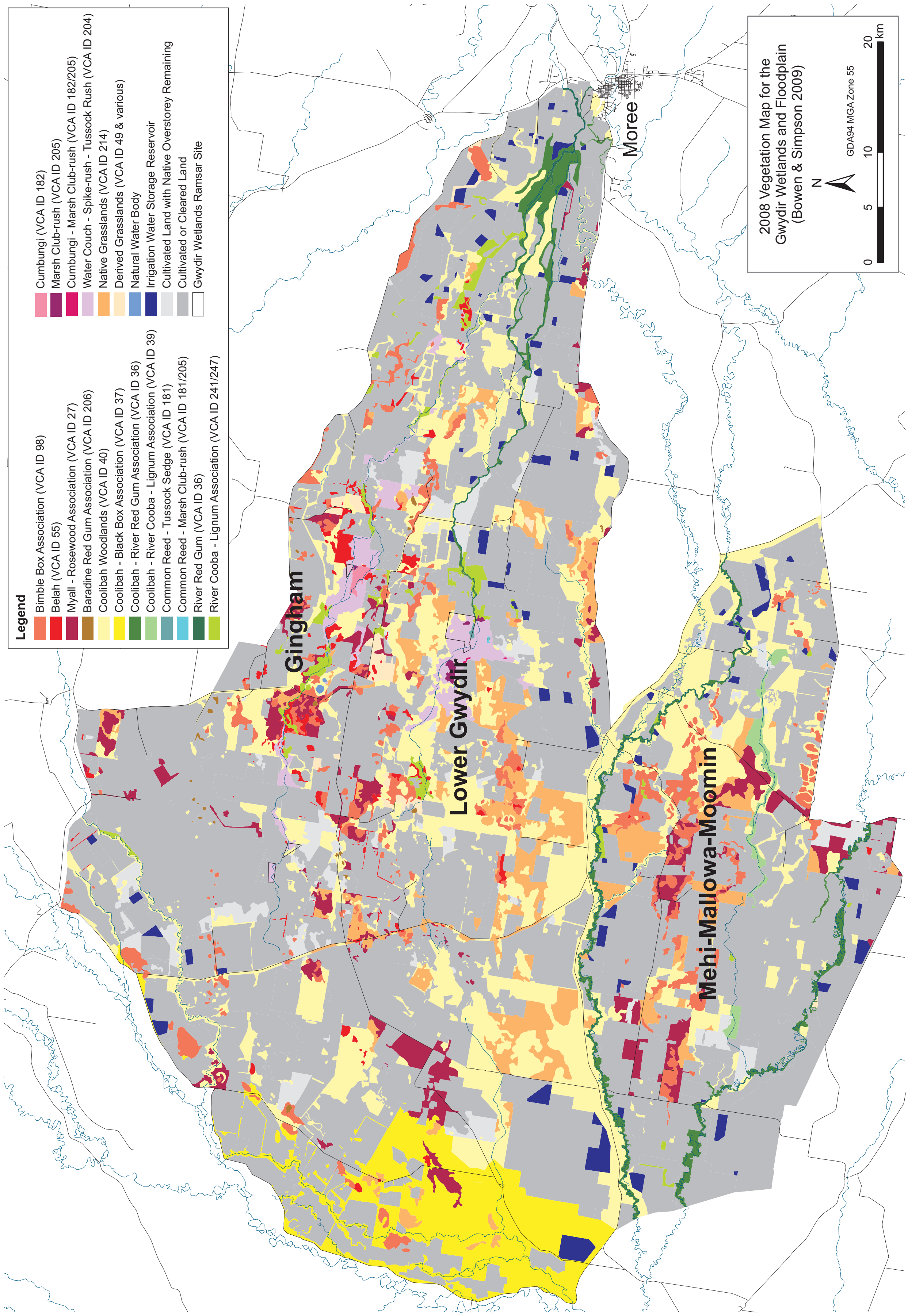


Figure 6 Vegetation of the Gwydir Wetlands and floodplain 2008 (Bowen & Simpson 2010).

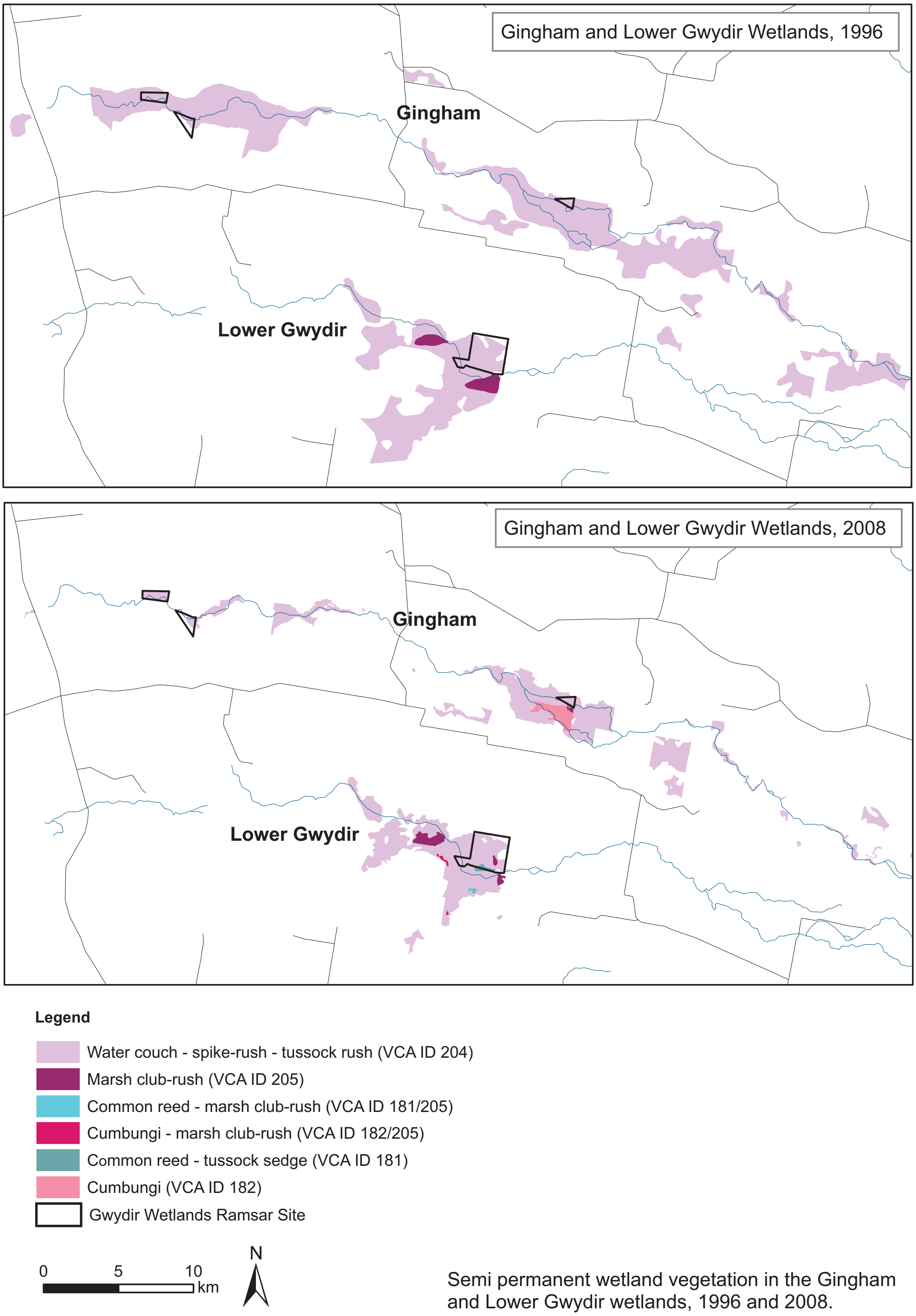


Figure 7 Changes in semi-permanent wetland vegetation in the Gwydir Wetlands 1996–2008 (Bowen & Simpson 2010).

Table 2 Change in extent of semi-permanent wetland vegetation, Gingham and Lower Gwydir watercourses, 1996–2008 (Bowen & Simpson 2010).

Location	Vegetation community	Area (ha)		
		1996	2005	2008
Gingham Watercourse	Water couch–spike rush	9,393	5,298	3,485
	Marsh club-rush			11
	Cumbungi			257
	Total	**9,393**	**5,298**	**3,753**
Lower Gwydir Watercourse	Water couch–spike rush	4,254	2,726	2,816
	Marsh club-rush	317	132	181
	Common reed–marsh club-rush			11
	Cumbungi–marsh club-rush			20
	Common reed		36	48
	Total	**4,571**	**2,894**	**3,076**
Total		**13,964**	**8,192**	**6,829**

In 1996, approximately 13,600 hectares of water couch grassland were mapped in the Gingham and Lower Gwydir watercourses. By 2008, approximately 6,300 hectares remained. These communities can recover, given suitable flows and best practice land management.

Water couch is a prolific seeder, but the success of seed germination is limited, and it can regenerate more successfully from fragments or buried nodes (Middleton 1999). Loss of water couch from large areas might lead to its failure to recover quickly because regeneration depends on the presence of mature, healthy plants that have trailing stems. Water couch marsh is considered to be an endangered community (Benson 2006).

Marsh club-rush

Marsh club-rush occurs in three frequently flooded areas of the Gingham and Lower Gwydir watercourses. Under favourable conditions it grows as a dense stand to two metres tall (McCosker 1997). Keyte (1994) reported that decreased inflows had caused a contraction in the area of marsh club-rush from a reported 2,200 hectares in 1974 to less than 700 hectares in 1993. The area of marsh club-rush declined to 317 hectares in 1996 and 132 hectares in 2005. However, including 31 hectares co-dominant with common reed and cumbungi, the area had increased to 223 hectares in 2008. This community has been recently listed as critically endangered under the TSC Act.

The ecological requirements of marsh club-rush, (*Bolboschoenus fluviatilis*) are mostly unknown. However a closely related species, *Bolboschoenus medianus,* on the Murray River requires regular flooding (80–215 days a year) to a depth of less than 60 centimetres (Roberts

Photo 5 Marsh club-rush and river cooba (Photo: Daryl Albertson).

& Marston 2000). Grazing appears to create openings for other mainly native species in marsh club-rush communities (P. Berney pers comm 2009). While this increases local species diversity, it can threaten the survival of the marsh club-rush ecological community.

2.2.2 Floodplain wetland vegetation

Lignum, river cooba, and coolibah are widespread in Gwydir Wetlands. Lignum and river cooba are present on the inner floodplain, on the margins of semi-permanent wetland. Coolibah occurs on the inner floodplain, in association with lignum, river cooba and river red gum, and extends to the outer floodplain where it coexists with black box.

Table 3 shows the changes in extent between 1996 and 2008 for all the floodplain wetland communities in the Gingham and Lower Gwydir floodplains, which amount to a decline in area of 37%.

Less information on the historical extent of vegetation communities is available for the Mehi, Mallowa and Moomin floodplains, although the remaining native vegetation on the floodplain is a small fraction of its original extent. Table 4 shows the changes in floodplain wetland vegetation in this area from 2005–2008.

Table 3 Change in extent of floodplain wetland vegetation, Gingham Watercourse and Lower Gwydir floodplains, 1996–2008 (Bowen & Simpson 2010).

Location	Vegetation community	Area (ha)		
		1996	2005	2008
Inner floodplain	River cooba swamp–lignum shrubland	5,527	3,628	3,207
	Coolibah–river red gum	3,653	3,543	3,512
	Total (inner floodplain)	**9,180**	**7,171**	**6,719**
Outer floodplain	Coolibah open woodland*	119,108	55,623	51,652
	Coolibah–black box woodland	18,742	19,952	19,578
	Total (outer floodplain)	**137,850**	**75,575**	**71,230**
Total		**147,030**	**82,746**	**77,949**

* Includes coolibah/river cooba–lignum (not mapped in 1996).

Table 4 Change in extent of floodplain wetland vegetation, Mehi, Mallow and Moomin floodplains, 1996–2008 (Bowen & Simpson 2010).

Location	Vegetation community	Area (ha)	
		2005	2008
Inner floodplain	River cooba–lignum association	456	393
	Coolibah–river cooba–lignum association	not mapped	1,616
	Coolibah–river red gum association	2,457	4,411
	Total (inner floodplain)	**2,913**	**6,420**
Outer floodplain	Coolibah open woodlands	24,893	19,956
Total		**27,306**	**26,376**

Lignum shrubland and river cooba

Lignum and river cooba provide valuable waterbird breeding habitat, especially for colonially nesting species. Lignum occurs throughout Gwydir Wetlands as an understorey plant but forms shrubland in only a few areas on Gingham Watercourse and Mallowa Creek. Lignum is considered to be vulnerable (Benson 2006). Little is known about the ecology of river cooba.

Lignum occurs in areas flooded at frequencies of once in 2–10 years for durations of 3–12 months. It responds rapidly to flooding by producing an abundance of shoots, leaves, flowers and seeds. Seeds ripen quickly, disperse on floodwaters and germinate under moist soil conditions. To maximise seed germination, seeds settle in moist, but not flooded, soil within approximately eight weeks of flower development (Chong & Walker 2005).

River cooba and lignum covered an area of 42,000 hectares in the Gingham Watercourse in 1985. By 1993, it was reported that little of this vegetation remained healthy (McCosker & Duggin 1993, Bowen & Simpson 2010). In 1996, 5,527 hectares were mapped in the Gingham and Lower Gwydir floodplains. By 2008, the area that remained in the two systems was 3,207 hectares, most of which is now infested with lippia. Less than 10% of the river cooba and lignum shrubland that grew in the Gingham and Lower Gwydir floodplains in the 1970s remains (Bowen & Simpson 2010).

Coolibah and black box woodlands

Coolibah is found along a gradient of decreasing flood frequency and duration, between the margins of semi-permanent wetlands and black box woodlands on the outer floodplain. Woodland communities with coolibah as a dominant species are a component of 'Coolibah–Black Box Woodland of the northern riverine plains in the Darling Riverine Plains and Brigalow Belt South bioregions', which is listed as an EEC under the TSC Act (Department of Environment, Climate Change and Water 2009). The determination of the NSW Scientific Committee states:

> Coolibah–Black Box Woodland of the northern riverine plains in the Darling Riverine Plains and Brigalow Belt South bioregions is usually formed as a woodland or open woodland with a grassy ground layer. *Eucalyptus coolabah* (Coolibah) is typically the most common tree in this community, and it may occur with or without *Acacia stenophylla* (River Cooba), *Acacia salicina* (Cooba), *Casuarina cristata* (Belah), *Eremophila bignoniiflora* (Eurah), *Eucalyptus largiflorens* (Black Box), and *Eucalyptus populnea* subsp. *bimbil* (Bimble Box).
>
> Department of Environment, Climate Change and Water 2009

Photo 6 Coolibah woodland on 'Old Dromana' in March 2008 (Photo: Sharon Bowen).

There are some vegetation communities in the Gwydir Wetlands that are listed in the NSW VCA and included under the above definition. These communities are coolibah woodlands (NSW VCA ID 40), black box woodlands (NSW VCA ID 37) and coolibah–river cooba–lignum woodlands (NSW VCA ID 39) (Benson 2006, Bowen & Simpson 2010).These communities have previously been included in various coolibah open woodland communities in earlier mapping of the Gwydir floodplain (McCosker et al 1993, McCosker 2007, Cox et al 2001).

Vegetation mapping recorded 150,000 hectares of coolibah open woodlands on the Gingham Watercourse floodplain in 1985 (McCosker et al 1993). They occur on fertile soils and have been cleared extensively for agricultural development, including irrigation and dryland cropping (McCosker 2007). In 1996, coolibah open woodlands were the most extensive vegetation communities on the Gwydir River floodplain but in the NSW northern wheat belt between 1985 and 2000, such woodlands were one of the most heavily cleared vegetation types (Cox et al 2001).

Coolibah open woodlands covered about 120,000 hectares on the Gingham and Lower Gwydir watercourses in 1996, decreasing to 52,000 hectares in 2008. Most of this reduction in area was caused by clearing (Bowen & Simpson 2010). All remaining coolibah woodland communities have high conservation value in the Gwydir valley.

Coolibah–black box woodlands are at the eastern extremity of their distribution on the Gwydir floodplain. In 2008, about 19,500 hectares of coolibah–black box woodland were mapped on the Gingham and Lower Gwydir floodplains (Bowen & Simpson 2010). On the western parts of these floodplains, grassy coolibah woodlands are present in a fragmented network of remnants and strips along travelling stock routes and road reserves. On the eastern floodplain, coolibah woodlands remain in larger remnants and merge with coolibah–river cooba–lignum and coolibah–river red gum communities along watercourses and more frequently inundated areas (Bowen & Simpson 2010). Lippia has invaded extensive areas of coolibah open woodlands along the Gingham and Lower Gwydir watercourses (McCosker 2007).

Knowledge of the ecological requirements of coolibah is limited. It is likely that coolibah requires wet soils or shallow flooding for regeneration (Roberts and Marston 2000) but it will die if inundated for too long. It is recommended that inundation of coolibah woodland lasts no longer than 6–8 months.

Coolibah–river red gum woodland and river red gum forest

These communities are relatively recent. It is thought that they established in the 1950s in response to the stabilisation of the Gwydir Raft (McCosker & Duggin 1993). Their condition is poor, as they are infested heavily by exotic species. African boxthorn forms impenetrable thickets in many areas. Ground cover is dominated by introduced species including lippia, prickly pear, and cobblers pegs. Noogoora burr grows in abundance after summer floods (McCosker 2007).

2.3 Species and communities of special significance

This category includes threatened species, EECs and species of conservation concern, including the aquatic ecological community, silver perch, reptiles, frogs, woodland birds and myall woodland.

Industry & Investment NSW (Fisheries) is developing priority action statements to recover threatened fish species, populations and communities.

2.3.1 The aquatic ecological community

The aquatic ecological community of the Gwydir Wetlands, which is part of the natural drainage system of the lowland catchment of the Darling River, is listed under the NSW FM Act as an EEC (NSW Government 2005). This community includes all the area's native fish and aquatic invertebrates as well as the natural rivers, creeks, lagoons, billabongs, wetlands, lakes, tributaries and anabranches in which they live.

Photo 7 Watermilfoil (a native aquatic plant) in the Gingham Channel (Photo: Tracy Fulford).

The key threatening processes listed under the FM Act that may affect the Gwydir Wetlands aquatic ecological community are:

- the installation and operation of in-stream structures and other mechanisms that alter natural flow regimes of rivers and streams
- the removal of large woody debris
- the degradation of native riparian vegetation
- the introduction of fish to fresh waters within a river catchment outside their natural range.

2.3.2 Fish

During surveys conducted in 2007 and 2008, 11 species of native fish and three species of introduced fish were recorded in Gwydir Wetlands. The most common native species were Australian smelt, bony bream and Murray Darling rainbowfish, which are all small-bodied fish. The introduced species, carp, gambusia and goldfish, made up less than 10% of the total numbers of fish captured during these surveys (Spencer et al 2010).

Severe declines in some native species such as Murray cod, golden perch and eel-tailed catfish have been reported anecdotally since the 1970s, coinciding with river regulation and the invasion of carp (Copeland et al 2003, Siebentritt 1999). River regulation changes the flow conditions on which many native fish depend and, with other changes to the condition of the river, contributes to the degradation of native fish habitat. Changed flow patterns and degraded riparian zones increase bank erosion, turbidity and sedimentation in channels, filling pools and smothering habitats that include macrophytes, woody debris and gravel substrates (Murray–Darling Basin Commission 2003). Constant low flows reduce ecosystem productivity by removing the wetting and drying cues that trigger and sustain aquatic cycles (Poff et al 1997, Ward 1998). Other threats to native fish include increased contaminant runoff, removal of logs and debris from streams, competition with introduced species, and structures in the river that act as barriers to movement (Murray–Darling Basin Commission 2003, Spencer 2010).

Native fish often move long distances in the river to feed and spawn, and many depend on access to the floodplains. Levee banks, weirs and channelisation reduce connectivity between river channels and floodplain wetlands (Spencer 2010, Kelleway et al 2010). In the Gwydir Wetlands, significant barriers to fish movement include weirs, rock weirs, regulators and road crossings (Siebentritt 1999).

Larval and juvenile fish are directly extracted from the river when water is pumped for irrigation and town water supply. Collaborative research on this problem is being undertaken between Industry & Investment NSW, the Australian Cotton Cooperative Research Centre (CRC) and Murrumbidgee Irrigation (Department of Primary Industries 2005).

Releases of cold, poor-quality water from the bottom of Copeton Dam potentially affect aquatic habitat and native fish populations adversely for up to several hundred kilometres downstream (Lugg 1999) but ecological impacts have yet to be quantified (Preece 2004). Habitat degradation and control of introduced fish, especially carp, must be undertaken across whole river systems.

All native fish species in the Gwydir Wetlands and lower Gwydir River typically recruit during spring and early summer. Appropriate flows are needed for spawning, so eggs can be protected and larval and juvenile fish can survive. For most species, warmer temperatures are important during this period. Flow conditions must be suitable while fish larvae are growing and the summer irrigation flows that follow must not wash the larvae and their prey from nursery habitats (Humphries et al 2002). Late-winter and spring floods enable adult fish to feed and grow before they spawn (Humphries et al 2002) and floodplain habitats to develop a rich supply of food for larval and juvenile fish (Gehrke et al 1995).

Several species recorded in the Gwydir catchment are listed as threatened under the FM Act, including silver perch, olive perchlet, purple-spotted gudgeon, river snail and the Murray–Darling Basin population of eel tail catfish (Morris et al 2001). The Murray cod is listed as vulnerable under the EPBC Act. Of these species, only Murray cod has been collected in Gwydir Wetlands during recent sampling programs, in small numbers (Spencer et al 2010, Wilson et al 2009).

2.3.3 Reptiles

Information on reptiles in Gwydir Wetlands is limited (Torrible et al 2008). Caddy (2005) stated there were 20 reptile species on the Gingham floodplain, although no species names or references were presented. At least three turtle species (*Chelodina longicolis*, *C. expansa*, *Emydura macquarii*) are likely to occur in ephemeral and permanent pools and lagoons (Wilson and Swan 2003). However, no information on flow responses or flooding requirements that enable these species to thrive is available from this catchment (Wilson et al 2009).

The red-bellied black snake is not a threatened species, but it could be a useful indicator of the health of the wetlands. Keyte (1994) reported a decline in black snake numbers in the Lower Gwydir Wetlands, but the reasons are unknown. However, frogs are its main food (Cogger 1996), and changes in frog populations might be a factor.

2.3.4 Frogs

Frogs, including their tadpole stages, are periodically very abundant and play an important role in the food web of Gwydir Wetlands. The inspection of regurgitated food under egret nests showed that tadpoles and frogs are a major food source for egret nestlings (McCosker 1999b).

Wilson et al (2009) reviewed reports by McCosker (1999b, 2001) and Courtney (1997) on frog surveys in the Gwydir Wetlands during floods from 1995–96 to 2000–01. These surveys used frog calls to identify species and assess their relative abundance, which allow areas to be rapidly surveyed but do not provide quantitative data on abundance of adults, or any information on the numbers of tadpoles.

Wilson et al (2009) listed 14 species occurring in Gwydir Wetlands, of which the spotted marsh frog was the most abundant.

There is no information about the current status of frog populations or about ways in which flows might be better managed to ensure the survival of frog populations. Information is needed on

Photo 8 Striped burrowing frog (Photo: Neal Foster).

abundance, species distributions and diversity of frog communities, as well as habitat factors that influence populations, such as length of time since the most recent flood, inundation frequency, habitat structure and water quality.

2.3.5 Woodland birds

In south-eastern Australia, many woodland bird species that were once common are now declining. Of 20 woodland bird species whose numbers have declined significantly since the 1980s (Reid 1999), 19 are found in Gwydir Wetlands. Four species, the brown treecreeper, diamond firetail, hooded robin and grey-crowned babbler, are listed as vulnerable under the TSC Act.

According to research undertaken in the NSW central Murray catchment, woodland bird abundance and species richness were highest in woodlands that extended for more than 100 hectares and were less than a kilometre from other patches of woodland that had good canopy cover and tree health, and many different shrubs, ground covers, leaf litter and logs (Oliver & Parker 2006). The researchers also found that when they compared river red gum woodlands and forests with woodlands and forests of white cypress pine, black box, yellow box, grey box, buloke and myall (boree), the river red gum woodlands and forests had the highest total bird abundance and species richness.

The main reasons that woodland bird species decline are loss of habitat, fragmentation of woodland vegetation, and simplification or degradation of the remaining woodland vegetation (Reid 1999). In south-eastern Australia, large intact woodlands that contain native shrubs and groundcover plants are now extremely rare, especially on fertile soils. In Gwydir Wetlands, woodlands on fertile soils are still important habitat for woodland birds.

2.3.6 Myall woodland

Myall or weeping myall woodland is listed as an EEC under both the TSC Act and the EPBC Act (DECCW 2009, DEWHA 2009b). In NSW, only 14% of its original area remains (Benson 2006). Little is known about its ecological requirements. It occurs on the outer floodplain or higher ground in the wetlands. Recent surveys show that in 2008, 8,289 hectares of weeping myall woodland remained in the Gingham and Lower Gwydir watercourses, and 4,671 hectares in the Mehi–Mallowa–Moomin systems (Bowen & Simpson 2010).

2.4 Location and condition of assets in Gwydir Wetlands

This section provides more detail on the location and condition of the assets and values identified in the previous sections, and discusses some water management issues affecting them.

2.4.1 Gingham Watercourse (north)

Gingham Watercourse begins at the Gwydir Raft/Tyreel, seven kilometres west of Moree. It contains areas of semi-permanent and floodplain wetland in varying condition on the properties ‘Bunnor’, ‘Westholme’, ‘Lynworth’, ‘Yarrol’, ‘Munwonga’, ‘Baroona’, ‘Jacksons’, ‘Boyanga’, ‘Talmoi’, ‘Tillaloo’, ‘Glen Idol’, ‘Te Mona’, ‘Wayholm’, ‘Old Dromana’ (Gingham section), ‘Glendarra’, ‘Curragundi’, ‘Molladree’, ‘Townsberry’, and other properties east of ‘Te Mona’. It also contains the small components of the Ramsar site on ‘Goddard’s Lease’, ‘Crinolyn’ and ‘Windella’, which support some semi-permanent wetland vegetation.

Photo 9 Gingham Watercourse (centre) (Photo: Simon Hunter).

The Gingham system supports river red gum forest and woodland, coolibah woodland, water couch grassland, lignum shrubland, river cooba, cumbungi, spike rush meadows and native floodplain grasslands. It contains relatively deep and protected open water lagoons, including Gingham Waterhole, Pear Paddock Lagoon and Boyanga Waterhole. It provides habitat for critically important breeding colony sites and feeding habitat for colonially nesting waterbirds, and supports many other waterbird species. Colonies of egret, heron, cormorant, spoonbill, ibis and darter are among the largest ever recorded in Australia. On 'Tillaloo' in 1998, McCosker and Johnson counted 800 glossy ibis nests in river cooba. The Gingham system provides habitat for the threatened species brolga, magpie goose, Australian painted snipe, Australasian bittern, blue-billed duck and black-necked stork, and species listed under JAMBA, CAMBA and ROKAMBA.

Photo 10 Gingham Waterhole (Photo: Neal Foster).

River red gum woodlands in the area of the Gwydir Raft are in fair to poor condition, and extensively colonised by weeds. Coolibah woodlands, and water couch and marsh club-rush communities throughout the system, are declining in condition and area. The river cooba–lignum community is an important habitat for many species, especially nesting waterbirds. Lignum occurs in many areas of Gingham Watercourse as an understorey plant and as shrublands in some areas. Lignum shrubland on 'Lynworth' and 'Yarrol', the site of the main colonially nesting waterbird breeding colony in Gwydir Wetlands, is critical nesting habitat for straw-necked ibis.

McCosker and Duggin (1993) used aerial photographs from 1958, 1967 and 1985 to determine the distribution of wetland and floodplain vegetation on Gingham Watercourse. They recorded 42,000 hectares of river cooba–lignum shrubland, 13,500 hectares of semi-permanent wetland vegetation (water couch, spike rush, tussock rush and common reed) and 150,000 hectares of coolibah open woodland.

Photo 11 Gingham Watercourse near Ramsar site on 'Crinolyn' (Photo: Neal Foster).

By 1993, none of the 42,000 hectares of river cooba–lignum community were in good condition. Lignum shrubs were reduced to clumps and river cooba showed signs of extreme stress. Of the 13,500 hectares of semi-permanent wetland communities on Gingham Watercourse, 1,000 hectares were in a healthy condition, 7,000 hectares were weed infested and of low vigour and the remaining 5,500 hectares were extensively infested with terrestrial weeds (McCosker & Duggin 1993). Recent surveys show that 3,753 hectares of semi-permanent wetland and 2,190 hectares of river cooba–lignum remained on Gingham Watercourse in 2008 (Bowen & Simpson 2010).

Photo 12 Gingham Watercourse and wheat crops (Photo: Neal Foster).

The declining area and condition of wetland vegetation is the most significant ecological issue for Gingham Watercourse (McCosker & Duggin 1993, Keyte 1994, Bowen & Simpson 2010). Much of the vegetation is infested with lippia, and water hyacinth could cause major problems in the channels and waterholes if it is not adequately controlled.

2.4.2 Lower Gwydir Watercourse (central)

The Lower Gwydir Watercourse extends from the Gwydir Raft through a number of remnant semi-permanent wetland areas and waterholes. Before the 1970s, most floodwaters and flows terminated in the intermittent and semi-permanent wetlands of the Lower Gwydir Watercourse (also known as the Big Leather Watercourse) and large floods inundated wetlands, woodlands and grasslands to the west (Keyte 1994). Some of the water that historically reached the wetlands of the Lower Gwydir Watercourse is now diverted into the Lower Gwydir Channel (South Arm) for irrigation, stock and domestic use (McCosker 2001).

The Lower Gwydir Watercourse supports river red gum woodland, river cooba, water couch marsh, marsh club-rush and common reed. It contains open-water lagoons and provides important feeding habitat for colonially nesting species, especially ibis and spoonbill. Under suitable conditions it supports threatened species including brolga, magpie goose, Australian painted snipe, Australasian bittern, blue-billed duck and black-necked stork, as well as species that are listed under JAMBA, CAMBA and ROKAMBA. The Lower Gwydir Watercourse contains the 'Big Leather' section of the Gwydir Wetlands Ramsar site on the property 'Old Dromana'.

Photo 13 Ramsar site at 'Old Dromana', Lower Gwydir Watercourse (Photo: Simon Hunter).

Photo 14 Marsh club-rush on 'Old Dromana' (Photo: Daryl Albertson).

Photo 15 Wandoona (Troy) Waterhole surrounded by coolibah trees and with emerging tall spike rush (Photo: Tracy Fulford).

Wandoona (Troy) Waterhole is the most westerly standing water body that receives natural flows. The properties 'Wandoona' and 'Old Dromana' are declared wildlife refuges under the *National Parks and Wildlife Act 1974* (Keyte 1994).

Areas of semi-permanent wetland vegetation remain on 'Old Dromana' (both inside and outside the Ramsar site) and on 'Belmont', 'Wandoona', and 'Gallimbarray' (formerly 'Retreat'). These properties also contain some small remnants of floodplain wetland and dryland vegetation communities including coolibah open woodland, weeping myall open woodland, belah and native grasslands.

Wandoona (Troy) Waterhole has been identified as one of the last lagoons in the Lower Gwydir Watercourse to dry out during extended periods of no inflow. It therefore provides a valuable refuge for waterbirds and other wetland-dependent animals. Birds observed include brolga, intermediate egret, Australian pelican, straw-necked ibis and plumed whistling duck, while 35 pairs of magpie geese were observed nesting in February 2000.

2.4.3 Mehi, Mallowa and Moomin system (south)

The southern parts of Gwydir Wetlands include the Mehi River corridor and floodplain south of Gwydir Highway and the floodplains of Mallowa and Moomin creeks. Mallowa Creek is a distributary stream of Mehi River. It begins approximately 50 kilometres downstream of Moree and flows through alluvial plains for approximately 40 kilometres until it joins Moomin Creek.

The Mehi–Mallowa–Moomin floodplain supports coolibah–river red gum woodland as a riverine corridor, coolibah woodland, river cooba and lignum shrubland, and associations of these species. Small areas of water couch are found in frequently flooded areas in these communities (Bowen & Simpson 2010). The floodplain supports threatened species including brolga, magpie goose, Australian painted snipe, Australasian bittern and blue-billed duck as well as species that are listed under JAMBA, CAMBA and ROKAMBA.

The flows of this system have been changed, especially since the widening and leveeing of the Mehi River, and construction of Copeton Dam and the Gundare and Mallowa Creek regulators. These regulators and their operation now cause most water to go down Mehi River and reduce flows to the Mallowa system (Wyllie 2009).

Mallowa Creek

River regulation and development have affected the natural flow regime in Mallowa Creek and its catchment. This has decreased the frequency and volume of overland flows running into Mallowa Creek and the Cookabunna Watercourse from Mehi River. Distribution of flows is now concentrated in the north, and flooding of the lower Mallowa Creek is less frequent and reduced in extent. A flow to land holders for domestic and stock use along the length of Mallowa Creek is controlled by the Mallowa Regulator at Gundare (Wyllie 2009).

The Mallowa floodplain historically supported coolibah woodland, floodplain wetlands dominated by river cooba and lignum, and wet meadows dominated by spike rush and water couch. River red gum woodland and river cooba–lignum shrubland occur along the banks of Mallowa Creek on the eastern side of the Mallowa floodplain (Torrible et al 2009). Remnant coolibah–river cooba–lignum communities on the properties ‘Derra’ and ‘Valletta’ in the eastern Mallowa system and ‘Baroona’ and ‘Currotha’ in the west are important habitats. ‘Valletta’ has frontage to Mehi River and Mallowa Creek, and is the largest area of wetland and

Photo 16 View east across Mehi River (Photo: Simon Hunter).

woodland in the Mehi–Mallowa–Moomin system. 'Baroona', 'Currotha', 'Burragillo' and 'Box Ridge' support the largest remaining areas of lignum and native grasslands in this system. The lower parts of this system are generally in poor condition.

Since river regulation, much of the water that has sustained this system has come from flows from streams from the south-east such as Tycannah Creek.

Mehi River

This system is extensively modified with only a very narrow riverine corridor of coolibah–river red gum. However, this corridor is generally in good condition.

Whittakers Lagoon is an isolated wetland on the Mehi River floodplain, located 18 kilometres west of Moree on a travelling stock route adjacent to the Gwydir Highway. DECCW has identified the lagoon as a priority for restoration, due to its value as a refuge and breeding site for waterbirds, and for its Aboriginal cultural values.

Moomin Creek

This is a highly cultivated system with only a very narrow strip of riparian vegetation along the creek. This area supports coolibah woodland, lignum, river cooba and water couch (Bowen & Simpson 2010). Although much of the remaining native vegetation is in poor condition, it has landscape value as a corridor.

The wetlands in the Mehi–Mallowa–Moomin systems are degraded from lack of suitable flows and clearing, although the upper parts of all these systems are still in reasonable condition.

Photo 17 Intermediate egret at Whittakers Lagoon, Mehi River (Photo: Daryl Albertson).

Photo 18 View east at the junction of Mallowa and Moomin Creeks (centre) (Photo: Simon Hunter).

2.5 Ecological outcomes

The desired ecological outcomes from managing Gwydir Wetlands are restoration and maintenance of critical ecological processes and functions, especially habitats. If these outcomes are to be achieved, the assets identified in this section of the AEMP will need to be restored where possible and subsequently maintained to the greatest possible extent to support a diversity of species, habitat types and ecosystems.

The general water requirements of the ecological components that contribute to the character and values of the wetlands are known. For a given area it is possible to give a reasonable assessment of the volume of water needed to maintain wetland functions and processes that support the assets identified in this AEMP. It is also possible to assess the area and location of wetland that can be maintained with an available volume of water. Water availability and its implications for the wetlands are discussed in section 3.

3 Water management

3.1 Flow regime and flooding in the Lower Gwydir Valley

Flows to Gwydir Wetlands are linked to rainfall and runoff in the upper catchment. Major flooding most commonly occurs during January and February, although the size and frequency of these floods is highly variable. Winter floods also occur but tend to be smaller than those in summer. Between flooding, the core wetlands are replenished by small flows generated from localised rain in the catchments of tributaries downstream of Copeton Dam (Keyte 1994).

Pallamallawa lies downstream of the major tributaries of Gwydir River and above the off-take of the first major distributary, Mehi River. It is the gauging point at which the highest flows in Gwydir River are recorded (CSIRO 2007). The channel capacity here is greater than the combined capacity of the four major streams forming the distributary system – Gwydir River, Mehi River, Moomin Creek and Carole Creek. Thus even small rises at Pallamallawa cause overbank flow downstream (Pietsch 2006).

The distribution of flows in the wetlands depends on the magnitude of river flows, but is strongly influenced by how much water is stored in the soil from previous flooding and local rainfall, described as 'antecedent conditions' (Johnson 2005). Prolonged, severe drought depletes stores of water in soil, which means that larger flows are then required to inundate the wetlands.

With the exception of isolated pockets of high ground associated with sand dunes and remnant palaeochannels, the whole of the lower Gwydir floodplain is prone to flooding, which may last for weeks or months during large floods. However, most floods spill along a particular floodway rather than inundating the entire plain (Pietsch 2006).

The flow regime of Gwydir River has been substantially altered since the construction of Copeton Dam and the weirs and regulators that allow water to be diverted into the Mehi/Moomin system and Carole Creek to supply irrigators along those streams. Regulation of the river system has caused significant reduction in moderate to high flows in the lower Gwydir. It has also contributed to an increase in the average period between large flows, and a reduction in the average volume of large flows (CSIRO 2007).

3.2 Inundation mapping

The gauge at Yarraman Bridge measures inflow to the wetlands of the Gingham and Lower Gwydir watercourses. Flooding in these wetlands starts to occur when river flows at Yarraman are between 5,000 and 10,000 megalitres per day, depending on the amount of extraction between the gauge and the wetlands and the antecedent conditions in the channels and wetlands. Flows smaller than 5,000 megalitres per day may wet low lying areas adjacent to the channels (Powell et al 2008).

There is no simple relationship between river flows at Yarraman and flooding patterns in the downstream wetlands. Two flows of the same magnitude may inundate different areas, and seasonal inundation patterns are irregular. Therefore, to gain an understanding of flooding patterns and ecological responses, inundation needs to be measured directly, and monitored over a long period.

Thomas et al (in press) studied inundation extent and frequency in Gwydir Wetlands from 1988 when the first Landsat imagery was available to 2009. The methodology investigated both the presence of surface water and the response of vegetation to watering, as measuring surface water alone underestimates the extent of flooding.

Maps of the extent of inundation were prepared for 32 floods using 56 Landsat Thematic Mapper images from 1988–2009. Mapping is affected by cloud cover, so not all floods were mapped, including the flood in 1998. Mapping demonstrated that maximum flood extent was closely related to the total inflow volume and the duration of inflow to the Gingham–Lower Gwydir system (Thomas et al in press).

Inundation frequency strongly influences the distribution of vegetation communities of dryland river floodplains. Potential wetland areas and flow paths were identified using an inundation frequency index. The index measures the relative probability of flooding and was calculated by dividing the number of times a location was inundated by the total number of inundation maps. An average recurrence interval (ARI) (i.e. the average number of years between floods) was calculated for each zone of inundation probability (Thomas et al in press) (Figure 8).

Figure 8 indicates distinct differences in flooding frequency across the floodplain. It clearly delineates core wetland areas, as well as off-river storages. In the Lower Gwydir–Gingham region, inundation zones with a relatively high likelihood of flooding, depicted in blue on the map, resulted from small, high-frequency flows (ARI equal to or less than 0.5). These flows inundated relatively small areas (about 9,000 hectares) with at least 20% of those areas representing off-river storages which also appear as dark blue shapes on the map. The core

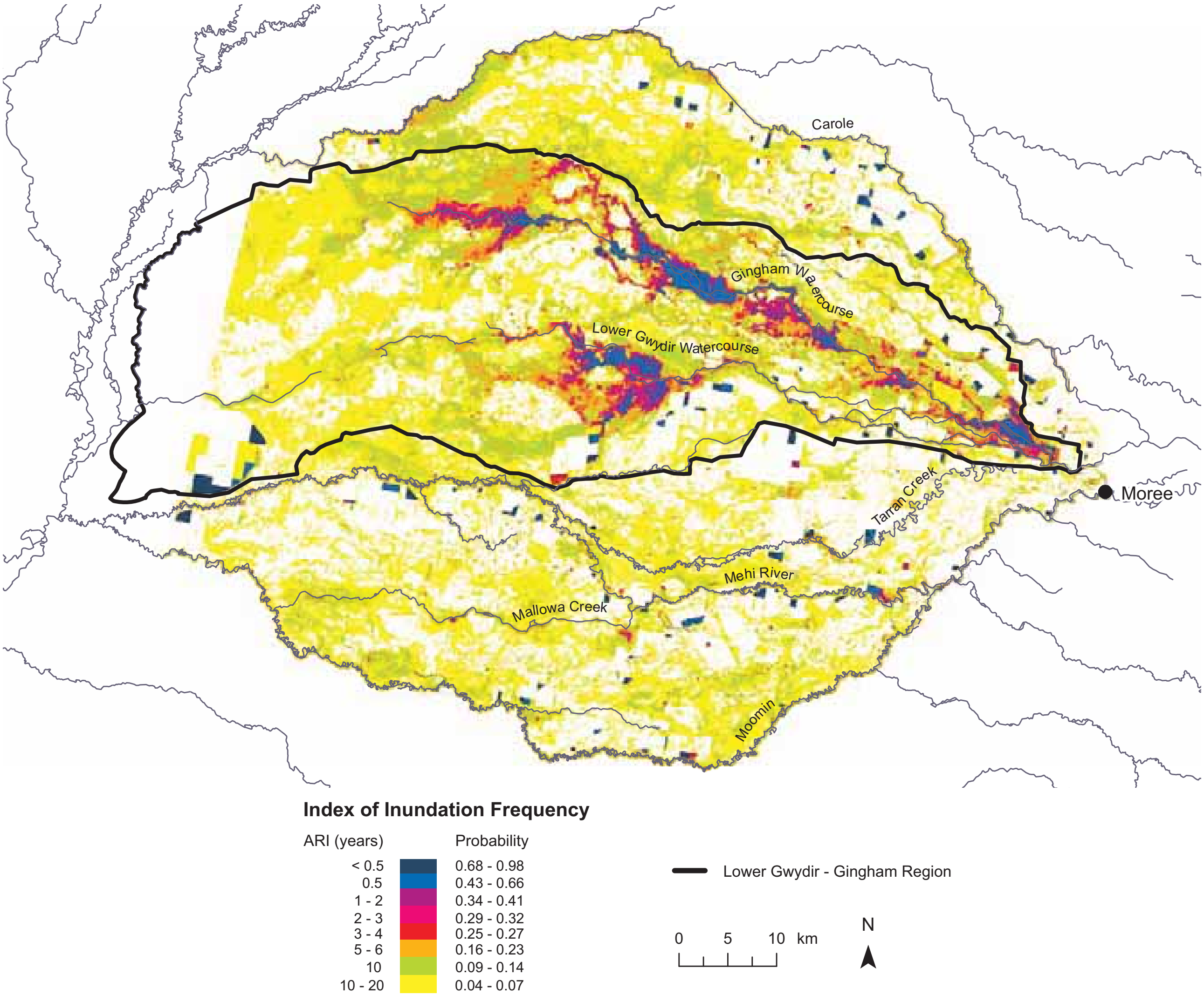


Figure 8 Inundation frequency map for the Gwydir floodplain below Moree.

wetland areas of the Lower Gwydir–Gingham region were inundated by larger, moderate-frequency flows (ARI of 1–4 years). These areas (coloured red, pink or purple on the map) either sustain or have previously sustained semi-permanent wetland vegetation, including marsh club-rush, water couch–spike rush grasslands, cumbungi and common reed; some floodplain wetland vegetation such as river cooba, lignum and river red gum; and some coolibah woodland.

The zones that have the lowest probability of inundation (coloured yellow, green or orange on the map), mainly due to their higher elevation (Keyte 1994), are flooded by large flows that occur infrequently (ARI of 5–6 or 10–20 years) but inundate large areas of the Lower Gwydir–Gingham floodplain (between 40,000 and 150,000 hectares). These zones comprise coolibah and coolibah–black box woodlands, native grasslands, myall–rosewood woodlands and cultivated land.

Areas that are located on ridges or behind large levee banks were not inundated even by relatively large flows. These areas are shown as white on the map.

3.3 Water sharing

The potential for irrigation development in the Gwydir Valley was recognised in the 1930s. In 1936, several dam sites were identified, but it was not until 1976 that Copeton Dam was completed. With a storage capacity of 1,364,000 megalitres, Copeton Dam is one of the largest dams in NSW (Jeffcoat 1996).

With the construction of diversionary weirs and other regulatory works downstream, the annual usable regulated flow was estimated at 345,000 megalitres, considered sufficient to supply some 50,000 hectares of irrigation after providing for stock and domestic use and transmission losses (Pigram 2007).

By 1979, irrigation licences had been issued for an area of 86,000 hectares, and the Water Resources Commission (WRC) placed an embargo on applications for irrigation licences on streams served by Copeton Dam (Keyte 1994). In 1981, the WRC introduced a volumetric water allocation scheme (Water Resources Commission nd) which converted area-based water allocation to a specified volume for each licence.

The Gwydir WSP provides the framework for sharing the available water in the regulated rivers of the Gwydir catchment. It estimates the essential annual water requirements as:

- 4,245 megalitres for domestic and stock access licences
- 3,836 megalitres for local water utility access licences.

For other access licences, the remaining available water is allocated in proportion to the number of shares held under each licence, in the following order of priority:

- 19,293 unit shares for regulated river (high security) access licences
- 509,500 unit shares for regulated river (general security) access licences
- 178,000 unit shares for regulated river (supplementary water) access licences (NSW Government 2003).

The Gwydir WSP also establishes an environmental contingency allowance (ECA) to be held in Copeton Dam. The ECA account is credited with up to 45,000 megalitres a year (in proportion to general security available water determinations), but may accumulate up to 90,000 megalitres by carrying over unused allocations from one water year to the next. All the accumulated allocations may be used in one year (Department of Infrastructure, Planning and Natural Resources 2004).

Environmental water rules in the Gwydir WSP also protect a specified proportion of natural inflows to the Gingham and Lower Gwydir wetlands (Department of Infrastructure, Planning and Natural Resources 2004). These rules require:

- flows into the wetlands (i.e. past Yarraman Bridge) to be at least equal to the sum of inflows from three unregulated streams – Horton River, Myall Creek and Halls Creek – up to 500 megalitres per day
- 50% of tributary flows above 500 megalitres per day to be protected for the environment.

The environment's share of water has been increased by the purchase of access licences from willing sellers since the commencement of the Gwydir WSP. Both the NSW and Australian governments have purchased water entitlements in the Gwydir Valley.

Water can also be recovered for environmental purposes by water-savings projects. It is estimated that the completion of the Gingham pipeline will secure an additional 958 megalitres of high security entitlement for the environment.

3.4 Water availability

The Gwydir WSP contains rules for the allocation of the available regulated water, which is estimated based on inflows to Copeton Dam. An available water determination (AWD) is made at the start of the water year (1 July) for each licence category. In most years, unless severe drought conditions occur, local water utilities and domestic and stock licences receive an allocation equal to 100% of their entitlement, and high security licences receive 1 megalitre per unit share.

The allocations to general security licences vary from year to year (up to a maximum of 1 megalitre per share) depending on the water held in Copeton Dam. If the initial AWD is less than 1 megalitre per share for any licence category, water availability is reviewed monthly or whenever significant dam inflows occur and an additional AWD is made if warranted (Department of Infrastructure, Planning and Natural Resources 2004).

Gwydir WSP accounting rules allow up to 1.5 megalitres per general security share to be accumulated in a water account. These rules provide some flexibility for both irrigators and environmental water holders to match available water to production or environmental management needs.

Both the ECA and most environmental water licences receive the same proportional allocation as general security licences. Therefore, the AWD, along with any carry over from the previous year, determines the amount of water available for the environment in the form of a secure volume that can be ordered for delivery as required. However, in most years unregulated tributary inflows downstream of Copeton Dam provide the greater volume of flows to the wetlands.

Descriptions of water availability and use are often given as averages. For example, the long-term average annual flow in the Gwydir Regulated River Water Source is 875,400 megalitres a year, and long-term average annual extractions are 388,000 megalitres a year, which means that on a long-term basis approximately 56% of yearly flows in the river are protected to maintain environmental health (NSW Government 2003). However, long-term averages, especially in a highly variable system such as Gwydir River, can be misleading when managing at the shorter time scales relevant to agricultural systems and river and wetland ecosystems.

The variability of Gwydir River is demonstrated by the three indicators of water availability:

1. total system flows, calculated as surface water flow into storages and from tributaries downstream of Copeton Dam
2. extractive use of licensed surface water shares in the regulated river
3. flows to the wetlands at Yarraman gauge (Figure 9).

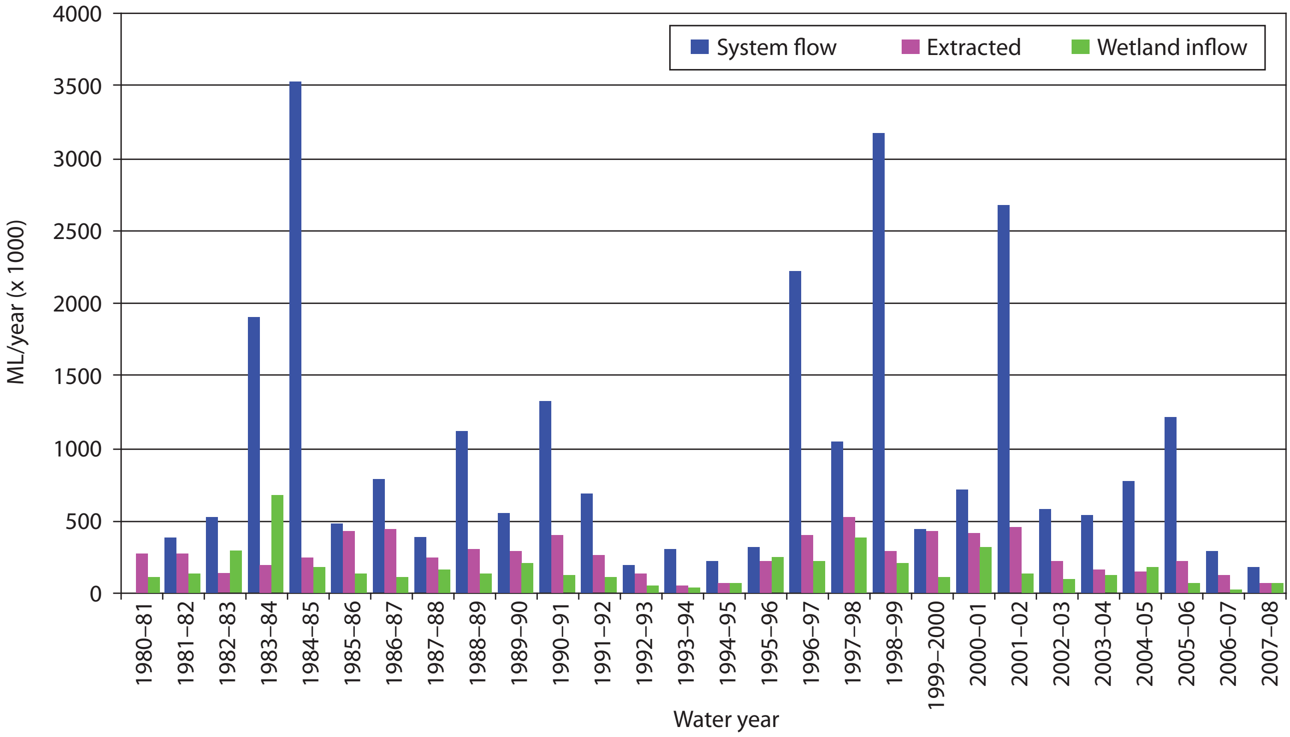


Figure 9 Water flows and use in the Gwydir Valley (data provided by State Water).

Note: Extractive use includes licensed surface water extraction from the regulated river. It does not include extractions from unregulated tributaries, groundwater or other sources. Total system flows are greater than the combined total of extractions and flows to the wetlands because of operational losses and extensive floodplain and distributary system flows during high flows.

A large proportion of total flow occurs in relatively few years, and many years have extremely low flows. Extended periods of low flows highlight the risk of planning based on long-term averages. The wetlands experienced low inflows during the 11 years from 1984–85 to 1994–95. The eight years since 2001 have also been years of low inflows to the wetlands and during both these periods clearing and floodplain development have affected the area and condition of the wetlands.

Another indicator of water availability is the AWD for general security licences, which affects both extractive water users and available environmental water. Figure 10 shows the annual AWD since 1980, with averages calculated for decades as well as for the period from 2001–02 to 2008–09, which spans the recent dry period in terms of water allocations.

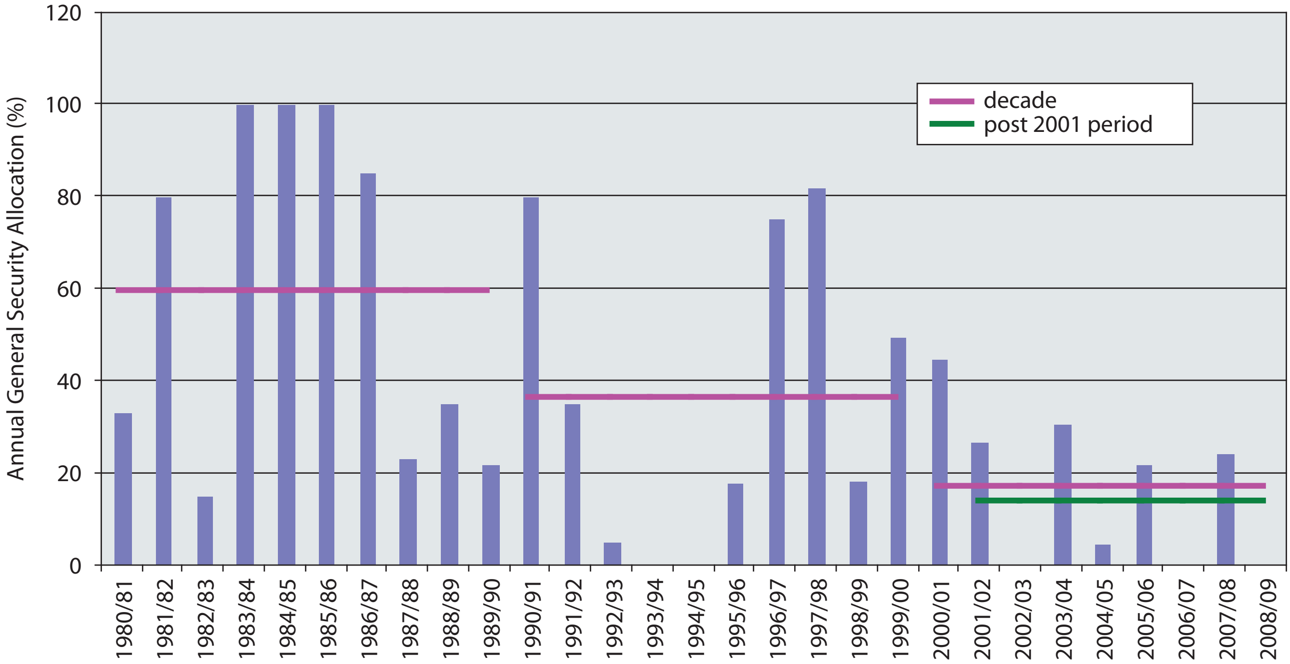


Figure 10 Gwydir Valley general security allocation history.

Note: Horizontal bars indicate the average allocations to general security shares over the past three decades and the period 2001–02 to 2008–09.

3.5 Climate variability, climate change and the Gwydir Valley

Modelling for the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Murray–Darling Basin Sustainable Yields Project indicates that the recent climate (1997–2006) was not statistically different to long-term average values (CSIRO 2007). It also indicates that future runoff in the Gwydir Valley is more likely to decrease than increase. Forecast scenarios for 2030, presented by CSIRO, range from extreme wet to extreme dry, with a mid-range 'best estimate', as follows:

- extreme wet – 34% increase in surface water availability, 20% increase in total diversions, and 33% increase in end-of-system flows
- extreme dry – 29% decrease in surface water availability, 25% decrease in total diversions, and 27% decrease in end-of-system flows
- best estimate – 10% decrease in surface water availability, 8% decrease in total diversions, and 6% decrease in end-of-system flows.

Flows to Gwydir Wetlands have been affected by water resource development, and may be affected further by climate change. Under the best estimate of the 2030 climate, the average annual flooding volume to the wetlands would fall by 20% relative to current conditions, to be less than half the pre-development event volume. This change would be likely to have additional effects on vegetation condition and structure and affect waterbird breeding (CSIRO 2007).

Regional climate change modelling and prediction by DECCW (2010) indicates that wetlands in north-west NSW, including Gwydir Wetlands, are at risk from increased temperatures, increased fire frequency and minor changes in the water regime. The report also notes that if there is less frequent flooding colonial nesting water bird breeding would lessen. Extended hot periods are likely to cause heat stress and death in birds.

3.6 Water requirements of ecological assets

Wetland plants and animals have different tolerances to environmental conditions. For example, each plant species requires a particular range of soil types, climate variables and water regimes. These individual differences, interacting with complex habitat patterns, create the high biodiversity found in wetlands.

A common approach to maintaining the biodiversity of wetland ecosystems is to mimic natural inundation as closely as possible. However, the situation in Gwydir Wetlands is complicated by the presence of two highly invasive exotic weeds: water hyacinth and lippia. Under these circumstances, wetland watering regimes must aim to minimise the impact of these weeds by reducing their growth and reproduction rate, thus giving the native wetland plants as much competitive advantage as possible.

The optimal watering regime will vary for different wetland management objectives. For example, livestock production can be maximised by providing short (10–30 days) annual flooding during late spring or summer (McCosker & Duggin 1993). Where lippia is established, flooding for longer than 30 days, and to a deeper level, may help native species to compete more successfully against this weed.

On the other hand, restoring natural vegetation communities and maintaining them in good condition requires the frequency and duration of flooding to be varied according to the characteristics of key plant species (McCosker & Duggin 1993). While not all species' requirements are known, there is enough information to make informed decisions to guide watering strategies.

Based on the best available information (Bowen & Simpson 2010), environmental watering objectives may be set for two vegetation types:

- **water couch–spike rush** – inundate for at least 6 months of the year, at least 8 years in 10
- **lignum shrubland (associated with river cooba or coolibah)** – inundate for at least 3 months between September and March, at least 5 years in 10.

Marsh club-rush is also known to require frequent watering, but current knowledge is insufficient to set a specific objective. For other vegetation types such as coolabah–-river red gum associations, setting of objectives for environmental water management is less relevant as flooding of these areas cannot be effectively managed with current delivery constraints.

Large-scale waterbird breeding depends on flooding of nesting sites for 4–5 months. Suitable conditions occur irregularly and depend on natural flooding, but the environmental water available at the time (ECA, licensed holdings and tributary inflows) can be used to maintain the desired extent and depth of floodwaters to give the chicks the best chance of survival.

3.7 Providing water to Gwydir Wetlands

Inflows from the unregulated tributaries are essential for maintaining the general health of Gwydir Wetlands. However, the environmental share of regulated water held in Copeton Dam, as ECA and environmental licences, can be used to achieve more specific management objectives, including:

- extending natural flooding to increase the chances of successful waterbird breeding
- maintaining refuges for aquatic organisms during droughts
- providing favourable conditions for native fish breeding and movement.

It is therefore important to make the most effective use of this limited resource.

The volume of water from regulated sources needed to inundate a specific area of the wetlands for a specific purpose depends on many factors, including the area of the wetland to be watered, the time of year, recent rainfall in the wetlands, the volume of unregulated flows, flow history and the desired duration and extent of flooding. The different frequencies of flooding required by different types of wetland vegetation add further complexity to calculations.

Several attempts have been made to calculate the volumes of water needed to maintain identified values, such as an area of semi-permanent wetland vegetation or breeding of colonially nesting waterbirds (Bennett & Green 1993, McCosker & Duggin 1993, McCosker 1994a, Keyte 1994, Rea 1994, Johnson 2001). The estimates varied depending on whether conditions were wet or dry, the season, and the area and duration of flooding.

Bennett and Green (1993) estimated that 100,000 megalitres for one month at Yarraman Bridge was needed to flood 20,000 hectares of semi-permanent wetland, amounting to about 5 megalitres per hectare. However, estimates did not deal with floods of longer duration. McCosker and Duggin (1993) and McCosker (1994a) estimated volumes needed to inundate 13,500 and 42,000 hectares for one to three months, proposing volumes of between 3.7 and 5.1 megalitres per hectare in cool, wet conditions, and 8.4 to 17.4 megalitres per hectare in hot, dry conditions. Keyte (1994) estimated that volumes of between 2 and 8 megalitres per hectare were needed to inundate 3,000 and 8,000 hectares for one month.

Johnson (2001) focussed on the volume of regulated general security water needed to be provided from Copeton Dam to flood 28,000 hectares of semi-permanent wetland, proposing 170,000 megalitres of regulated share, provided at 48% reliability, delivering an average of 81,600 megalitres a year. Assuming that about as much water again will be available from unregulated flows, this volume suggests about 4 megalitres per hectare to maintain 28,000 hectares of identified wetland, or 6 megalitres per hectare if twice as much unregulated flow as regulated flow occurs.

These estimates assume that some values are relatively stable, particularly the area of remaining wetland, and climate, weather and water availability. However, recent years have shown these factors to be highly variable, with direct effects on water requirements at specific times, and on the amount of water available for the environment.

3.8 Scenarios of water availability for the environment

Another way to consider the water needs of wetlands is to find out how much of the wetland can be restored, protected and maintained with a given volume of water. This approach estimates the amount of water required to maintain specific ecological values, calculates the volume of water likely to be available under different scenarios and estimates how many hectares of wetland can be maintained by a certain volume of water.

As at 30 June 2010, the total regulated environmental share available for use in the Gwydir Valley was equivalent to around 150,500 general security unit shares, consisting of 45,000 megalitres of ECA provided in the Gwydir WSP, over 17,000 unit shares of general security entitlement held by the NSW Government and over 88,500 unit shares of general security entitlement held by the Commonwealth Environmental Water Holder (CEWH). This amount did not include the 440 unit shares of NSW-held supplementary access entitlement and 19,000 unit shares of supplementary access entitlement held by the CEWH.

Up-to-date information on NSW's holdings can be found at www.environment.nsw.gov.au/environmentalwater/waterpurchase.htm and the CEWH's holdings at www.environment.gov.au/water/policy-programs/cewh/holdings.html.

Four scenarios of water availability were selected to illustrate ways in which the approach described in the first paragraph of this section could be used (Table 5). The scenarios use AWDs for general security access licences and the environmental water allowance as an indicator of water availability, and are based on findings of the CSIRO Sustainable Yield Project (CSIRO 2007), long-term average conditions, and the history of allocations to general security licences.

The scenarios were chosen to reflect a range of likely water allocations. A scenario of 13.5% allocation is therefore included, as this was average allocation over the recent dry period from 2001–02 to 2008–09 (CSIRO 2007, State Water Corporation 2009).

The scenarios also take account of inflows from unregulated tributaries. A considerable volume of these flows are protected under the Gwydir WSP, so can be expected to reach the wetlands in most years. Table 5 includes three possibilities considered realistic for Gwydir Wetlands:

1. unregulated inflows equal to the volume of regulated environmental flow
2. twice as much unregulated as regulated flow
3. four times as much unregulated as regulated flow.

Table 5 Approximate area of wetland estimated to be supported under various scenarios for water availability, based on 150,500 megalitres of general security share.

Percentage of AWD for general security and the environment	Volume per hectare required (megalitres)	Regulated environmental share (megalitres)	Hectares maintained with equal volume of unregulated flow	Hectares maintained with 2 x volume of unregulated flow	Hectares maintained with 4 x volume of unregulated flow
60	5	90,300	36,100	54,200	90,300
40	7	60,200	17,200	25,800	43,000
20	9	30,100	6,700	10,000	16,700
13.5	10	20,320	4,100	6,100	10,200

3.8.1 Scenario 1: 60% allocation to general security access licences and the environmental allowance

Under the relatively wet conditions represented by this scenario, the current regulated environmental share of 150,500 megalitres will provide about 90,300 megalitres of available regulated water.

Assuming about 5 megalitres per hectare is needed under these conditions, and that unregulated flows contribute equal, double or four times the regulated volume, it is possible that functions and habitats could be maintained in an area of between 36,100 and 90,300 hectares.

3.8.2 Scenario 2: 40% allocation to general security access licences and the environmental allowance

This scenario is close to the modelled historical average AWD for general security licences, under the rules of the Gwydir WSP. Under these conditions the current regulated environmental share of 150,500 megalitres will provide about 60,200 megalitres of available regulated water.

Assuming about 7 megalitres per hectare is needed under these conditions, and that there are contributions from unregulated flows of equal, double or four times this volume, it is possible that functions and habitats could be maintained in an area of between 17,200 and 43,000 hectares.

3.8.3 Scenario 3: 20% allocation to general security access licences and the environmental allowance

Under these conditions, the current regulated environmental share of 150,500 megalitres will provide about 30,100 megalitres of available regulated water.

Assuming about 9 megalitres per hectare is needed under these conditions, and that there are contributions from unregulated flows of equal, double or four times this volume, it is possible that functions and habitats could be maintained in an area of between 6,700 and 16,700 hectares.

3.8.4 Scenario 4: 13.5% allocation to general security access licences and the environmental allowance

Under the conditions prevailing between 2001–02 and 2008–09, with general security allocations averaging 13.5%, the current regulated environmental share of 150,500 megalitres would provide about 20,320 megalitres of environmental water.

Assuming about 10 megalitres per hectare is needed under these conditions, and that there are contributions from unregulated flows of equal, double or four times this volume, it is possible that functions and habitats could be maintained in an area of between 4,100 and 10,200 hectares.

3.9 Implications for managing environmental water

The above scenarios are based on the regulated environmental water share at the time of writing this AEMP. Additional water recovered under existing government initiatives will add to the environmental share and increase the area that can be maintained under each scenario. Greater volumes of unregulated flows would also increase the area of wetland that can be maintained.

The scenarios suggest that the remaining area of semi-permanent wetland in Gwydir Wetlands can be maintained during wetter then average periods with the current share of water for the environment. They also demonstrate the necessity of setting priorities for watering during drier periods.

Environmental watering strategies must attempt to match the duration and frequency of wetland inundation to the ecological requirements of wetland vegetation communities and target fauna. Long flows that are too infrequent and frequent flows that are too short are both ineffective in maintaining wetland vegetation. Available water should not be distributed over too large an area, as this would lead to continuing decline of the wetlands.

More accurate estimates are needed of the volumes required to provide suitable flow regimes in different parts of the wetlands under a range of climatic conditions. Digital elevation and hydrodynamic models being developed will assist environmental flow managers to narrow the range of volumes required for different climate sequences.

Small flows to specific areas of the wetlands can be managed under dry conditions, although for some areas this may require new or modified infrastructure. Determining priorities for wetland areas on both public and private land will involve considering the ecological importance of each area and its importance for the character of Gwydir Wetlands, legislative status, proximity to water supply and ease of delivery, and likelihood of achieving ecological outcomes and objectives.

Land management (e.g. grazing regimes, weed control) in different areas will have a bearing on the ecological benefits achieved by watering and is likely to be an important consideration in developing watering priorities, especially in a drying climate.

Under the scenarios outlined above, floodplain wetland vegetation, except for some areas on the fringes of semi-permanent wetlands, will rarely receive managed flows from allocated shares. In most cases, inundation of these communities will rely on unregulated flows.

3.10 Structures for managing water in Gwydir Wetlands

Structures including banks, weirs, regulators and diversion channels in Gwydir Wetlands are used for flood protection, erosion control and water supply. An important task for government agencies and land holders is to clarify the role, effectiveness and status of the structures in the wetlands and determine their effects on flows.

Three initiatives will contribute to this outcome:

1. the Gingham pipeline and restoration project
2. the licensing of floodplain harvesting activities
3. the development of a valley-wide floodplain management plan for the lower Gwydir valley.

3.11 Measurement of water extraction

The measurement of water extractions, including the reliability of meters, has been a matter of concern since the introduction of volumetric allocations (Minister for Water Resources 1986, Armstead & Johnson 1993). Measurement of all water extractions, including regulated river allocations, groundwater use, unregulated flows, and floodplain harvesting, must be as accurate and reliable as possible. A draft national metering standard framework has been developed, and aims to provide an acceptable level of confidence whereby non-urban metering across Australia has a maximum permissible error limit, in the field, of plus or minus 5%. Each state will develop a metering implementation plan.

The Australian Government has made an in-principle agreement to provide up to $90 million to NSW under its Water for the Future program, subject to due diligence assessment, to replace existing customer-owned meters on regulated rivers. Meters will be owned by State Water and larger meters may be connected by telemetry.

4 Aquatic habitat management and restoration

Possible reasons for the decline in native fish in Gwydir River, as in other highly regulated rivers, include reduced water quality, flow alteration, the introduction of pest species, over-fishing and barriers to movement (Murray–Darling Basin Commission 2003). There is also concern about fish mortality due to downstream passage through weirs and extraction via pumps or other irrigation infrastructure (Department of Primary Industries 2005, 2007). The quality of aquatic habitat is critical for maintaining the diversity of aquatic plants and animals. Refuge pools that rarely dry out enable native fish to survive through dry periods and subsequently recolonise other areas. Aquatic habitat and aquatic ecosystems are often degraded by channelisation, the removal of woody debris to improve the efficiency of water delivery, and degradation of riparian vegetation (Murray–Darling Basin Commission 2003).

4.1 Water quality

Water quality is an important factor in the suitability of aquatic habitat for fish and other aquatic organisms (Spencer et al 2010). The *National Water Quality Management Strategy* (NWQMS) includes policies, a process and guidelines for improving water quality in Australia's waterways. The *Australian and New Zealand guidelines for fresh and marine water quality* (ANZECC & ARMCANZ 2000) are the key water quality guidelines.

The NSW Government has endorsed the community's environmental values for water, known as 'water quality objectives' (WQOs). WQOs were developed for each catchment in NSW in line with the national guidelines. Those for Gwydir River may be found at www.environment.nsw.gov.au/ieo/Gwydir. The WQO for protecting aquatic ecosystems is particularly relevant to this AEMP and should help guide management decisions.

The catchment action plan (CAP) developed by the Border Rivers–Gwydir Catchment Management Authority (BRG CMA) contains six water-related management targets. These aim to maintain or improve water quality in all sub-catchments, reduce streambank erosion in priority locations, improve riparian vegetation in priority locations, maintain or improve native aquatic biodiversity in priority locations, reduce river salinity, and maintain or improve the condition of priority wetlands including Gwydir Wetlands. The management actions that BRG CMA is implementing to achieve these targets will improve water quality and therefore the health of aquatic habitats in Gwydir Wetlands.

The Australian Government's Murray–Darling Basin Plan will include a water quality and salinity management plan that will set water quality and salinity objectives and targets for the basin's water resources. The water quality and salinity management plan will refer to the NWQMS, and targets set in the plan will be reviewed every five years (Murray–Darling Basin Authority 2008).

Monitoring in the Gwydir catchment has revealed a general improvement in water quality (Mawhinney 2005). Between 1991 and 2004, the amount of pesticides found in waterways decreased significantly, which may be attributed to restrictions on their use and best management practices (Mawhinney 2005, Wilson 2009).

Pesticides are still occasionally detected in the Gwydir catchment such as the widely used herbicide, atrazine, although levels are typically well below the national guideline levels (Mawhinney 2005, Wilson 2009). Any high concentrations of pesticides would be addressed through legislation such as the *Pesticides Act 1999* and the *Protection of the Environment Operations Act 1997*.

Wilson et al (2009) found high nutrient and turbidity levels in waterways of Gwydir Wetlands. While flow releases for environmental purposes appeared to reduce nutrient concentrations through dilution, total nutrient and sediment loads increased due to higher discharges. Spencer et al (2010) recommended revegetation of riparian areas and restriction of stock access to waterways as strategies to improve water quality.

Photo 19 Copeton Dam (Photo: Neal Foster).

Water in large dams tends to form layers of different temperatures, with the bottom layer up to 15 degrees Celsius cooler than the surface layer. Cold water pollution affects water quality for town water supplies, damages aquatic communities downstream of the dam and may eliminate native fish populations if temperature thresholds to initiate breeding are not reached. The effects of cold water releases from Copeton Dam have been recorded more than 250 kilometres downstream of the dam (McCosker et al 1999). The NSW Government identified Copeton Dam as one of the dams in NSW likely to cause severe cold water pollution (Preece 2004) and has adopted a strategy to address pollution impacts from large dams over time.

State Water will address the issue of cold water pollution under the terms of the Gwydir Water Supply Work Approval issued by the NSW Office of Water. The work approval requires State Water to 'develop options, including a preferred option, for the mitigation of cold water pollution from Copeton Dam for consideration and approval by the Minister by July 2012'. No specific actions regarding cold water pollution are proposed in this AEMP.

4.2 Impacts of instream structures and extraction on fish

Native fish may travel long distances to find food and complete their life cycles. Structures such as dams, weirs, culverts and river crossings form barriers that prevent fish moving through the river (Murray–Darling Basin Commission 2003). Fish attempting to migrate upstream may become easy prey for birds as they gather downstream of barriers.

Fish larvae are usually poor swimmers, and travel with currents. Weirs cause injury or death of larval golden perch and Murray cod, as well as small-bodied native species as they move downstream (Baumgartner et al 2006, 2009).
The weirs are of two designs:

1. overshot, whereby the water passes over a crest
2. undershot, whereby the water passes under a gate.

Fish can be injured as they pass over the crest and fall to the bottom of the weir, or by turbulence and pressure changes as water passes under the gate. Tareelaroi Weir is an example of an undershot design that is known to cause the highest mortality among larval and juvenile fish (Department of Primary Industries 2007).

Photo 20 Tareelaroi Weir (Photo: Neal Foster).

Fish can also be captured by infrastructure used to extract water from rivers. Most irrigation occurs during the warmer months and coincides with spawning and migration, and there is evidence that many fish are being extracted from rivers through channels or pumps (Baumgartner et al 2007). Even if the fish are not injured, it is unlikely they would be able to return to the river as used irrigation water is not permitted to be returned to waterways. Industry & Investment NSW (Fisheries), the Australian Cotton CRC and Murrumbidgee Irrigation are undertaking collaborative research into this problem (DPI 2005).

4.3 Degradation of riparian zone and in-stream habitat

Industry & Investment NSW is the lead agency for statewide programs aimed at restoring aquatic habitat and the riparian zone of river systems. Healthy riparian vegetation is important for river health because of its role in stabilising river banks and reducing water temperature fluctuations by shading, and as a source of large woody debris (as fish habitat) and fine organic matter which is the base of aquatic food chains.

One ongoing project involving the University of New England and the BRG CMA involves identifying important fish refuge areas in inland river systems. Waterholes and lagoons which retain water through long dry periods allow local fish populations to survive and recolonise other aquatic habitats when conditions improve.

5 Land management

Land capability investigations carried out during the 1960s indicated that the areas most suitable for irrigated agriculture in the Gwydir Valley were in the vicinity of Moree and west in Gwydir Wetlands. Irrigation in this area increased rapidly after the completion of Copeton Dam in 1976. However, flooding of the wetlands was an impediment to irrigation development, and 'could render the land both inaccessible and unproductive for several months at a time' (Department of Water Resources nd). Several flood management schemes were developed for the wetlands to prevent flooding of irrigation land.

Clearing, cultivation, grazing, fire, and obstruction of floodways by diversion banks and channels fragmented the wetlands, leaving narrow corridors of vegetation along flow lines and disconnected vegetation remnants.

5.1 Clearing

The vegetation communities most affected by clearing in Gwydir Wetlands are river cooba and lignum shrublands and coolibah and black box woodlands. Semi-permanent wetlands have also been lost because inundation is less frequent and large areas have been infested by lippia. These are challenging issues for farmers working to progress agricultural productivity on their lands. DECCW and BRG CMA are undertaking vegetation awareness campaigns and incentive programs to begin restoring parts of the wetlands.

Research undertaken for this AEMP found the extent of native vegetation in Gwydir Wetlands and on the floodplain between 1996 and 2008 had been reduced due to clearing (Bowen & Simpson 2010). On the Gingham and Lower Gwydir floodplains, native vegetation had been reduced by more than 75,000 hectares, declining from 61% in 1996 to 38% in 2008 of the total land area. The communities most heavily cleared included coolibah–black box woodlands, weeping myall open woodland and native grasslands.

In 2008, about 71,000 hectares of coolibah–black box remained in the Gingham and Lower Gwydir area, which is 28% of the estimated 250,000 hectares that occurred prior to regulation of the Gwydir River in the 1970s. The area of weeping myall open woodland had been reduced by 33% from about 12,400 hectares in 1996 to about 8,300 hectares in 2008 (Bowen & Simpson 2010).

In the mapped section of the southern Gwydir Wetlands (Mehi–Mallowa–Moomin creeks and their floodplains) about 76,000 hectares or 64% of the total land area of native vegetation was cleared by 2008. Most clearing had been of floodplain woodland communities, primarily coolibah–black box woodland (coolibah open woodland, coolibah–river cooba–lignum) and weeping myall open woodland. In the Mehi–Mallowa–Moomin systems, about 21,000 hectares of coolibah–black box woodland (consisting of about 19,500 hectares of coolibah open woodland and 1,500 hectares of coolibah–river cooba–lignum open woodlands) remained in 2008. Areas formerly supporting semi-permanent and inner floodplain wetland communities, primarily water couch grasslands and river cooba–lignum shrublands, had been cleared.

Between 1996 and 2008, the area of semi-permanent wetland communities in the Gingham and Lower Gwydir watercourses declined by 51%, from about 14,000 to 6,800 hectares. Water couch grassland and marsh club-rush communities declined in area and condition between 1996 and 2008. In 2008, only 9% of the 1974 area of marsh club-rush remained and less than 10% of these remnants were contained in the Gwydir Wetlands Ramsar Site.

In the southern Gwydir Wetlands (Mehi, Mallowa and Moomin floodplains), about 6,400 hectares of semi-permanent and floodplain wetland communities, or 5% of the floodplain area, remained in 2008. These areas exist as narrow riverine corridors and as small fragmented floodplain channel remnants, particularly in the western half of the Moomin Creek floodplain and the eastern part of the Mallowa floodplain. These isolated remnants remain under threat from insufficient inundation, colonisation by terrestrial and exotic species such as lippia, and clearing (Bowen & Simpson 2010).

In the Gwydir floodplain most clearing of native vegetation before 2005 was concentrated in the fertile western alluvial plains. In 2005–08, proportionally more clearing occurred in areas of non-woody semi-permanent and floodplain vegetation habitat in the lower lying areas of the floodplain (Figure 11). Reduced flooding has caused degradation of semi-permanent and floodplain wetlands and led to the clearing of semi-permanent wetland communities for cropping and management of exotic species such as lippia and water hyacinth (Bowen & Simpson 2010).

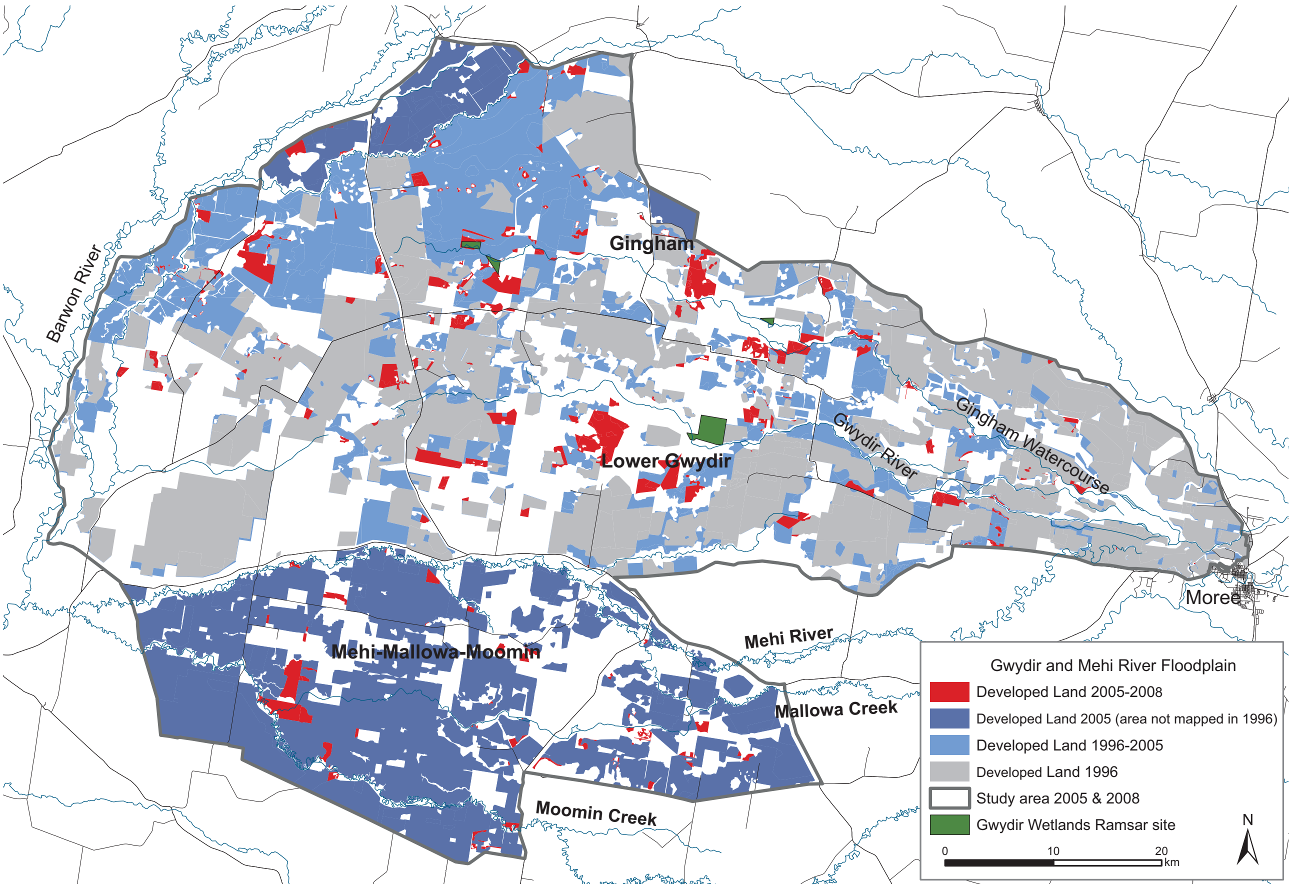


Figure 11 Clearing of the floodplain of the Gwydir River below Moree: 1996–2008 (Bowen & Simpson 2010).

5.2 Grazing

Flows to Gwydir Wetlands have always been variable. However, there has been a major alteration to wetland hydrology since river regulation, and the recent dry period is as severe as any drought on record. Under these conditions, managing the effects of grazing on wetlands has become more important (Holmes et al 2009). Researchers from the University of New England investigated the effects of grazing on five aspects of wetland condition: vegetation composition, the soil seedbank, soil chemistry, water quality and aquatic invertebrates (Wilson et al 2008).

Long-term grazing exclusion plots established in 1994 were used to assess the effects of grazing by both domestic stock and native herbivores on four different wetland plant communities. Results indicated the major cause of vegetation change was flow regime and that grazing had a relatively small impact (Wilson et al 2008). Grazing by cattle was important in maintaining the dominance of water couch in grassy wetland communities. In contrast, grazing disturbance created openings for other, mainly native species in a marsh club-rush wetland. Although grazing increased species diversity at the site, that is not necessarily a desirable outcome for this community. At drier sites where inundation was less frequent, grazing showed only minor detectable impacts on community composition (Wilson et al 2008). Inundation at these sites was the factor most capable of causing changes in condition (Wilson et al 2008).

To best determine the ways in which grazing affects a wetland, the system's resilience needs to be studied. A species-rich and abundant seedbank is vital for a wetland plant community to cope with variable environmental conditions and inundation patterns. The soil seedbank study from the wetlands demonstrated that the seedbank was abundant and diverse, with a broad range of wetland and terrestrial species. Species richness in the seedbank was significantly higher in plots where cattle (but not native herbivores) were excluded.

These findings indicate that plant communities are showing considerable resilience to the disturbance caused by grazing of domestic stock and other herbivores. The benefits of grazing need to be balanced with the needs of plant species to reach maturity and set seed, and thrive in the long-term (Wilson et al 2008).

If grazing is reduced, more species can complete their lifecycle and contribute seed to the seedbank. To facilitate this, programs that provide an incentive for land holders to fence wetland paddocks into smaller units should be considered. Smaller paddocks provide the opportunity to protect sections of the wetland, especially during periods following inundation, allow plants to set seed, and help maintain the diversity of wetland plant communities (Wilson et al 2008).

In general, stocking rates in Gwydir Wetlands have been low compared to other parts of the Murray–Darling Basin due to prevailing drought conditions and the invasive species lippia, which has reduced the carrying capacity of many parts of the floodplain by up to 50%, especially where the water is shallow (Wilson et al 2008). This reduction in stocking rate has probably contributed to a reduction in the impact of grazing on many wetland sites (Wilson et al 2008).

Industry & Investment NSW, in conjunction with the University of New England, has developed grazing guidelines for Gwydir Wetlands and Macquarie Marshes. Scientific knowledge was reviewed and graziers in Gwydir Wetlands and Macquarie Marshes contributed specific issues and management practices. The guidelines advise on managing grazing in the wetlands to protect the system and provide for sustainable grazing enterprises (Holmes et al 2009).

5.3 Weeds and pest animals

5.3.1 Weeds

The Gwydir Wetlands are a highly disturbed system and are infested with many weeds (McCosker 1999a, 1999b, Bowen & Simpson 2010). These include lippia, water hyacinth, African boxthorn, prickly pear, noogoora burr, Bathurst burr, variegated thistle, cobblers pegs and wild turnip (Bowen & Simpson 2010). Some areas are dominated by mimosa bush, black roly-poly and soft roly-poly (Bowen & Simpson 2010). The species that cause the most concern are lippia and water hyacinth.

Lippia

Lippia (*Phyla canescens*) is widespread in riparian and wetland areas of the Murray–Darling Basin, infesting about 5,300,000 hectares, and degrading agricultural land and natural ecosystems (McCosker 1994b, 1999a, Crawford 2008). Most of the wetland and floodplain vegetation communities in the Gwydir Wetlands are infested with lippia (Bowen & Simpson 2010). Lippia can germinate in a wide range of conditions, grow quickly, flower early, produce many seeds, reproduce vegetatively and compete strongly with native species. It can produce a dense mat of growth, spread rapidly, remain dormant when moisture is low, and survive prolonged inundation.

Research in the Gwydir Wetlands showed that water couch grew more prolifically than lippia under flooding, and that lippia was less able to tolerate deeper water. When covered with 20 centimetres of water, lippia plants remained alive but produced very little new growth (Wilson et al 2008). Wetlands susceptible to infestation by lippia should be flooded regularly and for long enough to allow native wetland plants to compete (McCosker 1994b, 1999a, 1999b, 2001; Crawford 2008).

Some lippia infestations can be managed by herbicides, but these practices encourage perennial pastures, clearing, cultivating and cropping. To control lippia and increase the productivity of pastures, land holders are sowing existing native pastures with introduced perennial species such as bambatsi panic. This may result in substantial alteration to some wetland areas. If areas of dense lippia continue to expand, the replacement of native pastures with introduced species may become increasingly common (Wilson et al 2008).

Photo 21 Lippia along the Gingham Channel (Photo: Neal Foster).

Water hyacinth

Water hyacinth (*Eichhornia crassipes*) is a declared Class 2 noxious weed. A native of South America, it has been described as the world's worst aquatic weed due to its ability to rapidly cover whole waterways. It has been in Australia since the 1890s and is now distributed along the east coast from Kiama to Cape York Peninsula (Burton et al 2010). In the Gwydir region, water hyacinth was first confirmed in the Gingham Watercourse in 1955 and major floods in the 1970s caused it to spread over a wide area. By 1976, over 7,000 hectares were infested (SPCC 1981).

Water hyacinth can be spread by high flows that break up infestations and carry whole plants to new areas, or by seeds carried in water or mud (Burton et al 2010). The plant has a number of growth forms and can adapt to widely different growing conditions, which makes it very difficult to eradicate (SPCC 1978).

In 1976, an inter-departmental project team was established to conduct an integrated water hyacinth control program, including researching the ecology of species in Gwydir Wetlands (McCosker & Duggin 1993). It became apparent that the soil seedbank was the key to reducing the extent of the infestation.

Photo 22 Water hyacinth on the Gingham Channel (Photo: Neal Foster).

The management strategy relied on manipulating the hydrology of the wetland. Natural off-takes from Gwydir Pool were blocked with banks to prevent flows and minor floods from entering the Gingham Watercourse, which was cleared of obstructions to a width of 50 metres to help drain the weed-infested areas. During the control period, flows were diverted down Mehi River to dry out the Gingham Watercourse. After the main infestation was controlled by desiccation, the watercourse was periodically flooded to promote germination of the seedbank. Young plants were killed before they could flower with herbicides or by re-drying the area. The program reduced the infestation to a manageable area that is now regularly monitored and treated as necessary.

Despite these efforts, water hyacinth remains a major threat to the wetlands and the risk of spread into the Barwon River and beyond remains an important consideration (Torrible et al 2008).

5.3.2 Feral animals

Pest species in Gwydir Wetlands include pigs, foxes and alien species of fish. Livestock health and pest authorities and land holders have long-standing control programs for pigs and foxes.

Gwydir Wetlands are a known ‘hotspot’ for breeding carp (Gilligan et al 2008), and ongoing control measures are required. The *NSW draft control plan for the noxious fish carp (Cyprinus carpio)* was released for public comment in November 2009 (Industry & Investment NSW 2009). Submissions received have been included in the revised plan where appropriate, and the *NSW control plan for the noxious fish carp (Cyprinus carpio)* was released in December 2010. The final plan describes the most up-to-date information about the biology and impacts of this species and outlines what is being done – or should be done – to stop further spread of carp, control the size of carp populations, better understand the species and increase the understanding and involvement of the community.

6 Aboriginal cultural values of Gwydir Wetlands

6.1 Introduction

Gwydir Wetlands lie within the traditional country of the Gamilaroi people. Gamilaroi country covers a large area of north-western NSW, including most of the length of Gwydir River. Aboriginal cultural values relate to the deep history of Aboriginal interaction with the wetlands, and the values, interests and aspirations of contemporary Gamilaroi and other Aboriginal communities who have custodial relationships to the wetlands. These communities have a connectedness to the landscape and a sense of responsibility to care for this important part of their Country.

However, over the past two centuries non-Aboriginal settlement has made it increasingly difficult, if not impossible, for Aboriginal people to exercise custodial duties. Enhancing Aboriginal cultural values involves strengthening the relationships of Aboriginal communities with Gwydir Wetlands.

There is strong alignment between protecting the cultural and natural values of the wetlands. However, there are significant differences as well, including differences in emphasis for on-ground protection. For instance, the land in Gwydir Wetlands is an important part of the Aboriginal cultural landscape, containing culturally important vegetation communities and a range of important cultural heritage sites. These areas are a priority for conservation.

6.2 History of Aboriginal settlement and occupation of Gwydir Wetlands

6.2.1 Traditional settlement of Gwydir Wetlands

For Aboriginal people, the wetlands, riverine forests, grasslands and elevated sandy ridges of the Lower Gwydir floodplain were rich assets to complement the vast swathe of Country on the plains and ranges.

The wetland landscape was at the centre of Aboriginal culture and spirituality. Aboriginal people were connected to the natural world through totem and kinship relationships, which established relationships of mutual care and responsibility. The landscape, particular places in the landscape, and specific plants and animals, were all animated through events in the Dreamtime. The creation spirits still inhabited the landscape, often resting in large waterholes or in the form of animals.

Bora (initiation) ceremonies occurred to the west of the core semi-permanent wetland areas, with an iconic Bora site at Collymungle. The ecologically rich and reliable wetland environments provided the reliable setting and quantity of resources capable of sustaining Bora ceremonies (Bowdler 2005). The wetlands landscape was a 'nourishing terrain' for Gamilaroi as the traditional owners, and other groups who had relationships with this place (Rose 1996).

During flood times, the people living on the wetlands would have eaten the abundant waterbirds and their eggs. When not in flood, the large river channels and semi-permanent areas of water would also have been a major feature of the cultural landscape, providing water and associated resources. Food, tools, shelter and medicinal items were harvested from plant and animal resources. These plants and animals provided a cultural and material contribution to the social and ceremonial aspects of Aboriginal life in the region. Aboriginal people adapted and developed sophisticated technologies to live in the wetland environment, including nets and fish traps and processing of cumbungi.

A key aspect of living in Gwydir Wetlands would have been movement between the 'red country' (thin elevated ridges that run sinuously through the wetlands and floodplain) and 'black country' (floodplain and wetlands). During floods, the black country was uninhabitable but, as the flood waters dried up, people would move back to the main river channels and core wetland areas (Witter 1999). Today, elevated red ridges are the dominant location for stone artefact sites. The black soil floodplains, with self-mulching alluvial soils and periodic floods, provide poor conditions for preserving stone artefacts and far fewer traces of Aboriginal occupation have been identified there (Biosis Research 2008).

Photo 23 Aboriginal scarred tree on 'Old Dromana' (Photo: Daryl Albertson).

Core semi-permanent wetland areas provided the important, and iconic, wetland plants including cumbungi (bulrush) and nardoo. The riverine forests, woodland and grasslands would have provided other important plants including river cooba, river red gum, coolibah, Mitchell grass and native millet. Scarred trees located in the wetlands today, typically coolibah trees, indicate the use of floodplain trees for implements (such as coolamons) and shelter. These scarred trees have added importance because few of the actual wooden implements have survived. Many surviving mill stones indicate the importance of grasses and seeds in the wetlands (Biosis Research 2008).

The elevated ridges also provided important resources. Some of the important plants include wilga, bumble/wild orange, belah, leopardwood, quinine bush, nepine, quandong and western boobialla. Today, the elevated ridges are a key area for plants with cultural values.

After over 200 years of non-Aboriginal settlement, most of the country has been radically changed, which explains the Aboriginal concern for those remnants which survive in a relatively natural condition.

6.2.2 Post-contact history

Colonisation of Gwydir Wetlands from the 1830s caused radical changes for Aboriginal people in the Gamilaroi country and more broadly across western NSW. Aboriginal people were usurped from their lands and their social, cultural and spiritual ways of being were severely disrupted.

However, Aboriginal people were not dispossessed (Goodall 1996, 2001, Hope 2004). In the colonial situation, Aboriginal people maintained a connection to the area. While physical 'openings' into the landscape were constrained, Aboriginal people used a range of strategies to maintain connections with the wetlands under greatly changed circumstances (Byrne & Nugent 2004).

Throughout the nineteenth century and into the early twentieth century, Aboriginal people were valued workers in pastoral properties in the region, working on stations including 'Tyreel', 'Noonah', 'Goonal', 'Combadello' and 'Gingham'. Aboriginal people lived in communal camps at pastoral stations, at camps on riverbanks and on reserves created by the Aboriginal Protection Board. Up to the late 1890s, Aboriginal people continued to conduct ceremonial activities in the region.

The 1930s marked a radical increase in the supervision of Gamilaroi and other Aboriginal people living in the wetlands area. In the 1930s the Aboriginal Protection Board, as part of a policy of segregation, began concentrating Aboriginal people onto a small number of Board-run reserves, including the reserve at Brewarrina (Goodall 1996, Hope 2004). As this forced removal from Country happened relatively recently, older people still remember it.

To escape the control of the Protection Board and seek education for their children, Aboriginal people moved from the wetlands to informal camps outside towns across the region. By the 1950s, there were few Aboriginal families living permanently on properties in the wetlands area. However, many Aboriginal people based in surrounding towns continued to work in the wetlands as shearers, stock workers and fencers.

By the late 1950s a pattern of limited physical access to the wetlands was in place and this has continued until today. Significant Aboriginal communities live in the towns surrounding the wetlands: Moree, Mungindi, Collarenebri and Walgett. Few Aboriginal people live in the wetlands area.

In this situation, physical access to the wetlands depended on good relationships with private land holders. As the amount of work on properties decreased, these relationships were more difficult to maintain. Many Aboriginal people report that in trying to gain access to favoured areas of the wetlands, for fishing or just for visiting places, they faced fences and locked gates. The ecological decline in the wetlands since the 1970s has been experienced as another form of loss, because the Country itself is rapidly declining.

Restriction of physical access has led to a loss of detailed knowledge of areas of Country. However, Aboriginal people have sustained detailed knowledge of some areas of Country which they continued to access, such as the area surrounding reserves in which they lived, places they accessed through work, or riverbanks which they visited. Land continued to be at the centre of culture, identity and spirituality for Aboriginal people in the region (Goodall 2001).

Since the 1970s, Aboriginal rights relating to land have been reasserted and Aboriginal people have become increasingly confident about accessing land, protecting cultural heritage sites and managing the environment. The practice of environmental management has also slowly changed, with incremental increases in the involvement of Aboriginal people in conservation and environmental management issues creating new 'openings' into the landscape of Gwydir Wetlands.

6.3 Values, interests and aspirations of contemporary Aboriginal communities

The issues below were documented in community consultation activities conducted in 2007–08, including workshops held in the Gwydir Wetlands area. This section also draws on oral history interviews with key community members (Waters Consulting 2008).

6.3.1 Gamilaroi traditional descendants – key priorities

The Gamilaroi people, as traditional owners of Country, have a special role in planning for Country. Gamilaroi traditional descendents have identified the following key priorities for the Gwydir Wetlands:

1. cultural flows to Country
2. access to Country to conduct cultural activities
3. inclusion in management of Country
4. training and working for Country
5. cultural continuity and heritage protection on Country
6. caring for Country: enacting cultural and ecological responsibility for Country.

As first people, Gamilaroi have inherent rights in Country. Gamilaroi people, along with other Aboriginal people, have never given up sovereignty over or connection to their lands and water. Gamilaroi people have a particular interest in re-engaging with Country to enhance their spiritual connection to Country, and to revive their cultural practices.

Many Aboriginal communities have strong associations with Gwydir River through their ancestors' ceremonial and cultural practices. Gamilaroi people have a holistic view of land management and aspire to be involved in all aspects of cultural, environmental, economic and social management processes. Gamilaroi people hold a vision for a healthy, living river system with natural flows and cycles, shared with other Aboriginal peoples of the Gwydir and Barwon–Darling Rivers. Today, Gamilaroi descendants and other Aboriginal people wish to become equal participants in the protection and regeneration of the ecology of Gwydir Wetlands, and in the protection of Aboriginal culture and heritage. In addition, the Gamilaroi community wants to ensure a sustainable economic base for all Gamilaroi people for present and future generations.

Although the Gamilaroi have a special position as descendents of the traditional people of the area, other Aboriginal communities also have important associations with Gwydir Wetlands, including:

- traditional owner groups from upstream and downstream of Gwydir Wetlands
- traditional owner groups who gathered on Gamilaroi Country for ceremonial purposes
- Aboriginal people with historic connections to the wetlands, particularly through working in the pastoral and agricultural industries
- Aboriginal people who currently reside on Gamilaroi Country.

It is important that all these groups are also recognised in planning for Country.

6.3.2 Values, interests and priorities – Gamilaroi and other Aboriginal people

During the community consultations, the following values, interests and priorities arose.

Recognising custodianship

An overarching issue was acknowledging and strengthening Aboriginal custodianship. Contemporary custodianship could be recognised by maintaining place names and renaming places with Aboriginal place names, by welcoming people to Country at the beginning of events, and by increasing Aboriginal people's participation in managing the environment.

Protecting Country

During the consultations, specific aspects of Country were acknowledged as being particularly important to the Aboriginal community and in need of conservation and protection. The priorities were:

- to restore core wetlands
- to protect other areas and ecosystems – riverine forests, woodlands and grasslands, elevated sandy ridges
- to protect cultural heritage sites, ceremonial and dreaming sites, scarred trees, campsites and places where people lived and worked
- to take a holistic approach to managing Country
- to establish conservation reserves in the Gwydir wetlands.

Undertaking activities on Country

Aboriginal people described the following activities they wanted to undertake on Country:

- having access to Country to conduct cultural activities
- having work, training and economic opportunities on Country
- being involved in managing Country, especially in managing environmental water
- establishing conservation reserves in the region and forming partnerships with DECCW in managing these reserves
- establishing an Aboriginal cultural flow of water.

6.4 Identifying and protecting Aboriginal cultural values

6.4.1 Protecting Country

Aboriginal cultural values and ecological health

The Aboriginal cultural values of the wetlands are strongly associated with their overall ecological health. Protecting the natural values of wetlands enhances their cultural values. However, there are differences of emphasis. For instance, Aboriginal communities have a strong interest in protecting wetland plants with iconic cultural values such as nardoo, cumbungi, river cooba, coolibah and river red gum. Along with the core semi-permanent wetland areas, other ecosystems and vegetation communities in the Gwydir Wetlands are highly significant in terms of Aboriginal cultural values. Riverine forests, woodlands and grassland, and the elevated ridge country (often called 'red country') all support significant plants and animals with cultural values and are important for the preservation of cultural heritage sites.

Aboriginal cultural values and the management of environmental water: a cultural flow of water

Water is a key factor in sustaining wetland plants and animals with cultural values, and for sustaining the health of the landscape in general. There is strong community aspiration for a dedicated cultural allocation of water for the Gwydir Wetlands. Cultural flows are allocations of water controlled by Aboriginal people to improve the spiritual, cultural, environmental, social and economic conditions of Country (Morgan et al 2004). A cultural allocation of water is a way for Aboriginal community members to enact their custodial responsibilities for Gwydir Wetlands and to protect the health of the environment. The primary focus of these flows would be providing water for plants, animals, sites, and the broader landscape that depend on water. Cultural flows could be used in conjunction with environmental flows in many circumstances.

Bringing about broader recognition of Aboriginal cultural values in managing environmental water involves other steps, including having Aboriginal representatives on committees that manage environmental flows and including Aboriginal cultural values as criteria in managing environmental water.

Aboriginal cultural heritage sites

More than 160 sites have been recorded in the Gwydir Wetlands area (Biosis Research 2008). These places are important indicators of the long history of Aboriginal peoples' interaction with the Gwydir Wetlands; they indicate how Aboriginal people adapted to and used the resources these wetlands provided.

Cultural heritage sites in the Gwydir Wetlands include:

- carved trees
- burials in soft sediment
- a large number of scarred trees
- flaked stone and ground stone assemblages
- stone artefacts (Biosis Research 2008).

Cultural heritage sites occur predominantly on the red ridge country and are most common near water sources. They face a range of threats including land clearing, tramping and erosion from stock, and vegetation die back from lack of water. Cultural heritage sites occur across private land, travelling stock reserves and wildlife refuges.

6.4.2. Cultural activities on Country

Access to Country for cultural purposes

Access to Country is a key contributor to cultural renewal, creating opportunities for Aboriginal people to reconnect with their Country, carry out cultural practices and pass on knowledge. Restoring access to Country addresses the long history of exclusion from the wetlands.

Activities that Aboriginal communities want to conduct on Country include:

- conducting family camps, back to Country camps and camps for conducting cultural practices
- undertaking education and cultural awareness activities
- collecting bush foods and wild resources – including sedges and reeds for weaving
- conducting men's and women's specific activities and specific activities for young people.

Access to Country can be facilitated through negotiating access to private land and establishing public conservation reserves in Gwydir Wetlands.

Working on Country: increased employment, training and economic opportunities on the wetlands

Employment and training in conservation and natural resource management activities are important ways for Aboriginal people to restore connections to Country. (For the benefits of working on Country programs in northern Australia, see Altman & Whitehead 2003, Garnett & Stilhole 2007.) Aboriginal people in Gwydir Wetlands could be employed to work on conservation projects, DECCW programs or natural resource and environmental management activities on private land supported by CMA projects. In the longer term, there may be opportunities for Aboriginal-owned businesses or Aboriginal contractors to undertake work in conservation, natural resource and environmental management activities.

6.4.3 Participation in management of the wetlands

It is important that environmental management agencies engage with Aboriginal communities early in the process, and on an ongoing basis, so Aboriginal people have the best opportunities to be involved in environmental management of Gwydir Wetlands. Aboriginal communities would then be involved in decisions that affect them and be able to enact their custodial responsibilities to Country (DAA 2003, DECC 2006, 2007).

In the context of Gwydir Wetlands, a natural area with strong cultural values, it is important that Aboriginal communities participate in overall environmental management of the wetlands as well as management of cultural heritage. A key forum for participation of Aboriginal communities is the Environmental Contingency Allowance Operations and Advisory Committee (ECAOAC).

There are other important ways for Aboriginal communities to be involved. The formation of an Aboriginal community reference group would be a key avenue for increasing engagement in environmental management, especially in managing environmental water. This would be a forum for Aboriginal communities to develop and advocate perspectives on environmental management in the wetlands. Agencies or the BRG CMA could support the reference group by providing resources to meet on Country a number of times a year.

Given that Aboriginal peoples' involvement in environmental management forums is relatively new, it is important that management agencies provide ongoing support and training for Aboriginal community representatives. To assist Aboriginal representatives on these forums, cultural awareness training should be available for non-Aboriginal committee members.

7 Implementing the AEMP

Action is needed to arrest the decline of the Gwydir Wetlands and ensure their ecological functions and processes are maintained. It is clear from the many plans and reports prepared for the wetlands since the early 1990s, and reviewed for this AEMP, that stakeholders are aware of many actions needed to restore, maintain and protect the wetlands.

Activities are being carried out or planned under existing funding programs, policies or legislation. DECCW is responsible for managing environmental water allocations established under water sharing plans (WSPs) and water access licences held by the NSW Government for an environmental purpose. The Environmental Contingency Allowance Operations and Advisory Committee (ECAOAC), established under the Gwydir WSP, advises DECCW on managing this water and helps DECCW prepare an annual watering plan. The NSW Office of Water (NOW) is responsible for developing and implementing WSPs and for water licensing, including enforcement and compliance. The Basin Plan will establish 'sustainable diversion limits' for water sources in the basin and future WSPs will need to comply with these limits.

Under the *Water Act 2007* (Commonwealth), the independent CEWH determines the use of the Commonwealth's environmental water holdings. In the Murray–Darling Basin, the holdings are managed in accordance with the Basin Plan to protect or restore environmental assets. Priority given to watering actions by the CEWH is based on an assessment of environmental benefits against publicly available criteria and after receiving advice from the Environmental Water Scientific Advisory Committee, as well as input from state governments and other stakeholders. The criteria are available at www.environment.gov.au/water/policy-programs/cewh.

Governments, through the Murray–Darling Basin Reform Intergovernmental Agreement signed in 2008, have agreed to cooperate on environmental water management. In early 2009, DECCW and CEWH signed a memorandum of understanding to ensure close cooperation on Australian Government and state environmental water planning and management.

7.1 Determining priorities for delivering water

Tables 6–8 set out objectives for the duration and frequency of inundation to maintain the values of semi-permanent and floodplain wetlands in Gwydir Wetlands. The Murray-Darling Basin Plan will also indicate the environmental watering requirements for important wetlands across the basin, including Gwydir Wetlands.

This AEMP does not prescribe the priorities for watering the environmental assets described in section 2. It is not possible to anticipate every event that could influence the future condition of the wetlands and priorities for environmental watering. The determination of priorities for delivering water is most appropriately undertaken on an annual basis with an understanding of the current condition of and threats to assets and values. Over longer time scales, these priorities will be influenced by the scale of water recovery achieved in the medium term and the capacity of the wetlands to recover from the recent dry sequence of years.

Prioritising the delivery of environmental water to specific assets and for specific objectives will be undertaken annually with input and advice from the Gwydir ECAOAC and will include:

- considering the ecological assets, values and water needs described in this AEMP
- agreeing on the condition of the wetlands and appropriate management responses (DECCW, BRG CMA and ECAOAC)
- considering the amount of water available under a range of likely climate scenarios (DECCW, ECAOAC)

- determining priority areas for water delivery to sustain the assets, values and character of the wetlands (DECCW, BRG CMA, ECAOAC and affected stakeholders) in the context of the above point
- identifying flow paths and means of delivering water to identified areas (DECCW and ECAOAC).

Information to be considered in this process includes:

- the ecological, social and cultural assets and values that may be threatened as a result of recent and expected climatic conditions
- the location, character and significance of wetland systems, including their complexity and diversity; when possible, management will support the complexity and diversity of the larger system as well as the complexity and diversity of specific assets or areas
- legislative and policy responsibilities
- the nature of land and water management activities within or along flow paths to ecological assets, including the number and role of banks, channels, regulators and other structures; management practices; and formal management agreements
- the likelihood that identified management activities will lead to achievement of land and water management objectives
- the capacity to deliver water to different areas, including existing or potential works for directing, holding or otherwise managing water.

7.2 Delivering and managing water in Gwydir Wetlands

Extensive public and private works have been built throughout the wetlands to manage water; to direct, control, harvest and store flows; and to control channel erosion. Although many of these works are essential for managing the wetlands, others are of limited or of no benefit. Some works will have to be modified or removed to protect assets, and in some cases, new works may be needed.

An environmental allocation has existed in the Gwydir Valley and has been actively delivered to the Gwydir Wetlands since 1995. Many members of the Gwydir community have considerable expertise in managing environmental flows and will contribute to operational plans either at a site scale or on a broader wetland scale.

7.3 Cooperation and community participation in management

The centrepiece of community participation in management of environmental flows in the river and wetlands is the Gwydir ECAOAC, which has developed a high degree of skill in water management. The members include representatives of DECCW, NOW, State Water, I&I NSW, Gwydir Valley Irrigators Association, Gingham Watercourse Association, Lower Gwydir Watercourse Association, BRG CMA, the Aboriginal community, conservation interests (World Wildlife Fund) and scientific expertise. The Australian Government Department of Sustainability, Environment, Water, Population and Communities (DSEWPC) has observer status on the ECAOAC.

Effective communication will be an essential part of community participation. Credible, trusted knowledge will not be developed without strong links and communication between relevant stakeholders. A communication plan will be developed for actions that either affect or potentially affect people and sectors.

Effective community participation in management of the Gwydir Wetlands will rely on addressing five key challenges:

1. Ensuring effective representation by creating an explicit statement of roles, responsibilities and expectations and providing leadership and support so roles can be undertaken effectively.
2. Designing workable and useful processes.
3. Including scientific, expert and local knowledge in decision-making.

Photo 24 Environmental watering of semi-permanent wetland vegetation will support native plants such as watermilfoil. Photo: Tracy Fulford.

4. Developing a common understanding of the system and the challenges that it faces.
5. Evaluating whether decisions are effective and whether they achieve management objectives (Scholz & Stiftel 2005).

7.4 Research, monitoring, evaluation and reporting

To manage the wetlands adaptively, different sources and types of information are needed including the knowledge of landholders and Aboriginal people. Community ownership of scientific research will be more likely if people are involved in the conception, implementation and completion of research projects. Information is sometimes not available, and sometimes science cannot answer the questions that managers and policy makers ask. Strong links and effective communication between researchers, managers and policy makers must be developed and fostered. A research plan will be developed as part of implementing the AEMP.

Monitoring, evaluating and reporting on the effectiveness of policies and management actions are essential for learning and adaptive management. The NSW Wetlands Monitoring, Evaluation and Reporting Rapid Assessment is an example of a system which can be used to report on wetland condition. However, more comprehensive monitoring will be necessary to evaluate management in the Gwydir Wetlands. Water delivery must be monitored to ensure that it reaches identified assets, and the distribution of water in the assets must be measured. Gauges are already in place for monitoring and measurement in most areas, but some additional measuring points may need to be installed. Satellite mapping of inundation is also an effective way of measuring inundated areas.

NOW has been implementing the Integrated Monitoring of Environmental Flows (IMEF) program for long-term monitoring of WSPs across the state since 1998. In Gwydir Wetlands, IMEF has focused on researching and monitoring the ecological responses to flows in the wetlands and the Gwydir River channel.

The environmental water provisions in the Gwydir WSP are expected to increase the inundation of benches and riparian zones in the river reach downstream of Copeton Dam and within the network of effluent channels occurring on the floodplains. The many small wetland systems which occur in and adjacent to these channels should also benefit from the improved water regime.

Lagoons and floodplain wetlands are expected to be replenished more frequently and for longer times, resulting in the creation and maintenance of wetland habitat for a wide range of plant and animal species. Specific monitoring of ECA releases from Copeton Dam, which target Ramsar sites among other key environmental assets, is also undertaken to inform short-term flow management requirements.

Several wetland sites in the Gingham and Lower Gwydir watercourses have been assessed to determine the linkages between river flows and the ecological response of aquatic vegetation and aquatic macroinvertebrates. Studies have also investigated the transfer of dissolved organic carbon to and from the floodplain and the relationship between flows and native fish recruitment.

A review of the Gwydir WSP's effectiveness will consider the economic and social elements of WSP objectives. To this end, key indicators for monitoring the irrigation sector have been identified and a survey was conducted in 2006 to establish baseline information for ongoing assessment. It is expected that outcomes of the IMEF program will also inform the ongoing development and review of the AEMP.

The effectiveness of management should be assessed against objectives related to restoration of critical ecological functions and habitats. The effectiveness of environmental flow management in meeting the objectives will be of special interest, particularly in relation to:

- changes in the extent of semi-permanent wetland vegetation
- the proportion of healthy and stressed semi-permanent wetland vegetation
- the diversity and density of aquatic invertebrates
- the diversity and density of waterbird species.

Scientific research and monitoring activities should also be evaluated, including the extent to which their findings are used to inform management actions.

DECCW is developing a decision support system (DSS) to improve its capacity to optimise the use of environmental flows for wetlands. The DSS will enable DECCW to compare scenarios relating to the volume and timing of water delivered to meet ecological outcomes, to guide decisions about the use of environmental water. The DSS is based on integrated ecosystem response and hydrological models.

7.5 Projects and actions to deliver the AEMP

For Gwydir Wetlands to have a sustainable future, communities and government must establish a shared view of the condition of the wetlands, ways in which wetland condition is changing, why it is changing, and suitable management and research responses.

A range of actions to restore and protect the ecological assets described in section 2 of this plan are outlined in Tables 9 to 14 covering water management, aquatic habitat management and restoration, land management, application of scientific knowledge to management and policy, Aboriginal cultural values and adaptive management.

Some actions already under way include:

- developing guidelines for managing breeding of colonially nesting waterbirds
- modifying weirs and other barriers to improve conditions for native fish
- piping the Gingham stock and domestic channel
- undertaking environmental restoration of the Gingham Channel
- improving irrigation efficiency and purchasing water from willing sellers to return water to the environment
- applying guidelines for grazing management to ensure the best outcomes from environmental water management
- establishing processes for ensuring that community members participate effectively in river and wetland management.

DECCW and the BRG CMA will coordinate the implementation of these actions, including progressing further feasibility assessments where necessary, in the context of the ongoing review and implementation of the AEMP. An annual review of the implementation of the AEMP by DECCW and the BRG CMA will seek to ensure that other agencies, interest groups and individuals are involved in resourcing and progressing relevant actions.

DSEWPC, Industry & Investment NSW (I&I NSW), NSW Office of Water, State Water, Aboriginal communities, Land & Property Management Authority and Gwydir Wetlands land holders will be critical participants in this implementation process.

Table 6 Gingham Watercourse wetland vegetation watering objectives.

Vegetation community and watering objective	Location	Area (hectares) in 2008	Tenure	Current vegetation condition	Environmental water delivery potential
River red gum woodland Objective not set as watering needs likely to be met by flows to other assets	Riverine corridors near the Gwydir Raft	253 total for Gingham and Lower Gwydir watercourses	Private	Fair to poor: infested with many exotic species	Good
Coolibah–river red gum Objective not set as watering needs likely to be met by flows to other assets	Riverine corridors near the Gwydir Raft, extending west along the Gwydir River	3,259 total for Gingham and Lower Gwydir watercourses	Private	Fair to poor: infested with many exotic species	Good
Coolibah woodland Objective not set as flooding required for regeneration is likely to be uncontrolled	'Bunnor', 'Old Dromana', 'Crinolyn', 'Boyanga', 'Whitewood', 'Norwood', 'Glen Idle', 'Lynworth'	51,652 total for coolibah woodland in Gingham and Lower Gwydir watercourses: (about 18,080 hectares located in Gingham) (73,230 total for coolibah–black box woodland in Gingham and Lower Gwydir watercourses)	Private/ public	Good to poor: some partially cleared, some poor and water-stressed, some infested with lippia.	Good
River cooba swamp–lignum shrubland Provide water to inundate for at least 3 months between September and March, at least 5 years in 10	'Tillaloo', 'Jacksons', 'Wayholm', 'Westholme', 'Bunnor', 'Old Dromana', 'Lynworth', 'Yarrol', 'Munwonga', 'Boyanga', 'Boyanga South', 'Curragundi', others east of 'Wayholm'	2,190	Private/ public	Fair to poor: water-stressed, some areas heavily grazed, some areas infested with lippia	Good

Table 6 (continued) Gingham Watercourse wetland vegetation watering objectives.

Vegetation community and watering objective	Location	Area (hectares) in 2008	Tenure	Current vegetation condition	Environmental water delivery potential
Water couch–spike rush Provide water to inundate for at least 6 months of the year, at least 8 years in 10	'Tillaloo', 'Jacksons', 'Wayholm', 'Westholme', 'Bunnor', 'Old Dromana', 'Lynworth', 'Yarrol', 'Boyanga', 'Curragundi', 'Glendarra', 'Goddards Lease', 'Te Mona', 'Molladree', 'Townsby', 'Crinolyn', 'Windella', and others east of 'Te Mona'	3,485	Private/ public	Good to poor: many areas infested with lippia	Good to poor
Marsh club-rush, very tall sedgeland Objective not set as current knowledge is insufficient to determine an optimal watering regime	'Bunnor'	11	Private	Seasonal: ranges from good to poor – heavily grazed in November 2009	Good

Table 7 Lower Gwydir Watercourse wetland vegetation watering objectives.

Vegetation community and watering objective	Location	Area (hectares) in 2008	Tenure	Current vegetation condition	Environmental water delivery potential
Coolibah woodland Objective not set as flooding required for regeneration is likely to be uncontrolled	'Old Dromana', 'Gallimbarray' (Retreat), 'Te Mona', and properties to the east	51,652 total coolibah woodland in Gingham and Lower Gwydir watercourses: (about 33,572 hectares located in Lower Gwydir) (73,230 total coolibah–black box woodland in Gingham and Lower Gwydir watercourses)	Private/ public	Some good, some areas closest to watercourses infested with lippia	Good
River cooba swamp–lignum shrubland Provide water to inundate for at least three months between September and March, at least 5 years in 10	'Old Dromana', 'Belmont', 'Birrah', others	908	Private/ public	Generally fair to poor: some areas infested with lippia	Good
Water couch–spike rush Provide water to inundate for at least six months of the year, at least 8 years in 10	'Old Dromana', 'Gallimbarray' (Retreat), 'Troy', others	2,816	Private/ public	Good to poor: infested with lippia	Good
Marsh club-rush, very tall sedgeland Objective not set as current knowledge is insufficient to determine an optimal watering regime	'Old Dromana', 'Belmont', 'Gallimbarray' (Retreat), 'Wandoona'	197	Private/ public	Seasonal: some good, some fair	Good

Table 8 Mehi, Mallowa, Moomin system wetland vegetation watering objectives.

Vegetation community and watering objective	Location	Area (hectares) in 2008	Tenure	Current vegetation condition	Environmental water delivery potential
Coolibah–river red gum association Objective not set as watering needs likely to be met by flows to other assets	Riverine corridors along Mehi and Mallowa	4,411	Private	Fair to good	Good – possibly accessing groundwater from streams
Coolibah open woodlands Objective not set as flooding required for regeneration is likely to be uncontrolled	'Burragillo', 'Baroona', 'Currotha', 'Valetta', 'Derra', 'The Glen', 'The Brigalows'	19,956	Private	Some good, some lippia infested	Poor
Coolibah–river cooba–lignum association Provide water to inundate for at least three months between September and March, at least 5 years in 10	'Valetta', 'Derra', 'Baroona', 'Currotha'	1,616	Private	Some good along Mallowa, some lippia infested	Poor
River cooba–lignum association Provide water to inundate for at least three months between September and March, at least 5 years in 10	'Valetta', 'Derra', 'Baroona', 'Currotha', 'Burragillo', 'Box Ridge'	393	Private	Some good, some poor	Poor

Table 9 Water management.

Issue	Management action	Responsibility	Mechanism	Timeline
Flow regime, including flow size, frequency, duration and timing	Consider further water purchases for the environment	DECCW, DSEWPC	NSW RiverBank Australian Government Water for the Future; Restoring the Balance	2011 2018
	Increase water efficiency through upgrading irrigation and water delivery systems and improving metering	State Water, DSEWPC, irrigation industry, BRG CMA, DECCW	Australian Government Water for the Future; Sustainable Rural Water Use and Infrastructure program	2018
	Gingham Watercourse pipeline and restoration project	DECCW, NOW	WRP and RERP	2011
	Assess modification of Tyreel Weir to improve capacity to control flow distribution downstream	DECCW, State Water	To be determined	
	Works to ensure water for Mallowa Creek: Stage 1 – survey and environmental assessments Stage 2 – Audit of structures Stage 3 – Modify structures as necessary to ensure reliable delivery of environmental water	DECCW, NOW	Stage 1 funded by RERP Stages 2 and 3 to be determined	Stage 1 completed 2009
	Clarify the role, effect and status of water management structures in the wetlands	NOW, with support from DECCW, DSEWPC, I&I NSW (Fisheries), BRG CMA	Healthy Floodplains Project (Water for the Future – subject to due diligence assessment)	2010–14
	License and measure all floodplain harvesting extractions	NOW, DECCW	Healthy Floodplains Project (Water for the Future – subject to due diligence assessment)	2010–14
	95% of extraction under non-floodplain harvesting water access licences to be metered	State Water, NOW	Murray–Darling Basin Metering Project (Water for the Future – subject to due diligence assessment)	2010–14

Table 10 Aquatic habitat management and restoration.

Issue	Management action	Responsibility	Mechanism	Timeline
Water quality	Apply the *Protection of the Environment Operations Act 1997* to regulate polluting activities	DECCW	Legislative responsibility	Ongoing
	Implement BRG CMA Catchment Action Plan targets	BRG CMA	Legislative responsibility	Ongoing
Impacts of in-stream structures and extraction on fish	Install fishways on weirs, improve access through road culverts	I&I NSW, State Water, local government, BRG CMA	BRG CMA incentive funding to improve fish passage Local government works plans for new/replaced road crossings State Water Memorandum of Understanding (MoU) for fish passage and weir upgrades	Ongoing Ongoing Ongoing
	Minimise impacts of pumps on fish with screen technology	I&I NSW, Gwydir irrigation industry	Research and implement screening technology to reduce pump impacts	Ongoing
	Address impacts of undershot weirs on downstream larval and juvenile fish mortality	I&I NSW	State Water MoU for fish passage and weir upgrades MDBA Native Fish Strategy incentive programs	Ongoing
Degradation of riparian zone and in-stream habitat	Identify and protect important refuge areas for fish in dry times	I&I NSW Fisheries, University of New England (UNE), BRG CMA	Survey and assessment project	Ongoing
	Develop and implement guidelines for restoring fish habitat and fish passage in the Gwydir River and Gwydir Wetlands	I&I NSW, BRG CMA, DECCW, State Water	BRG CMA incentive programs Local council incentive programs MDBA Native Fish Strategy incentive programs State Water MoU for fish passage and weir upgrades	Ongoing Ongoing Ongoing Ongoing

Table 11 Land management.

Issue	Management action	Responsibility	Mechanism	Timeline
Clearing	Prevent clearing of core wetland vegetation communities	DECCW	*Native Vegetation Act 2003*	Ongoing
	Review identification of semi-permanent and ephemeral wetland during dry cycles	DECCW	'Review of the non-woody vegetation in NSW' project	2011
Grazing	Improve understanding of the effects of grazing on wetland vegetation and determine grazing strategies required to protect and restore wetland vegetation	BRG CMA, I&I NSW, DECCW	Implement grazing guidelines developed under Wetland Recovery Program (WRP)	Ongoing
	Provide incentives to improve management of wetlands on private land	BRG CMA, DECCW, I&I NSW	BRG CMA incentives programs RERP sub program IV Fish Friendly Farms Habitat Action Program	Ongoing 2008–2010 2009–2010 (potential to extend) Ongoing
Weed management	Minimise the effects of weeds on wetland values	Landholders, Moree Plains Shire Council, Livestock Health and Pest Authority (LHPA), I&I NSW, BRG CMA	Ongoing management informed by lippia mapping, research and best management practice manual undertaken by WRP Water hyacinth control (funded by WRP and RERP SPIV)	Ongoing 2010
Feral animal control	Maintain feral control programs	LHPA, landholders	Core business activity	Ongoing
Wetland restoration	Establish conservation reserve in the wetlands	DECCW	Purchase land	In accordance with reserve acquisition strategy

Table 11 (continued) Land management.

Issue	Management action	Responsibility	Mechanism	Timeline
Identify Crown land that could enhance the conservation of the Gwydir Wetlands	Undertake a detailed review of Crown land in the Gwydir Wetlands	Land and Property Management Authority (LPMA)	Audit by Crown Lands Division of LPMA	2011
	Identify land management opportunities on leasehold land	LPMA	Negotiate covenants with leaseholders Consider lease exclusion options	Ongoing
	Create a network of Crown land managed to achieve AEMP objectives	LPMA, North West LHPA	Create regional Crown reserve or similar reserve structure Develop a plan of management	2011

Table 12 Application of scientific knowledge to management and policy.

Issue	Management action	Responsibility	Mechanism	Timeline
Improve links between management, policy and science	Prepare waterbird breeding management manual	DECCW	WRP	2011
	Map inundation frequency	DECCW	Rivers and Wetlands Unit (funded by WRP)	2011
	Map vegetation area and condition	DECCW, University of NSW	Rivers and Wetlands Unit (completed 2005 and 2008 under WRP) Statewide Land and Tree Survey program	Completed Ongoing
	Monitor, evaluate and report on wetland condition	DECCW, NOW, I&I NSW, Fisheries	Wetlands Monitoring, Evaluation and Reporting Program; Integrated Monitoring of Environmental Flows program	2008 and ongoing
	Measure environmental water delivery and distribution	NOW, DECCW	Inundation mapping, field inspections, review gauging stations	Ongoing
	Develop hydrodynamic model of the wetlands	DECCW	RERP sub program II	2011
	Improve technical and scientific support for managers and decision-makers	DECCW	DECCW Rivers and Wetlands Unit (funded by DECCW, WRP, RERP sub program II) University of New England	Ongoing

Table 13 Aboriginal cultural values.

Issue	Management action	Responsibility	Mechanism	Timeline
Aboriginal cultural values and environmental water	Negotiate Aboriginal cultural values as criteria for the management of environmental water	DECCW	ECAOAC	Short term
	Define Aboriginal cultural flow	DECCW	Policy development	Medium term
Aboriginal cultural heritage sites	Identify Aboriginal cultural heritage sites and take appropriate conservation action	DECCW BRG CMA landholders	Statutory responsibility BRG CMA incentive programs	Ongoing
Plants and animals with Aboriginal cultural values	Identify and protect plants and animals with cultural values	DECCW, BRG CMA, land holders	Aboriginal representation on ECAOAC	Ongoing
	Protect culturally significant areas, plants or animals within conservation reserve	DECCW, BRG CMA	Purchase land for conservation	Short and medium term
Access to Country	Increase negotiated access to private land in the Gwydir Wetlands to undertake cultural activities	BRG CMA, DECCW, private land holders	BRG CMA incentive programs RERP sub-program IV	Medium term
Working on Country	Increase employment, training and economic opportunities on the wetlands		BRG CMA incentives programs Involvement in DECCW programs, purchase of reserves and employment and training of Aboriginal staff	Short and medium term
Increased participation in management of the wetlands	Aboriginal representative(s) on ECAOAC should have access to appropriate training	DECCW	ECAOAC	2010 and ongoing
	Aboriginal cultural awareness training for other members of ECAOAC	DECCW	ECAOAC	2010 and ongoing
	Support formation of a Gwydir Aboriginal cultural heritage and land management reference group	DECCW, BRG CMA	CMA programs	Medium term
Acknowledging Aboriginal connection to Country and custodianship	Welcome to Country, acknowledgement of Country before major events in the Gwydir Wetlands	DECCW	Event organisers to be advised of acknowledgement request	In place

Short term: 2–3 years   Medium term: 3–5 years

Table 14 Adaptive management – participatory processes and consultation.

Issue	Management action	Responsibility	Mechanism	Timeline
Ensure stakeholder involvement in river and wetland management	Support community role in environmental flow management	DECCW, BRG CMA	ECAOAC	Established, ongoing
	Ensure stakeholder participation in coordination and review of AEMP	DECCW	Carry out annual review of implementation of AEMP and identify priorities for watering assets in the wetlands. Include DECCW, BRG CMA, State Water, I&I NSW, DSEWPC, ECAOAC and affected land holders.	Ongoing
	Develop strategic adaptive management research program	DECCW, UNE, BRG CMA	Review information needs for strategic adaptive management	Ongoing
	Develop communication strategy	DECCW	Various	Ongoing

References

AgEconPlus 2007, *Information audit of socio-economic activities in the Gwydir River Catchment*, report prepared by AgEconPlus Consulting, Sydney, for the NSW Department of Environment and Climate Change, Sydney.

Altman J and Whitehead P 2003, *Caring for country and sustainable indigenous development: opportunities, constraints and innovation,* Canberra, CAEPR Working Paper 20/2003, Australian National University.

ANZECC & ARMCANZ 2000, *Australian Guidelines for Water Quality Monitoring and Reporting,* National Water Quality Management Strategy Paper No 7, Australian and New Zealand Environment Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra, see www.environment.gov.au/water/publications/quality/index.html#nwqmsguidelines

Argent N, Rolley F and Sorensen T 2007, *The economic geography of the Gwydir and Macquarie river catchment towns: current features, future prospects and challenges,* report prepared at the University of New England, Armidale, for the NSW Department of Environment and Climate Change, Sydney.

Armstead KJ and Johnson J 1993, *North West Rivers Audit,* Department of Land and Water Conservation, Sydney.

Australian Bureau of Statistics 1996, *Census of Population and Housing, Basic Community Profile, Time Series Profile and Working Population Profile,* Australian Bureau of Statistics.

Australian Bureau of Statistics 2006a, *Agricultural Census, NSW Statistical Local Areas,* Australian Bureau of Statistics.

Australian Bureau of Statistics 2006b, *Census of Population and Housing, Basic Community Profile, Time Series Profile and Working Population Profile,* Australian Bureau of Statistics.

Australian Bureau of Statistics 2010, *National Regional Profile, Local Government Areas (Moree Plains, Gwydir, Uralla, Guyra),* Australian Bureau of Statistics.

Australian Bureau of Statistics, Australia Bureau of Agricultural and Resource Economics and Bureau of Rural Sciences 2009, *Socio-economic context for the Murray-Darling Basin – descriptive report*, Report to the Murray–Darling Basin Authority, Canberra.

Australian Cottongrower 2009, *Cotton Yearbook 2009*, Towoomba.

Australian Government 2004, *Intergovernmental Agreement on a National Water Initiative,* Australian Government, Canberra.

Australian Heritage Commission 2002, *Australian Natural Heritage Charter for conservation of places of natural heritage significance*, second edition, Australian Heritage Commission, Canberra.

Australian Nature Conservation Agency 1996, *A directory of important wetlands in Australia,* Australian Nature Conservation Agency, Canberra.

Barnhart RK 1986, *Dictionary of science,* Houghton Mifflin Company, Boston, MA.

Baumgartner LJ, Reynoldson N and Gilligan DM 2006, 'Mortality of larval Murray cod *(Maccullochella peelii)* and golden perch *(Macquaria ambigua)* associated with passage through two types of low-head weirs', *Marine and Freshwater Research* 57, pp 187–91.

Baumgartner L, Reynoldson N, Cameron L and Stanger J 2007, *The effects of selected irrigation practices on fish of the Murray–Darling Basin*, Fisheries Final Report Series No. 92, NSW Department of Primary Industries, Cronulla.

Baumgartner L, Bettanin M, Doyle J and Stanger J 2009, *Impacts of weirs on downstream movement of native fish in the Murray Darling Basin*, pp.98–104, Proceedings of Native Fish Forum 2009, Murray-Darling Basin Authority.

Bennett M and Green J 1993, *Preliminary assessment of Gwydir Wetlands water needs,* NSW Department of Water Resources, Technical Services Division, Sydney, NSW.

Benson JS 2006, 'New South Wales vegetation classification and assessment: Introduction – the classification, database, assessment of protected areas and threat status of plant communities', *Cunninghamia* 9(3), pp 329–450.

Benson JS, Allen CB, Togher C and Lemmon J 2006, New South Wales vegetation classification and assessment: Part 1 Plant communities of the NSW western plains, *Cunninghamia* 9(3), pp 383–450.

Berkes F, Colding J and Folke C 2003, 'Introduction', in *Navigating Social-Ecological Systems: Building Resilience for Complexity and Change,* Cambridge University Press, Cambridge, UK.

Biosis Research 2008, *Macquarie Marshes and Gwydir Wetlands archaeological project,* Sydney, Report to Department of Environment and Climate Change NSW.

Blandford D, Douglas I, Maye B and Pigram JJ 1977, *Irrigation development in the lower Gwydir valley*, Australian Water Resources Council Technical Paper No 30, Australian Government Publishing Service, Canberra.

Border Rivers–Gwydir Catchment Management Authority 2007, *Border Rivers–Gwydir Catchment Action Plan,* Border Rivers–Gwydir Catchment Management Authority, Inverell.

Bowdler S 2005, 'Movement, exchange and ritual life in south-eastern Australia', in Macfarlane I, Mountain M and Paton R (eds), *Many exchanges: archaeology, history, community and the work of Isabel McBryde,* Aboriginal History Monograph 11, pp131–46.

Bowen, S & Simpson, S 2010, *Changes in extent and condition of floodplain wetland vegetation communities in the Gwydir Wetlands and floodplain 1996–2009*, Department of Environment and Climate Change, Sydney.

Burton J, van Oosterhout E and Ensby R 2010, 'Water hyacinth', *Primefact* 876, Industry and Investment NSW, Orange.

Byrne D and Nugent M 2004, *Mapping attachment: a spatial approach to Aboriginal post-contact heritage,* Department of Environment and Conservation NSW, Sydney, NSW.

Caddy H 2005, *Lower Gingham Watercourse floodplain management study,* New South Wales Department of Infrastructure, Planning and Natural Resources, Sydney, NSW.

Chong C and Walker KF 2005, 'Does lignum rely on a soil seed bank? Germination and reproductive phenology of *Muehlenbeckia florulenta* (Polygonaceae)', *Australian Journal of Botany* 53, pp 407–15.

Cogger HG 1996, *Reptiles and amphibians of Australia,* Reed Books, Melbourne, Australia.

Copeland C, Schooneveldt-Reid E and Neller S 2003, *Fish everywhere: an oral history of fish and their habitats in the Gwydir River,* NSW Fisheries, Ballina, NSW.

Courtney J 1997, 'An annotated list of the species of frogs (Amphibia: Anura) recorded from the Gwydir Wetlands, Moree (Report No 1)', in *Gwydir Wetlands; ecological response to flooding 1998,* McCosker RO (1999), report to NSW National Parks and Wildlife Service, Dubbo.

Cox SJ, Sivertsen DP and Bedward M 2001, 'Clearing of native vegetation in the New South Wales northern wheatbelt: extent, rate of loss, and implications for biodiversity conservation', *Cunninghamia* 7(1), pp 101–51.

Crawford P 2008, *Lippia (*Phyla canescens*) management; challenges, opportunities and strategies,* National Lippia Working Group.

CSIRO 2007, *Water availability in the Gwydir. A report to the Australian Government from the CSIRO Murray–Darling Basin Sustainable Yields Project,* CSIRO, Australia, 134 pp.

Department of Aboriginal Affairs 2003, *Two Ways Together: NSW Aboriginal Affairs Plan 2003–2012,* Department of Aboriginal Affairs, Sydney.

Department of Environment and Climate Change NSW 2006, *Aboriginal people, the environment and conservation,* Department of Environment and Climate Change NSW, Sydney.

Department of Environment and Climate Change NSW 2007, *An Aboriginal community engagement framework,* Department of Environment and Climate Change NSW, Sydney.

Department of Environment, Climate Change and Water NSW 2009, 'Species profile – coolibah–black box woodland of the northern riverine plains in the Darling Riverine Plains and Brigalow Belt South bioregions – Border Rivers/Gwydir: Distribution and vegetation associations in the Border Rivers/Gwydir', Department of Environment, Climate Change and Water NSW, see www.threatenedspecies.environment.nsw.gov.au/tsprofile.

Department of Environment Climate Change and Water 2010, *NSW climate impact profile*, Department of Environment Climate Change and Water, Sydney, see www.environment.nsw.gov.au/climatechange/understanding.htm.

Department of the Environment, Water, Heritage and the Arts 2009a, *Ramsar Convention on Wetlands*, Department of the Environment, Water, Heritage and the Arts, Canberra, see www.environment.gov.au/water/topics/wetlands/ramsar-convention/index.html.

Department of the Environment, Water, Heritage and the Arts 2009b, 'Weeping myall woodlands' Department of the Environment, Water, Heritage and the Arts, Canberra, see www.environment.gov.au/sprat.

Department of Infrastructure, Planning and Natural Resources 2004, *A guide to the water sharing plan for the Gwydir Regulated River Water Source,* Department of Infrastructure, Planning and Natural Resources, Sydney.

Department of Natural Resources 2006, *Lower Gingham Watercourse Floodplain Management Plan,* Department of Natural Resources, Sydney.

Department of Primary Industries 2005, *Native fish in irrigation supply offtakes,* Department of Primary Industries, Sydney.

Department of Primary Industries 2007, *Mortality of fish during downstream passage,* Department of Primary Industries, Sydney.

Department of Water Resources no date, *Water resources of the Gwydir Valley… doing more with water,* Department of Water Resources, Sydney.

Garnett S and Stilhole B 2007, *Sustainable northern landscapes and the nexus with Indigenous health: Healthy Country, Healthy People,* Land & Water Australia, Canberra.

Gehrke PC, Brown P, Schiller CB, Moffatt DB and Bruce AM 1995, 'River regulation and fish communities in the Murray–Darling river system, Australia', *Regulated Rivers: Research and Management* 11, pp 363–75.

Gilligan D, Hartwell D and McGregor C 2008, *Identification of 'hot-spots' of carp reproduction in the Murray-Darling Basin*, presentation to the 14th Australasian Vertebrate Pest Conference, Darwin, June 2008.

Goodall H 1996, *Invasion to embassy: land in Aboriginal politics in New South Wales, 1770–1972,* Allen and Unwin, Sydney.

Goodall H 2001, 'Renewing Country: Aboriginal people and their lands in rangeland environments', *Rangelands Journal* 23(1), pp 99–115.

Hassall & Associates 2007, *Technical review of irrigated agriculture in the Macquarie and Gwydir river catchments,* report prepared by Hassall & Associates Pty Ltd, Sydney, for the Department of Environment and Climate Change NSW, Sydney.

Holmes S, Speirs S, Berney P and Rose H 2009, *Guidelines for grazing in the Gwydir Wetlands and Macquarie Marshes,* NSW Department of Primary Industries.

Hope J 2004, 'The Aboriginal People of the Darling River', in Breckwoldt R, Boden R and Andrew J (eds), *The Darling,* Canberra, Murray–Darling Basin Commission, pp 8–21.

Humphries P, Serafini LG and King JA 2002, 'River regulation and fish larvae: variation through space and time', *Freshwater Biology* 47, pp 1307–31.

Industry & Investment NSW 2009, *NSW draft control plan for the noxious fish carp* (Cyprinus carpio)*,* Industry & Investment NSW.

Jeffcoat K 1996, *Major rural dams in New South Wales,* Department of Land and Water Conservation.

Jenkins KM and Wolfenden BJ 2006, *Invertebrates, fish and river flows: historical and baseline data analysis of the Macquarie Marshes Environmental Management Plan,* University of New England, Armidale.

Johnson W 2001, *Water for the environment in the Gwydir River; providing water for the environment from Copeton Dam,* report to the Gwydir Regulated River Management Committee, NSW National Parks and Wildlife Service, Dubbo.

Johnson WJ 2005, *Adaptive management of a complex social-ecological system: the regulated Macquarie River in south-eastern Australia,* thesis for the Master of Resource Science, University of New England, Armidale.

Keith, D 2004, *Ocean shores to desert dunes: the native vegetation of New South Wales and the ACT,* Department of Environment and Conservation NSW, Sydney.

Keith DA, Orschega C, Simpson CC, Clarke PJ, Hughes L, Kennelly S, Majora RE, Soderquist TR, Wilson AL and Bedward M 2009, 'A new approach and case study for estimating extent and rates of habitat loss for ecological communities', *Biological Conservation* 142, pp 1469–79.

Kelleway J, Mazumder D, Wilson GG, Saintilan N, Knowles L, Iles J and Kobayashi T 2010, 'Trophic structure of benthic resources and consumers varies across a regulated floodplain wetland', *Marine and Freshwater Research* 61, pp 430–40.

Keyte PA 1994, *Lower Gwydir Wetland Plan of Management – 1994 to 1997,* report by NSW Department of Water Resources for the Lower Gwydir Steering Committee, NSW Department of Water Resources, Sydney.

Lugg A 1999, *Eternal winter in our rivers: addressing the issue of cold water pollution,* NSW Fisheries, Nowra.

Marchant S and Higgins PJ 1990, *Handbook of Australian, New Zealand and Antarctic birds, vol.1: ratites to ducks,* Oxford University Press, Melbourne.

Marchant S and Higgins PJ 1993, *Handbook of Australian, New Zealand and Antarctic birds, vol.2: raptors to lapwings,* Oxford University Press, Melbourne.

Marsden Jacob Associates 2010, *Gwydir irrigation region community profile*, report to the Murray–Darling Basin Authority, Canberra.

Mawhinney W 2005, *Water quality in the Gwydir Catchment 2003–2004*, NSW Department of Natural Resources, Sydney.

McCosker RO 1994a, *The preparation of a plan of management for the Gingham Watercourse,* a thesis submitted at the University of New England for the degree of Master of Resource Science, University of New England, Armidale.

McCosker RO 1994b*, Lippia (*Phyla nodiflora*); an invasive plant of floodplain ecosystems in the Murray–Darling Basin,* Department of Ecosystem Management, University of New England, Armidale.

McCosker RO 1996, *Gwydir Wetlands; ecological response to flooding, 1995–1996,* report for the NSW National Parks and Wildlife Service, Dubbo.

McCosker RO 1997, 'Gwydir Watercourse vegetation map 1996' and 'Explanation of the vegetation types of the Gwydir floodplain', unpublished reports to the Department of Land and Water Conservation.

McCosker RO 1999a, *Gwydir Wetlands; ecological response to flooding 1997,* report for the NSW National Parks and Wildlife Service, Dubbo.

McCosker RO 1999b, *Gwydir Wetlands; ecological response to flooding 1998,* report for the NSW National Parks and Wildlife Service, Dubbo.

McCosker RO 2001, *Gwydir Wetlands; ecological response to flooding, 2000–2001,* report for the Gwydir Regulated River Management Committee, Tamworth.

McCosker RO 2007, *Gwydir floodplain vegetation map 2007 explanatory notes on vegetation communities,* report to the Department of Environment and Climate Change NSW, Sydney.

McCosker RO and Duggin JA 1993, *Gingham Watercourse Management Plan; final report,* Department of Ecosystem Management, University of New England, Armidale.

McCosker RO, Blanch SJ, Duggin JA and Brock MA 1993, *Lower Gwydir Watercourse Vegetation Survey – report,* University of New England, Armidale.

McCosker RO, Briszga SO, Arthington AA and Macfarlane W 1999, *Gwydir environmental scan: draft report to the Gwydir River Management Committee*, Department of Land and Water Conservation, Moree, NSW.

Meffe GK, Nielson LA, Knight RL and Schenborn DA 2002, *Ecosystem management: adaptive, community-based conservation,* Island Press, Washington, DC.

Middleton B 1999, 'Succession and herbivory in monsoonal wetlands', *Wetlands Ecology and Management* 6, pp 189–202.

Minister for Water Resources 1986, *WRC checks rural water meters,* press release, 23 July 1986.

Mitchell DS 1996, *The management of the Lower Gwydir and Gingham Watercourses,* consultancy report to the Gwydir Valley Irrigators' Association, Johnstone Centre of Parks, Recreation and Heritage, Charles Sturt University, Albury.

Morgan M, Strelein L and Weir J 2004, *Indigenous rights to water in the Murray Darling Basin: in support of the Indigenous final report to the Living Murray Initiative,* Native Title Research Unit, AIATSIS, Canberra.

Morris SA, Pollard DA, Gehrke PC and Pogonoski JJ 2001, *Threatened and potentially threatened freshwater fishes of coastal New South Wales and the Murray–Darling Basin,* NSW Fisheries.

Morse FC 1922, 'Egret and glossy ibis rookeries', *Emu* 22**,** pp 36–38.

Murray–Darling Basin Authority 2008, *Key elements of the Basin Plan*, see www.mdba.gov.au/basin_plan/concept-statement/key-elements

Murray–Darling Basin Commission 2003, *Native Fish Strategy,* Murray–Darling Basin Commission, Canberra.

Mussared D 1997, *Living on floodplains,* Cooperative Research Centre for Freshwater Ecology, Murray–Darling Basin Commission, Canberra.

NSW Government 2003, *Water Sharing Plan for the Gwydir Regulated River Water Source,* NSW Government, Sydney, see www.legislation.nsw.gov.au/maintop/view/inforce/subordleg+178+2003+cd+0+N

NSW Government 2005, *Darling River endangered ecological community,* Department of Primary Industries, Sydney.

Oliver DL and Parker DG 2006, *Woodland birds of the NSW Central Murray Catchment: measuring outcomes of the Greening Australia fencing and tree-planting program,* report for Birds Australia.

Pietsch TJ 2006, *Fluvial geomorphology and late quaternary geochronology of the Gwydir fan-plain*, PhD thesis, School of Earth and Environmental Science, University of Wollongong.

Pigram JJ 2007, *Australia's water resources: from use to management*, CSIRO Publishing, Collingwood.

Poff N, Leroy Allan JD, Bain MM, Karr JR, Prestegaard KL, Richter BD, Sparks RE and Stromberg JC 1997, 'The natural flow regime, a paradigm for river conservation and restoration', *BioScience* 47, pp 769–84.

Powell SJ, Letcher RA and Croke BFW 2008, 'Modelling floodplain inundation for environmental flows: Gwydir wetlands, Australia', *Ecological Modelling* 211, pp 350–62.

Preece R 2004, *Cold water pollution below dams in New South Wales; a desktop assessment,* NSW Department of Infrastructure, Planning and Natural Resources, Sydney.

Puckridge JT, Sheldon F, Walker KF and Boulton AJ 1998, 'Flow variability and the ecology of large rivers', *Marine and Freshwater Research* 49, pp 55–72.

Ramsar Convention 1987, *Convention on wetlands of international importance especially as waterfowl habitat*, see http://www.ramsar.org/key_conv_e.htm

Rea N 1994, *Water requirements of the Gwydir Valley Wetlands – an assessment and consolidation of prior studies*, NSW Department of Water Resources, Environmental Studies Unit, Sydney.

Reid JRW 1999, *Threatened and declining birds in the New South Wales sheep–wheat belt: diagnosis, characteristics and management,* consultancy report to the NSW National Parks and Wildlife Service, CSIRO Wildlife and Ecology, Canberra.

Roberts J and Marston F 2000, *Water regime of wetland and floodplain plants in the Murray–Darling Basin: a source book of ecological knowledge,* CSIRO Land and Water, Technical Report 30/00, Canberra.

Rose D 1996, *Nourishing terrains: Australian Aboriginal views of landscape and wilderness,* Australian Heritage Commission, Canberra.

Scholz JT and Stiftel B (eds) 2005, *Adaptive governance and water conflict: new institutions for collaborative planning,* Resources for the Future, Washington, DC, USA.

Siebentritt MA 1999, *Fish and the Lower Gwydir floodplain,* WetlandCare Australia, Berri, South Australia.

Spencer JA 2010, *Historical records of waterbirds and fish populations in the Gwydir wetlands,* final report for the NSW Wetland Recovery Program, Department of Environment and Climate Change NSW, Sydney.

Spencer JA, Heagney EC and Porter JL 2010, *Final report on the Gwydir waterbird and fish habitat study,* NSW Wetland Recovery Program, Department of Environment and Climate Change NSW, Sydney.

State Pollution Control Commission 1978, *Water hyacinth environmental study: background review*, NSW Government Printer, Sydney.

State Pollution Control Commission 1981, *Water hyacinth eradication campaign*, NSW State Pollution Control Commission, Sydney.

State Water Corporation 2009, *Water allocation reports: NSW water information*, see < www.waterinfo.nsw.gov.au/ac/allocation.shtml

The Resilience Alliance 2007, *Assessing and managing resilience in social-ecological systems: a practitioner's workbook,* vol. 1, v 1.0, see www.resalliance.org/3871.php

The Resilience Alliance 2009, *Key concepts*, see www.resalliance.org/576.php

Thomas RT, Lu Y, Cox S and Hunter S in press, 'Inundation mapping and monitoring in the Gwydir wetlands (1988–2008)', final report to the Wetland Recovery Program, Department of Environment, Climate Change and Water NSW, Sydney.

Torrible L, Wettin P and Roberts J 2008, *Gwydir Wetlands Knowledge Audit,* report for the Department of Environment and Climate Change NSW by IRPEC Pty Ltd, Annandale, Sydney, see www.wetlandrecovery.nsw.gov.au/download/GwydirWetlandsKnowledgeAudit.pdf

Torrible L, Sainty G and Hobcroft D 2009, *Assessment of the water dependent vegetation and fauna of the Mallowa Creek, results from a field visit February 2009,* IRPEC Pty Ltd.

Ward JV 1998, 'Riverine landscapes, biodiversity patterns, disturbance regimes, and aquatic conservation', *Biological Conservation* 83(3), pp 269–78.

Water Resources Commission 1984, *Gwydir River Basin; water demands, present supplies and possible future supply options,* Water Resources Commission, Sydney.

Waters Consulting 2008, *Oral history report: Aboriginal cultural values of the Macquarie Marshes and Gwydir Wetlands,* Sydney, report for Department of Environment and Climate Change NSW.

Water Resources Commission 1980, *Water Resources Inventory*, Water Resources Commission, Sydney.

Wilson GG, Berney PJ, Ryder DS and Price JN 2008, *Grazing/landuse in the Macquarie Marshes and Gwydir Wetlands*, final report to the Department of Environment and Climate Change NSW.

Wilson GG, Bickel TO, Berney PJ and Sisson JL 2009, *Managing environmental flows in an agricultural landscape: the Lower Gwydir floodplain,* final report to the Australian Government Department of the Environment, Water, Heritage and the Arts, University of New England and Cotton Catchment Communities CRC, Armidale.

Wilson S and Swan G 2003, *A complete guide to reptiles of Australia,* Reed New Holland, Sydney.

Witter D 1999, *Field guide to the archaeographic regions of Central New South Wales: a planning aid for Design Network and Construction*, Witter Archaeology report to NDC Ltd.

Wyllie SJ 2009, *Mallowa Creek surface flow: preliminary investigations,* Technical Report 2006/22, University of New South Wales Water Research Laboratory, Manly Vale.

Young WJ 2001, *Rivers as ecological systems: The Murray–Darling Basin,* Murray–Darling Basin Commission, Canberra.

Lower Broken Creek and Nine Mile Creek Environmental Watering Plan

May 2010

DOCUMENT STATUS

Version	Doc type	Reviewed by	Approved by	Date issued
V01i	Draft EWP – 2nd workshop			30/3/2010
V01k	Draft EWP		T Loffler	7/4/2010
V02	Final Draft EWP	D Judd	T Loffler	19/4/2010
V03	Final EWP	NVIRP/DSE	S Casanelia	28/5/2010

PROJECT DETAILS

Project Name	Lower Broken Creek and Nine Mile Creek EWP
Client	Goulburn Broken CMA on behalf of NVIRP
Client project manager	Simon Casanelia
Water Technology project manager	Tim Loffler
Report authors	Tim Loffler
Job number	J1412-01
Report number	R01
Document Name	1412-01_R01v02 Broken and Nine Mile EWP

Cover Photo: Nine Mile Creek, Reach 28, ISC photo
http://www.vicwaterdata.net/vicwaterdata/data_warehouse_content.aspx?option=5

First Floor, 103 Murphy Street, Wangaratta VIC 3677
PO Box 792, Wangaratta VIC 3676

Telephone 03 5721 2650
Fax 03 5721 3063

ACN No. 093 377 283
ABN No. 60 093 377 283

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. EXECUTIVE SUMMARY

The Broken, Boosey and Nine Mile Creek system lies within the Broken River Basin in the Goulburn-Broken catchment in northern Victoria. The flow regime of Broken Creek and its anabranch, Nine Mile Creek is highly modified with irrigation development commencing over 100 years ago. Broken Creek and Nine Mile Creek now carry irrigation water, with drains and outfalls from the Shepparton Irrigation Area and the Murray Valley Irrigation area within the Goulburn-Murray Irrigation District discharging directly to both waterways. Broken Creek and Nine Mile Creek have been altered from ephemeral systems, commonly ceasing to flow during summer and autumn, to perennial streams with significant flows maintained through summer and autumn to supply water for irrigation, stock and domestic use.

Despite (and in some cases because of) the hydrologic change, the Broken, Boosey and Nine Mile Creek system is recognised for locally and regionally significant environmental values including:

- The presence of Victorian and nationally threatened flora and fauna species dependent on the aquatic ecosystem including the nationally Vulnerable Murray Cod (*Maccullochella peelii peelii)* and the State Vulnerable Golden Perch *(Maquaria ambigu).*
- The presence of significant wetlands, with Broken Creek listed in the Directory of Important Wetlands in Australia and the Ramsar listed Barmah Forest on the Murray River at the downstream end of Broken Creek.
- The Broken-Boosey State Park system covering approximately 60% of the stream frontage downstream of Katamatite. The park system provides habitat for a range of threatened flora and fauna, contains stands of threatened Ecological Vegetation Classes and provides an important vegetated linear corridor across a generally cleared agricultural landscape.

The Northern Victoria Irrigation Renewal Project (NVIRP) is proposed to upgrade existing irrigation infrastructure in the Goulburn-Murray Irrigation District to achieve water savings. NVIRP proposes to rationalise and re-configure the existing outfalls from the Murray Valley Irrigation Area to the Broken Creek downstream of Katamatite, resulting in an expected reduction of 85% in the total volume of outfalls in excess of orders. The Shepparton Irrigation Area which has previously been upgraded will not be further modified under NVIRP.

This Environmental Watering Plan assesses the hydrologic impact of the NVIRP on the creek system downstream of Katamatite and reviews the likely impact of the hydrologic modification on the high value environmental assets. Of the high value environmental assets supported by the stream system, Murray Cod and Golden Perch are considered to be the most vulnerable to changes in the flow regime due to their high dependence on flow and water quality to provide suitable habitat and passage.

The hydrologic assessment indicates that the vast majority of inflows to the creek system come through channel outfall structures that connect directly to the creeks. Inflows through outfall structures are comprised of two parts – inflows ordered by local diverters or environmental managers, and inflows in excess of orders. However, the contribution of this ‘excess’ to total inflows is minor, especially post 2002/03 and a reduction in outfalls in excess of orders by 85% is expected to reduce monthly inflows by less than 4% in the creek system based on the 2004/05 base case. This is equivalent to approximately 6.6 ML/d along a waterway that is 196 km long and is not expected to impact on its high value environmental assets and in particular Murray Cod and Golden Perch habitat and passage. Therefore, mitigation water is not required to protect the environmental assets. However, due to the ongoing dependency of the environmental values on ordered inflows, the delivery of water through the irrigation areas (e.g. River Murray Water passed through the Murray Valley Irrigation Area) to the Broken Creek should continue. In addition, flows of 100-250 ML/d past Rices Weir (the bottom of the creek system) are required between September and April to provide habitat and passage for native fish. These flows cannot always be met by inflows ordered by local diverters, environmental managers, inflows in excess of orders and inflows from the upstream catchments and drains. Therefore, the NVIRP will investigate increasing the capacity of the Murray Valley Irrigation Area infrastructure so River Murray water can be diverted through the creek system to help supply the required flows.

2. PURPOSE OF THE PLAN

The Broken Creek system in northern Victoria currently conveys water used for irrigation within the Goulburn-Murray Irrigation District (GMID). The hydrology of the Broken Creek system has been significantly modified. However the system supports a range of high value environmental assets, some of which are dependent on the modified hydrologic regime resulting from the delivery of irrigation water. The implementation of the Northern Victoria Irrigation Renewal Project (NVIRP) is intended to improve the efficiency of the GMID and will result in hydrologic modification due to reduced outfall volumes to the Broken Creek system.

This Environmental Watering Plan (EWP) has been prepared as a component of the Water Change Management Framework (WCMF) which is the means by which the effects of implementation of NVIRP on aquatic and riparian ecological values will be assessed, managed and mitigated (NVIRP 2010). The need for an EWP for the Broken Creek system was determined following a short-listing process which identified the presence of high value environmental assets comprising threatened flora and fauna species potentially impacted by a change in outfall water volumes (Feehan Consulting 2009).

This EWP documents the current aquatic and riparian ecological values within those reaches of the Broken Creek system likely to experience hydrologic modification as a result of implementation of NVIRP. The likely impact of the hydrologic modification on these assets is considered and where necessary means to mitigate these impacts, either through the delivery of "mitigation water[1]" or the implementation of complementary actions are identified. The EWP focuses on identifying and mitigating negative impacts of NVIRP and does not specifically consider any positive environmental outcomes which may result, albeit that none have been identified during the EWP development process.

The EWP specifically relates to the impact of NVIRP on the regulated flow regime which, within the subject reaches of the Broken Creek system, comprises in channel flows. NVIRP is not expected to have any impact on the occurrence or passage of flood events which may inundate riparian and floodplain zones and thus the EWP does not relate to or discuss environmental assets which are reliant on watering in events larger than those managed by system regulation.

The EWP is only a component of the overall management framework for the Broken Creek system. The EWP will be implemented in the context of broader strategies which provide for the integrated management of the waterway and catchment, along with the hydrologic regime, including:

- Overarching waterway and catchment management plans (that consider integrated land, water and biodiversity management of the waterway) such as the Lower Broken Creek Waterway Management Strategy (GHD / URS 2005), Biodiversity Action Plans (Heard 2007 and DSE 2008) and the Broken-Boosey State Park Management Plan (Parks Victoria 2006).
- Agency roles and responsibilities documented in the NVIRP Water Change Management Framework (WCMF) (NVIRP 2010), the Northern Region Sustainable Water Strategy (DSE 2009) and the Lower Broken Creek operational guidelines (G-MW 2003).
- Victorian and regional strategies for healthy rivers, estuaries and waterways (still in development but likely to contain details of how environmental water is to be managed in regions).

[1] Mitigation water is defined as the water that is required to ensure no net impacts due to NVIRP on high environmental values (NVIRP 2010).

3. BACKGROUND

3.1 NVIRP

NVIRP proposes to upgrade existing irrigation infrastructure in the GMID. The upgrade works will improve the efficiency of water delivery through automation, remediation and reconfiguration of the channel system and implementation of modern metering and control systems. The resultant water savings from Stage 1 of NVIRP will be shared equally between the environment, irrigators and consumption in Melbourne (NVIRP 2010).

In relation to the Broken Creek system, NVIRP will rationalise and re-configure the existing outfalls to Broken Creek. Through the system rationalisation and improved system operation, the total volume of outfalls in excess of orders is expected to reduce by 85%.

3.2 EES decision

In February 2009, NVIRP submitted a referral to the Victorian Minister for Planning seeking advice as to the requirement for preparation of an Environment Effects Statement (EES) under the Environment Effects Act 1978. The Minister for Planning's decision (14 April 2009) stated that NVIRP did not require an EES subject to NVIRP complying with certain conditions. Full details of the referral and the Minister for Planning's decision are available at DPCD (2010). Of the five conditions, two related directly to the protection of wetlands and waterways, as outlined below.

> **Condition 3** – *Before operation of the relevant works commences, NVIRP must prepare a framework for protection of aquatic and riparian ecological values through management of water allocations and flows within the modified GMID system to the satisfaction of the Minister for Water...*

A Water Change Management Framework (WCMF) (NVIRP 2010) has been developed by NVIRP to address the requirements of Condition 3 of the Minister for Planning's decision as discussed in Section 3.3.

> **Condition 5** – *Before operation of relevant works commences, an approved Environmental Watering Plan is required for 'at risk' waterways and wetlands ... Approval of an Environmental Watering Plan is required prior to operation of modified irrigation infrastructure that could affect 'at risk' waterways or wetlands.*

Broken Creek is identified in the Minister for Planning's decision as an 'at risk' waterway and thus development and approval of an EWP is required prior to operation of modified irrigation infrastructure. This document (Lower Broken Creek and Nine Mile Creek Environmental Watering Plan) has been prepared to address Condition 5 of the Minister for Planning's decision.

3.3 WCMF

A Water Change Management Framework (WCMF) has been developed by NVIRP to satisfy the requirements of Condition 3 of the Minister for Planning's decision as outlined in Section 3.2. The WCMF was signed off in August 2009 but NVIRP is currently revising the WCMF. The WCMF (NVIRP 2010) identifies the following key environmental principles for operation of the modified GMID:

- NVIRP will strive for efficiency in both water supply and farm watering systems.
- NVIRP will design and construct the modernised GMID system to comply with environmental requirements as specified in the no-EES conditions.

- NVIRP will develop management and mitigation measures consistent with established environmental policies and programs in place in the GMID.
- Renewal or refurbishment of water infrastructure will be undertaken to the current best environmental practice, including any requirements to better provide environmental water. Best environmental practice will require irrigation infrastructure required to deliver environmental water to be retained (no rationalisation at these waterways or wetlands) or upgraded to allow for future use.
- Management and mitigation measures will be maintained into the future through establishment of or modification to operating protocols and operational arrangements.

Additionally, the WCMF (NVIRP 2010) identifies additional environmental principles guiding the development of the WCMF:

- NVIRP will adopt a risk management approach and will aim to:
    - Avoid and mitigate the adverse effects of NVIRP's implementation on high environmental values associated with wetlands and waterways.
    - Avoid adverse effects on other environmental values where practicable.
    - Retain infrastructure, and improving it where practicable, where it will be required for delivering environmental water by others, either now or in the future.
- NVIRP will actively seek to coordinate with relevant agencies to identify and assess impacts and to deliver effective management and mitigation measures.
- NVIRP will consult with relevant environment and land managers to identify infrastructure requirements for environmental watering.
- NVIRP will adopt an adaptive management approach (assess, design, implement, monitor, evaluate and adjust) to ensure that it is responsive to changing conditions (refer Section 11).
- NVIRP will ensure that adequate resources are provided to implement, monitor and review mitigation measures.

As required by the Minister for Planning's decision (refer Section 3.2), the WCMF establishes the process and methodology for preparation of EWPs to mitigate potential impacts of wetlands and waterways at risk from the implementation of the NVIRP through adaptive water management. This EWP for Lower Broken Creek and Nine Mile Creek has been prepared in accordance with the WCMF (NVIRP 2010).

3.4 Short listing process

The identification of wetlands and waterways potentially at risk from the implementation of NVIRP has been undertaken in stages as outlined below:

- A desktop assessment (SKM 2008) was undertaken to inform the referral submitted to the Minister for Planning under the Environment Effects Act 1978. This desktop assessment process included (NVIRP 2010):
    - Identification of wetlands / waterways in the GMID.
    - Identification of high environmental values.
    - Assessment of type of connection to the irrigation system.
    - Assessment of the relative contribution of irrigation water to the flow regime of the wetland / waterway.

  The desktop assessment resulted in the identification of a preliminary list of wetlands and waterways with high environmental values whose water regime is likely to be altered by implementation of NVIRP or where insufficient data are available to determine if the water regime is likely to be altered by the implementation of NVIRP.

Broken Creek was included in the list of waterways with high environmental values potentially exposed to a change in hydrology as a result of implementation of NVIRP.

- The Minister for Planning's decision (DPCD 2010) identified 17 wetlands and 15 waterways as potentially 'at risk' from implementation of NVIRP.

  The Minister for Planning's decision required the development of an EWP (refer Section 3.2) for 'at risk' waterways unless subsequent investigation revealed that specific waterways were not at risk.

  Broken Creek was one of the listed 'at risk' waterways[2].

- A Waterway Short-Listing Report (Feehan Consulting 2009) was prepared to further investigate the exposure of the 17 wetlands and 15 waterways listed in the Minister for Planning's decision to significant impacts from implementation of NVIRP. The method for the Waterway Short-Listing Report comprised (Feehan Consulting 2009):
  - Reviewing the Desktop report and recommendations relevant to the waterways assessed.
  - Documenting environmental values of candidate waterways by undertaking a review of relevant reports and literature, discussions with key staff and site field visits
  - Documenting more detailed information about channel outfalls and the hydrological regime of candidate waterways (if available)
  - Assessing the likelihood for significant negative impacts to be caused by a reduction in outfalls to waterways, and whether or not further work, or the development of an EWP, was warranted.

  Broken Creek (including a short reach of Boosey Creek downstream of Katamatite) was identified as one of five waterway systems 'at risk' from the implementation of NVIRP and therefore requiring the development of an EWP.

[2] Nine Mile Creek discussed in this EWP is an anabranch of Broken Creek and forms part of the Broken Creek system referred to in the Minister for Planning's decision. The Nine Mile Creek referred to in Attachment A to the Minister for Planning's decision is a part of the Serpentine Creek system in the Loddon catchment.

4. WATERWAY DESCRIPTION – THE BROKEN CREEK STREAM SYSTEM

The Broken, Boosey and Nine Mile Creek system lies within the Broken River Basin in the Goulburn-Broken catchment in northern Victoria. Broken Creek discharges to the Murray River upstream of Barmah while the Broken River discharges to the Goulburn River at Shepparton.

Broken Creek is a distributary channel of the Broken River, commencing at Casey's Weir on the Broken River approximately 10 km north of Benalla. From Caseys Weir, Broken Creek flows generally north and north-west for approximately 84 km to its confluence with Boosey Creek south-west of Katamatite. Broken Creek then trends generally west and north-west, flowing through Numurkah and Nathalia before entering the Murray River approximately 12 km upstream of the township of Barmah within the Barmah-Millewa Forest (SKM 1996).

Tributaries of Broken Creek include Boosey Creek, the Majors Creek and Nine Mile Creek system and Pine Lodge Creek. Boosey Creek drains the western slopes of the Warby Ranges near Wangaratta and enters Broken Creek at Katamatite. Majors Creek and Nine Mile Creek drain the area from Dookie to Youanmite before entering Broken Creek to the west of Katamatite immediately upstream of the Katandra or East Goulburn Main Channel weir. Downstream of the weir, Nine Mile Creek forms a regulated anabranch of Broken Creek over a length of approximately 50 km. Pine Lodge Creek enters Nine Mile Creek upstream from the confluence with Broken Creek. The arrangement of the major watercourses of the region is shown in Figure 4-1. The waterway reaches covered by this EWP (refer Section 4.2) are highlighted in Figure 4-1.

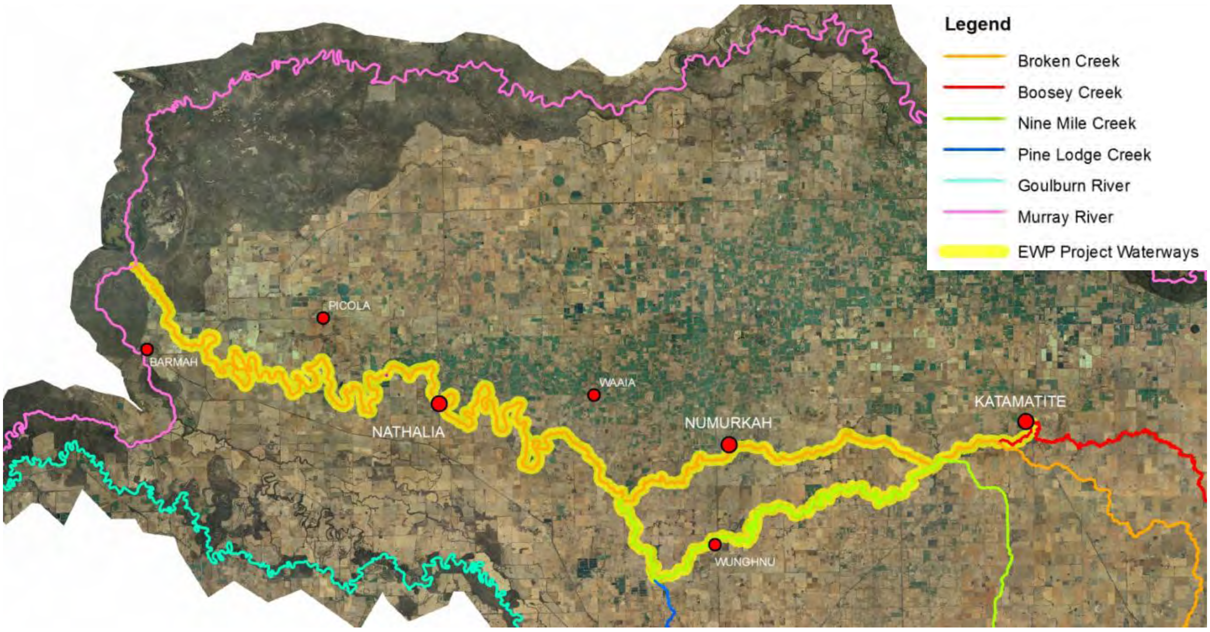


Figure 4-1 The Broken Creek waterway system

4.1 Spatial information and catchment setting

4.1.1 Catchment

The catchment area of Broken Creek covers approximately 3300 km^2 of the Murray Valley Riverine Plains (SKM 1996), encompassing the western slopes of the Warby Ranges and northern slopes of the foothills around Dookie. In addition to flows from the immediate catchment, Broken Creek historically received floodwaters from the catchment of the Broken River upstream of the present location of Caseys Weir in approximately 1 year in 5 (Reich *et al.* 2009) however the regulation of the system for irrigation has significantly modified the hydrologic regime in Broken Creek (refer Section 7).

Much of the catchment is cleared for grazing, with dairy farming the dominant land use in irrigated areas (SKM 1998). The Murray Valley and Shepparton irrigation districts lie generally to the north and south of Broken Creek within the current project area and cover 34% of the Broken Creek catchment (SKM 1998). Well developed drainage systems and arterial drains are features of these irrigation districts with numerous outfalls to Broken Creek and Nine Mile Creek (SKM 1998).

The project area lies within the Victorian Riverina and Murray Fans Bioregions.

4.1.2 Land use and management

The Broken Creek catchment lies in an area of intensive agricultural production, dominated by grazing in the south and mixed cereal and dryland grazing in the central region. The northern part of the catchment lies within the Murray Valley irrigation district where intensive horticultural, dairy and livestock production occurs (GBCMA 2005). The history of agricultural development has resulted in large scale land clearing and less than 3% of pre-European vegetation cover remains, with the majority of this located along the creeks and in Public Land reserves (DSE 2008). A significant portion of the stream frontage within the project area lies within State Park and Natural Features Reserves managed by Parks Victoria, namely:

- Broken Boosey State Park : 43.7 km of frontage within EWP project area
- Numurkah Natural Features Reserve : 50 km of frontage within EWP project area
- Nathalia Natural Features Reserve : 27.1 km of frontage within EWP project area
- Barmah State Forest : 5.4 km of frontage (one bank only) within EWP project area

4.1.3 History and impact of river regulation

Prior to the development of irrigation infrastructure, Broken Creek was an ephemeral system with flows dominantly occurring in winter and early spring. The current irrigation infrastructure and management has transformed the system to a largely perennial system with dominant summer flows and permanent weir pools (GHD / URS 2005). Irrigation within the project area occurs by pumping from the Broken Creek and Nine Mile Creek waterways. Annual diversion entitlement volumes for the Broken Creek system are summarised in Table 4-1. The diversion entitlements are dominantly located in the Lower Broken Creek system (EWP reaches 3 and 4 as discussed in Section 4.2).

Table 4-1 Broken Creek system – Diversion entitlements (GHD / URS 2005 after SKM 1998)

Waterway	Total diversion entitlement (ML/yr)	Supply source
Boosey Creek	359	–
Upper Broken Creek (above Katandra)	7044	Caseys Weir
Lower Broken Creek (Katandra Weir to Walshs Bridge[1])	4811	East Goulburn Main Channel (EGMC)
Lower Broken Creek (Walshs Bridge[1] to Rices Weir)	14342	
Nine Mile Creek	7245	

1. Walshs Bridge is located approximately 3 km downstream of the confluence of Broken Creek and Nine Mile Creek.

Irrigation development has occurred in stages, with the most significant impacts of regulation occurring since the 1960s when delivery of significant quantities of water via the EGMC from Goulburn Weir commenced. The principal stages of development, as documented in SKM (1996) (cited in GHD / URS 2005) included:

- Broken Creek used to supply stock and domestic water since the earliest days of settlement.
- Low timber weirs constructed in the lower Broken Creek in the late 1800s to improve the reliability of supply.
- East Goulburn Main Channel (EGMC) from Goulburn Weir constructed in 1911.
- EGMC extended to Nine Mile Creek at Katandra Weir (near the Broken Creek confluence), assuming its current form in 1929.
- Relatively small scale diversions of water from Broken Creek continued until the 1940s when the first channel outfalls were constructed.
- Yarrawonga Weir on the Murray River constructed in 1939, enabling the development of the Murray Valley irrigation area and associated drainage outfalls to the north of Broken Creek (SKM 1998).
- Weirs on the Broken Creek system were upgraded and parts of Nine Mile Creek and Broken Creek were regraded (re-aligned?) in the 1960s to facilitate drainage outfalls for irrigation development.
- Delivery of significant volumes of water via the EGMC commenced in the 1960s.
- Significant upgrading and automation of weirs and installation of fishways occurred between 1997 and 2003.

Broken Creek has thus been subject to a regulated flow regime for over 100 years, with peak irrigation development having occurred in the last 50 years. The aquatic and riparian ecosystems and communities present along the Broken Creek system within the EWP project area are thus significantly modified from those occurring under pre-regulation conditions.

4.2 Proposed EWP reaches

The project area for the current EWP covers the reaches of the Broken Creek system where the hydrologic regime is likely to be impacted by the modifications to the channel and drainage network proposed under NVIRP. The current EWP thus relates to a short reach of Boosey Creek downstream of the 7/3 Channel Outfall in Katamatite to its confluence with Broken Creek, Broken Creek downstream of its confluence with Boosey Creek and the length of Nine Mile Creek downstream of the EGMC Weir at Katandra.

Reach breaks for the EWP have been identified based on consideration of the hydrologic regime (determined by the location of tributaries, channel outfalls and drain outfalls), system operation and channel morphology. Four reaches are proposed:

- Reach 1 – 42.6 km
  - Boosey Creek downstream of the 7/3 Channel Outfall through to the confluence with Broken Creek (4.1 km).
  - Broken Creek from the confluence with Boosey Creek to the confluence with Nine Mile Creek west of Numurkah (38.5 km).
- Reach 2 – 49.8 km
  - Nine Mile Creek downstream from the EGMC Weir at Katandra (the offtake from Broken Creek) to the confluence with Broken Creek west of Numurkah.
- Reach 3 – 37.9 km
  - Broken Creek downstream of the confluence with Nine Mile Creek to the Nathalia town weir.
- Reach 4 – 65.8 km
  - Broken Creek downstream of the Nathalia town weir through to the confluence with the Murray River.

Reach extents are indicated in Figure 4-2. More detailed aerial imagery for each reach is provided in Figure 4-3 to Figure 4-6 while detailed project reach maps are provided in Appendix A.

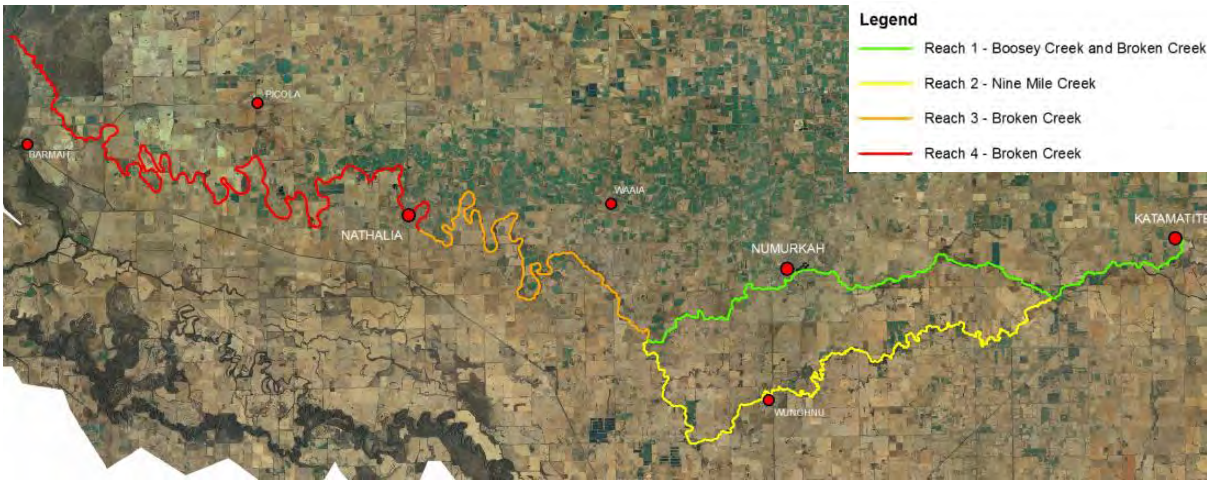


Figure 4-2 EWP project area and project reaches

4.2.1 Reach 1 – General description

Reach 1 comprises a short length (4.1 km) of Boosey Creek between Katamatite and Broken Creek and a 38.5 km reach of Broken Creek between Boosey Creek and the confluence of Broken Creek and Nine Mile Creek (refer Figure 4-3). The majority of the riparian land adjoining the streams in Reach 1 lies within the Broken-Boosey State Park (Boosey Creek) and the Numurkah Natural Features Reserve (Broken Creek) and is managed by Parks Victoria (refer Section 4.1.2).

Significant features within Reach 1 include:

- Discharge from the 7/3 channel outfall at Katamatite, defining the upstream end of Reach 1.
- The township of Katamatite located generally on the north-west bank of Boosey Creek.
- The offtake of Nine Mile Creek. The EGMC enters Nine Mile Creek a short distance downstream of Broken Creek. The flow distribution between Nine Mile Creek and Broken Creek is managed by a weir on each stream immediately downstream of the Nine Mile Creek offtake.
- The township of Numurkah located on both banks of Broken Creek near the downstream end of the reach.
- Two weirs (Station Street and Melville Street) located on Broken Creek within Numurkah
- Kinnairds Swamp located on the north bank of Broken Creek immediately upstream of Numurkah. Kinnairds Swamp is a part-public and part-privately owned wetland complex at the confluence of the Muckatah Depression and Broken Creek. Along with a suite of environmental attributes, Kinnairds Swamp also serves as a retardation basin and water quality improvement system for the Muckatah Surface Water Management Scheme (DPI 2003).

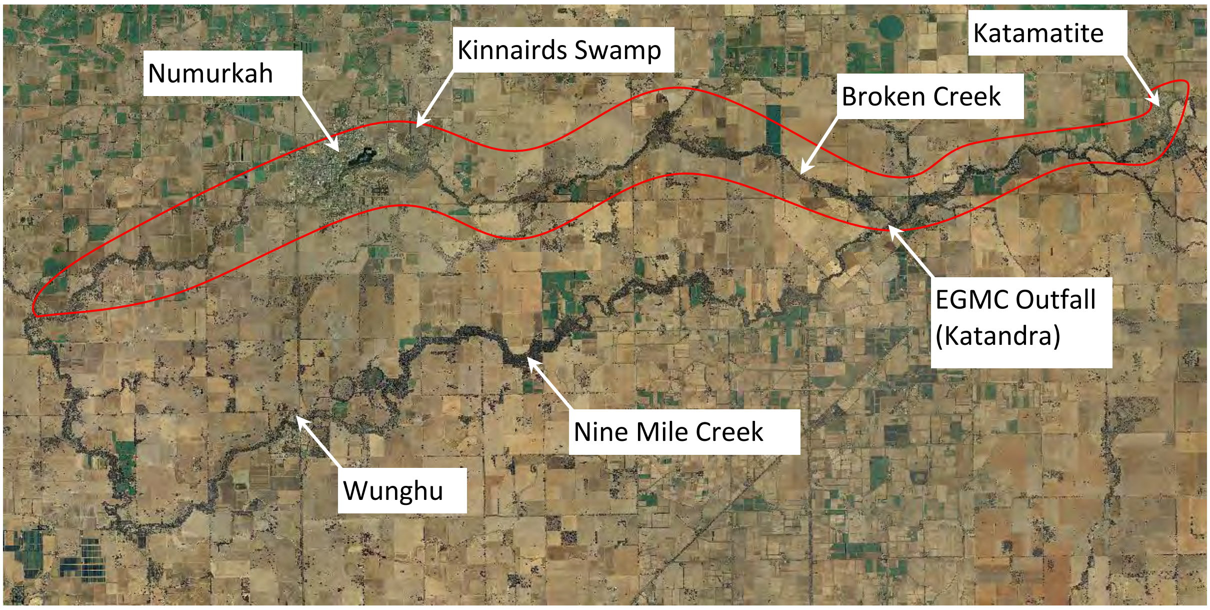


Figure 4-3 Reach 1 extent and aerial image

4.2.2 Reach 2 – General description

Reach 2 comprises a 49.8 km length of Nine Mile Creek between the EGMC Weir and the downstream confluence of Nine Mile Creek and Broken Creek (refer Figure 4-4). Nine Mile Creek in Reach 2 forms a regulated anabranch of Broken Creek, with a 70:30 flow distribution between Nine Mile Creek and Broken Creek. The EGMC weir is used to regulate the distribution of flows delivered to the system via the EGMC.

The entire length of Nine Mile Creek in Reach 2 upstream of Wunghu lies within the Broken-Boosey State Park managed by Parks Victoria (refer Section 4.1.2). Frontage over the remainder of the stream (between Wunghu and the confluence with Broken Creek) lies within public land water frontage.

Significant features within Reach 2 include:

- The outfall from the EGMC and the associated EGMC Weir on Nine Mile Creek immediately downstream of the offtake from Broken Creek.
- The township of Wunghu, located generally on the south bank of Nine Mile Creek.
- The Black Swamp and Purdies Swamp system lying to the north of Broken Creek immediately upstream of Wunghu.
- The confluence with Pine Lodge Creek near the downstream end of Reach 2. The lower reaches of Pine Lodge Creek are modified and form the outfall of Shepparton Irrigation District Drain 11.

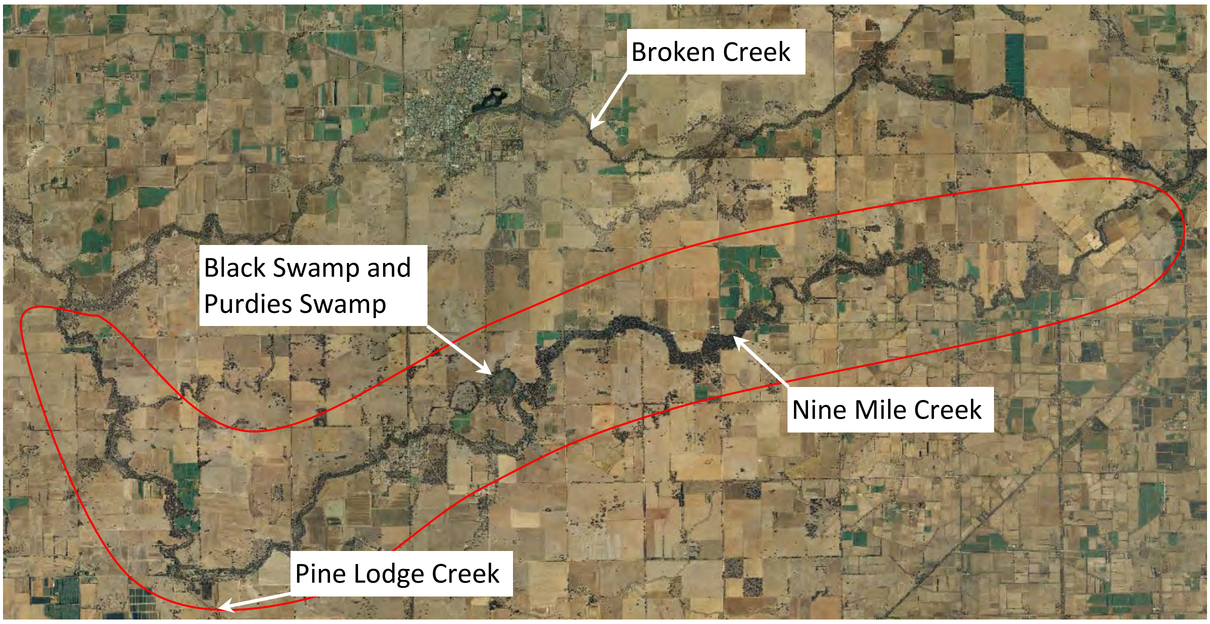


Figure 4-4 Reach 2 extent and aerial image

4.2.3 Reach 3 – General description

Reach 3 comprises a 37.8 km length of Broken Creek between the Nine Mile Creek confluence and Nathalia Weir (refer Figure 4-5). Apart from the Nathalia Weir defining the downstream end of the reach there are no other weirs on Broken Creek within this reach. The morphology of the stream changes mid-reach (approximately in the middle of Figure 4-5) where Broken Creek enters the Tallygaroopna Channel (a relic feature of the Goulburn River) and adopts significantly different meander geometry.

The stream frontage over the majority of this reach lies within the Numurkah Natural Features Reserve managed by Parks Victoria (refer Section 4.1.2). The remaining length (extending for approximately 11 km upstream of Nathalia) lies within public land water frontage.

Carlands Swamp is located to the south of Broken Creek approximately mid-reach.

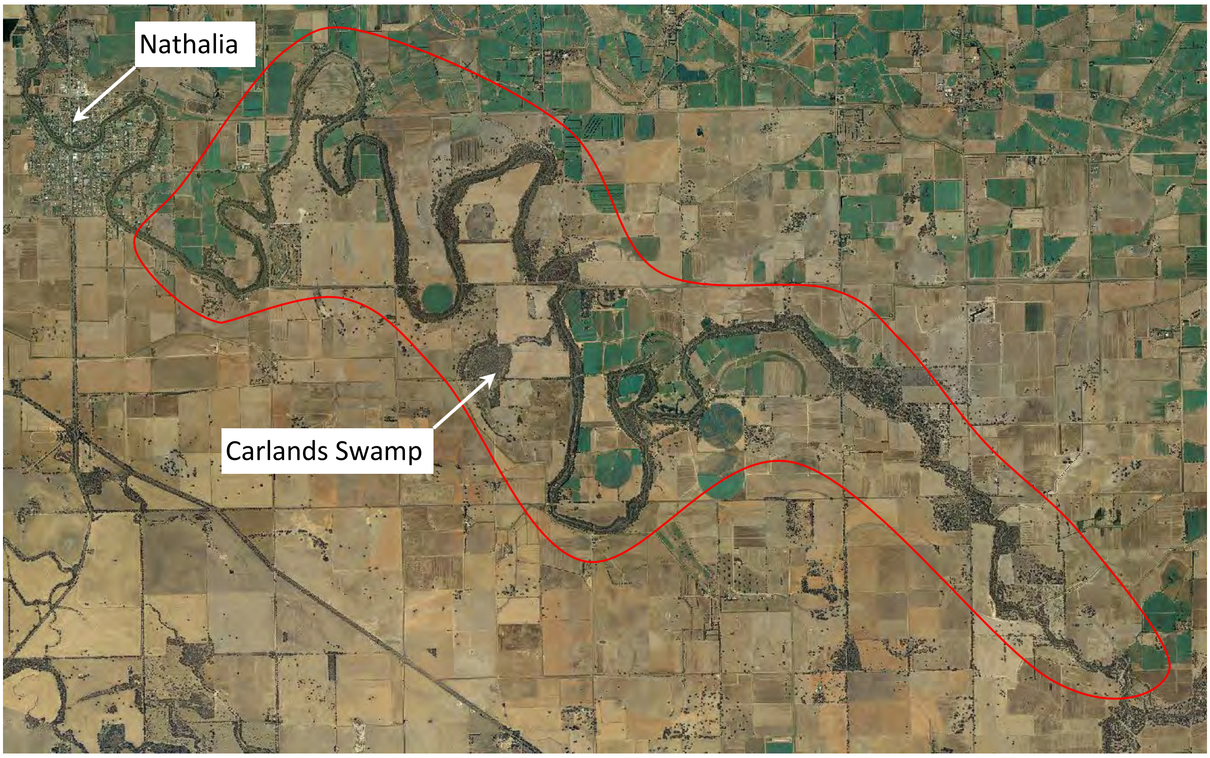


Figure 4-5 Reach 3 extent and aerial image

4.2.4 Reach 4 – General description

Reach 4 comprises a 65.8 km length of Broken Creek downstream of Nathalia Weir. Broken Creek within this reach occupies the ancestral Tallygaroopna Channel (refer Section 6.2) resulting in a larger meander wavelength and amplitude than that in upstream reaches. The character of this reach is however largely determined by the regulated flow regime and the presence of eight low weirs managed to provide a near-constant water level over the entire length of the stream, facilitating the extraction of irrigation water by pumping. The distance and drop in pool level between adjacent weirs is summarised in Table 4-2. The location of each weir is shown in the reach map in Appendix A.

Rices Weir is the most downstream weir on Broken Creek and is located approximately 1 km upstream of the confluence of the Murray River and Broken Creek within the Barmah State Park.

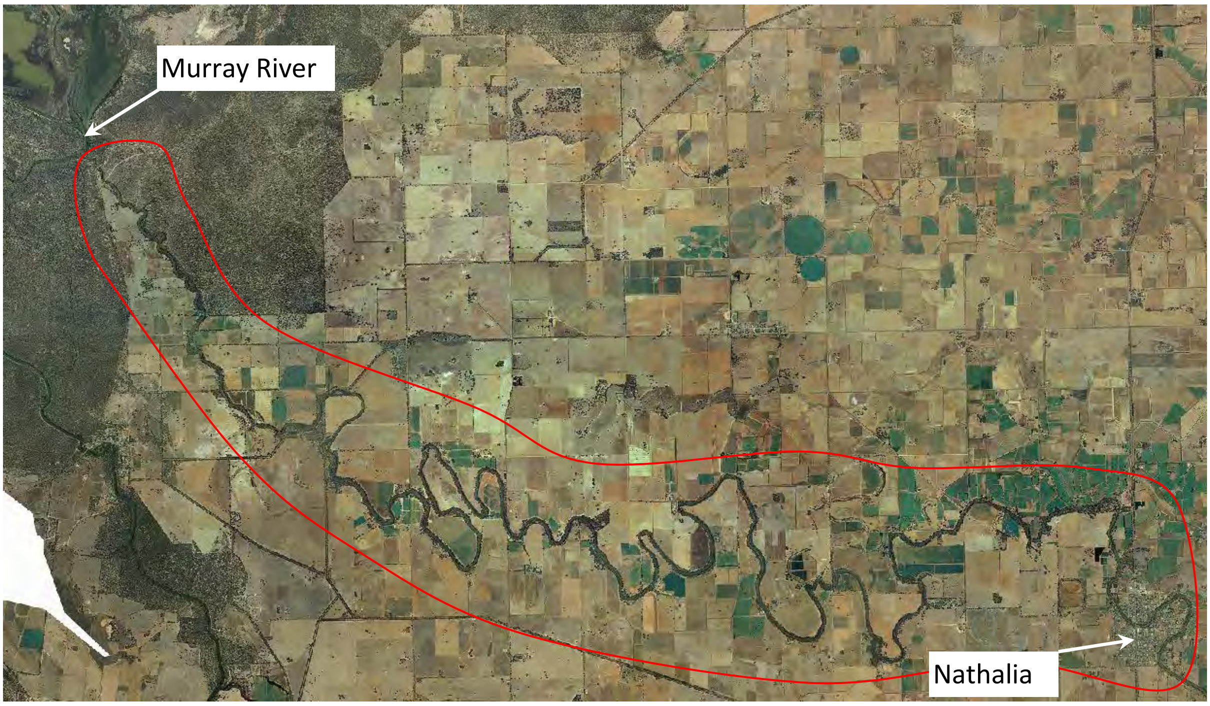


Figure 4-6 Reach 4 extent and aerial image

Table 4-2 Reach 4 weir details

Upstream weir	**Downstream weir**	**Distance [1] (km)**	**Drop in pool level [2] (m)**
Nathalia (Town)	Chinamans	4.8	0.69
Chinamans	Balls	6.1	0.95
Balls	Lukes	8.9	0.92
Lukes	Hardings	13.7	1.05
Hardings	Schiers	9.6	0.38
Schiers	Kennedys	8.9	0.66
Kennedys	Rices	12.8	1.1
Rices	Murray River	1.0	

Notes:
1. Stream length based on supplied GIS information
2. At maximum operating level, based on SKM (2003)

4.3 Previous relevant studies

The Broken-Boosey Creek system is highly modified from its natural condition, largely as a result of the altered flow regime brought about through regulation and use of the system to convey irrigation flows. Despite this hydrologic impact the Broken-Boosey Creek system (including Nine Mile Creek) is recognised for locally and regionally significant values demonstrated through the range of existing studies and plans relating to the management of the system. Values and studies of particular relevance to the EWP process are briefly discussed in the following sections.

4.3.1 The Goulburn Broken Regional River Health Strategy

The Goulburn Broken Regional River Health Strategy 2005-2015 (GBCMA 2005) provides the strategic framework for the protection and enhancement of river health and water quality within the Goulburn Broken catchment and aims to achieve four main objectives for the rivers and streams of the Goulburn Broken catchment:

- "Enhance and protect the rivers that are of highest community value (environmental, social and economic) from any decline in condition;
- Maintaining the condition of ecologically healthy rivers;
- Achieving an 'overall improvement' in the environmental condition of the remainder of rivers;
- Preventing damage from inappropriate development and activities." (GBCMA 2005)

The majority of the project area for development of the current EWP lies within Management Unit L2 (Lower Broken Creek) as identified in the Regional River Health Strategy (GBCMA 2005) and shown in Figure 4-7. The lower section of Boosey Creek and the short reach of Broken Creek upstream of Katandra Weir lie within Management Unit M6 (Upper Broken and Boosey Creeks). The Regional River Health Strategy adopts the reach breaks defined by the statewide Index of Stream Condition (ISC) program as shown in Figure 4-8. While the ISC reach breaks do not correspond exactly with the reach breaks proposed for the EWP process, the ISC reaches associated with each EWP reach are summarised in Table 4-3.

Table 4-3 Reach summary

	EWP Reach 1	EWP Reach 2	EWP Reach 3	EWP Reach 4
RRHS Management Unit	M6 (Broken Creek and Boosey Creek) L2 (Broken Creek D/S of Katandra Weir)	L2 (Nine Mile Creek D/S of Katandra Weir)	L2 (Broken Creek D/S of Katandra Weir)	L2 (Broken Creek D/S of Katandra Weir)
ISC Reaches	32 (Boosey Creek) 24 (Broken Creek)	28 (Nine Mile Creek)	23 (Broken Creek)	21 (Broken Creek) 22 (Broken Creek)

GBCMA (2005) identifies the following reaches of Broken Creek within the current project area as High Priority reaches within the Goulburn Broken catchment, based on their value to the community, namely:

- Association with significant wetlands:
  - Broken Creek – Reach 21 (part of EWP Reach 4) – associated with the Ramsar listed Barmah-Millewa Forest wetland
  - Broken Creek – Reaches 22-26 (EWP Reaches 1, 3 and 4) – associated with various wetlands (Broken Creek, Muckatah Depression) listed in the Directory of Important

Wetlands in Australia (refer Section 4.3.3). The wetland listing extends from 8 km NNW of Benalla to the Barmah Forest, covering an area of 2500 ha.

- Presence of fauna listed under the Federal Environment Protection and Biodiversity Act, 1999 (EPBC) and Australian Rare or Threatened (AROT) flora critically dependent on stream environments
  - Broken Creek – Reaches 21, 22 and 23 (EWP Reaches 3 and 4) – presence of Murray cod (Murray cod are also known to be present in the Katandra Weir pool (upstream end of Reach 24 (O'Connor 2008)

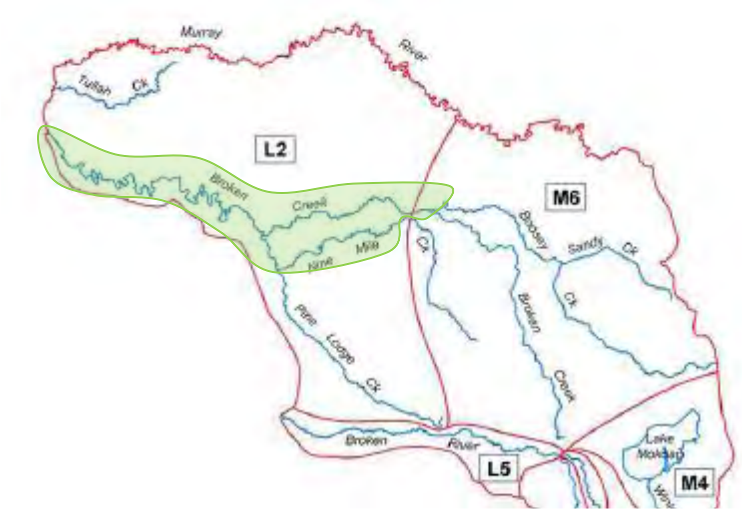


Figure 4-7 Regional River Health Strategy (GBCMA 2005) – Broken Basin Management Units (EWP project area highlighted)

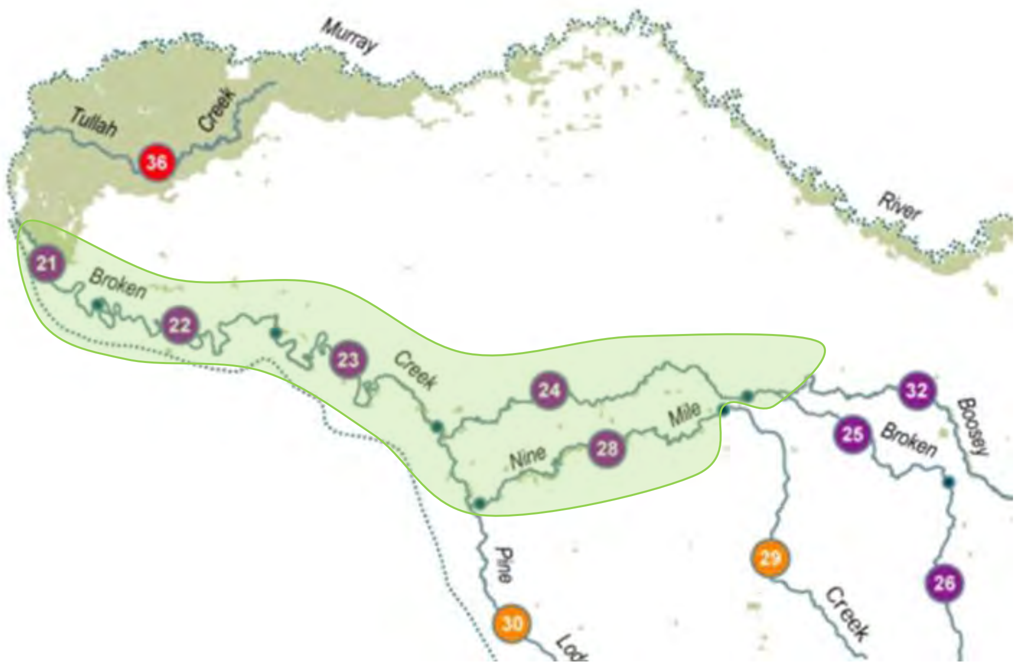


Figure 4-8 ISC Reach location map (EWP project area highlighted)

4.3.2 Box dominated grassy woodland

Approximately 61% of the Broken-Boosey Creek system within the area of the current EWP lies within public land managed by Parks Victoria (Broken-Boosey State Park, Numurkah Natural Features Reserve and Nathalia Natural Features Reserve). This park and reserve system was proclaimed in October 2002 based on recommendations of the Environment Conservation Council (ECC) Box Ironbark Forests and Woodlands Investigation (Parks Victoria 2006). Much of the land now forming the park and reserve system was formerly held in various public land reserves (i.e. Bushland, Town and Streamside Reserves) and public land water frontage (Parks Victoria 2006). The Broken-Boosey State Park is "managed primarily for conservation of specific natural features" (under IUCN Category III) while the natural features reserves are "managed primarily for the sustainable use of natural ecosystems" (under IUCN Category VI) (Parks Victoria 2006).

The Broken-Boosey State Park and associated Natural Features Reserves protect stands of remnant Box-dominated grassy woodland and includes important habitat for many rare and threatened flora and fauna species. Noted natural values identified in Parks Victoria (2006) include:

- The largest remaining example of grassy woodland on the eastern Northern Plains.
- One of the few surviving patches of remnant vegetation in the Northern Plains landscape (Robinson & Mann 1996).
- Approximately 30% of Victoria's endangered Plains Grassy Woodland / Gilgai Plains Woodland / Wetland Mosaic Ecological Vegetation Classes.
- Ecologically distinctive riparian Grey Box vegetation compared to most other Victorian rivers and creeks (Robinson & Mann 1996).
- The only known site for the endangered Amulla (*Eremophila debilis*) and one of only two known sites in Victoria for the endangered Spiny-fruit Saltbush (*Atriplex spinibractea*).
- Broken Creek – one of the most important stream systems for Murray Cod (*Maccullochella peelii peelii*) and Freshwater Catfish (*Tandanus tandanus*) (Robinson & Mann 1996).
- Habitat for a significant number of woodland-dependent bird species associated with the Victorian temperate-woodland bird community listed under the Flora and Fauna Guarantee Act 1988 (Vic.), including the Bush Stone-curlew (*Burhinus grallarius*), Brown Treecreeper (*Climacteris picumnus*)and Black-chinned Honeyeater (*Melithripterus gularis*).
- Habitat for threatened fauna including the Growling Grass Frog (*Litoria raniformis*), Swift Parrot (*Lathamus discolor*) and Tree Goanna (*Varanus varius*), and supplementary feeding ground for the threatened Brolga (*Grus rubicund*).

Importantly the park and reserve system forms a linear corridor extending approximately 140 km across agricultural land (Parks Victoria 2006).

4.3.3 Wetland systems

Broken Creek between Caseys Weir and Barmah Forest is listed In the Directory of Important Wetlands in Australia (Environment Australia 2001). The criteria for listing of Broken Creek are:

- Criteria 1 – It is a good example of a wetland type occurring within a biogeographic region in Australia.
- Criteria 2 – It is a wetland which plays an important ecological or hydrological role in the natural functioning of a major wetland system/complex.
- Criteria 3 – It is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail.

The spatial coverage of the listing is shown in Figure 4-9. The listing does not cover Nine Mile Creek or some of the main floodplain wetlands within the EWP project area (Black Swamp, Purdies Swamp, Kinnairds Swamp discussed in Section 6.4.2).

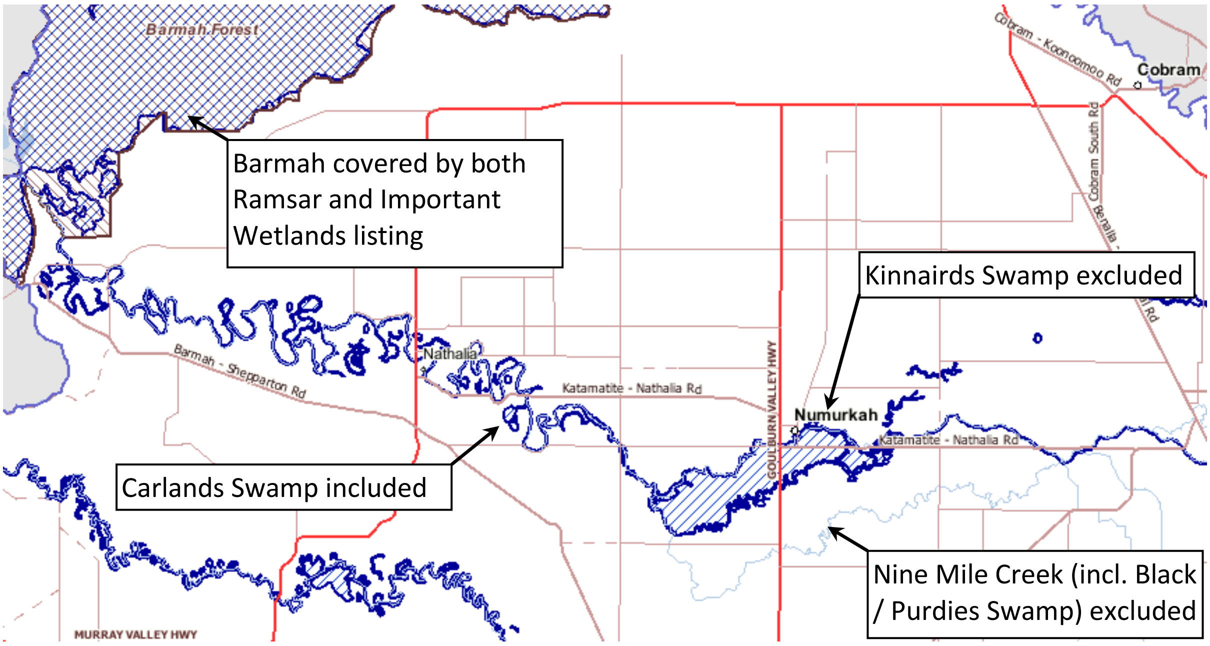


Figure 4-9 Spatial coverage of Broken Creek Directory of Important Wetlands listing (from DSE 2010)

Barmah Forest, located around the Murray River at the downstream end of the EWP project area, is a Ramsar listed wetland. The Ramsar listing includes the Barmah State Forest and Barmah State Park which cover the northern bank of Broken Creek over at the downstream end of EWP Reach 4 however the hydrologic regime of the Barmah Forest system is dominated by flows in the Murray River, not Broken Creek.

5. MANAGEMENT OBJECTIVES

Broad management objectives for the subject reaches of Boosey Creek, Broken Creek and Nine Mile Creek have been established in existing strategies and documents including:

- The Scientific Panel report on the environmental condition and flow in the Broken River and Broken Creek (Cottingham *et al.* 2001).
- The Regional River Health Strategy (GBCMA 2005).
- The Lower Broken Creek Waterway Management Strategy (GHD / URS 2005).
- Broken Boosey and Nine Mile Creeks Wetland Implementation Plan (Hale *et al.* 2006).
- Interim environmental flow objectives for Lower Broken Creek and Nine Mile Creek (GBCMA 2008).
- The Northern Region Sustainable Water Strategy (DSE 2009).

The range of objectives and their relevance to the current project are briefly discussed in the following sections.

Site or asset specific objectives are documented in other management plans including:

- Black Swamp (SKM 2007);
- Kinnairds Swamp (DPI 2003);
- Broken-Boosey State Park and Nathalia, Numurkah, Tungamah and Youarang Natural Features Reserves (Parks Victoria 2006).

5.1 Scientific Panel report on the environmental condition and flow in the Broken River and Broken Creek

A Scientific Panel was appointed by the Broken Basin Bulk Entitlement Project Group in 2001 to "consider environmental issues and to provide independent advice on the opportunities that exist through the Bulk Entitlement Conversion Process to better protect and enhance existing environmental values associated with the regulated waterways in the Broken River Basin". The investigation and recommendations from the Scientific Panel are documented in Cottingham *et al.* (2001). The Scientific Panel's deliberations included four reaches on the Broken River and a single reach on Broken Creek from Katamatite to the Murray River (encompassing EWP reaches 1, 3 and 4).

The study method did not specifically result in the establishment of objectives for management of the Broken Creek reach however the overall objective for the Bulk Entitlement conversion process was identified as "to ensure that current environmental values are to be protected and, where possible, enhanced." The Scientific Panel identified the significant environmental values in the subject reaches and, making use of the Flow Events Method (FEM) (Stewardson 2001), developed a recommended flow regime to protect and enhance the identified values in the Broken River reaches.

The Scientific Panel report did not include specific environmental objectives or flow regime recommendations for the Broken Creek reach, but provided management recommendations to improve environmental conditions. Despite the absence of detailed environmental objectives for Broken Creek, the discussion and justification of recommended flow regimes for the other reaches provides some useful information for the current EWP process.

5.2 Regional River Health Strategy

The four broad objectives of the Regional River Health Strategy (GBCMA 2005) for management of the rivers and streams of the Goulburn Broken catchment are presented in Section 4.3.1. In relation to the Broken River (including Broken Creek), the following specific river reach objective is identified:

> "to allocate water resources in a way that balances the needs of the environment with those of water users and to improve the ecological health of Broken River, and associated wetlands and floodplains."

Within the EWP project area, the entire length of Broken Creek is identified as a High Priority Reach (refer Section 4.3.1). This designation applies to EWP Reach 1 (excluding Boosey Creek), Reach 3 and Reach 4. The majority of the EWP project area (excluding Nine Mile Creek) thus lies within identified High Priority Reaches, with management and works to be implemented under RRHS Program A – Protection and enhancement of high priority reaches.

5.3 The Lower Broken Creek Waterway Management Strategy

The Lower Broken Creek Waterway Management Strategy (GHD / URS 2005) covers the full extent of the current EWP project excluding Boosey Creek (part of EWP Reach 1). The Waterway Management Strategy adopts the asset-based approach to natural resource management applied in development of the Regional River Health Strategy (GBCMA 2005). The following vision for the subject reach of Broken Creek was developed though consultation with the project Community Reference Group:

> "A healthy system that provides water for human and agricultural use, protects and enhances our social, economic and cultural values, and sustains a vibrant range and abundance of native flora and fauna." (GHD / URS 2005)

The following management objectives were identified:

- Conserve existing genetic diversity.
- Provide effective water supply that meets the needs of users.
- Provide regional and irrigation drainage.
- Maintain and enhance existing riparian vegetation structures and intactness.
- Enhance in-stream ecological values.
- Improve the quality of recreational fishing and other recreation opportunities.
- Improve in-stream water quality to ensure that the above objectives can be met.

GHD / URS (2005) recognises the potential for conflict between objectives and seeks to find a balance between sustainable use and environmental outcomes.

5.4 Broken Boosey and Nine Mile Creeks Wetland Implementation Plan

The Broken Boosey and Nine Mile Creeks Wetland Implementation Plan (Hale *et al.* 2006) covers the entire EWP project area and identifies the ecological values of the wetland systems, including the waterway channels and discrete floodplain wetlands. The following management goals for the Wetland Implementation Plan were developed with reference to the Regional Catchment Strategy (GBCMA 2003) and the 2004 draft of the Regional River Health Strategy GBCMA (2005):

- Maintain or improve the condition of wetlands of the highest ecological value;
- Maintain or improve the condition of ecologically healthy wetlands;
- Achieve "overall improvement" in the ecological condition of remaining wetlands
- Protect a diverse range of wetland habitats; and
- Prevent damage from future management activities.

Hale *et al.* (2006) recommended that "all remaining wetlands within the Planning Area should be considered of high conservation value and given the small amount of native vegetation remaining in this area, all remnant vegetation patches should be considered ecologically significant."

5.5 Interim Environmental Flow Recommendations

5.5.1 Background

Interim environmental flow recommendations were developed by Goulburn Broken Catchment Management Authority (Goulburn Broken CMA) at the request of the Department of Sustainability and Environment to inform the development of the Northern Region Sustainable Water Strategy. The interim recommendations and the process followed in their development are documented in GBCMA (2008). The interim recommendations were developed using an approach consistent with the FLOWS methodology (NRE 2002) but excluded field assessments and hydraulic modelling, relying instead on existing knowledge held by the project team.

5.5.2 Reaches

Three reaches were used in development of the interim environmental flow recommendations:

- Reach 1 – Broken Creek downstream of the Boosey Creek confluence to the Nine Mile Creek confluence (Equivalent to EWP Reach 1 however EWP Reach 1 also includes a short length of Boosey Creek between the 7/3 channel outfall and Broken Creek).
- Reach 2 – Nine Mile Creek and Broken Creek between the Nine Mile Creek confluence and the upstream end of the Nathalia Weir pool (covers EWP Reaches 2 and 3).
- Reach 3 – Broken Creek from the Nathalia Weir pool to the Murray River (equivalent to EWP Reach 4).

5.5.3 Assets, threats and objectives

Riparian environmental assets and threats within the project area were identified as geomorphology, native fish, riparian vegetation, in-channel vegetation, wetlands, aquatic macroinvertebrates and water quality. Of these, only on-stream wetlands, native fish and water quality were identified as subject to influence by the regulated flow regime of Broken and Nine Mile Creeks. The following objectives were identified:

- Native Fish (F1) – Improve native fish habitat and passage
  - Ensure persistence of aquatic habitats during migration and breeding seasons particularly for Murray Cod.
  - Supply sufficient flow to operate the fishways and provide fish access to appropriate habitat all year.
- Wetlands (W1) – Restore a more natural flood regime to Black and Purdies Swamp
- Low Dissolved Oxygen (DO1) – Maintain dissolved oxygen concentrations above 5 mg/L (based on ANZECC guidelines to maintain suitable conditions for oxygen dependent species
  - Dissolved oxygen levels maintained above 5 mg/L.
- Algal and azolla blooms (AB1) – Minimise the growth of azolla and algae
  - Reduced azolla and algal blooms and dissolved oxygen levels maintained above 5 mg/L.

Native fish habitat and native fish passage objectives (F1) were applied to all reaches while low dissolved oxygen (DO1) and algal and azolla bloom (AB1) objectives were applied only to Reach 3. The wetland objective (W1) applied only to Reach 2 but was phrased in terms of an annual or biannual inundation rather than a daily flow recommendation.

5.5.4 Flow recommendations

The report identifies the daily flows (Tables 5-1 – 5-3) required in each month of the year to address the ecological objective for native fish and the key threats to native fish. The report does not recommend daily flows for wetlands.

Table 5-1 Reach 1 flow recommendations

Flow Target	Daily Flow ML/d											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Native Fish Habitat									50	50	50	50
Native Fish Passage	40	40	40	40	40	40	40	40	40	40	40	40
Collective Requirement	40	40	40	40	40	40	40	40	50	50	50	50

Table 5-2 Reach 2 flow recommendations

Flow Target	Daily Flow ML/d											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Native Fish Habitat									250	250	250	250
Native Fish Passage	40	40	40	40	40	40	40	40	40	40	40	40
Collective Requirement	40	40	40	40	40	40	40	40	250	250	250	250

Table 5-3 Reach 3 flow recommendations

Flow Target	Daily Flow ML/d											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Azolla						80	80	80	80	80	80	
Dissolved Oxygen (DO)	100	100	100									100
Provisional DO and Azolla flows*	200	200	200			200	200	200	200	200	200	200
Native Fish Habitat									250	250	250	250
Native Fish Passage	40	40	40	40	40	40	40	40	40	40	40	40
Collective Requirement	100-200	100-200	100-200	40	40	80-200	80-200	80-200	250	250	250	250

* Additional flows up to 200 ML/d may be required to manage DO and Azolla.

5.6 Northern Region Sustainable Water Strategy

The Northern Region Sustainable Water Strategy (DSE 2009) examines water availability and allocations for consumptive use and the environment in northern Victoria, including the Broken River basin. The strategy considers the impacts of drought and climate change and identifies short and medium term actions to secure water supplies for the region over the next 50 years. The strategy discusses targeted recovery and efficient use of environmental water to sustain and protect high value rivers, wetlands and floodplains.

An environmental water recovery target of 25 GL has been set for the Broken Creek with the expected environmental outcomes to be:

- protection of drought refuge plus dry spell breaking under climate change conditions; and
- sustainable population of all in-stream species under current climatic conditions.

Application of the water recovery categories from DSE (2009) for Broken Creek in the context of the EWP process suggests that adoption of “protect and enhance” objectives for all identified in-stream species is appropriate.

The Northern Region Sustainable Water Strategy also suggests that River Murray supplies could be diverted via the Yarrawonga Main Channel, through the Murray Valley Irrigation District and down the Broken Creek system before returning to the Murray River. To facilitate this, channel and outfall capacities may need to be increased, which could be assessed and undertaken as part of the Murray Valley Service Enhancement project. This could reduce the water recovery target for the Broken Creek from 25 GL to 8 GL (DSE 2009).

5.7 Relevance of existing objectives to the EWP process

The existing literature does not provide a strong or consistent base for identifying appropriate flow related environmental objectives for the Broken-Boosey system in the current EWP process. The objectives are generally phrased around maintaining or enhancing existing environmental assets but do not identify specific species or asset classes. GBCMA (2008) and DSE (2009) provide the most relevant objectives in relation to actions required to sustain assets with identified flow dependence. More specific objectives for management of key environmental assets have been developed during the preparation of this EWP. These objectives are shown in Table 8-1.

6. ENVIRONMENTAL VALUES

6.1 Introduction

The current condition of Broken Creek and Nine Mile Creek within the project area is described in the following sections based on information from available literature and inputs from the Scientific Reference Group. Where relevant, conditions within each of the EWP reaches (refer Section 4.2) are discussed separately to assist in identification of the stream values, assets and threats within each reach.

This discussion of current condition and assets is focussed on water dependent in-stream and riparian assets influenced by the regulated flow regime as these assets are most likely to experience impacts as a result of implementation of modified irrigation drainage and outfalls. Broader floodplain assets which are impacted by flood events are discussed only briefly. The main assets thus considered in this review are:

- Geomorphology;
- Riparian and in-channel vegetation;
- Wetlands;
- Fish;
- Threatened flora and fauna found in the immediate riparian zone;
- Macroinvertebrates.

Many of these assets are potentially directly impacted by a change in flow regime. The impact of a flow regime modification resulting from implementation of NVIRP on these assets is discussed in Section 8. Other indirect threats to the condition of identified environmental values, as impacted by the flow regime within the creek system, are discussed in Section 6.8 and include:

- Poor water quality – high turbidity, high nutrient, low dissolved oxygen.
- Altered geomorphic processes – i.e. increased sedimentation in weir pools and channel reaches.
- Aquatic weeds – particularly those favoured by permanent water and low flow velocity conditions.

Changes in surface water / groundwater interaction as a result of the NVIRP have potential impacts on the identified environmental assets. The impacts of NVIRP on regional groundwater, with resultant local impact on waterways are documented in other studies (i.e. SKM 2008) prepared in support of the NVIRP approvals process and are not specifically considered in this EWP.

6.2 Geomorphology

6.2.1 Introduction

Cottingham *et al.* (2001) and GBCMA (2005) indicate that there has been no formal study of the geomorphic character of the Broken Creek system. GHD / URS (2005) provides a brief discussion of the overall planform, while SKM (1998) briefly describes the channel morphology and its association with the natural and modified hydrology. Cottingham *et al.* (2001) indicates that flow regulation is likely to have had little impact on river geomorphology as regulation has not significantly altered the occurrence of larger flow events in the system however this assessment is likely to relate principally to the large scale geomorphic character of the system. For the purposes of the current EWP project, channel morphology is considered to have been significantly impacted by regulation, both due to the modification of the low flow components of the flow regime and through the construction of in-channel weirs, floodplain levees, channel re-alignments and removal of in-stream habitat (snags).

6.2.2 Reach scale morphology

SKM (1996) cited in GHD / URS (2005) identifies two distinct geomorphic zones along Broken Creek within the project area. Upstream of Waaia (EWP Reaches 1 and 2 and upstream portion of EWP Reach 3), the channel is sinuous with a small meander amplitude and wavelength. Downstream of Waaia, Broken Creek occupies the channel of an ancestral river, the Tallygaroopna Channel, with a much larger meander wavelength and wider meander belt than the current Murray and Goulburn Rivers (Bowler 1978 and SKM 1998). The planform of Broken Creek downstream of Waaia (i.e. the downstream end of EWP Reach 3 and all of Reach 4) is therefore largely determined by the character of this ancestral channel (GHD / URS 2005). Adopting the terminology of Rosengren (1987), the Tallygaroopna Channel would be identified as a site of State geological and geomorphological significance on the basis that it includes "features which are important in the context of developing an understanding of the geological and geomorphological development of Victoria".

6.2.3 In channel morphology

SKM (1998) describes the natural channel morphology of the streams upstream of the current project area as typical of those found in lowland, low gradient settings, consisting of poorly incised, low capacity creek-lines or depressions, drying seasonally to waterholes in the summer months but spilling to the adjacent broad floodplain following heavy rains. Downstream of Katamatite (i.e within the EWP project area) the degree of incision increases but other characteristics are as described for the upstream reaches.

While not describing directly the streams within the project area, Reich *et al.* (2009) reviews the impacts of returning an ephemeral flow regime to the Broken and Boosey Creek systems upstream of Katamatite (following implementation of the Tungamah Pipeline). A total of ten study sites across the hydrologic regime (from unregulated to heavily regulated) were assessed to describe the current condition of the streams. None of the study sites in Reich *et al.* (2009) were located in weir pools. Geomorphic characteristics considered included channel width and bank slope, pool depth, sediment depth and degree of wiggliness (variation in bed elevation along the thalweg). Highly regulated sites were found to exhibit greater depths of unconsolidated benthic sediment and less variation in thalweg depth than found at unregulated sites. The reduction in bed variability at the regulated sites was considered likely to result from two factors:

- the delivery of high suspended sediment loads in water diverted from Lake Mokoan; and
- the lack of wetting and drying cycles at the highly regulated sites limiting sediment consolidation and breakdown of organic material, leading to greater depths of unconsolidated sediment.

A reduction in the frequency and duration of flow events exporting sediments from pools is also likely to contibute

The situation within Broken and Nine Mile Creeks within the EWP project area is likely to be similar to that documented in Reich *et al.* (2009). The presence of significant weir pools, particularly in EWP Reach 4 is likely to exacerbate the sediment accumulation.

Significant channel modification works have been undertaken historically, as outlined in GHD / URS (2005), including:

- Channelization works on 32 km of Broken Creek and Nine Mile Creek downstream of Shepparton Irrigation District Drain 12.
- Excavations and control of Cumbungi growth in Broken Creek (EWP Reach 1) to achieve a relatively constant low flow channel capacity.
- Regrading and dredging of Broken Creek (EWP Reach 3) to improve drainage outfall capacity, resulting in lowering of the bed by up to 1 m and associated removal of large woody debris.

- Re-alignment of large woody debris in the lower reaches of Broken Creek (EWP Reach 4)
- Construction of weirs, especially in EWP Reach 4.

The cumulative result of these channel modifications is a reduction in bed and channel geomorphic diversity throughout much of the EWP project area.

6.3 Riparian and in-channel vegetation

6.3.1 Ecological Vegetation Class (EVC) mapping in the riparian zone

Ecological Vegetation Class (EVC) mapping is a vegetation classification system, derived from groupings of vegetation communities based on floristic, structural and ecological functions. Mosaics (combinations of EVCs) are a mapping unit, where the individual EVCs could not be separated, at the scale of 1:100,000 (Berwick 2003, cited in DSE 2008).

Current EVC mapping (based on 2005 extents) within the EWP project area has been reviewed. EVCs identified along the waterway (based on a 20 m buffer around the mapped waterway alignment) are summarised for each reach in Table 6-1 to Table 6-4. EVC maps for each reach, highlighting the EVCs found in proximity to the EWP waterways are provided in Appendix B. The greatest variation in EVC occurrence is around and downstream of Nathalia (EWP Reach 4) where there is greater geomorphic variability associated with the Tallygaroopna Channel features.

Four dominant EVCs / EVC mosaics (indicated in bold in the tables) are noted along the waterway frontage within the EWP project area, namely:

- EVC68 – Creekline Grassy Woodland is dominant throughout all reaches
- EVC168 – Drainage Line Aggregate occurs along substantial lengths of Reaches 1 and 4
- EVC259 – Plains Grassy Woodland / Gilgai Wetland Mosaic occurs commonly on the broader floodplain but occupies substantial lengths of stream frontage in Reaches 1 and 2
- EVC803 – Plains Woodland occurs commonly on the broader floodplain but occupies substantial lengths of stream frontage in Reaches 3 and 4

The conservation significance of EVCs is assessed on a bioregional status (Table 6-5), with the conservation status reflecting the rarity or degree of depletion of each EVC within a given bioregion. Three of the four dominant EVCs/mosaics along the waterway frontage in the project area are classified as Endangered while the fourth (EVC168 – Drainage Line Aggregate) is considered Vulnerable. The occurrence of significant stands of these endangered and vulnerable EVCs along the Broken Creek system, within the broader context of a generally cleared agricultural landscape, highlights their bioregional environmental significance. GBCMA (2008) indicates that the dominant EVCs (Plains Woodland and Creekline Grassy Woodland) are not flood dependent.

The dominant overstorey species in EWP Reaches 1 and 2 is Grey Box with occasional Yellow Box, River Red Gum and Buloke while Yellow Box are more dominant in EWP Reaches 3 and 4 (GBCMA 2008). The presence of riparian Grey Box vegetation within the Broken-Boosey system is recognised as ecologically distinctive compared to most other Victorian rivers and creeks (Robinson and Mann 1996, cited in Parks Victoria 2006) and reflect the frequently dry conditions prevailing in the stream prior to regulation (GHD / URS 2005). Robinson and Mann (1996) cited in Hale *et al.* (2006) suggest that waterlogging associated with flow regulation in these systems may lead to a replacement of Grey Box communities with more inundation tolerant Red Gum communities.

Table 6-1 EVCs in the immediate riparian zone within EWP Reach 1

EVC	EVC Name	Bioregional conservation status [1]	Occurrence in EWP Reach
68	**Creekline Grassy Woodland**	**E**	**Dominant along Boosey and Broken Creeks upstream of Numurkah**
74	Wetland Formation	E	Isolated occurrence near Nine Mile Creek offtake
168	**Drainage-line Aggregate**	**E**	**Along Broken Creek (and Box Creek) upstream of Numurkah**
259	**Plains Grassy Woodland/Gilgai Wetland Mosaic**	**E**	**Dominant on the floodplain throughout the reach and commonly adjacent the channel around and downstream of Numurkah**
803	Plains Woodland	E	Localised occurrence along Boosey Creek downstream of Katamatite and on Broken Creek around Nine Mile Creek offtake

1. For Victorian Riverina bioregion

Table 6-2 EVCs in the immediate riparian zone within EWP Reach 2

EVC	EVC Name	Bioregional conservation status [1]	Occurrence in EWP Reach
68	**Creekline Grassy Woodland**	**E**	**Near continuous along Nine Mile Creek, except downstream of Pine Lodge Creek**
259	**Plains Grassy Woodland/Gilgai Wetland Mosaic**	**E**	**Dominant on the floodplain throughout the reach and commonly adjacent the channel**
292	Red Gum Swamp	V	Black Swamp and Purdies Swamp and isolated occurrence near confluence with Broken Creek
803	Plains Woodland	E	On floodplain and locally near channel near confluence with Broken Creek
869	Creekline Grassy Woodland/Red Gum Swamp Mosaic	E	Along Nine Mile Creek downstream of Pine Lodge Creek

1. For Victorian Riverina bioregion

Table 6-3 EVCs in the immediate riparian zone within EWP Reach 3

EVC	EVC Name	Bioregional conservation status (1)		Occurrence in EWP Reach
		Vic Riv	Mur Fans	
68	**Creekline Grassy Woodland**	**E**	**E**	**Continuous along Broken Creek**
125	Plains Grassy Wetland		E	Floodplain wetland features with isolated occurrences adjoining Broken Creek
259	Plains Grassy Woodland/Gilgai Wetland Mosaic	E		Floodplain north of Broken Creek near upstream end of reach, with isolated occurrences near Broken Creek
333	Red Gum Swamp/Plains Grassy Wetland Mosaic		E	Carlands Swamp and other floodplain wetland features
803	**Plains Woodland**	**E**	**E**	**Southern floodplain of Broken Creek with significant occurrences along creek frontage**
873	Riverine Grassy Woodland/Riverine Chenopod Woodland/Wetland Mosaic		V	Adjacent Nathalia weir pool
882	Shallow Sands Woodland		V	Isolated occurrences near Broken Creek

1. Reach 3 crosses the boundary between the Victorian Riverina bioregion and Murray Fans bioregion. Bioregional conservation status is shown for each bioregion in which the EVC occurs within EWP Reach 3

Table 6-4 EVCs in the immediate riparian zone within EWP Reach 4

EVC	EVC Name	Bioregional conservation status [1]	Occurrence in EWP Reach
56	Floodplain Riparian Woodland	D	Localised occurrences adjacent Broken Creek downstream of Kennedys Weir
68	**Creekline Grassy Woodland**	**E**	**Dominant along Broken Creek upstream of Kennedys Weir**
106	Grassy Riverine Forest	D	Barmah State Forest upstream and downstream of Rices Weir
125	Plains Grassy Wetland	E	Isolated floodplain occurrences with minor stands around Schiers Weir
168	**Drainage-line Aggregate**	**V**	**Abandoned channel meanders (Tallygaroopna Channel) and Broken Creek downstream of Kennedys Weir**
264	Sand Ridge Woodland	E	Isolated occurrences adjacent channel (inside bends)
295	Riverine Grassy Woodland	V	Barmah State Forest
803	**Plains Woodland**	**E**	**Broad floodplain occurrences with significant Broken Creek frontage throughout reach**
814	Riverine Swamp Forest	D	Barmah State Forest
816	Sedgy Riverine Forest	D	Localised occurrence upstream of Rices Weir
817	Sedgy Riverine Forest/Riverine Swamp Forest Complex	D	Localised occurrence downstream of Rices Weir
867	Shallow Sands Woodland/Plains Woodland Mosaic	E	Northern floodplain of Broken Creek upstream of Picola, with local occurrences along Broken Creek frontage
873	Riverine Grassy Woodland/Riverine Chenopod Woodland/Wetland Mosaic	V	Localised occurrences along Broken Creek frontage around Nathalia
882	Shallow Sands Woodland	V	On frontage between Hardings Weir and Chinamans Weir
1040	Riverine Grassy Woodland/Riverine Swampy Woodland Mosaic	V	Barmah State Forest upstream and downstream of Rices Weir
1050	Mosaic of Floodplain Grassy Wetland/Grassy Riverine Forest-Riverine Swamp Forest Complex	E	Isolated occurrence downstream of Rices Weir
1068	Riverine Swamp Forest/Sedgy Riverine Forest Mosaic	D	Isolated occurrence between Rices Weir and Kennedys Weir

1. For Murray Fans bioregion

Table 6-5 EVC bioregional conservation status (from 2007_EVC_bioreg_bcs_gps.xls)

Code	Status	Definition
X	Presumed extinct	Probably no longer present in the bioregion OR if present, below the resolution of available mapping.
E	Endangered	Less than 10% of former range OR less than 10% of pre-European extent remains (or a combination of depletion, loss of quality, current threats and rarity that gives a comparable status e.g. 10 to 30% pre-European extent remains and severely degraded over a majority of this area).
V	Vulnerable	10 to 30% of pre-European extent remains (or a combination of depletion, loss of quality, current threats and rarity that gives a comparable status e.g. greater than 30% and up to 50% pre-European extent remains and moderately degraded over a majority of this area).
D	Depleted	Greater than 30% and up to 50% of pre-European extent remains (or a combination of depletion, loss of quality, current threats and rarity that gives a comparable status e.g. greater than 50% pre-European extent remains and moderately degraded over a majority of this area).
R	Rare	Rare (as defined by geographic occurrence) but neither depleted, degraded nor currently threatened to an extent that would qualify as endangered, vulnerable or depleted.
LC	Least concern	Greater than 50% or pre-European extent exists and subject to little to no degradation over a majority of this area.
na	Not applicable	The map unit is not a distinct native vegetation type and conservation status is not applicable.

6.3.2 Riparian vegetation condition

Hale *et al.* (2006) summarises riparian condition based on the results of 2004 Index of Stream Condition (ISC) assessments at 12 sites and Habitat-Hectares assessments at four riparian sites. While this review included reaches outside of the EWP project area (notably Boosey Creek and the upper reaches of Nine Mile and Broken Creeks) the general conclusion that the riparian condition is average to good, with a mature overstorey (often regrowth) but degraded understorey (reduced structural complexity, reduced species richness, little or no recruitment and an understorey of non-native species) is likely to reflect current condition within the EWP project area. The degraded understorey is attributed to past and present stock grazing pressures (GBCMA 2008) and timber removal for firewood (Hale *et al.* 2006). While large portions of the stream frontage within the EWP project area lie within the Broken-Boosey State Park and associated Natural Features Reserves, grazing, either under licence or illegally, continues in approximately 50% of the reserve area (Parks Victoria 2006).

6.3.3 In-channel vegetation

The distribution and character of in-channel vegetation within the EWP project area is dominated by the regulated flow regime within the Broken Creek system. Under natural conditions, flows in the system were ephemeral (refer Section 4.1.3) and would have provided habitat for a range of perennial and annual macrophytes adapted to wetting and drying cycles (GBCMA 2008). The modified flow regime favours robust perennial species adapted to permanent or near-permanent inundation and low flow velocity, with Cumbungi (Typha) and Common Reed (*Phragmites australis*) now dominating (GBCMA 2008). Localised patches of other species occur including Water milfoil (*Myriophyllum* sp), Water primrose (*Ludwigea peploides*), Water ribbons (*Triglochin* sp) and Ribbon weed (*Vallisneria* sp) (GBCMA 2008). Monitoring of Kinnairds Swamp after delivery of environmental water in 2008 located large populations of the nationally vulnerable Ridged Water Milfoil (*Myriophyllum porcatum*) and endangered (in Victoria) Slender Water Milfoil (*Myriopyllum gracile* var. *lineare*) (Australian Ecosystems 2009).

Aquatic weeds are becoming an increasing problem, favoured by high nutrient, low velocity flows (GBCMA 2008), as discussed in Section 6.8.2.

6.4 Wetlands

The Broken- Boosey and Nine Mile Creeks Wetland Implementation Plan (Hale *et al.* 2006) covers the entire EWP project area and provides the most complete review of current wetland condition within the project area. Hale *et al.* (2006) included assessment at two scales:

- "The floodplain / riparian zone associated with the creeks as a single connected wetland system; and
- The discrete wetlands within the floodplain."

The same classification of wetland assets has been adopted for the EWP process as discussed in the following sections.

6.4.1 Riparian wetland assets

As discussed in Section 4.3.3, Broken Creek within EWP Reaches 1, 3 and 4 is listed in the Directory of Important Wetlands in Australia (Environment Australia 2001). The listing covers the immediate riparian zone of Broken Creek however a number of floodplain features around and downstream of Nathalia (generally relic features within the Tallygaroopna channel meanders, refer Section 6.2.2) are also included in the listing. This is consistent with GHD / URS (2005) which identifies that the wetlands of the Broken River are "mostly confined to narrow riparian zones which are inundated frequently and which contribute to the habitat complexity of the system".

Hale *et al.* (2006) note that there is "little information available on the condition of wetlands within the Project Area. Previous investigations were limited to the larger wetlands with conservation reserves (Kinnairds, Black, Moodie and Rowan Swamps)". Hale *et al.* (2006) documents the presence and conservation status of EVCs within the wetland implementation plan project area (extending well outside of the area inundated by regulated flows) but does not provide a breakdown for those associated with the riparian wetland environment as distinct from the broader floodplain.

While there has been some subsequent assessment of wetland condition and hydrology within the project area (i.e. Australian Ecosystems 2009, SKM 2007) the value and condition of the riparian wetland asset is still generally poorly documented.

6.4.2 Floodplain wetland assets

A number of floodplain wetland features are associated with the Broken Creek system within the EWP project area. The distribution of wetlands, based on the DSE Wetlands 1994 layer (DSE 1994), is shown in Figure 6-2. Wetlands are classified into six categories (Corrick and Norman 1980) according to water depth, duration of inundation, salinity and dominant vegetation (Hale *et al.* 2006) as below:

- Deep freshwater marshes – deep freshwater wetlands that remain flooded for most of the year but may dry occasionally;

- Freshwater meadows – shallow freshwater wetlands holding water for less than four months of the year;
- Permanent open freshwater wetlands – deep freshwater wetlands that hold water permanently;
- Permanent saline wetlands – saline wetlands that rarely dry out, including tidal areas and saline inland lakes;
- Semi-permanent saline wetlands – saline wetlands flooded for less than eight months of the year, including salt pans and salt meadows; and
- Shallow freshwater marshes – shallow freshwater wetlands that usually dry out in mid-summer and refill with the onset of winter rains

The Freshwater Meadow, Shallow Freshwater Marsh, Deep Freshwater Marsh and Permanent Open Freshwater Wetlands categories occur within the EWP project area. All of the wetland features in proximity to Broken and Nine Mile Creeks within DSE (1994) lie within the Directory of Important Wetlands listing (Environment Australia 2001) discussed in Section 4.3.3.

Hale *et al.* (2006) reviewed the distribution and conservation significance of wetlands within the Broken, Boosey and Nine Mile Creek systems, encompassing (but extending beyond) the EWP project area. With reference to DSE (1994), the extent of wetlands in all wetland categories excluding Permanent Open Water (after Corrick and Norman 1980) have declined significantly in area since settlement. Based on review of 2001 aerial photography, Hale *et al.* (2006) conclude that this decline continued between the 1994 mapping (DSE 1994) and 2001. The greatest decline (in number and area of wetlands) has been in the "Freshwater Meadow" and "Shallow Freshwater Marsh" categories however the "Permanent Open Water" category has increased as a result of construction of dams and impoundments.

There are no Ramsar listed wetlands within the Broken Boosey and Nine Mile Creek systems, although Broken Creek discharges to the Barmah Forest Ramsar Site. The Black Swamp / Purdies Swamp system (see below) is listed as bioregionally significant within the National Land and Water Resources Audit (NLWRA 2002).

The largest discrete wetland systems in proximity to the Broken and Nine Mile Creek systems are:

- **Black Swamp and Purdies Swamp** – Located to the north of Nine Mile Creek near Wunghu in EWP Reach 2, discussed in further detail below.
- **Kinnairds Wetland** – Located near Numurkah in EWP Reach1, Kinnairds Wetland is a 93 ha terminal wetland complex near Numurkah. DPI (2003) describes the wetland as a Deep Freshwater Marsh in a prior stream depression (the Muckhatah Depression) with a vegetation community of sparse mature River Red Gum over Common Spike-Sedge, Water Milfoil and Moira Grass. Historically the wetland has been subject to waterlogging due to catchment clearing and irrigation development in the Muckatah catchment. More recently (approximately 2000 onwards) a more natural flooding regime has been reinstated.
- **Carlands Swamp** – Located approximately 20 km upstream of Nathalia on Broken Creek in EWP Reach 3, is identified as a Freshwater Meadow in the DSE Wetland 1994 layer but little other information is available on its condition or hydrology.

With the exception of the Black Swamp and Purdies Swamp system near Wunghu these wetlands are not able to be inundated by the regulation of in-channel flows (GBCMA 2008). For the purpose of this EWP it is therefore assumed that the other floodplain wetlands are unlikely to be impacted by the hydrologic modifications resulting from the NVIRP and only the Black Swamp / Purdies swamp system is described below.

Black and Purdies Swamps

Black Swamp and Purdies Swamp is a bioregionally significant wetland system lying to the north of Nine Mile Creek upstream of Wunghu (GBCMA 2008). Black Swamp and Purdies Swamp are both classified as Shallow Freshwater Marshes, with the channel joining the two swamps identified as Freshwater Meadow. Occupying an area of approximately 107 ha, the wetland complex supports aquatic, River Red Gum and Grey Box vegetation communities. Under natural conditions, Black Swamp received water from Nine Mile Creek to the east. Once Black Swamp filled, water overflowed to Purdies Swamp before returning to Nine Mile Creek (GBCMA 2008). Natural flooding would have occurred approximately annually during late winter and spring however with a shallow depth (approximately 50 cm), it would dry out most years during summer and autumn (GBCMA 2008).

More recently, Black Swamp has been subject to prolonged flooding under the regulated flow conditions prevailing in Nine Mile Creek. This has resulted in a change in species composition with the original Red Gum Swamp (EVC 292) now restricted to the perimeter of the wetland (Australian Ecosystems 2008), with the wetland floor dominated by species adapted to permanent inundation including Typha (GBCMA 2008). Purdies Swamp is currently hydraulically isolated from Black Swamp by a road through the middle of the site and has thus not been flooded for some years.

The recent (2008) refurbishment of a regulator on the inlet channel from Nine Mile Creek has facilitated the return to a more natural wetting and drying regime. A recommended flooding regime for Black Swamp was developed in 2007 (SKM 2007) with the objective of establishing a more diverse ecosystem and restoration of the original Red Gum Swamp community. The recommended flood regime for Black Swamp comprises:

- Timing: Winter/spring
- Frequency: Near annual
- Duration: 6 months
- Depth: Variable depths to 50 cm
- Rates of rise and fall: Driven by rate of rising flood and natural evaporation and seepage
- Variability: Based on variability in peak and natural flows

The regulator can be operated to prevent flows into the wetland system for events up to approximately bank full in Nine Mile Creek and thus unseasonal flooding can be prevented by regulator closure. Critically for the current EWP, the commence to flow level for flows into the wetland via the regulator is at a discharge of around 100 ML/d in Nine Mile Creek (SKM 2007). With a wetland volume of approximately 50 ML (excluding Purdies Swamp), and making allowance for seepage and losses from the system, a volume of approximately 100 ML is required to fill the wetland, requiring that the regulator remains open for approximately 10 days while flows in Nine Mile Creek exceed 100 ML/d (Simon Casanelia pers. comm. 2010). There may be some benefits in leaving the regulator open for a longer period than this minimum fill time (to facilitate access to the wetland for smaller bodied fish) however this may exacerbate issues with carp breeding in the wetland and then returning to the Nine Mile Creek system (Jarod Lyon pers. comm. 2010).

Recent drying and watering events have resulted in an improvement in health and species diversity of the wetland vegetation communities and provided improved habitat for wetland dependent birds (Australian Ecosystems 2009). The wetland is being flooded approximately annually (2008, 2009) at the present time but the frequency of inundation is likely to slightly reduced and be randomised in the future to enhance the role of the wetland as a drought refuge for waterbirds (Simon Casanelia pers. comm. 2010).

Figure 6-1 Black Swamp and Purdies Swamp north of Nine Mile Creek in Reach 2

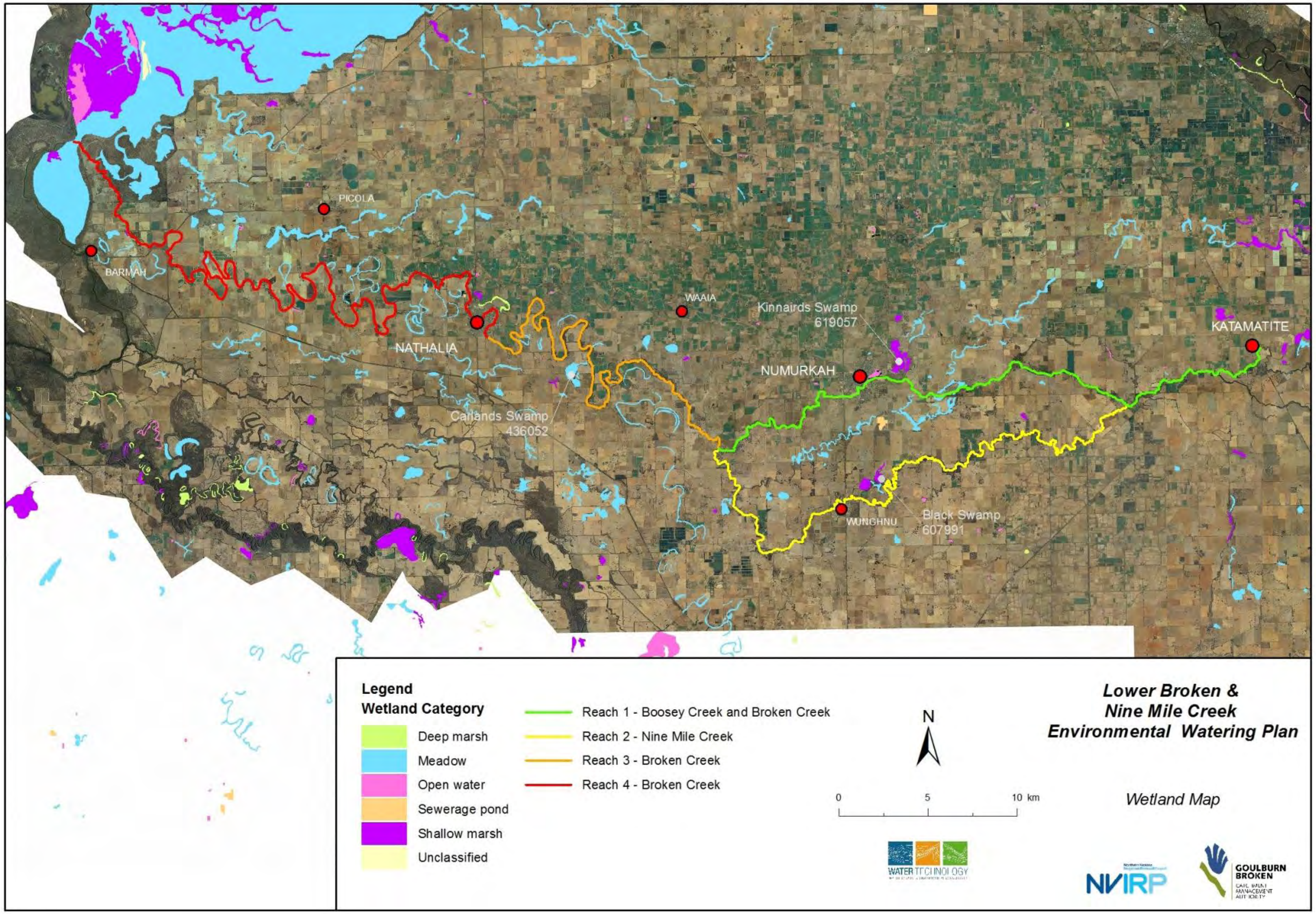


Figure 6-2 Wetland extents within the EWP project area (DSE 1994)

6.5 Fish

6.5.1 Introduction

While there is incomplete knowledge of the current status of the native and exotic fish populations in the Broken Creek system, available monitoring data indicates that the Broken system (including Broken River and Broken Creek) supports a diverse native fish community (O'Connor and Amtstaetter 2008). As noted in Section 4.3.1, Broken Creek below Nine Mile Creek is known as an important Murray Cod (*Maccullochella peelii peelii)* habitat and is identified as a high priority reach in the Regional River Health Strategy (GBCMA 2005) on this basis.

Native and exotic fish populations in the Broken Creek system have been investigated and documented in a number of studies in the last 10 years (O'Connor and O'Mahony 2008; O'Connor and Amtstaetter 2008; O'Connor and Koster 2005; O'Connor 2006; and O'Connor *et al*. 2003). Recent investigations have focussed on the planning and outcomes of the Broken Creek fishway installation program in which vertical slot fishways were constructed on all weirs between Nathalia and the Murray River between approximately 1998 and 2005. The majority of the monitoring effort has thus been in the lower reaches of Broken Creek (EWP Reaches 3 and 4) however there is a reasonable state of knowledge on conditions and fish populations in the upstream reach of Broken Creek (EWP Reach 1). By contrast, there has been no formal monitoring of fish populations in Nine Mile Creek (EWP Reach 2).

Current monitoring (i.e. O'Connor and Amtstaetter 2008, O'Connor 2006) indicates that the fishway installation program has facilitated the upstream movement of fish in the lower reaches of Broken Creek and that the diversity and abundance of native fish species around Nathalia has increased relative to the situation prior to construction of the fishways. However the native fish diversity and abundance between Nathalia and Numurkah is depressed relative to downstream populations but the cause is not clear.

O'Connor and Amtstaetter (2008) investigated possible factors limiting the population diversity and abundance upstream of Nathalia including habitat quality (depth and width variation) and in-stream structure. While habitat was found to be progressively poorer upstream, the presence of high quality habitat in the sites immediately upstream of Nathalia suggested that the low native fish population in this reach may be an indication of limited movement of fish from the downstream reach, either due to restrictions in fish passage at the Nathalia weir (due to low flow or inappropriate operation) or limited population pressures to drive upstream population processes. GBCMA (2008) recommends a minimum flow of 40 ML/d in the system to provide for passage of native fish species through the vertical slot fishways however O'Connor and Amtstaetter (2008) also highlight other factors (i.e. variation in flow level, full opening of fishway gates, removal of debris from within the fishway) which can enhance the effectiveness of the fishways.

In the reach between Nathalia and Numurkah (EWP Reach 3 and downstream end of EWP Reach 1), O'Connor and Amtstaetter (2008) identified that some areas of Broken Creek do not contain sufficient habitat to support permanent or temporary (migrating) fish populations. This habitat limitation reflects the impact of past de-snagging and channel modification works (refer Section 6.2.3). Despite the degraded state of EWP Reaches 1 and 3 (and by inference, EWP Reach 2 – Nine Mile Creek) native fish populations are still found in some locations within these reaches (refer Section 6.5.2)

6.5.2 Species distribution

The distribution of native and exotic fish species amongst the EWP reaches is summarised in Table 6-6, compiled based on information contained in Douglas (2000), O'Connor and Amtstaetter (2008) and GBCMA (2008) and the knowledge of historic and recent monitoring activities contributed by members of the Scientific Reference Group (refer Section 14.2). Table 6-6 also notes which species are migratory (from Douglas 2000) and characterises flow dependence of each species based on the distribution of species relative to the partially restored hydrology in upstream reaches of the Broken and Boosey system (after Reich *et al.* 2009). A number of other species have been captured in low numbers in EWP Reach 4 including Silver perch, Freshwater catfish, Short finned eel, Atlantic salmon and Brown trout (O'Connor and O'Mahony (2008); O'Connor (2006); O'Connor and Koster (2005) O'Connor *et al.* (2003)).

Table 6-6 Distribution of native and exotic fish species within EWP waterways

Species	Migratory (Douglas 2000)	Flow dependence (Reich *et al.* 2009)	EWP Reach 1	EWP Reach 2	EWP Reach 3	EWP Reach 4	Vic. status	Nat. status
Australian smelt (*Retropinna semoni*)	Yes	FG	Y	Y	Y	Y		
Carp gudgeon (*Hypseleotris* sp)	No?	FG	Y	Y	Y	Y		
Crimson-spotted rainbowfish (*Melanotaenia fluviatilis*)	No	FD				Y	DD, L	
Golden perch (*Maquaria ambigua*)	Yes	FD	Y	Y	Y	Y	Vul	
Murray cod (*Maccullochella peelii peelii*)	Yes	FD	Y	Y	Y	Y	End, L	V
Unspecked hardyhead *(Craterocephalus stercusmuscarum fulvus)*	No?	-				Y	DD, L	
Common carp (incl Goldfish X)* (*Cyprinus carpio*)	Yes	FG	Y	Y	Y	Y		
Gambusia* (*Gambusia holbrooki*)	No	FG	Y	Y	Y	Y		
Goldfish* (*Carassius auratus)*	No	FG	Y	Y	Y	Y		
Oriental weatherloach* (*Misgurnus anguillicaudatus*)	No?	FG	Y	Y	Y	Y		
Redfin* (*Perca fluviatilis*)	No	FD	Y	Y	Y	Y		

Notes:
* introduced species
Flow association (after Reich *et al.* 2009)
FD Flow dependent – Present at highly regulated sites with perennial flow and low monthly flow variation
FG Flow generalist – Present across the hydrological gradient
Victorian and National Status
DD data deficient within Victoria and suspected of being threatened
Vul considered vulnerable within Victoria
End considered endangered in Victoria
L listed as threatened under the Victorian Flora and Fauna Guarantee Act 1988
V vulnerable in Australia (listed under the EPBC Act)

Of the threatened native fish species present within the EWP waterway reaches, the large bodied species (Murray cod and Golden perch) are likely to be the most significantly exposed to potential changes in the flow regime as this may impact on:

- habitat quantity – depth and extent if pool or stream levels are significantly reduced;
- habitat suitability – if geomorphic change (i.e. sedimentation) reduces in-stream habitat; and
- habitat availability – if movement through fishways is compromised by modified flow.

Both large and small bodied species may potentially be impacted by:

- reduced water quality – if dissolved oxygen, temperature or turbidity levels cross biological thresholds; and
- modified food webs – if macroinvertebrate communities are significantly impacted.

Introduced species, particularly Common carp and Oriental Weatherloach may be favoured by reductions in the future flow regime if water temperatures increase.

6.6 Threatened species – Flora and fauna

Broken Creek and Nine Mile Creek retain remnants of the original vegetation cover within an otherwise broadly cleared landscape. The remaining vegetation is highly fragmented and occurs as small isolated remnants (DSE 2008). These remnants support threatened flora and fauna populations, including some potentially impacted by changes in the hydrology or character of the Broken Creek system.

Threatened flora and fauna species lists for flora and fauna found along or adjacent to the EWP waterways have been compiled from various existing reports (DSE 2008, Heard 2007, Parks Victoria 2006) and the DSE Threatened Flora and Fauna spatial layer (provided by Goulburn Broken CMA). These lists are provided in Appendix C.

The most comprehensive lists are those contained in the Biodiversity Action Plans (BAPs) covering the project area, namely:

- the Central Creek Landscape Zone (DSE 2008) covering EWP Reaches 1, 2 and part of Reach 3, and
- the Barmah Landscape Zone (Heard 2007) covering part of EWP Reach 3 and EWP Reach 4

Biodiversity Action Planning (BAP) identifies priorities for the conservation of native biodiversity at a landscape scale. These BAPs document the significant flora and fauna within the respective landscape zones. While the landscape zones extend beyond the immediate riparian environment, the threatened species lists contained in the BAPs are of relevance to the EWP as the major creeklines provide habitat for most of the threatened species found in the zone (DSE 2008), and are considered to be of "Very High" conservation value as they provide essential conduits of contiguous vegetation, which will facilitate species movement and provide habitat, food and shelter for a range of species, particularly fauna (Ahern *et al.* 2003 cited in Heard 2007).

In recognition of the scope of the EWP, namely that it is focussed on the impact of NVIRP on high value assets dependent on the current regulated flow regime, the threatened species lists from the BAPs have been reviewed to identify those species with a strong riparian zone or in-stream association. A considerable area of the Broken Creek system is contained within the Broken-Boosey State Park, with the most of the threatened species and communities associated with the floodplain and adjacent woodlands to the Creek (i.e. Plains Grassy Woodland or Plains Grassy Woodland/Gilgai Wetland Mosaic EVCs, based on Buloke or Grey Box overstorey (Parks Victoria 2006). It is highly likely that predominantly 'terrestrial' flora and fauna will not be impacted by changes in regulated flow, and it is only those taxa that are aquatic or typically found on the terrestrial/aquatic ecotone that will experience any change.

With this in mind, the total species list has been filtered to identify those species likely to be impacted by a change in the regulated flow hydrology, i.e. particularly the aquatic plants (Section 6.6.1) and fish and frogs (Section 6.6.2), and these more likely impacted groups have had potential impacts considered more fully. Some of the species of vascular flora found within the boundary zone, such as the *Cardamine* species, Pale Spike-sedge (*Eleocharis pallens*) and Small-flowered Mud-mat (*Glossostigma cleistanthum*), could be negatively impacted by changes in regulated flow, based on their habitat preferences, and position within the ecosystem. The full consideration of the potential impacts of changed regulated flow regime on these species is beyond the scope of this study, but should be undertaken prior to any changes in flow regime. Notwithstanding the need to more fully consider these species, the evaluation of the effect of change in regulated flow in this instance must be considered in the context that the existing regime is likely to result in the long term loss of existing threatened vegetation, and replacement with more tolerant River Red Gum communities (ECC 2001 from Parks Victoria 2006). The change in regime proposed is probably a significantly lesser disturbance than the imposition of the original altered flow and flooding regime.

While numerous other more terrestrial fauna (i.e. birds, lizards, mammals) are found in proximity to the waterway due to reliance on the habitat or food sources found in the riparian zone, the suitability of this zone for their role in the fauna lifecycle is more likely to be controlled by the riparian zone and adjacent community condition and management (i.e. vegetation composition and structure, and critical species abundance), than a minor alteration to the regulated hydrologic regime.

6.6.1 Threatened flora with waterway association

Parks Victoria (2006) states that no threatened aquatic plant species are known to occur within the Broken-Boosey State Park and associated reserves however large populations of the nationally vulnerable Ridged Water Milfoil (*Myriophyllum porcatum*) and endangered (in Victoria) Slender Water Milfoil (*Myriophyllum gracile* var. *lineare*) have been found in Kinnairds Swamp (adjacent Broken Creek) following flooding (Australian Ecosystems 2009) (refer Section 6.3.3).

A threatened species list, focussing on aquatic and flood dependent species has been developed from the full listings discussed above. This listing is provided in Table 6-7 and has been developed using plant habitat descriptions from NSW Flora Online (http://plantnet.rbgsyd.nsw.gov.au/)

Table 6-7 Threatened flora – Likely to be associated with waterways (after Heard 2007 and DSE 2008)

Common name	Scientific name	Australian status	Victorian status	FFG code	Waterway setting	Habitat description (from NSW flora online : http://plantnet.rbgsyd.nsw.gov.au/)
Slender Water-milfoil	*Myriophyllum gracile* var. *lineare*		e	N	a	Perennial herb, aquatic or fully emergent; stems mostly 1 mm diameter
Ridged Water-milfoil	*Myriophyllum porcatum*	V	v	N	a	??
Slender Water-ribbons	*Triglochin dubia*		r		a	Grows in still ephemeral freshwater to 50 cm deep, in swamps creeklets and floodplains
Pale Spike-sedge	*Eleocharis pallens*		k		e	Grows in seasonally wet situations such as floodways, usually on clayey soils
Slender Club-sedge	*Isolepis congrua*		v	L	e	Grows in seasonally damp situations
River Swamp Wallaby-grass	*Amphibromus fluitans*	V	k		m	Grows mostly in permanent swamps; uncommon
Western Water-starwort	*Callitriche cyclocarpa*	V	v	N	m	
Winged Water-starwort	*Callitriche umbonata*		r		m	In damp often swampy places
Riverina Bitter-cress	*Cardamine moirensis*		r		m	Grows in low-lying areas adjacent to streams and swamps
Long Eryngium	*Eryngium paludosum*		v		m	Grows in swampy, irrigated or flooded areas, depressions on sand, loam, clay and cracking clays
Small-flower Mud-mat	*Glossostigma cleistanthum*		r		M	Grows in silt in rock-pools, in clay on creek beds, on swamp margins or river flats or in dams, submerged or exposed
Bluish Raspwort	*Haloragis glauca f. glauca*		k		M	Often along seasonal watercourses
Swamp Star	*Hypoxis exilis*		v		M	Restricted to swampy areas on the floodplains of the Murray, Edward and Murrumbidgee Rivers
Button Rush	*Lipocarpha microcephala*		v		M	Grows in open damp places such as sandy stream banks; widespread but scattered

Common name	Scientific name	Australian status	Victorian status	FFG code	Waterway setting	Habitat description (from NSW flora online : http://plantnet.rbgsyd.nsw.gov.au/)
Leafless Bluebush	*Maireana aphylla*		k		m	Widespread in low-lying seasonally inundated areas with heavy soils
Smooth Minuria	*Minuria integerrima*		r		m	Grows in a variety of habitats and soils near places of permanent or ephemeral water
Striped Water-milfoil	*Myriophyllum striatum*		v	N	m	In damp situations on the banks of creeks and around waterholes, Creeping, matted herb, fully emergent
Large River Buttercup	*Ranunculus papulentus*		k		m	Grows in wet sites, on mud or in pools
Annual Buttercup	*Ranunculus sessiliflorus* var. *pilulifer*		k		m	Grows in intermittently moist sites, often in grassland or woodland on nutrient-rich soils

Definitions: Australian status
- V: vulnerable in Australia

Victorian status
- k: poorly known in Victoria
- e: endangered in Victoria
- v: vulnerable in Victoria
- r: rare in Victoria

FFG codes
- L: listed under FFG
- N: nominated under FFG

Waterway setting (assigned based on description from NSW flora online)
- a: aquatic
- e: seasonally flooded
- m: waterway margin

6.6.2 Threatened fauna dependent on the aquatic environment

As discussed in Section 6.6, the threatened species likely to be found within the EWP project waterways are documented in Appendix C. While the list includes a significant number of birds, including waterbirds, reptiles and mammals it is considered that the only species likely to be impacted by a change in the regulated flow regime are fish and frogs. The retention of sustainable populations of the other species dependent on the broader riparian environment is more dependent on the management of the broader riparian zone and the regime of floods above that impacted by NVIRP. Threatened fish and frogs within the EWP waterways are thus summarised in Table 6-8. The status and flow dependence of the identified fish species are discussed in Section 6.5. Information from the Scientific Reference Group suggests that the Trout cod (*Maccullochella macquariensis)*, Freshwater catfish (*Tandanus tandanus)* (a single Freshwater catfish was captured moving upstream through the Kennedys Weir fishway in 2000 (O'Connor *et al.* 2003)), Macquarie perch (*Macquaria australasica*), Giant Bullfrog (*Limnodynastes interioris*) and Growling Grass Fog (*Litoria reniformis*) are unlikely to be currently present within the EWP waterway reaches despite their inclusion on the threatened species lists.

Table 6-8 Threatened fish and frogs along EWP waterways (after DSE 2008 and Heard 2007)

Scientific name	English name	Australian status	Victorian status	FFG listed
Maccullochella macquariensis	Bluenose (Trout) Cod #	E	cr	L
Tandanus tandanus	Freshwater Catfish #		e	L
Macquaria ambigua	Golden Perch		v	
Craterocephalus stercusmuscarum fulvus	Unspecked hardyhead		dd	L
Macquaria australasica	Macquarie Perch #	E	e	L
Maccullochella peelii peelii	Murray Cod	V	e	L
Bidyanus bidyanus	Silver Perch		cr	L
Limnodynastes interioris	Giant Bullfrog#		cr	L
Litoria raniformis	Growling Grass Frog#	V	e	

Definitions: Victorian (denoted by lower case) Status of Species:
e = endangered, v = vulnerable, r = rare, k = poorly known,
cr = critically endangered, dd = data deficient
FFG (Flora Fauna Guarantee Act 1988) taxon:
L = listed
# - considered unlikely to be present within EWP reaches

6.7 Macroinvertebrates

Anthropogenic alteration of water regimes within lowland rivers such as the Broken Creek may affect the abundance of many taxa without eliminating them (Chessman *et al.* 2006). Historically, the macroinvertebrate communities within the Broken Creek would have been dominated by mobile taxa adapted to intermittent flows and capable of tolerating environmental extremes (e.g. floods and drying) (Cottingham *et al.* 2001, Chessman *et al.* 2006). The Broken Creek is now a permanently flowing creek and the macroinvertebrate community is likely to have changed to less mobile and more persistent taxa (Cottingham *et al.* 2001).

Within the Broken Creek there are three distinct habitat types:

- benthic substrate composed of sand or mud;
- stands of macrophytes (*Typha* and *Phragmites* spp.); and
- large woody debris (LWD).

In general, the communities within each habitat will have a similar number of taxonomic groups (i.e. similar diversity) but the composition of the communities will differ (i.e. a different suite of macroinvertebrates will be found in association with each habitat), and the LWD habitat type may support the highest macroinvertebrate densities (Humphries *et al.* 1998).

There is likely to be a change in macroinvertebrate communities longitudinally, with more diverse communities likely to be found in the upper reaches where there is potentially greater habitat diversity and better water quality compared to EWP Reach 4, which appears to have reduced habitat diversity and deteriorating water quality.

6.8 Threats to asset condition

The environmental assets documented in previous sections are exposed to various threatening processes. GHD / URS (2005) discusses threats in the context of the RiVERS database. Within the context of the EWP those threats which are potentially exacerbated by a modified flow regime and which pose the greatest threat to environmental condition include degraded water quality, the increasing dominance of aquatic weeds and potential geomorphic change impacting on in-stream habitat values. These threats are discussed in the following sections.

6.8.1 Water quality

The availability of water quality data within the EWP project waterway reaches is limited, with long term monitoring undertaken at only one site (Rices Weir) where data has been gathered since 1978 (GHD / URS 2005). SKM (2004) (cited in GHD / URS 2005) contains additional data for Broken Creek at Rices Weir and Shepparton irrigation district Drains 11 and 12, while water quality was also monitored on Boosey Creek at Katamatite (Waterwatch Site Code BOO010) between 1995 and 2002. There has been no long term monitoring of water quality in Nine Mile Creek (GBCMA 2008).

GHD / URS (2005) reviews the available water quality monitoring data (based principally on the Rices Weir site) and notes that while Broken Creek would have had naturally high turbidity levels for much of the year, land use changes have resulted in elevated turbidity and nutrient levels which, along with low flows and increased water temperatures, have resulted in an increased frequency of algal blooms and nuisance aquatic plant growth. Dissolved oxygen, turbidity and nutrient levels fail to meet State Environment Protection Policy (SEPP) – Waters of Victoria water quality objectives.

Drain and channel outfalls from the GMID, along with historic and current land management practices and urban drainage, contribute significant nutrient and turbidity loads to the Broken Creek system. There is potential that the rationalisation of the outfall and drainage network and ongoing changes in land and irrigation management may bring about a long-term reduction in sediment and nutrient supply. The most immediate ecological impact of the degraded water quality in the Broken Creek system is an increase in the occurrence of low dissolved oxygen conditions which compromises the survival of aquatic fauna (fish, macroinvertebrates, and zooplankton).

A major fish kill event in the Rices Weir pool in November 2002 has been attributed (Rees 2006) to low dissolved oxygen levels resulting from excessive growth of the floating fern *Azolla* sp. This occurred during a drought period when low creek flows, elevated air and water temperatures provided near optimal conditions for *Azolla* growth. While the fish kill event has focussed attention on Rices Weir the nutrient, sediment and water column conditions in Rices Weir essentially represent a worst-case scenario for the other weirs in the lower Broken Creek system (Rees 2006). No water quality data is available for upstream weir pools but similar issues are conceivable throughout EWP Reach 4.

Rees (2006) discusses the factors contributing to the 2002 fish kill event and the ecological implications of *Azolla* proliferation in the lower Broken Creek. The highly modified nature of the Broken Creek system is highlighted, with the lower reaches now comprised of a series of shallow weir pools with high nutrient levels in both incoming water and bed sediments. This contributes to very high in-stream primary production resulting in strong diurnal and seasonal variations in dissolved oxygen. It is identified that nutrient management is unlikely to resolve the *Azolla* issues in the short term due to high nutrient levels in the bed sediment.

A response plan has been implemented since the 2002 fish kill event based on the provision of flushing flows to prevent the build up of *Azolla* and to supply oxygenated water from upstream so as to prevent future fish deaths (GBCMA 2008). Typically this has required the provision of flushing flows (total flows over Rices Weir) of 100-250 ML/d from July to November (peak growth period), with flows adjusted based on real-time monitoring of dissolved oxygen and temperature in Rices Weir (GBCMA 2008). Goulburn Broken CMA has trialled the use of pulsed flushing flows rather than sustained flows over the growth period but this was not found to be effective. Mechanical removal or harvesting of *Azolla* from the Rices Weir pool has been trialled but issues relating to on-site impacts of machinery, limited disposal options for removed *Azolla* and the inability to remove all *Azolla* (leading to rapid re-infestation) mean that this approach is not currently recommended.

Rees (2006) supports management through provision of flushing flows, based on the current state of knowledge, as an effective means to minimise the effects of *Azolla* on water quality.

6.8.2 Aquatic weeds

Aquatic plants tolerant of or favoured by permanent water and low flow velocity conditions are an increasing issue within the Broken Creek system. Under natural conditions, flows in the system were ephemeral and would have provided habitat for a range of perennial and annual macrophytes adapted to wetting and drying cycles (GBCMA 2008). The modified flow regime favours robust perennial species adapted to permanent or near-permanent inundation and low flow velocity (GBCMA 2008).

Arrowhead (*Sagittaria graminea*) is the most significant aquatic weed species known to be present in the Broken Creek system (GHD / URS 2005, Parks Victoria 2006, GBCMA 2008). Large stands are known on Nine Mile Creek near Wunghu and as control is difficult further spread in shallow reaches (EWP Reaches 1 and 2) is likely (GHD / URS 2005).

Cabomba (*Cabomba caroliniana*), a Weed of National Significance, occurs in the Broken River between Benalla and Caseys Weir and has been recorded in the upper reaches of Broken Creek downstream of Caseys Weir (Jamie Kaye, pers. comm. 2010). While it is not known to occur within the EWP project area, future spread down Broken Creek is possible.

Lippia (*Phyla canescens*) occurs in the riparian zone of Broken Creek, and while not flow dependent, it is difficult to control and has the potential to spread widely throughout the riparian zone (GHD / URS 2005).

Two native species, Cumbungi (*Typha* sp.) and to a lesser degree, Common Reed (*Phragmites australis*) are now dominant in some locations. While they provide important in-stream habitat, particularly in the absence of LWD, their dense growth form and ability to colonise a range of water depths has seen an increase in their extent in the system. Cumbungi is noted as being a problem upstream of Numurkah around Kinnairds Swamp and upstream of Wunghu on Nine Mile Creek (GHD / URS 2005) and is said to impact on provision of water to Black Swamp. Control by spraying and mechanical removal or cutting below water level has been undertaken in some areas to facilitate passage of irrigation water.

Another native species, *Azolla*, has become prolific particularly in the weir pools in EWP Reach 4, and has been linked with a fish kill event in 2002 (GHD / URS 2005), refer Section 6.8.1,

6.8.3 Altered geomorphic processes

In a highly modified and regulated system such as Broken Creek, altered geomorphic processes can threaten other in-stream values. Unnaturally high levels of bed and bank instability can result in a change in geomorphic form and contribute elevated sediment loads, impacting on water quality, bed form and substrate composition. Weir pools can change stream flow and sediment transport processes, causing increased sediment deposition and loss of bed variability.

The history of bank and bed instability, along with historic channel modifications within the EWP waterway reaches are discussed in GHD / URS (2005).

Fluvial bank scour has generally not been a significant issue within the EWP project area, reflecting the low energy environment of the streams. Some bank erosion has been noted around weir pools due to constant water levels and the formation of an erosion notch in the bank and bank waterlogging. Significant bank erosion was reported in Nine Mile Creek following dredging and bed deepening in the 1960s (SKM 1998 cited in GHD / URS 2005) and SKM (1998) indicates that there is still minor bank erosion in Nine Mile Creek due to the relatively confined channel capacity relative to drainage outfall volumes.

Bed instability is not considered to pose a major threat to future waterway condition. Localised incision has occurred, particularly in response to dredging and weir construction but GHD / URS (2005) found little evidence of sediment build-up in weir pools. Recognising that the existing weirs in the lower Broken Creek are to be retained, the modification to channel form and flow dynamics and the historic removal of large woody debris from the channel are likely to be the most significant ongoing threats to habitat availability in the Broken Creek system.

6.9 Summary

Of the environmental values discussed above, Murray Cod and Golden Perch are considered to be the most vulnerable to changes in the flow regime due to their high dependence on flow and water quality to provide suitable habitat and passage.

7. HYDROLOGY

The hydrologic analysis and reporting components of the current EWP were undertaken by Sinclair Knight Merz (SKM) for the Goulburn Broken CMA. The complete report by SKM is provided in Appendix D. Relevant sections have been copied, with some abbreviation, to Section 7.2 onward. The reader is referred to Appendix D for full details of the hydrologic assessment.

7.1 Current operational regime

7.1.1 Operational guidelines

The "Lower Broken Creek Operational Guidelines" (G-MW 2003) were developed following the completion of the fishway installation program (refer Section 6.5.1). The operational guidelines document G-MW's role in operating the system to meet supply obligations and minimise environmental impact. The operational guidelines were developed by G-MW in consultation with the Department of Primary Industries (DPI), the Department of Sustainability and Environment (DSE), the Goulburn Broken CMA and the local community and were intended to allow flexibility in operation to meet broader strategic requirements (G-MW 2003). Given that the operational guidelines precede the most recent Waterway Management Strategy (GHD / URS 2005) they do not provide a full coverage of the operational requirements to satisfy environmental objectives but suggest that operational flexibility is provided to meet future environmental requirements.

The operational guidelines (G-MW 2003) establish the general principles of operation for three operational modes: "In season" (August to May), "Out of season" (May to August) and "Flood operation". Amongst other things, these principles include:

- Target operating levels for each weir.
- Management for environmental objectives – namely passage of fish (Murray Cod identified as the critical species) and management of nuisance flooding of Goose Swamp between Rices Weir and the Barmah Forest (by operation of regulators).
- Weed management – providing for passing flows over Rices Weir to flush *Azolla* mats downstream. No target flow volumes (ML/d) are established in the guidelines however this is not inconsistent with the current management practice where flows are varied dependent on monitored dissolved oxygen levels.

The operational guidelines (G-MW 2003) contain a large amount of useful information in relation to system operation however sections of the document may require updating to reflect current practice (i.e. modified provisions for flows at Rices Weir, where the timing and magnitude of flushing flows have changed in recent years).

7.1.2 Monitoring and incident response

A "Monitoring and Incident Response Management Manual" (G-MW 2004) was prepared in response to the fish kill event in November 2002. The manual documents monitoring activities, trigger levels (based on monitored DO levels in Rices Weir, *Azolla* coverage, reported fish death and low flow conditions) and management responses including passage of additional flows to remove *Azolla* and / or increase dissolved oxygen. The manual notes an agreement between G-MW and the River Murray Commission to provide a 40 ML/d allocation from the River Murray (passed to Broken Creek and returned to the River Murray) to manage the Azolla build up. The agreement was modified to 80 ML/d for the 2003/04 irrigation season but the current status of this agreement is unknown.

7.1.3 Delivery of irrigation water to manage environmental assets

The Operational Guidelines (G-MW 2003) and Monitoring and Incident Response Management Manual (G-MW 2004) jointly document the operational regime however there is no formal agreement concerning the delivery of water to manage environmental assets in the Broken Creek system. G-MW and Goulburn Broken CMA have a mutual interest in dealing with the low dissolved oxygen and *Azolla* issues and management of environmental assets in lower Broken Creek and to date have managed flow delivery cooperatively. As outlined in G-MW (2003), irrigation water has been delivered in such a manner as to achieve identified environmental outcomes (specifically for passage of Murray Cod during the irrigation season) where feasible.

Where sufficient or timely flows cannot be delivered as a component of irrigation water delivery, specifically in relation to low dissolved oxygen and *Azolla* issues, Goulburn Broken CMA has made recommendations concerning the flows that may be required and G-MW has agreed to these. As the resource manager G-MW has called upon the Goulburn Water Quality Reserve (a provision within the G-MW Goulburn Bulk Entitlement (Victorian Government 1995) which can be used for management of the Broken Creek) or arranged for Inter Valley Transfers (IVTs) to meet the recommended flows. Environmental water sources (including IVTs) are discussed in Section 7.1.4.

7.1.4 Other environmental water sources

Environmental water to protect or enhance environmental values in the Broken Creek system can be sourced from outside of the Broken Creek system as outlined below.

Inter-Valley Transfers (IVT)

As a result of water entitlements trading from the Goulburn Supply System to the Murray Supply System, water needs to be physically transferred from the Goulburn System to the Murray River to supply these traded entitlements. These transfers are requested by the Murray Darling Basin Authority when the Murray Supply System can best use them. This is usually between December and April. Instead of the water flowing along the Goulburn River downstream of Goulburn Weir, it can be diverted at Goulburn Weir through the Shepparton Irrigation Area channel system (and particularly the EGMC) to Broken Creek, and then along Broken Creek and back to the Murray River. It requires the planned volume to be returned to the River Murray. Further discussion of the potential application of Inter Valley Transfers in relation to the Broken Creek system is provided in the Northern Region Sustainable Water Strategy (DSE 2009).

Goulburn Water Quality Reserve

The Goulburn Water Quality Reserve is a provision in the Eildon-Goulburn Weir Bulk Entitlement (Victorian Government 1995). Up to 30,000 ML is available in every financial year to maintain water quality in the Goulburn River and Broken Creek. For Broken Creek, the water is diverted at Goulburn Weir through the Shepparton Irrigation Area channels to Broken Creek. This water can be consumed or passed to the River Murray.

Murray Flora and Fauna Bulk Entitlement

The River Murray Flora and Fauna Bulk Entitlement (Victorian Government 1999) is 27,600 ML of high reliability water shares. Water availability in any year is subject to seasonal allocations for the Victorian Murray Supply System. Water can be diverted from the River Murray at Lake Mulwala and through the Murray Valley Irrigation Area channel system to Broken Creek, or it can be traded into the Goulburn Supply System and delivered through the Shepparton Irrigation Area channel system. This water can be consumed or passed back to the River Murray.

7.2 Natural water regime

The Lower Broken Creek[3] and Nine Mile Creek have been regulated for more than 100 years. Under natural conditions the creeks would have ceased to flow during summer and autumn. There is no long-term gauge record available to describe the natural flow regime in the system prior to regulation (refer Section 7.3.2).

7.3 Current water regime before NVIRP

7.3.1 Introduction

Under regulated flow conditions, the Lower Broken Creek and Nine Mile Creek are perennial streams with significant flows maintained through summer and autumn to supply water for irrigation, stock and domestic use. There are a number of weirs downstream of Katamatite which maintain water levels for private pumps (refer Section 4.2). Water quality in the weir pools during summer and autumn is often poor, and in recent years environmental managers have passed increasing volumes of water down the creek to manage the threats posed by low dissolved oxygen levels and *Azolla* blooms (refer Section 6.8.1).

Of the regulated inflows to the Lower Broken Creek, the major sources are the EGMC outfall and the Murray Valley 7/3 channel outfall (Figure 7-2). The major sources of unregulated inflows are the upstream catchments (i.e. the Upper Broken Creek and Boosey Creek), Shepparton Drain 11, Shepparton Drain 12 and Murray Valley Drain 13. In recent years, unregulated inflows have become a very small proportion of total inflows. All together, there are currently eleven outfall structures and six drains that connect directly to the Lower Broken Creek from the Murray Valley irrigation district, while five outfall structures and six drains connect directly to the Lower Broken Creek and Nine Mile Creek from the Shepparton irrigation district. As part of the NVIRP, seven of the eleven Murray Valley outfall structures connected to the creek will be decommissioned. The outfall structures that will be retained are denoted by an asterisk in Figure 7-2. Some outfall structures discharging to drains will also be removed.

7.3.2 Gauged flow records

Three stream flow gauges are located within the study area:

- Boosey Creek at Tungamah (404204)
- Broken Creek at Katamatite (404214)
- Broken Creek at Rices Weir (404210)

The flow records for each of the three gauges begin in the mid 1960s (Figure 7-1). The gauge records thus represent the hydrology of the system during the period of flow regulation (refer Section 4.1.3), rather than indicating flows under natural conditions. The records for the Boosey Creek at Tungamah and the Broken Creek at Katamatite are generally of good quality. In contrast, there is much data missing from the Broken Creek at Rices Weir record. Some of these missing periods coincide with floods along the Murray River, when water would have backed up Broken Creek and drowned out the gauging station.

Missing data for the Boosey Creek at Tungamah and Broken Creek at Katamatite records were short enough to infill using linear interpolation. Linear interpolation was not appropriate for infilling the Broken Creek at Rices Weir record. Instead, the Murray Darling Basin Authority (MDBA) supplied a daily time-series of modelled flows past Rices Weir (1891 – 2009), assuming current conditions. While not exactly comparable to historically gauged streamflows (which captures the range of

[3] Downstream of the confluence of Broken Creek and Boosey Creek at Katamatite

development and management conditions the creek has been subjected to), the current modelled time-series does provide a good indication of flows expected at Rices Weir under the system's current regulation, were the past 120 years of climate repeated.

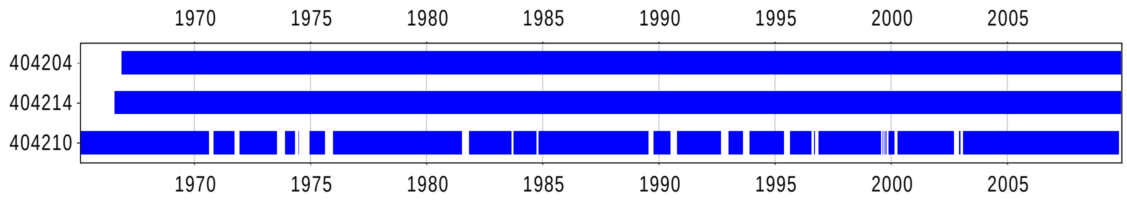


Figure 7-1 Extent of streamflow data available

Based on the flows observed at gauges 404204, 404214 and 404210, and the modelled flows for Rices Weir (404210) assuming current conditions, the following observations can be made:

- Flow in the Boosey Creek at Tungamah and the Broken Creek at Katamatite ceases for approximately 20% of the time. In contrast, there is flow past Rices Weir for all but a small portion of time (Figure 7-3).
- Flows past Rices Weir are elevated in summer and autumn by regulated releases through outfall structures located along the Lower Broken Creek (Figure 7-4). In winter and spring, the average recorded flow is of similar magnitude to the average flow recorded in summer and spring, but this is because there are significant periods of data missing during winter and spring for 16 of the 45 years of record. In contrast, the MDBA modelled time-series for Rices Weir, while showing elevated flows in summer and autumn, has the highest average flows occurring in spring. In recent years however, drought conditions have seen recorded flow past Rices Weir fall below 10 ML/d for extended periods during winter and spring. The flow regime for the Boosey Creek at Tungamah and the Broken Creek at Katamatite follows a more natural pattern, with low flows in summer and higher flows in winter and spring, including occasional flood events.
- On average, flows to the study area from the upstream catchments for the period of record available are 33 ML/d for December to May and 157 ML/d in for June to November (Table 7-1). The bulk of these inflows come from the Boosey Creek catchment. Average daily flows past Rices Weir for December to May and June to November are 300 ML/d – 500 ML/d, depending on whether the recorded or modelled streamflows are analysed.
- Although average flows at Rices Weir are greater than for the Boosey Creek at Tungamah and the Broken Creek at Katamatite, the peaks of high flow events recorded at the upstream end of the study area are often attenuated by the time they reach Rices Weir (Figure 7-5).

Page 961

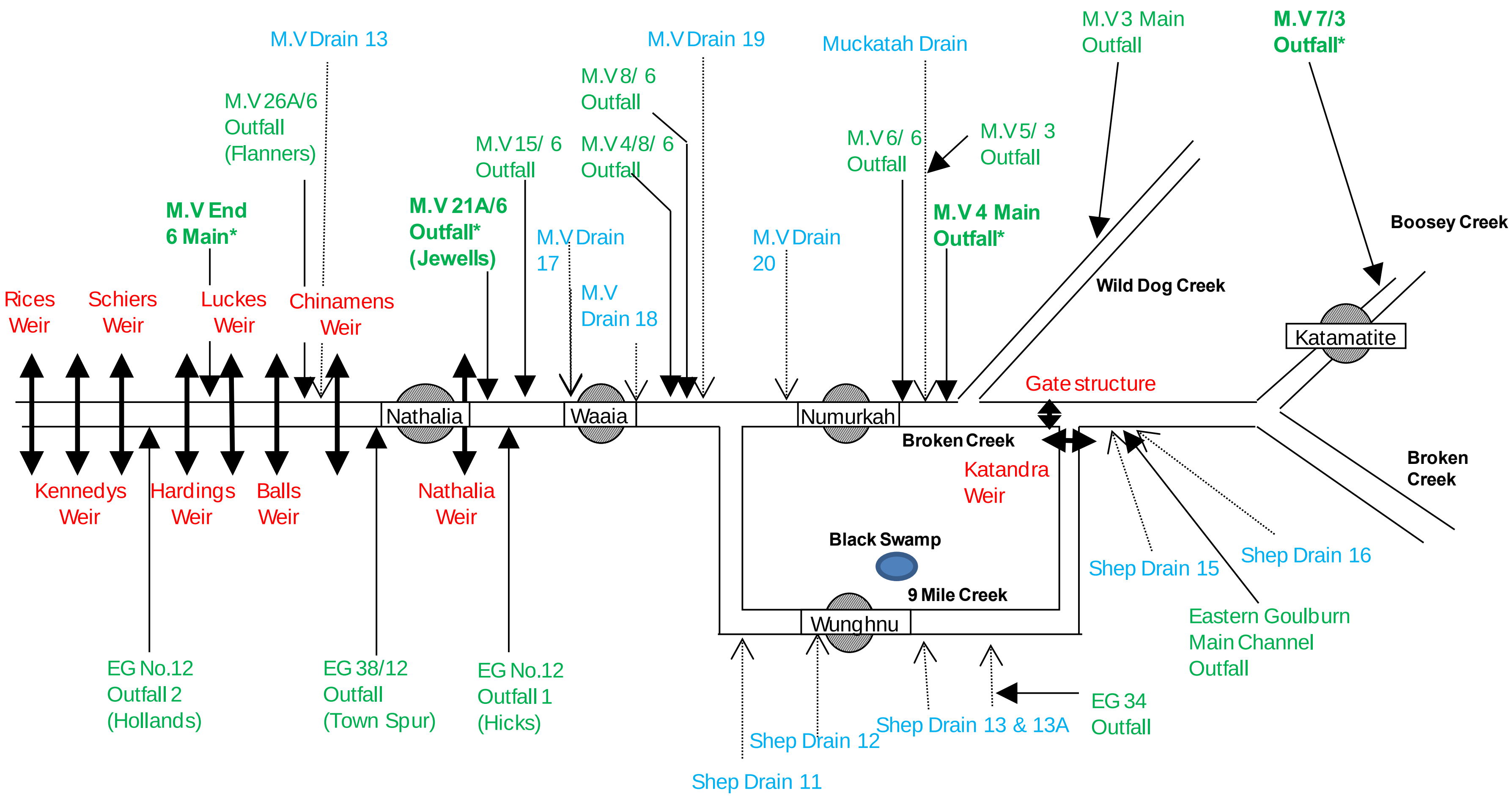


Figure 7-2 A schematic of the lower Broken Creek and Nine Mile Creek system

Names of regulating structures are in red, names of drains are in blue and outfall numbers are in green. Murray Valley outfall structures that will not be removed as part of the NVIRP are shown by an asterisk. All outfall structures on the Shepparton side of the creeks are being retained.

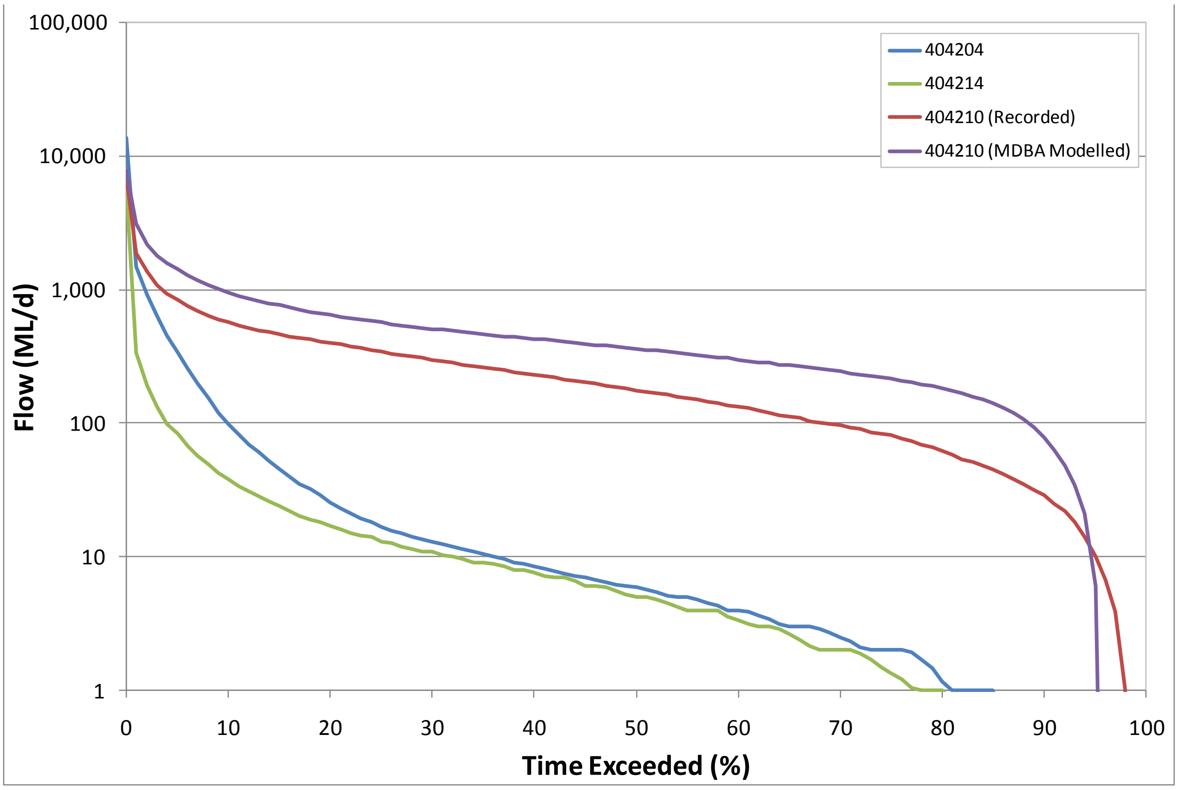


Figure 7-3 **Daily flow duration curve for streamflow gauges 404204, 404214 and 404210**

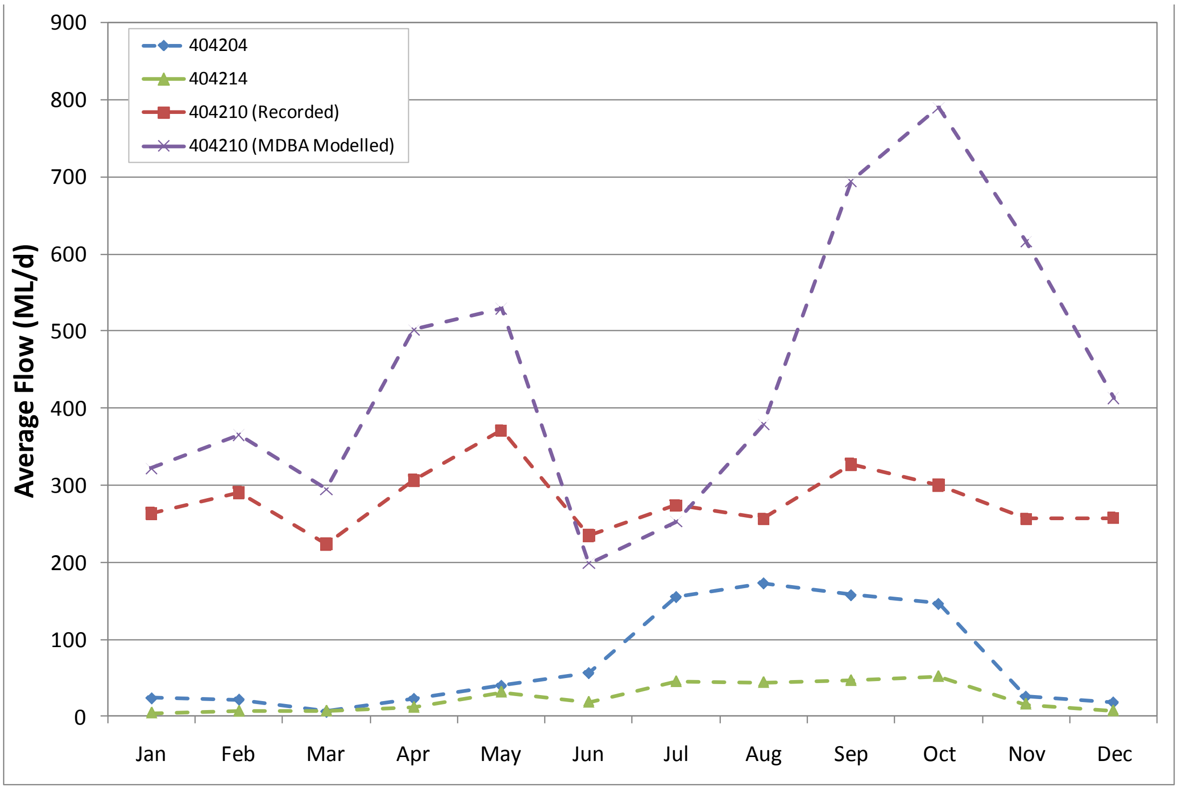


Figure 7-4 **Average daily flow for streamflow gauges 404204, 404214 and 404210**

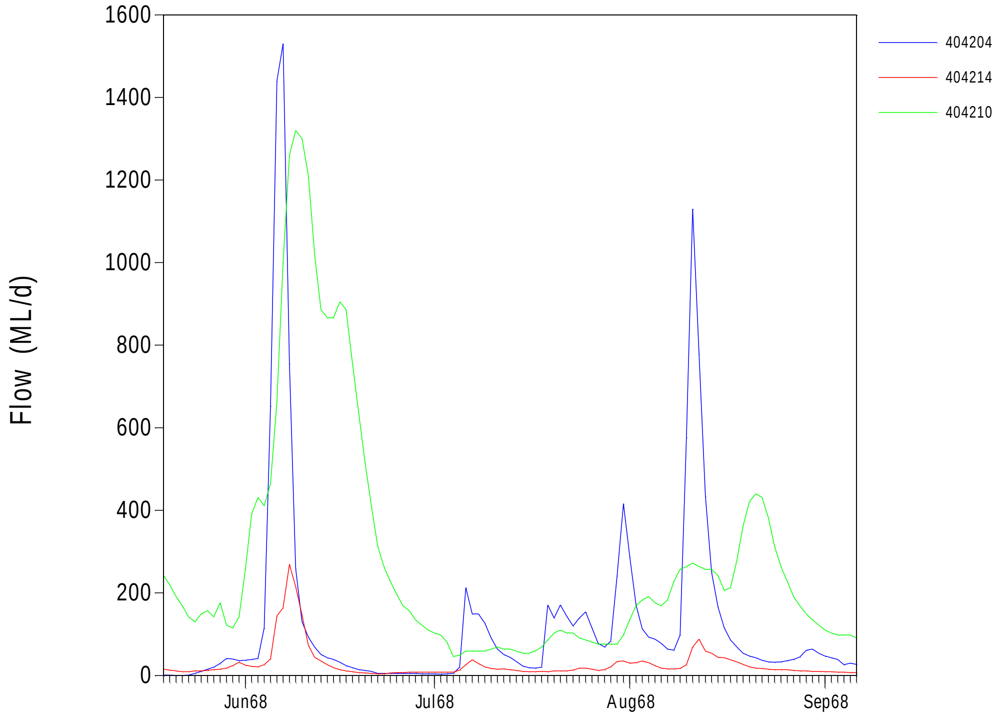


Figure 7-5 **Attenuation of high flow events as they move from the upstream end of the study area (404204 and 404214) to the downstream end (404210)**

Table 7-1 **Flow statistics for gauges 404204 and 404214, and downstream gauge 404210**

Statistic (ML/d)	*Flow Gauge*				
	404204	*404214*	*404204 + 404214*	*404210 (Recorded)^*	*404210 (Modelled)**
Minimum daily flow	0	0	0	0	0
Average daily flow	71	24	95	280	492
Maximum daily flow	13,700	5,910	15,800	7,050	7,670
Summer minimum daily flow	0	0	0	0	0
Summer average daily flow	22	11	33	286	468
Summer maximum daily flow	3,390	4,800	6,920	7,020	4,390
Winter minimum daily flow	0	0	0	0	0
Winter average daily flow	120	37	157	273	549
Winter maximum daily flow	13,700	5,910	15,800	7,050	7,670

Note: Summer refers to the months December to May, while winter refers to the months June to November.
Note:^ Without infilling missing periods in the gauge record.
Note: *Modelled time-series was provided by the MDBA from BigMod for the period 1891-2009.

7.3.3 Current outfall contributions

Inflows to the Lower Broken Creek and Nine Mile Creek come from three sources:

- The upstream catchments;
- Irrigation channels that outfall directly to the creeks; and
- Drains that discharge to the creeks.

The flow contribution from the upstream catchments is described in Section 7.3.2.

Flow through outfall structures to the creeks is comprised of two parts:

- Inflows ordered by local diverters or environmental managers; and
- Inflows in excess of orders.

In addition to the outfall structures that connect directly to the creeks, a number discharge to drains. Flows through the outfall structures into drains combine with drainage flows. Often a portion of drainage flows will be diverted by irrigators before reaching the creek. Isolating the contribution of outfalls to drainage flows that enter the creeks is difficult.

Data on inflows to the Lower Broken Creek and Nine Mile Creek through outfall structures and drains was sourced from G-MW and Thiess for the period of available record from 1998 to 2009. Missing data was infilled as outlined in Appendix D.

Total inflows

Of the total inflows to the Lower Broken Creek and Nine Mile Creek system, a large portion flows downstream and passes to the Murray River (Figure 7-6). Over the past 10 water years, the annual flow past Rices Weir has only been 25% to 45% lower than total estimated inflows. In this report, water year 1997/98 is defined as 1st July 1997 to 30th June 1998.

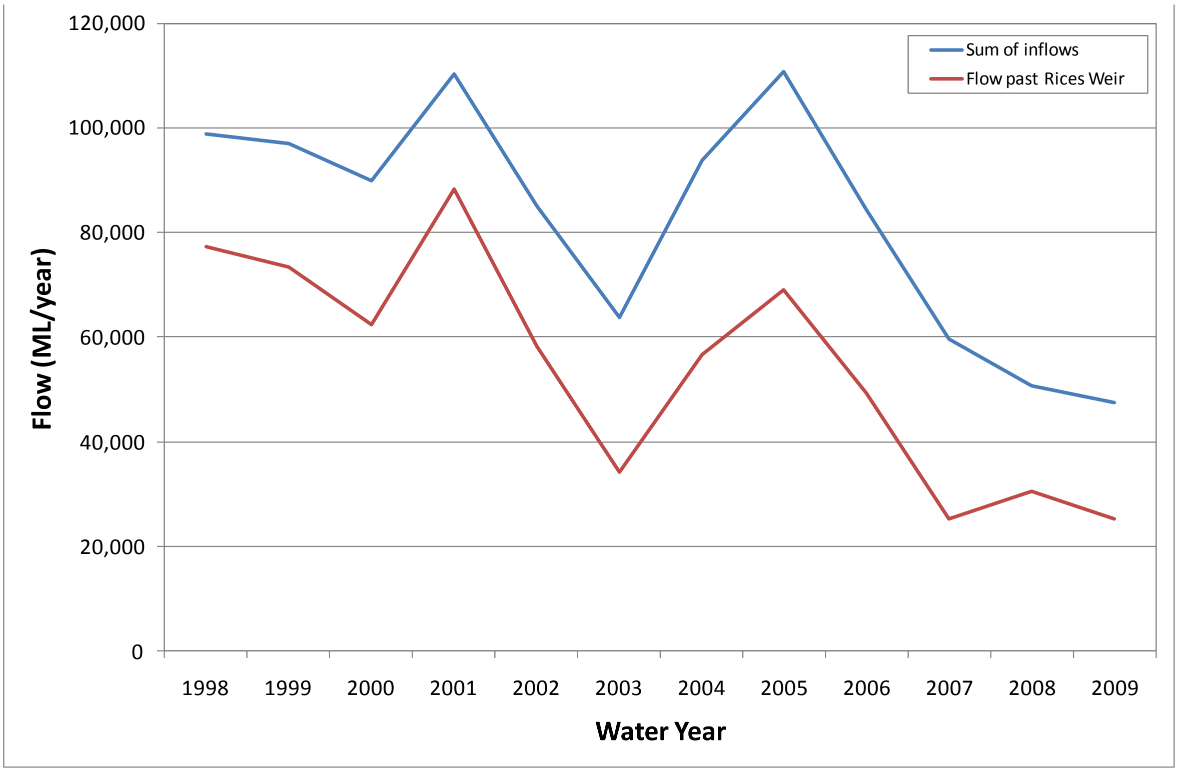


Figure 7-6 A comparison of annual total inflows (including from the upstream catchments, outfalls and drains) and annual flow past Rices Weir (some data infilled as outlined in Appendix D).

Total inflows through outfall structures

Of total inflows to the Lower Broken Creek and Nine Mile Creek systems, the majority comes through the channel outfall structures (Figure 7-7). Over the past 10 years, as drought conditions have reduced the percentage contributions from unregulated sources of water (i.e. the upstream catchments and drains), the percentage contribution from outfall structures has increased. In 2008-09, inflows from outfall structures contributed approximately 95% of total inflows.

At the same time as the percentage contribution to inflows from outfall structures has increased, the inflows through outfall structures in excess of orders has decreased. In short, the distribution of water through outfall structures to the Lower Broken Creek and Nine Mile Creek has been managed more tightly in recent years.

Interestingly, over the past five years, the volume of water ordered through outfall structures by environmental managers (using environmental allocations or inter valley transfers (IVTs)) has rapidly increased, while the volumes ordered by diverters has decreased (Figure 7-9). In 2008-09, the volume of water ordered for the environment and IVTs exceeded local diverter orders for the first time. The decrease in diverter orders can be linked with Murray and Goulburn irrigation allocations (Table 7-2). As allocations have decreased, and the volume of water ordered by diverters has also decreased. Environmental managers have therefore needed to order more water for the Lower Broken Creek and Nine Mile Creek systems for the purpose of maintaining sufficient water quality in the weir pools.

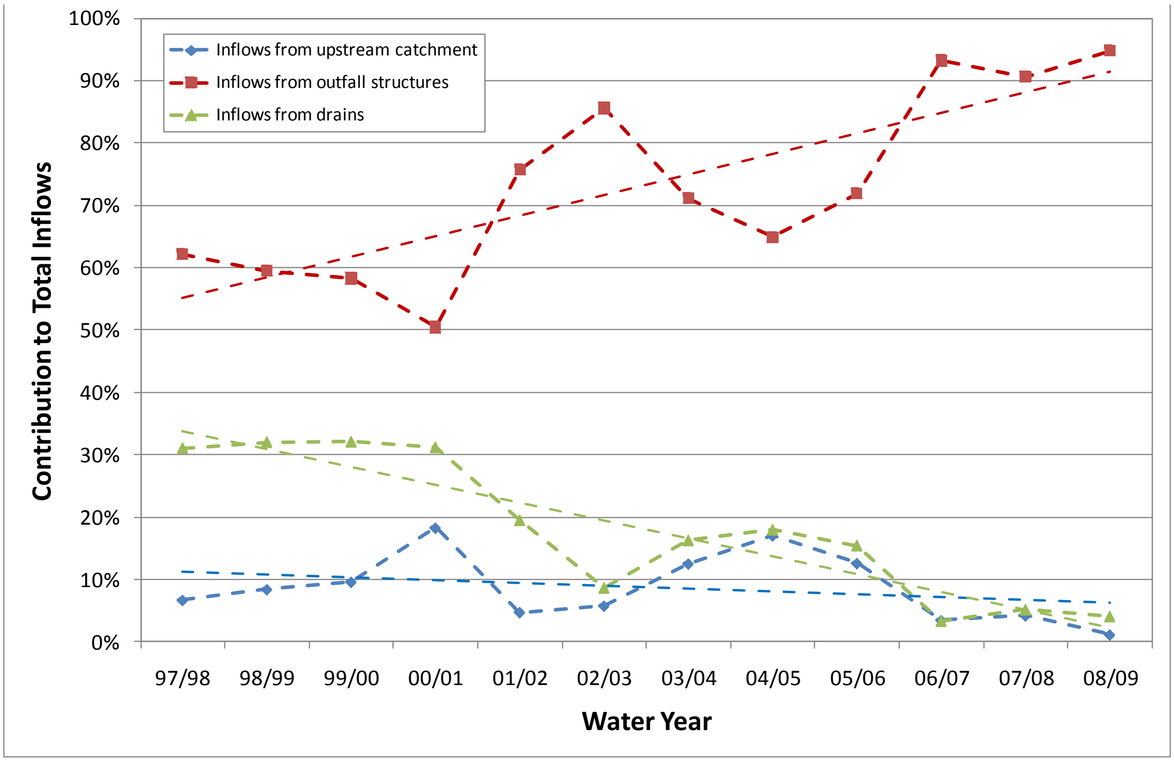


Figure 7-7 The contribution of inflows from the upstream catchment, outfall structures and drains

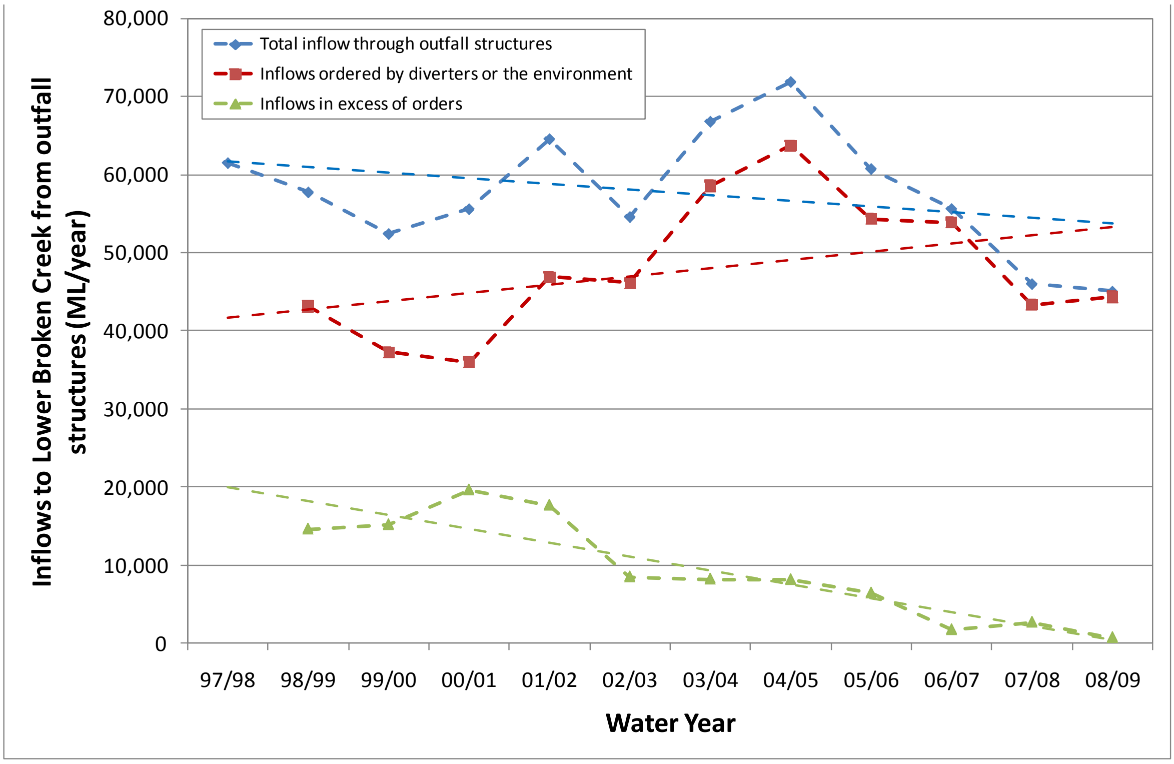


Figure 7-8 **The total inflow through outfall structures, divided into ordered inflows and inflows in excess of orders**

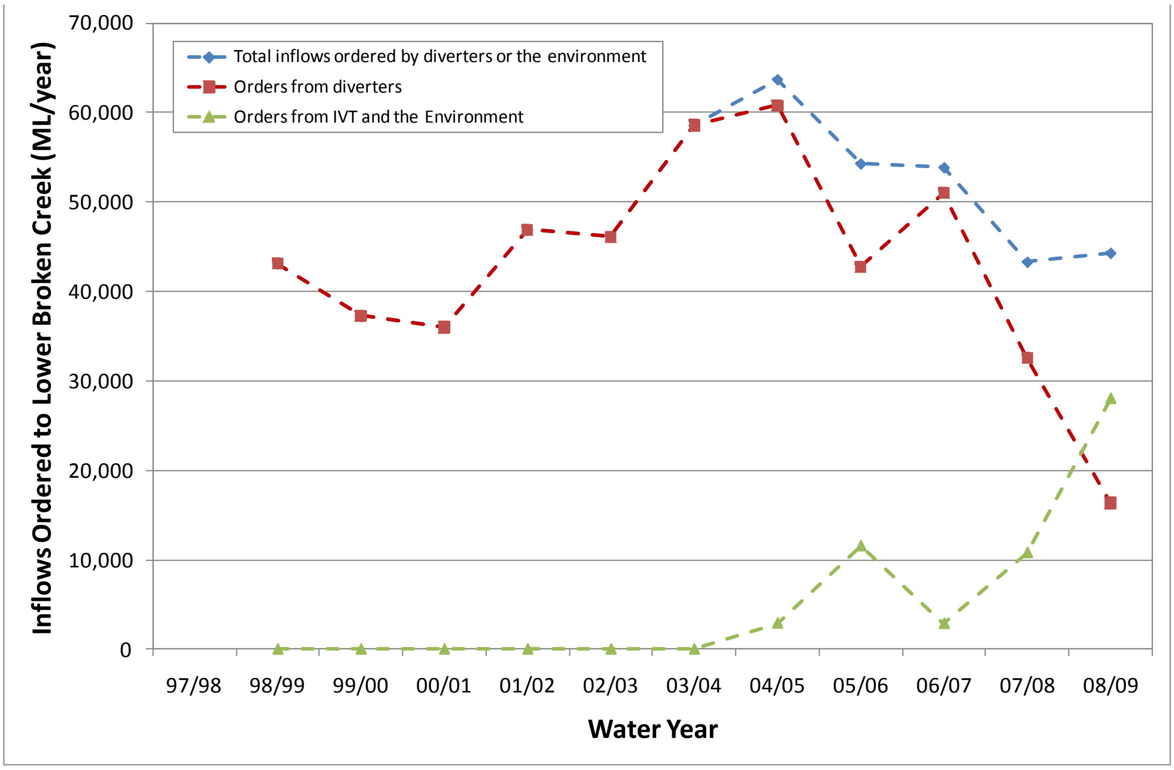


Figure 7-9 **The volume of ordered water for diverters, the environment and IVTs**

Table 7-2 Murray and Goulburn February irrigation allocations

Water Year	Murray Allocation	Goulburn Allocation
1997/98	130%	120%
1998/99	200%	100%
1999/00	130%	100%
2000/01	200%	100%
2001/02	200%	100%
2002/03	129%	53%
2003/04	100%	100%
2004/05	100%	100%
2005/06	141%	100%
2006/07	95%	25%
2007/08	42%	53%
2008/09	35%	33%

Inflows through outfall structures in excess of orders

Inflows to the Lower Broken Creek and Nine Mile Creek system in excess of orders have declined significantly over the past 10 years. In 2004/05 (which is often used as a base case for assessing the impacts of NVIRP), inflows through outfall structures in excess of orders were approximately 8,100 ML. Of this, 6,000 ML was contributed from the Shepparton irrigation district and 2,100 ML was from the Murray Valley irrigation district. In 2009, inflows in excess of orders were only 730 ML, half of which came from both irrigation districts (Figure 7-10). Inflows in excess of orders through Shepparton outfall structures are likely to have been impacted by the Shepparton Modernisation Project, which was in place for the 2008/09 irrigation season.

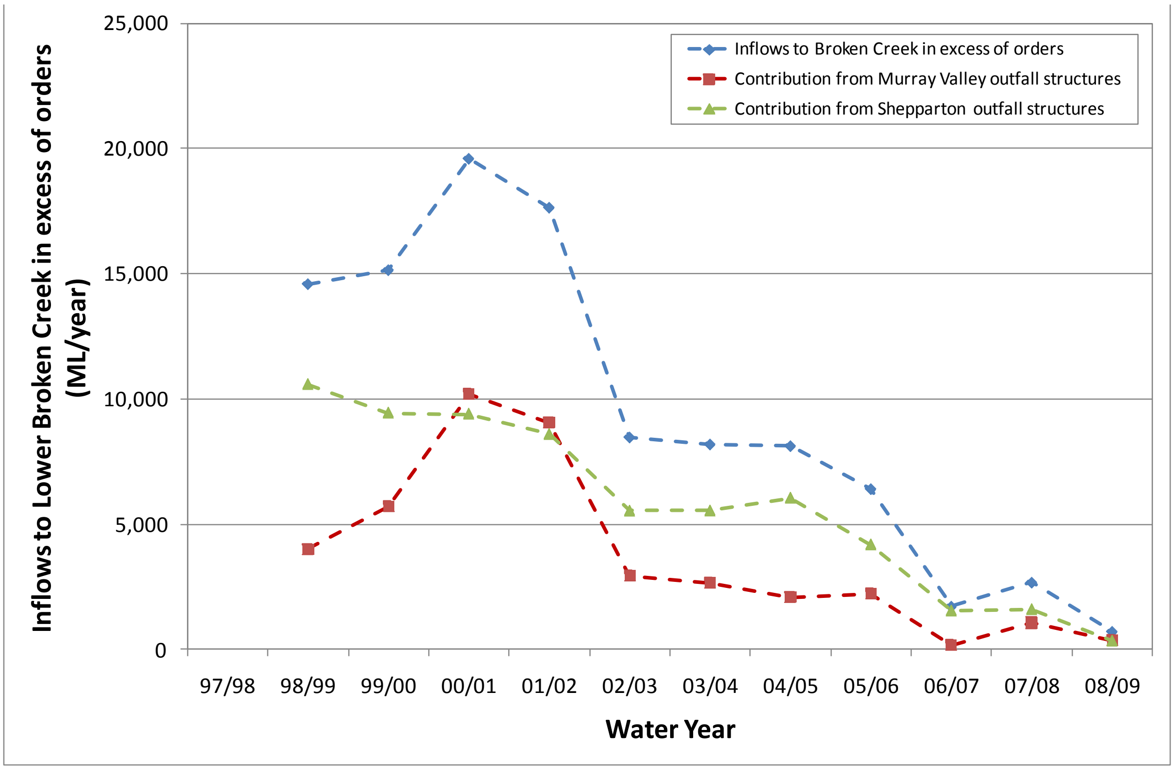


Figure 7-10 The inflows in excess of orders contributed by the Murray Valley outfall structures and the Shepparton outfall structures

Inflows through drains

Inflows to the Lower Broken Creek and Nine Mile Creek system through drains have also declined significantly over the past 10 years. In the late 1990s and early 2000s, drainage inflows to the system were 30,000 ML/year – 35,000 ML/year. In the past few years however, inflows from drains have been a minor component of total inflows. This reduction in drainage inflows is probably attributable to a combination of less rainfall runoff, less runoff from irrigation application, less channel outfalls into drainage systems and increased drainage diversions.

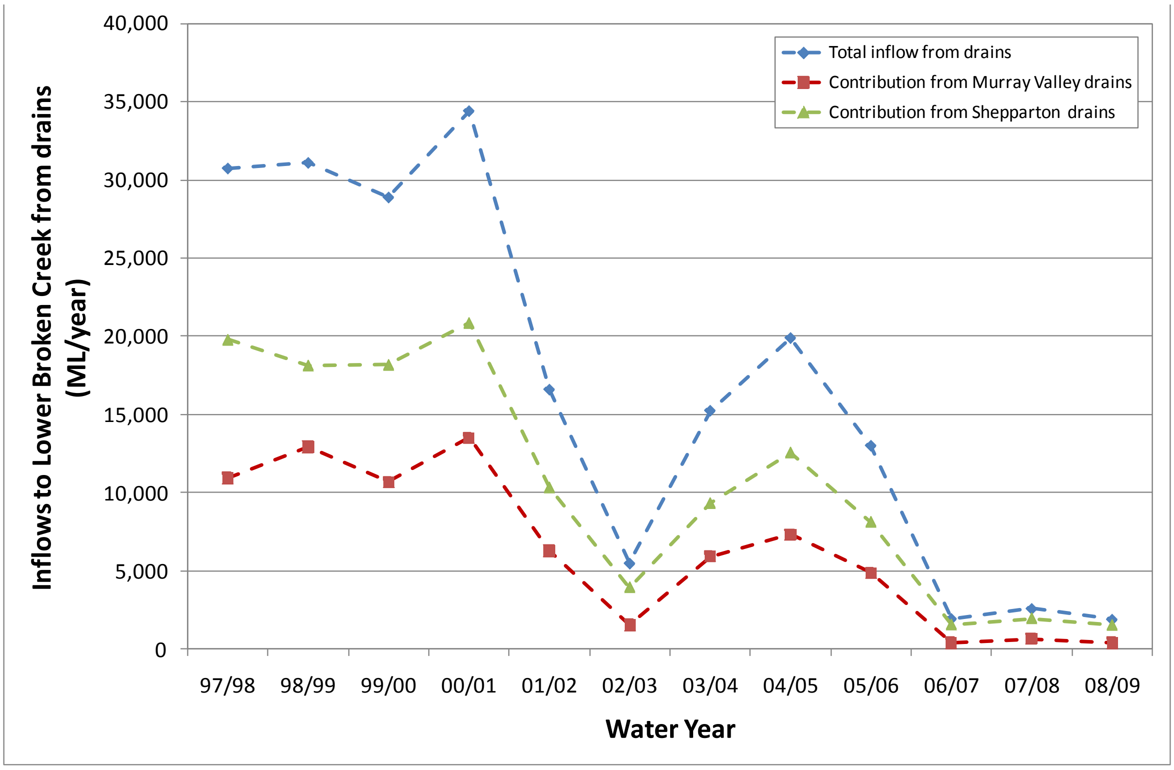


Figure 7-11 The inflow volume from drains contributed by the Murray Valley drains and the Shepparton drains

Murray Valley contributions to total inflows

NVIRP works are being implemented in the Murray Valley irrigation district. Therefore, changes to the Lower Broken Creek and Nine Mile Creek flow regimes attributable to NVIRP, will be reflected in changes to flow contributions from the Murray Valley side of the creeks. Figure 7-12 shows the inflows through Murray Valley outfall structures (ordered and in excess of orders) and the inflows through Murray Valley drains in comparison with total inflows to the system. This figure shows that inflows in excess of orders through Murray Valley outfall structures are a small component of total inflows.

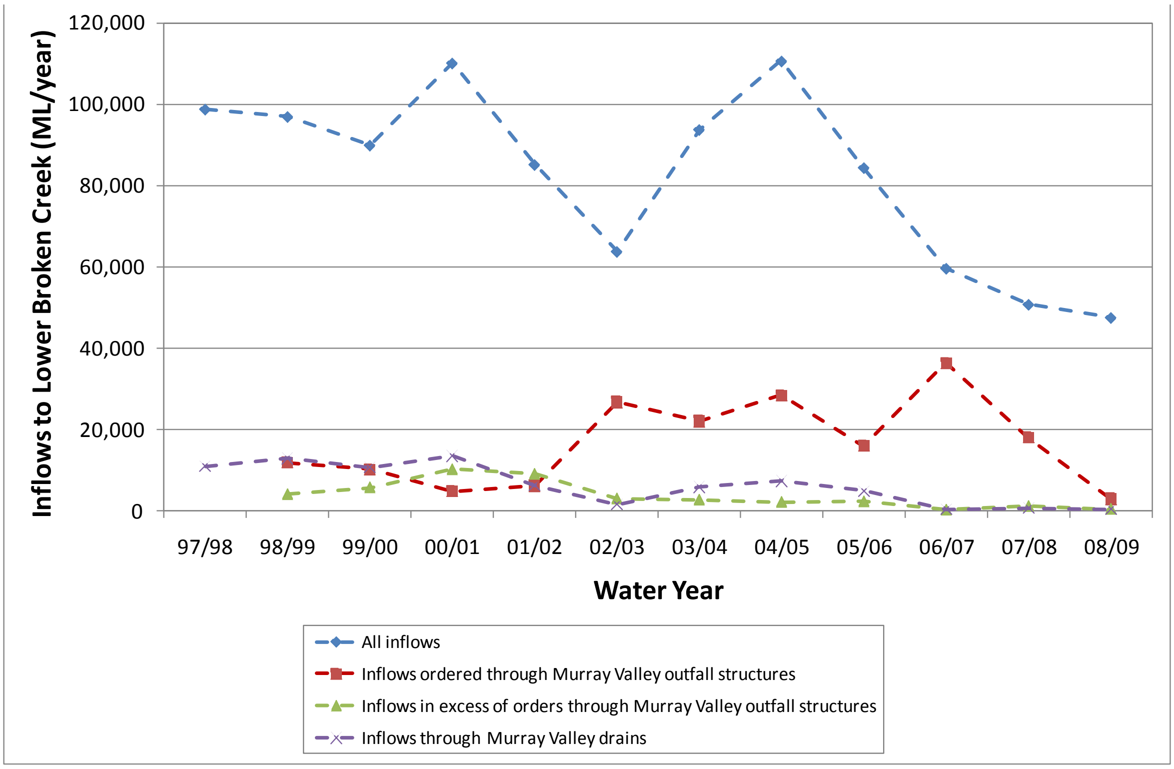


Figure 7-12 Total inflow, inflow through outfalls that will be decommissioned (both ordered and in excess of orders) and inflows through Murray Valley drains

Reach inflows

On a reach by reach basis, the contribution of total inflows is weighted to the upstream end of the study area. This is particularly the case in recent years (i.e. 2008/09), when minimal inflows to the system were recorded downstream of where the Lower Broken Creek and Nine Mile Creek split (Figure 7-13). If it is assumed that flows are split 30%:70% down the Lower Broken Creek and Nine Mile Creek at Katandra weir, inflows to each of the four environmental reaches can be calculated (Figure 7-14).

Given this analysis focuses on inflows, and the contribution of inflows in excess of orders, it needs to be recognised that inflows may not be a reliable indication of flows within the creeks because of diversions and losses. However, for the Lower Broken Creek at least, an understanding of total inflows generally provides a reasonable understanding of flow passing Rices Weir (Figure 7-15). That is, the pattern of inflows generally matches the pattern of flow at Rices Weir, with the differences in magnitude attributable to diversions and losses.

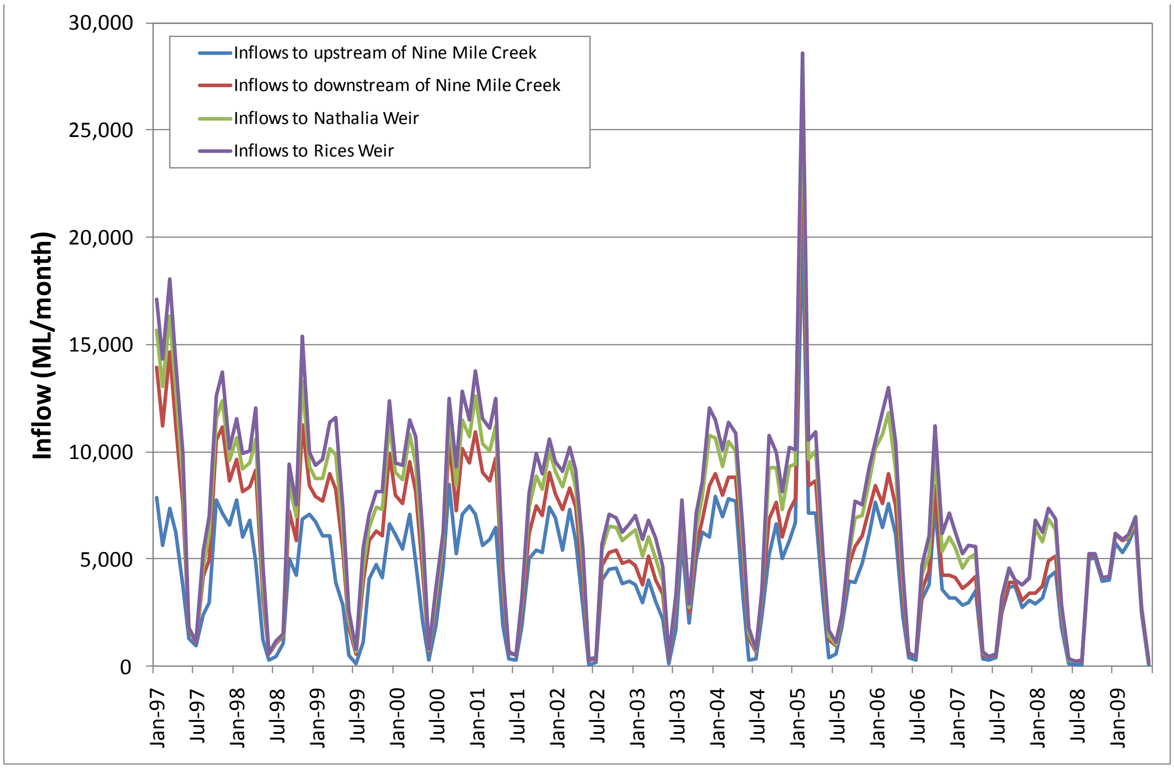


Figure 7-13 Inflows to different locations along the Lower Broken Creek

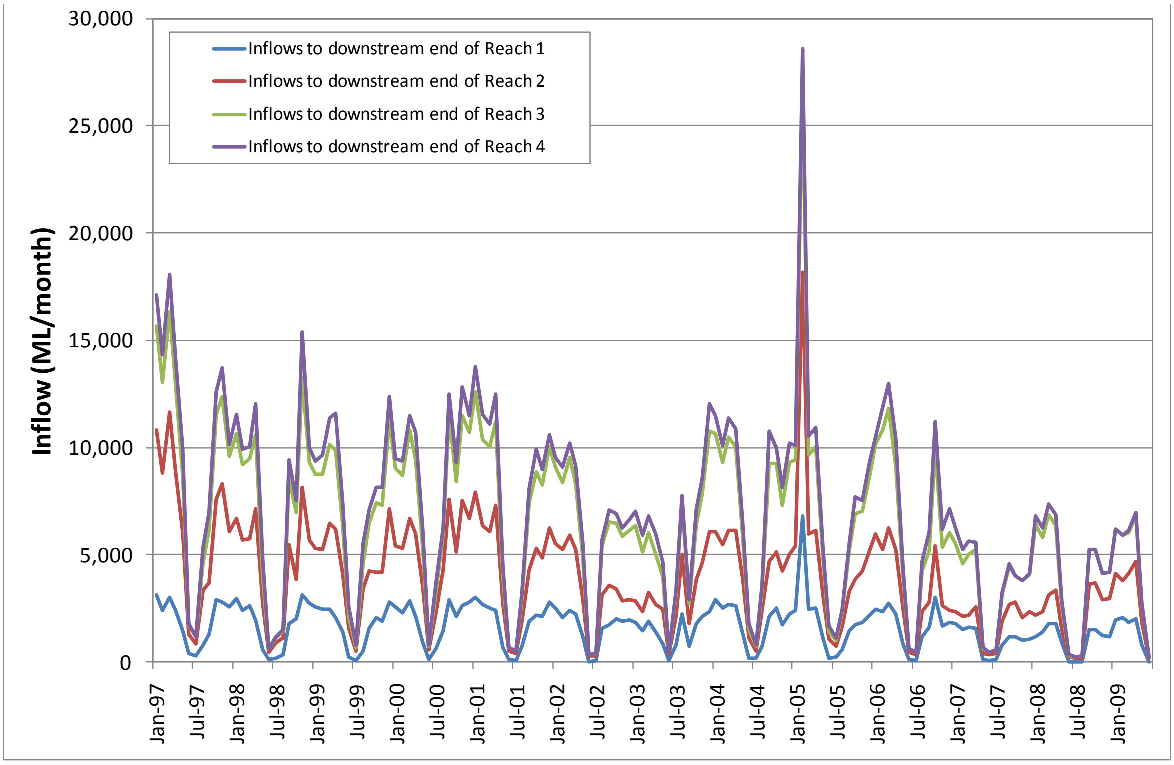


Figure 7-14 Inflows to the four environmental reaches, assuming a 30%:70% division of flows where the Lower Broken Creek and Nine Mile Creek split

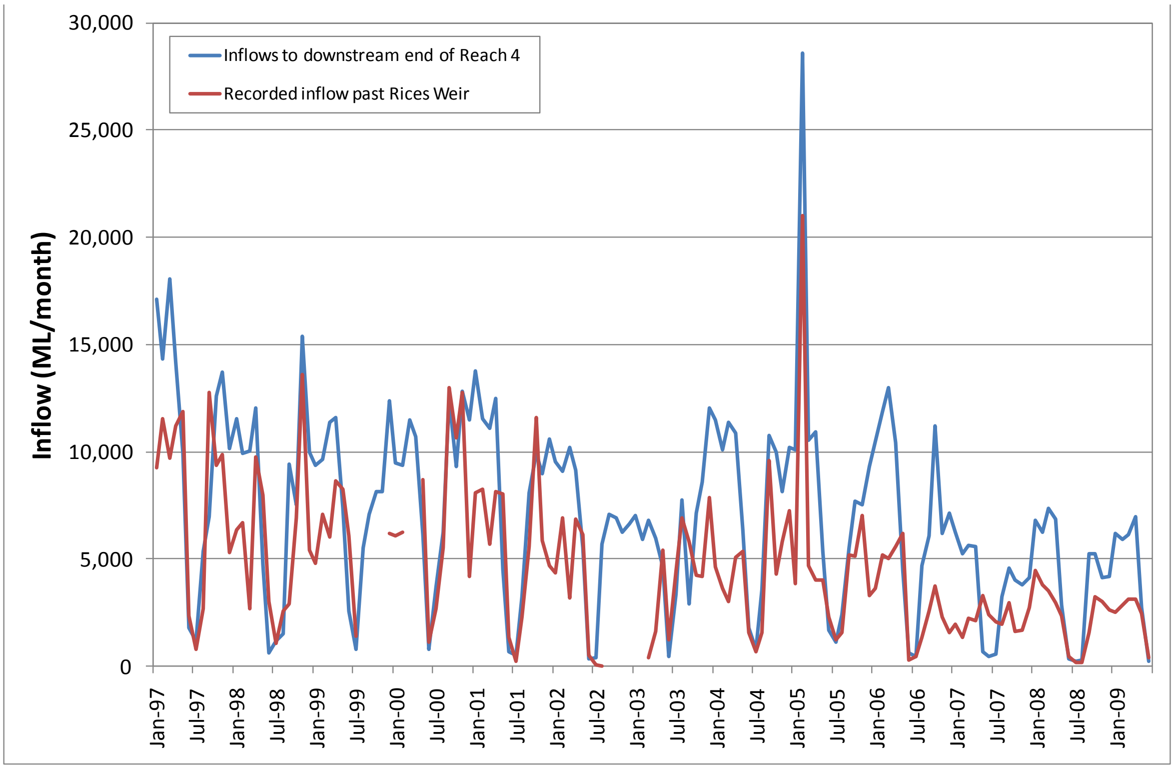


Figure 7-15 Inflows to Rices Weir (the downstream end of Reach 4), compared to recorded flow past Rices Weir

7.4 NVIRP impact assessment

7.4.1 Modelling and data sources

There is currently no long term computer model of the Lower Broken Creek (an existing daily FORTRAN model only covers the period 1st January 1997 to 30th June 2002) and building such a model was well outside the scope and time available for this project.

The analysis of the existing flow regime (Section 7.3) is therefore undertaken using historical records sourced from G-MW and Thiess (refer Section 7.3.3). The analysis of NVIRP impacts (Section 7.4.2 onward) is based on modification of the outfall volumes recorded for the period 1998-2009 to reflect the expected impact of the implementation of NVIRP on the Murray Valley outfalls (i.e. inflows in excess of orders reduced by 85%). The impact of this outfall reduction is then assessed based on the resultant total percentage change in inflows.

The use of recorded outfall volumes, manually modified to reflect the expected outfall reductions, is in contrast to the approach adopted in other EWPs, i.e. the Loddon River EWP (NCCMA 2010) which utilises modelled current and post-NVIRP flow sequences from existing REALM modelling.

Given the non-availability of a long-term REALM model for the Broken Creek system (as was available for the development of other EWPs), the adopted approach using recorded outfall volumes is considered a reasonable analysis method for Broken Creek. Had this study shown that the NVIRP was likely to have a significant impact on inflows, the time and money required to develop a long term model of the Lower Broken Creek may have been justified, but this is not the case. A limitation of the adopted approach is that it is not possible to translate the predicted inflow reductions into changes in streamflow for the long term average, base case year (2004/05) or the year with the lowest Murray allocations (2008/09). However, it is logical to surmise that if the NVIRP causes a minimal reduction in inflows, there will be a minimal reduction in streamflows through each of the environmental flow reaches.

7.4.2 Water regime after NVIRP – analysis

The stated aim of NVIRP is to reduce the inflows though Murray Valley outfall structures in excess of orders (i.e. the outfalls) by 85%. This situation is different to some other irrigation systems, where all the water flowing through an outfall structure is considered an outfall, 85% of which will be saved by the NVIRP. The Shepparton irrigation district was modernised in a separate project (the Shepparton Modernisation Project), but the impact of this project on inflows to the Lower Broken Creek and Nine Mile Creek is not assessed as part of this study.

To reduce the inflows in excess of orders, NVIRP will implement Total Channel Control (TCC). Implementing TCC involves replacing the manually operated drop boards currently used to regulate channel flows, with a system of remotely controlled flume gates. At the time of writing, NVIRP were planning to decommission seven of the eleven Murray Valley outfall structures. Those to be kept are denoted by an asterisk in Figure 7-2. However, for this study, it was assumed the 85% reduction of inflows in excess of orders is distributed along the Lower Broken Creek and Nine Mile Creek reaches in accordance with current inflows in excess of orders. This is considered appropriate, because all reaches will still have inflows from Murray Valley outfall structures (reach two receives a contribution from the Murray Valley 7/3 outfall structure), and the remaining structures will need to pass the flows previously carried by the decommissioned outfalls to meet local diverter orders.

Figure 7-16 to Figure 7-19 show the estimated total inflows to each reach for January 1997 to June 2009, and the total inflows assuming inflows through Murray Valley outfall structures in excess of orders are reduced by 85%. Information for categorising monthly inflows through Murray Valley outfall structures as 'ordered' or 'excess' are not available for 2000/01, or the years prior to 1998/99. Regardless, these figures show that reducing inflows through Murray Valley outfall structures in excess of orders by 85% would not have a material impact on inflows to the Lower Broken Creek or Nine Mile Creek, especially for 2002/03 onwards.

The expected reduction in inflows in percentage terms is shown in Figure 7-20. If the years 1997/98 to 2001/02 were repeated with the NVIRP completed, the reduction in inflows to Reach 1 would be as high as 18%. Inflows to Reach 3 and Reach 4 would be reduced by as much as 10% and 12% respectively however this was prior to G-MW undertaking a loss management program and this level of input is unlikely to occur again. However if the years 2004/05 onwards were to be repeated with the NVIRP completed, the reduction in inflows would be less than 5% for all reaches. Reach 2 (Nine Mile Creek) is particularly unaffected, given no Murray Valley outfall structures discharge to Nine Mile Creek, and only one discharges upstream of where Lower Broken Creek and Nine Mile Creek split.

On a yearly time-step, the expected reduction in inflows would range from 9% in 2001/02 to 0.3% in 2006/07 (Table 7-3).

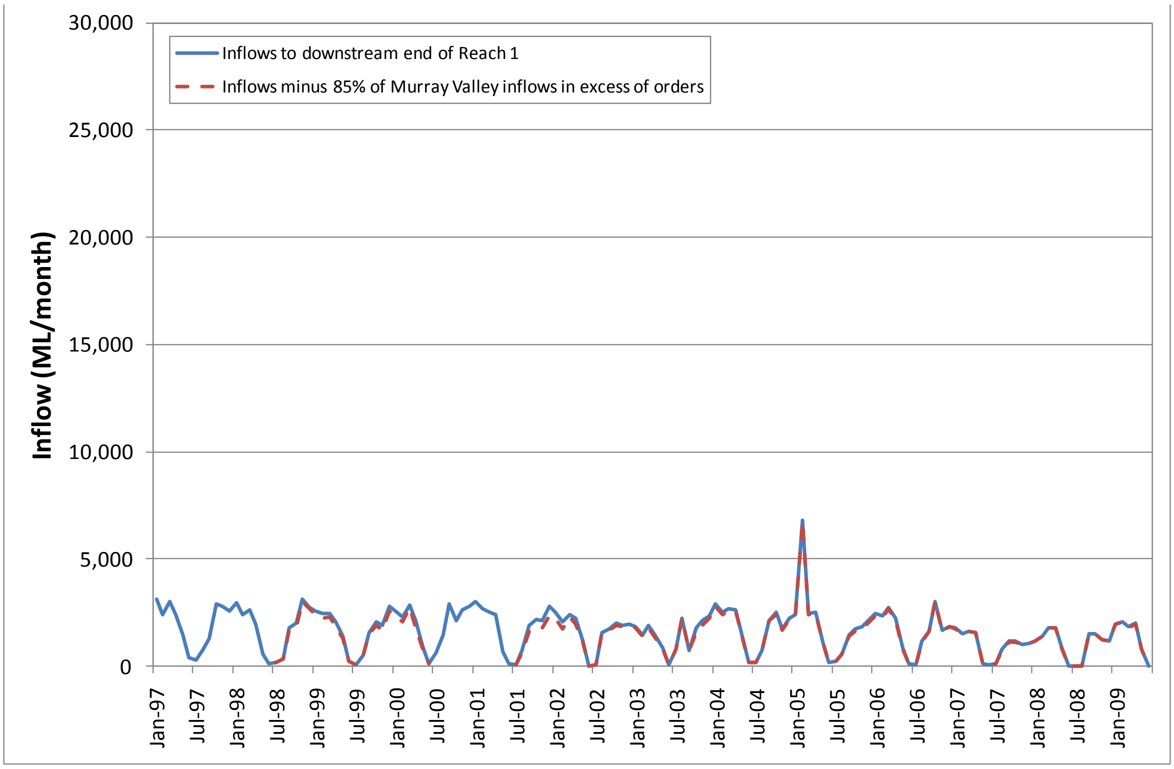


Figure 7-16 The impact of the NVIRP on monthly flows in Reach 1

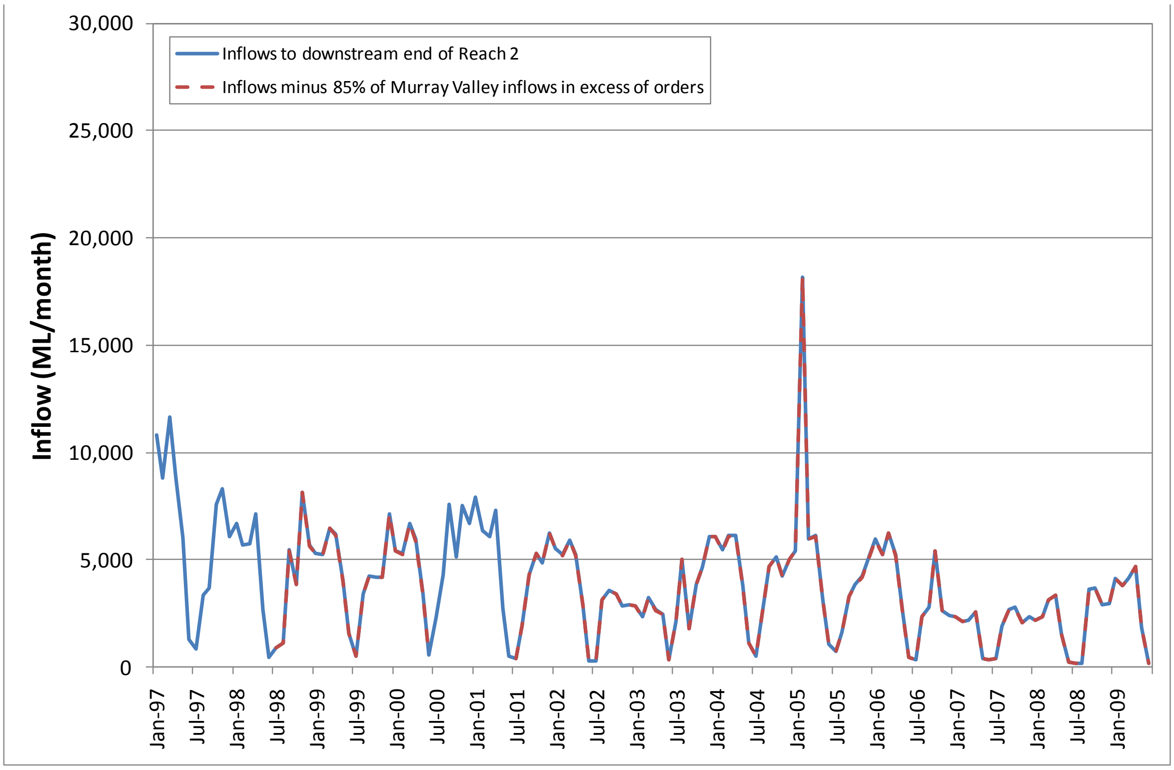


Figure 7-17 The impact of the NVIRP on monthly flows in Reach 2

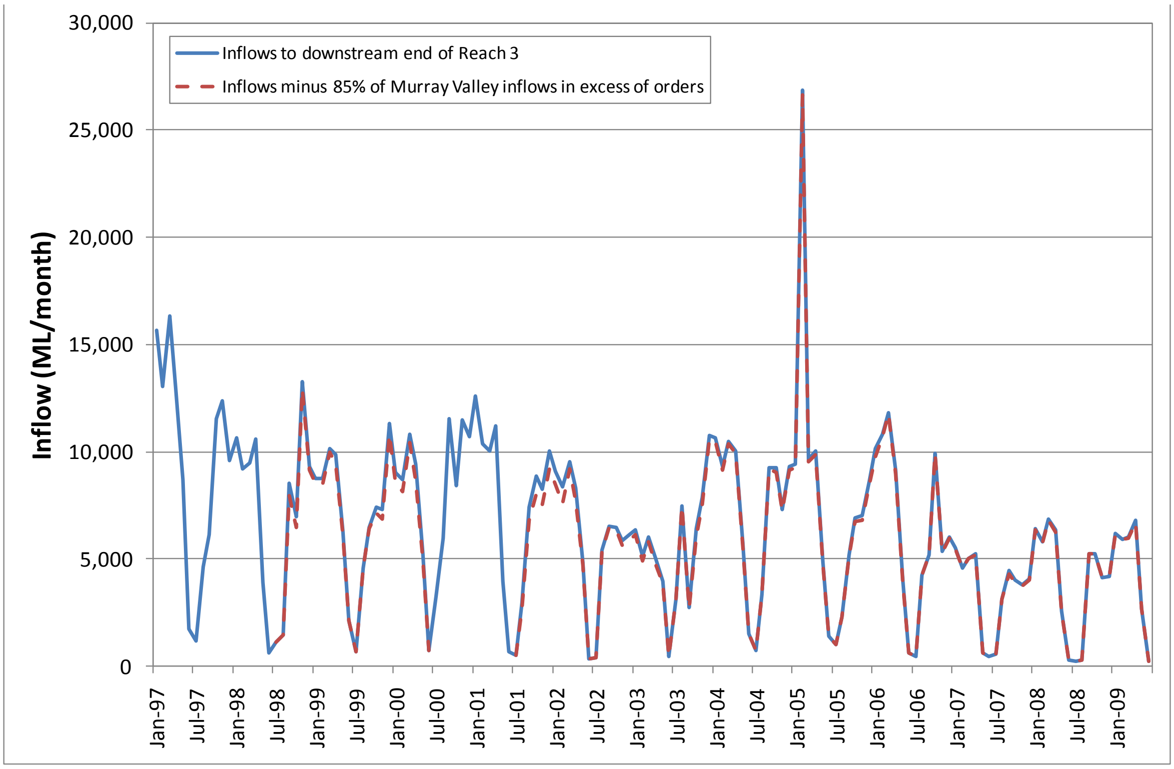


Figure 7-18 The impact of the NVIRP on monthly flows in Reach 3

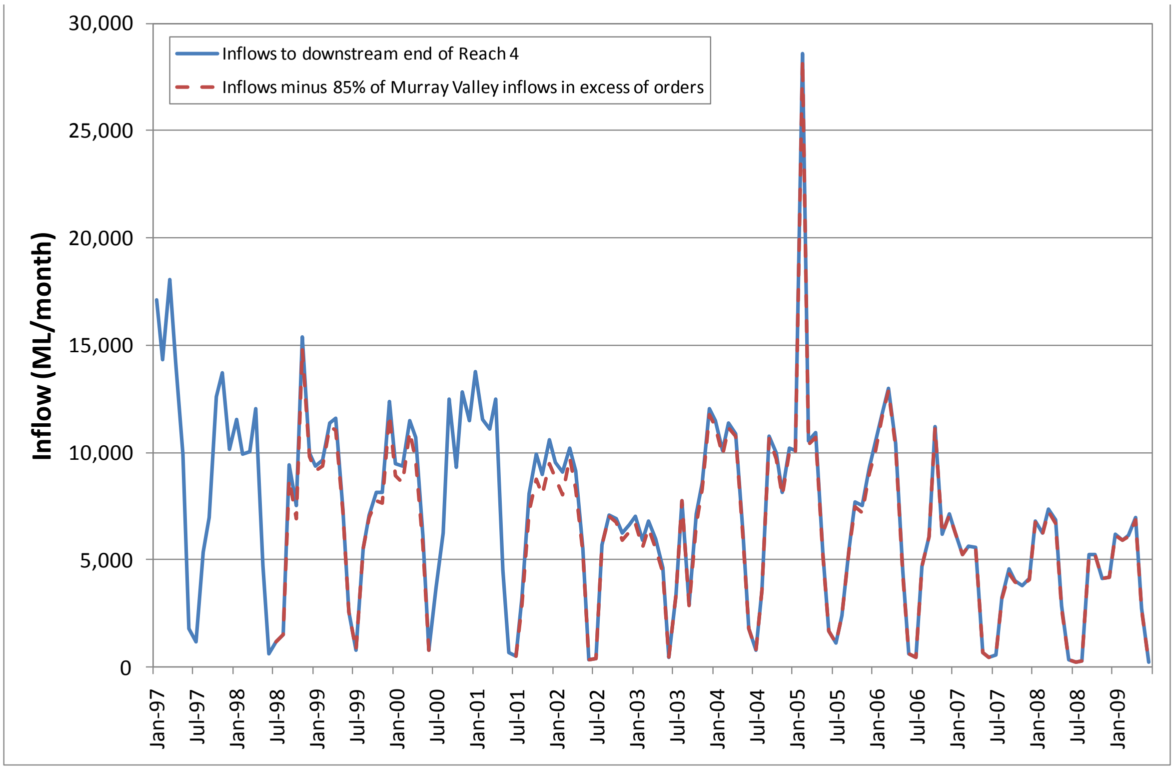


Figure 7-19 The impact of the NVIRP on monthly flows in Reach 4

The expected reduction in inflows to each environmental flow reach in percentage terms is shown in Figure 7-20. If the years 1997/98 to 2001/02 were repeated with the NVIRP completed, the reduction in inflows to Reach 1 would be as high as 18%. Inflows to Reach 3 and Reach 4 would be reduced by as much as 10% and 12% respectively. However if the years 2004/05 onwards were to be repeated with the NVIRP completed, the reduction in inflows would be less than 5% for all reaches. Reach 2 (Nine Mile Creek) is particularly unaffected, given no Murray Valley outfall structures discharge to Nine Mile Creek, and only one discharges upstream of where Lower Broken Creek and Nine Mile Creek split.

On a yearly time-step, the expected reduction in total inflows would range from 9% in 2001/02 to 0.3% in 2006/07 (Table 7-3). However, it should also be recognised that G-MW implemented a loss management program in 2002/03, and losses observed in 2001/02 and prior are unlikely to be repeated while this loss management program continues.

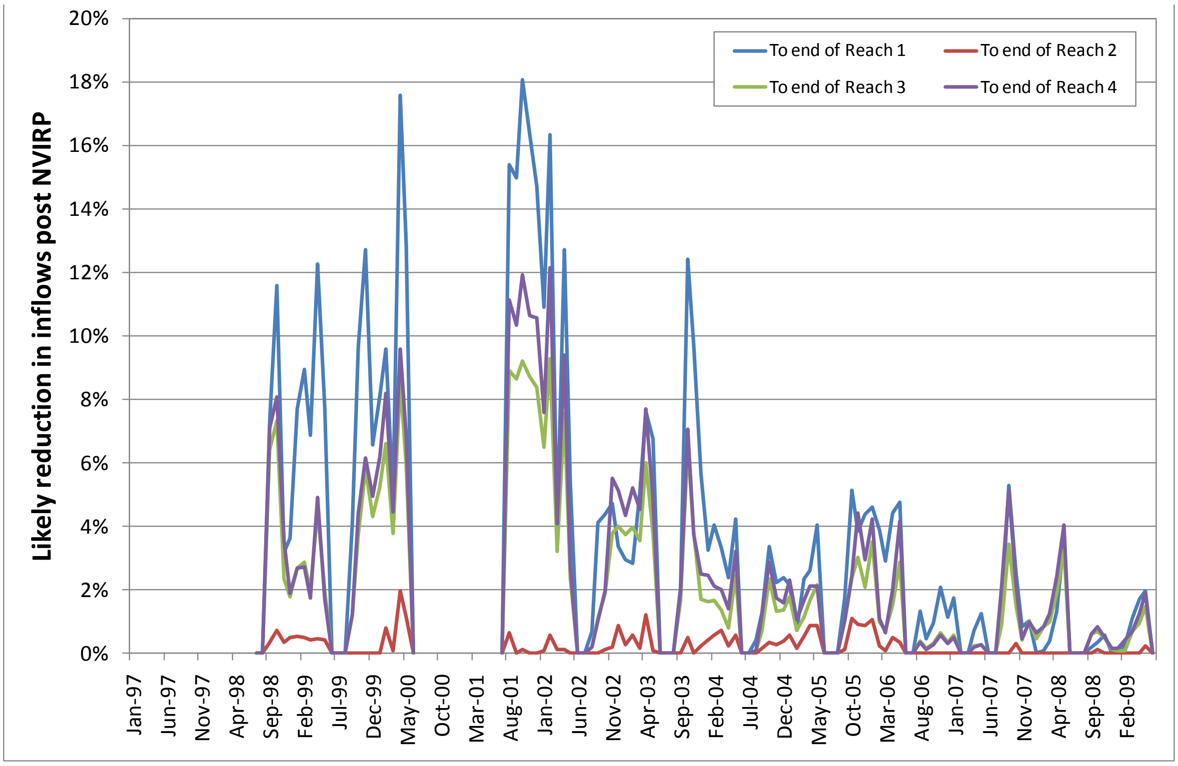


Figure 7-20 **Reduction in inflows because of the NVIRP, assuming inflows through Murray Valley outfall structures in excess of orders are reduced by 85%**

Table 7-3 The annual impact of the NVIRP on total inflows to the Lower Broken Creek and Nine Mile Creek, assuming inflows through Murray Valley outfall structures in excess of orders are reduced by 85%

Year	Total Inflow	85% of Murray Valley Inflows in Excess of Orders (1)	Total Inflow minus (1)	Percent Reduction
1997/98	98,800			
1998/99	97,000	3,400	93,600	3.5%
1999/00	90,000	4,900	85,100	5.4%
2000/01	110,200	8,700	101,500	7.9%
2001/02	85,200	7,700	77,500	9.0%
2002/03	63,800	2,500	61,300	3.9%
2003/04	93,800	2,300	91,500	2.4%
2004/05	110,700	1,800	108,900	1.6%
2005/06	84,400	1,900	82,500	2.2%
2006/07	59,650	100	59,500	0.3%
2007/08	50,800	900	49,900	1.8%
2008/09	47,500	300	47,200	0.7%

7.4.3 Water regime after NVIRP – discussion

Current practice is to analyse the impact of the NVIRP assuming a 2004/05 base case (Figure 7-21, which isolates 2004/05 from Figure 7-20). Were the year 2004/05 repeated, the monthly reduction in inflows attributable to the NVIRP would be less than 1% for Reach 2, between 1% and 3% for Reaches 1 and 3, and up to 4% for Reach 4. The impact of the NVIRP during 2008/09 is also of interest, given irrigation allocations in the Murray system that year were the lowest on record. Were the year 2008/09 repeated, the monthly reduction in inflows because of the NVIRP would be less than 2% for each reach (Figure 7-22).

Figure 7-21 and Figure 7-22 present the reduction in inflows assuming the only impact of the NVIRP is to reduce inflows through Murray Valley outfall structures in excess of orders. However, this is probably a conservative estimate of the impact of the NVIRP, because there are a number of Murray Valley outfall structures that connect to drains, which in turn discharge to the Lower Broken Creek.

Isolating the contribution of outfalls to drainage flows that enter the creek is difficult. Flows through the outfall structures into drains combine with flows from other sources. Often a portion of drainage flows will be diverted by irrigators before reaching the creek. To test the sensitivity of total inflows to changes in drainage inflows that may result from the NVIRP, it was assumed that drainage flows are evenly comprised of the three major contributors (i.e. 33% rainfall runoff, 33% irrigation runoff and 33% channel outfalls).

Assuming 85% of channel outfalls are saved by the NVIRP, drainage inflows to the Lower Broken Creek and Nine Mile Creek through Murray Valley drains would reduce by approximately 30%.

Figure 7-23 and Figure 7-24 show the impact of the NVIRP on total inflows assuming that inflows in excess of orders through Murray Valley outfall structures that connect directly to the creek are reduced by 85% **and** inflows through Murray Valley drains are reduced by 30%. It should be kept in mind that this 30% reduction in drainage inflows is subjective and most Murray Valley drains are not metered. However, Figure 7-23 and Figure 7-24 show that assuming drain inflows will also reduce does not invalidate the conclusion that the NVIRP will have a minimal impact on total inflows.

Given a long term computer model of the Lower Broken Creek is yet to be developed (an existing daily FORTRAN model only covers the period 1st January 1997 to 30th June 2002), and building such a model was well outside the scope and time available for this project, it is not possible to translate the predicted inflow reductions into changes in streamflow for the long term average, base case year (2004/05) or the year with the lowest Murray allocations (2008/09). However, it is logical to surmise that if the NVIRP causes a minimal reduction in inflows, there will be a minimal reduction in streamflows through each of the environmental flow reaches. Had this study shown that the NVIRP was likely to have a significant impact on inflows, the time and money required to develop a long term model of the Lower Broken Creek may have been justified, but this is not the case.

The changes in water levels throughout the Lower Broken Creek and Nine Mile Creek system attributable to the NVIRP is also predicted to be negligible, given the minimal changes in inflow. This is especially true for the lower reaches of the Lower Broken Creek, where water levels are held artificially high, and variations are dampened, by the many weirs between Nathalia and Rices Weir.

In summary, the flows that pass through the Lower Broken Creek and Nine Mile Creek are much more sensitive to irrigation allocations, the volumes of water ordered by local diverters or environmental managers, and the extent to which the waterway is used for inter-valley transfers, than the contribution of inflows in excess of orders through Murray Valley outfall structures.

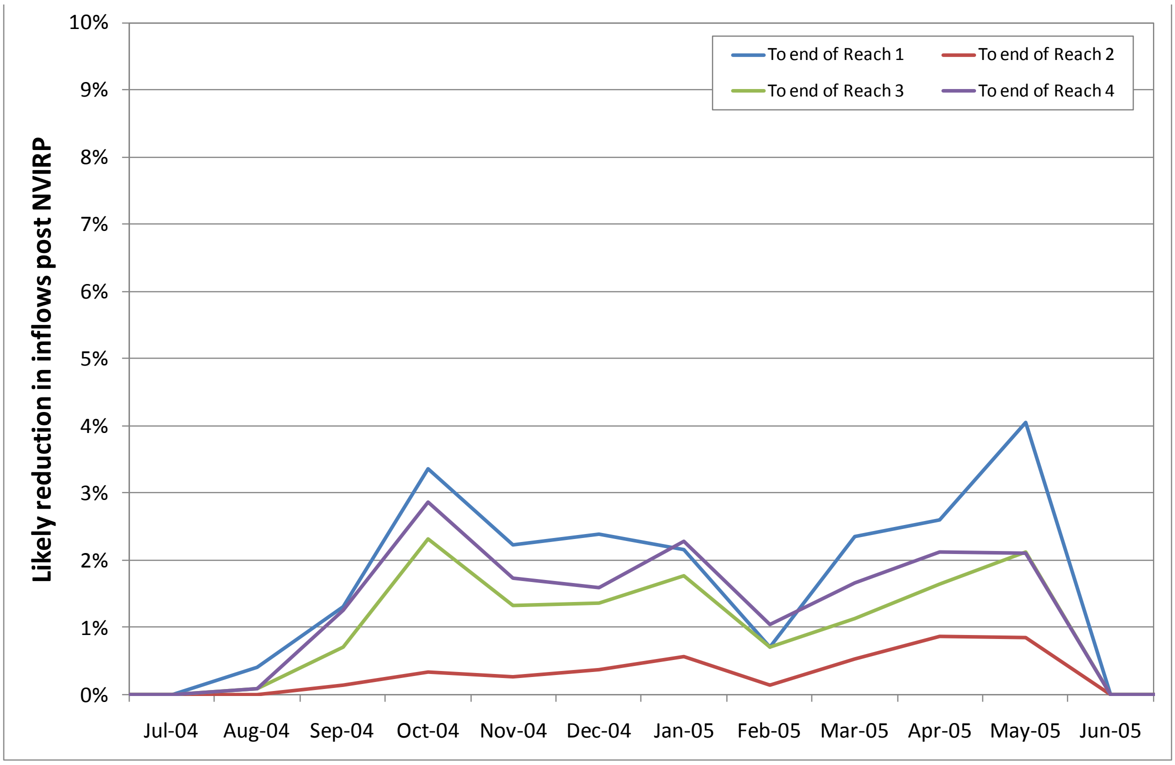


Figure 7-21 Reduction in inflows because of the NVIRP for 2004/05, assuming inflows through Murray Valley outfall structures in excess of orders are reduced by 85%

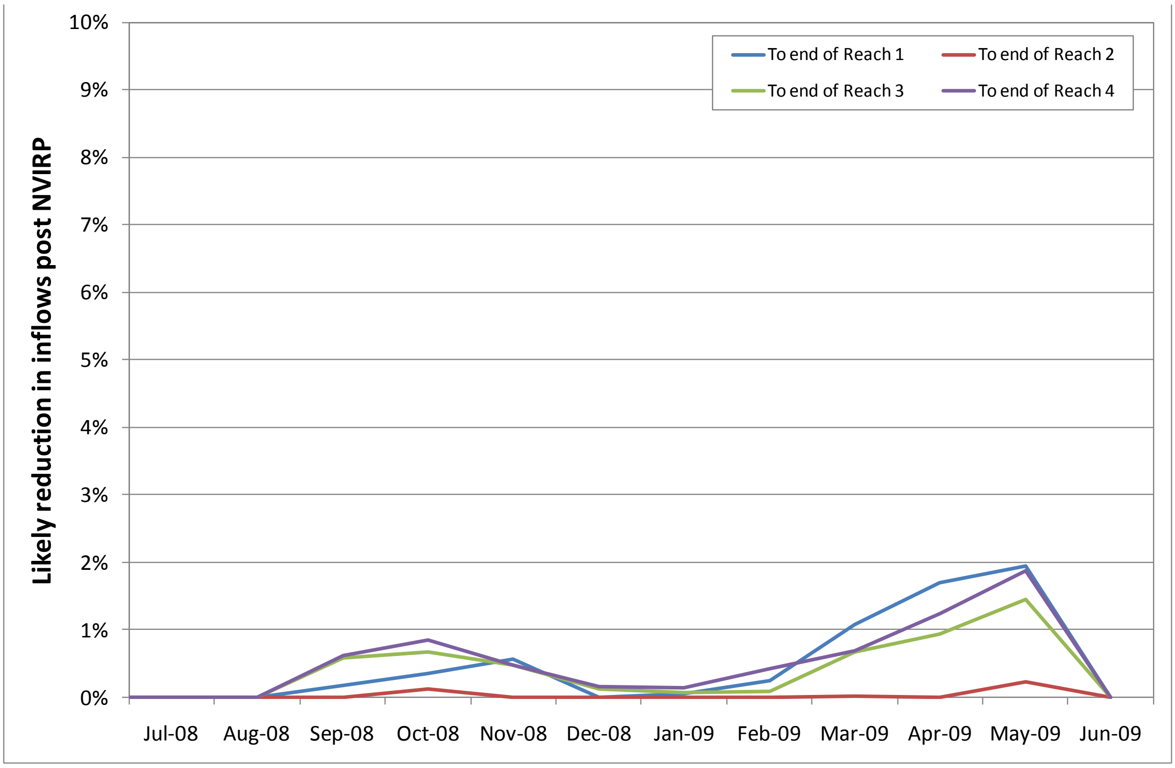


Figure 7-22 **Reduction in inflows because of the NVIRP for 2008/09, assuming inflows through Murray Valley outfall structures in excess of orders are reduced by 85%**

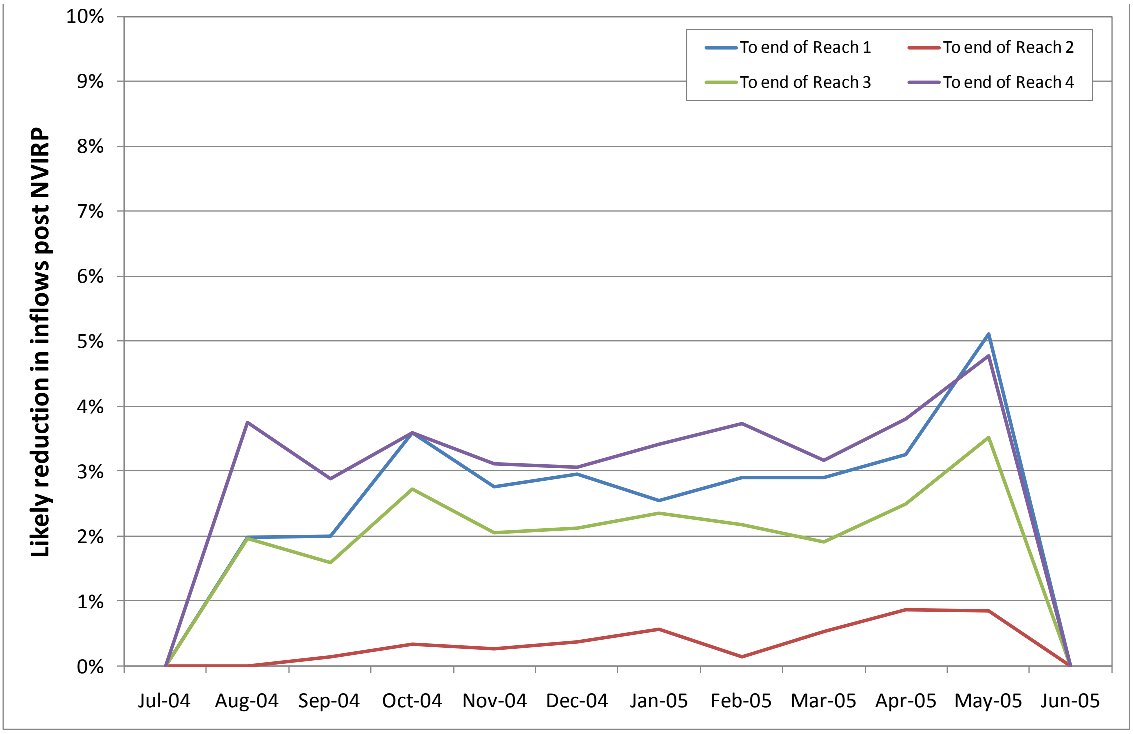


Figure 7-23 **Reduction in inflows because of the NVIRP for 2004/05, assuming inflows through Murray Valley outfall structures in excess of orders are reduced by 85% and inflows through Murray Valley drains are reduced by 30%**

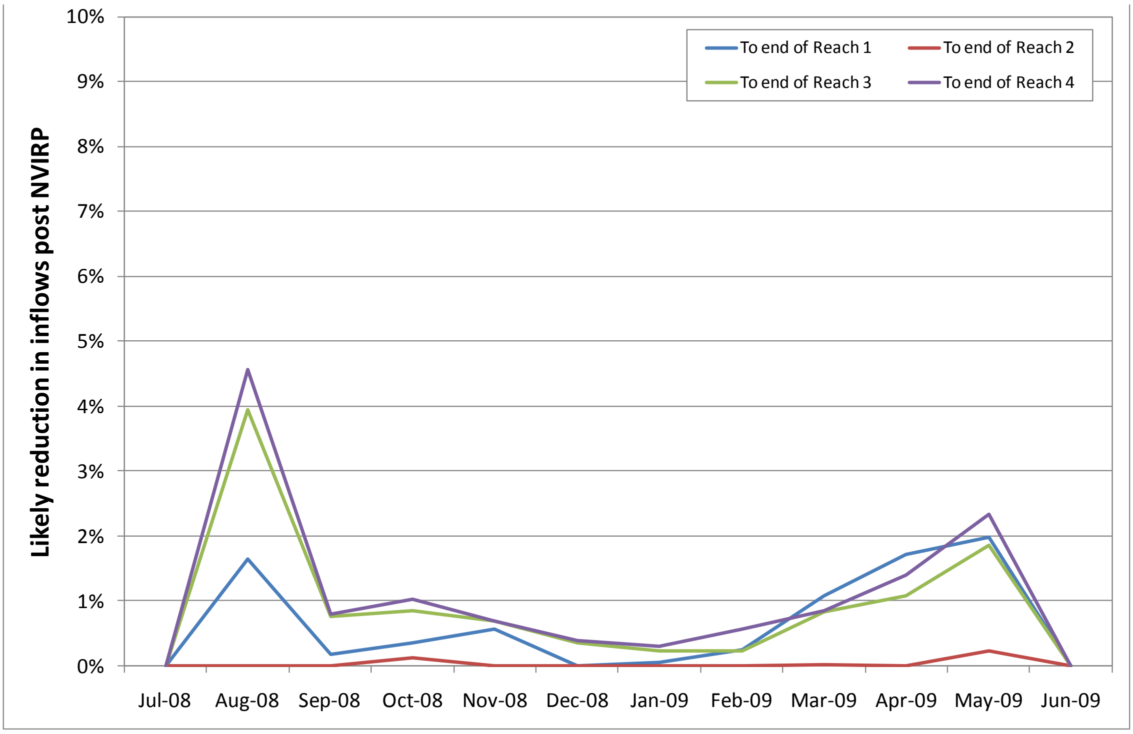


Figure 7-24 Reduction in inflows because of the NVIRP for 2008/09, assuming inflows through Murray Valley outfall structures in excess of orders are reduced by 85% and inflows through Murray Valley drains are reduced by 30%

7.4.4 Water regime after NVIRP – summary and conclusions

The Lower Broken Creek and Nine Mile Creek is a highly regulated system. The vast majority of inflows to the system come through channel outfall structures that connect directly to the creeks from both the Murray Valley and Shepparton irrigation districts. Inflows through outfall structures are comprised of two parts – inflows ordered by local diverters or environmental managers, and inflows in excess of orders.

NVIRP plans to reduce the inflows through Murray Valley outfall structures in excess of orders by 85%. This is likely to reduce the volume of water flowing down the creeks. However, the contribution of this 'excess' to total inflows is minor, especially post 2002/03. Therefore, reducing Murray Valley inflows in excess of orders by 85% is expected to reduce monthly inflows by less than 4% for all environmental flow reaches, assuming 2004/05 is the base case for this assessment. Even when assuming Murray Valley drainage inflows are reduce by 30% because of the NVIRP, the reduction in monthly inflows in 2004/05 remains below 5% for all environmental flow reaches.

8. MITIGATION WATER ASSESSMENT

8.1 Introduction

The implementation of NVIRP within the EWP project area is expected to result in a small reduction in the volume of outfalls to the Broken Creek system, as discussed in Section 7. This will be achieved by rationalisation and re-configuration of the existing water supply system and through improvements in system operation and management. Of the 11 existing drain outfalls discharging to the Broken Creek system waterways, seven will be retained and four removed as part of the system rationalisation. The distribution of outfall volumes may be altered as a result of the changed system operation however the total volume of excess outfall is expected to reduce by 85%.

NVIRP has developed a set of principles and environmental commitments in relation to managing the ecological consequences of hydrological changes arising from implementation of NVIRP, including avoiding any contribution to diminishing ecological values in waterways and wetlands (NVIRP 2010). Under these principles “Mitigation water will be provided where water to be saved is shown to have a material and beneficial effect on high environmental values” (NVIRP 2010).

In this context “mitigation water” is defined as the water that is required to ensure no net impacts due to the project on high environmental values. Water savings resulting from the implementation of the NVIRP are calculated after supply of mitigation water with water savings defined as the total (gross) volumes saved less the volume of water required to ensure no net impacts due to the project on high environmental values. (NVIRP 2010)

The process for calculation of mitigation water is set out in Attachment G of the NVIRP Water Change Management Framework (NVIRP 2010). Six steps are identified:

- Step 1 Obtain the desired filling frequency or flow regime
- Step 2 Determine the baseline year loss contributions
- Step 3 Assess dependency on mitigation water
- Step 4 Calculate the baseline mitigation water volume
- Step 5 Calculate the mitigation water commitment
- Step 6 Calculate the LTCE[4] mitigation water volume (this is a requirement of the NVIRP water saving reporting and is not included in the EWP)

The calculation of mitigation water in accordance with Steps 1 to 5 is outlined in Sections 8.2 to **Error! Reference source not found.**.

8.2 Step 1 – Describe the desired water or flow regime

Establishment of the desired flow regime for the EWP waterway reaches is informed by the preceding sections of the EWP. For most of the other waterway systems within the GMID impacted by the NVIRP, a full environmental flow assessment (using the FLOWS method (NRE 2002)) has been previously undertaken. For the Broken Creek system, a FLOWS study has not previously been completed and thus some additional work is required in the documentation of the required flow regime.

A brief summary of the relevant information from earlier sections of the EWP (principally Section 6 – Environmental Values) is therefore provided in Table 8-1 to highlight known or likely flow dependencies of the existing environmental assets and assist in identification of the requirements for mitigation water.

[4] LTCE = Long-term cap equivalent as defined by NVIRP (2010)

Table 8-1 forms the basis for the mitigation water assessment and includes:

- A summary of **high value assets** within each asset group.
- A management **objective** for each high value asset. The objectives currently established in existing plans and strategies (Section 5) for the management and condition of these assets are typically generic and do not directly identify the association between flow or hydrologic regime and the expected environmental outcomes. Asset specific objectives have therefore been developed during the preparation of this EWP based on the broad objectives discussed in Section 5 and inputs from the Scientific Reference Group.
- Known **flow associations** (linkages between environmental asset condition and flow).
- **Associated threats or processes** which have the potential to impact on the flow association.
- **Flow recommendations (magnitudes)** where identifiable and comment on **the potential for implementation of NVIRP to impact on the identified assets**, based on the flow magnitude reductions indicated in Section 7. Native fish are the only high value assets that have flow recommendations and are considered to be the most vulnerable to changes in the flow regime due to their high dependence on flow and water quality to provide suitable habitat and passage (highlighted in Table 8-1).

The approach documented in Table 8-1 is consistent with the general process followed in the FLOWS method (NRE 2002) for determination of environmental flow objectives and recommendations, specifically identification of ecological assets, development of environmental objectives for each asset or asset class and identification of key flow processes and flow magnitudes to meet each objective. The main omission relative to the FLOWS method is the cross-section survey and hydraulic modelling which normally informs the process (excluded from the scope of this EWP).

In this regard, the main risk is that the flow magnitudes required to sustain environmental processes (where identified in Table 8-1) are based on the opinion and experience of members of the flow rather than outcomes from hydraulic modelling. This is in contrast to the full application of the FLOWS method where expert opinion is supported by the use of metrics such as flow depth, velocity, wetted area obtained by hydraulic modelling. As the regulated flow regime under consideration in this EWP is comprised of in-channel flows (i.e. overbank flooding is not influenced by flow regulation), the NVIRP impacts in terms of wetted area and habitat availability will be relatively small and thus the absence of hydraulic modelling is less likely to be a critical shortcoming.

Table 8-1 Summary of environmental values and flow association

Asset group	High value assets	Objective	Flow association	Threat or process with potential to impact on high value asset	Flow recommendation	Potential for NVIRP impact on identified assets
Geomorphology	The inherited form of the Tallygaroopna channel is likely to be of state or regional significance (based on Rosengren 1987).	Avoid or mitigate impact of hydrologic change on reach scale morphology.	Geomorphic change at the reach scale (planform, channel capacity, anabranch development) is most dominantly influenced by bankfull and larger flows. The hydrologic changes discussed in Section 7 are unlikely to contribute to changes in reach scale geomorphic processes.	Significant change in hydrology influencing large scale geomorphology.	None	None – The predicted minor reduction in flow is not likely to impact on geomorphology.
	Channel form is not of itself a high value asset but can have critical impact on other high value assets (i.e. Fish habitat, wetland form etc) and therefore should be protected from impact.	Avoid or mitigate impact of hydrologic change on in-channel morphology, specifically avoid further loss of geomorphic diversity.	Process will be dominant in weir pools (principally Reach 4) but could occur locally in upstream reaches. Reduction in flow generally has potential to increase this but velocity reduction in weir pools will be negligible so unlikely to see a significant change.	Ongoing deposition and limited potential for remobilisation of sediment will result in continued aggradation, loss of habitat and contribute to ongoing DO/nutrient issues.	None	None – The predicted minor reduction in flow is not likely to impact on in-channel morphology.
Floodplain vegetation	Dominant near channel EVCs are endangered: • EVC68 – Creekline grassy woodland • EVC259 – Plains Grassy Woodland / Gilgai Wetland Mosaic • EVC803 – Plains Woodland • EVC168 – Drainage Line Aggregate (Vulnerable)	Avoid or mitigate impact of hydrologic change on high value floodplain EVCs.	Dominant near channel EVCs are Endangered but not identified as flow dependent.	Major change of hydrology above regulated flow level would cause redistribution of communities to suit habitat niche. Increase in permanent water in channel could cause loss of non waterlogging tolerant species (box) found in the existing community.	None	None – The predicted minor reduction in flow is not likely to impact on floodplain vegetation communities.
In-channel vegetation	Much of the Broken Creek system is covered under the Directory of Important Wetlands in Australia listing. The riparian wetland asset is therefore considered of high value.	Maintain and enhance extent and diversity of native in-channel vegetation associated with the riparian wetland asset (covered under the Directory of Important Wetlands in Australia listing).	In-channel vegetation is now dominated by the historically prevailing regulated flow regime (rather than natural regime) and comprises species adapted to permanent and near permanent water with low flow velocities. Species diversity is much reduced compared to natural conditions. Hydrologic modification resulting from the NVIRP will not restore ephemeral system and is unlikely to change species composition although may provide some additional zones for colonisation if there is an increase in short term water level variations.	Vegetation community composition will be influenced by flooding regime and habitat niches. Modification to regime has potential to change composition.	None	None – The predicted minor reduction in flow is not likely to impact on in-channel vegetation. However, improvements in diversity and extent could result from an increase in flow variability.
			Aquatic weeds, particularly Sagittaria are an increasing problem. Reduction in flows may increase weed threat in some reaches if conditions for establishment or spread are enhanced.	Suitable areas for colonisation or spread of existing infestations may be increased by modified hydrology.	None	None – The predicted minor reduction in flow is not likely to impact on the spread of aquatic weeds.
Floodplain wetlands	The Black Swamp / Purdies Swamp system is bioregionally significant as a drought refuge and waterbird habitat and is the only large floodplain wetland with connectivity to the Broken Creek system under regulated flows. Kinnairds Swamp contains significant populations of threatened, flood dependent species but is not flooded by Broken Creek, except in large events (outside EWP scope) – can be connected by system manipulation but is more commonly flooded by Muckatah system.	Avoid detrimental impact on hydrologic regime of floodplain wetland assets.	The Black Swamp / Purdies Swamp system is the only major floodplain wetland with the potential to be connected under regulated flow conditions. Flow greater than 100 ML/d in Nine Mile Creek required to facilitate filling.	Flows in Nine Mile Creek do not exceed CTF of 100 ML/d during period when filling is required.	None	None – The predicted minor reduction in flow is not likely to impact on the capacity to deliver environmental water to Black Swamp / Purdies Swamp system.
Native fish	Murray Cod (Nationally Listed - Endangered) and Golden Perch (Vulnerable) are found in all reaches but more significant populations in Reaches 3 and 4.	Maintain or enhance self-sustaining native fish populations at current levels with diversity of size classes (all reaches).	Suitable water quality (DO) and temperature. DO<5mg/L increases mortality. Temperatures greater than 30 deg C are undesirable - lowered growth and productivity of individuals and metabolic damage to fish.	DO in Reach 4 likely to drop below limits in Oct-Apr. Require DO > 5mg/L year round. Temperature limits are less frequently exceeded than DO.	Flows of 100-250 ML/d past Rices Weir from Oct-Apr to flush Azolla and boost DO levels.	Minimal – The predicted minor reduction in flow is not likely to impact on native fish. For the outfalls in excess of the orders contribute a small proportion of the flow required to manage DO levels and Azolla. The outfalls in excess of orders is approximately 7.5 ML/d (see Table 8-2), which is 3%-7.5% of the required 100 -250 ML/d.

Asset group	High value assets	Objective	Flow association	Threat or process with potential to impact on high value asset	Flow recommendation	Potential for NVIRP impact on identified assets
			Spring spawning – Inundate habitat during spawning season (Sep-Nov). Water temperature will trigger spawning and flow will trigger movement.	No ability to move during spawning period.	Flows of 250 ML/d past Rices Weir from Sept-Nov to trigger movement, spawning and inundate habitat	Minimal – The predicted minor reduction in flow is not likely to impact on the delivery of the required flow.
			Ability to move through system. Available and suitable habitat is dominated by weir pools – levels unlikely to be impacted by reduced flow in Reach 4.	Loss of connectivity through fishways and natural / other constructed barriers in all reaches for spawning and location of suitable habitat.	Minimum flows of 35-40 ML/d in each reach for operation of fishways and provide fish passage.	Minimal – The predicted minor reduction in flow is not likely to impact on the delivery of the required flow. However, the flow may not be met outside of the irrigation season.
	Murray Darling rainbowfish and Unspecked hardyhead (FFG – Threatened) in all reaches.		Availability of wetted habitat with in-channel / fringing vegetation is the critical control on population (+ competition from small bodied introduced species). Subject to the same biological limits (temperature and DO) as large bodied species.	Drying of channel or loss of connectivity for longitudinal movement.	None	Minimal –Minimum flows required for passage of large bodied fish will satisfy habitat requirements for small bodied fish. The predicted minor reduction in flow is not likely to impact on the incidence of cease to flow events.
Threatened species – Flora	19 Threatened Flora species with a likely waterway association/habitat have been identified within the EWP reaches. Of these, three are aquatic, 14 grow on or around waterway margins and two require seasonal flooding.	Maintain or enhance self-sustaining populations of identified flood/water dependent threatened species.	Aquatic species will require wet habitat (shallow-deep), other species will be found around the margin of pools, particularly where water level variation occurs. Ephemerally flooded species may be on higher ground.	Significant modification in the extent of wetted, marginal or ephemerally flooded habitat may impact on species distribution or viability.	None	None – The predicted minor reduction in flow is not likely to impact on threatened flora species.
Threatened species – Fauna	Large number of threatened fauna species but only fish and to a lesser degree frogs are fully dependent on the aquatic habitat influenced by regulated flows. Birds, mammals and reptiles are dependent on the health of the riparian zone but within the context of the EWP this is more significantly influenced by land management practice than modified hydrology. The listed fish species (as discussed above) therefore remain as the aquatic / water dependent threatened fauna species.	Maintain or enhance self-sustaining populations of identified threatened fauna species dependent on the aquatic environment.	Impact on threatened fauna species is dominated by the impact on fish, discussed above. Birds may utilise the waterway zone for breeding but this will be dominated by flooding events in the broader floodplain wetlands (outside the scope of the EWP). Provision of food is dependent on aquatic and riparian ecosystems covered under the other asset groups and / or not influenced by the regulated flow regime. The threatened frogs (Giant Bullfrog *Limnodynastes interioris* and Growling Grass Frog *Litoria raniformis*) are dominantly associated with wetland habitats not influenced by the NVIRP hydrologic modifications.	Related to fish only – see above	None	None (excluding fish above) - The predicted minor reduction in flow is not likely to impact on threatened fauna species.
Macro-invertebrate community	No specific high value species or communities.	Manage to increase diversity of macroinvertebrates by complementary actions.	Macroinvertebrate population in Reaches 1-3 is probably typical of other lowland river systems. Degraded community composition in Reach 4 reflects constant weir pool levels and limited habitat variability. Macroinvertebrate population and composition is dominated by habitat availability, not flow regime. Modifications to hydrology are unlikely to impact macroinvertebrate diversity.	Absence of refuge in cease to flow periods would cause community deterioration.	None	None – The predicted minor reduction in flow is not likely to impact on the incidence of cease to flow events.
				Loss of habitat variability due to changed geomorphic process or in-channel vegetation	None	None – The predicted minor reduction in flow is not likely to impact on geomorphic processes or in-channel vegetation. However, the introduction of large woody debris would increase macroinvertebrate habitat and diversity.

8.3 Step 2 – Determine the baseline year incidental water for each hydrological connection and the incidental water contribution at the waterway or wetland

The baseline year loss contribution is the amount of water received by the Creeks from outfalls in excess of orders. The baseline year (2004-2005) outfall recorded in excess of orders was 2,100 ML and all of this water reached the Creeks.

Table 8-2 Murray Valley outfalls in excess of orders in 2004-2005

Murray Valley Outfall	Gross baseline year incidental water contribution at origin (ML)	Estimated losses between origin (irrigation system) and stream (for baseline year) (ML)	Net baseline year incidental water contributions at waterway (ML)	Average daily incidental water contributions at waterway (ML)
MV 7/3 outfall	365	0	365	1.3
MV 3 main outfall	64	0	64	0.2
MV 4 main outfall	62	0	62	0.2
MV 5/3 outfall	155	0	155	0.6
MV 6/6 outfall	169	0	169	0.6
MV 8/6 outfall	106	0	106	0.4
MV 4/8/6 outfall	120	0	120	0.4
MV15/6 outfall	310	0	310	1.1
MV 21A/6 outfall (Jewells)	105	0	105	0.4
MV 26A/6 outfall (Flanners)	118	0	118	0.4
MV End 6 main outfall	510	0	510	1.9
Total	**2084**	**0**	**2084**	**7.5**

Note – 2,084 has been rounded to the nearest 100 to arrive at the gross and net baseline year incidental water contribution of 2,100 ML. The average daily incidental water contribution was determined by dividing the net baseline year incidental water contribution by 272 (the average number of days in the irrigation season). If the net baseline year incidental water contribution of 2,100 ML was reduced by the proposed 85% (1800 ML), only 300 ML of incidental water would enter the Broken Creek System each year. The average daily incidental contribution is reduced to approximately 6.6 ML from 7.5 ML if 85% of the net baseline year incidental water contribution of 2,100 ML (1800 ML) is used in the calculation.

8.4 Step 3 – Assess dependency on baseline incidental water contributions

Section 9 of the Water Change Management Framework (NVIRP 2010) requires mitigation water to be provided where both:

- the waterway or wetland has received incidental irrigation water beneficial and material to high environmental values before the modernisation associated with NVIRP; and
- where a similar contribution is assessed as being a beneficial part of a water regime which is proposed to continue to support high environmental values following the modernisation.

To meet this intent, mitigation water should be assessed as being required for a wetland or waterway with high environmental values except in circumstances where there is demonstrable information to the contrary. Therefore, subject to meeting the above intent, the determination of mitigation water requirements has been assessed for the Broken Creek system using the criteria outlined in Table 8-3.

Table 8-3 Mitigation water assessment criteria

Criteria by which mitigation water may be assessed as not required	Link between incidental water (losses) and environmental values
1. Mitigation water may be assessed as not required where:	
1.1. There is no hydraulic connection (direct or indirect) between the irrigation system and the wetland or waterway.	The irrigation system is directly linked to the Broken Creek system with 11 Murray Valley outfall structures currently discharging directly to the Broken Creek system. A total of 12 outfalls discharge to drains with subsequent discharge to the creek system. As discussed in Section 7.4, the impact of NVIRP on total outfall volumes is small even using conservative assumptions regarding the percentage of outfalls discharged via drains which subsequently enter the creek system. **Mitigation maybe required.**
1.2. The water does not reach the wetland or waterway with environmental values (e.g. the outfall is distant from the site and water is lost through seepage and evaporation before reaching the area with environmental values).	
2. Mitigation water may be assessed as not required where the wetland or waterway receives water from the irrigation system:	
2.1. That is surplus to the water required to support the environmental values (e.g. changing from a permanently wet to an intermittently wet or ephemeral regime is beneficial or has no impact).	While the seasonality of flows in the Broken Creek system is essentially reversed compared to natural conditions, the identified environmental values are dependent on the habitat provided by the regulated flow regime. **Mitigation water maybe required.**
2.2. That occurs at a time that is detrimental to the environmental values.	
2.3. That is of poor quality (or results in water of poor quality entering a site e.g. seepage resulting in saline groundwater intrusions to wetlands) and the removal of which would lead to an improvement in the environmental values.	Drainage water and catchment runoff are thought to be the major contributors to poor water quality in the system, along with high nutrient loads in the bed sediment. Reducing outfalls in excess of orders by 85% would not rectify this problem. **Mitigation water maybe required.**
3. Mitigation water may be assessed as not required where the environmental values:	
3.1. Do not directly benefit from the contribution from the irrigation system (e.g. river red gums around a lake may not directly benefit from an outfall and may be more dependent on rainfall or flooding)	The identified environmental values are dependent on the habitat provided by the regulated flow regime, which the outfalls in excess of orders forms a component. **Mitigation water maybe required.**
4. Mitigation water may be assessed as not required where the removal of the contribution from the irrigation system does not:	
4.1. Increase the risk of reducing the environmental values (e.g. outfalls form a very small portion of the water required to support the environmental values and their removal will not increase the level of risk).	Native fish (Murray Cod in particular) have been identified as the high environmental values most vulnerable to flow regime changes (see section 6.9). Flows of 100-250 ML/d past Rices Weir are required between September and April to provide habitat and passage (see Table 8-1) for native fish. Reducing the outfalls in excess of orders by 85% would reduce the overall flow in the Broken Creek system by less than 4% of (refer Section 7.4.3), which is equivalent to 6.6 ML/d along a waterway that is approximately 196 km long (see table 8-2). Reducing outfalls in excess of orders by 85% is therefore unlikely to impact upon their habitat and passage. **Mitigation water is not required.**
4.2. Diminish the benefits of deploying any environmental water allocations (over and above the contribution from the irrigation system).	Although the outfalls form a very small portion of the water required to support the environmental values, more environmental water would be required if the outfalls were removed. **Mitigation water maybe required.**
5. Further investigation should be undertaken where:	
5.1. The margin of error in the estimate of	Not assessed.

Criteria by which mitigation water may be assessed as not required	Link between incidental water (losses) and environmental values
mitigation water is greater than the savings available from the relevant operating component (e.g. the specific outfall).	

Although the above assessment demonstrates that Murray Cod and other native fish supported by the Broken Creek system benefit from outfalls in excess of orders. A reduction in outfalls in excess of orders by 85% is unlikely to impact upon their habitat and passage, for it would reduce the overall flow in the Broken Creek system by less than 4% (refer Section 7.4.3). This is equivalent to approximately 6.6 ML/d along a waterway that is 196 km long (see table 8-2). Therefore, on balance **mitigation water is not required**. However, in recognition of the potential impact of reduced outfalls diminishing the benefits of deploying any environmental water allocations (over and above the contribution for the irrigation system), and the ongoing dependency of the environmental values on delivered consumptive water, the supply of consumptive water through the irrigation areas (e.g. River Murray water through the Murray Valley Irrigation Area) to the Broken Creek System should be ongoing. Furthermore, NVIRP should investigate the possibility of enhancing the capacity of the Murray Valley Irrigation Area infrastructure to facilitate this (see section 10).

9. USING MITIGATION WATER TO MANAGE IMPACTS

No requirements for mitigation water have been identified in the development of this EWP.

10. INFRASTRUCTURE

As outlined in sections 6.8, 7.1 and 8.4 flows of 100-250 ML/d past Rices Weir are required between September and April to provide habitat and passage for native fish. These flows can not always be met by inflows ordered by local diverters, environmental managers, inflows in excess of orders and inflows from the upstream catchments and drains. This is exacerbated by dry conditions and the subsequent reduction in irrigation allocations, which we have experienced over the last 10 years. To meet these flow requirements G-MW have called upon the Goulburn Water Quality Reserve and arranged for Inter Valley Transfers. Since 2004-2005, a total of 56,098 ML of the Goulburn Water Quality Reserve and Inter Valley Transfers have been used by G-MW to maintain habitat and passage for native fish. Of this volume, 27,994 ML was used in 2008/2009 alone, which exceeded the volume of water ordered by local diverters (see Section 7.3.3). Alternatively, River Murray supplies (which are a more reliable source of water) can be diverted via the Yarrawonga Main Channel, through the Murray Valley Irrigation District and down the Broken Creek system before returning to the Murray River. To facilitate this, channel and outfall capacities may need to be increased, which could be assessed and undertaken as part of the Murray Valley Service Enhancement project. In addition, the following 11 Murray Valley outfalls connected to the Broken Creek system should be placed on the NVIRP's environmental infrastructure register, to ensure any infrastructure modifications planned as part of the Murray Valley Service Enhancement project do not affect the capacity of the irrigation infrastructure to supply the flows required for native fish habitat and passage:

- MV 7/3 outfall;
- MV 3 main outfall;
- MV 4 main outfall;
- MV 5/3 outfall;
- MV 6/6 outfall;
- MV 8/6 outfall;

- MV 4/8/6 outfall;
- MV15/6 outfall;
- MV 21A/6 outfall (Jewells);
- MV 26A/6 outfall (Flanners); and
- MV End 6 main outfall.

11. RISKS

While no requirement for mitigation water has been identified in development of this EWP, risks to the future condition of the high value environmental assets may still arise in association with implementation of the NVIRP. Critical risks are summarised in Table 11-1. Recommendations to manage these risks are included in Section 12 (Adaptive Management) and Section 16 (Management Actions).

Table 11-1 Risks associated with NVIRP implementation

Risk	Impact	Management response
Flow dependency of environmental assets not fully represented by EWP process.	Flow regime assessed as providing acceptable conditions for environmental asset may not allow objective to be satisfied.	Address key knowledge gaps as identified in Section 15. Monitor condition of environmental assets and provide for review of EWP and water delivery in the future (refer Section 12).
NVIRP works provide greater water savings than targeted, resulting in greater impact on stream flows.	Additional hydrologic impact (i.e. reduction in stream flow) could stress environmental assets beyond thresholds.	
Reduction in outfalls due to NVIRP has local effects not identified by reach scale analysis.	Assets or values in immediate proximity to outfalls may be more exposed to changed hydrologic regime than indicated by analysis undertaken at reach scale.	
Timing, spatial distribution or magnitude of irrigation deliveries (and hence stream flows) change significantly due to factors external to NVIRP (i.e. climate change, industry change).	Potentially greater impact than the water savings proposed under NVIRP as environmental assets dependent on relatively large water volumes (passage for fish, flushing flows for water quality and *Azolla*) are largely supported by irrigation deliveries currently.	Monitor condition of environmental assets and provide for review of EWP and water delivery in the future (refer Section 12). Review and formalise means by which irrigation deliveries including IVTs are managed to achieve water supply obligations and protection of environmental assets (refer Section 16).
Flows currently available through IVTs or the Goulburn Water Quality Reserve become unavailable to the Broken Creek due to changed operation of waterway systems external to Broken Creek.	As Broken Creek within the EWP project area has no current environmental flow entitlement (excluding some undefined portion of the Goulburn Water Quality Reserve), reduction in IVT usage or availability of the Goulburn Water Quality Reserve has potential large impact on those objectives not satisfied by flows associated with irrigation deliveries.	

12. ADAPTIVE MANAGEMENT FRAMEWORK

12.1 Introduction

A key NVIRP principle is that an adaptive management approach is adopted to ensure an appropriate response to changing conditions (Section 9.4, NVIRP 2010).

Adaptive management is a continuous management cycle of assessment and design, implementation, monitoring, review and adjustment. Table 11-1 shows how the adaptive management approach will be applied in the context of this EWP. Further detail is given in later sections.

Table 12-1 Adaptive management approach applied to the EWP

Adaptive management phase	Application to this EWP (Responsible agency)	When (Section 15 and 19, NVIRP 2010)
Assessment and design	Assessment identifies environmental values, their water dependencies, and the potential role of incidental water. Design determines the desired water regime to support environmental values and determines any mitigation water commitment. Details of both these phases are documented in this EWP. (NVIRP)	2010
Implementation	Implementation is the active management of environmental water, of which mitigation water may form a portion, consistent with this EWP. (Agencies as appropriate))	Continuous
Monitoring (and reporting)	Monitoring is gathering relevant information to facilitate review and enable any reporting obligations to be met. Two types of monitoring are required. Compliance monitoring is checking that the intended water regime is applied. Performance monitoring is used to inform the review of the effectiveness of the interim mitigation water contribution to achieving the water management goal. (NVIRP – to resource or coordinate monitoring to meet its reporting obligations Other agencies – monitoring to inform assessment of achievement of environmental objectives).	Annual
Review	Review is evaluating actual results against objectives and identifying any improvement opportunities which may be needed. (NVIRP, until responsibilities transferred to other Agencies	2012, 2015, 2020, 2025, etc

Adjustment	Adjustment is determining whether changes are required following review or after considering any new information or scientific knowledge and making any design changes in an updated version of the EWP. (NVIRP, until responsibilities transferred to other Agencies)	2012, 2015, 2020, 2025, etc

12.2 Monitoring and reporting

It is assumed that if mitigation water is supplied in accordance with the desired watering regime proposed within the EWP then environmental values potentially impacted by NVIRP will be maintained. NVIRP will report, annually, on the contribution, or provision, of "NVIRP Mitigation Water" towards achieving the watering regime (Section 18, NVIRP 2010). This will be done by monitoring and reporting:

- whether mitigation water was available for delivery to the wetland or waterway;
- whether a decision was made that water was required for the wetland or waterway for that year;
- whether mitigation water was delivered to the wetland or waterway in accordance with the desired watering regime proposed within the EWP (i.e. quantity, timing, duration, frequency); and
- whether the ecological objectives were achieved or are being achieved?

The reporting of delivery of environmental water other than mitigation water is required because it is impossible to partition achievement of ecological objectives between NVIRP mitigation water and other sources of environmental water. In addition, mitigation water may only form a minor portion of the desired watering regime and is likely to be required to be delivered in association with other sources of water (i.e. environmental water allocation).

NVIRP is to include this reporting in the annual report to the Secretary of DSE.

It is expected the environmental water holder will monitor environmental water delivery (i.e. quantity, timing, duration and frequency) and implement a detailed monitoring program to enable assessment of ecological condition. NVIRP will not implement a detailed monitoring program. It is beyond the scope of this EWP to provide a detailed monitoring program to determine the effectiveness of the recommended watering regime in achieving ecological objectives and the overall water management goal.

12.3 Review

The review phase will include:

- Evaluation; and
- adjustment.

It is expected this EWP will be reviewed in 2012, 2015, 2020 and every five years thereafter, or at any time, if requested by the Minister for Water or Commonwealth Minister for Environment Protection (Sections 15 and 19, NVIRP 2010).

Five yearly reviews will, amongst other things:

- address the question "are long term objectives being achieved"; and
- set the parameters against which the following 5 year review will be evaluated.

Monitoring results will need to be evaluated against predicted environmental outcomes and responses. Evaluation should occur on two components:

- operational management i.e. whether the volumes estimated as part of the surface water balance are satisfying the hydrological requirements (e.g. required duration and depth); and
- environmental response i.e. whether the recommended watering regime is resulting in the predicted responses (e.g. vegetation composition, waterbird occurrence).

12.4 Adjustment

Adjustments may be made to:

- operational management;
- expected outcomes (i.e. ecological objectives); and
- cope with unexpected issues.

These adjustments will be incorporated into the EWP.

13. MANAGEMENT AND GOVERNANCE ARRANGEMENTS

A summary of the roles and responsibilities of the various bodies relating to the delivery and review of management and mitigation measures is provided in Table 10-2 (NVIRP 2010). The table outlines the roles and responsibilities before and during the implementation of NVIRP in the modified GMID.

Table 13-1 Roles and responsibilities

Agency	Assess and develop management and mitigation measures	Deliver and review management and mitigation measures during NVIRP implementation
NVIRP	• identify and account for water savings, subject to audit by DSE accredited auditor • Lead the assessment and development processes for management and mitigation measures including developing and gaining approval to the WCMF (which guides the development of EWPs and the assessment of mitigation water). • Maintain short-list of all wetlands, waterways and groundwater dependent ecosystems for mitigation. • Identify and source mitigation water required to implement management and mitigation measures including the adaptive development of EWPs. • Retain or provide infrastructure to deliver water to wetlands and waterways. • Convene and chair the Technical Advisory Committee. • Convene the Expert Review Panel	• Apply, review and, as necessary, develop amendments and gain approval to updated versions of the WCMF. • Provides resources to enable monitoring and review of management and mitigation measures • Establish protocols for transfer of responsibility to relevant agencies. • Coordinate with other agencies to improve management and mitigation measures. • Arrange for the provision of delivery and measurement infrastructure including capacity and operational flexibility for mitigation water • Work closely with system operator.

Catchment Management Authority	• Identify and inform NVIRP of opportunities for best practice. • Inform NVIRP of its infrastructure requirements to deliver environmental water. • Participate in Technical Advisory Committee. • Agree to implementing relevant components of Environmental Watering Plans. • Agree to implementing other relevant regional management and mitigation measures required due to the implementation of NVIRP.	• Advise Environmental Water Holder and system operator on priorities for use of environmental entitlements (including mitigation water) in line with recommendations outlined in the EWPs • Implement the relevant components of Environmental Watering Plans. • Operate, maintain and replace, as agreed, the infrastructure required for delivery of mitigation water, where the infrastructure is not part of the G-MW irrigation delivery system . • Report on environmental outcomes (e.g. wetland or waterway condition) from the delivery of the water, in the course of normal reporting on catchment condition. • Where agreed conduct the periodic review of EWPs and report results to NVIRP. • Manage and report on other relevant catchment management and mitigation measures required due to the implementation of NVIRP.

Land Manager (Public and private as relevant)	• Identify and inform NVIRP of opportunities for best practice. • Participate in Technical Advisory Committee. • Agree to implementing relevant components of Environmental Watering Plans. • Agree to implementing other relevant regional management and mitigation measures required due to the implementation of NVIRP.	• Implement the relevant components of Environmental Watering Plans. • Operate, maintain and replace, as agreed, the infrastructure required for delivery of mitigation water, where the infrastructure is not part of the G-MW irrigation delivery system. • Where agreed, participate in the periodic review of relevant EWPs. • Manage and report on other relevant catchment management and mitigation measures required due to the implementation of NVIRP.

System Operator	• Identify and inform NVIRP of opportunities for best practice. • Participate in Technical Advisory Committee. • Agree to implementing relevant components of Environmental Watering Plans. • Administer management and operational arrangements.	• Implement the relevant components of Environmental Watering Plans, namely delivery of mitigation water. • Operate, maintain and replace, as needed, the infrastructure required for delivery of mitigation, or other, water, where the infrastructure is part of the G-MW irrigation delivery system. • May negotiate transfer of ownership of infrastructure to the environmental water/land manager for provision of mitigation water if it is no longer required for the public distribution system, in accordance with the principles set out in section 9. • Where the infrastructure assets are due for renewal or refurbishment, the water corporation will undertake the upgrade to the best environmental practice, including any requirements to better provide Environmental Water Reserve. • Report annually on the availability and delivery of water for mitigating environmental impacts as part of reporting upon meeting obligations under its bulk entitlement. In some instances, it will be appropriate to measure mitigation flows to ensure mitigation volumes of water are delivered. • Work closely with NVIRP

DSE	• Identify and inform NVIRP of opportunities for best practice. • Participate in Technical Advisory Committee. • Arrange funding to enable environmental water manager, catchment manager and land manager to deliver agreed measures. • Develop policies to address relevant issues (assuming that other agencies will participate policy development).	• Participate in the periodic review of the Water Change Management Framework and relevant EWPs. • Conduct review as part of the long-term water resource management; a requirement specified in Section 22L of the *Water Act 1989*. The process will allow: - the balance of the environmental obligations and consumptive water to be assessed and restored based on certain conditions. - the need for the obligation reviewed based on the environmental values at the time of the review.
Environmental Water Holder (to be established) **DSE pending appointment of the Environmental Water Holder**	Environmental Water Holder not yet in place. Role fulfilled by DSE in the meantime.	• Hold and manage environmental entitlements, including mitigation water that becomes a defined entitlement. • Consult with CMAs in identifying priority wetlands, waterways and groundwater systems for environmental watering. Plan and report on the use of environmental entitlements. • Participate in the periodic review of relevant EWPs. • Negotiate with Commonwealth Environmental Water Holder to arrange delivery of Commonwealth environmental water.

14. CONSULTATION

14.1 Community consultation

No specific community consultation activities were undertaken in the development of the EWP.

14.2 Scientific and technical review

A Scientific Reference Group was established by Goulburn Broken CMA at the commencement of the EWP development process. The use of a Scientific Reference Group, comprising specialists with relevant knowledge of current and historic conditions in the Broken Creek system assisted in providing an appropriate level of scientific rigour to the process.

This Scientific Reference Group (refer Table 14-1) provided inputs in the collation and review of relevant information, site inspection, identification of environmental assets and condition, establishment of management objectives for assets and review of flow dependencies for the identified assets. This input was provided during a field trip on 11 February 2010, an initial project workshop on 19 February 2010 and a second workshop on 31 March 2010. Members of the Scientific Reference Group also reviewed the draft EWP and provided comment to ensure that their respective areas of expertise are appropriately addressed by the EWP and that the likely impacts of any hydrologic modification resulting from the NVIRP are understood within the context of current knowledge.

Table 14-1 Scientific Reference Group for development of the EWP

Name	Expertise	Role	Field trip 11 Feb	Workshop 1 19 Feb	Workshop 2 31 March
Darren Baldwin	Biogeochemistry / water quality / aquatic ecology	Scientific Reference Group	✓	✓	X
Daryl Nielsen	Invertebrates / aquatic ecology	Scientific Reference Group	✓	✓	✓
Gavin Rees	Microbial ecology / water quality / azolla	Scientific Reference Group	✓	✓	X
Jarod Lyon	Fish biology	Scientific Reference Group	✓	✓	X
Rick Stoffels	Fish / aquatic ecology	Scientific Reference Group	X	✓	✓

Peter Cottingham and Nick Bond provided peer reviews of the Draft EWP.

Additional inputs and strategic direction were provided by personnel outlined in Table 14-2.

Table 14-2 Personnel involved in project management, support and reporting during development of the EWP

Name	Expertise	Role	Field trip 11 Feb	Workshop 1 19 Feb	Workshop 2 31 March
Simon Casanelia	GBCMA river health and environmental water reserve	Project manager	✓	✓	✓
Wayne Tennant	GBCMA Manager strategic river health	Strategic direction	X	✓	✓
Simon Lang	Hydrology	Hydrology consultant	✓	✓	✓
Chris Solum	NVIRP	System knowledge	X	✓	X
Mark Poole	NVIRP	System knowledge	X	✓	X
Anne Graesser	Goulburn-Murray Water	System knowledge	X	X	✓
Jim Castles	Site knowledge / ecology	Project support	✓	X	X
Tim Barlow	Ecology	Project support	✓	X	X
Toby Alker-Jones	Project support	Project support and mapping	✓	✓	X
Tim Loffler	Project management	Project co-ordinator and author	✓	✓	✓

15. KNOWLEDGE GAPS

Key knowledge gaps or risks which must be acknowledged and addressed through ongoing management and monitoring are outlined below.

- As a full environmental flow study utilising the FLOWS method (NRE 2002) has not been undertaken for Broken Creek (refer Section 8.2), the flow requirements documented in this EWP have been developed based on available information (including inputs from the Scientific Reference Group) and desktop review of flow dependencies. While the approach used is consistent with that of the FLOWS method it has not included any survey or hydraulic modelling to assess the sensitivity of variables such as depth, velocity and wetted area to changes in flow magnitude. Some modelling or monitoring of conditions in the field at a range of flows could be useful to validate the flow magnitudes required to achieve certain in-stream conditions (i.e. passage of fish through fishways, mobilisation of *Azolla* mats).
- There is an incomplete understanding of sediment, water quality and flow interactions in the development of low DO conditions in the lower reaches of Broken Creek (Rees 2006).
- There is a lack of water quality data in weir pools excluding Rices Weir to understand the extent of the waterway reach with potential exposure to low DO conditions (dominantly within EWP Reach 4). Additional data in upstream weir pools may provide additional information to enable management intervention to response rapidly to site conditions.
- Current and future hydrology (under the implementation of NVIRP) have been assessed based on historic flow records (refer Section 7). Flow records are generally weekly or monthly and it is currently not possible to interpret the implementation of NVIRP on daily flows. When considered at a finer time scale NVIRP may have an impact greater than that revealed by the monthly data. Of the assets and threats considered in the EWP assessment, water quality is most likely to be impacted by short term flow variations possibly influenced by NVIRP, as *Azolla* and DO interactions in EWP Reach 4 respond rapidly to changes in flow, temperature and nutrients.
- The EWP has identified flow dependencies for specific threatened or high value flora and fauna based on existing literature and / or expert knowledge. Flow dependencies are not well documented or understood for some assets so some uncertainty remains in the mitigation water assessment.
- Identification of waterway assets has been based on existing knowledge and mapping. This information may be incomplete or inaccurate. The possible existence of high value assets, with exposure to modified hydrology under implementation of NVIRP activities cannot be ruled out but is not addressed through this EWP.

16. RECOMMENDATIONS AND COMPLEMENTARY ACTIONS

This EWP is only a component of the overall management framework for the Broken Creek system. For example, the Lower Broken Creek Waterway Management Strategy (GHD / URS 2005) and the Goulburn Broken Regional River Health Strategy (GBCMA 2005) recommend management actions based on broad reviews of threats to waterway condition. This EWP is more focussed in its scope relating to threats to waterway environmental assets resulting from the implementation of the NVIRP. Recommendations and complimentary actions to protect or enhance these waterway environmental assets, as identified during development of the EWP are outlined below. However reference should also be made to the afore-mentioned strategies (amongst others) for a more complete listing of recommendations and actions of relevance to the Broken Creek system.

Recommendations:

1. Divert River Murray water through the Murray Valley Irrigation District and down the Broken Creek to help provide flows required to maintain native fish passage and habitat.
2. The NVIRP to investigate enhancing the capacity of the Murray Valley Irrigation District infrastructure to facilitate the diversion of River Murray water down the Broken Creek.

Complementary actions:

1. Flow dependencies of the environmental assets / threats which have the greatest impact on flow magnitudes currently delivered under the regulated flow regime (critically passage and habitat for Murray Cod and Azolla / DO management) should be further investigated through survey and hydraulic modelling (as is the case for other systems where the FLOWS method has been applied).
2. Investigate the potential to increase the short-term (typically < 1 week) variation in water levels through all EWP reaches to increase cover and diversity of native aquatic and fringing vegetation. An identified factor possibly limiting the effectiveness of fish passage at the installed fishways (vertical slots) is lack of flow variation. Flow should be manipulated to improve fish migration and create a more natural healthy stream. Flow variation of as little as 0.15 m can be a strong stimulus for fish migration (O'Connor and Amtstaetter 2008).
3. It is recognised that this variability is likely to be negatively impacted by NVIRP (in seeking more consistent and efficient system operations) but consideration should be given to short term variation at ecologically critical times.
4. Install water quality monitoring equipment in weir pools upstream of Rices Weir (already monitored) to improve the understanding of water quality, Azolla and DO interactions in the lower reaches of Broken Creek. There is an opportunity to link this to existing telemetry at four existing ARI sites (used for remote monitoring of fish movements within the fish ladders) at Rices, Kennedys, Schiers and Nathalia Town weirs.
5. Provide for further research and development of the adaptive management approach for the low DO / Azolla issues in the Lower Broken Creek (beyond that contained in G-MW (2004)) to extend the system understanding and response model beyond the current Rices Weir focus. Modelling of weir pool hydraulic and water quality processes may provide an opportunity to tailor the delivery of flows to mitigate the water quality concerns while using less water.
6. Review of the Lower Broken Creek Operational Guidelines (G-MW 2003) to encompass more up to date and detailed information (including information contained in this EWP) would provide a more explicit basis for operation of the system to protect key environmental assets. The revised Guidelines (possibly formalised in a MOU) would provide more formal protection for those assets dependent on the current operational practices.
7. Secure a minimum passing flow for the creek during the irrigation season of about 100 ML/d (over Rices Weir) to maintain DO and control the build up of Azolla. The water could be diverted

from the Murray River through the Murray Valley Irrigation network into the Broken Creek and back to the Murray River. This would be a reliable source of water and would require agreement from G-MW and the MDBA. The capacity of the Murray Valley Irrigation network may need to be increased to deliver this passing flow, which could be undertaken as part of the NVIRP's planned water saving initiatives. Flows up to 150 ML/d may be required in addition to the 100 ML/d minimum passing flow to managed Azolla and DO. This water may be sourced from the Murray River, IVT or the Goulburn water quality reserve.

17. REFERENCES

1. Ahern L D, Lowe K W, Berwick S, Robinson D and Handley K (2003). "Biodiversity Action Planning: Landscape Plans for the Goulburn Broken Catchment Management Authority (GBCMA) – SIR – North Zones". DSE, Victoria.
2. Australian Ecosystems Pty Ltd (2009). "Ecological response of four wetlands to the application of environmental water: Final report on monitoring from May to December 2008". Report prepared for Goulburn Broken Catchment Management Authority. January 2009.
3. Berwick S (2003). "Map Unit Descriptions of Lower Goulburn Broken (draft)". State of Victoria, Melbourne.
4. Bowler J (1978). "Quaternary climate and tectonics in the evolution of the Riverine Plain, Southeastern Australia." In: Davies J L and Williams M A J (Editors), Landform evolution in Australasia. Australian National University Press, Canberra, pp. 70-112.
5. Chessman B C, Thurtell L A and Royal M J (2006). "Bioassessment in A Harsh Environment: A Comparison of Macroinvertebrate Assemblages at Reference and Assessment Sites in An Australian Inland River System". Environmental Monitoring and Assessment, 119, 303-330.
6. Corrick A H and Norman F I (1980). "Wetlands of Victoria I. Wetlands and waterbirds of the Snowy River and Gippsland Lakes catchment". Proceedings of the Royal Society of Victoria 91, 1-15.
7. Cottingham P, Stewardson M, Roberts J, Metzeling L, Humphries P, Hillman T and Hannan G (2001). "Report of the Broken River Scientific Panel on the environmental condition and flows of the Broken River and Broken Creek". Technical Report 10/2001, Cooperative Research Centre for Freshwater Ecology, University of Canberra. December 2001.
8. Department of Planning and Community Development (DPCD) Vic (2010). "Environment assessment referrals from July 2008 to June 2009". http://www.dse.vic.gov.au/DSE/nrenpl.nsf/LinkView/E6DAFE581144D1FFCA25757B0008A28314CD70100E11BFB5CA2572DA007FAA9C, accessed April 2010.
9. Department of Primary Industries (DPI) (2003). "Kinnairds Swamp Environmental Management Plan". Environmental Management Program, DPI, Tatura, Victoria. October 2003.
10. Department of Sustainability and Environment (DSE) (1994). Wetland 1994 – Victorian Wetlands Environment and Extent GIS Layer (DSE Interactive Maps Website – Biodiversity Interactive Map 2.0). Department of Sustainability and Environment.
11. Department of Sustainability and Environment (DSE) (2008). "Conservation Plan for the Central Creek Landscape Zone – Biodiversity Action Planning in the Shepparton Irrigation Region". Water and Biodiversity Group, Department of Sustainability and Environment, State Government of Victoria. Final (Version 1), January 2008.
12. Department of Sustainability and Environment (DSE) (2009). "Northern Region Sustainable Water Strategy". Department of Sustainability and Environment, State Government of Victoria, Melbourne. November 2009.
13. Department of Sustainability and Environment (DSE) (2010). Biodiversity Interactive Map, http://mapshare2.dse.vic.gov.au/MapShare2EXT/imf.jsp?site=bim Department of Sustainability and Environment, State Government of Victoria, Melbourne, accessed March 2010.
14. Douglas J (2000). "A preliminary assessment of the Broken Creek fishways". Marine and Freshwater Resources Institute, Freshwater Resources Program, Snobs Creek, Victoria, Department of Natural Resources and Environment. Report prepared for Goulburn Broken Catchment Management Authority. March 2000.
15. Environment Australia (2001). "A Directory of Important Wetlands in Australia, Third Edition". Environment Australia, Canberra.

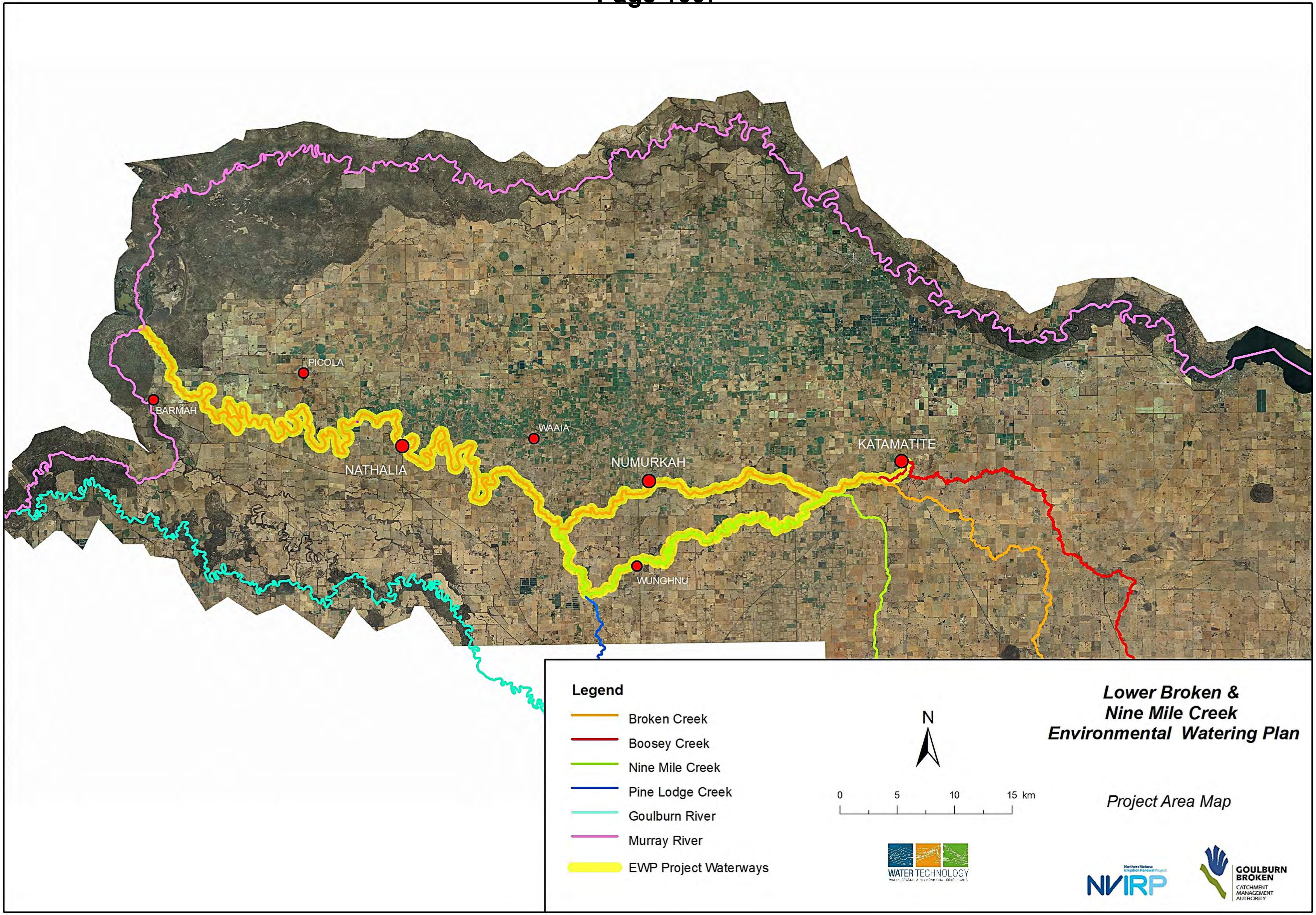
16. Environment Conservation Council (ECC) (2001). “Box-Ironbark Forests and Woodlands Investigation Final Report”. Environment Conservation Council, Melbourne.
17. Feehan Consulting (2009). “NVIRP Waterway Shortlisting Report – Final Report”. Report prepared for NVIRP. August 2009.
18. GHD Pty Ltd and URS Pty Ltd (2005). “Lower Broken Creek Waterway Management Strategy – Final Report”. Report prepared for Goulburn Broken Catchment Management Authority. July 2005.
19. Goulburn Broken Catchment Management Authority (GBCMA) (2003). “Goulburn Broken Regional Catchment Strategy”. Goulburn Broken Catchment Management Authority, Shepparton, Victoria.
20. Goulburn Broken Catchment Management Authority (GBCMA) (2005). “Goulburn Broken Regional River Health Strategy 2005”. Goulburn Broken Catchment Management Authority, Shepparton, Victoria.
21. Goulburn Broken Catchment Management Authority (GBCMA) (2008). “Lower Broken Creek and Nine Mile Creek Interim Environmental Flow Recommendations”. Goulburn Broken Catchment Management Authority, Shepparton, Victoria. March 2008.
22. Goulburn-Murray Water (G-MW) (2003). “Lower Broken Creek operational guidelines”. Goulburn-Murray Water, Tatura, Victoria. September 2003.
23. Goulburn-Murray Water (G-MW) (2004). “Broken Creek – Monitoring and incident response management manual”. Goulburn-Murray Water, Tatura, Victoria. Issue 2, January 2004.
24. Hale J, Roberts J, Butcher R and Kobryn H (2006). “Broken Boosey and Nine Mile Creeks wetland implementation plan”. Regional Ecosystem Services. Report prepared for Goulburn Broken Catchment Management Authority. July 2006.
25. Heard R (2007). “Conservation Plan for the Barmah Landscape Zone: Biodiversity Action Planning in the Shepparton Irrigation Region”. Department of Primary Industries, Victoria.
26. Humphries P, Growns J E, Serafini L G, Hawking J H, Chick A J and Lake P S (1998). “Macroinvertebrate sampling methods for lowland Australian rivers”. Hydrobiologia, 364, 209-218.
27. Meredith S and Beesley L (eds) (2009). “Watering floodplain wetlands in the Murray Darling Basin to benefit fish: a discussion with managers”. Arthur Rylah Institute for Environmental Research, Technical Report Series No. 189. Department of Sustainability and Environment, Heidelberg, Victoria. Report prepared for Goulburn Broken Catchment Management Authority. July 2008.
28. National Land and Water Resources Audit (NLWRA) (2002). “Australian Terrestrial Biodiversity Assessment 2002”. Land and Water on behalf of the Commonwealth of Australia.
29. Natural Resources and Environment (NRE) (2002). “FLOWS – A method for determining environmental water requirements in Victoria”. Report prepared by Sinclair Knight Merz Pty Ltd for the Victorian Department of Natural Resources and Environment. January 2002.
30. North Central Catchment Management Authority (NCCMA) (2010). “Loddon River long term environmental watering plan”. North Central Catchment Management Authority, Huntly, Victoria. March 2010.
31. Northern Victoria Irrigation Renewal Project (NVIRP) (2010). “Water Change Management Framework – Draft Amendment”. February 2010.
32. O’Connor J, O’Mahony D and O’Mahony J (2003). “Downstream movement of adult Murray-Darling fish species”. Report to Agriculture Fisheries and Forestry Australia. Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, Heidelberg, Victoria. June 2003.
33. O’Connor J P and Koster W (2005). “Assessment of fish communities in the lower Broken Creek after a fish kill in 2002”. Report to Goulburn-Broken Catchment Management

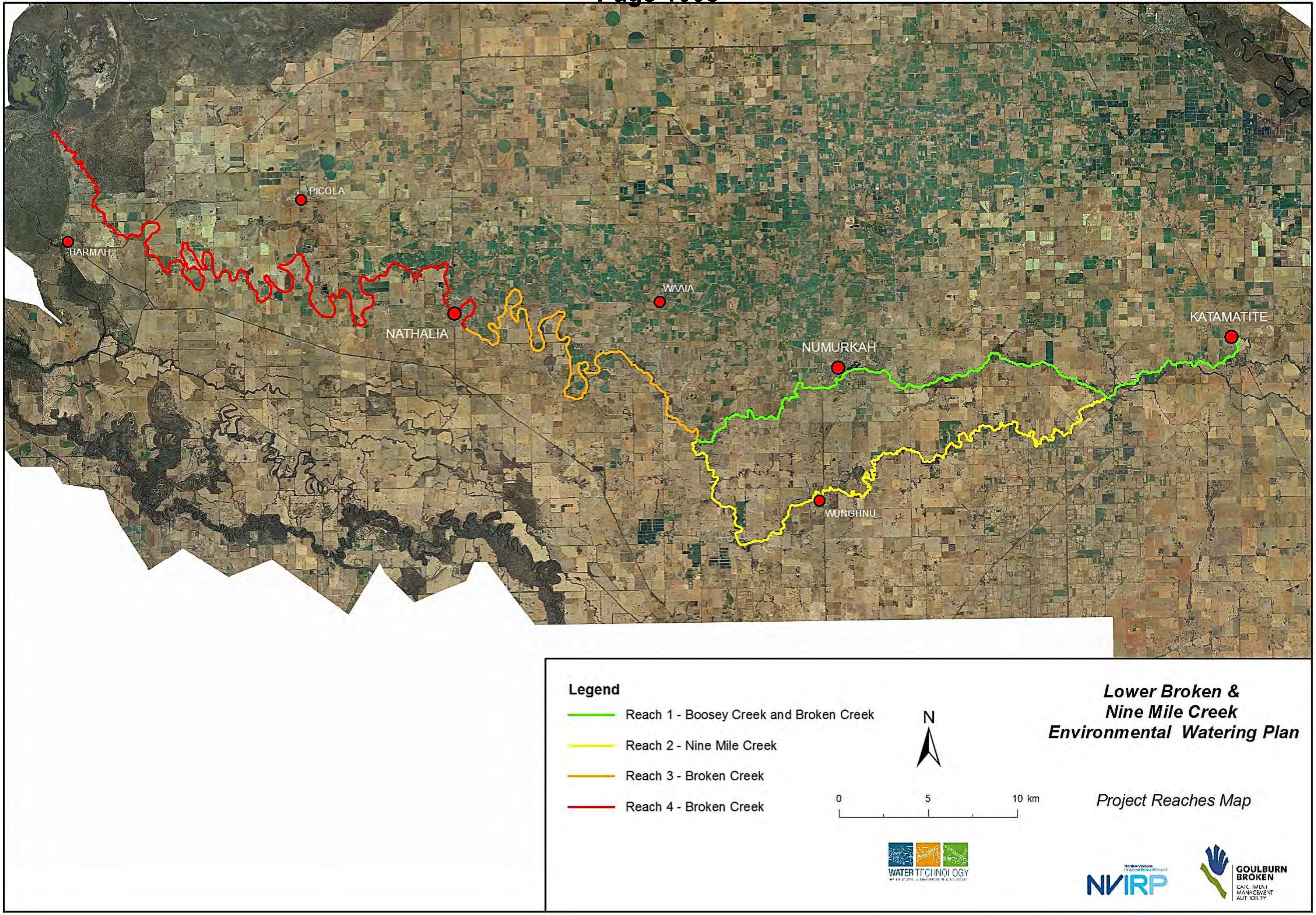
Authority. Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, Heidelberg, Victoria. February 2005.

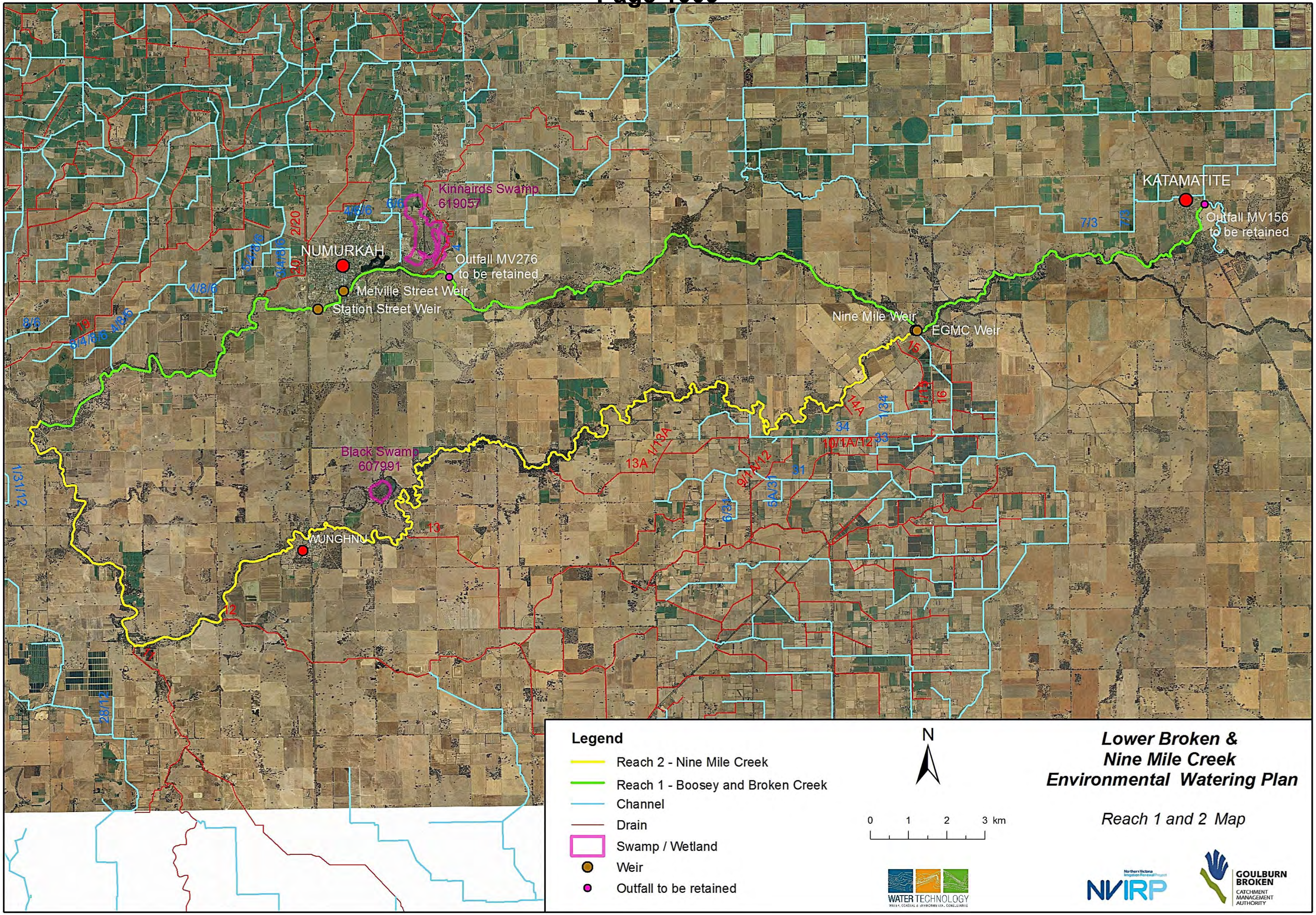
34. O'Connor J (2006). "Assessment of the Broken Creek fishways installation program". Report to Goulburn Catchment Management Authority. Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, Heidelberg, Victoria. July 2006.
35. O'Connor J and Amtstaetter F (2008). "Monitoring native fish communities in the Broken Creek and Broken River". Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, Heidelberg, Victoria. Report prepared for Goulburn Broken Catchment Management Authority. July 2008.
36. O'Connor J and O'Mahony J (2008). "Broken Creek drought management plan – A response to low or no flow drought conditions". Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, Heidelberg, Victoria. June 2008.
37. Parks Victoria (2006). "Broken-Boosey State Park and Nathalia, Numurkah, Tungamah and Youarang Natural Features Reserves Management Plan". Parks Victoria, Melbourne. October 2006.
38. Rees G (2006). "Ecological implications of *Azolla* proliferation events in the Lower Broken Creek". The Murray-Darling Freshwater Research Centre, Wodonga, Victoria. Report prepared for Goulburn Broken Catchment Management Authority. March 2006.
39. Reich P, McMaster D, Bond N, Metzeling L and Lake S (2009). "Examining the ecological consequences of restoring flows intermittency to artificially perennial lowland streams: Patterns and predictions from the Broken-Boosey Creek system in northern Victoria, Australia". River Research and Applications, 2009.
40. Robinson D and Mann S (1996). "Natural values of the public lands along the Broken, Boosey and Nine Mile Creeks of north eastern Victoria. A report to the Australian Heritage Commission on the natural values, human uses and threatening processes found along the creeks with recommendations for listings and future management". Goulburn Valley Environment Group, Victoria.
41. Rosengren N J (1987). "Sites of geological and geomorphological significance in the western region of Melbourne". Prepared by the Department of Geography, University of Melbourne for the Department of Conservation, Forests and Lands; Arthur Rylah Institute – Ecological Inventory and Evaluation Section, Melbourne.
42. Sinclair Knight Merz Pty Ltd (1996). "A management strategy for Broken Creek, Study Report Stage 1, Volume 2". Report prepared for Lower Goulburn Waterway Management Authority.
43. Sinclair Knight Merz Pty Ltd (1998a). "Broken Creek model development – Model calibration report". Report prepared for Goulburn-Murray Water. February 1998.
44. Sinclair Knight Merz Pty Ltd (1998b). "Lower Goulburn waterways – Broken Creek management strategy – Final Report, Volume 1". Report prepared for Goulburn Broken Catchment Management Authority. June 1998.
45. Sinclair Knight Merz Pty Ltd (2003). "Broken Creek Model – Stage 2 – Final Report". Report prepared for Goulburn-Murray Water. January 2003.
46. Sinclair Knight Merz Pty Ltd (2007). "Black Swamp flood regime determination – Project Report, Final". Report prepared for Goulburn Broken Catchment Management Authority. October 2007.
47. Sinclair Knight Merz Pty Ltd (2008). "Food Bowl Modernisation Project – Environmental Referrals". Report prepared for Department of Sustainability and Environment. November 2008.
48. Stewardson M (2001). "The flow events method for developing environmental flow regimes." In Rutherfurd I, Sheldon F, Brierley G and Kenyan C. (Eds). Third Australian Stream Management Conference, Brisbane, 2001.

49. Victorian Government (1995). "Bulk Entitlement (Eildon-Goulburn Weir) Conversion Order 1995". Gazette No: G35, Gazette Date 9/7/1995.
50. Victorian Government (1999). "Bulk Entitlement (River Murray – Flora and Fauna) Conversion Order 1999". Gazette No: G24, Gazette Date 6/17/1999.

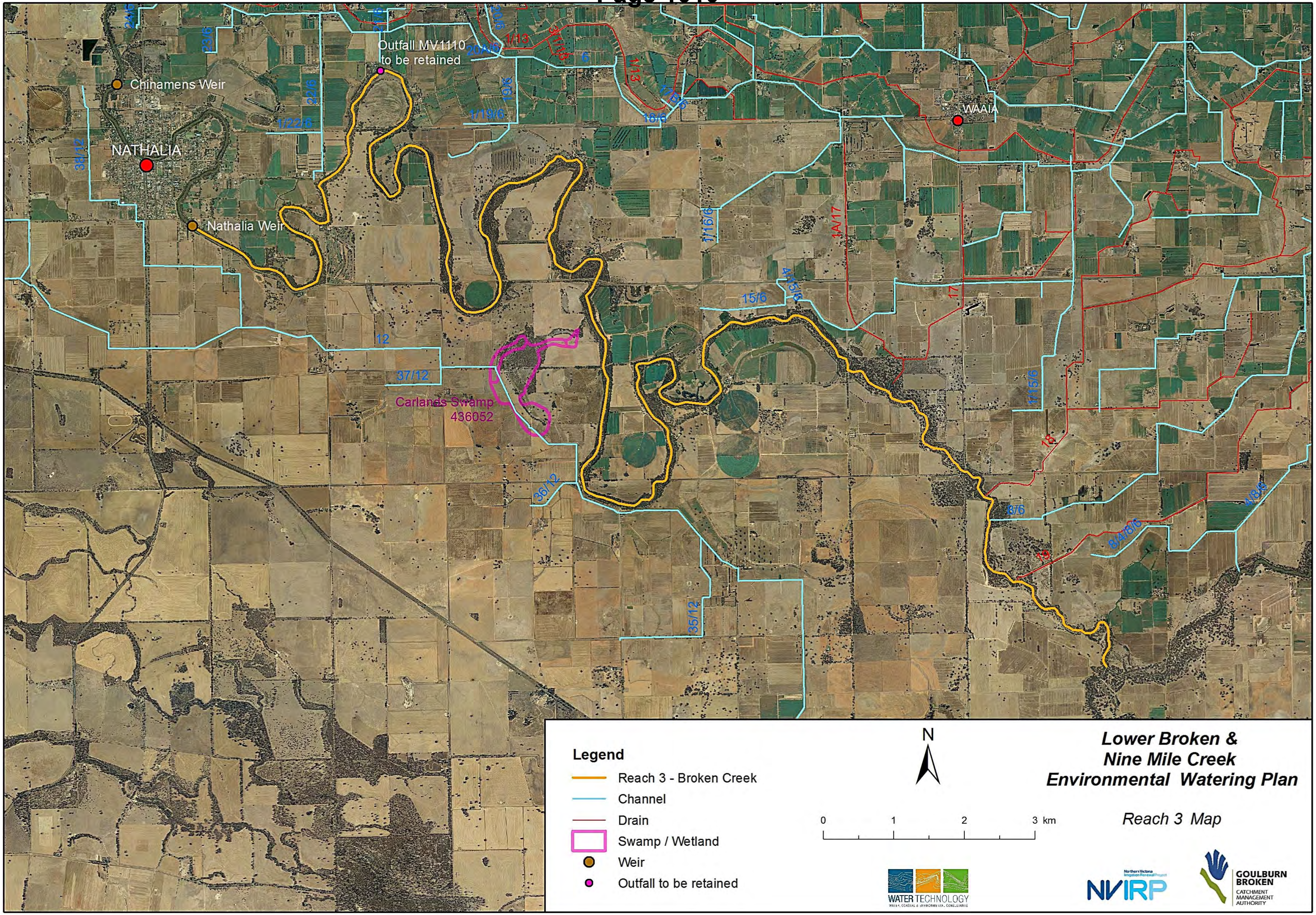
APPENDIX A PROJECT AREA AND REACH MAPS

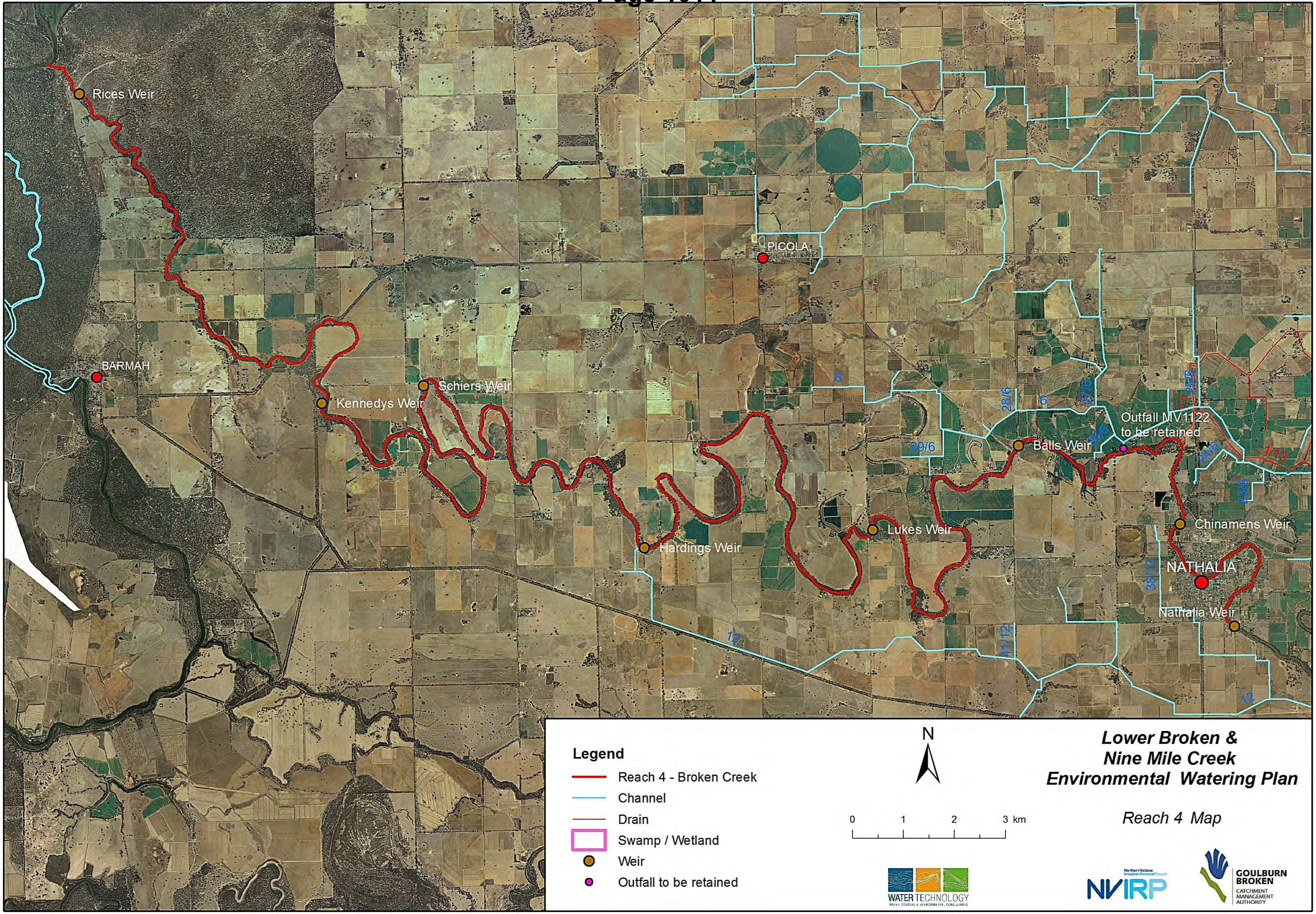

PICOLA
BARMAH
WAAIA
NATHALIA
NUMURKAH
KATAMATITE
WUNGHNU
Legend
Broken Creek
Boosey Creek
Nine Mile Creek
Pine Lodge Creek
Goulburn River
Murray River
EWP Project Waterways
N
0 5 10 15 km
Lower Broken & Nine Mile Creek Environmental Watering Plan
Project Area Map
WATER TECHNOLOGY
NVIRP
GOULBURN BROKEN CATCHMENT MANAGEMENT AUTHORITY


PICOLA
BARMAH
NATHALIA
WAAIA
NUMURKAH
KATAMATITE
WUNGHNU
Legend
Reach 1 - Boosey Creek and Broken Creek
Reach 2 - Nine Mile Creek
Reach 3 - Broken Creek
Reach 4 - Broken Creek
N
0
5
10 km
Lower Broken &
Nine Mile Creek
Environmental Watering Plan
Project Reaches Map
WATER TECHNOLOGY
NVIRP
GOULBURN
BROKEN

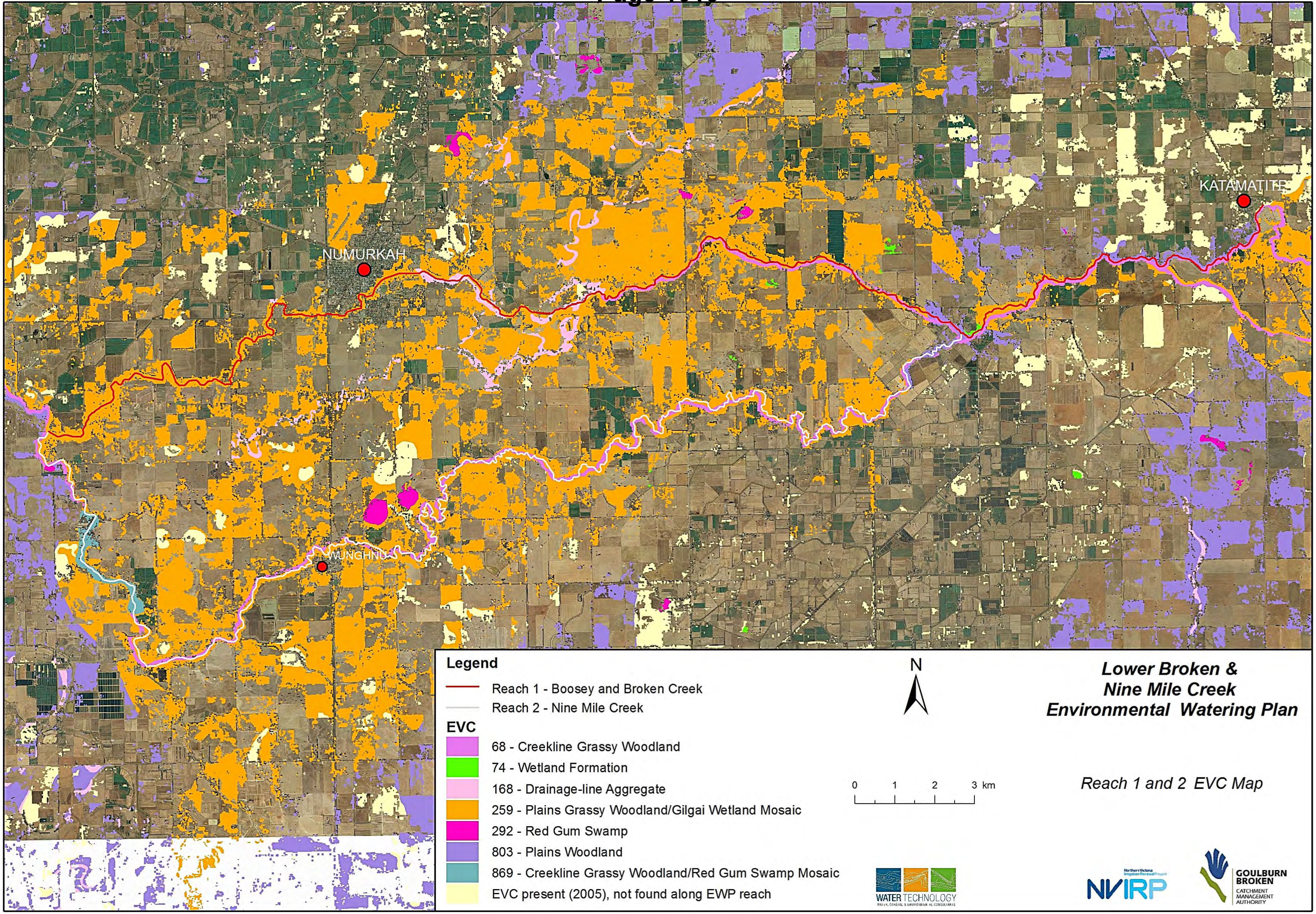


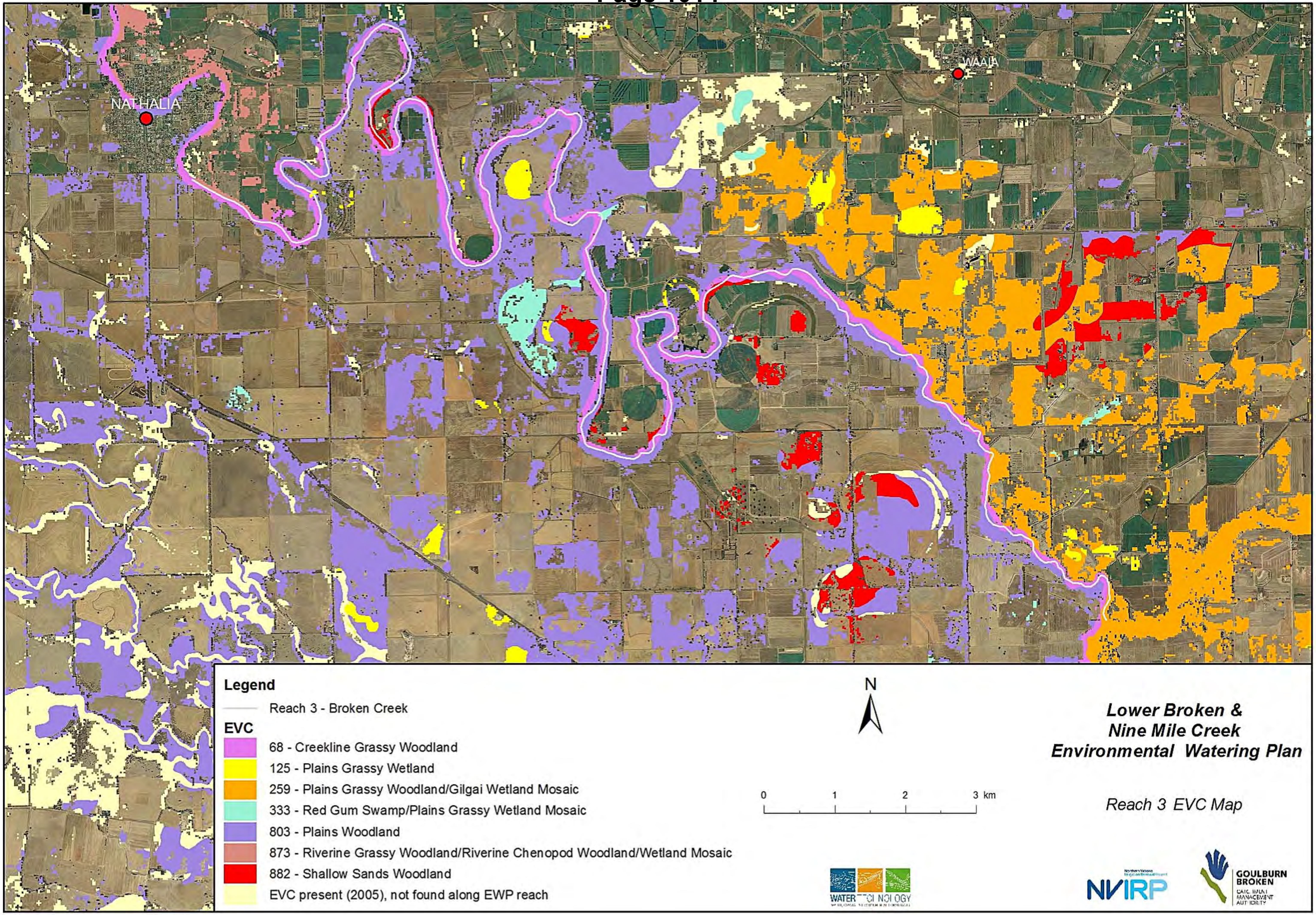
KATAMATITE
Outfall MV156 to be retained
Kinnairds Swamp 619057
NUMURKAH
Outfall MV276 to be retained
Melville Street Weir
Station Street Weir
Nine Mile Weir
EGMC Weir
Black Swamp 607991
WUNGHNU
Legend
Reach 2 - Nine Mile Creek
Reach 1 - Boosey and Broken Creek
Channel
Drain
Swamp / Wetland
Weir
Outfall to be retained
N
0 1 2 3 km
Lower Broken & Nine Mile Creek Environmental Watering Plan
Reach 1 and 2 Map
WATER TECHNOLOGY
NVIRP
GOULBURN BROKEN CATCHMENT MANAGEMENT AUTHORITY

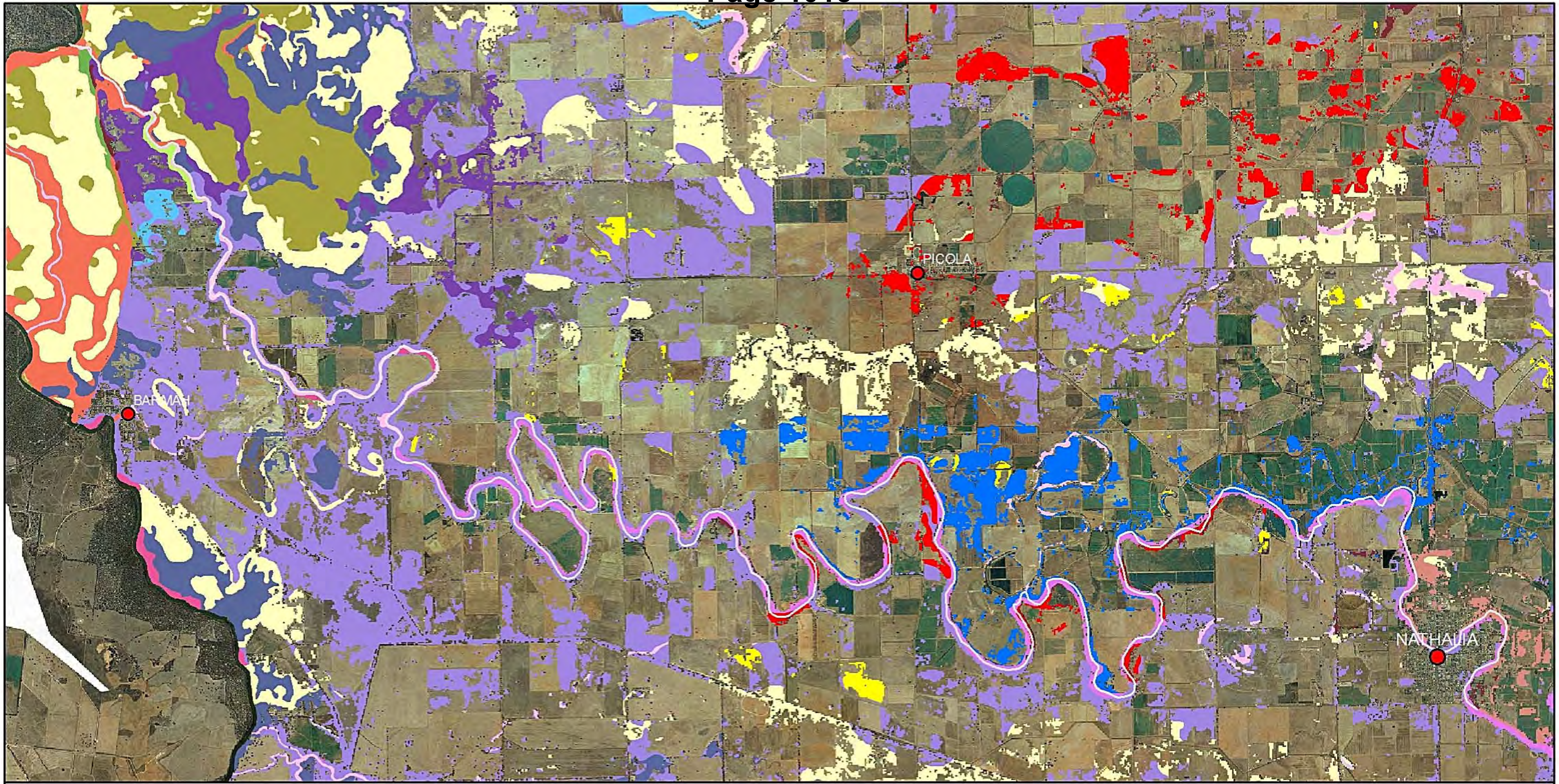

Outfall MV1110 to be retained
Chinamens Weir
NATHALIA
Nathalia Weir
WAAIA
Carlands Swamp 436052
12
37/12
36/12
35/12
38/12
15/6
1/16/6
4/15/6
1/15/6
1A/17
17
18
19
8/6
8/4/8/6
4/8/6
16/6
1/19/6
1/22/6
22/6
23/6
19/6
1/13
Legend
Reach 3 - Broken Creek
Channel
Drain
Swamp / Wetland
Weir
Outfall to be retained
N
0 1 2 3 km
Lower Broken & Nine Mile Creek Environmental Watering Plan
Reach 3 Map
WATER TECHNOLOGY
NVIRP
GOULBURN BROKEN CATCHMENT MANAGEMENT AUTHORITY


Rices Weir
PICOLA
BARMAH
Kennedys Weir
Schiers Weir
Hardings Weir
Lukes Weir
Balls Weir
Outfall MV1122
to be retained
Chinamens Weir
NATHALIA
Nathalia Weir
28/6
27/6
29/6
38/12
41/12
12
Legend
Reach 4 - Broken Creek
Channel
Drain
Swamp / Wetland
Weir
Outfall to be retained
N
0
1
2
3 km
Lower Broken &
Nine Mile Creek
Environmental Watering Plan
Reach 4 Map
WATER TECHNOLOGY
NVIRP
GOULBURN
BROKEN
CATCHMENT
MANAGEMENT
AUTHORITY

APPENDIX B REACH EVC MAPS (2005 EXTENTS)


KATAMATITE
NUMURKAH
WUNGHNU
Legend
Reach 1 - Boosey and Broken Creek
Reach 2 - Nine Mile Creek
EVC
68 - Creekline Grassy Woodland
74 - Wetland Formation
168 - Drainage-line Aggregate
259 - Plains Grassy Woodland/Gilgai Wetland Mosaic
292 - Red Gum Swamp
803 - Plains Woodland
869 - Creekline Grassy Woodland/Red Gum Swamp Mosaic
EVC present (2005), not found along EWP reach
N
0 1 2 3 km
Lower Broken &
Nine Mile Creek
Environmental Watering Plan
Reach 1 and 2 EVC Map
WATER TECHNOLOGY
NVIRP
GOULBURN BROKEN CATCHMENT MANAGEMENT AUTHORITY


NATHALIA
WAAIA
Legend
Reach 3 - Broken Creek
EVC
68 - Creekline Grassy Woodland
125 - Plains Grassy Wetland
259 - Plains Grassy Woodland/Gilgai Wetland Mosaic
333 - Red Gum Swamp/Plains Grassy Wetland Mosaic
803 - Plains Woodland
873 - Riverine Grassy Woodland/Riverine Chenopod Woodland/Wetland Mosaic
882 - Shallow Sands Woodland
EVC present (2005), not found along EWP reach
N
0 1 2 3 km
Lower Broken &
Nine Mile Creek
Environmental Watering Plan
Reach 3 EVC Map



Legend

Reach 4 - Broken Creek

EVC

- 56 - Floodplain Riparian Woodland
- 68 - Creekline Grassy Woodland
- 106 - Grassy Riverine Forest
- 125 - Plains Grassy Wetland
- 168 - Drainage-line Aggregate
- 264 - Sand Ridge Woodland
- 295 - Riverine Grassy Woodland
- 803 - Plains Woodland
- 814 - Riverine Swamp Forest
- 816 - Sedgy Riverine Forest
- 817 - Sedgy Riverine Forest/Riverine Swamp Forest Complex
- 867 - Shallow Sands Woodland/Plains Woodland Mosaic
- 873 - Riverine Grassy Woodland/Riverine Chenopod Woodland/Wetland Mosaic
- 882 - Shallow Sands Woodland
- 1040 - Riverine Grassy Woodland/Riverine Swampy Woodland Mosaic
- 1050 - Mosaic of Floodplain Grassy Wetland/Grassy Riverine Forest-Riverine Swamp Forest Complex
- 1068 - Riverine Swamp Forest/Sedgy Riverine Forest Mosaic
- EVC present (2005), not found along EWP reach

N

0 1 2 3 km

Lower Broken & Nine Mile Creek Environmental Watering Plan

Reach 4 EVC Map

APPENDIX C THREATENED FLORA AND FAUNA LISTS

Table C-1 Threatened flora – Central Creek landscape zone (DSE 2008)

Scientific name	English name	Australian status	Victorian status	FFG code
Allocasuarina luehmannii	Buloke			L
Alternanthera nodiflora	Common Joyweed		k	
Atriplex spinibractea	Spiny-fruit Saltbush		e	
Brachyscome chrysoglossa	Yellow-tongue Daisy		v	L
Brachyscome muelleroides	Mueller Daisy	V	e	L
Callitriche umbonata	Winged Water-starwort		r	
Calotis cuneifolia	Blue Burr-daisy		r	
Calotis lappulacea	Yellow Burr-daisy		r	
Cardamine moirensis	Riverina Bitter-cress		r	
Cardamine paucijuga s.s.	Annual Bitter-cress		v	
Eleocharis pallens	Pale Spike-sedge		k	
Eryngium paludosum	Long Eryngium		v	
Glossostigma cleistanthum	Small-flower Mud-mat		r	
Haloragis glauca f. glauca	Bluish Raspwort		k	
Hypoxis exilis	Swamp Star		v	
Leiocarpa leptolepis	Pale Plover-daisy		e	N
Lepidium pseudohyssopifolium	Native Peppercress		k	
Maireana aphylla	Leafless Bluebush		k	
Minuria integerrima	Smooth Minuria		r	
Myoporum montanum	Waterbush		r	
Myriophyllum gracile var. lineare	Slender Water-milfoil		e	N
Myriophyllum porcatum	Ridged Water-milfoil	V	v	N
Myriophyllum striatum	Striped Water-milfoil		v	N
Panicum laevinode	Pepper Grass		v	
Panicum queenslandicum var. queenslandicum	Coolibah Grass		e	
Ranunculus sessiliflorus var. pilulifer	Annual Buttercup		k	
Sclerolaena muricata var. muricata	Black Roly-poly		k	
Swainsona behriana	Southern Swainson-pea		r	
Swainsona sericea	Silky Swainson-pea		v	N
Triglochin dubia	Slender Water-ribbons		r	
Tripogon loliiformis	Rye Beetle-grass		r	

Definitions:
V: vulnerable in Australia
k: poorly known in Victoria
e: endangered in Victoria
v: vulnerable in Victoria
r: rare in Victoria
L: listed under FFG
N: nominated under FFG

Table C-2 Threatened fauna – Central Creek landscape zone (DSE 2008)

Scientific name	English name	International Status	Australian status	Victorian status	FFG code
Botaurus poiciloptilus	Australasian Bittern			e	L
Anas rhynchotis	Australasian Shoveler			v	
Falco subniger	Black Falcon			v	
Melithreptus gularis	Black-chinned Honeyeater			n	
Coturnix ypsilophora	Brown Quail			n	
Climacteris picumnus	Brown Treecreeper			n	
Burhinus grallarius	Bush Stone-curlew			e	L
Stagonopleura guttata	Diamond Firetail			v	L
Stictonetta naevosa	Freckled Duck			e	L
Ardea alba	Great Egret	C, J		v	L
Litoria raniformis	Growling Grass Frog		V	e	L
Aythya australis	Hardhead			v	
Gallinago hardwickii	Latham's Snipe	C, J		n	
Biziura lobata	Musk Duck			v	
Nycticorax caledonicus	Nankeen Night Heron			n	
Todiramphus pyrrhopygia	Red-backed Kingfisher			n	
Platalea regia	Royal Spoonbill			v	
Circus assimilis	Spotted Harrier			n	
Petaurus norfolcensis	Squirrel Glider			e	L
Polytelis swainsonii	Superb Parrot		V	e	L
Lathamus discolor	Swift Parrot		E	e	L
Varanus varius	Tree Goanna			v	
Chlidonias hybridus	Whiskered Tern			n	

Definitions: C: CAMBA listed (China-Australia Migratory Bird Agreement)
J: JAMBA listed(Japan-Australia Migratory Bird Agreement)
V: vulnerable in Australia
E: Endangered in Australia
e:endangered in Victoria
v: vulnerable in Victoria
n: near threatened in Victoria
L: listed under FFG

Table C-3 Threatened flora – Barmah landscape zone (Heard 2007)

Scientific name	English name	Australian status	Victorian status	FFG listed
Amyema linophylla ssp. Orientale	Buloke Mistletoe		v	
Lipocarpha microcephala	Button Rush		v	
Cyperus bifax	Downs Nutgrass		v	
Menkea crassa	Fat Spectacles		e	L
Hakea tephrosperma	Hooked Needlewood		v	
Ranunculus papulentus	Large River Buttercup		k	
Maireana aphylla	Leafless Bluebush		v	
Eryngium paludosum	Long Eryngium		v	
Acacia notabilis	Mallee Golden Wattle		v	
Swainsona recta	Mountain Swainsona-pea	E	e	L
Brachyscome muelleroides	Mueller Daisy	V	e	L
Acacia loderi	Nealie		v	
Myriophyllum porcatum	Ridged Water-milfoil	V	v	L
Amphibromus fluitans	River Swamp Wallaby-grass	V	k	
Swainsona sericea	Silky Swainson-pea		v	N
Digitaria ammophila	Silky Umbrella-grass		v	
Isolepis congrua	Slender Club-sedge		v	L
Swainsona murrayana	Slender Darling-pea	V	e	L
Rhodanthe stricta	Slender Sunray		e	L
Myriophyllum gracile var. lineare	Slender Water-milfoil		e	N
Cullen parvum	Small Scurf-pea	E	e	L
Cullen tenax	Tough Scurf-pea		e	L
Sida intricata	Twiggy Sida		v	
Acacia oswaldii	Umbrella Wattle		v	
Swainsona adenophylla	Violet Swainson-pea		e	N
Acacia pendula	Weeping Myall		e	L
Callitriche cyclocarpa	Western Water-starwort	V	v	N
Acacia omalophylla	Yarran Wattle		e	L
Brachyscome chrysoglossa	Yellow-tongue Daisy		v	L

Definitions: * Victorian (denoted by lower case) Status of Species:
e = endangered, v = vulnerable, r = rare, k = poorly known, cr = critically endangered.
* FFG (Flora Fauna Guarantee Act 1988) taxon:
L = listed, N = Nominated to be Listed (individual species only - not if part of listed communities) and the accompanying identification number.
* Species Number:
State identification number/code attributed to individual species.

Table C-4 Threatened fauna – Barmah landscape zone (Heard 2007)

Scientific name	English name	Australian status	Victorian status	FFG listed
Botaurus poiciloptilus	Australasian Bittern		e	
Anas rhynchotis	Australasian Shoveler		v	
Porzana pusilla	Baillon's Crake		v	
Ninox connivens	Barking Owl		e	L
Falco subniger	Black Falcon		v	
Oxyura australis	Blue-billed Duck		e	L
Maccullochella macquariensis	Bluenose (Trout) Cod	E	cr	L
Grus rubicunda	Brolga		v	L
Climacteris picumnus	Brown Treecreeper		k	
Phascogale tapoatafa	Brush-tailed Phascogale		v	L
Burhinus grallarius	Bush Stone-curlew		e	L
Morelia spilota metcalfei	Carpet Python		e	L
Stagonopleura guttata	Diamond Firetail		v	L
Stictonetta naevosa	Freckled Duck		e	L
Tandanus tandanus	Freshwater Catfish		e	L
Limnodynastes interioris	Giant Bullfrog		cr	L
Macquaria ambigua	Golden Perch		v	
Ardea alba	Great Egret		v	L
Accipiter novaehollandiae	Grey Goshawk		v	
Pomatostomus temporalis	Grey-crowned Babbler		e	L
Coracina maxima	Ground Cuckoo-shrike		v	L
Aythya australis	Hardhead		v	
Ardea intermedia	Intermediate Egret		cr	L
Rallus pectoralis	Lewin's Rail		v	L
Ixobrychus minutus	Little Bittern		e	
Egretta garzetta	Little Egret		e	
Macquaria australasica	Macquarie Perch	E	e	L
Cacatua leadbeateri	Major Mitchell's Cockatoo		v	L
Tyto novaehollandiae	Masked Owl		e	L
Maccullochella peelii peelii	Murray Cod		e	L
Biziura lobata	Musk Duck		v	
Grantiella picta	Painted Honeyeater		v	L
Rostratula benghalensis	Painted Snipe		c	
Ninox strenua	Powerful Owl		v	L
Xanthomyza phrygia	Regent Honeyeater	E	cr	L
Gadopsis marmoratus	River Blackfish		c	
Platalea regia	Royal Spoonbill		v	
Bidyanus bidyanus	Silver Perch		cr	L
Chthonicola sagittata	Speckled Warbler		v	
Petaurus norfolcensis	Squirrel Glider		e	L
Polytelis swainsonii	Superb Parrot	V	e	L
Lathamus discolor	Swift Parrot	E	e	L

Scientific name	English name	Australian status	Victorian status	FFG listed
Varanus varius	Tree Goanna		v	
Litoria raniformis	Growling Grass Frog	V	e	
Haliaeetus leucogaster	White-bellied Sea-Eagle		v	L

Definitions: * Victorian (denoted by lower case) Status of Species:
e = endangered, v = vulnerable, r = rare, k = poorly known,
cr = critically endangered.
* FFG (Flora Fauna Guarantee Act 1988) taxon:
L = listed, N = Nominated to be Listed (individual species only - not if part of listed communities) and the accompanying identification number.

Table C-5 Rare or threatened flora – Broken Boosey State Park and reserves (Parks Victoria 2006)

Scientific name	Common name	Conservation status
Acacia notabilis	Mallee Golden Wattle	v
Allocasuarina luehmannii	Buloke	L
Alternanthera nodiflora	Common Joyweed	k
Atriplex spinibractea	Spiny-fruit Saltbush	e
Brachyscome chrysoglossa	Yellow-tongue Daisy	L, v
Cullen parvum	Small Scurf-pea	L, e, E
Cullen tenax	Tough Scurf-pea	L, e
Desmodium varians	Slender Tick-trefoil	k
Eleocharis pallens	Pale Spike-sedge	k
Eremophila debilis	Winter Apple (Amulla)	e
Eryngium paludosum	Long Eryngium	v
Glossostigma cleistanthum	Small-flower Mud-mat	r
Haloragis glauca f. glauca	Bluish Raspwort	k
Hypoxis exilis	Swamp Star	v
Maireana aphylla	Leafless Bluebush	k
Minuria integerrima	Smooth Minuria	r
Myoporum montanum	Waterbush	r
Myriophyllum gracile var. lineare	Slender Water-milfoil	L, e
Myriophyllum striatum	Striped Water-milfoil	L, v
Panicum laevinode	Pepper Grass	v
Panicum queenslandicum var. queenslandicum	Coolibah Grass	e
Swainsona behriana	Southern Swainson-pea	-

Victorian status	e	endangered in Victoria
	v	vulnerable in Victoria
	d	depleted in Victoria
	e	rare in Victoria
	k	species poorly known in Victoria
	L	listed under the Flora and Fauna Guarantee Act
National status:	E	endangered

Table C-6 Rare or threatened fauna – Broken Boosey State Park and reserves (Parks Victoria 2006)

Scientific name	Common name	Conservation status
Birds		
Ardea alba	Great Egret	Vul, L, C, J
Burhinus grallarius	Bush Stone-curlew	End, L, A, LC
Climacteris picumnus	Brown Treecreeper	NT
Gallinago hardwickii	Latham's Snipe	NT, C, J
Grus rubicunda	Brolga	Vul, L, A
Melithripterus gularis	Black-chinned Honeyeater	NT, LC
Numenius madagascariensis	Eastern Curlew	NT, C, J
Nycticorax caledonicus	Nankeen Night Heron	NT
Platalea regia	Royal Spoonbill	Vul
Polytelis swainsonii	Superb Parrot	V, End, L
Pomatostomus temporalis	Grey-crowned Babbler	End, L, A, LC
Stagonopleura guttata	Diamond Firetail	Vul, L, LC
Todiramphus pyrropygia	Red-backed Kingfisher	NT
Members of the FFG-listed Victorian-temperate woodland bird community		
Glossopsitta pusilla	Little Lorikeet	LC
Lichenostomus fuscus	Fuscous Honeyeater	LC
Melithreptus brevirostris pallidiceps	Brown-headed Honeyeater	LC
Microeca fascinans	Jacky Winter	LC
Petroica goodenovii	Red-capped Robin	LC
Turnix varia	Painted Button-quail	LC
Mammal		
Petaurus norfolcensis	Squirrel Glider	End, L, A
Reptile		
Varanus varius	Lace Monitor	Vul
Amphibian		
Litoria raniformis	Growling Grass Frog	V, End, L
Fish		
Maccullochella peelii peelii	Murray Cod	Vul, L, A
Macquarie australasica	Macquarie Perch	End, L
Maquaria ambigua	Golden Perch	Vul
Melanotaenia fluviatilis	Crimson-spotted Rainbowfish	dd, L
Maccullochella macquariensis	Trout Cod	Cen,L
Tandanus tandanus	Freshwater Catfish	End, L

Victorian status	Cen	critically endangered in Victoria
	End	endangered in Victoria
	Vul	vulnerable in Victoria
	NT	near threatened in Victoria
	dd	data deficient in Victoria
	L	listed under the Flora and Fauna Guarantee Act
	LC	member species of the FFG-listed Victorian temperate-woodland

Scientific name	Common name	Conservation status

		bird community
	A	an Action Statement has been prepared for its management
National status:	E	endangered
	V	Vulnerable in Australia
Migratory species:	J	listed under the Japan-Australia Migratory Bird Agreement (JAMBA)
	C	listed under the China-Australia Migratory Bird Agreement (CAMBA)

APPENDIX D HYDROLOGY ASSESSMENT REPORT – SKM

SINCLAIR KNIGHT MERZ

GOULBURN BROKEN CATCHMENT MANAGEMENT AUTHORITY

Lower Broken Creek and Nine Mile Creek Hydrology

DRAFT REPORT

- Version 1
- April 2010

Lower Broken Creek and Nine Mile Creek Hydrology

DRAFT REPORT

- Version 1
- April 2010

Sinclair Knight Merz
ABN 37 001 024 095
590 Orrong Road, Armadale 3143
PO Box 2500
Malvern VIC 3144 Australia
Tel: +61 3 9248 3100
Fax: +61 3 9248 3400
Web: www.skmconsulting.com

Contents

Document history and status

Revision	Date issued	Reviewed by	Approved by	Date approved	Revision type
Draft 1	06.04.2010	T. Sheedy	T. Sheedy	06.04.2010	Internal review

Distribution of copies

Revision	Copy no	Quantity	Issued to
Draft 1	1	1 (.doc)	Simon Casanelia, Goulburn Broken CMA
	1	1 (.doc)	Tim Loffler, Water Technology

Printed:	6 April 2010
Last saved:	6 April 2010 11:02 AM
File name:	I:\VWES\Projects\VW04954\Deliverables\Reports\r06_sml_Lower Broken EWP_Draft.docx
Author:	Simon Lang and Avril Horne
Project manager:	Simon Lang
Name of organisation:	Goulburn Broken CMA
Name of project:	Lower Broken Creek and Nine Mile Creek Hydrology
Name of document:	Draft Report
Document version:	Version 1
Project number:	VW04978

1. Introduction

The Northern Victoria Irrigation Renewal Project (NVIRP) is a $2 billion works program to upgrade ageing irrigation infrastructure across the Goulburn-Murray Irrigation District (GMID) and save a proportion of the water currently lost through seepage, leakage, evaporation, metering error and system inefficiencies. Works will include automating channel regulation, lining channels, building pipelines and installing new outlet meters. These works will increase the efficiency with which irrigation water is delivered, and reduce losses by an average of 425 GL of per year.

The GMID uses a number of natural waterways and wetlands with significant environmental values to both store and convey water. NVIRP has identified four waterways that may be impacted by proposed water savings initiatives, including the lower Broken Creek and Nine Mile Creek. NVIRP plans to reduce the current number of outfall structures that discharge directly from the Murray Valley irrigation district to the lower Broken Creek from eleven to four, and reduce the volumes supplied above customer requirements by 85%. This is likely to reduce the volume of water flowing down the creeks.

NVIRP has committed to ensuring there is no net environmental loss caused by the works program. To achieve this commitment, NVIRP requires that environmental watering plans (EWP) be developed for the lower Broken Creek and Nine Mile Creek that:

- assess the ecological impacts of the planned water savings initiatives; and
- identify mitigation measures.

To assess the ecological impacts of the planned water savings, the likely changes in hydrology resulting from the NVIRP works need to be understood. Therefore, this report includes the following:

- Chapter 2 describes the characteristics of the study area (including schematics showing the location of regulating structures, and natural tributaries, drains and outfalls that contribute flows).
- Chapter 3 analyses the flow regimes of the upstream and downstream ends of the study area, using the gauge records for the Boosey Creek at Tungamah (404204), the Broken Creek at Katamatite (404214) and the Broken Creek at Rices Weir (404210). The records for these gauges begin in the mid-1960s.
- Chapter 4 examines the current contribution of outfalls to flows in the lower Broken Creek and Nine Mile Creek, using data provided by Goulburn-Murray Water (G-MW) and NVIRP.
- Chapter 5 predicts the likely impact on flows of reducing the volume of outfalls.
- Chapter 6 provides a summary of key findings and conclusions.

2. Study Area

The Broken Creek is formed by a breakaway on the Broken River at Caseys Weir (Figure 1). The terms Upper Broken Creek and Lower Broken Creek are often used to refer to reaches of the creek upstream and downstream of the Boosey Creek confluence. The study area for this project includes a small section of the Boosey Creek downstream of the Murray Valley 7/3 channel outfall, the Lower Broken Creek, Nine Mile Creek, and connected wetlands (Figure 2). The Murray Valley irrigation district is north of the creeks, while the Shepparton irrigation district is to the south.

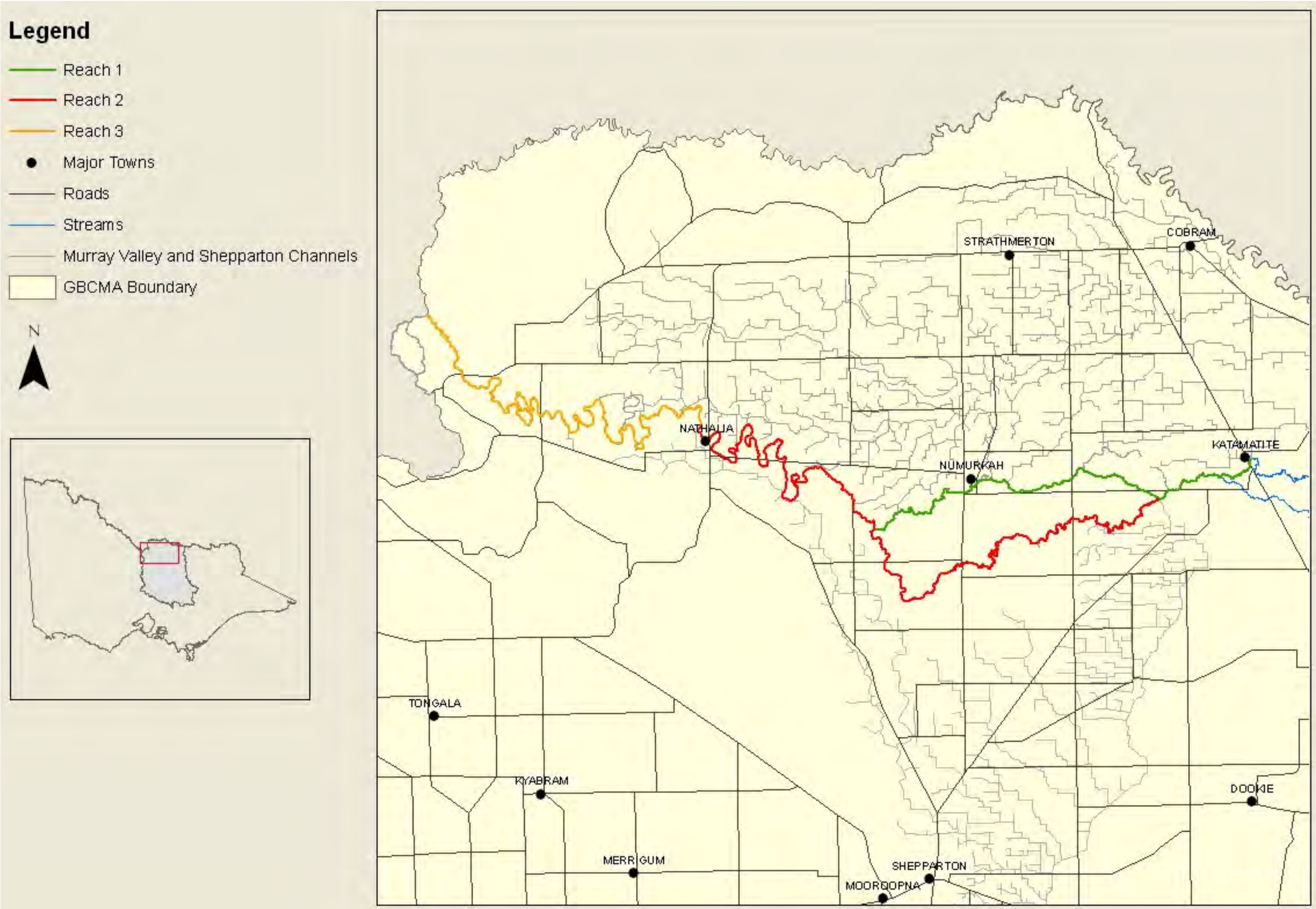
For this project, the study area has been divided into four environmental flow reaches by the Scientific Reference Group, based on the group's understanding of the creek's hydrology, geomorphology and environmental values. The four reaches are:

- Reach 1 – The Boosey Creek downstream of the Murray Valley 7/3 channel outfall, and the Broken Creek downstream of the Boosey Creek confluence to the Nine Mile Creek confluence
- Reach 2 – The Nine Mile Creek
- Reach 3 – The Broken Creek downstream of the Nine Mile Creek confluence to the upstream end of the Nathalia weir pool.
- Reach 4 – From the Nathalia weir pool to the Murray River.

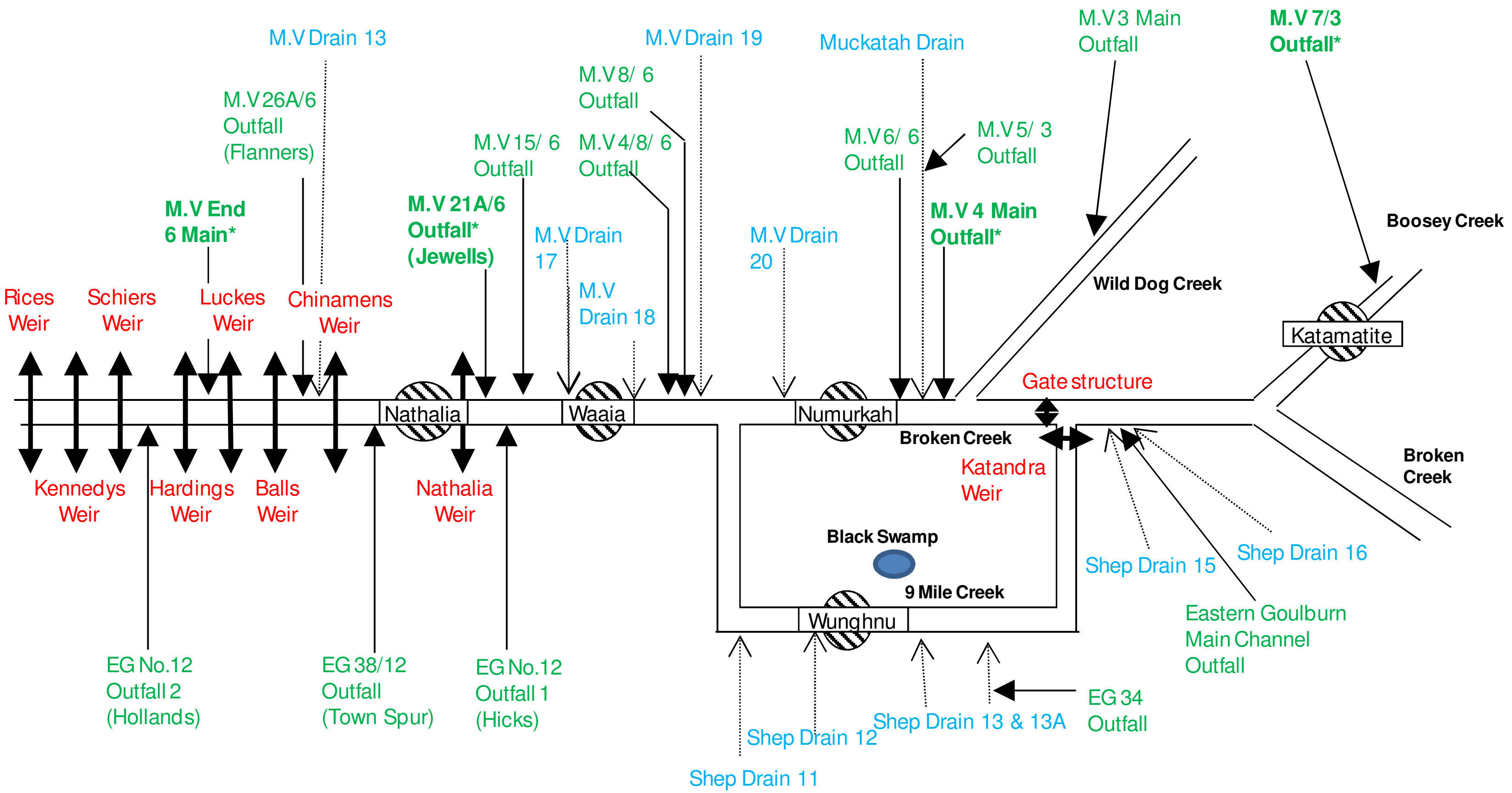
The Lower Broken Creek and Nine Mile Creek have been regulated for more than 100 years. Under natural conditions the creeks would have ceased to flow during summer and autumn. Today the creeks are perennial streams with significant flows maintained through summer and autumn to supply water for irrigation, stock and domestic use. There are a number of weirs downstream of Katamatite which maintain water levels for private pumps. Water quality in the weir pools during summer and autumn is often poor, and in recent years environmental managers have passed increasing volumes of water down the creek to manage the threats posed by low dissolved oxygen levels and Azolla blooms.

Of the regulated inflows to the Lower Broken Creek, the major sources are the East Goulburn Main channel outfall and the Murray Valley 7/3 channel outfall (Figure 3). The major sources of unregulated inflows are the upstream catchments (i.e. the Upper Broken Creek and Boosey Creek), Shepparton Drain 11, Shepparton Drain 12 and Murray Valley Drain 13. In recent years, unregulated inflows have become a very small proportion of total inflows (Section 4). All together, there are currently eleven outfall structures and six drains that connect directly to the Lower Broken Creek from the Murray Valley irrigation district, while five outfall structures and six drains connect directly to the Lower Broken Creek and Nine Mile Creek from the Shepparton irrigation district. As part of the NVIRP works, seven of the eleven Murray Valley outfall structures connected to the creek will be decommissioned. The outfall structures that will be retained are denoted by an asterisk in Figure 3. Some outfall structures discharging to drains will also be removed.

- **Figure 1 – Broken Creek, within the context of the Broken River basin. The term Lower Broken Creek refers to the reach from the confluence with Boosey Creek through to the Murray River (RWC, 1987).**



- **Figure 2 – The project study area. The Murray Valley irrigation district is to the north of Reach 1, 2 and 3, while the Shepparton irrigation district is to the south. (UPDATE)**



- **Figure 3 – A schematic of the lower Broken Creek and Nine Mile Creek system. The names of regulating structures are in red, the names of drains are in blue and the numbers of outfalls are in green. Murray Valley outfall structures that will not be removed as part of the NVIRP works are shown by an asterisk. All outfall structures on the Shepparton side of the creeks are being retained.[1]**

---

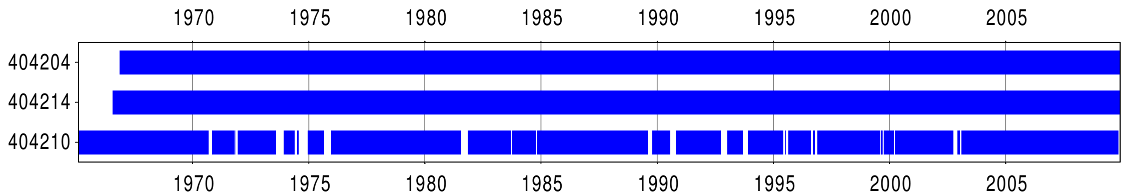
[1] SKM (2003) Broken Creek Model – Stage 2, Final Report, Prepared for Goulburn Murray Water, January 2003, p. 10.

3. Gauged Flow Records

Three stream flow gauges are located within the study area. The Boosey Creek at Tungamah (404204) and Broken Creek at Katamatite (404214) gauges are located at the upstream end of the study area, while the Broken Creek at Rices Weir (404210) gauge is located at the downstream end of the catchment.

The flow records for each of the three gauges begin in the mid 1960s (Figure 4). The records for the Boosey Creek at Tungamah and the Broken Creek at Katamatite are generally of good quality. In contrast, there is much data missing from the Broken Creek at Rices Weir record (Appendix A). Some of these missing periods coincide with floods along the Murray River, when water would have backed up Broken Creek and drowned out the gauging station.

Missing data for the Boosey Creek at Tungamah and Broken Creek at Katamatite records were short enough to infill using linear interpolation. Linear interpolation was not appropriate for infilling the Broken Creek at Rices Weir record. Instead, the Murray Darling Basin Authority (MDBA) supplied a daily time-series of modelled flows past Rices Weir (1891 – 2009), assuming current conditions. While not exactly comparable to historically gauged streamflows (which captures the range of development and management conditions the creek has been subjected to), the current modelled time-series does provide a good indication of flows expected at Rices Weir under the system's current regulation, were the past 120 years of climate repeated.



- **Figure 4 – Extent of streamflow data available.**

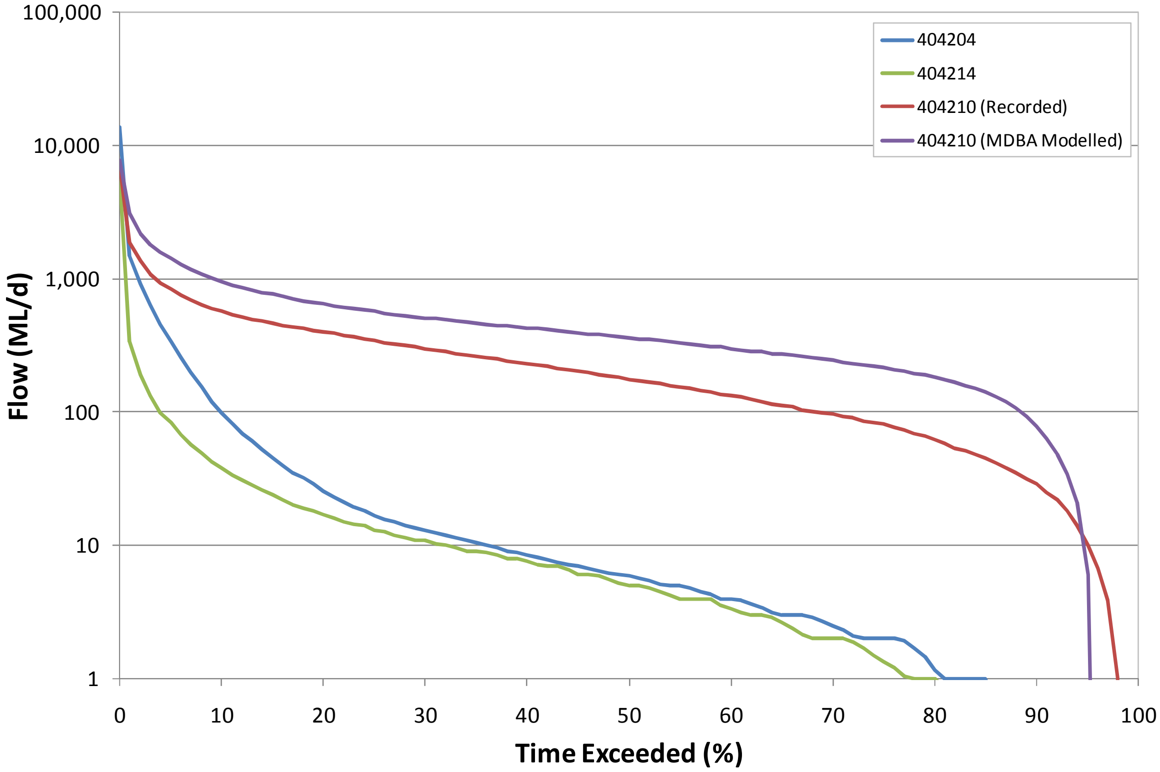
Based on the flows observed at gauges 404204, 404214 and 404210, and the modelled flows for Rices Weir (404210) assuming current conditions, the following observations can be made:

Flow in the Boosey Creek at Tungamah and the Broken Creek at Katamatite ceases for approximately 20% of the time. In contrast, there is flow past Rices Weir for all but a small portion of time (Figure 5).

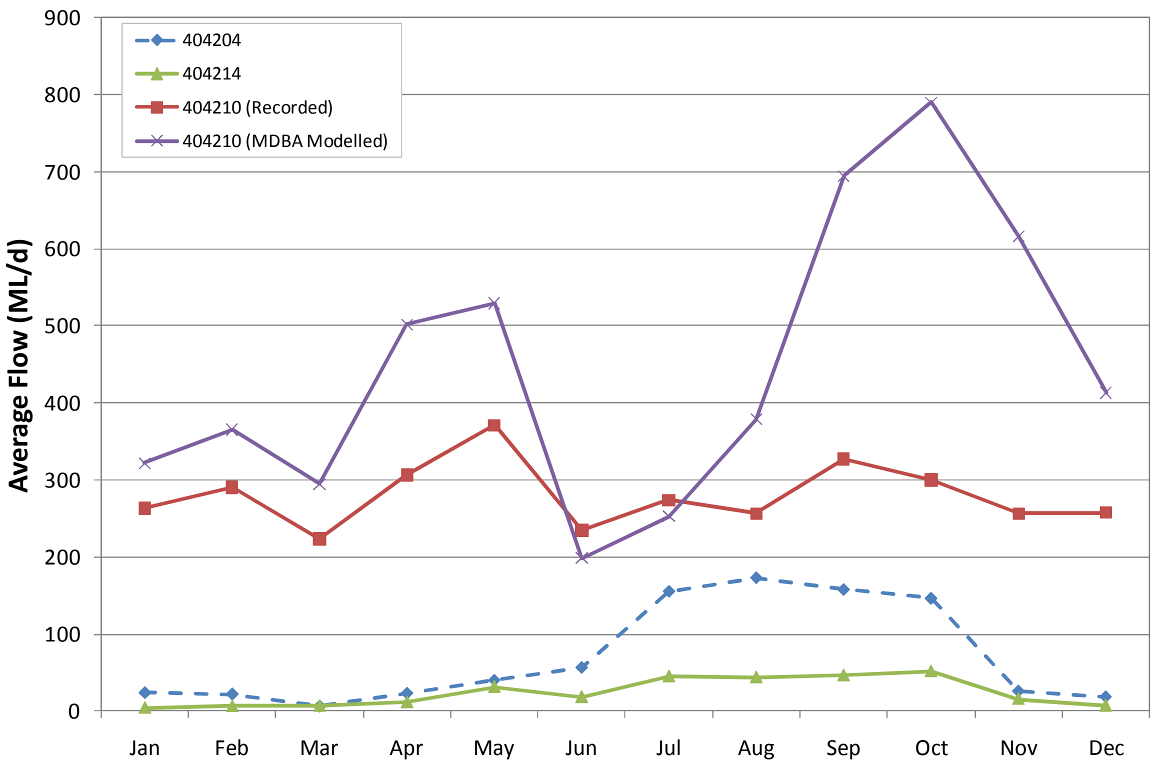
Flows past Rices Weir are elevated in summer and autumn by regulated releases through outfall structures located along the Lower Broken Creek (Figure 6). In winter and spring, the average *recorded* flow is of similar magnitude to the average flow *recorded* in summer and spring, but this is because there are significant periods of data missing during winter and spring for 16 of the 45 years of record. In contrast, the MDBA modelled time-series for Rices Weir, while showing elevated flows in summer and autumn, has the highest average flows occurring in spring. In recent years however, drought conditions have seen recorded flow past Rices Weir fall below 10 ML/d for extended periods during winter and spring (Appendix A). The flow regime for the Boosey Creek at Tungamah and the Broken Creek at Katamatite follows a more natural pattern, with low flows in summer and higher flows in winter and spring, including occasional flood events (Appendix A).

On average, flows to the study area from the upstream catchments for the period of record available are 33 ML/d for December to May and 157 ML/d in for June to November (Table 1). The bulk of these inflows come from the Boosey Creek catchment. Average daily flows past Rices Weir for December to May and June to November are 300 ML/d – 500 ML/d, depending on whether the recorded or modelled streamflows are analysed.

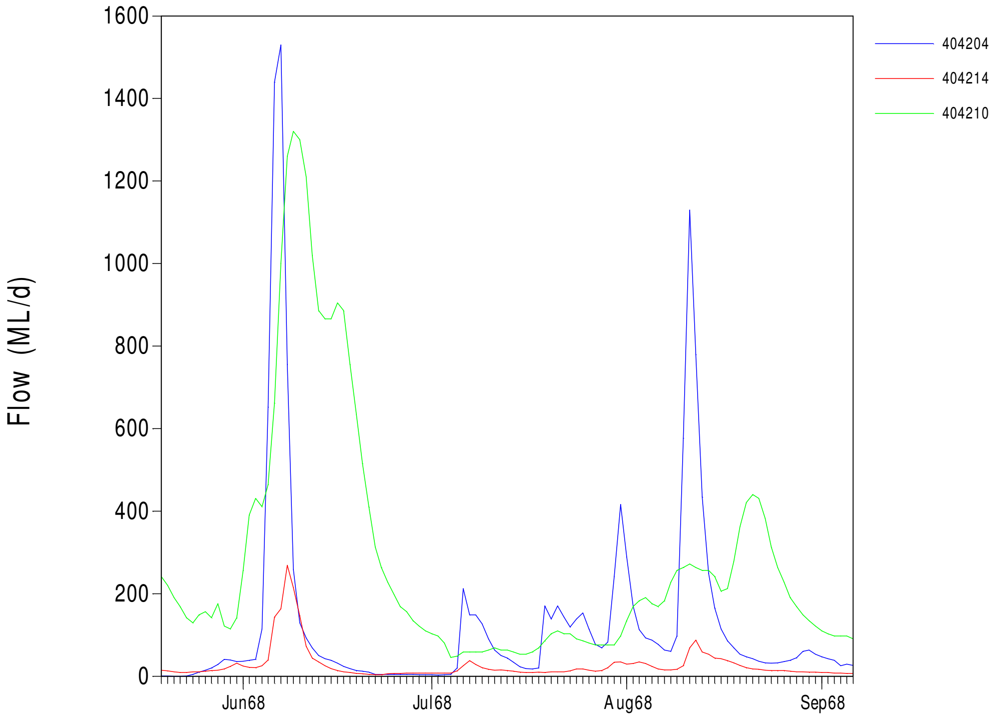
Although average flows at Rices Weir are greater than for the Boosey Creek at Tungamah and the Broken Creek at Katamatite, the peaks of high flow events recorded at the upstream end of the study area are often attenuated by the time they reach Rices Weir (Figure 7).



- **Figure 5 – Daily flow duration curve for streamflow gauges 404204, 404214 and 404210.**



- **Figure 6 – Average daily flow for streamflow gauges 404204, 404214 and 404210.**



- **Figure 7 – Attenuation of high flow events as they move from the upstream end of the study area (404204 and 404214) to the downstream end (404210).**

- **Table 1 – Flow statistics for gauges 404204 and 404214, and downstream gauge 404210.**

Statistic (ML/d)	*Flow Gauge*				
	404204	*404214*	*404204 + 404214*	*404210 (Recorded)^*	*404210 (Modelled)**
Minimum daily flow	0	0	0	0	0
Average daily flow	71	24	95	280	492
Maximum daily flow	13,700	5,910	15,800	7,050	7,670
Summer minimum daily flow	0	0	0	0	0
Summer average daily flow	22	11	33	286	468
Summer maximum daily flow	3,390	4,800	6,920	7,020	4,390
Winter minimum daily flow	0	0	0	0	0
Winter average daily flow	120	37	157	273	549
Winter maximum daily flow	13,700	5,910	15,800	7,050	7,670

Note: Summer refers to the months December to May, while Winter refers to the months June to November.

Note:^ Without infilling missing periods in the gauge record.
Note: *Modelled time-series was provided by the MDBA from BigMod for the period 1891-2009.

4. Current Outfall Contributions

4.1. Introduction

Inflows to the Lower Broken Creek and Nine Mile Creek come from three sources:

- The upstream catchments;
- Irrigation channels that outfall directly to the creeks; and
- Drains that discharge to the creeks.

The flow contribution from the upstream catchments is described in Section 3.

Flow through outfall structures to the creeks is comprised of two parts:

- Inflows ordered by local diverters or environmental managers; and
- Inflows in excess of orders.

In addition to the outfall structures that connect directly to the creeks, a number discharge to drains (Appendix C). Flows through the outfall structures into drains combine with drainage flows. Often a portion of drainage flows will be diverted by irrigators before reaching the creek. Isolating the contribution of outfalls to drainage flows that enter the creeks is difficult.

4.2. Data Availability and Infilling – Outfall Structures and Drains

Data on inflows to the Lower Broken Creek and Nine Mile Creek through outfall structures and drains was sourced from Goulburn-Murray Water and Thiess (Table 2; Table 3).

For the outfalls, the 2000/2001 data was missing for the Murray Valley irrigation district, and the 1998/99 data was missing for the Shepparton irrigation district. For the drains, gauged data was available for the Muckatah drain, Shepparton Drain 12 and Shepparton Drain 11. No data was available for the remaining drains.

Missing records were infilled using the relationships developed by SKM in 2003 when a daily model of the Broken Creek was built (the model covers the period 1st January 1997 to 30th June 2002). These infilling methods are summarised in Appendix D. For more information refer to Section 2.2 SKM (2003).

- **Table 2 – Outfall structures discharging directly to the Lower Broken Creek and Nine Mile Creek.**

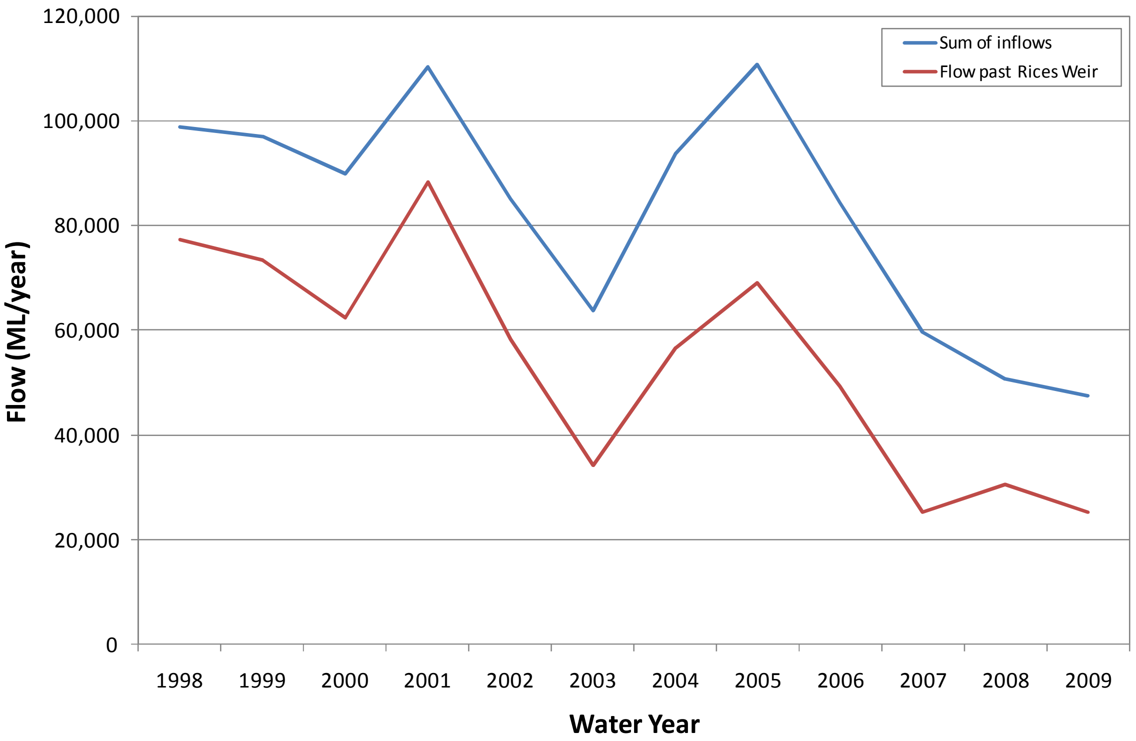
Asset Code	Asset Name	Data Source
ST066229	7/3	G-MW (Murray Valley)
ST072180	3 Main	G-MW (Murray Valley)
ST041815	4 Main	G-MW (Murray Valley)
ST057773	5/3	G-MW (Murray Valley)
ST056529	6/6	G-MW (Murray Valley)
ST056668	8/6	G-MW (Murray Valley)
ST056597	4/8/6	G-MW (Murray Valley)
ST066584	15/6	G-MW (Murray Valley)
ST058403	Jewells (21A/6)	G-MW (Murray Valley)
ST056428	Flanners (26A/6)	G-MW (Murray Valley)
ST056447	End 6 Main	G-MW (Murray Valley)
ST043762	EGM Outfall	G-MW (Shepparton)
ST018998	EG.34 Union Rd	G-MW (Shepparton)
ST019005	EG.34 End	G-MW (Shepparton)
ST045754	EG.12 No 1 (Hicks)	G-MW (Shepparton)
ST046200	EG.38/12 Town Spur	G-MW (Shepparton)
ST045802	EG.12 No 2 (Hollands)	G-MW (Shepparton)

- **Table 3 – Drains discharging to the Lower Broken Creek and Nine Mile Creek.**

Asset Name	Data Source
Muckatah Drain	Thiess (404712)
Murray Valley Drain 20	Not available
Murray Valley Drain 19	Not available
Murray Valley Drain 18	Not available
Murray Valley Drain 17	Not available
Murray Valley Drain 13	Not available
Shepparton Drain 16	Not available
Shepparton Drain 15	Not available
Shepparton Drain 13	Not available
Shepparton Drain 13A	Not available
Shepparton Drain 12	Thiess (405758)
Shepparton Drain 11	Thiess (405757)

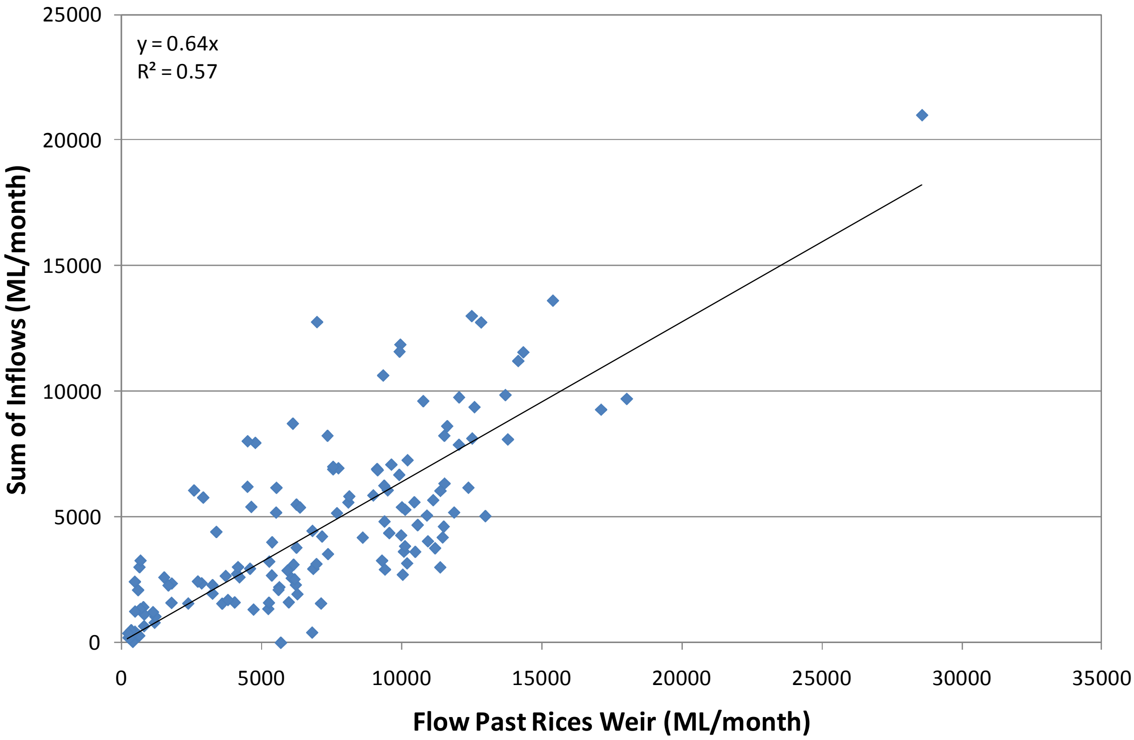
4.3. Total Inflows

Of the total inflows to the Lower Broken Creek and Nine Mile Creek system, a large portion flows downstream and passes to the Murray River (Figure 8). Over the past 10 water years, the annual flow past Rices Weir has only been 25% to 45% lower than total estimated inflows. In this report, water year 1998 is defined as 1st July 1997 to 30th June 1998.



- **Figure 8 – A comparison of annual total inflows (including from the upstream catchments, outfalls and drains) and annual flow past Rices Weir.**

Two aspects of the data plotted in Figure 8 are noted as follows. Firstly, missing data in the flow record for Rices Weir (Aug-99 to Nov 99; Mar-00 to Apr-00 and Sep-02 to Feb-03) was infilled using the relationship shown in Figure 9. Secondly, to check that the sum of inflows was a reasonable estimate, the difference between the sum of inflows and flow past Rices Weir was compared to the water use along the Lower Broken Creek and Nine Mile Creek as reported by SKM (2003) (Table 4). The difference between the sum of inflows and flow past Rices Weir would be attributable to diversions and losses, and therefore you would expect this number to be similar to but slightly higher than the estimated water use. In general, the difference calculated is not too dissimilar to the estimated water use, indicating that the sums of inflows estimated are within the order of magnitude expected.



- **Figure 9 – The regression relationship used to infill missing periods in the Rices Weir flow record.**

- **Table 4 – Comparing the sum of inflows with flow past Rices Weir, and the total water along the Lower Broken Creek and Nine Mile Creek (as estimated by SKM (2003)).**

Water Year	Sum of Inflows (ML)	Flow Past Rices Weir (ML)	Difference (ML)	Water Use (ML) (SKM, 2003)
1998	98,800	77,200	21,600	26,900
1999	97,000	73,300	23,700	28,600
2000	90,000	62,400	27,600	18,400
2001	110,200	88,200	22,000	22,900
2002	85,200	58,200	27,000	25,600
2003	63,800	34,200	29,600	
2004	93,800	56,700	37,100	
2005	110,700	69,000	41,700	
2006	84,400	49,300	35,100	
2007	59,650	25,300	34,400	
2008	50,800	30,600	20,200	

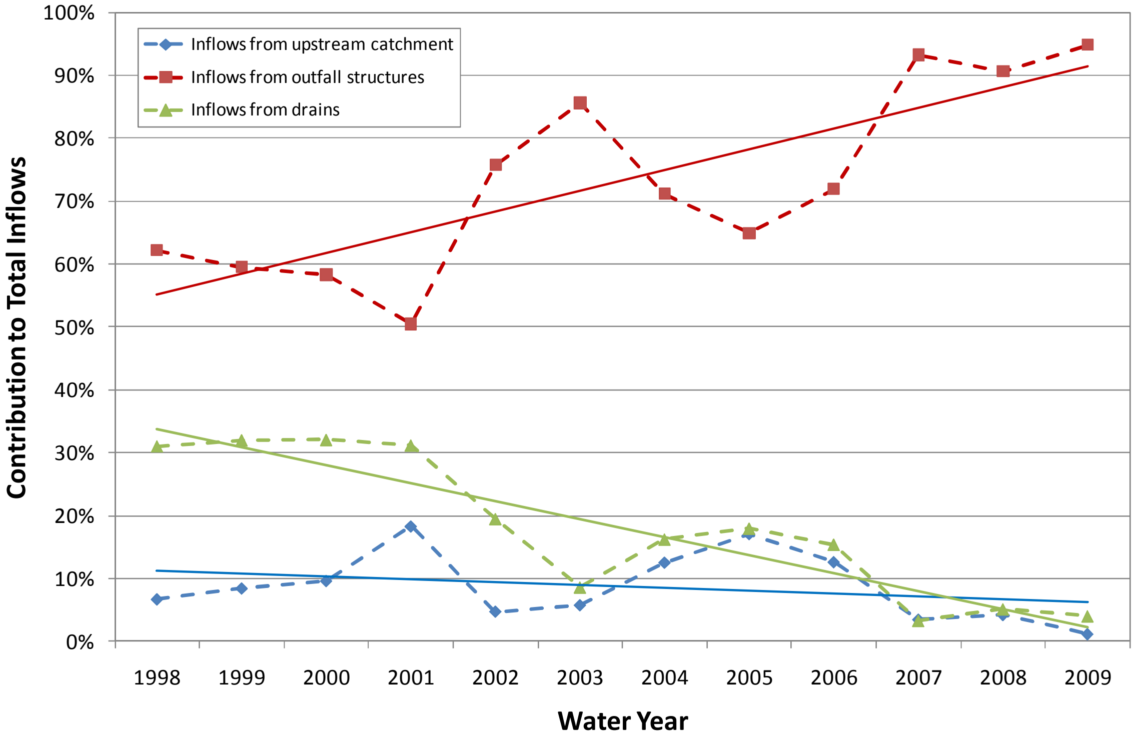
Water Year	Sum of Inflows (ML)	Flow Past Rices Weir (ML)	Difference (ML)	Water Use (ML) (SKM, 2003)
2009	47,500	25,300	22,200	

4.4. Total Inflows through Outfall Structures

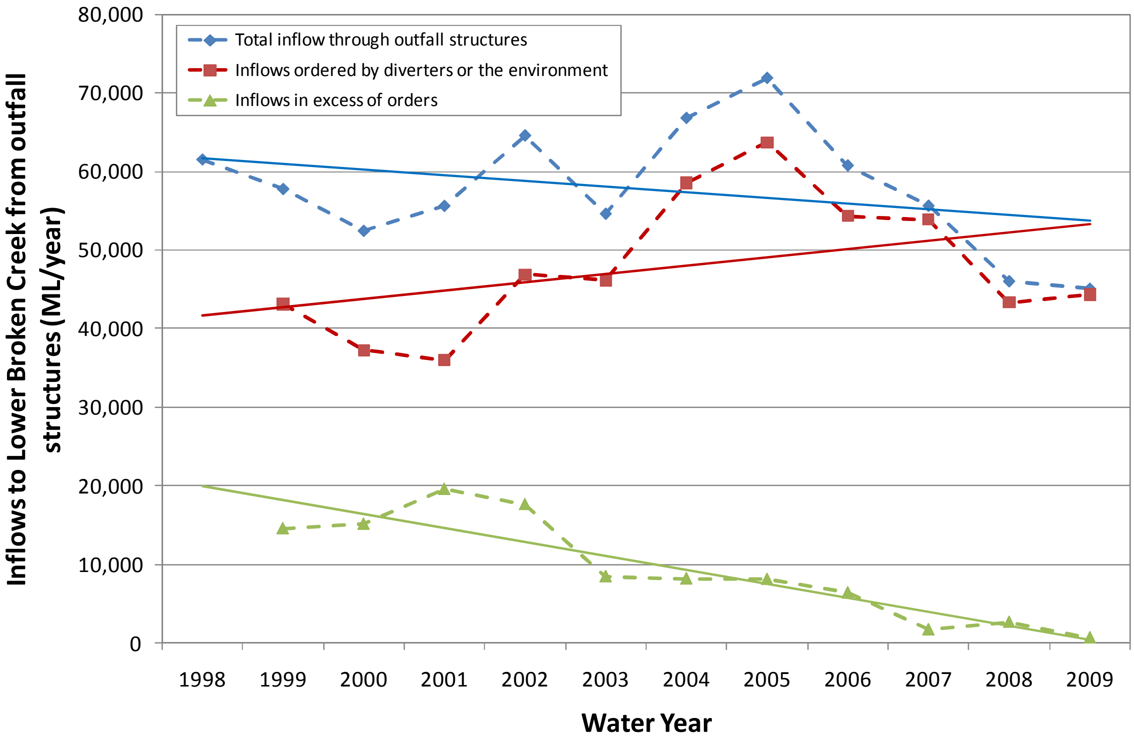
Of total inflows to the Lower Broken Creek and Nine Mile Creek systems, the majority comes through the channel outfall structures (Figure 10). Over the past 10 years, as drought conditions have reduced the percentage contributions from unregulated sources of water (i.e. the upstream catchments and drains), the percentage contribution from outfall structures has increased. In 2008-09, inflows from outfall structures contributed approximately 95% of total inflows.

At the same time as the percentage contribution to inflows from outfall structures has increased, the inflows through outfall structures in excess of orders has decreased. In short, the distribution of water through outfall structures to the Lower Broken Creek and Nine Mile Creek has been managed more tightly in recent years.

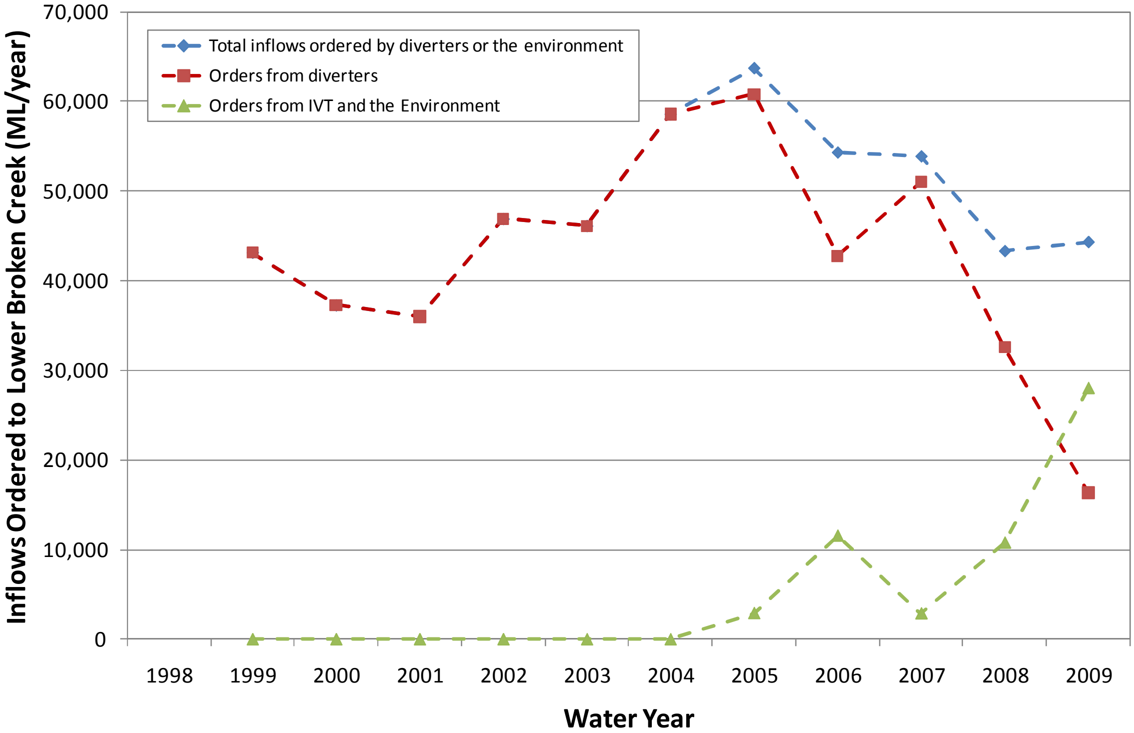
Interestingly, over the past five years, the volume of water ordered through outfall structures by environmental managers (using environmental allocations or inter valley transfers (IVTs)) has rapidly increased, while the volumes ordered by diverters has decreased (Figure 12). In 2008-09, the volume of water ordered for the environment and IVTs exceeded local diverter orders for the first time. The decrease in diverter orders can be linked with Murray and Goulburn irrigation allocations (Table 5). As allocations have decreased, and the volume of water ordered by diverters has also decreased. Environmental managers have therefore needed to order more water for the Lower Broken Creek and Nine Mile Creek systems for the purpose of maintaining sufficient water quality in the weir pools.



■ **Figure 10 – The contribution of inflows from the upstream catchment, outfall structures and drains.**



- **Figure 11 – The total inflow through outfall structures, divided into ordered inflows and inflows in excess of orders.**



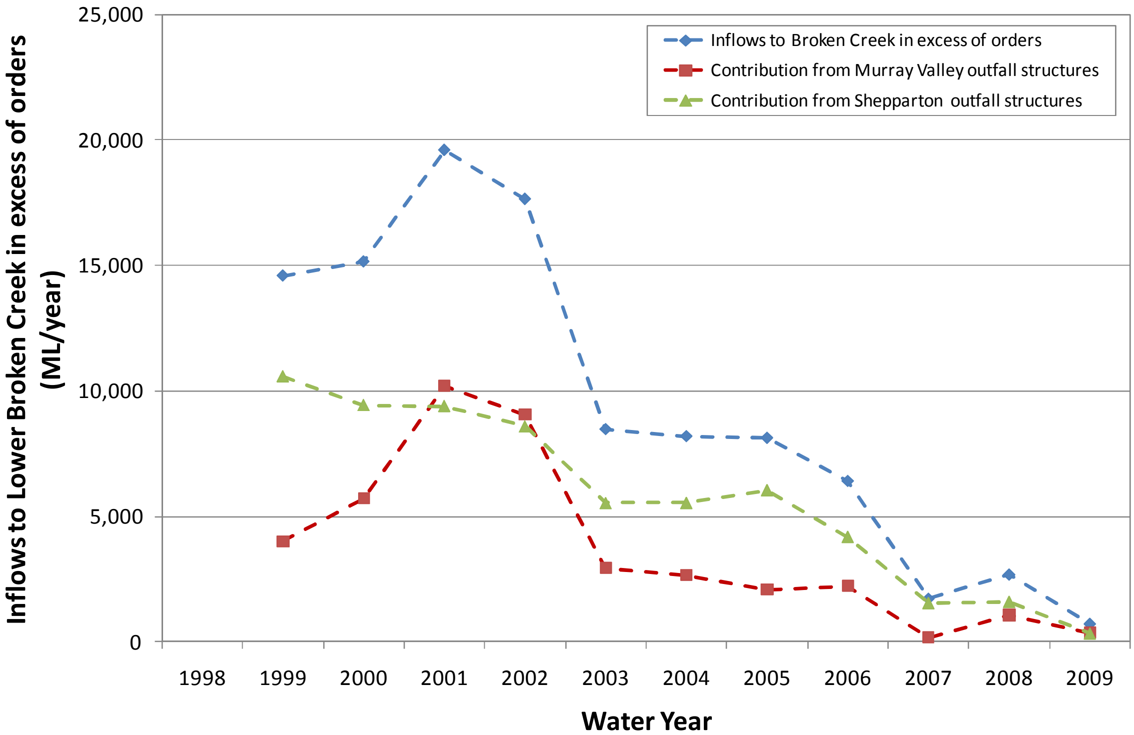
- **Figure 12 – The volume of ordered water for diverters, the environment and IVTs.**

- **Table 5 – Murray and Goulburn February irrigation allocations.**

Water Year	Murray Allocation	Goulburn Allocation
1997	200%	200%
1998	130%	120%
1999	200%	100%
2000	130%	100%
2001	200%	100%
2002	200%	100%
2003	129%	53%
2004	100%	100%
2005	100%	100%
2006	141%	100%
2007	95%	25%
2008	42%	53%
2009	35%	33%

4.5. Inflows through Outfall Structures in Excess of Orders

Inflows to the Lower Broken Creek and Nine Mile Creek system in excess of orders have declined significantly over the past 10 years. In the water year 2005 (which is often used as a base case for assessing the impacts of NVIRP works), inflows through outfall structures in excess of orders were approximately 8,100 ML. Of this, 6,000 ML was contributed from the Shepparton irrigation district and 2,100 ML was from the Murray Valley irrigation district. In 2009, inflows in excess of orders were only 730 ML, half of which came from both irrigation districts (Figure 13). Inflows in excess of orders through Shepparton outfall structures are likely to have been impacted by the Shepparton Modernisation Project, which was in place for the 2009 water year.

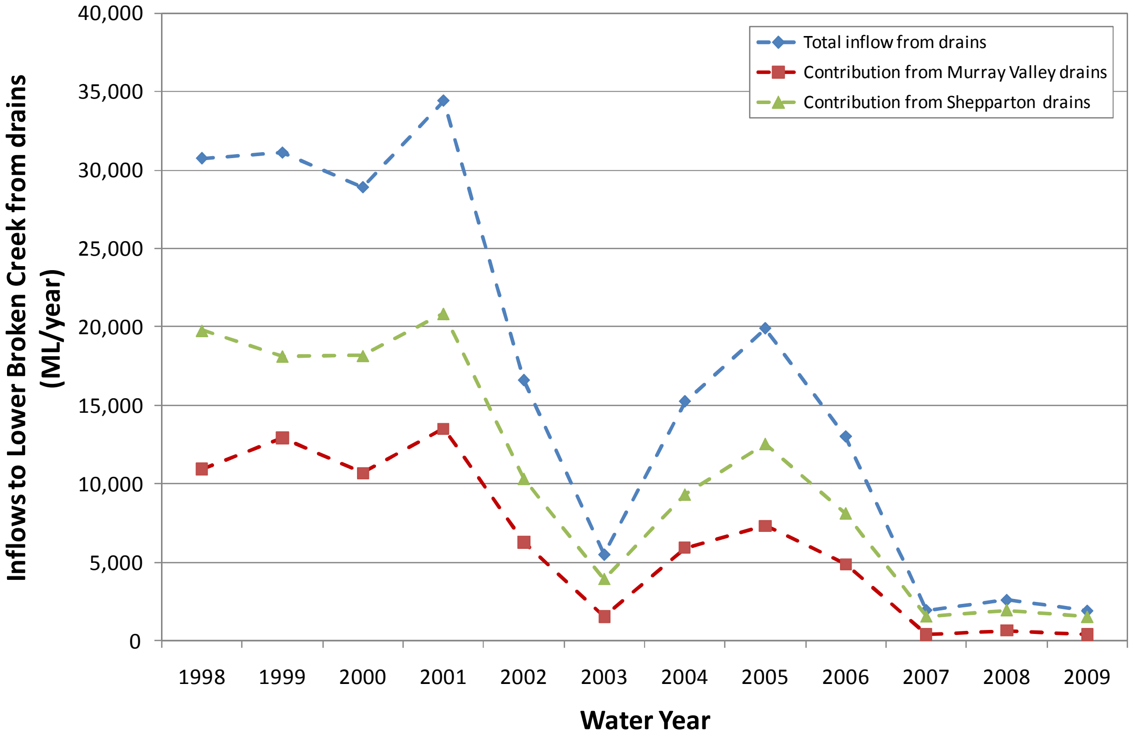


- **Figure 13 – The inflows in excess of orders contributed by the Murray Valley outfall structures and the Shepparton outfall structures.**

SINCLAIR KNIGHT MERZ SKM

4.6. Inflows through Drains

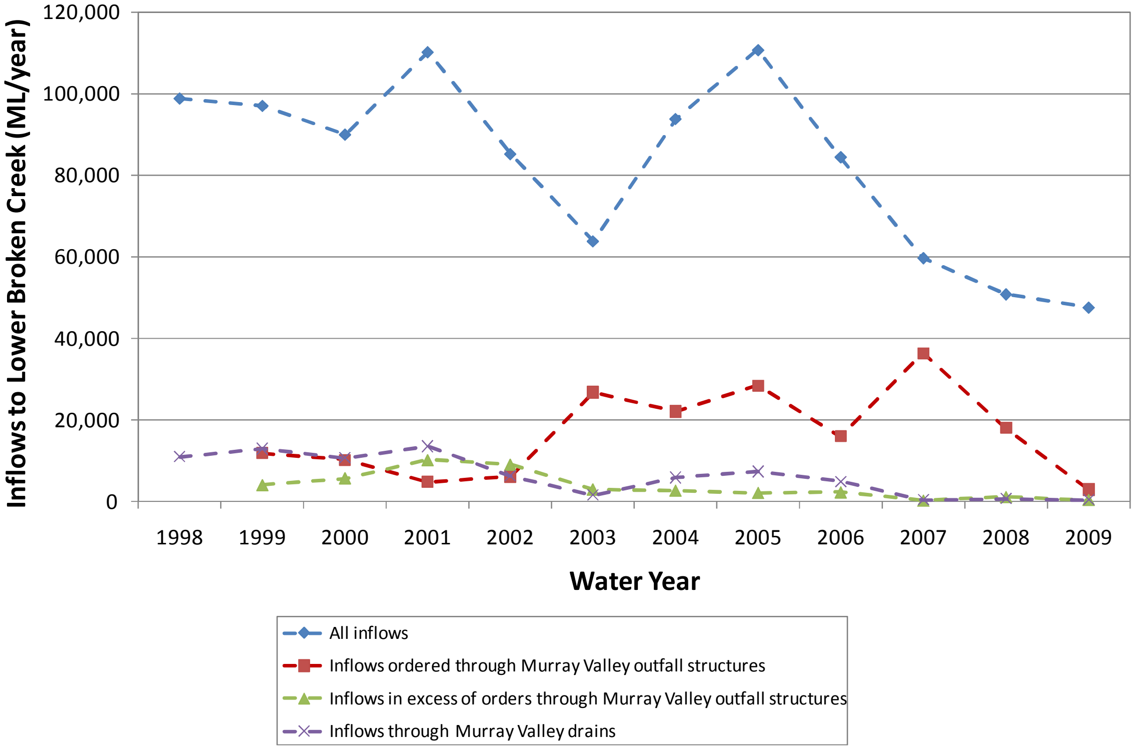
Inflows to the Lower Broken Creek and Nine Mile Creek system through drains have also declined significantly over the past 10 years. In the late 1990s and early 2000s, drainage inflows to the sytem were 30,000 ML/year – 35,000 ML/year. In the past few years however, inflows from drains have been a minor component of total inflows. This reduction in drainage inflows is probably attributable to a combination of less rainfall runoff, less runoff from irrigation application, less channel outfalls into drainage sytems and increased drainage diversions.



- **Figure 14 – The inflow volume from drains contributed by the Murray Valley drains and the Shepparton drains.**

4.7. Murray Valley Contribution to Total Inflows

NVIRP works are being implemented in the Murray Valley irrigation district. Therefore, changes to the Lower Broken Creek and Nine Mile Creek flow regimes attributable to NVIRP, will be reflected in changes to flow contributions from the Murray Valley side of the creeks. Figure 15 shows the inflows through Murray Valley outfall structures (ordered and in excess of orders) and the inflows through Murray Valley drains in comparison with total inflows to the system. This figure shows that inflows in excess of orders through Murray Valley outfall structures are a small component of total inflows.

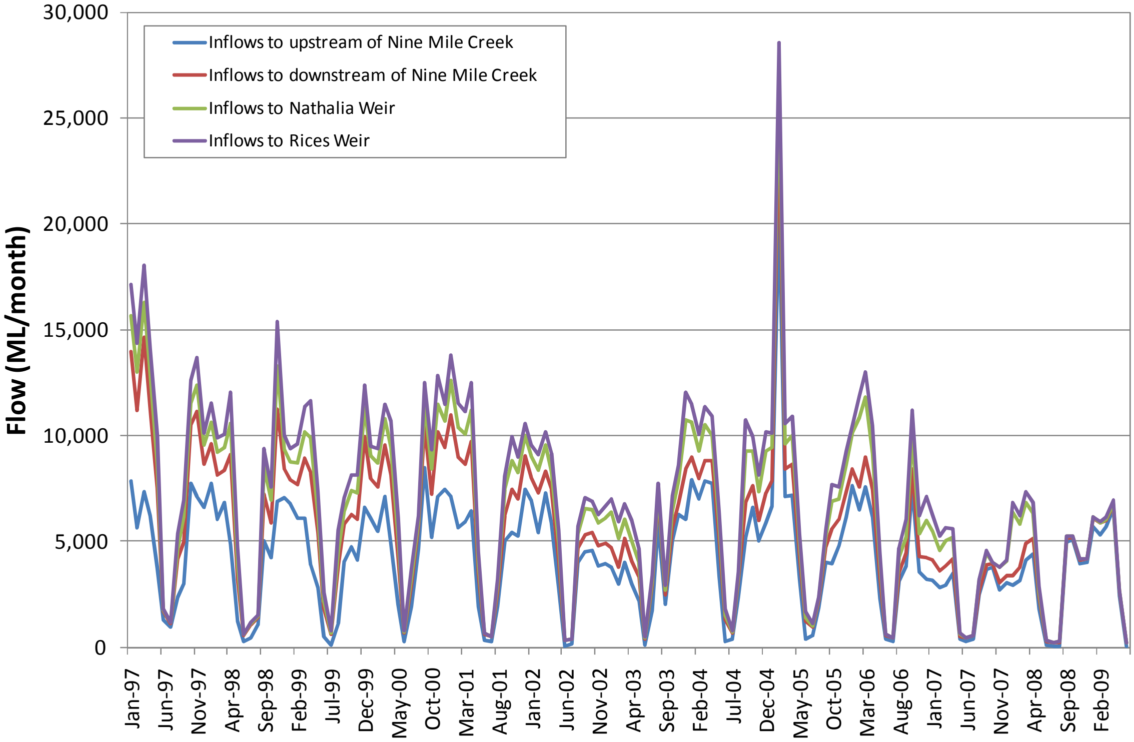


- **Figure 15 – Total inflow, inflow through outfalls that will be decommissioned (both ordered and in excess of orders) and inflows through Murray Valley drains.**

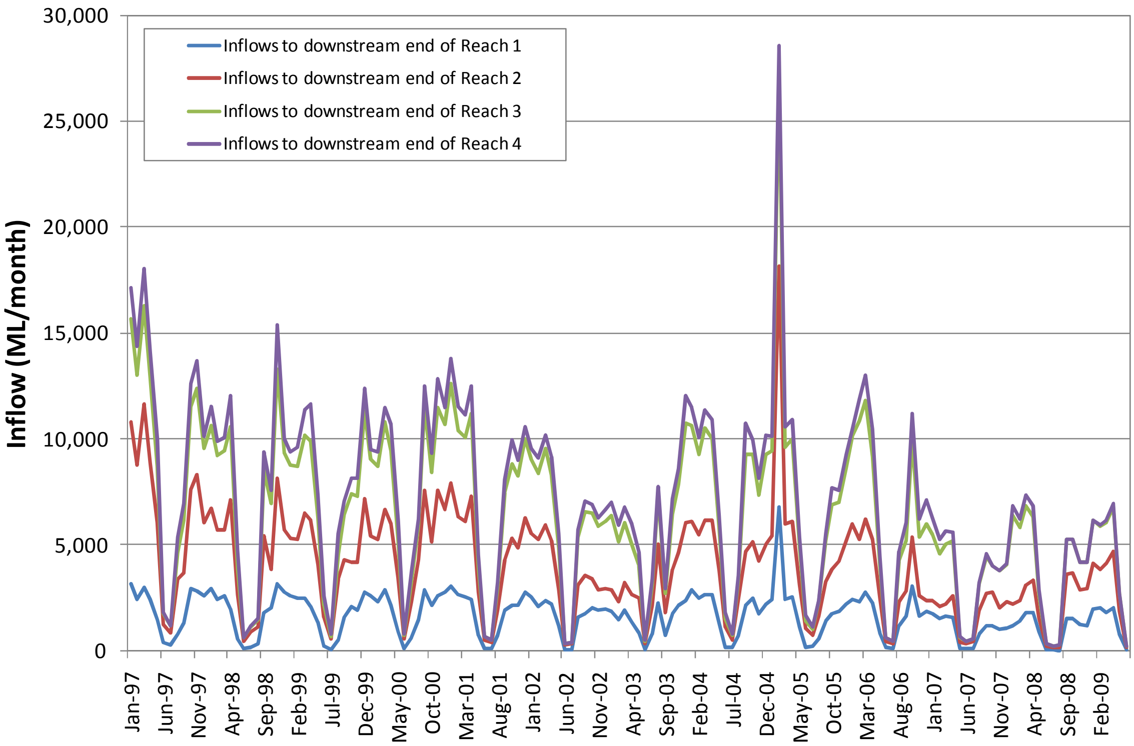
4.8. Reach Inflows

On a reach by reach basis, the contribution of total inflows is weighted to the upstream end of the study area. This is particularly the case in recent years (i.e. water year 2009), when minimal inflows to the system were recorded downstream of where the Lower Broken Creek and Nine Mile Creek split (Figure 16). If it is assumed that flows are split 30%:70% down the Lower Broken Creek and Nine Mile Creek at Katandra weir, inflows to each of the four environmental reaches can be calculated (Figure 17). Inflows for each of the reaches compared to inflows through outfalls structures, drains and from the upstream catchments are shown in Appendix E.

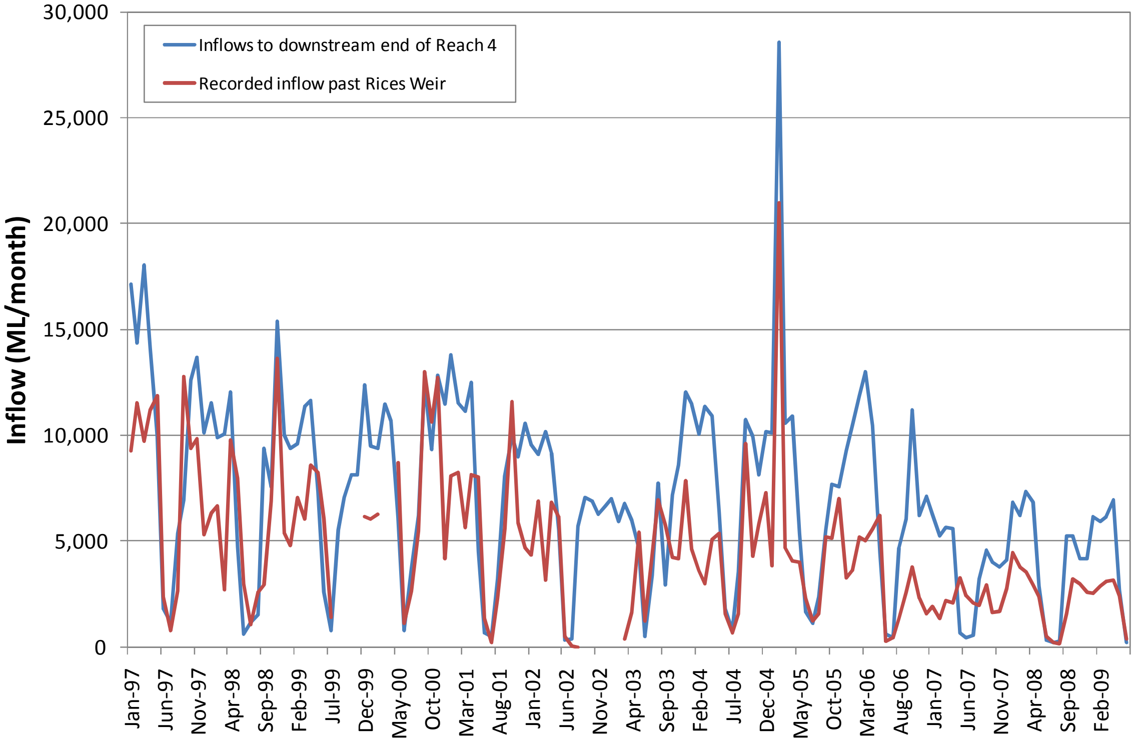
Given this analysis focuses on inflows, and the contribution of inflows in excess of orders, it needs to be recognised that inflows may not be a reliable indication of flows within the creeks because of diversions and losses. However, for the Lower Broken Creek at least, an understanding of total inflows generally provides a reasonable understanding of flow passing Rices Weir (Figure 18). That is, the pattern of inflows generally matches the pattern of flow at Rices Weir, with the differences in magnitude attributable to diversions and losses.



- **Figure 16 – Inflows to different locations along the Lower Broken Creek.**



- **Figure 17 – Inflows to the four environmental reaches, assuming a 30%:70% division of flows where the Lower Broken Creek and Nine Mile Creek split.**



- **Figure 18 – Inflows to Rices Weir (the downstream end of Reach 4), compared to recorded flow past Rices Weir.**

5. Likely Impacts of NVIRP Works

The stated aim of NVIRP is to reduce the inflows though Murray Valley outfall structures in excess of orders (i.e. the outfalls) by 85%. This situation is different to some other irrigation systems, where all the water flowing through an outfall structure is considered an outfall, 85% of which will be saved by NVIRP works. The Shepparton irrigation district was modernised in a separate project (the Shepparton Modernisation Project), but the impact of this project on inflows to the Lower Broken Creek and Nine Mile Creek is not assessed as part of this study.

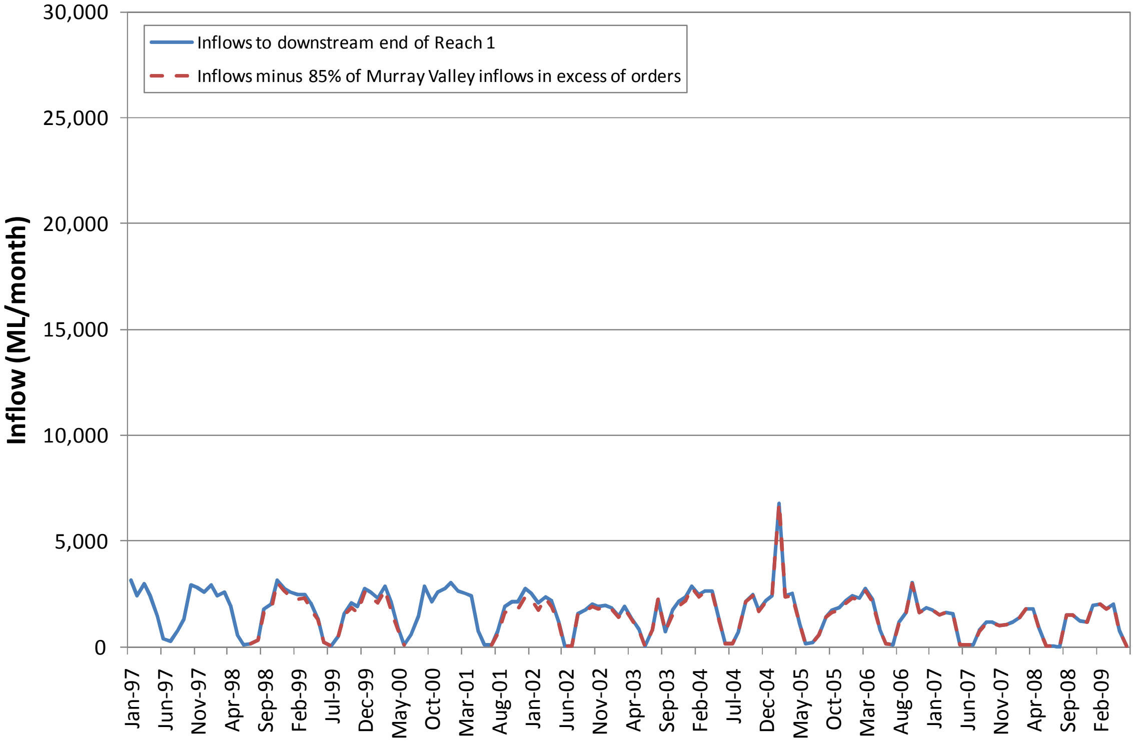
To reduce the inflows in excess of orders, NVIRP will either decommission existing outfall structures, or implement Total Channel Control (TCC). Implementing TCC involves replacing the manually operated drop boards currently used to regulate channel flows, with a system of remotely controlled flume gates. At the time of writing, NVIRP were planning to decommission seven of the eleven Murray Valley outfall structures. Those to be kept are denoted by an asterisk in Figure 3. However, for this study, it was assumed the 85% reduction of inflows in excess of orders is distributed along the Lower Broken Creek and Nine Mile Creek reaches in accordance with current inflows in excess of orders. This is considered appropriate, because all reaches will still have inflows from Murray Valley outfall structures (reach two receives a contribution from the Murray Valley 7/3 outfall structure), and the remaining structures will need to pass the flows previously carried by the decommissioned outfalls to meet local diverter orders.

Figure 19 to Figure 22 shows the estimated total inflows to each reach for January 1997 to June 2009, and the total inflows assuming inflows through Murray Valley outfall structures in excess of orders are reduced by 85%. Information for categorising monthly inflows through Murray Valley outfall structures as ‘ordered’ or ‘excess’ are not available for 2000/01, or the years prior to 1998/99. Regardless, these figures show that reducing inflows through Murray Valley outfall structures in excess of orders by 85% would not have a material impact on inflows to the Lower Broken Creek or Nine Mile Creek, especially for 2002/03 onwards.

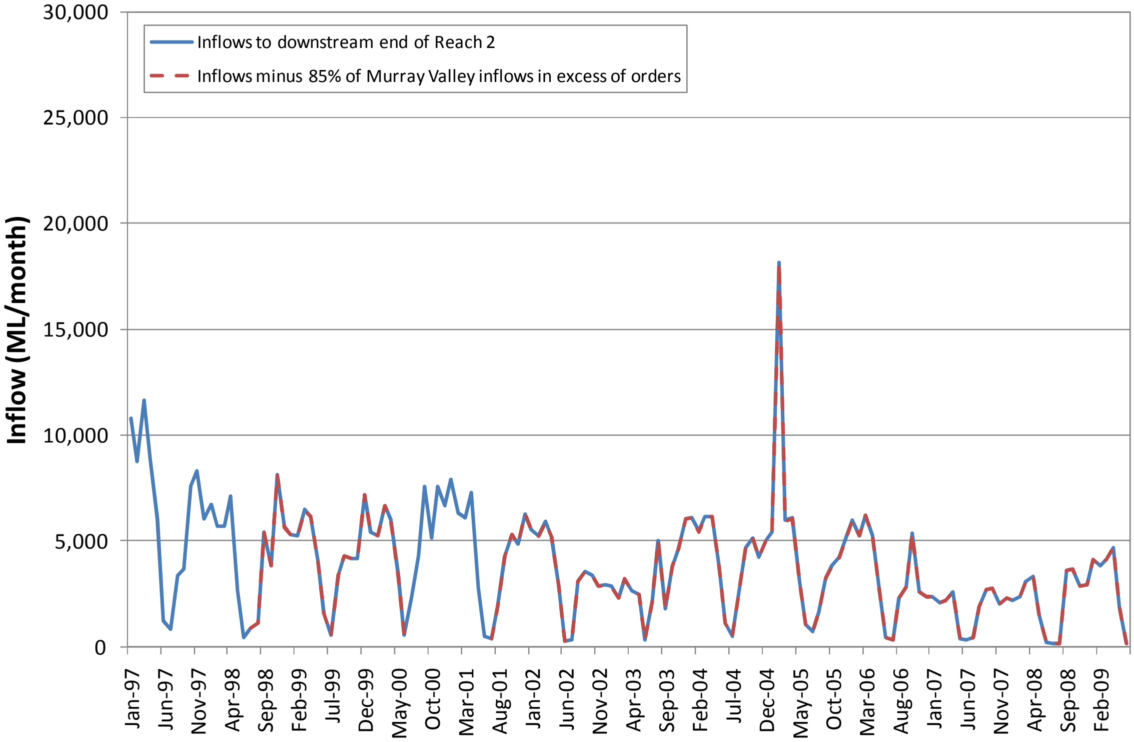
The expected reduction in inflows in percentage terms is shown in Figure 23. If the years 1997/98 to 2001/02 were repeated with NVIRP works in place, the reduction in inflows to Reach 1 would be as high as 18%. Inflows to Reach 3 and Reach 4 would be reduced by as much as 10% and 12% respectively. However if the years 2004/05 onwards were to be repeated with NVIRP works in place, the reduction in inflows would be less than 5% for all reaches. Reach 2 (Nine Mile Creek) is particularly unaffected, given no Murray Valley outfall structures discharge to Nine Mile Creek, and only one discharges upstream of where Lower Broken Creek and Nine Mile Creek split.

On a yearly time-step, the expected reduction in inflows would range from 9% in 2001/02 to 0.3% in 2006/07 (Table 6).

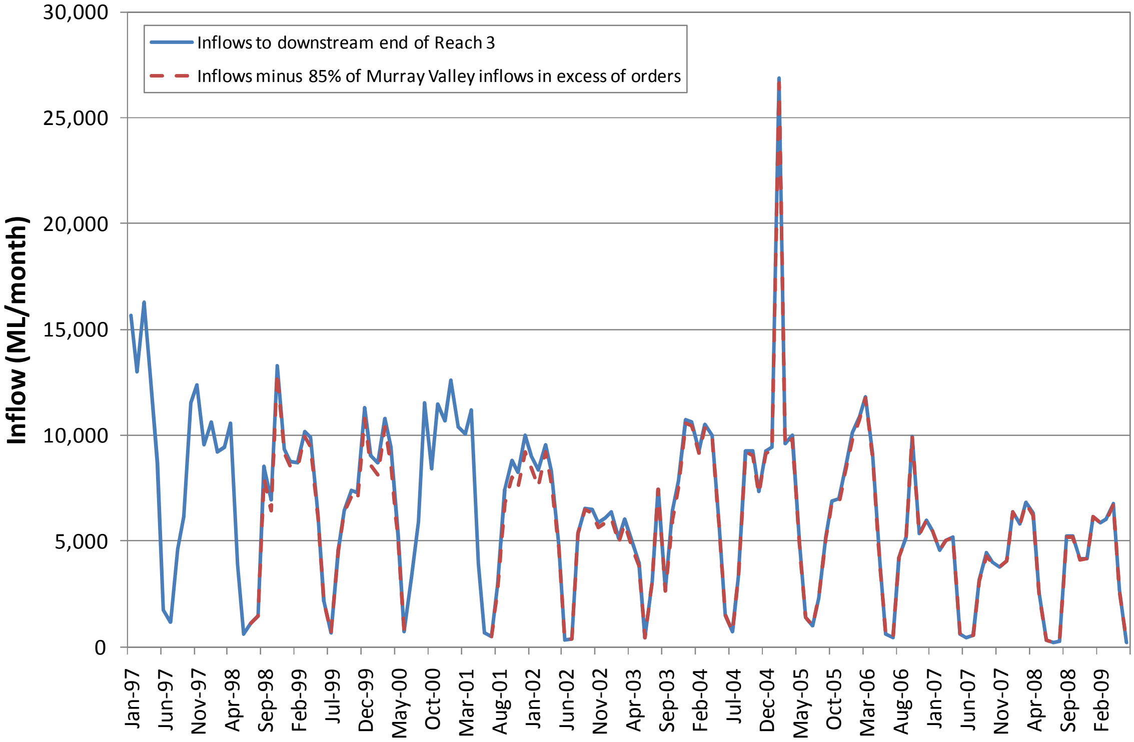
SKM SINCLAIR KNIGHT MERZ



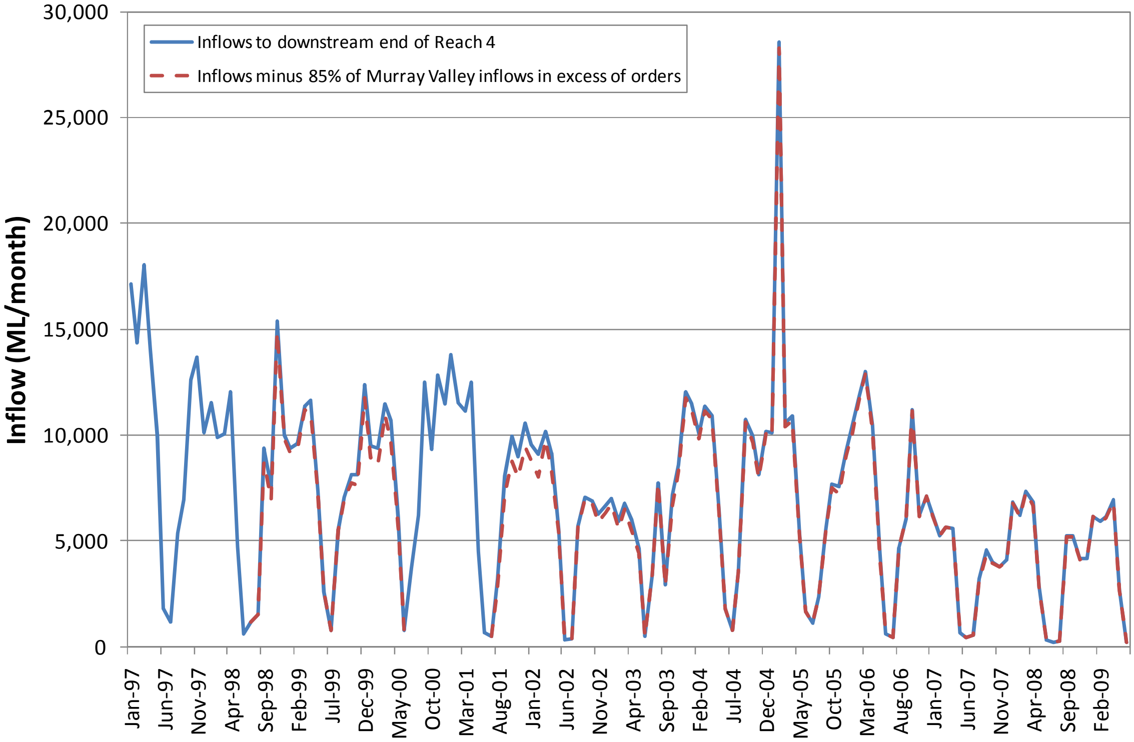
- **Figure 19 – The impact of NVIRP works on Reach 1.**



- **Figure 20 – The impact of NVIRP works on Reach 2.**

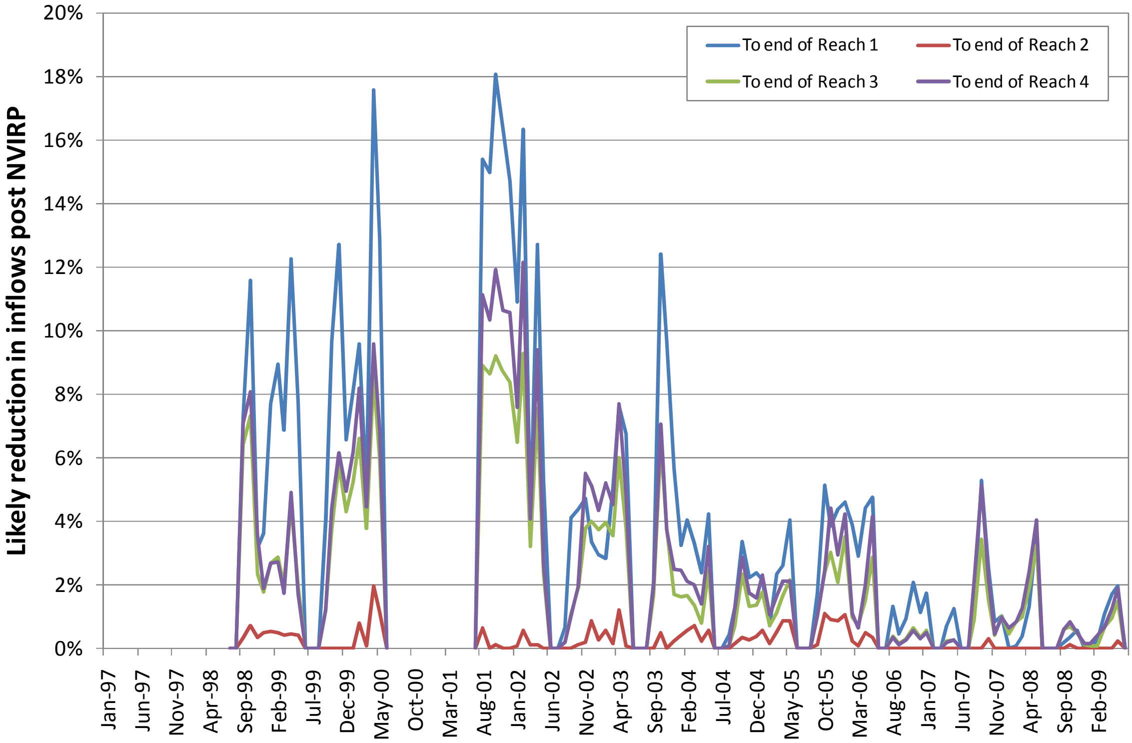


- **Figure 21 – The impact of NVIRP works on Reach 3.**



- **Figure 22 – The impact of NVIRP works on Reach 4.**

SINCLAIR KNIGHT MERZ
SKM



- **Figure 23 – Reduction in inflows because of NVIRP works, assuming inflows through Murray Valley outfall structures in excess of orders are reduced by 85%.**

- **Table 6 – The annual impact of NVIRP works on total inflows to the Lower Broken Creek and Nine Mile Creek, assuming inflows through Murray Valley outfall structures in excess of orders are reduced by 85%.**

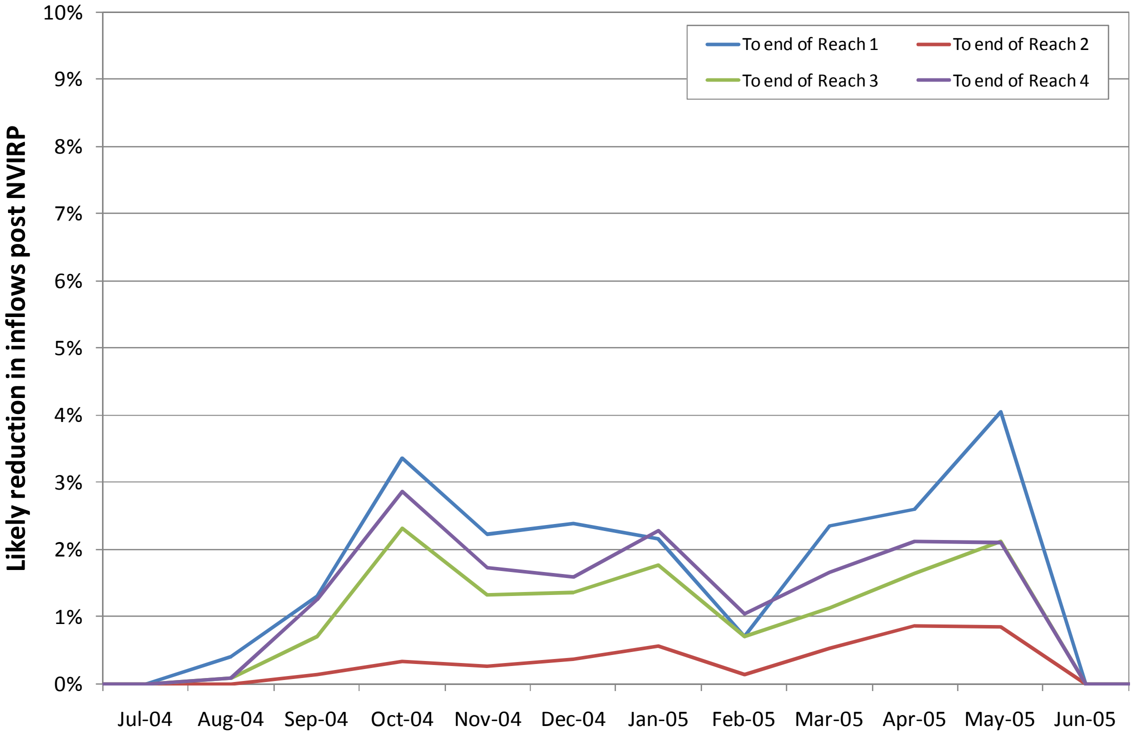
Year	Total Inflow	85% of Murray Valley Inflows in Excess of Orders (1)	Total Inflow minus (1)	Percent Reduction
1997/98	98,800			
1998/99	97,000	3,400	93,600	3.5%
1999/00	90,000	4,900	85,100	5.4%
2000/01	110,200	8,700	101,500	7.9%
2001/02	85,200	7,700	77,500	9.0%
2002/03	63,800	2,500	61,300	3.9%
2003/04	93,800	2,300	91,500	2.4%
2004/05	110,700	1,800	108,900	1.6%
2005/06	84,400	1,900	82,500	2.2%
2006/07	59,650	100	59,500	0.3%
2007/08	50,800	900	49,900	1.8%
2008/09	47,500	300	47,200	0.7%

Current practice is to analyse the impact of NVIRP works assuming a 2004/05 base case (Figure 24, which isolates 2004/05 from Figure 23). Were the year 2004/05 repeated, the monthly reduction in inflows attributable to NVIRP works would be less than 1% for Reach 2, between 1% and 3% for Reaches 1 and 3, and up to 4% for Reach 4. The impact of NVIRP works during 2008/09 is also of interest, given irrigation allocations in the Murray system that year were the lowest on record. Were the year 2008/09 repeated, the monthly reduction in inflows because of NVIRP works would be less than 2% for each reach (Figure 25). Appendix F shows how total monthly inflows would change in 2004/05 and 2008/09 given these percentage reductions.

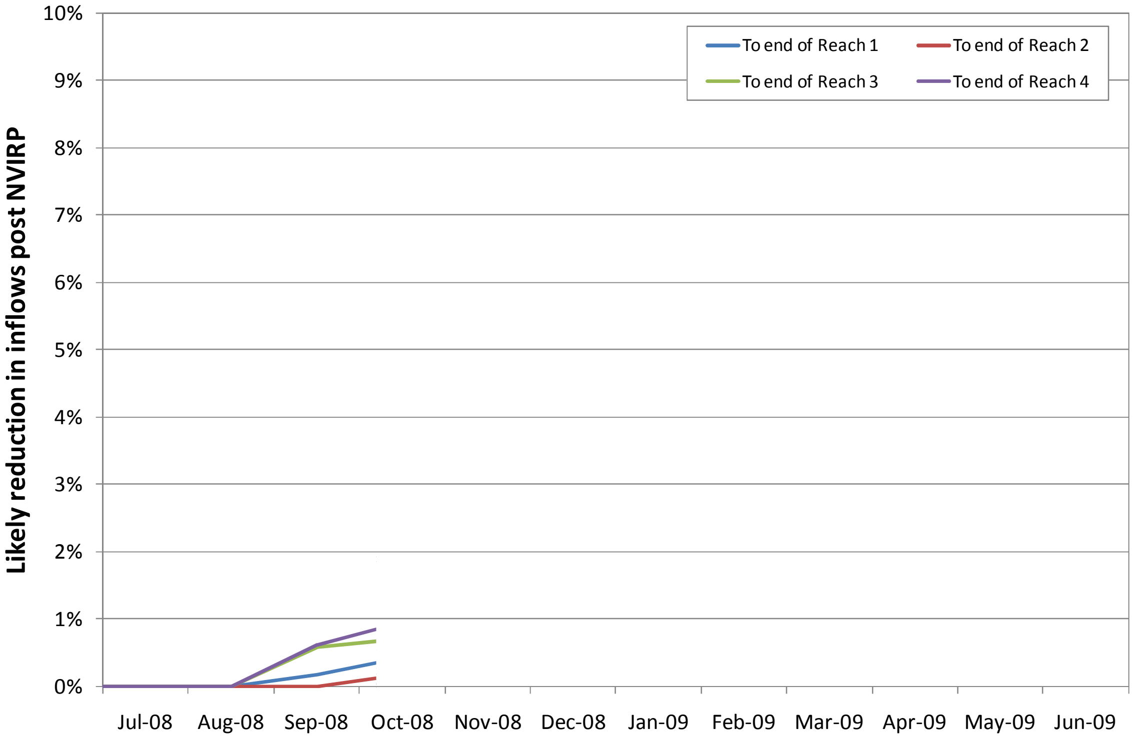
Figure 24 and Figure 25 present the reduction in inflows assuming the only impact of NVIRP works is to reduce inflows through Murray Valley outfall structures in excess of orders. However, this is probably a conservative estimate of the impact of NVIRP works, because a there are a number of Murray Valley outfall structures that connect to drains, which in turn discharge to the Lower Broken Creek (Appendix C).

Isolating the contribution of outfalls to drainage flows that enter the creek is difficult. Flows through the outfall structures into drains combine with flows from other sources. Often a portion of drainage flows will be diverted by irrigators before reaching the creek. But to test how NVIRP works may affect drainage inflows, it was assumed that drainage flows are evenly comprised of the three major contributors (i.e. 33% rainfall runoff, 33% irrigation runoff and 33% channel outfalls). Then, if 85% of channel outfalls are saved by NVIRP works, drainage inflows to the Lower Broken Creek and Nine Mile Creek through Murray Valley drains will reduce by approximately 30%.

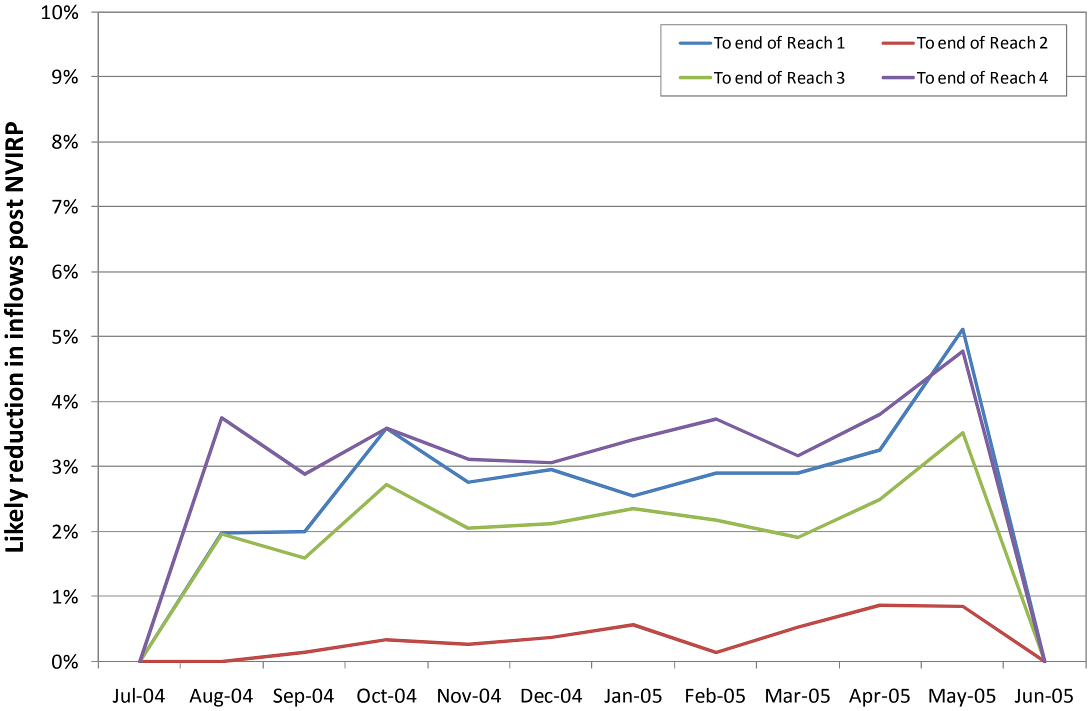
Figure 26 and Figure 27 show the impact of NVIRP works on total inflows assuming that inflows in excess of orders through Murray Valley outfall structures that connect directly to the creek are reduced by 85% **and** inflows through Murray Valley drains are reduced by 30%. It should be kept in mind that this 30% reduction in drainage inflows is subjective and most Murray Valley drains are not metered. However, Figure 26 and Figure 27 show that assuming drain inflows will also reduce does not invalidate the conclusion that NVIRP works will have a minimal impact on total inflows.



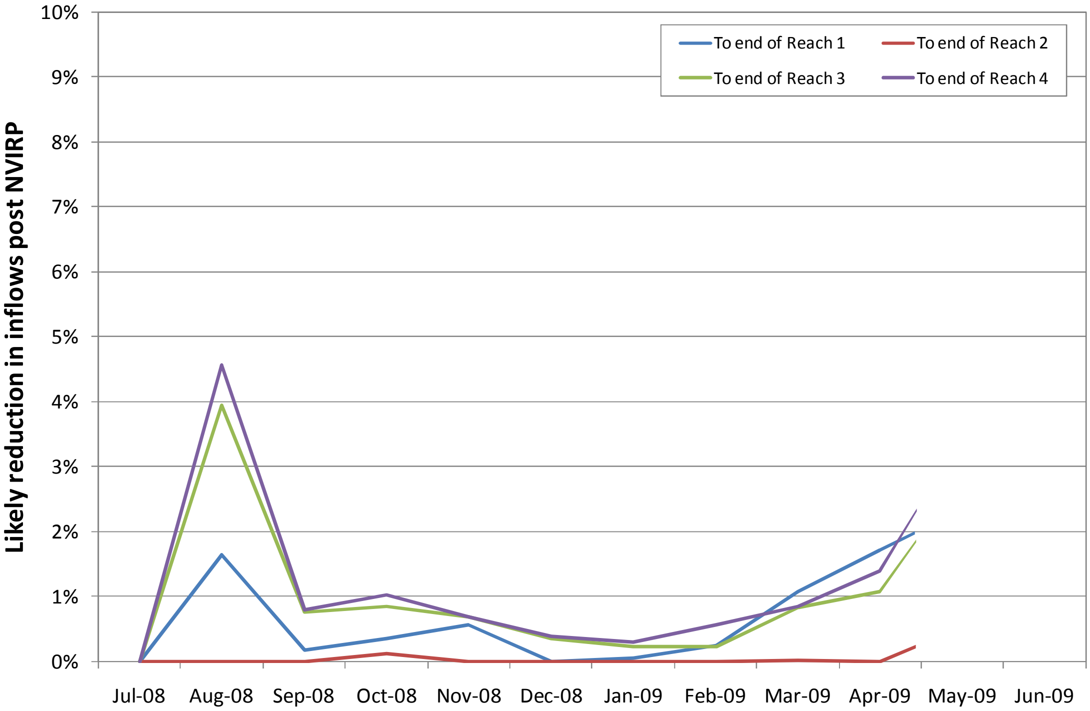
- **Figure 24 – Reduction in inflows because of NVIRP works for 2004/05, assuming inflows through Murray Valley outfall structures in excess of orders are reduced by 85%.**



- **Figure 25 – Reduction in inflows because of NVIRP works for 2008/09, assuming inflows through Murray Valley outfall structures in excess of orders are reduced by 85%.**



- **Figure 26 – Reduction in inflows because of NVIRP works for 2004/05, assuming inflows through Murray Valley outfall structures in excess of orders are reduced by 85% and inflows through Murray Valley drains are reduced by 30%.**



- **Figure 27 – Reduction in inflows because of NVIRP works for 2008/09, assuming inflows through Murray Valley outfall structures in excess of orders are reduced by 85%, and inflows through Murray Valley drains are reduced by 30%.**

6. Summary and Conclusions

The Lower Broken Creek and Nine Mile Creek is a highly regulated system. The vast majority of inflows to the system come through channel outfall structures that connect directly to the creeks from both the Murray Valley and Shepparton irrigation districts. Inflows through outfall structures are comprised of two parts – inflows ordered by local diverters or environmental managers, and inflows in excess of orders.

NVIRP plans to reduce the inflows through Murray Valley outfall structures in excess of orders by 85%. This is likely to reduce the volume of water flowing down the creeks. However, the contribution of this ‘excess’ to total inflows is minor, especially post 2002/03. Therefore, reducing Murray Valley inflows in excess of orders by 85% is expected to reduce monthly inflows by less than 4% for all environmental flow reaches, assuming 2004/05 is the base case for this assessment. Even when assuming Murray Valley drainage inflows reduce by 30% because of NVIRP works, the reduction in monthly inflows in 2004/05 remains below 5% for all environmental flow reaches.

7. References

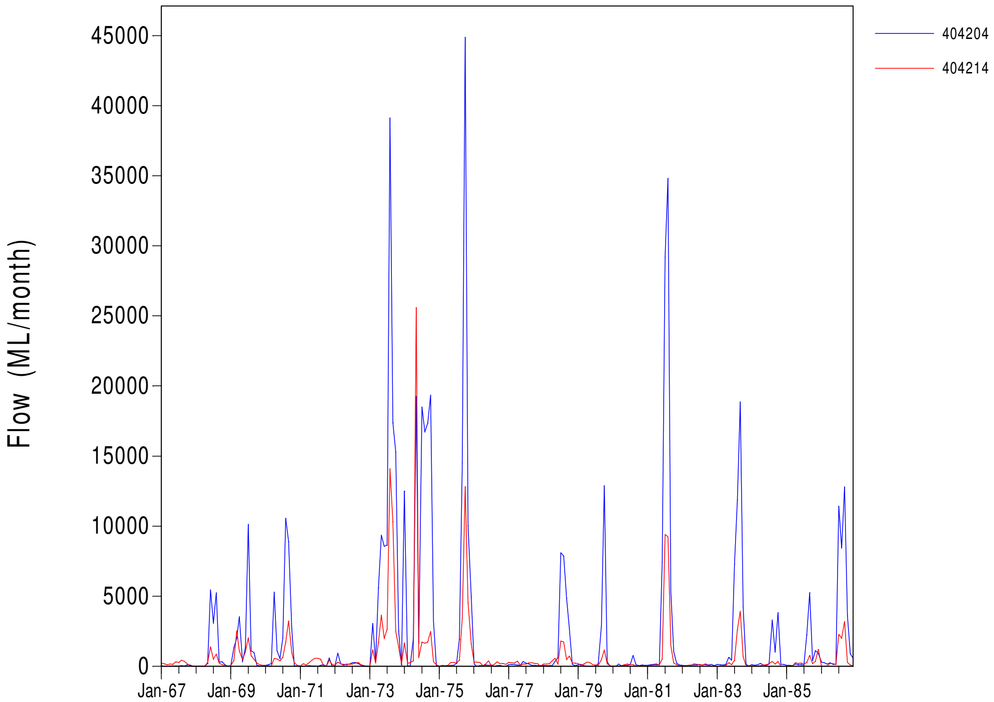
RWC (1987). Victorian Surface Water Information to 1987. Volume 3.

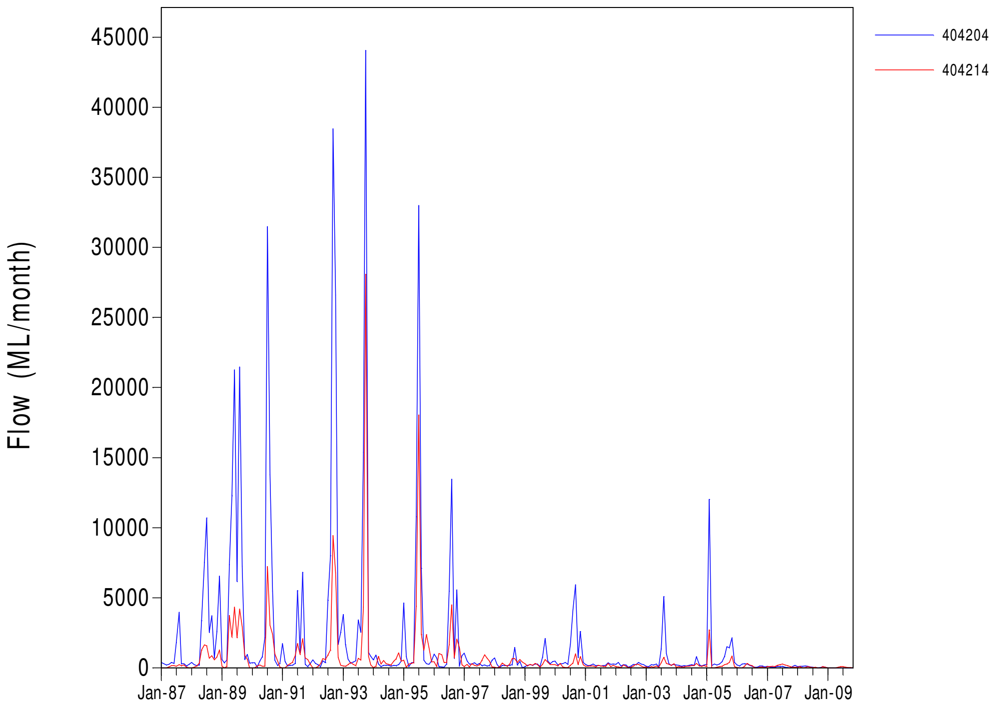
SKM (2003). Broken Creek Model – Stage 2, Final Report, Prepared for Goulburn Murray Water, January 2003.

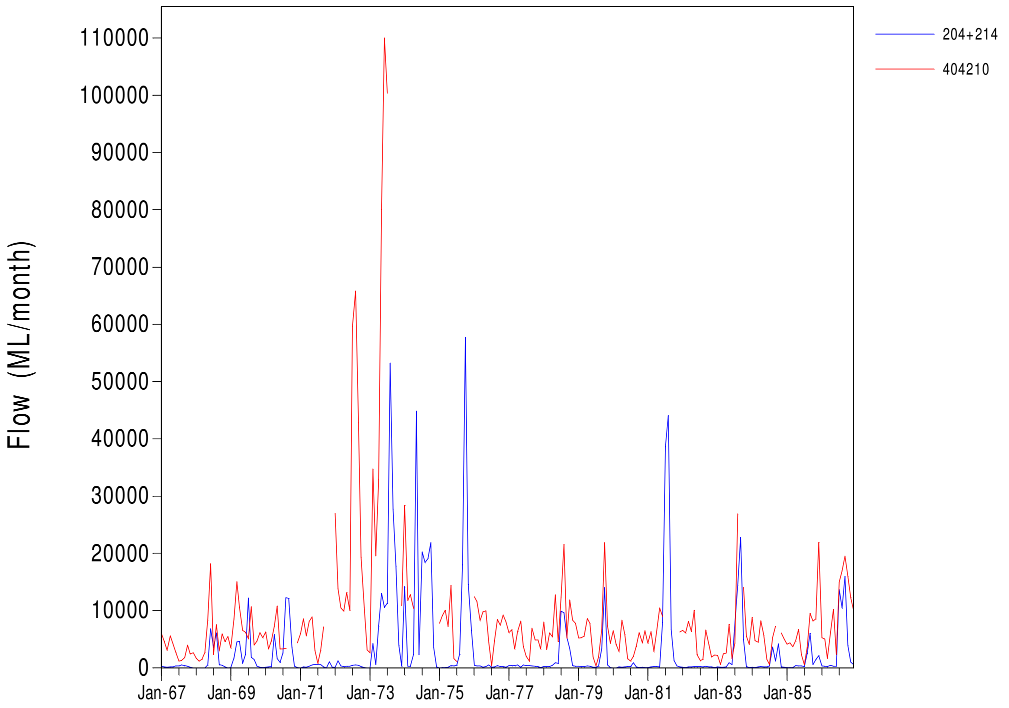
Appendix A Quality of Gauge Records

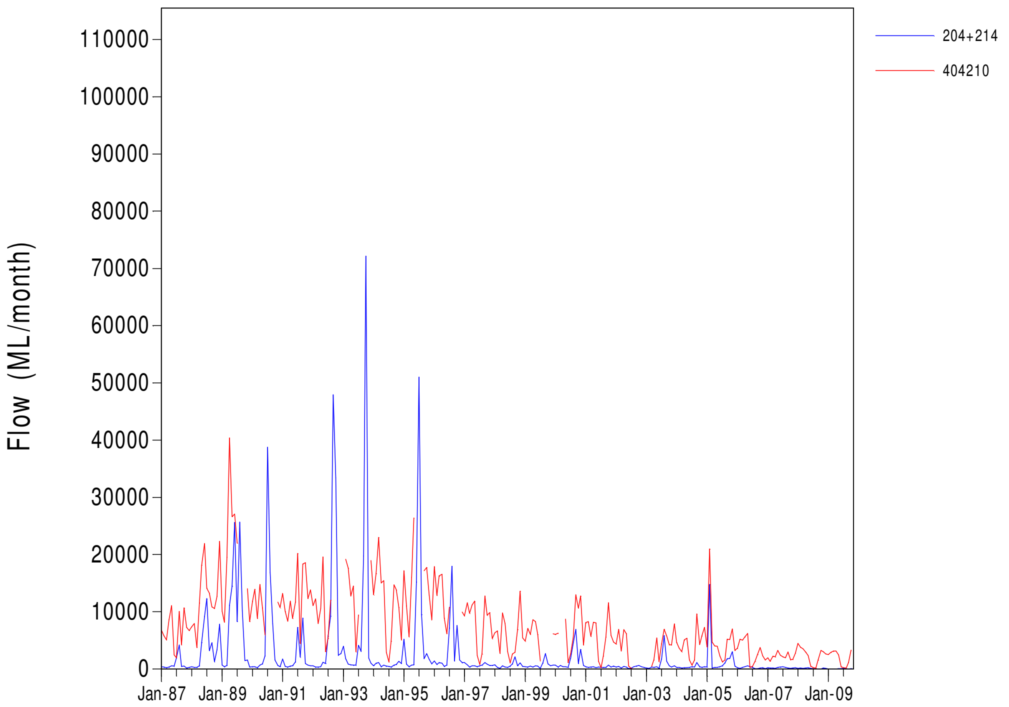
Gauge	Quality Code	Thiess Quality Statement	Percentage of Record
404204 Boosey Creek at Tungamah	1	Good continuous records	73.72
	2	Good quality edited data	22.29
	3	Linear infill to first value in block (no data lost)	0.29
	8	Pool reading only	0.53
	9	Pool dry - no data collected	2.01
	10	Data transposed from recorder chart	0.29
	82	Linear interpolation across gap in records	0.51
	104	Records estimated	0.33
	255	No data exists	0.04
404214 Broken Creek at Katamatite	1	Good continuous records	36.95
	2	Good quality edited data	58.14
	3	Linear infill to first value in block (no data lost)	0.32
	8	Pool reading only	1.36
	9	Pool dry - no data collected	0.23
	10	Data transposed from recorder chart	0.63
	15	Minor editing	0.07
	82	Linear interpolation across gap in records	0.47
	104	Records estimated	0.18
	150	Rating extrapolated due to insufficient gaugings	1.33
	254	Rating table exceeded	0.29
	255	No data exists	0.04
404210 Broken Creek at Rices Weir	1	Good continuous records	63.19
	2	Good quality edited data	21.61
	3	Linear infill to first value in block (no data lost)	0.18
	10	Data transposed from recorder chart	0.15
	15	Minor editing	0.67
	20	Edited to measurements	0.45
	26	Daily read records	1.79
	50	Medium editing	0.21
	65	Other authorities data	0.74
	75	Height correction applied	0.06
	76	Reliable interpolation	0.31
	77	Correlation with other station, same variable	0.58
	82	Linear interpolation across gap in records	0.50
	100	Irregular data use with caution	0.07
	104	Records estimated	1.38
	150	Rating extrapolated due to insufficient gaugings	0.04
	153	Water below instrument threshold	0.30
	160	Backed-up by d/s influence	2.13
	170	Raw unedited data stored in archive	0.26
	180	Equipment malfunction	0.18
	255	No data exists	5.21

Appendix B Recorded Flows






Flow (ML/month)
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
Jan-67
Jan-69
Jan-71
Jan-73
Jan-75
Jan-77
Jan-79
Jan-81
Jan-83
Jan-85
204+214
404210


Flow (ML/month)
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
Jan-87
Jan-89
Jan-91
Jan-93
Jan-95
Jan-97
Jan-99
Jan-01
Jan-03
Jan-05
Jan-07
Jan-09
204+214
404210

Appendix C Outfall Structures

C.1 Murray Valley Outfall Structures

Asset Code	Asset Name	Outfalls To…	Enters Broken Creek via…
ST066229	7/3	Boosey Creek	direct outfall
ST072180	3 Main	Wild Dog Creek	direct outfall
ST041815	4 Main	Broken Creek	direct outfall
ST057773	5/3	Drain 2	Muckatah Drain
ST056529	6/6	Broken Creek	direct outfall
ST056668	8/6	Broken Creek	direct outfall
ST056597	4/8/6	Broken Creek	direct outfall
ST056669	10/8/6	Drain 1/18	MV Drain 18
ST056373	6 Main Dr 18	Drain 18	MV Drain 18
ST064176	End 13/6	Drain 13	MV Drain 18
ST058386	14/6	Drain 2/18	MV Drain 18
ST066584	15/6	Broken Creek	direct outfall
ST069070	15B/6	Drain 1/17	MV Drain 17
ST058403	Jewells (21A/6)	Broken Creek	direct outfall
ST066583	12/6	Drain 9/13	MV Drain 13
ST066577	Middle 13/6	Drain 13	MV Drain 13
ST071907	Middle 9/6	Drain 10	MV Drain 13
ST058439	Bourkes	Drain 1/13	MV Drain 13
ST058499	20/6	Drain 13	MV Drain 13
ST058488	Vallender (19A/6)	Drain 1/13	MV Drain 13
ST056428	Flanners (26A/6)	Broken Creek	direct outfall
ST056447	End 6 Main	Broken Creek	direct outfall

C.2 Shepparton Outfall Structures

Asset Code	Asset Name	Outfalls To…	Enters Broken Creek via…
ST043762	EGM.Outfall InverWeir	Drain 16	direct outfall
ST018998	EG.34 Union Rd	Drain 2/13A	Shep Drain 13A
ST019005	EG.34 End	Drain 1/13A	Shep Drain 13A
ST015505	EG.5/25	Drain 1/1B/1/12	Shep Drain 13
ST015903	EG.30	Drain 5/1A/12	Shep Drain 13A
ST015731	EG.18	Drain 12	Shep Drain 12
ST015618	EG.22	Drain 1/5/12	Shep Drain 12
ST015415	EG.4/24	Drain 1B/12	Shep Drain 12
ST015432	EG.24	Drain 1/1B/12	Shep Drain 12
ST015462	EG.2/25	Drain 1/12	Shep Drain 12
ST015467	EG.1/2/25	Drain 4/1/12	Shep Drain 12
ST015536	EG.2/3/25	Drain 12	Shep Drain 12
ST015546	EG.3/25	Drain 1B/12	Shep Drain 12
ST015488	EG.1/4/25	Drain 1/1/12	Shep Drain 12
ST015495	EG.25	Drain 1/1/12	Shep Drain 12
ST015566	EG.2/28	Drain 6/8/1A/12	Shep Drain 12
ST015324	EG.28	Drain 1B/1/12	Shep Drain 12
ST015883	EG.29	Drain 5/1A/12	Shep Drain 12
ST015846	EG.1/1/30	Drain 11/1A/12	Shep Drain 12
ST015920	EG.1/30	Drain 1/A/12	Shep Drain 12
ST018959	EG.31	Drain 4/1A/12	Shep Drain 12
ST018977	EG.33	Drain 10/1A/12	Shep Drain 12
ST017240	EG.1/1/15	Drain 5/11	Shep Drain 11
	EG.2/15		
ST066259	EG.15 Andersen's	Drain 5/11	Shep Drain 11
ST017227	EG.15 End Blake's	Drain 4/11	Shep Drain 11
ST049324	EG.3/17	Drain 11	Shep Drain 11
ST015400	EG.17	Drain 11	Shep Drain 11
ST052367	EG.1/18	Congupna Creek	
ST045754	EG.12 No 1 (Hicks)	Broken Creek	direct outfall
ST046200	EG.38/12 Town Spur	Broken Creek	direct outfall
ST045802	EG.12 No 2 (Hollands)	Broken Creek	direct outfall

SINCLAIR KNIGHT MERZ SKM

Appendix D Outfall and Drainage Data Infilling

Inflows through channel outfall structures

Where flows through outfall structures were recorded on a weekly time-step, the following pattern was used to disaggregate the data to a daily time-step.

- **Table 7 – Daily pattern of irrigation outfalls (SKM, 2003).**

Day	Proportion of weekly outfall flow
Monday	0.16
Tuesday	0.12
Wednesday	0.12
Thursday	0.14
Friday	0.12
Saturday	0.15
Sunday	0.19

Data for one irrigation season was missing for both irrigation districts. Murray Valley data was missing for 2000/2001, and Shepparton data was missing for 1998/1999 irrigation season. The absence of any other data was interpreted as meaning that no flow was recorded on that day[2]. The 1998/99 and 2000/2001 periods had been previously infilled by SKM (2003), and these time-series were adopted for this study. The infilling was based on relationships between total flows through outfall structures, and therefore in 2000/01 it was not possible to separate the time-series into Murray Valley inflows that were 'ordered' or 'in excess'. However, in one of the datasets provided for this study, a yearly estimate of inflows ordered through Murray Valley outfall structures was available for 2000/01, and this was used to back calculate inflows 'in excess', given the SKM (2003) estimate of total inflows through outfall structures.

Inflows through drains

Only limited records were available for flows in the drains discharging to Broken Creek. Thiess has daily gauged flow data for three sites from 1998 onwards (Muckatah Drain, Shepparton Drain 12 and Shepparton Drain 11), and spot gauge readings for some Murray Valley drains. Regressions

[2] This is the approach adopted during development of the Broken Creek Model in 2003.

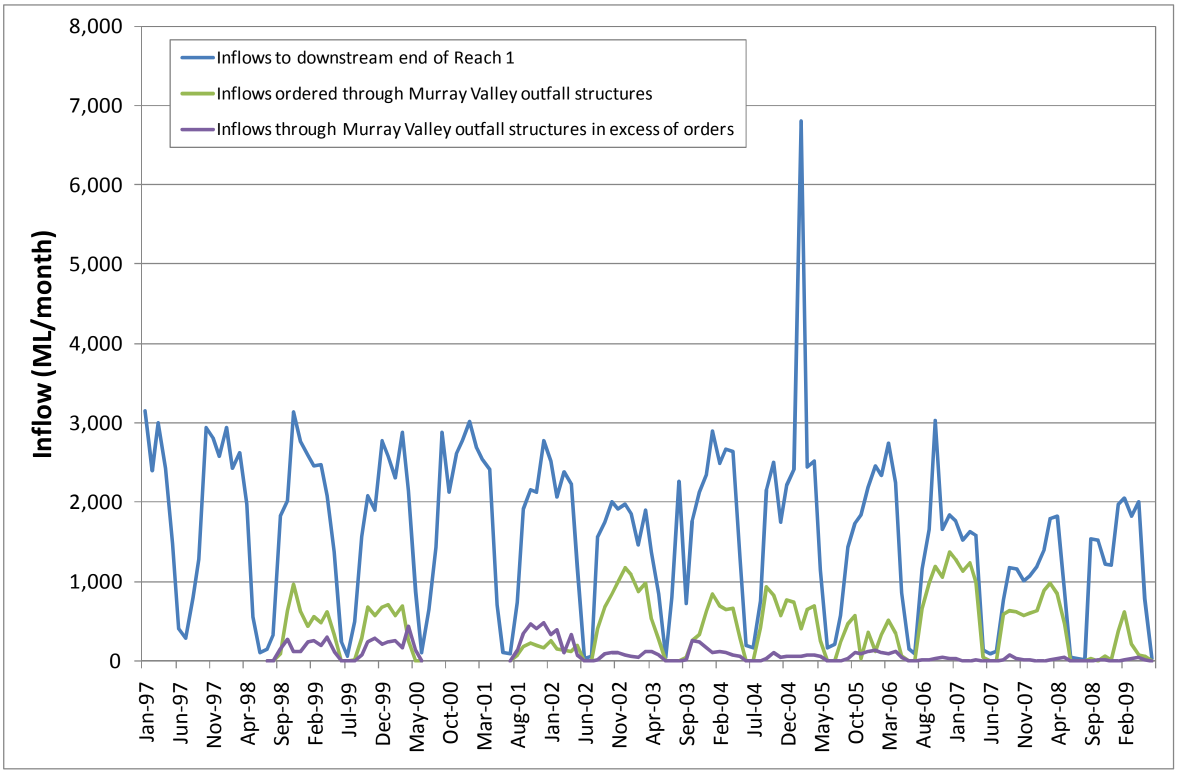
were used to infill periods missing in the Thiess records, and estimate discharge from drains that are not continuously monitored. These regressions were developed in 2003 (SKM, 2003).

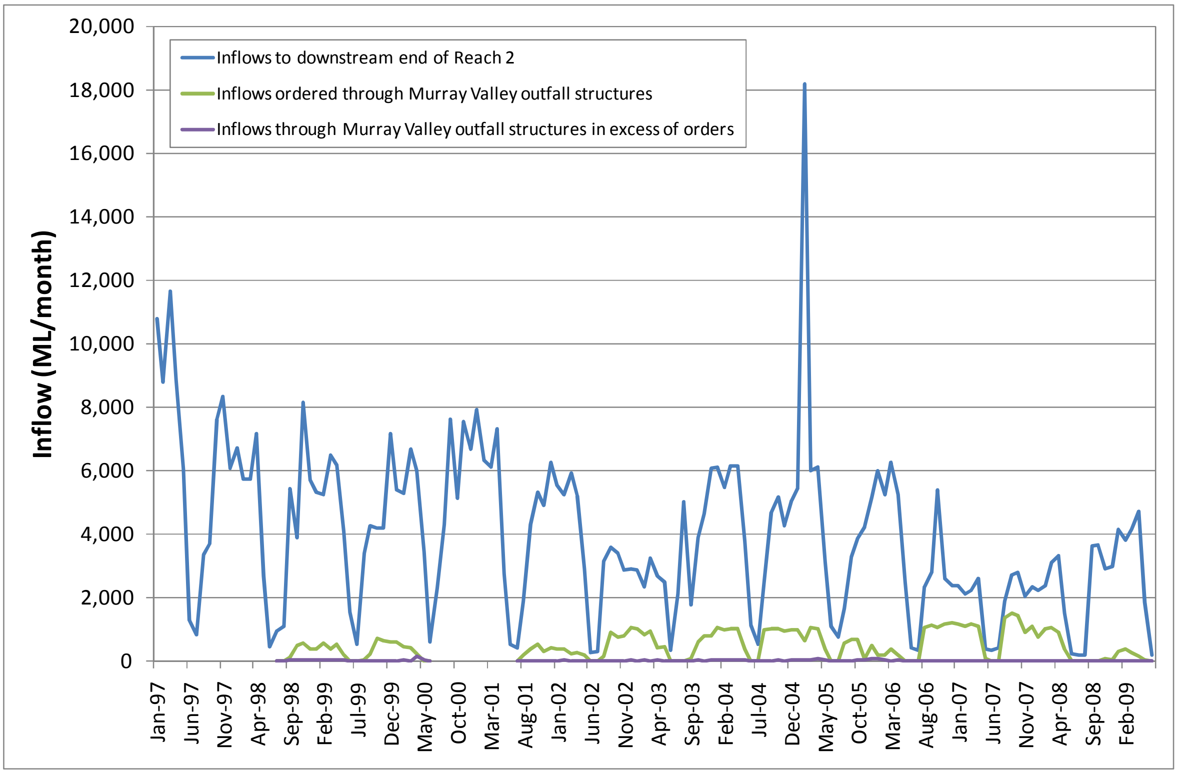
- **Table 8 – Regression relationships for estimating drainage inflows (SKM, 2003).**

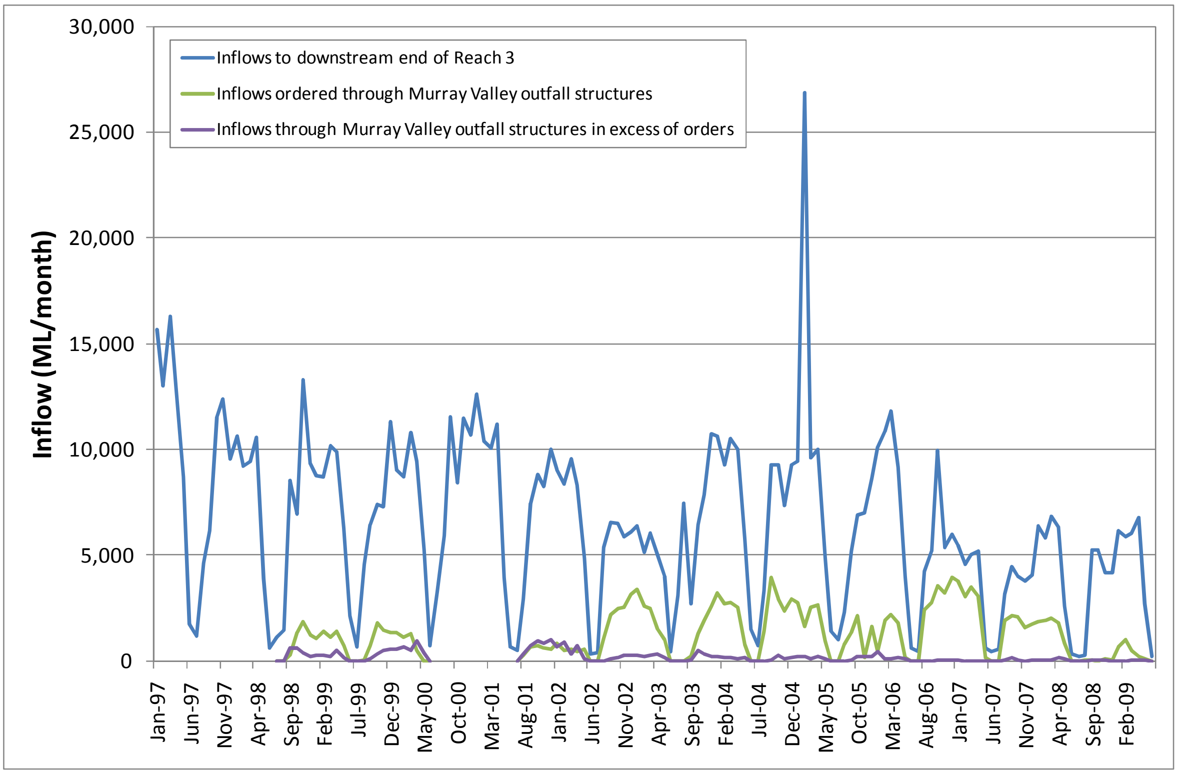
Drain Name	*Relationship for infilling missing data*
Muckatah Drain	Average monthly flow
Murray Valley Drain 20	0.1654 x Shepparton Drain 11, R^2 = 0.1
Murray Valley Drain 19	0.1048 x Shepparton Drain 11, R^2 = 0.13
Murray Valley Drain 18	0.531 x Shepparton Drain 11, R^2 = 0.3
Murray Valley Drain 17	Assume 1 ML/d throughout year
Murray Valley Drain 13	1.041 x Shepparton Drain 11
Shepparton Drain 16	Transposed from Shepparton Drain 11 on the basis of catchment area
Shepparton Drain 15	Transposed from Shepparton Drain 11 on the basis of catchment area
Shepparton Drain 13	Assume 1 ML/d throughout year
Shepparton Drain 13A	Assume 3 ML/d throughout year
Shepparton Drain 11	0.4865 x Shepparton Drain 12

Appendix E Reach Inflow Plots

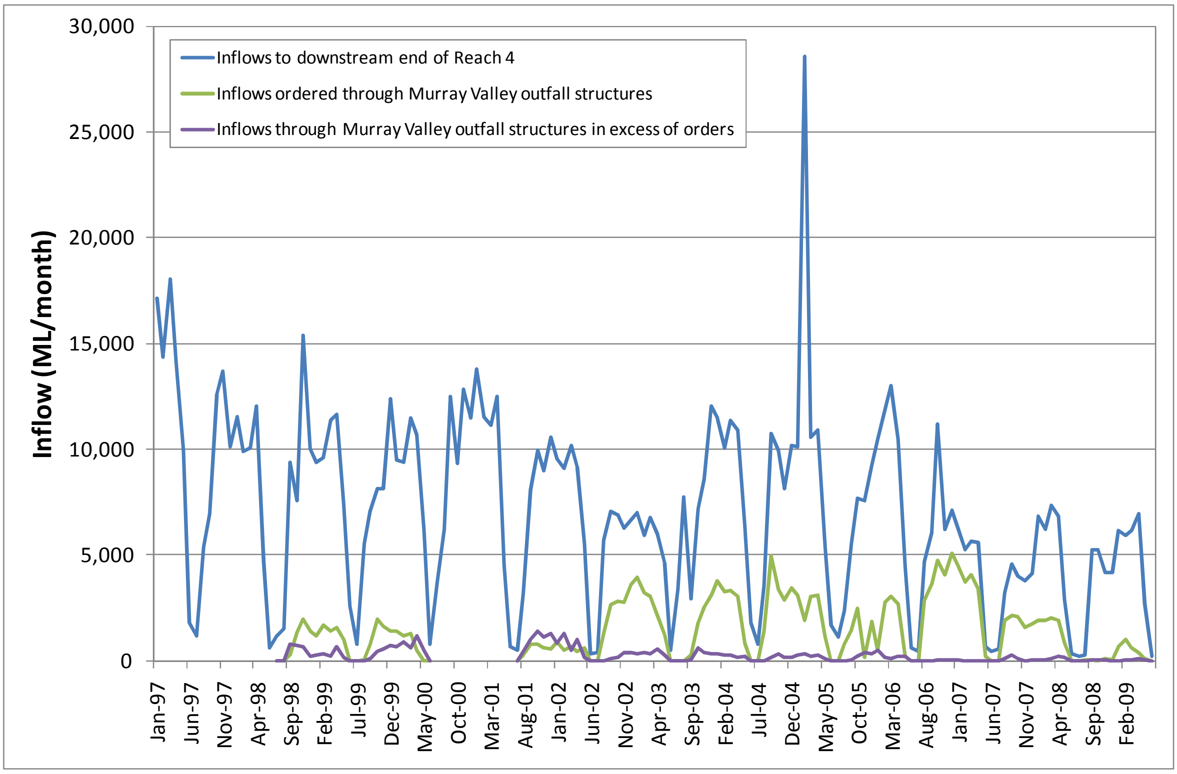
E.1 Inflows through Murray Valley outfall structures



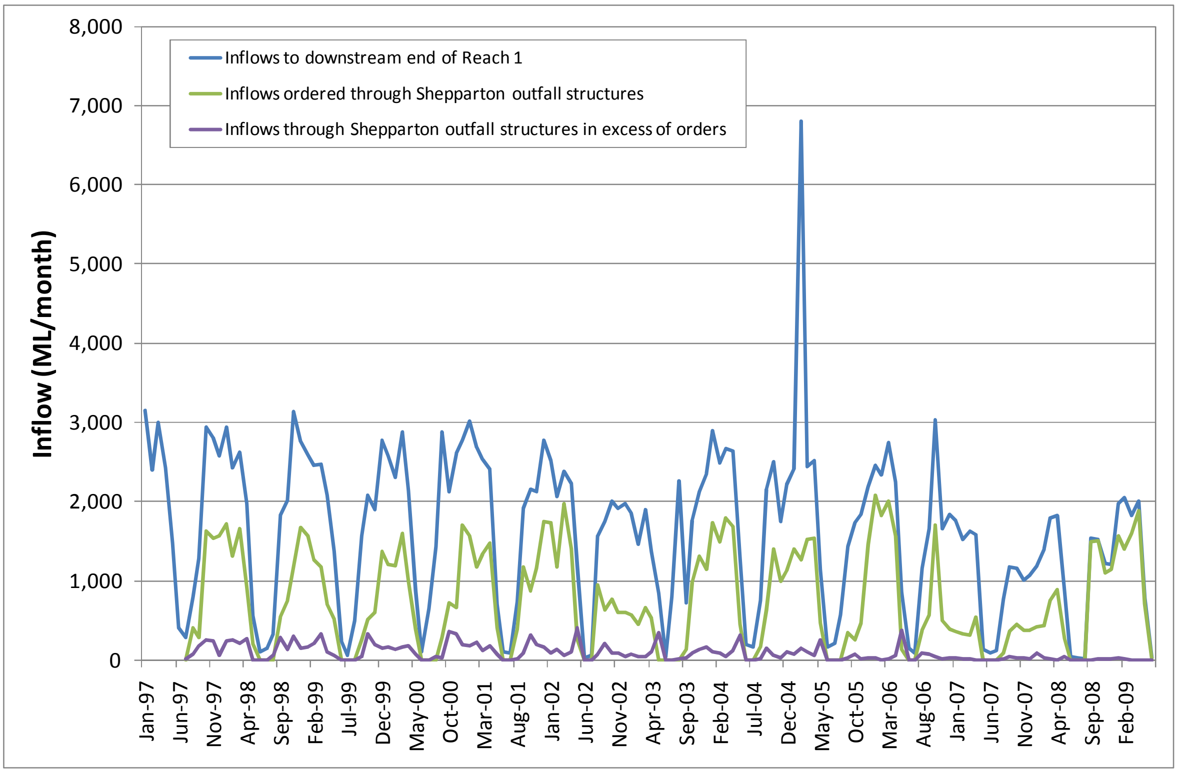

20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Inflow (ML/month)
Inflows to downstream end of Reach 2
Inflows ordered through Murray Valley outfall structures
Inflows through Murray Valley outfall structures in excess of orders
Jan-97
Jun-97
Nov-97
Apr-98
Sep-98
Feb-99
Jul-99
Dec-99
May-00
Oct-00
Mar-01
Aug-01
Jan-02
Jun-02
Nov-02
Apr-03
Sep-03
Feb-04
Jul-04
Dec-04
May-05
Oct-05
Mar-06
Aug-06
Jan-07
Jun-07
Nov-07
Apr-08
Sep-08
Feb-09


30,000
25,000
20,000
15,000
10,000
5,000
0
Inflow (ML/month)
Inflows to downstream end of Reach 3
Inflows ordered through Murray Valley outfall structures
Inflows through Murray Valley outfall structures in excess of orders
Jan-97
Jun-97
Nov-97
Apr-98
Sep-98
Feb-99
Jul-99
Dec-99
May-00
Oct-00
Mar-01
Aug-01
Jan-02
Jun-02
Nov-02
Apr-03
Sep-03
Feb-04
Jul-04
Dec-04
May-05
Oct-05
Mar-06
Aug-06
Jan-07
Jun-07
Nov-07
Apr-08
Sep-08
Feb-09

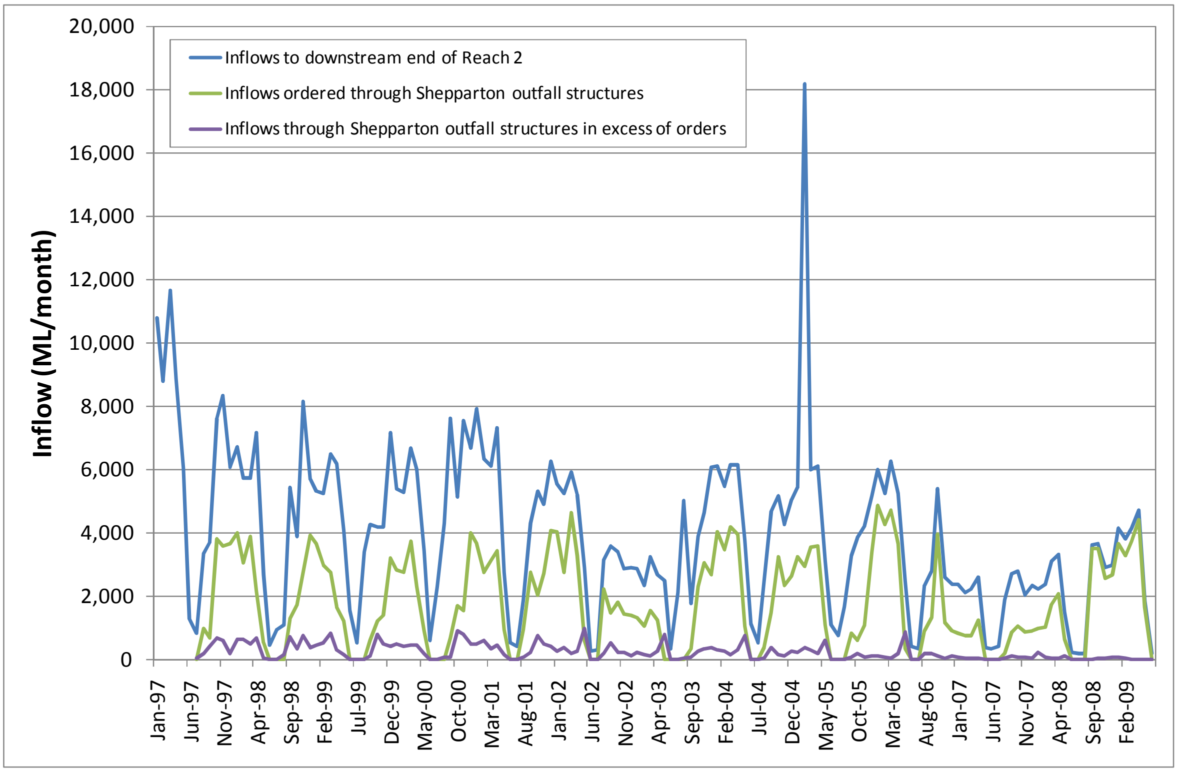
SINCLAIR KNIGHT MERZ
SKM

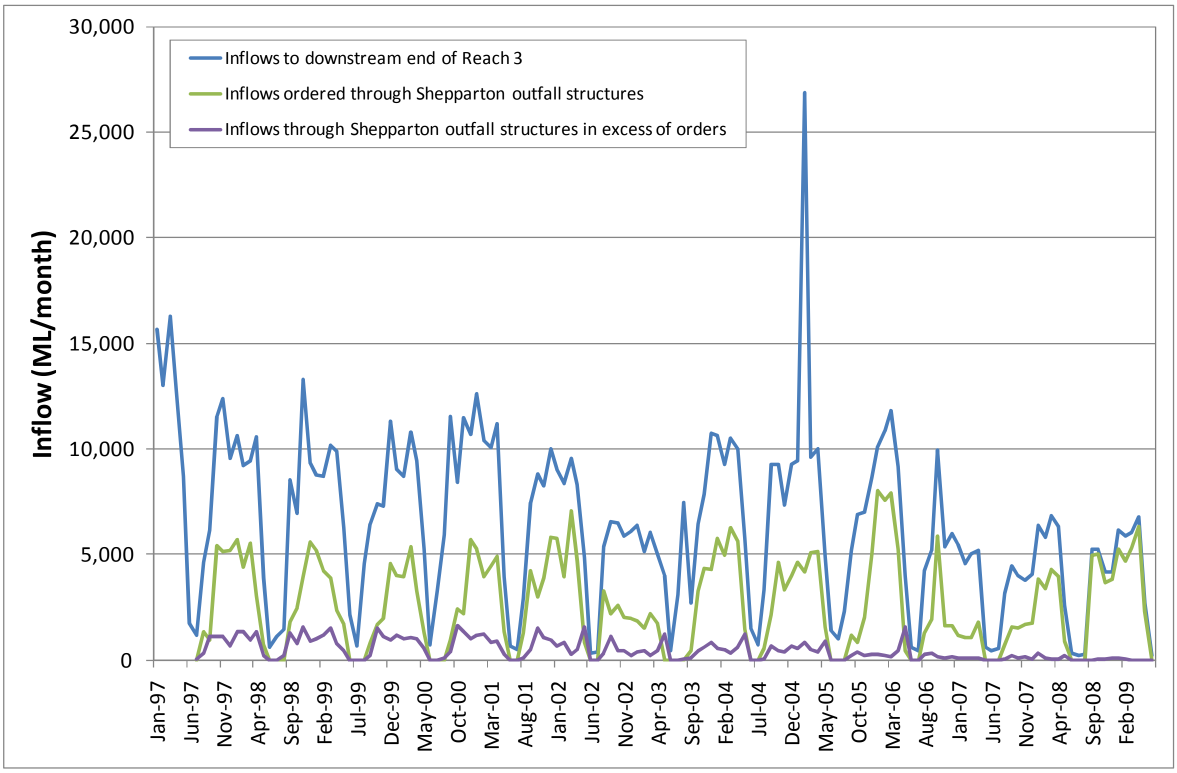


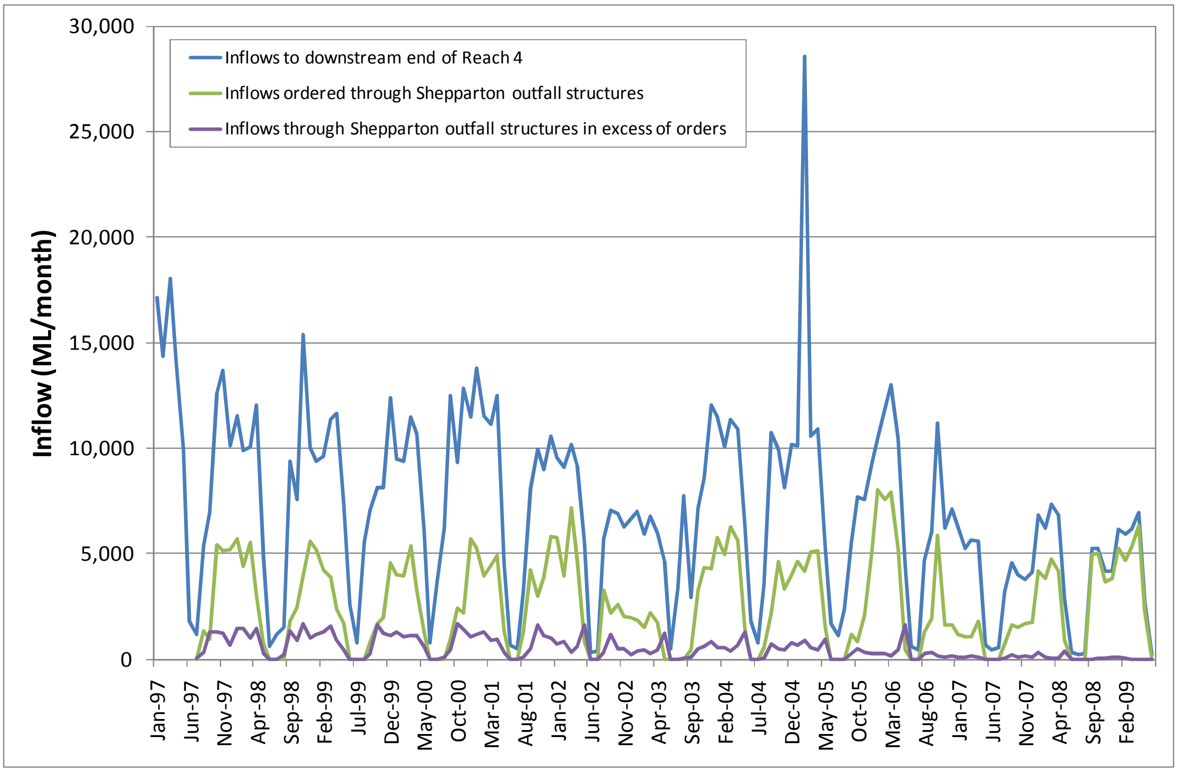
E.2 Inflows through Shepparton outfall structures

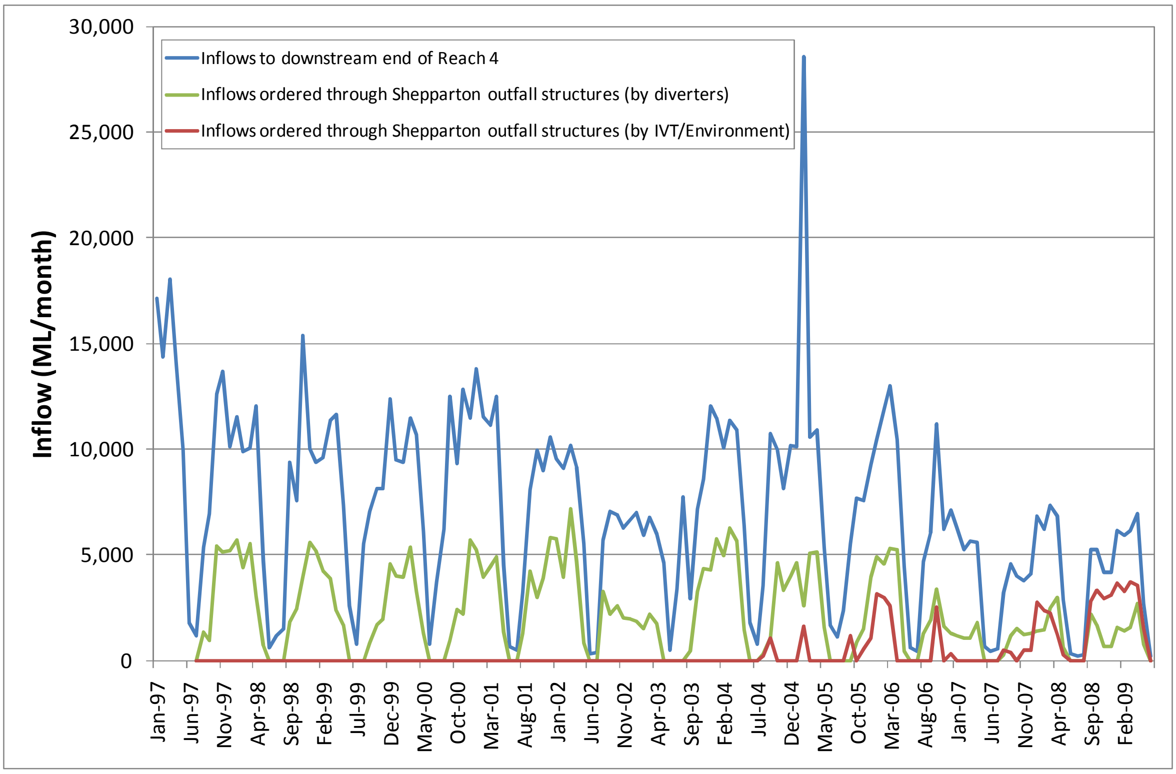


SINCLAIR KNIGHT MERZ SKM

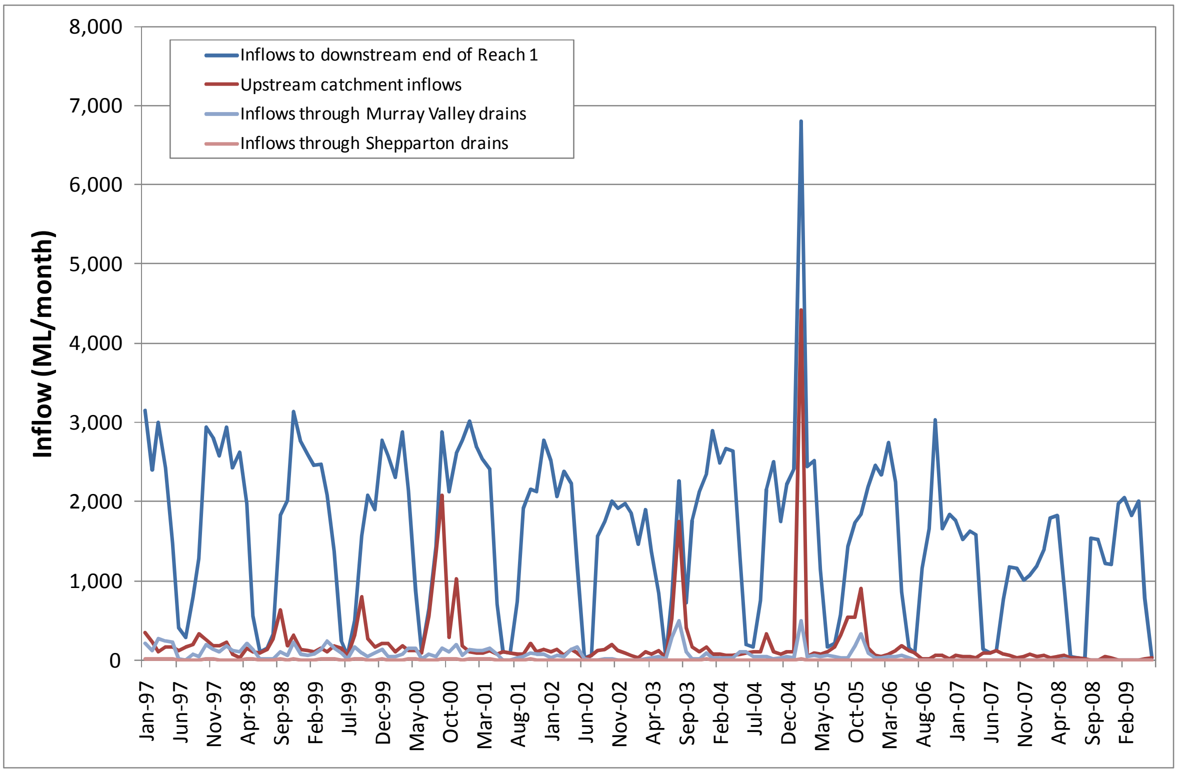


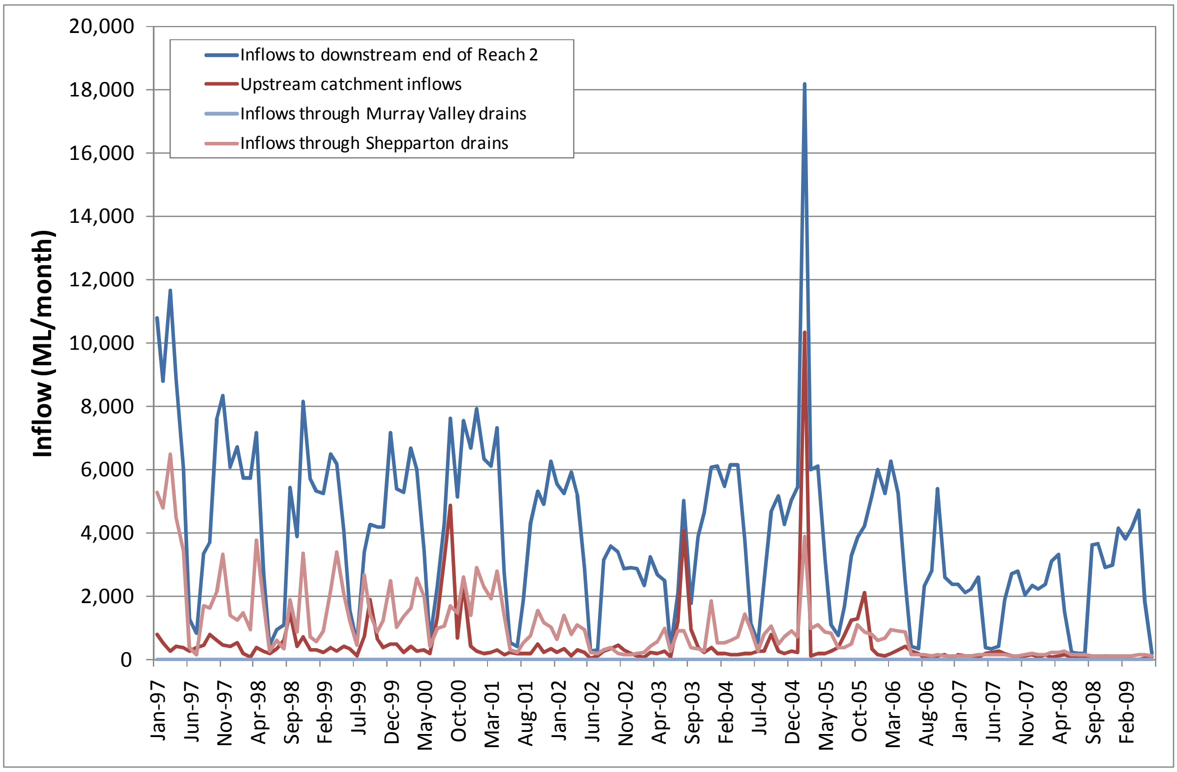


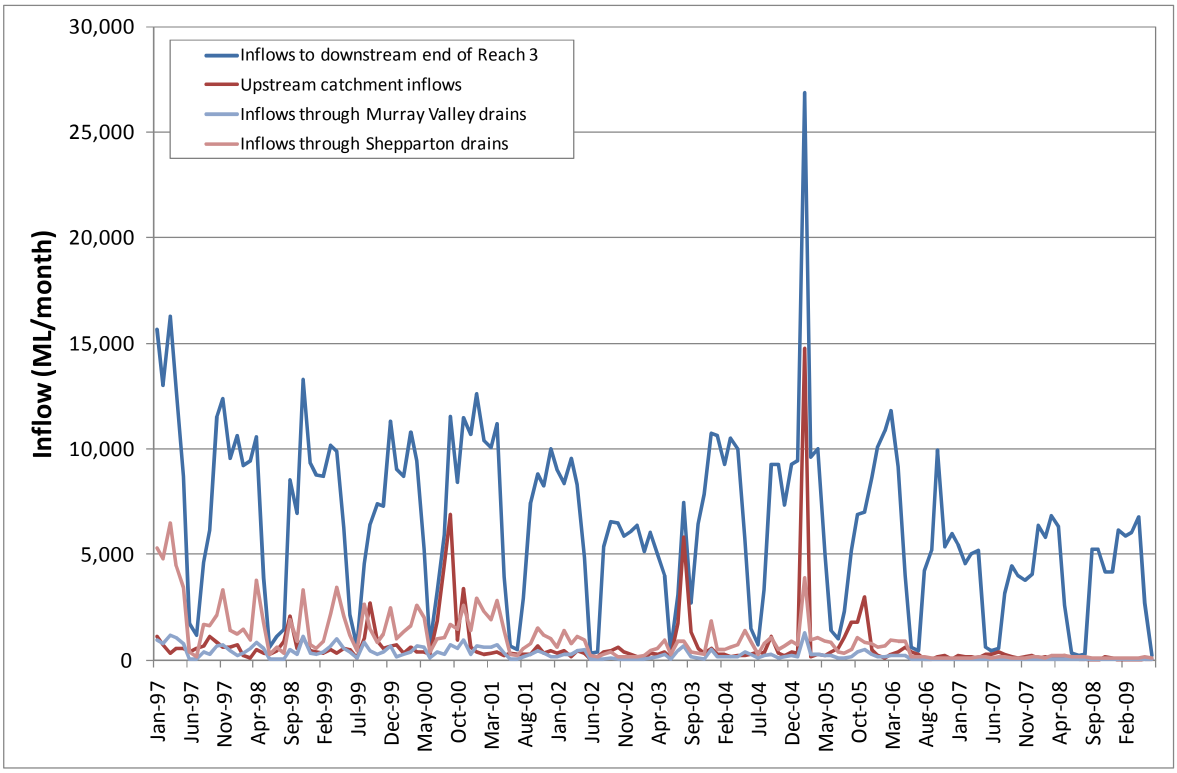

30,000
25,000
20,000
15,000
10,000
5,000
0
Inflow (ML/month)
Inflows to downstream end of Reach 4
Inflows ordered through Shepparton outfall structures
Inflows through Shepparton outfall structures in excess of orders
Jan-97
Jun-97
Nov-97
Apr-98
Sep-98
Feb-99
Jul-99
Dec-99
May-00
Oct-00
Mar-01
Aug-01
Jan-02
Jun-02
Nov-02
Apr-03
Sep-03
Feb-04
Jul-04
Dec-04
May-05
Oct-05
Mar-06
Aug-06
Jan-07
Jun-07
Nov-07
Apr-08
Sep-08
Feb-09

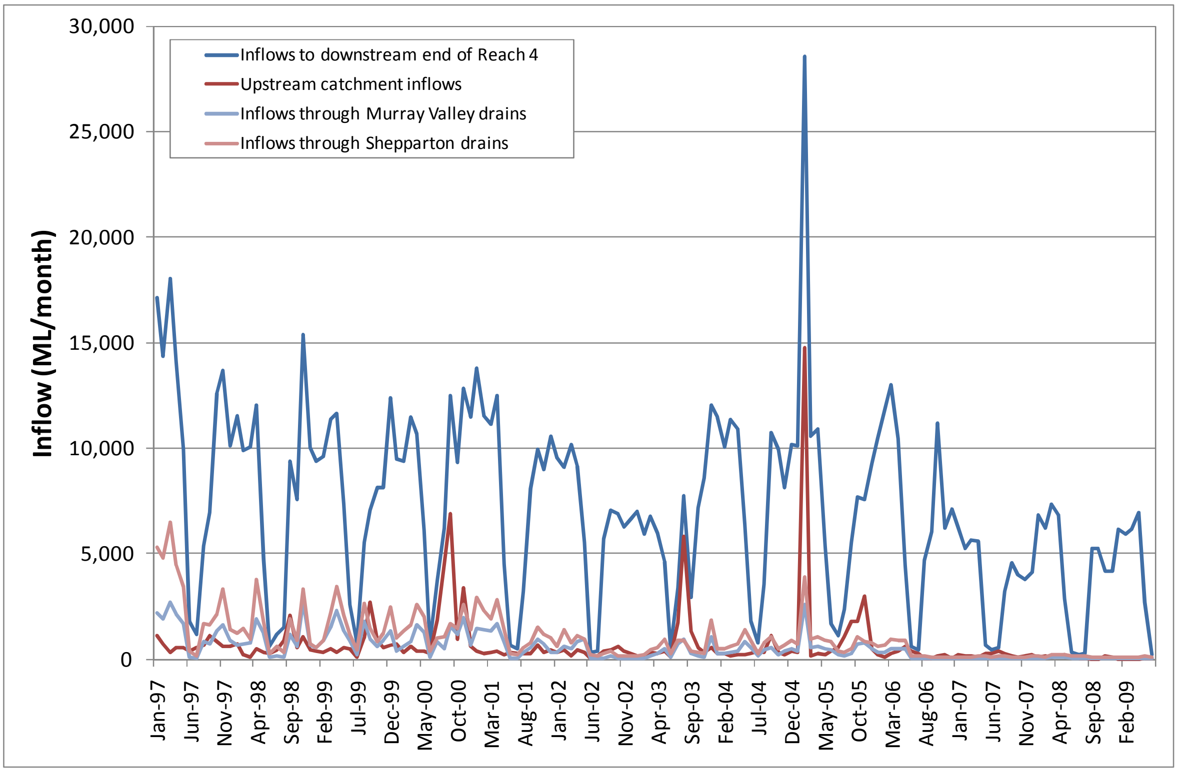

30,000
25,000
20,000
15,000
10,000
5,000
0
Inflow (ML/month)
Inflows to downstream end of Reach 4
Inflows ordered through Shepparton outfall structures (by diverters)
Inflows ordered through Shepparton outfall structures (by IVT/Environment)
Jan-97
Jun-97
Nov-97
Apr-98
Sep-98
Feb-99
Jul-99
Dec-99
May-00
Oct-00
Mar-01
Aug-01
Jan-02
Jun-02
Nov-02
Apr-03
Sep-03
Feb-04
Jul-04
Dec-04
May-05
Oct-05
Mar-06
Aug-06
Jan-07
Jun-07
Nov-07
Apr-08
Sep-08
Feb-09

E.3 Inflows through Murray Valley and Shepparton drains

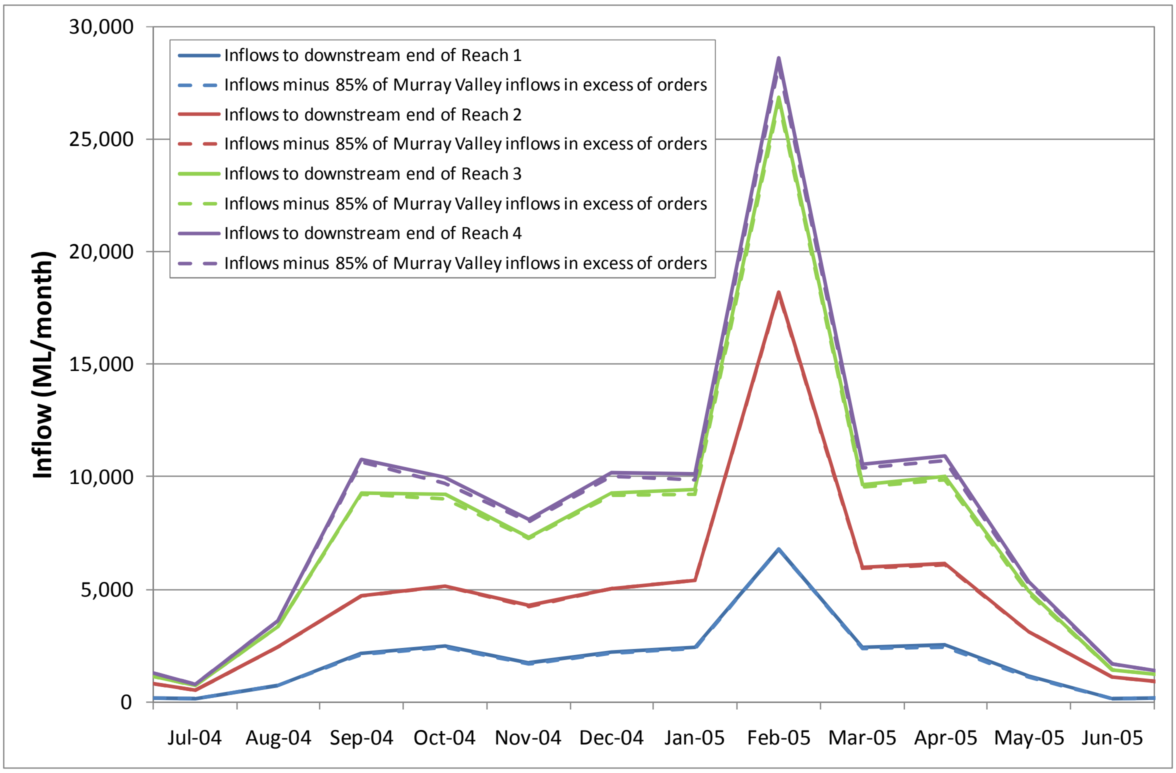


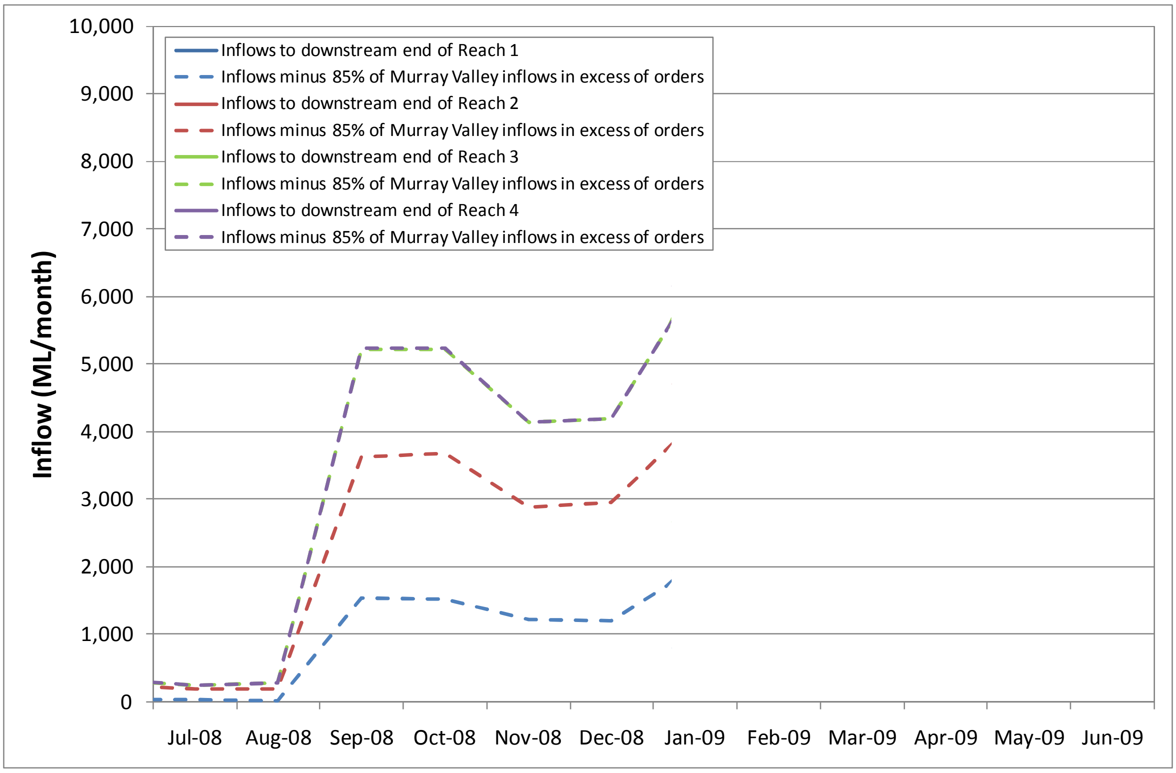

20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Inflow (ML/month)
Inflows to downstream end of Reach 2
Upstream catchment inflows
Inflows through Murray Valley drains
Inflows through Shepparton drains
Jan-97
Jun-97
Nov-97
Apr-98
Sep-98
Feb-99
Jul-99
Dec-99
May-00
Oct-00
Mar-01
Aug-01
Jan-02
Jun-02
Nov-02
Apr-03
Sep-03
Feb-04
Jul-04
Dec-04
May-05
Oct-05
Mar-06
Aug-06
Jan-07
Jun-07
Nov-07
Apr-08
Sep-08
Feb-09


30,000
25,000
20,000
15,000
10,000
5,000
0
Inflow (ML/month)
Inflows to downstream end of Reach 3
Upstream catchment inflows
Inflows through Murray Valley drains
Inflows through Shepparton drains
Jan-97
Jun-97
Nov-97
Apr-98
Sep-98
Feb-99
Jul-99
Dec-99
May-00
Oct-00
Mar-01
Aug-01
Jan-02
Jun-02
Nov-02
Apr-03
Sep-03
Feb-04
Jul-04
Dec-04
May-05
Oct-05
Mar-06
Aug-06
Jan-07
Jun-07
Nov-07
Apr-08
Sep-08
Feb-09


Inflows to downstream end of Reach 4
Upstream catchment inflows
Inflows through Murray Valley drains
Inflows through Shepparton drains
Inflow (ML/month)
30,000
25,000
20,000
15,000
10,000
5,000
0
Jan-97
Jun-97
Nov-97
Apr-98
Sep-98
Feb-99
Jul-99
Dec-99
May-00
Oct-00
Mar-01
Aug-01
Jan-02
Jun-02
Nov-02
Apr-03
Sep-03
Feb-04
Jul-04
Dec-04
May-05
Oct-05
Mar-06
Aug-06
Jan-07
Jun-07
Nov-07
Apr-08
Sep-08
Feb-09

Appendix F NVIRP Impacts – 2004/05 and 2008/09





Annual Environmental Watering Plan 2008-09

For Period 1 July 2008 – 30 June 2009

Last updated 18 September 2008

Version 1.4

Table of Contents

Introduction

The Living Murray (TLM) was established in 2002 in response to evidence that the health of the River Murray system is in decline. In November 2003 the Murray Darling Basin Ministerial Council announced its historic Living Murray First Step Decision. An additional average of 500 GL of water per year (to be recovered by June 2009) and a structural works program are to be delivered as part of this decision. The Living Murray's First Step focuses on the achievement of agreed ecological objectives at six 'icon sites' along the River with this combination of 'water and works'. The six icon sites are:

- Barmah-Millewa Forest;
- Gunbower-Koondrook-Perricoota Forests;
- Hattah Lakes;
- Chowilla Floodplain, Lindsay-Wallpolla Islands;
- Lower Lakes, Coorong and Murray Mouth; and
- River Murray Channel.

This document is the Annual Environmental Watering Plan (AEWP) 2008-09 (hereafter 'annual watering plan') which focuses on the 'water' delivery, not the works, aspects of TLM. The plan sets out the environmental watering priorities across the River Murray system between 1 July 2008 and 30 June 2009.

The annual watering plan sits within the broader framework of The Living Murray Environmental Watering Plan (TLM EWP) which outlines the policy and management framework for TLM environmental watering. The annual water planning process is responsive to changing water resource conditions, opportunities and environmental priorities throughout the season. Implementation of the AEWP, including any changes to priorities or other aspects of the plan, is recorded separately for reporting purposes at the end of the year.

Infrastructure works and other management actions that contribute towards meeting TLM First Step ecological objectives are detailed in the individual icon site Environmental Management Plans and are supported by the jurisdictions' management plans.

For information about TLM go to http://thelivingmurray.mdbc.gov.au/

1 Environmental watering activities 2007-08 and available carry-over

For the watering period 1 July 2007 to 30 June 2008 16.522 GL (of the available 16.96 GL) was used for the implementation of seven environmental watering actions. The volume of water available for environmental purposes under The Living Murray was less than 1% of that available for consumption. The environmental watering actions undertaken were targeted at critical locations within icon sites and other locations within the River Murray system that will provide a material benefit to achieving TLM objectives. A summary of these actions and their net water use is provided in Table 1.

Table 1: Environmental watering activities 2007-08

Icon Site/Site	Watering Action	Volume Allocated (of 16.96 GL available)	Benefit	Volume of water used to 30 June 08
RMC	Pumping to Wetlands below Lock 1 to mitigate acidification	Revised to 1.5 GL*	Prevent irreversible damage to some wetlands	1.5GL
CLW	Watering critical drought refuge sites at Chowilla	Revised to 2.3 GL*	Contribute to maintaining river red gums, black box, other high priority vegetation, wildlife; provide drought refuge	2.28 GL
BMF	Replenish small permanent wetlands	0.5 GL	Sustain populations of Southern Pigmy Perch.	0.125 GL
Wakool	Replenishing waterhole refuges to maintain fish populations in the Wakool River system	6 GL (plus additional 24 GL NSW Stock & Domestic)	Survival of local fish populations (including iconic, vulnerable and endangered species)	6 GL
CLW	Watering critical drought refuges at Lindsay-Wallpolla	Up to 4 GL (plus additional 2.5 GL of Murray FFE[1])	Contribute to maintaining river red gum communities, and providing drought refuge for birds, frogs, tortoises and understorey communities.	4 GL
GKP	Watering wetlands in Gunbower.	Up to 2 GL (plus additional 5.7 GL of Murray FFE[1])	Contribute to providing critical drought refuge for colonial waterbirds and Murray cod in Gunbower Creek	2 GL
Banrock Wetlands	Replenishment of wetlands in the Ramsar listed Banrock Wetlands in SA	0.617 GL (plus an additional 0.215 GL donated by Hardy Wines)	Recharging soil moisture and the freshwater lens in the Banrock wetland complex to maintain riparian vegetation, including River Red Gums.	0.617 GL
	TOTAL	**16.917 GL**		**16.522 GL**

[1] Victoria Flora and Fauna Entitlement

The net use against each 2007-08 allocation is presented in Table 2. A volume of 0.438 GL of River Murray Increased Flows (RMIF) was not used in 2007-08. The interim RMIF rules allow for this water to be carried over for use in 2008-09.

Table 2: Summary of water use in 2007-08

Environmental Water Entitlement	Volume available in 2007-08	Volume used	Volume remaining
RMIF	12.8 GL	12.362 GL	0.438
SA Securing Government held water for environmental use*	4.16 GL	4.16 GL	0
Victoria – Goulburn Murray Water Package – Part A*	0 GL	0 GL	0
TOTAL	**16.96 GL**	**16.522 GL**	**0.438GL**

*These water products were only available for use under TLM EWP following the Ministerial Council decision on 7 March 2008.

1.1 River Murray System Water Resource Outlook for 2008-09

The Basin has experienced its 4th driest autumn on record in 2008. As a result, Murray system inflows in autumn approached the record low levels experienced in the previous year. The dry weather has continued in the southern half of the Basin and the monthly inflows for June 2008 set a new record low of only 95 GL, compared with 220 GL in June 2007 and a long term average of 680 GL. Similarly, inflows into Snowy Hydro's storages in the Snowy Mountains remain extremely low and their storage levels are similar to the record lows observed at this time last year.

Inflows during the 2007-08 season were generally higher compared with the record lows of 2006-07, but were still well below average levels (Figure 1).

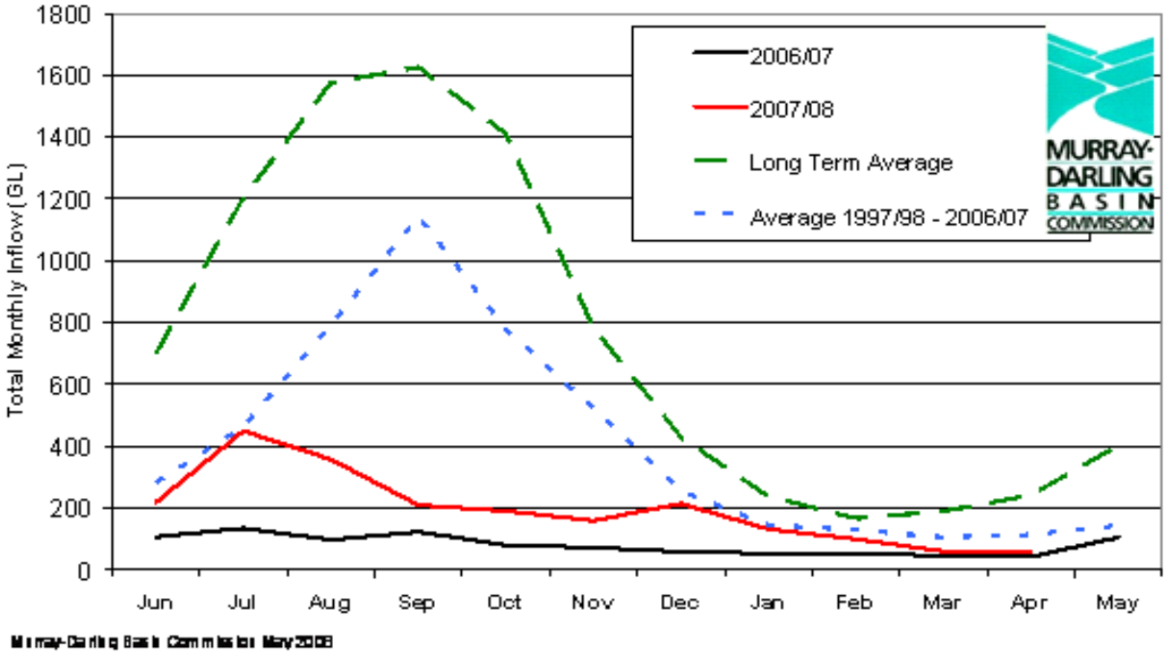


Figure 1 Inflows to the River Murray system (excluding the Darling and Snowy) in selected years for comparison

As at 11 June 2008 the active storage volume for the River Murray system was 1,176 GL (14%). This is higher compared with the same time last year (740 GL) but remains well below the long term average storage level (Figure 2).

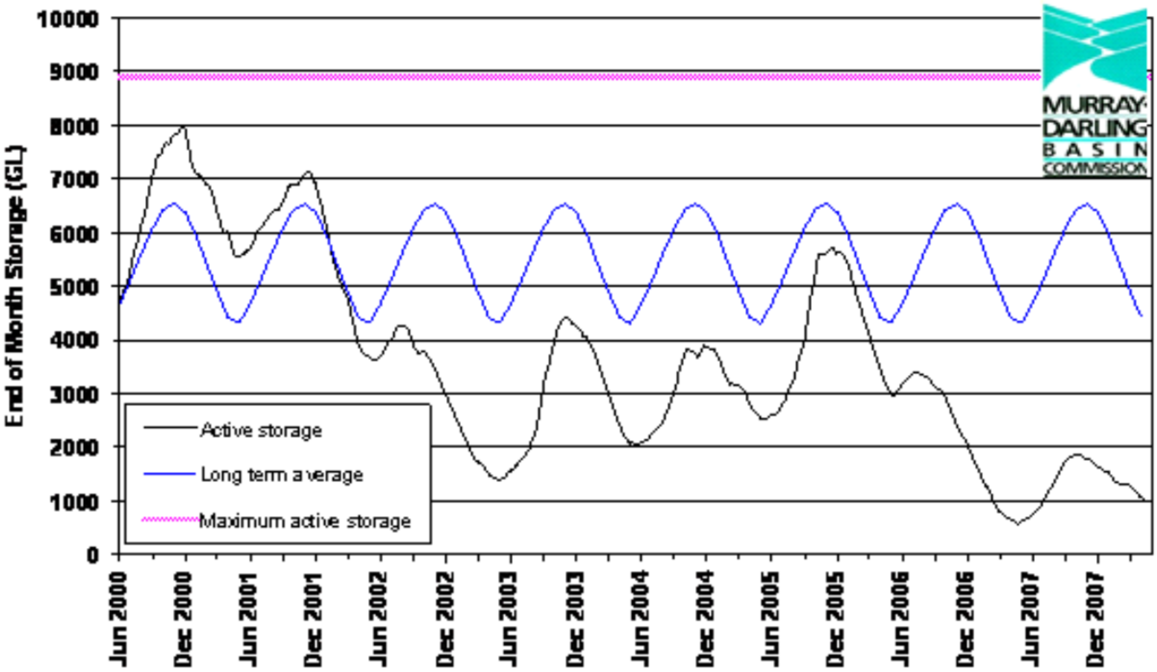


Figure 2.Comparison of active, long term average and maximum active storage levels in the River Murray system.

The prospects for irrigation allocations in 2008-09 are entirely dependent on an improvement in system inflows during winter and spring, which is the critical period for runoff in the upper Murray and its tributaries. The current situation is reflected in the opening State irrigation allocations for 2008-09 which are between 0 and 2 %.

The most recent seasonal climate outlook issued by the Bureau of Meteorology shows a shift in the odds favouring drier than average conditions across the Murray-Darling Basin from July to September. The chances of exceeding median rainfall are only about 40 % for the high yielding catchments in the Victorian Alps and Snowy Mountains, and only 30 to 40 % over South Australia, western Victoria and south-western New South Wales.

Overall, the drought in the Murray-Darling Basin is getting worse. The chance that upper Murray inflows will experience above average rainfall for the remainder of winter and spring is very low.

1.2 System-wide operating strategy for 2008-09

The Murray Darling Basin Commission has been working closely with partner governments throughout the unprecedented drought to develop contingency plans to manage water supplies.

In view of the ongoing extreme conditions, contingency measures will continue to be applied until critical urban, stock and domestic water requirements for 2008-09 are guaranteed. As at 13 May 2008 these critical water requirements were reasonably assured, though not guaranteed.

Under the ‘worst case’ scenario some additional contingency measures beyond those used in 2007-08 may be required, involving Menindee Lakes, the tributaries, Lake Mulwala and other in-river storages.

At the start of the 2008-09 water season the message remained that there is ‘a long way to go’ to break the current drought.

2 Environmental water allocations in 2008-09

2.1 The Living Murray Environmental Water

The Living Murray water is being recovered as part of the TLM First Step decision and managed in accordance with the Intergovernmental Agreement on Addressing water over-allocation and achieving environmental objectives in the Murray-Darling Basin (the MDB-IGA) and The Living Murray Business Plan. TLM water is managed toward meeting the agreed ecological objectives across the icon sites.

At the beginning of the 2008-09 season, there was 133 GL listed on the TLM water recovery Environmental Water Register (EWR). However, the actual volume of water available against these entitlements is dependent on state irrigation allocations. Opening state irrigation allocations are very low or zero at the beginning of the season but may increase if conditions improve.

A summary of environmental water entitlements for management under The Living Murray Environmental Watering Plan, along with the available volumes in 2008-09, are outlined in Table 3. Additional details regarding River Murray Increased Flows (RMIF) and the Barmah-Millewa EWA are outlined in the following two sections.

Table 3 Summary of entitlements and allocations for TLM Environmental Watering Plan in 2008-09

Product		Entitlement (GL)	Reliability (H/M/L)	Opening allocation (as at 1 July 08)	Allocation as of 18 August 2008	Volume (GL) available as at 18 September 2008
TLM Water	Victoria – Goulburn Murray Water Package – Part A *(interim listing)*	120	Low reliability	0%	0%	0
	Pilot Environmental Water Purchase project	13.102	Comprises a range of entitlements with different levels of reliability	0%	0%	0
	SA Securing Government held water for environmental use	13	High	2%	6%	1.43
RMIF		Annual volume advised by 30 April each year	Low*	0.438**	na	0.438
BMF EWA* **		100 50	High Low	0	0	0
TOTAL						**1.868**

* The delivery of RMIF from the Snowy makes reliability low.
**This is a volume in GL and is comprised only of carry-over from 2007-08
*** This entitlement is managed by NSW and VIC in accordance with the BMF EWA operating rules and contributes to achieving the icon site objectives for the Barmah-Millewa Icon SIte

Further information on TLM water recovery can be found at:
http://thelivingmurray.mdbc.gov.au/programs/water_recovery

2.2 River Murray Increased Flows (RMIF)

River Murray Increased Flows (RMIF) is water recovered under investment in the Snowy Joint Government Enterprise and is managed under the TLM framework. Under the Snowy Water Inquiry Outcomes Implementation Deed, New South Wales (NSW), Victoria (VIC) and the Commonwealth government are committed to providing a total of 282 GL by 2012 for environmental purposes. This consists of 212 GL for the Snowy River and 70 GL for the Murray River.

The volume of RMIF delivered from the Snowy Mountains Scheme to the Murray is advised on 30th April each year. No new allocation is available yet for the 2008-09 period. However, 0.438 GL of RMIF was carried over from 2007-08 to 2008-09 (refer section 2).

2.3 Barmah-Millewa Forest Environmental Water Allocation

The Barmah-Millewa Forest Environmental Water Allocation (BMF EWA) is a significant state-based (NSW & Victorian) EWA for the Barmah-Millewa Forest. The ecological objectives of the BMF EWA and TLM's First Step for Barmah-Millewa Forest are complementary.

The Murray Darling Basin Ministerial Council agreed at Meeting 42 – 25 May 2007 to adopt revised Operating Rules for the BMF EWA. Annual allocation of entitlement to the BMF EWA is supplied equally by NSW and Victoria and consists of two components:

- 100 GL high security allocation - This allocation has the same reliability as Victoria's Water Right or High Reliability Water Share along the Murray. High security allocations are made throughout the season as Victoria's allocations are announced; and
- 50 GL lower security allocation - This allocation is allocated when total unregulated inflow to Hume Reservoir for preceding months exceed defined triggers. Low security allocations made after July can not be reduced and cannot be increased after December.

The BMF EWA revised Operating Rules (effective 1 July 2007) specify rules for the accounting, storage and release of the BMF EWA, including provisions for borrow and payback for consumptive and other environmental uses.

As at 1 July 2008 the account balance of the BMF EWA is on loan to NSW and Victorian irrigators and will be repaid in accordance with the revised Operating Rules.

2.4 Other state-based Environmental Water Allocations

There are other state-based EWA's for the Murray River. These entitlements are managed through State based environmental water planning processes. In previous years, there have been opportunities to supplement TLM watering activities with these allocations to achieve Icon Site outcomes. Examples of other environmental entitlements include the NSW Murray Wetlands EWA (30 GL/year) and Moira Lakes savings (2.027 GL/year), and the Victorian Flora and Fauna Entitlement (27.6 GL/year).

2.5 River Murray Unregulated Flows (RMUF)

RMUF is defined as: the volume of water which cannot be captured in Lake Victoria (due to either the lake being full or flow exceeding the lake's inlet capacity) that is in excess of the volume notified by SA for the month*.
(* this is normally the minimum volume provided in the Agreement, but it is currently less than the minimum volume due to the severe drought. The volume is calculated on a daily basis as necessary.)

The environment's share of RMUF, available for environmental management, is the volume remaining from the RMUF event after all existing State entitlements/ rights/ obligations have been provided for

The issue of achieving improved environmental outcomes from the management of RMUF remains a priority of the Murray Darling Basin Ministerial Council. To progress this complex matter, both shorter term opportunities and longer term policy issues are being considered separately.

The general TLM principles for the environmental use of River Murray Unregulated Flows in the River Murray system are:

- Based upon RMW declared unregulated flows;
- Consistent with a 'One River' approach' in that the areas of highest environmental need and benefit are given priority;
- Managed in the context of existing obligations and initiatives, and maximisation/optimisation of environmental outcomes;
- Integrate with planned environmental water releases;
- Based upon opportunity and relative environmental priority (as determined by the EWG) where there are competing opportunities; and
- Agreement on a case-by-case basis in real-time.

3 TLM Environmental Watering Priorities in 2008-09

3.1 Prioritising Environmental Watering Actions for use of Water Entitlements

Acknowledging the continuing decline in condition of icon sites as informed by the condition monitoring programs, the continuing drought and very low water availability for 2008-09, the Environmental Watering Group (EWG) continued to adopt the Extreme Dry Objectives applied in 2007-08 to identify critical environmental water requirements.

Proposed watering actions for use of environmental entitlements (refer section 4) were identified by EWG members for key areas of the River Murray system which have a material influence on achieving the objectives of the icon sites. To support assessment of these actions, information was sought in the context of the dry year objectives and criteria to enable prioritisation. The objectives and criteria are:

Primary Objective

- Environmental benefit (in terms of the stated objectives for each site)

Extreme Dry Objectives

- Avoid critical loss of threatened species
- Avoid irretrievable damage or catastrophic events
- Provide refuges to allow recolonisation following drought

Ranking Criteria

- Significance of outcome
- Amount of benefit for the volume of water (including the opportunity to take advantage of other events)
- Risk of not watering – Recovery or not
- Certainty/Likelihood of Benefit

Based on this information, the EWG regularly reviews the watering actions to ascertain if any require immediate intervention. To date, the EWG has agreed that no single action proposed currently has had an urgency that would warrant it being put forward as the first to implement.

Following this review, the EWG recommended to Commission that the small volume of environmental water currently available (1.218 GL) be held in reserve to mitigate any catastrophic environmental risks that may eventuate during the year as a result of the drought. This includes those critical areas identified at icon sites in Table 4 below.

Based on the EWG recommendations, Commission (MDBC 96 – 26 August 2008) agreed to a list of high priority environmental watering actions in Table 4, totalling 31.14 GL. In the event that there are improvements in TLM allocations during the season, these watering actions can now be initiated using the Chief Executive delegation (MDBC92) on advice from the EWG. The delegation approved by MDBC92 gives the Chief Executive and General Manager Natural Resources delegated responsibility to make decisions regarding re-distribution of environmental water between actions within a season at the icon sites on the advice of the Environmental Watering Group. However if new, unforeseen environmental risks emerge through out the year, they will require the approval of EWG before a watering event may be initiated to mitigate these risks.

The EWG will review the criticality of environmental watering proposals and other risks on a monthly basis and provide advice to the CE on whether any environmental water should be allocated. Criticality will be reviewed in the context of the criticality principles, probability of a successful outcome, operational constraints, and any other emerging issues. These issues are likely to change depending on water resource conditions and river operations. The review will also consider icon sites and other areas of the River Murray System[1] that will make a material difference to achieving TLM objectives, particularly in relation to recovery from the drought.

[1] River Murray system includes: the main course of the River Murray and all its effluents and anabranches downstream of Hume Dam to the sea including the Edward-Wakool River system, the Mitta Mitta River downstream of Dartmouth Dam and the Darling River & Great Darling Anabranch downstream of Menindee Lakes

Table 4 – MDBC96 Approved Regulated* Environmental Watering Actions 2008-09

Icon Site	Brief action description & delivery mechanism	Extreme Dry Eligibility Objective - 1,2,3	TLM Objective/ environmental values protected	TLM volume required (GL)	Beneficial timing window (range)	Complimentary works required	Immediate Risk Level - Do actions require water immediately?	Seasonal Risk of Watering	Seasonal Risk of Non Watering
Chowilla	Pump water to existing environmental watering sites (this proposal consists of 20 individual watering actions)	2 - avoid irretrievable loss	Prevent loss of long-lived vegetation including River Red Gums. Protect previous investment. Prevent loss of important flood dependent understorey. Drought refuge for waterbirds. Breeding site for frogs including the EPBC Act listed Southern Bell Frog.	5.355	Spring to Summer for maximum benefit for flora and fauna, but River Red Gums would benefit from watering Aug. - June.	None banks, retaining banks created for last watering of site.	Future requirement	Low	High
Lindsay Wallpolla	Pump water from Murray River to site (this proposal consists of 13 individual watering actions)	2 - avoid irretrievable loss	Water highly stressed river red gums	11.035	Up to Dec, after Feb	None	Future requirement	Low	High
Millewa	Maintain pools in small permanent wetlands known to contain habitat for populations of Southern Pigmy Perch (threatened in NSW) and watering of wetland vegetation (this proposal consist of 2 individual watering actions)	3 - Refuge	Action will provide refuge habitat for threatened fish species and recovery of wetland vegetation following wildfire.	2.25	September - November	Fish species monitoring, regulator operation.	Future requirement	Low	High
Barmah	Open regulators to provide for connecting and top-up of existing remnant pools when flows > 3,500 ML/day downstream of Yarrawonga (this proposal consists of 2 individual watering actions)	3 - Refuge	Protect and maintain habitat for native fish and turtles - one of last refuges in the forest; animals trapped behind regulators in residual pools. Refilling pools will maintain water quality and habitat connectivity in upper reaches of Gulf Creek.	1	Any month	None	Future requirement	May trigger further native fish to enter the creek system or potential for blackwater.	Threatened native fish and turtle fauna lost (Consequence - high for local populations as many fish mature / breeding age adults; Likelihood - almost certain).
Hattah	Pumping (this proposal consists of 1 individual watering action)	2 - avoid irretrievable loss	Water highly stressed RRG; about 94% of RRG in this area are in declining condition or dead, based on Shaun Cunningham et al (2007) assessment of RRG condition. Many in this area are likely to recover if watered.	0.5	Up to December	Parks requesting upgrade to earthern banks. $50,001	Future requirement	Concern regarding community reaction given previous experience.	Critical to health of regumms along chalka creek as they did not get water in the Autumn.
Koondrook	Water Pollack Swamp (118ha) via private irrigation channel in order to maintain wetland vegetation.(this proposal consists of 1 individual watering action)	2 - avoid irretrievable loss	Action will facilitate maintenance and recovery of wetland vegetation, and willl contribute to the maintenance of bird breeding and foraging habitat.	1	September - November	Monitoring, regulator operation.	Future requirement	Low (Unlikely risk of minor impact if bird breeding is triggered and unsustained)	Significant (Likely moderate impact - no wetting phase this year).

*Regulated relates to the use of environmental water entitlements that are managed under the Living Murray Environmental Watering Plan

3.2 Prioritising Environmental Watering Actions for use of River Murray Unregulated Flows

Proposed environmental watering actions for use of River Murray Unregulated Flows (RMUF) for all reaches of the River Murray System[1] (refer Figure 3 below) were identified by jurisdictions to be considered as part of the Living Murray Environmental Water Plan prioritisation process. The RMUF environmental watering priorities identified for 2008-09 by jurisdictions are summarised at river reach level in Table 5.

As each RMUF event varies in magnitude, location, duration and operational opportunities, prioritisation of the environmental watering proposals prior to an event is impractical and will not deliver the best outcome for a 'one river' approach. Thus, decision making for RMUF will need to occur on a real-time basis.

In response to the real-time nature of the prioritisation and decision making, on advice from the EWG, the Commission has adopted a process whereby the priority would be agreed in real-time as the event is emerging. Initial filters, such as location, magnitude and feasibility will be evaluated before prioritisation of the environmental watering actions in Table 5.

The environmental call on River Murray Unregulated Flows in the River Murray system[1] will in principle:

a. Be based upon a River Murray Water declared River Murray Unregulated Flow;
b. Be consistent with a 'One River' approach in that the areas of highest environmental need and benefit are given priority;
c. Recognise existing obligations, initiatives and rights;
d. Maximise/optimise environmental outcomes including integration with planned environmental water releases;
e. Be based upon opportunity and relative environmental priority following ranking criteria agreed by the EWG; and
f. Be agreed on a case-by-case basis in real-time.

To assist prioritisation in a real-time event, the principles adopted for the prioritisation of TLM regulated watering actions (section 5.1 above) will also be applied to the unregulated environmental watering actions, and are therefore incorporated into one real-time prioritisation list (Table 5) In order to facilitate this process, and recognising the critical condition of the Lower Lakes, EWG recommended the following high-level principle to be applied in the first instance:

a. For each RMUF event the material benefit for the Lower Lakes will be assessed before any other environmental asset is considered for prioritisation; and,
b. Deliberately surcharging weir pools for environmental benefit would be a low priority, unless it can be guaranteed that any return flows water will remain available solely for environmental purposes.

Following this initial appraisal, the EWG will apply the ranking criteria as per the regulated prioritisation process for TLM water entitlements (in section 5.1 above) to the environmental watering actions in Table 5. These ranking criteria are:

i. Environmental benefit for the volume of water;
ii. Significance of outcome;
iii. Risk of not applying water; and,

. [1] River Murray system includes: the main course of the River Murray and all its effluents and anabranches downstream of Hume Dam to the sea including the Edward-Wakool River system, the Mitta Mitta River downstream of Dartmouth Dam and the Darling River & Great Darling Anabranch downstream of Menindee Lakes

iv. Certainty/likelihood of benefit.

The decision to implement an RMUF environmental watering action is the responsibility of the relevant jurisdiction in both physically implementing the agreed priority and in allowing the declared RMUF to be used consistent with the identified priorities. Therefore the process could follow that upon EWG advice of the priority watering actions during a real-time RMUF event, the watering actions will be implemented by the jurisdictions directly with the Commission office performing a coordination role. TLM Committee and MDBC will receive notification of the action taken.

The environmental water volumes delivered during an RMUF event will be collated by EWG and reported as part of The Living Murray environmental water reporting. This will enable a more comprehensive understanding of environmental water delivered in the River Murray System.

3.3 Implementation and Delivery

All environmental watering actions undertaken under this plan are required to follow normal processes for ordering and delivery of water managed through River Murray Water. River Murray Water will also work with Icon Site Managers to identify opportunities to optimise delivery of TLM water with consumptive water en route to maximise ecological outcomes.

Figure 3 Reaches of the River Murray System

River Reaches for Unregulated Flows
1 Mitta Mitta River downstream of Dartmouth Dam
2 Hume Dam to Yarrawonga Weir
3 Yarrawonga Weir to Barmah
4 Barmah to Torrumbarry Weir
5 Edward River upstream of Stevens Weir
6 Edward River Stevens Weir to Moulamein
7 Torrumbarry Weir to Barham
8 Edward River Moulamein to Leiwah
9 Barham to Swan Hill
10 Edward River Leiwah to Wakool Junction
11 Swan Hill to Murrumbidgee Junction
12 Murrumbidgee Junction to Wentworth Weir
13 Darling River Menindee Lakes to Wentworth Weir
14 Wentworth Weir to S.A. border

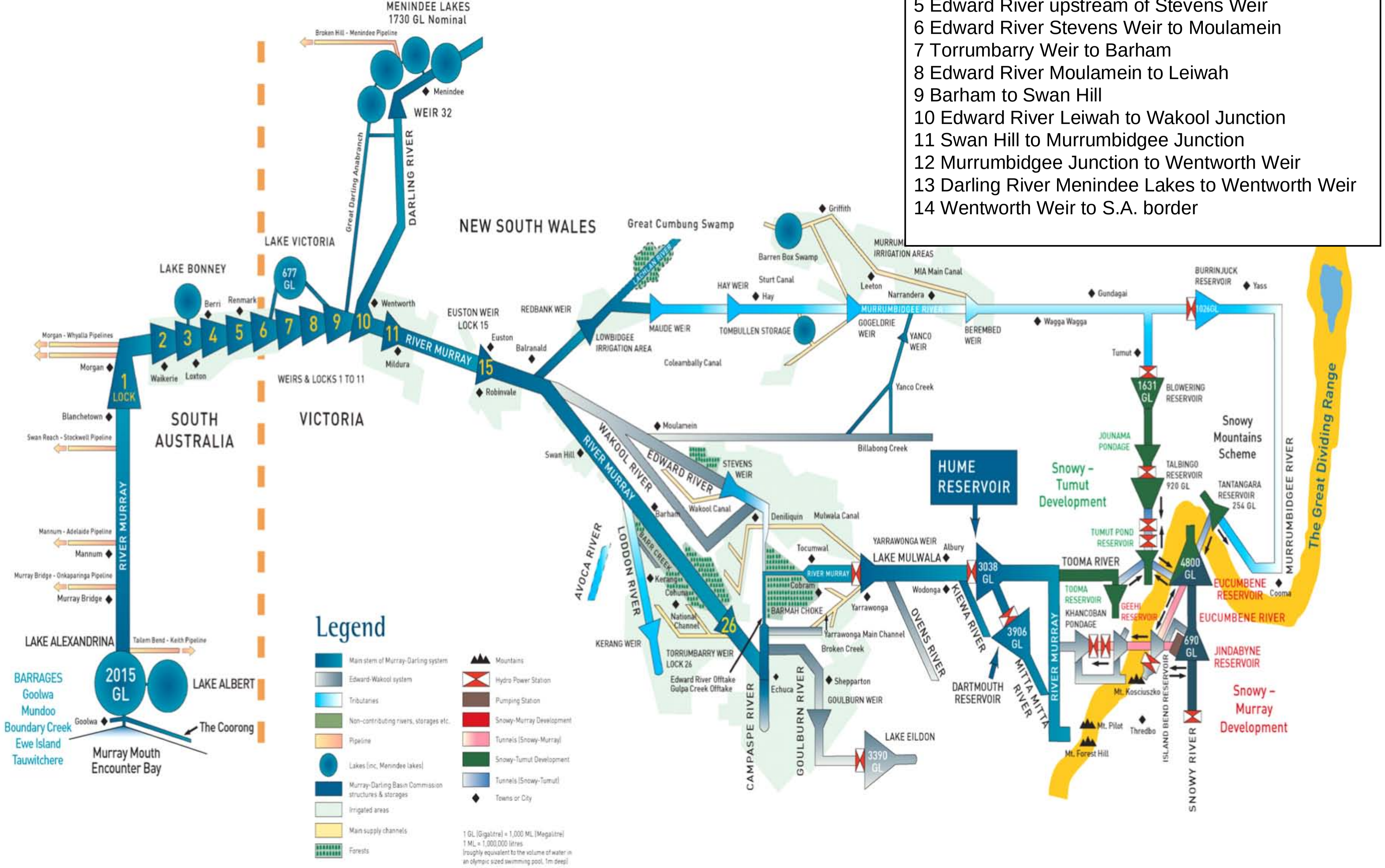


Table 5 – Proposed Environmental Priorities for use of River Murray Unregulated Flows, by River Reach, for 2008-09

River Reach (1-15)	River Reach Name (refer map of reaches Attachment C)	Number of Proposed Actions	Location Descriptions (Icon Site, Ramsar Wetland, other significant feature)	Criticality Criteria 1,2,3	Environmental Objective	Indicative Preferred Volume 2008-09 (GL)
2	Hume to Yarrawonga Weir	1	Riparian zone Hume to Yarrawonga	2 - Avoid irretrievable loss 3 - Refuge	●Protect loss of 250 ha of wetland vegetation	To be determined
3	Yarrawonga Weir to Barmah	8	Barmah-Millewa Icon Site and other wetlands	1 - Avoid critical loss of threatened species 2 - Avoid irretrievable loss 3 - Refuge	●Provide refuge habitat for threatened fish and other aquatic species (for example turtles) ●Maintain colonial bird breeding habitat ●Water highly stressed river red gum communities	10.65
4	Barmah to Torrumbarry Weir	No identified actions				0
5	Edward River upstream to Stevens Weir	1	Barmah-Millewa Icon Site	3 - Refuge	●Assist recovery of wetland vegetation and provide drought refuge	2
6	Edward River Stevens Weir to Moulamein	1	State Forest	3 - Refuge	●Facilitate recovery of wetland vegetation and provide drought refuge	0.6
7	Torrumbarry Weir to Barham	4	Gunbower-Koondrook-Perricoota Icon Site	1 - Avoid critical loss of threatened species 3 - Refuge	●Facilitate recovery of wetland vegetation ●Provide drought refuge for birds, fish and frogs ●Maintain healthy river red gum communities	21.5
8	Edward River Moulamein to Leiwah	No identified actions				0
9	Barham to Swan Hill	2	Wetlands	1 - Avoid critical loss of threatened species	●Protect national threatened Murray Hardyhead populations	1.6
10	Edward River Leiwah to Wakool Junction	No identified actions				0
11	Swan Hill to Murrumbidgee Junction	5	State Forest and other wetlands	1 - Avoid critical loss of threatened species 2 - Avoid irretrievable loss	●Water highly stressed river red gum communities ●Maintain refuges for fish populations, including Murray Cod	4
12	Murrumbidgee Junction to Wentworth Weir	18	Hattah Lakes Icon Site, State Forest and other wetlands	1 - Avoid critical loss of threatened species 2 - Avoid irretrievable loss	●Water highly stressed river red gum communities ●Maintain refuges for fish populations, including Murray Hardyhead	11.82
13	Darling River Menindee Lakes to Wentworth Weir	3	Chowilla-Lindsay-Wallpolla Icon Site	2 - Avoid irretrievable loss	●Water highly stressed river red gum communities	3.075
14	Wentworth Weir to South Australian Border	7	Chowilla-Lindsay-Wallpolla Icon Site and other wetlands	2 - Avoid irretrievable loss	●Water highly stressed river red gum communities	4.7
15a*	South Australian Border to the Lower Lakes	59	Chowilla-Lindsay-Wallpolla Icon Site, Ramsar wetlands and other wetlands	1 - Avoid critical loss of threatened species 2 - Avoid irretrievable loss 3 - Refuge	●Water highly stressed vegetation communities including river red gums and black box ●Mitigate increasing salinisation of floodplains and wetlands ●Maintain refuges for fish and waterbird populations ●Maintain critical habitats for threatened species, including the EPBC listed southern bell frog and Murray cod populations	35.664
15b*	Lower Lakes, Coorong & Murray Mouth	1	Lower Lakes, Coorong & Murray Mouth	2 - Avoid irretrievable loss	●Avoid catastrophic acidification of the Lower Lakes	Any
					TOTAL (Not including volumes for Lower Lakes, Coorong & Murray Mouth)	**95.609**

*note reach 15 is usually the South Australian Border to the Murray Mouth. However, for the purpose of this exercise it is appropriate to separate the Lower Lakes due to the required volumes that are orders of magnitude larger than other wetlands in this reach

4 Ecological monitoring for TLM

The Living Murray Environmental Monitoring program delivers the requirements of The Living Murray Business Plan relating to monitoring and evaluating the achievement of the environmental objectives. These objectives are identified in The Living Murray Environmental Management Plans for each icon site. A monitoring framework titled the Outcomes Evaluation Framework (OEF) has guided the development of the monitoring and evaluation arrangements. This framework outlines the types of monitoring undertaken in The Living Murray. These are River Murray system, condition, intervention and compliance monitoring and knowledge generation. A key principle of TLM monitoring is to use information from monitoring in an adaptive management sense to optimise the approaches to achieving positive ecological outcomes for the River Murray system.

The Living Murray Environmental Monitoring program coordinates with other MDBC programs including the Sustainable Rivers Audit, Native Fish Strategy and Natural Resources Information, to provide a coordinated approach to monitoring across the Murray-Darling Basin.

The priority areas of activity in the TLM Environmental Monitoring Program in 2008-09 include:

4.1 River Murray System scale monitoring

Monitoring and evaluation at the River Murray System scale to determine if the health of the River Murray System improves following implementation of the First Step Decision. The questions addressed by monitoring at this scale differ from those of the Sustainable Rivers Audit (SRA), which provides a condition assessment for the Murray-Darling Basin (i.e. the scale is different and hence the design is not tailored to address questions at the River Murray System scale). However, some data collected through SRA will be applicable to the River Murray System and where possible, monitoring at this scale will utilise data collected for the SRA.

4.2 Icon Site condition monitoring

Icon site condition monitoring is to determine the change in the environmental condition of individual Icon sites resulting from water application and implementation of works programs under The Living Murray. Icon site condition monitoring is specifically tailored to determine if the objectives for each icon site are being met. Monitoring and evaluation at the icon site-scale are surveillance in type and typically undertaken on a medium frequency (months to years).

Condition monitoring activities planned for 2008-09 include ongoing monitoring as per the Icon Site Condition Monitoring Plans that have been developed for each icon site. These plans detail the approaches and methods for monitoring the fish, bird and vegetation communities as they relate to the ecological objectives for the site. A core set of consistent approaches to monitoring the condition of fish, birds and vegetation have been developed and agreed across the Icon sites. For example a project is being developed that will assess River Red Gum and Black Box stand condition across the forest Icon sites using remote sensing. This project will link with on-ground tree condition assessments at the icon sites.

4.3 Intervention monitoring

Intervention monitoring assesses the ecological response to ‘types’ of interventions or environmental management actions implemented under The Living Murray. In doing so, it will provide the major link to understanding how the ecological responses to specific environmental management actions result in changes at icon sites. It will also provide the foundation information for adopting an adaptive management approach to implementing The Living Murray. Intervention monitoring will not occur for each watering action, but will be targeted at watering actions, which provide the opportunity to test key hypotheses that evaluate and quantify causes and effects relationships. The information can subsequently be extrapolated to other Living Murray sites.

Event monitoring has become important in managing implementation of environmental watering activities during the drought to inform real-time decision making in relation to achieving ecological outcomes and minimising risks. This monitoring is focussed on the specific objectives of the environmental watering event, or to avoid risks, and is targeted in time and spatial scale.

The process for event monitoring will need to be responsive to the environmental watering plan, including recognition that speedy resourcing and implementation will be required. The trigger for event monitoring will be impacted by the water available for environmental watering, and it is possible that events may not be monitored or monitoring will need to be prioritised. Reporting processes for event monitoring will recognise the level of monitoring undertaken.

4.4 Compliance monitoring

Compliance monitoring assists TLM meet its obligations concerning monitoring against certain environmental management actions and to determine if actions, works or measures are implemented in the manner intended. Measuring the volume of water used at Icon sites and the timing, volume and quality of any return flows, is needed to account and report for the use and management of environmental water.

Compliance monitoring determines if the works and water regime at an icon site have been undertaken as agreed. Specifically, compliance monitoring will ensure:

- the MDBC and partner governments are meeting legal obligations in regard to certain environmental watering actions;
- works and measures are being implemented and operated as outlined in the investment proposals;
- any negative environmental impacts/risks that may occur as a result of interventions are measured, specifically electrical conductivity (EC), black water events and blue green algal blooms in areas that are connected to the river, or in water that is to be released back into the river; and
- environmental water applied/used at the Icon sites is accounted for.

There are a number of existing long-term projects funded by the MDBC that provide data and information within and around the Icon sites. The compliance monitoring program for TLM will where appropriate draw upon this information.

River Murray system scale monitoring and icon site condition monitoring relate to reporting over a long time period. In terms of monitoring the annual watering actions intervention monitoring and compliance monitoring are designed to provide specific information on watering actions.

5 Accounting for TLM environmental watering

TLM Business Plan states the following in relation to accounting for environmental water use:

“All uses of environmental water will be managed and accounted consistent with the Living Murray Environmental Watering Plan.” (Annex E, paragraph 44); and

"…the actual volumes delivered to each icon site will be accounted for and reported on an annual basis and will include;

- how much water was released for each icon site;
- how much was delivered to each icon site;
- how much was used (i.e. consumed in the application to that icon site);
- how much water was returned to the River Murray Channel; and
- the net use of the environmental account." (Annex E, paragraph 47).

The Living Murray Environmental Watering Plan outlines the main components of, and current procedures for environmental water accounting including:

- *Measurement* – assess the volume of water used at an Icon Site and where possible estimates the return flow;
- *Rules* – the arrangements for managing environmental entitlements including their storage, spill, delivery and use; and
- *Reporting* – communication of the status of environmental water accounts, either before, during or after use of environmental allocations.

6 Reporting on TLM environmental watering

Reporting requirements for environmental watering are detailed in *TLM Business Plan*. Specific requirements for reporting against the annual environmental watering actions include:

- environmental management actions at icon sites during the previous year;
- volumes and timing of water application;
- progress with achieving environmental objectives for icon sites; and
- consultation activities undertaken during the year.

Information is provided throughout, and at the end of the season by icon site Managers on the status and outcomes of any environmental watering at the icon sites. This information is included in the Annual Environmental Watering Report.

Australian Government

MURRAY–DARLING BASIN AUTHORITY

MURRAY-DARLING BASIN AUTHORITY

The Living Murray
Annual Environmental Watering Plan 2009–10

The Living Murray
Annual Environmental Watering Plan 2009–10

Published by Murray-Darling Basin Authority
Postal Address GPO Box 1801, Canberra ACT 2601
Office location Level 4, 51 Allara Street, Canberra City
Australian Capital Territory

Telephone (02) 6279 0100 international + 61 2 6279 0100
Facsimile (02) 6248 8053 international + 61 2 6248 8053
E-Mail info@mdba.gov.au
Internet http://www.mdba.gov.au

For further information contact the Murray-Darling Basin Authority office on (02) 6279 0100

This report may be cited as: *The Living Murray Annual Environmental Watering Plan 2009-10*, Murray-Darling Basin Authority.

MDBA Publication No. 28/09

ISBN 978-1-921557-32-3

Front cover image: Doctor's Swamp 2008-Keith Ward.

CONTENTS

1. INTRODUCTION

The Living Murray (TLM) was established in 2002 in response to evidence that the health of the Murray River system[1] is in decline. In November 2003 the Murray–Darling Basin Ministerial Council announced its historic Living Murray First Step Decision. An additional average of 500 GL of water per year (to be recovered by June 2009) and a structural works program are being delivered as part of this decision. The Living Murray's First Step focuses on the achievement of agreed ecological objectives at six 'icon sites' along the River Murray with a combination of 'water and works'. The six icon sites are:

- Barmah–Millewa Forest
- Gunbower–Koondrook–Perricoota Forests
- Hattah Lakes
- Chowilla Floodplain, Lindsay–Wallpolla Islands
- Lower Lakes, Coorong and Murray Mouth
- Murray River Channel.

The Annual Environmental Watering Plan was established by the TLM Business Plan. This document is the Annual Environmental Watering Plan 2009–10 which focuses on the water delivery aspects of TLM. It has been jointly developed by the Murray-Darling Basin Authority (MDBA) and Environmental Working Group (EWG). The plan sets out the decision framework for prioritising environmental watering actions across the Murray River system between 1 July 2009 and 30 June 2010.

Under the current arrangements post transition from the Murray–Darling Basin Commission the Annual Environmental Watering Plan will be approved by the Chief Executive of the MDBA based on the advice of EWG and The Living Murray Committee. This may change as appropriate arrangements are identified.

The annual water planning process is responsive to changing water resource conditions, opportunities and environmental priorities throughout the season. Implementation of the Annual Environmental Watering Plan, including any changes to priorities or other aspects of the Plan is recorded separately and reported at the end of the year.

For information about TLM go to http://www.mdba.gov.au/programs/tlm

1 Murray River system includes: the main course of the Murray River and all its effluents and anabranches downstream of Hume Dam to the sea including the Edward-Wakool River system, the Mitta Mitta River downstream of Dartmouth Dam and the Darling River and Great Darling Anabranch downstream of Menindee Lakes.

2. ENVIRONMENTAL WATERING ACTIVITIES 2008–09

For the watering period 1 July 2008 to 30 June 2009, 6.728GL (of the available 13,046 GL) was allocated for the implementation of environmental watering actions at the icon sites. The environmental watering actions undertaken were targeted at critical locations within icon sites that would provide a material benefit to achieving TLM objectives. A summary of these actions and the allocated water volumes is provided in Table 1.

Table 1. TLM environmental watering activities 2008–09

Icon Site/Site	Watering Action	Volume committed (GL) (of 12.331 GL available)	Period of watering	Benefit
Barmah–Millewa Forest	Connect and replenish existing remnant pools in Barmah	0.3	Nov '08	Protect and maintain habitat for native fish and turtles; maintain water quality and habitat connectivity in upper reaches of Gulf Creek.
Chowilla Lindsay–Wallpolla	Watering critical drought refuge sites at Chowilla	2.403	Dec'08 – Jan'09 & Apr – May '09	Contribute to maintaining river red gums, black box, other high priority vegetation and wildlife; provide drought refuge
Gunbower–Koondrook–Perricoota	Watering of Pollock Swamp in Perricoota Forest	1	May '09	Maintain wetland vegetation, and contribute to the maintenance of bird breeding and foraging habitat.
Hattah Lakes	Watering of Lake Lockie, Lake Little Hattah and Little Lake Hattah	1	May – Jun '09	Maintain fringing red gum communities and provide drought refuge for water birds
Lower Lakes, Coorong and Murray Mouth (Turvey Drain and Boggy Creek)	Replenish refuges to maintain fish populations	0.025	May – Jun '09	Maintain critical refuge habitat for threatened Murray hardyhead and Southern pygmy perch species in the Lower Lakes
Chowilla Lindsay–Wallpolla	Watering critical drought refuges at Lindsay-Wallpolla	2	May – Jun '09	Contribute to maintaining river red gum communities, and providing drought refuges for birds, frogs, tortoises and understorey communities
	TOTAL	6.728		

Table 2 presents the reliability class of entitlements held by TLM in 2008–09 with their associated entitlement, allocation and net use volumes as well as carry over volumes to 2009–10. A volume of 0.050GL of River Murray Increased flows (RMIF) was not used in 2008–09. The interim RMIF rules allow for this water to be carried over for use until October 2009.

In 2008–09 TLM received 13.046 GL of water against entitlements held on the TLM Environmental Water Register (Table 2). 6.728 GL was allocated for environmental watering actions throughout the water year. As a significant proportion of the TLM water did not become available until later in the year, it has been carried over to 2009–10. Currently only 60% of carryover water is expected to be available on 1 July 2009. Goulburn-Murray Water has stated that the delivery of carryover will depend on the availability of sufficient water to operate distribution systems. It is estimated that the carry over available on 1 July 2009 will be 3.788 GL.

Table 2. TLM Entitlements 2008–09

Entitlement type	Entitlement (GL)	Allocation Available to TLM** (GL)	Use (GL)	Carryover to 2009–10 (GL)	Carryover available 1 July 09 (GL)
NSW High Security	1.597	0.398	0	0.398	0.239
NSW General Security	191.246	9.211	4	5.206*	3.123
NSW Supplementary water	350	0	0	0	0
VIC High Reliability	1.885	0.659	0	0.627****	0.376
VIC Low reliability	247.65	0	0	0	0
SA water licence	34.44	2.34	2.34	0	0
RMIF carried over 2007–08***	0	0.438	0.388	0.050	0.050
TOTAL	826.818	13.046	6.728	6.281	3.788

*a small volume was used to pay back encumbrances.

** some water allocated to entitlements purchased in 2008–09 has been utilised by the previous owner.

***MDBA managed environmental water entitlement (not specifically TLM). This water is permitted to be carried over to October 2009.

****5% transmission loss fee for carryover of allocation against Victorian water entitlements

3. FORECAST 2009–10

3.1 Inflows

Inflows for the 2008–09 water year (June 2008 to May 2009) were the third driest in 118 years of records (Figure 1). Inflows for May 2009 were only 90 GL which is well below the long term average of 390 GL. The persistence and severity of this drought, particularly over the past three years, is unprecedented.

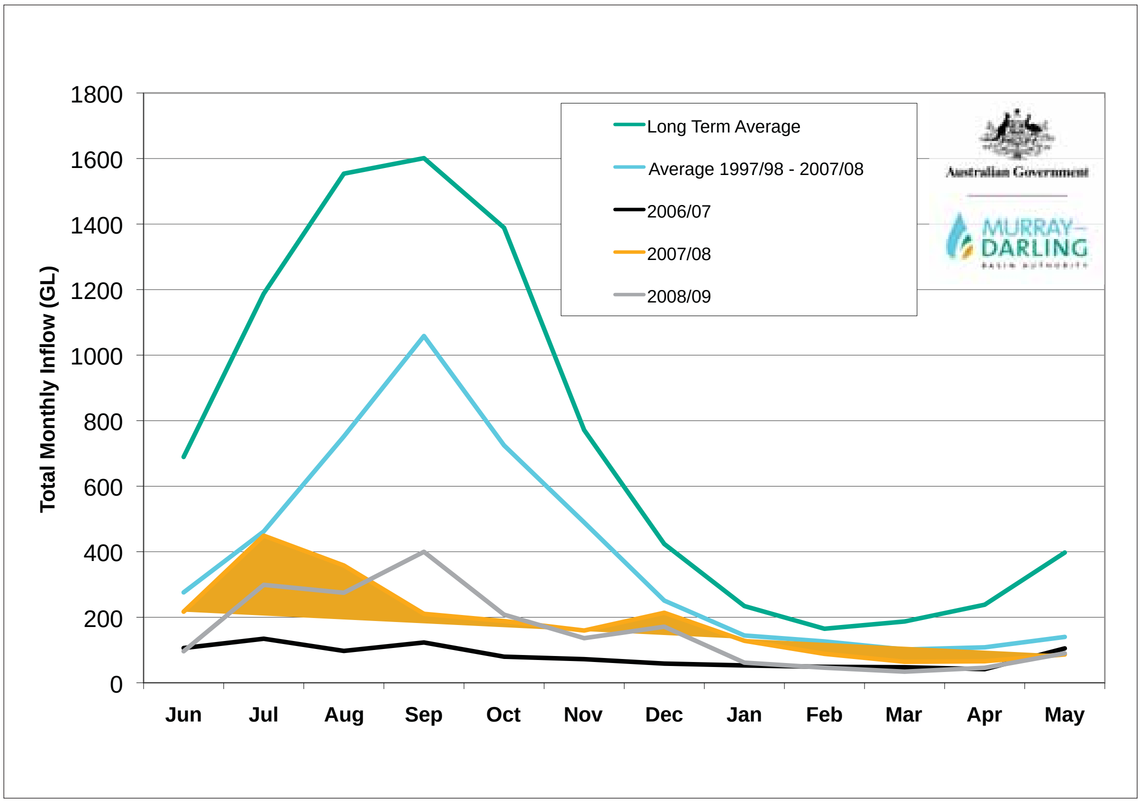


Figure 1. Comparison of inflows to River Murray system (excluding the Darling River and Snowy River) in selected years

3.2 Storage

Total MDBA active storage for the Murray system at the end of May 2009 was 980 GL (11 % of capacity) which is well below the end of May long term average of 4,670 GL (Figure 2). Total storage across the whole of the Murray-Darling Basin also remains low, at about 17 % capacity.

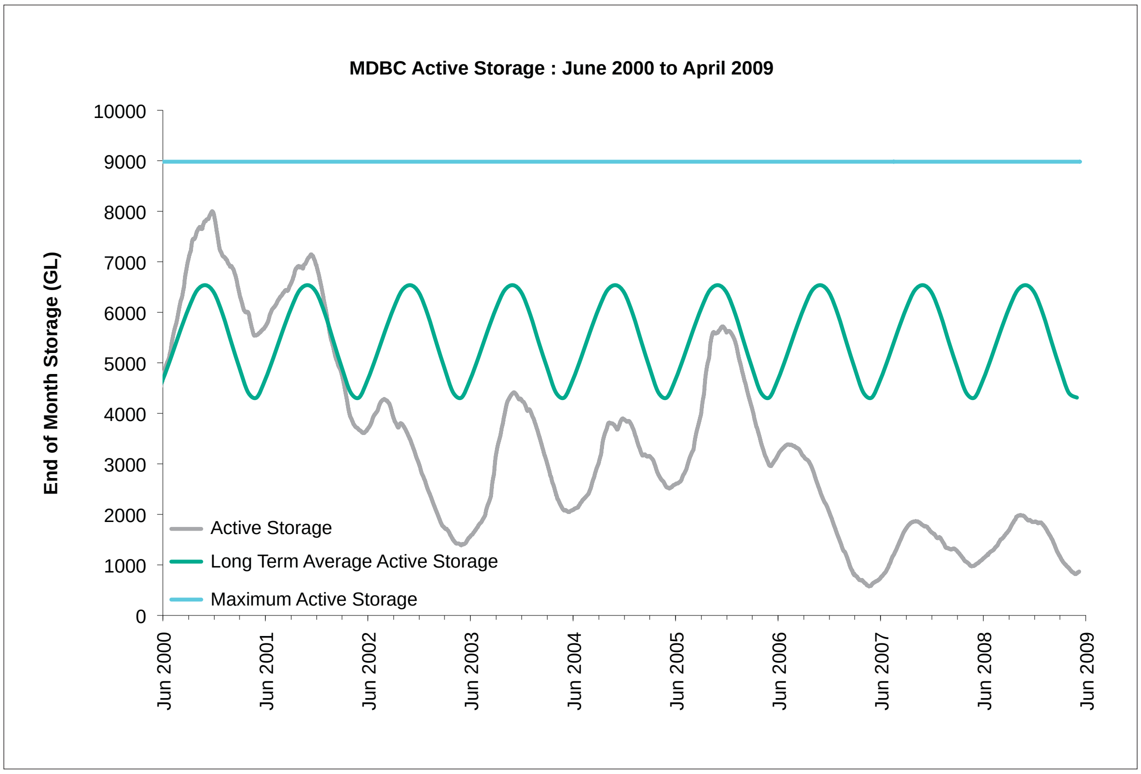


Figure 2. Comparison of active, long-term average and maximum active storage levels in the River Murray system June 2000 to June 2009.

3.3 Outlook

After good falls of rain across the southern Murray-Darling Basin in late April, there was very little follow-up rain in May. Whilst there was also very heavy rainfall in Queensland and northern NSW in May, little is expected to reach the Menindee Lakes due to small stream flow responses and high river transmission losses. As a result, Murray system inflows have remained close to record lows.

The latest rainfall outlook (June to August 2009) issued by the Bureau of Meteorology indicates that for the next three months above average rainfall is about as equally likely as below average rainfall. However, recent trends in Pacific climate patterns, and the latest computer models indicate an increased risk of an El Niño developing during winter and spring. The Indian Ocean Dipole has also become increasingly positive in recent months and this tends to suppress the formation of rain-bearing cloud bands across Australia.

Therefore there will need to be a sustained period of above average rainfall before system inflows show a significant improvement.

3.4 System-wide river operating strategy for 2009–10

The MDBA has been working closely with partner governments throughout the unprecedented drought to develop contingency plans to manage water supplies.

All three south-eastern States have set aside sufficient water to reasonably assure critical human water needs in 2009–10, but the prospects for irrigation will be highly dependent on future rainfall and system inflows. As in 2008–09, access to 'carried over water' may be restricted in early 2009–10.

Overall, the outlook for the beginning of the 2009–10 water year is grim, as was the case for the previous two years.

3.5 Outlook for TLM water entitlements 2009–10

Further entitlements are expected to enter the TLM Environmental Register throughout 2009–10. Table 3 provides estimates of the entitlement volumes and their reliability class.

Table 3. Entitlements expected June 2009–10

Reliability	Entitlement volume (GL)*
Low	267
General	194
High	78
TOTAL	**539**

*Approximate forecasts only. Note the volumes are not Long Term Cap Equivalents.

An estimate of the potential allocations against TLM entitlements in 2009–10 is given in Table 4. This is only an approximate estimate as many of these purchases are yet to be settled. The lower range of figures is based on Goulburn-Murray's outlook for 2009–10 and the higher range is based on allocations similar to 2008–09. As allocations in 2009–10 could vary depending on climatic variability, it is important to note there is potentially a greater range of available water volumes in 2009–10.

Table 4. Forecasted available TLM water 2009–10

Season	Forecasted allocation amounts (GL)	Carryover available (GL)	TOTAL (GL)
Spring 2009	2.5–7	3	6–10
Autumn 2010	25–65	5.57	31–73

4. TLM WATER PLANNING 2009–10

4.1 Regulated Flows

The increasing number of entitlements held by TLM has led to a potentially greater range of allocation volumes available in 2009–10 depending on climatic variability. This range could be expanded further with the possible supplementation of Commonwealth environmental water. Particularly in an extreme dry scenario, this water will need to be delivered as quickly and efficiently as possible to ensure the maximum benefits to the watering sites.

In order to respond to the potential variability in water resources, EWG agreed to utilise a model that outlines management objectives for different water resource scenarios (Table 5). This model is based on principles developed by the Victorian Department of Sustainability and Environment (DSE) and the Commonwealth Department of the Environment, Water, Heritage and the Arts (DEWHA). The ecological objectives for extreme dry/dry/median and wet scenarios outlined in the model provide guidance on how TLM water would be utilised under different flow and climatic conditions.

The primary objective of the Annual Environmental Watering Plan 2009–10 is to provide environmental benefit (in terms of the stated objectives for each site). Regardless of climatic conditions, EWG has agreed to use the following ranking criterion to prioritise between individual watering actions throughout the year. This ranking criterion constitutes the basis of the material benefit test for all watering actions.

Ranking criterion

- Significance of outcome
- Amount of benefit for the volume of water (including the opportunity to take advantage of other events)
- Risk of not watering – recovery or not
- Certainty/likelihood of benefit.

Due to the continuing drought and the forecasted low water availability, EWG adopted the management objectives for the extreme dry water resource scenario to identify critical environmental water requirements for 2009–10. Whilst there is the opportunity to review this during the water year all the proposed watering schedules presently use the extreme dry criteria. A transition to dry criteria would only occur if inflows and icon site conditions improved and/or most of the drought refuge actions had been completed.

The extreme dry objectives are:

- Avoid critical loss of threatened species
- Avoid irretrievable damage or catastrophic events
- Provide refuges to allow recolonisation following drought.

Table 5. Proposed ecological watering objectives under different water resource availability scenarios (*based on principles established by DSE Victoria and DEWHA*)

	Extreme Dry	Dry	Median	Wet
Ecological watering objectives	Avoid irretrievable loss of key environmental assets	Ensure priority river reaches and wetlands have maintained their basic functions	Ecological health of priority river reaches and wetlands have been protected or improved	Improve the health and resilience of aquatic ecosystems
Management objectives	• Avoid critical loss of species, communities and ecosystems • Maintain key refuges • Avoid irretrievable damage or catastrophic events	• Maintain river functioning with reduced reproductive capacity • Maintain key functions of high priority wetlands • Manage within dry -spell tolerances • Support connectivity between sites	• Enable growth, reproduction and small-scale recruitment for a diverse range of flora and fauna • Promote low-lying floodplain-river connectivity • Support medium flow river and floodplain functional processes	• Enable growth, reproduction and large-scale recruitment for a diverse range of flora and fauna • Promote higher floodplain-river connectivity • Support high flow river and floodplain functional processes
Management actions	• Water refugia and sites supporting species and communities • Undertake emergency watering at specific sites of priority assets • Use carryover volumes to maintain critical environmental needs	• Water refugia and sites supporting threatened species and communities • Provide low flow and freshes in sites and reaches of priority assets • Use carryover volumes to maintain critical needs	• Prolong flood/high-flow duration at key sites and reaches of priority assets • Contribute to the full-range of in-channel flows • Provide carry over to accrue water for large watering events	• Increase flood/ high-flow duration and extent across priority assets • Contribute to the full range of flows incl. over-bank • Use carryover to provide optimal seasonal flow patterns in subsequent years

Avoid catastrophic or irretrievable loss & maintain capacity for potential recovery → Improved capacity for recovery → Protect ecological health → Improved health and resilience

In order to prioritise the watering actions, EWG recognised there was a need for a decision framework that could address some of the issues that arose during the 2008–09 water year. These issues included:

- assessment of material benefit to Lower Lakes
- water delivery costs
- possibility to bank water
- potential combination of Commonwealth and TLM water.

These issues have been incorporated into a flexible decision framework that will guide the prioritisation of environmental watering actions in 2009–10 (Table 6). This decision framework provides the focus for the initial prioritisation of environmental watering actions, an assessment of the associated risks and the timeframes for the review of all other potential watering actions. These reviews will compare TLM water availability against the ranking criteria to determine material benefit to all sites including the Lower Lakes. The reviews will consider factors including the availability of other sources of environmental water, conditions at the sites, antecedent and forecasted flows. The flow chart in Figure 3 shows how the issues stated above are incorporated into the process for prioritising environmental water actions.

To be event ready EWG have identified proposed watering actions which align with the decision framework (refer Schedule A, B & C). Schedule A provides a list of refuge sites that require annual or regular watering in order to consolidate the benefits achieved by previous watering events. Schedule B expands the list of critical drought refuge sites (including sites that don't require annual/regular watering) whilst Schedule C includes sites that require larger volumes of water. As outlined in the framework, actions recommended for implementation throughout the year will not be limited to those identified in the schedules to this plan.

During the 2009–10 water year, EWG will review the list of environmental watering proposals at designated periods utilising the process outlined in Figure 3. The availability of other sources of water will be incorporated into these reviews. Based on the outcomes of the review, EWG will provide advice to the MDBA on whether any environmental watering actions should be implemented at that stage.

All watering actions will be implemented in accordance with the decision framework and prioritisation process outlined in the Annual TLM Watering Plan 2009–10. It is proposed that the approval of any environmental watering actions recommended by EWG within icon sites will be delegated to the Executive Director of Natural Resource Management.

Table 6. TLM Environmental Watering Decision Framework

Timing	Decision steps	Water resource scenario	Associated risks
July 2009 initial allocation	0–16 GL prioritise* critical refuge sites that require annual/regular watering to consolidate previous watering events. # Watering actions may include but not be limited to those identified in **Schedule A**.	Extreme Dry Scenario	• Critical drought refuges that have not been watered on a regular basis will be excluded • Water would not be banked for potential larger actions in the future
July – mid-November 2009	Bank any additional water (above 16 GL) to enable a wider scope of watering actions to be considered, including the material benefit to the Lower Lakes. Banking would not be considered if other proposed watering sites could be irretrievably lost during this period.	Extreme Dry Scenario	• Banking could limit the water available for drought refuges • Banking water could delay the watering of critical drought refuges
Mid-November 2009	Review of TLM water availability against the benefit to all sites including the Lower Lakes using the ranking criteria* (this constitutes the basis of material benefit for the Lower Lakes). Factors to be considered include local site conditions/other potential sources of environmental water/antecedent flows/forecasted flows.# Based on the review, EWG to use available water to, EITHER the available TLM water will be banked in order to enable a wider scope of watering actions to be considered in February OR TLM water will be allocated to sites that may include, but not be limited to, those identified in **Schedule B**. OR a combination of banking and use of water	Extreme Dry Scenario Depending on rainfall, icon site condition and the volume of water available, there may be a possibility to incorporate some management objectives of the dry scenario within the prioritisation process if the volumes of water available to TLM increase significantly through the year.	• Banking or larger watering actions could limit the water available for drought refuges • Water may be delivered at a time that does not maximize environmental outcomes • A focus on smaller drought refuges could limit larger watering actions • Banking may not result in sufficient water being accumulated for larger scale future watering actions • Risk associated with carry over
November – February 2009–10	Continue to bank water. Banking would not be considered if other proposed watering sites could be irretrievably lost during this period.	Extreme Dry / Dry Scenario depending on conditions	• Banking could limit the water available for drought refuges • Banking water could delay the watering of critical drought refuges
February 2010 onwards	Review watering actions against the ranking criteria* to allocate water to proposed sites or continue to hold any water if appropriate#	Extreme Dry / Dry Scenario depending on conditions	• As listed above

Note: Exceptions that arise throughout the water year will be reviewed by EWG as required using the process outlined in the decision framework

*Watering actions will be prioritized within this framework using the ranking criteria outlined in this Annual Environmental Watering Plan

The availability of other sources of environmental water will be considered for any proposed watering actions

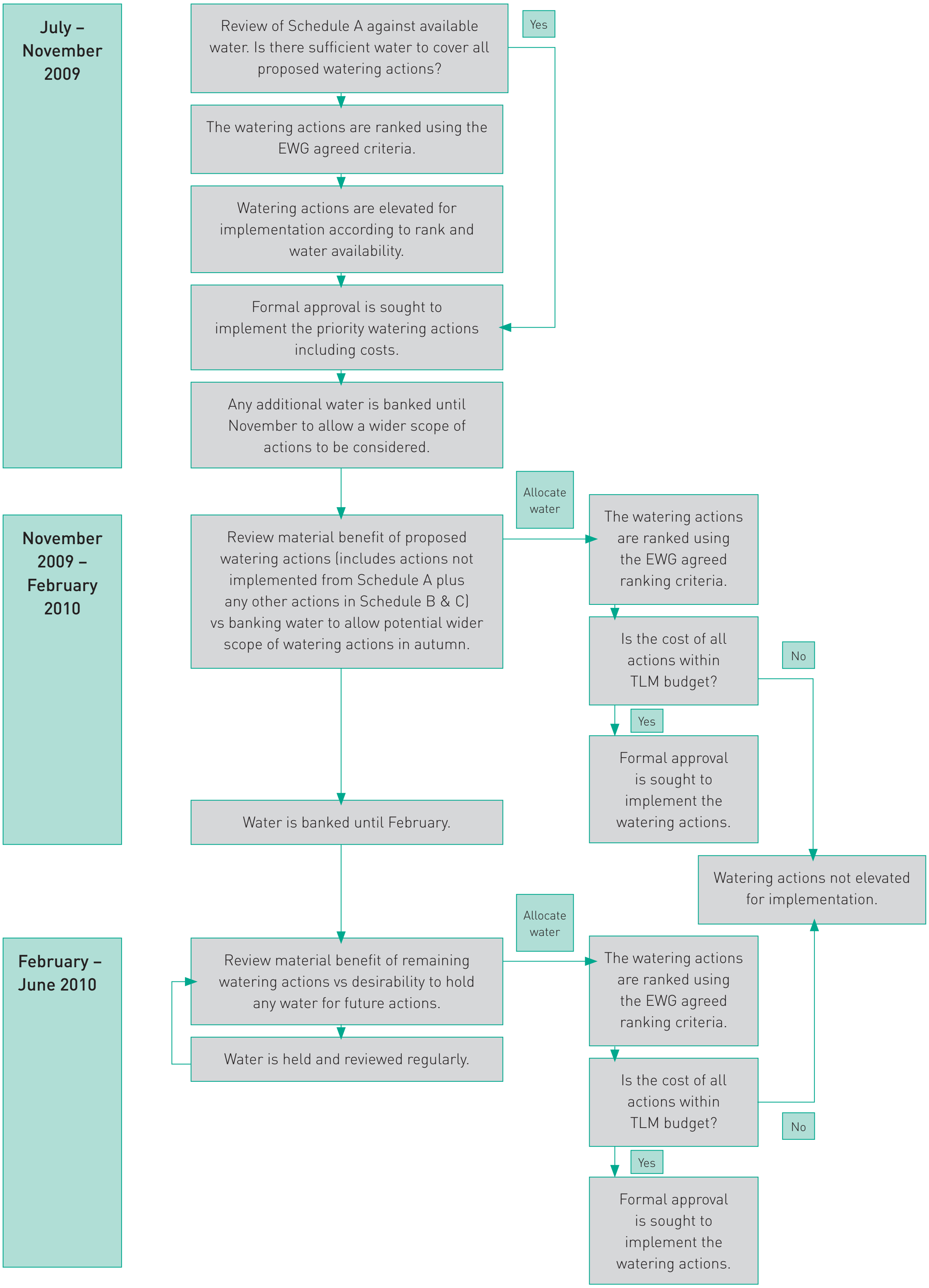


Figure 3. Flow chart of prioritisation process for regulated flows

4.2 River Murray Unregulated Flows

In 2008–09 EWG agreed to trial the prioritisation of environmental watering actions during a River Murray Unregulated Flows (RMUF) event. Although a simulation exercise was held in April – May 2009, there was no opportunity to test this prioritisation process during a real-time RMUF event. Therefore this trial will continue during 2009–10.

As each RMUF event varies in location, duration and operational opportunities, it is not possible to prioritise watering proposals prior to a RMUF event. To be event ready EWG has pre-prepared both small and large unregulated watering actions for 2009–10 (refer Schedule D & E, respectively). These actions will need to be reviewed/updated as an unregulated event occurs and supplementary information is included so that filters such as location, magnitude and feasibility can be evaluated before the prioritisation of the environmental watering actions in real time.

The prioritisation of environmental watering actions during RMUF events in the River Murray system will in principle:

- be based upon a RMUF event declared by River Murray Operations
- be consistent with a one-river approach in that the areas of highest environmental need and benefit are given priority
- recognise existing obligations, initiatives and rights
- maximize/optimize environmental outcomes including integration with planned environmental water releases
- be based upon opportunity and relative environmental priority following ranking criteria agreed by the EWG; and
- be agreed on a case-by-case basis in real-time.

Recognising the critical condition of the Lower Lakes, EWG recommended the following high-level principles to be applied in the first instance:

- For each RMUF event the material benefit for the Lower Lakes be assessed before any other environmental asset is considered for prioritisation; and
- Deliberately surcharging weir pools for environmental benefit would be a low priority unless it can be guaranteed that any return flows will remain solely for environmental purposes.

To assist in a real-time event, the extreme dry climate objectives and ranking criteria adopted for the prioritisation of TLM regulated watering actions are also applied to the unregulated watering actions. Figure 4 outlines the process for prioritising watering actions during a RMUF event. This process was refined during the RMUF simulation exercise in April – May 2009.

The decision to implement a RMUF environmental watering action is the responsibility of the relevant jurisdiction in both physically implementing the agreed priority and in allowing the declared RMUF to be used according to the EWG agreed principles.

The environmental water volumes delivered during a RMUF event will be collated by the EWG and reported as part of TLM environmental water reporting. This will enable a more comprehensive understanding of environmental water delivered in the River Murray system.

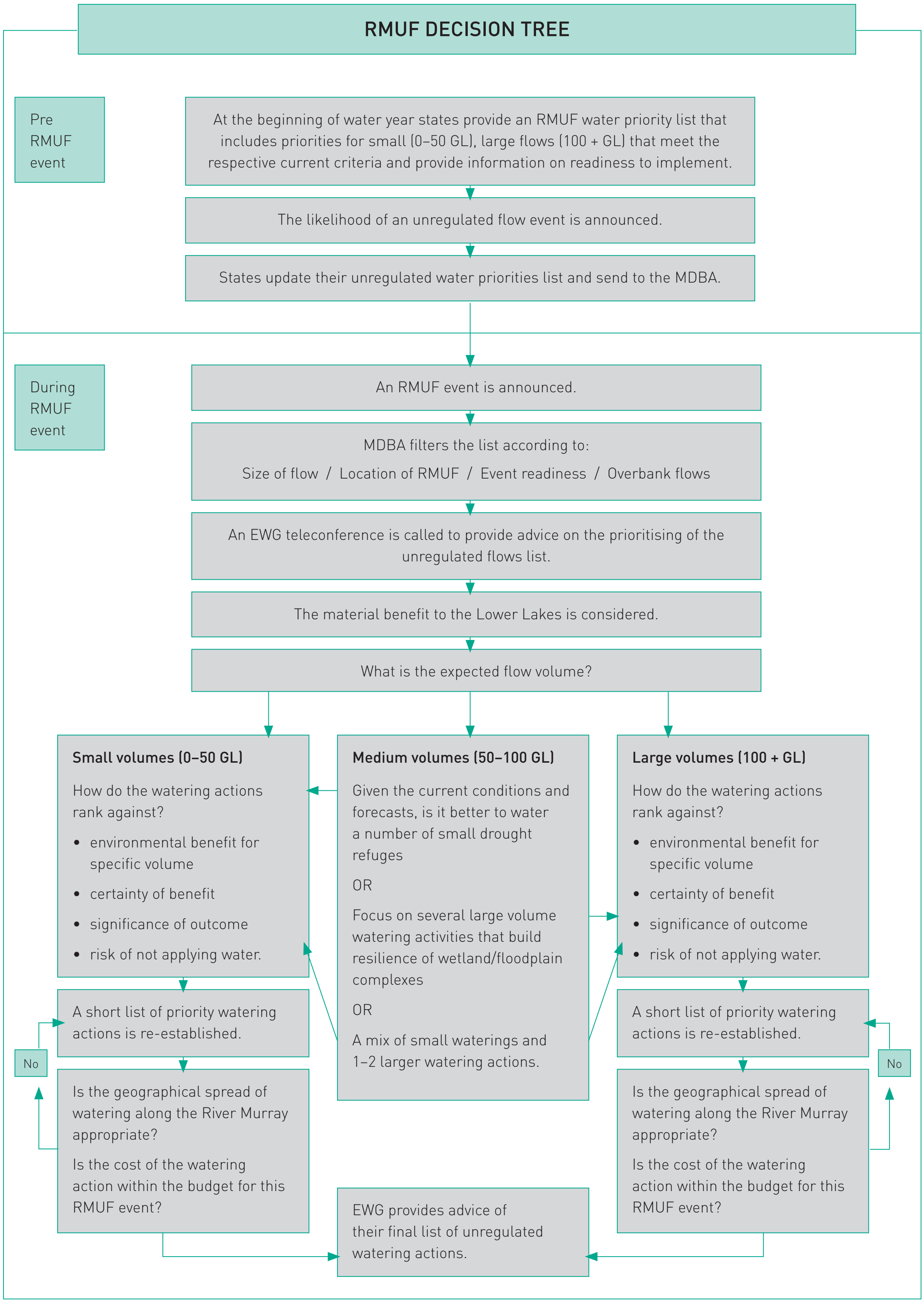


Figure 4. Prioritisation process for unregulated flows

5. ECOLOGICAL MONITORING FOR TLM

Monitoring and evaluating the achievement of the environmental objectives is part of the TLM Business Plan. A monitoring framework titled the Outcomes Evaluation Framework (OEF) has guided the development of monitoring arrangements and outlines the types of monitoring undertaken in The Living Murray. These are Murray River system, condition, intervention and compliance monitoring and knowledge generation. A key principle of TLM monitoring is to use information from monitoring in an adaptive-management sense to optimise the approaches to achieving positive ecological outcomes for the Murray River system.

The Living Murray Environmental Monitoring program coordinates with other MDBA programs including the Sustainable Rivers Audit, Native Fish Strategy and Natural Resources Information, to provide a coordinated approach to monitoring across the Murray-Darling Basin.

5.1 Murray River system-scale monitoring

Monitoring at the Murray River system scale to determine if the health of the Murray River system improves following implementation of the First Step decision. The questions addressed by monitoring at this scale differ from those of the Sustainable Rivers Audit (SRA), which provides a condition assessment for the Murray-Darling Basin (i.e. the scale is different and hence the design is not tailored to address questions at the Murray River system scale). However, some data collected through SRA will be applicable to the Murray River system and where possible, monitoring at this scale will utilise data collected for the SRA. Currently the approach for fish, birds and vegetation are

- A co-ordinated fish monitoring approach is being implemented to monitor fish response to TLM along the Murray River linked to fishway construction and the Native Fish Strategy.
- The Annual Aerial Waterbird Survey has been implemented in October – November, linked to the Eastern Australia Aerial waterbird Survey, so that geographical context is incorporated.
- A Red Gum and Black Box Stand Condition assessment is being implemented using remote sensing approaches (Landsat) to allow reporting annually on stand condition.

5.2 Icon site condition monitoring

Icon site condition monitoring will determine change in the environmental condition of individual icon sites resulting from water application and implementation of works programs under The Living Murray. Icon site condition monitoring is specifically tailored to determine if the objectives for each icon site are being met. Monitoring and evaluation at the icon site–scale is surveillance in type and typically undertaken on a medium frequency (months to years).

Condition monitoring activities planned for 2009–10 include ongoing monitoring as per the icon site condition monitoring plans that have been developed for each icon site. These plans detail the approaches and methods for monitoring the fish, bird and vegetation communities as they relate to the ecological objectives for the site. A core set of consistent approaches to monitoring the condition of fish, birds and vegetation has been developed and agreed across the icon sites. These approaches will be implemented during 2009–10 and include linkages to the system assessments identified in the system monitoring section. For example, the river red gum and black box on ground condition assessment will provide key support to the Red Gum and Black Box Stand Condition remote sensing assessments.

5.3 Intervention monitoring

Intervention monitoring assesses the ecological response to types of interventions or environmental management actions implemented under The Living Murray. In doing so, it will provide the major link to understanding how the ecological responses to specific environmental management actions result in changes at icon sites. It will also provide the foundation information for adopting an adaptive-management approach to implementing The Living Murray. Intervention monitoring will not occur for each watering action, but will be targeted at watering actions that provide the opportunity to test key hypotheses that evaluate and quantify cause-and-effect relationships. The information can subsequently be extrapolated to other icon sites.

Event monitoring has become important in managing implementation of environmental watering activities during the drought to inform real-time decision making in relation to achieving ecological outcomes and minimising risks. This monitoring is focused on the specific objectives of the environmental watering event or to avoid risks, and is targeted in both temporal and spatial scales.

The process for event monitoring will need to be responsive to the environmental watering plan, including recognition that speedy resourcing and implementation will be required. The trigger for event monitoring will be impacted by the water available for environmental watering, and it is possible that events may not be monitored or monitoring will need to be prioritised. Reporting processes for event monitoring will recognise the level of monitoring undertaken.

During 2009–10, monitoring interventions will be focused around three broad areas.

- Monitoring the impacts of fishways and resnagging on fish populations throughout the Murray River.
- Obtaining and compiling key information needs on the response of vegetation, birds, habitat and fish recruitment to watering and works interventions.
- Monitoring the direct impacts of watering events at icon sites in relation to the event watering objectives.

5.4 Compliance monitoring

Compliance monitoring assists TLM to meet its obligations concerning monitoring against certain environmental management actions and to determine if actions, works or measures are implemented in the manner intended. Measuring the volume of water used at icon sites and the timing, volume and quality of any return flows is needed to account and report for the use and management of environmental water.

There are a number of existing long-term projects funded by the MDBA that provide data and information within and around the icon sites. The compliance monitoring program for TLM draws upon this information where appropriate, however in 2009–10 further work will be undertaken on water accounting needs for each icon site.

6. ACCOUNTING FOR TLM ENVIRONMENTAL WATERING

Environmental water accounting provides information on the volume of water released, delivered and used at each icon site, volume of water returned to the Murray River and the environmental water account figures.

The Living Murray Business Plan (2007) states the accounting and reporting of environmental water should be incorporated into environmental management planning, reporting to the Murray-Darling Basin Ministerial Council and development of national standards for water accounting. In addition to the requirements outlined in The Living Murray Business Plan, The Living Murray Outcomes and Evaluation Framework (2007) requires environmental water used at icon sites to be measured, accounted and reported. The Living Murray Environmental Watering Plan outlines policy and procedural frameworks for how environmental water will be measured and accounted for in accordance with the TLM Business Plan.

Measurement and accounting of environmental water will depend on the properties of the water, where the water is being used and the delivery mechanism or technique. Some of these techniques include, incorporating Murray River Operations accounts who gather data from regulating structures and gauges throughout the Murray River system, mathematical models to calculate water savings and water behaviour on wetlands, permanent and temporary gauging stations within icon sites and at pumping sites.

7. REPORTING ON TLM ENVIRONMENTAL WATERING

As mentioned previously, environmental water accounting provides information on the volume of water released, delivered and used at each icon site, volume of water returned to the Murray River and the environmental water account figures. The Living Murray Business Plan requires these aspects to be reported on annually, consistent with The Living Murray Environmental Watering Plan.

Environmental water is accounted and reported for at an icon site and River Murray system scale throughout and at the end of the watering season. This information will be incorporated into the development of the National Standards for Water Accounting (Intergovernmental Agreement on a National Water Initiative 2004), the Annual Environmental Watering Report and Murray-Darling Basin Authority Annual Report.

SCHEDULE A: Critical regulated watering actions (critical drought refuges that require water to consolidate previous waterings)

Icon Site	Reach – Section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or drought criteria	TLM volume required (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Risk level: Likelihood of benefit (High, Medium, Low)	Risk level: Risk of NOT applying water (High, Medium, Low)
Barmah–Millewa										
Barmah/ Millewa– Douglas Swamp	3	Water small terminal wetland system	Action will facilitate maintenance and recovery of wetland vegetation, and will contribute to the maintenance of bird breeding and foraging habitat.	0.5	September – November	Via Nestrons regulator (river >10,000 ML/ day @ Yarrawonga)	Desilt inlet	Approx $5000	Low risk	High risk, loss of drought refuge
Barmah/ Millewa– Walthours Swamp	3	Water small terminal wetland system	Action will facilitate maintenance and recovery of wetland vegetation, and will contribute to the maintenance of bird breeding and foraging habitat.	0.25	September – November	Via Walthours regulator (river >10,000 ML/ day @ Yarrawonga)	Desilt inlet	Approx $5000	Low risk	High risk, loss of drought refuge
Barmah– Millewa– Reed Beds	3	Re-watering to maintain vegetation health and potential bird breeding event	Action will provide refuge habitat and potential breeding site for colonial bird.	0.5	September – November	Regulator direct from Murray River (>= 1000 ML/day)	Monitoring, regulator operation.		Low (Unlikely to fail to maintain habitat)	Moderate (Likely moderate impact).
Barmah– Gulf Creek	3	Use pumps to water river red gums around wetlands and creeklines	Maintain drought refuge for native fish and turtles – one of last refuges in the forest. This site was watered in 2008–09 (0.25 GL).	0.25	Spring – Summer	Via Gulf Ck Regulator (when river flows > 4,000 ML/day downstream Yarrawonga)	None	N/A	High	High

Icon Site	Reach – Section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or drought criteria	TLM volume required (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Risk level: Likelihood of benefit (High, Medium, Low)	Risk level: Risk of NOT applying water (High, Medium, Low)
Gunbower–Koondrook – Perricoota Forest										
Perricoota–Koondrook–Pollack's Swamp	7	Water Pollack Swamp (118 ha) via private irrigation channel in order to maintain wetland vegetation.	Action will facilitate maintenance and recovery of wetland vegetation, and will contribute to the maintenance of bird breeding and foraging habitat.	0.5	September – November	Via private irrigation channel.	Monitoring, regulator operation.	$20,000	Low (Unlikely risk of minor impact if bird breeding is triggered and unsustained)	Significant (Likely moderate impact – no wetting phase this year).
Gunbower wetlands	4	Open regulators on Gunbower creek to top up small area of wetlands (~ 300 ha)	Maintain drought refuge in Little Gunbower Complex and Reedy Lagoon	3	September – October	Temporary pumps	None	$58,500 (3000 ML @ $19.5/ML)	High	High
Chowilla Floodplain, Lindsay and Wallpolla Islands										
Coppermine	15	Use temporary pumps to inundate wetland complex, including lignum habitat and the large Coppermine waterhole	***1. Avoid catastrophic loss –*** prevent decline in health/loss of long-lived vegetation. ***2. Maintain drought refuge –*** provide drought refuge for large numbers of waterbirds. ***3. Prevent critical loss of threatened species –*** provide breeding opportunities for Environmental Protection and Biodiversity Conservation (EPBC) Act listed southern bell frog and NSW listed long-thumbed frog to enable recovery when more water is available	2	August – October	Temporary pumps	N/A	$110,000	High	High
Werta Wert	15	Use temporary pumps to inundate the wetland basin and fringing long-lived vegetation	***1. Avoid catastrophic loss –*** prevent decline in health/loss of long-lived vegetation. Prevent loss of flood-dependent seedbank. ***2. Maintain drought refuge –*** provide drought refuge for large numbers of waterbirds. ***3. Prevent critical loss of threatened species –*** provide breeding opportunities for the EPBC Act listed southern bell frog to enable recovery when more water is available.	0.75	August – October	Temporary pumps	N/A	$41,500	High	High

Icon Site	Reach – Section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or drought criteria	TLM volume required (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Risk level	
									Likelihood of benefit (High, Medium, Low)	Risk of NOT applying water (High, Medium, Low)
Lake Littra	15	Use temporary pumps to inundate wetland basin and fringing long-lived vegetation	***1. Avoid catastrophic loss –*** prevent loss of long-lived vegetation. ***2. Maintain drought refuge –*** provide drought refuge for large numbers of waterbirds. ***3. Prevent critical loss of threatened species –*** provide breeding opportunities for the EPBC Act listed southern bell frog to enable recovery when more water is available.	1	August – October	Temporary pumps	N/A	$55,000	High	High
Twin Creeks	15	Use temporary pumps to water river red gums, replenish freshwater lens and support river red gum recruits	***1. Avoid catastrophic loss –*** prevent loss of long-lived vegetation. Prevent loss of large number of river red gum recruits that germinated after previous watering.	0.14	August – October	Temporary pumps	N/A	$7,700	High	High
Monoman Island Horseshoe	15	Use temporary pumps to inundate wetland basin, replenish freshwater lens and support river red gum recruits	***1. Avoid catastrophic loss –*** prevent decline in health/loss of long-lived vegetation. Prevent loss of flood-dependent seedbank. Prevent loss of large number of river red gum recruits that germinated after previous watering.	0.15	August – October	Temporary pumps	N/A	$8,250	High	High
Kulkurna	15	Use temporary pumps to inundate wetland basin and water long-lived vegetation	***1. Avoid catastrophic loss –*** prevent decline in health/loss of long-lived vegetation. Prevent loss of flood-dependent seedbank. ***2. Prevent critical loss of threatened species –*** provide breeding opportunities for the EPBC Act listed southern bell frog to enable recovery when more water is available. ***3. TLM objectives –*** maintain high value wetlands, maintain current area of river red gum, and maintain ≥ 20% original area black box	0.14	August – October	Temporary pumps	N/A	$7,700	High	High

Icon Site	Reach – Section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or drought criteria	TLM volume required (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Risk level: Likelihood of benefit (High, Medium, Low)	Risk level: Risk of NOT applying water (High, Medium, Low)
Pilby Lagoon	15	Open regulators to inundate wetland and maintain semi-permanent ecological character	***1. Avoid catastrophic loss –*** prevent loss of semi-permanent ecological character. ***2. Maintain drought refuge –*** provide drought refuge and breeding opportunities for large numbers of waterbirds (incl. up to 9 state-listed species).	0.16	August – October	Gravity	N/A	N/A	High	High
Punkah Creek	15	Use temporary pumps to raise water levels in the anabranch and water fringing long-lived vegetation	***1. Avoid catastrophic loss –*** prevent decline in health/ loss of long-lived vegetation, including mature river red gum and black box.	0.05	August – October	Aqua dam or rock bank	N/A	$30,000	High	High
Wallpolla Island	14	Use temporary pumps to water river red gums along anabranches and around wetlands	Water stressed river red gums and provide some drought refuge	3	Spring or autumn (July – November or May – June)	Temporary pumps	Maintenance of 2 levees to pond water	$219,000 (3000 ML @ $65/ML + 2 earthen levees @ $12,000 each)	High	High
Lindsay Island	12	Use pumps to water river red gums around wetlands and creeklines	Water stressed river red gums and provide some drought refuge	3	Spring or autumn (July – November or May – June)	Temporary pumps	Maintenance of 2 levees to pond water	$253,000 (3000 ML @ $71/ML + 2 earthen levees @ $20,000 each)	High	High

Icon Site	Reach – Section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or drought criteria	TLM volume required (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Risk level: Likelihood of benefit (High, Medium, Low)	Risk level: Risk of NOT applying water (High, Medium, Low)
Lower Lakes, Coorong and Murray Mouth										
Channels on Mundoo Island	15	Use temporary pumps to top-up water levels for threatened fish populations	***1. Prevent critical loss of threatened species –*** Prevent the loss of one of only two populations of the genetically-distinct Lake Alexandrina subpopulation of southern pygmy perch (SA listed), and loss of the largest remaining population of the genetically-distinct Lower Lakes subpopulation of Murray hardyhead (EPBC listed). ***2. Avoid catastrophic event –*** prevent acidification upon drawdown. ***3. Maintain drought refuge –*** maintain one of only a few remaining aquatic refuges within the Lower Lakes icon site for numerous aquatic species endemic to the area, including threatened species.	0.02	ASAP	Trucking/pumping	N/A	$15,000	High	High
Turveys Drain	15	Use temporary pumps to maintain water levels for threatened fish populations	***1. Prevent critical loss of threatened species –*** Prevent the loss of one of only two populations of the genetically-distinct Lake Alexandrina subpopulation of southern pygmy perch (SA listed), and loss of a population of the genetically-distinct Lower Lakes subpopulation of Murray hardyhead (EPBC listed). ***2. Maintain drought refuge –*** maintain one of only a few remaining aquatic refuges within the Lower Lakes icon site for numerous aquatic species endemic to the area, including threatened species. Provide recruitment opportunities to enable recovery when more water is available.	0.008	ASAP	Temporary pumps	Some excavation of existing water delivery channel	$5,600	High	High

Icon Site	Reach – Section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or drought criteria	TLM volume required (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Risk level	
									Likelihood of benefit (High, Medium, Low)	Risk of NOT applying water (High, Medium, Low)
Narrung	15	Use temporary pumps to inundate wetland area	***1. Maintain drought refuge –*** maintain one of only a few remaining aquatic refuges within the Lower Lakes icon site, providing refuge to numerous aquatic species endemic to the area. Provide recruitment opportunities to enable recovery when more water is available. Provide habitat for numerous EPBC-listed migratory waders. Prevent loss of aquatic vegetation, including state-listed *Muehlenbeckia horrida.*	0.45	late July & early Sept	Temporary pumps	Minor earthworks to prevent leakage	$17,050	High	High

SCHEDULE B: Key regulated watering actions (drought refuges)

Icon Site	Reach – Section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or drought criteria	TLM volume required (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Risk level: Likelihood of benefit (High, Medium, Low)	Risk level: Risk of NOT applying water (High, Medium, Low)
Barmah–Millewa										
Barmah–Millewa–Moira/ Sheldrake Lakes	5	Prevent encroachment of giant rush. Maintaining character of wetland	Action will facilitate maintenance and recovery of wetland vegetation, and willl contribute to the maintenance of bird breeding and foraging habitat.	8	September – November	Regulators on Swifts, Bunnydigger Cks (>= 1000ML/day)	Monitoring, regulator operation.	$ 35,000.00	Low (Unlikely to fail to maintain habitat)	Significant (Likely moderate impact – vegetation change likely)
Barmah–Millewa–Duck Lagoon	5	Water Duck Lagoon via Gulpa Creek in order to assist recovery of wetland vegetation.	Action will enable recovery of wetland vegetation following wildfire.	2	September – November	Via Gulpa Creek (assumes > 350 ML/day in Gulpa Creek)	Monitoring, regulator operation.	$10,000.00	Low (Unlikely to fail to support vegetation response)	Significant (Likely moderate impact – vegetation recovery prevented)
Barmah–Millewa–Reed Beds	3	Re-watering to maintain vegetation health and potential bird breeding event	Action will provide refuge habitat and potential breeding site for colonial birds.	2	September – November	Regulator direct from Murray River (>= 1000ML/ day)	Monitoring, regulator operation.		Low (Unlikely to fail to maintain habitat)	Moderate (Likely moderate impact).
Barmah–Millewa–Toupna Creek	3	Consecutive dry years has severely impacted on in stream habitat and limited connection with main river channel.	Action will provide refuge habitat for threatened fish species.	2	September – November	Regulator direct from Murray River (>= 1000ML/ day)	Fish species monitoring, regulator operation.	$10,000.00	Low (Unlikely to fail to maintain habitat)	Moderate (Likely moderate impact).

Icon Site	Reach – Section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or drought criteria	TLM volume required (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Risk level: Likelihood of benefit (High, Medium, Low)	Risk level: Risk of NOT applying water (High, Medium, Low)
Barmah–Top Island	3	Open Island & Sapling Creek regulators to allow inflows at river flows of >8000 ML/day (100 ML/day)	Provide ~500 ha drought refuge for waterbirds and water stressed vegetation (trees and wetlands)	2.5	Spring	Via Island & Sapling creek regulators (when river flows > 8,000 ML/day downstream Yarrawonga)	Removal of silt upstream of regulators (towards Murray confluence)	7,000	High	Medium
Barmah–Boals Deadwoods	3	Open Boals Ck regulator at flows of 6000 ML/day, water will pond in wetland	Provide ~100 ha drought refuge for waterbirds	1	Spring	Via Boals Ck Regulator (when river flows > 7,500 ML/day downstream Yarrawonga)	None	N/A	High	Medium
Barmah–Goose Swamp	3	High flows in Broken Creek or pumping to deliver water	Provide ~100 ha drought refuge for waterbirds and water stressed vegetation (trees and wetlands)	0.5	Spring – Summer	Broken Creek flows >300 – 600 ML/day, otherwise need to pump	None	N/A or ~$30,000 (500 ML @ $60/ML)	High	Medium
Gunbower–Koondrook – Perricoota Forest										
Perricoota–Koondrook–Pollack's Swamp	7	Water Pollack Swamp (118 ha) via private irrigation channel in order to maintain wetland vegetation.	Action will facilitate maintenance and recovery of wetland vegetation, and willl contribute to the maintenance of bird breeding and foraging habitat.	1	September – November	Via private irrigation channel.	Monitoring, regulator operation.	$5,000.00	Low (Unlikely risk of minor impact if bird breeding is triggered and unsustained)	Significant (Likely moderate impact – no wetting phase this year).
Gunbower wetlands	4	Open regulators on Gunbower creek to top up small area of wetlands (~ 300 ha)	Maintain drought refuge in Little Gunbower Complex and Reedy Lagoon	5	September – October	Via Little Gunbower, Yarran and Reedy regulators	None	$97,500 (5000 ML @ $19.5/ML)	High	High

Icon Site	Reach – Section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or drought criteria	TLM volume required (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Risk level	
									Likelihood of benefit (High, Medium, Low)	Risk of NOT applying water (High, Medium, Low)
Hattah Lakes										
Hattah Lakes	14	Pump water into Chalka Creek to flood wetlands	Water stressed river red gum and provide ~500 ha drought refuge in wetlands	5	Spring or Autumn (July – November or May – June)	Temporary pumps	Installation of 2 aqua dams	$355,000 (5000 ML @ $65/ML + 2 aqua dams @ $15,000 each)	High	High
Chowilla Floodplain, Lindsay and Wallpolla Islands										
Coombool Swamp (incl Brandy Bottle)	15	Use temporary pumps to inundate wetland complex and connecting floodplain	***1. Avoid catastrophic loss –*** freshen groundwater to prevent decline in health/loss of long-lived vegetation. Prevent loss of flood-dependent seedbank. ***2. Maintain drought refuge –*** provide drought refuge for large numbers of waterbirds.	4.65	August – October	Temporary pumps	Some earthworks may be required	$260,000.00	High	High
Lake Limbra (Hancock Creek)	15	Use temporary pumps to inundate wetland basin and associated anabranch	***1. Avoid catastrophic loss –*** halt saline groundwater intrusion and prevent ecosystem decline. ***2. Maintain drought refuge –*** provide drought refuge for large numbers of waterbirds (incl. colonial nesting species).	4.5	August – October	Temporary pumps	Some earthworks may be required	$247,500.00	High	High
Slaney Creek Anabranches	15	Use temporary pumps to inundate anabranches	***1. Avoid catastrophic loss –*** prevent decline in health/loss of long-lived vegetation (incl. river red gum and black box). Prevent decline in health of floodplain vegetation	0.2	August – October	Temporary pumps	Some earthworks may be required	$11,000.00	High	High
Kulkurna Blackbox Site 1	15	Use temporary pumps to inundate black box community	***1. Avoid catastrophic loss –*** prevent decline in health/loss of long-lived vegetation	0.15	Spring – early summer	Temporary pumps	Some earthworks may be required	$8,250.00	High	High

Icon Site	Reach – Section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or drought criteria	TLM volume required (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Risk level: Likelihood of benefit (High, Medium, Low)	Risk level: Risk of NOT applying water (High, Medium, Low)
Lindsay Island	12	Use pumps to fill Lake Wallawalla from Lindsay River	Water stressed river red gums around the lake and provide ~840 ha drought refuge	12	Spring or autumn (July – November or May – June)	Temporary pumps	Construction of 2 levees to pond water	$852,000 (12,000 ML @ $71/ML)	High	High
Lower Lakes, Coorong and Murray Mouth										
Lake Alexandrina	15	Release water from Lake Victoria/ River Channel to provide material benefit to Lake	***1. Avoid catastrophic event –*** delay water levels in Lake Alexandrina falling below -1.5m AHD, leading to acidification and ecosystem loss. ***2. Prevent critical loss of threatened species –*** prevent loss of in-situ populations of threatened fish. ***3. Maintain drought refuge –*** drain/channel refuges will remain connected to Lake Alexandrina and be maintained as drought refuge for small-bodied threatened fish and other obligate aquatic species	>25?	ASAP	Gravity	N/A	–	High	High
Murray River Channel										
River Murray Chanel	1 – Hume to Yarrawonga	Using the elevated flows associated with the irrigation season, provide a short term boost to the hydrograph. The spike in flows will enable up to 200 ha. of wetlands, anabranches and billabongs which have not received water for at least the last 2 years to be watered. Ecosystems watered would include Croppers Lagoon, Dairy Lagoon, Coyles Creek and Maggies Lagoon.	Protect and enhance riparian ecosystems. Ecosystems watered would contain areas of open water, emergent macrphytes as well as limited areas of river red gums	1 – 1.5	Summer (1 week)	Gravity flow	Nil	Nil	Medium	Low

SCHEDULE C: Key regulated watering actions (require larger volumes of water)

Icon Site	Reach – Section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or drought criteria	TLM volume required (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Risk level: Likelihood of benefit (High, Medium, Low)	Risk level: Risk of NOT applying water (High, Medium, Low)
Barmah–Millewa										
Barmah–Steamer/ War Plains	3	None – high flows in river	Provide ~1500 ha drought refuge for waterbirds and water stressed vegetation (trees and wetlands)	7.5*	Winter-early summer	River flows >10,500ML/day downstream Yarrawonga	None	N/A	High	Medium
Barmah–Smiths Creek	3	Open Sandspit regulator to provide connecting flows to access Smiths Creek.	Provide drought refuge, also water stressed red gums lining creek banks	0.5 – 1	Spring	Via Sandspit Ck Regulator (when river flows >8,700ML/day downstream Yarrawonga), ~14 days to deliver	None	N/A	High	Medium
Barmah–network of 15 small wetlands in northern forest	3	Open regulators as required	Provide drought refuge for waterbirds and water stressed vegetation in network of small wetlands, some have supported colonial waterbird breeding in past	2	Spring	Various regulators once flows 10,000–15,000 ML/day	None	N/A	High	Medium

Icon Site	Reach – Section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or drought criteria	TLM volume required (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Risk level: Likelihood of benefit (High, Medium, Low)	Risk level: Risk of NOT applying water (High, Medium, Low)
Gunbower–Koondrook – Perricoota Forest										
Gunbower	4	Via regulators on Gunbower Creek (Yarran, Reedy & Little Gunbower) or via River Murray regulators (Shillinglaws and Barham Cut) if flows are high enough	Significant contribution to meeting wetland objectives; maintain drought refuge and water fringing river red gum; water Reedy Lagoon (permanent wetland now dry for over 2 years); maintain flows in Gunbower Ck and critical habitat for Murray cod and freshwater catfish	16 (assumes Gunbower Creek is charged, otherwise up to 40 GL needed to charge creek)	Spring or autumn (July – November or May – June)	Via regulators on Gunbower Creek or River Murray	None	Up to $312,000 (16,000 ML @ $19.5ML)	High	High
Hattah Lakes										
Hattah Lakes	14	Pump water into Chalka Creek to flood up to 15 wetlands	Water stressed river red gum and provide ~1100 ha drought refuge in wetlands	25	Spring or autumn (July – November or May – June)	Pumping	Installation of 2 aqua dams	Total $1,297,500. delivery of 19500 ML @ ($65/ML) aqua dams (2 @$15000)	High	High
Chowilla Floodplain, Lindsay and Wallpolla Islands										
Mulcra Island	14	Water stressed river red gums and flood ~500 ha (assumes TLM structures in place)	40 (note that 35 GL returns)	40 (note that 35 GL returns)	Spring or autumn (July – November or May – June)	Lock 8 surcharge	None	N/A	High	High

SCHEDULE D: Unregulated Watering Actions (small)

Site	Reach – Section of River Murray	Objectives of watering. Relate to TLM objectives or current drought criteria	Minimum effective volume (GL)	Maximum effective volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Preferred duration of RMUF availability (range)	Complimentary works required	Costs (water delivery and complimentary works)	Readiness to implement		Ranking criteria				Is this action on the regulated flow list (Y/N)?
										Set up time	Volume that can be delivered in 4–5 days	Environmental benefit for volume (high, medium or low)	Significance of outcome (high, medium or low)	Certainty of benefit (high, medium or low)	Risk of not applying water (high, medium or low)	
Barmah–Millewa Forest																
Barmah–Millewa Duck Lagoon (NSW)	5	Water Duck Lagoon via Gulpa Creek in order to assist recovery of wetland vegetation.	2	5	September – November	Via Gulpa Creek (assumes > 350 ML/day in Gulpa Creek)		Monitoring, regulator operation.	$10,000						Significant (Likely moderate impact – vegetation recovery prevented)	Y
Gulpa Creek–Reed Beds	5	Action will facilitate maintenance and recovery of wetland vegetation, and will contribute to the maintenance of bird breeding and foraging habitat.	1	1	September – November	Via Gulpa Creek (assumes > 350 ML/day in Gulpa Creek)		Monitoring, regulator operation.	$10,000						Moderate. Reduced bird breeding opportunities becoming critical for populations.	N
Gunbower–Koondrook – Perricoota Forest																
Pollack Swamp	7	Action will facilitate maintenance and recovery of wetland vegetation, and will contribute to the maintenance of bird breeding and foraging habitat.	0.8	1.5	September – November	Via private irrigation channel.	40 days	Monitoring, regulator operation, liaison with Bringan Irrigation Trust.	$25,000						Significant (Likely moderate impact – no wetting phase this year).	Y

Site	Reach – Section of River Murray	Objectives of watering. Relate to TLM objectives or current drought criteria	Minimum effective volume (GL)	Maximum effective volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Preferred duration of RMUF availability (range)	Complimentary works required	Costs (water delivery and complimentary works)	Readiness to implement: Set up time	Readiness to implement: Volume that can be delivered in 4–5 days	Ranking criteria: Environmental benefit for volume (high, medium or low)	Ranking criteria: Significance of outcome (high, medium or low)	Ranking criteria: Certainty of benefit (high, medium or low)	Ranking criteria: Risk of not applying water (high, medium or low)	Is this action on the regulated flow list (Y/N)?
Lower Lakes, Coorong and Murray Mouth																
Lake Alexandrina	15 (Below Lock 1)	**TLM Objectives:** 'enhanced migratory wader bird habitat in the Lower Lakes'– by maintaining water levels in the Lower Lakes over winter/ spring, mudflats will remain saturated and benthic invertebrate populations will be maintained and enhanced, leading to increased food resources for migratory wading birds in the Lower Lakes; 'more frequent estuarine fish recruitment'– releasing greater volumes of fresh water over current dilution flows into the Lower Lakes will provide localised salinity gradients, leading to recruitment in estuarine fish populations.	30	50	ASAP	Releases from Lake Victoria/ River Channel	June – October	No complimentary works required	No costs associated with watering	No set-up time required	Depends on volumes able to be passed over Lock 1 – assume 20–25 GL in 5 days?	Medium	High	Medium	High	Y

Site	Reach – Section of River Murray	Objectives of watering. Relate to TLM objectives or current drought criteria	Minimum effective volume (GL)	Maximum effective volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Preferred duration of RMUF availability (range)	Complimentary works required	Costs (water delivery and complimentary works)	Readiness to implement: Set up time	Readiness to implement: Volume that can be delivered in 4–5 days	Ranking criteria: Environmental benefit for volume (high, medium or low)	Ranking criteria: Significance of outcome (high, medium or low)	Ranking criteria: Certainty of benefit (high, medium or low)	Ranking criteria: Risk of not applying water (high, medium or low)	Is this action on the regulated flow list (Y/N)?
Lower Lakes, Coorong and Murray Mouth (continued)																
		Drought Criteria: 'maintain drought refuge'– drain/ channel refuges still connected to Lake Alexandrina will be maintained as drought refuge for small-bodied threatened fish and other obligate aquatic species; 'avoid catastrophic loss' – delivery of water will delay water levels in Lake Alexandrina falling below – 1.5m AHD, leading to acidification and ecosystem loss; 'prevent critical loss of threatened species' – threatened fish populations can be maintained in-situ in the short-term through the delivery of this water														

Site	Reach – Section of River Murray	Objectives of watering. Relate to TLM objectives or current drought criteria	Minimum effective volume (GL)	Maximum effective volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Preferred duration of RMUF availability (range)	Complimentary works required	Costs (water delivery and complimentary works)	Readiness to implement		Ranking criteria				Is this action on the regulated flow list (Y/N)?
										Set up time	Volume that can be delivered in 4–5 days	Environmental benefit for volume (high, medium or low)	Significance of outcome (high, medium or low)	Certainty of benefit (high, medium or low)	Risk of not applying water (high, medium or low)	
River Murray Channel																
Werai Forest–Niemur River	6 – Edward Wakool	Based on previous trail, provide environmental water to 500 Ha's of floodplain ecosystems (ecosystems watered would contain areas of emergent macrophytes as well as areas of river red gum).	2	7	Spring (September – November)	Open Regulators	2 weeks	Nil	Nil	Immediate	100%	High	High	High	Low	N
Non Icon Site																
Werai State Forest–Edward River	6	To facilitate recovery of a significant area of wetland vegetation, particularly Phragmite beds.	0.5	7	September – November	Via Tummudgery Creek if Edward exceeds 2100ML/day. The maximum volume includes raising Edward River – may include extra costs	14 days	Monitoring, regulator operation, liaison with State Water.	$10,000.00						Significant (Likely minor impact – continued decline).	N

SCHEDULE E: Unregulated Watering Actions (Large)

Site	Reach – Section of River Murray	Objectives of watering. Relate to TLM objectives or current drought criteria	Minimum effective volume (GL)	Maximum effective volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Preferred duration of RMUF availability (range)	Complimentary works required	Costs (water delivery and complimentary works)	Readiness to implement – set up time	Time period since last watering	Ranking criteria: Env. benefit for volume (high, medium or low)	Ranking criteria: Significance of outcome (high, medium or low)	Ranking criteria: Certainty of benefit (high, medium or low)	Ranking criteria: Risk of not applying water (high, medium or low)	Is this action on the regulated flow list (Y/N)?
Lower Lakes, Coorong and Murray Mouth																
Lake Alexandrina	15 (below Lock 1)	**TLM Objectives:** 'enhanced migratory wader bird habitat in the Lower Lakes'– by maintaining and raising water levels in the Lower Lakes, mudflats will remain saturated and benthic invertebrate populations will be maintained and enhanced, leading to increased food resources for migratory wading birds in the Lower Lakes; 'more frequent estuarine fish recruitment'– releasing fresh water into the Lower Lakes greater than current dilution flows will provide localised salinity gradients, leading to recruitment in estuarine fish populations. **Drought Criteria:** 'maintain drought refuge'– drain/channel refuges still connected to Lake Alexandrina will be maintained as drought refuge for small-bodied threatened fish and other obligate aquatic species, and the important 'littoral zone' on the edge of the water can be enhanced by maintaining and/or raising lake levels;	100GL	unlimited (i.e. barrage out-flows required)	ASAP	Releases from Lake Victoria / River Channel	Any time of year	No complimentary works required	No costs associated with watering	Can begin ASAP	Pool level from which barrage releases could be made last achieved in January 2007	High	High	High	High	Y

Site	Reach – Section of River Murray	Objectives of watering. Relate to TLM objectives or current drought criteria	Minimum effective volume (GL)	Maximum effective volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Preferred duration of RMUF availability (range)	Complimentary works required	Costs (water delivery and complimentary works)	Readiness to implement – set up time	Time period since last watering	Ranking criteria: Env. benefit for volume (high, medium or low)	Ranking criteria: Significance of outcome (high, medium or low)	Ranking criteria: Certainty of benefit (high, medium or low)	Ranking criteria: Risk of not applying water (high, medium or low)	Is this action on the regulated flow list (Y/N)?
Lower Lakes, Coorong and Murray Mouth (continued)																
		'avoid catastrophic loss' – water levels need to be maintained in Lake Alexandrina above – 1.5m AHD to avoid the onset of acidification, and to prevent the irretrievable loss of ecosystem function; 'prevent critical loss of threatened species'– last remaining habitat for Murray hardyhead and southern pygmy perch can be preserved through maintaining or enhancing lake levels.														
Non Icon Sites																
Poon Boon lakes		Action will facilitate maintenance and recovery of wetland vegetation, and will contribute to the maintenance of bird breeding and foraging habitat.	5 GL	12 GL	Any time	Gravity operated regulators	60 days	Monitoring, regulator operation.								N
Wakool System		Action will provide a replenishment/flushing flow to the system. Aim to provide benefits to instream habitat, riparian vegetation and low commence to fill connected wetlands	10 GL+	60 GL	Any time	Gravity operated regulators	60 days	Monitoring, regulator operation.								N

Australian Government

MURRAY–DARLING BASIN AUTHORITY

Australian Government

MURRAY–DARLING BASIN AUTHORITY

MURRAY-DARLING BASIN AUTHORITY

TLM Annual Environmental Watering Plan 2010–11

MURRAY-DARLING BASIN AUTHORITY

TLM Annual Environmental Watering Plan 2010–11

Published by Murray-Darling Basin Authority
Postal Address GPO Box 1801, Canberra ACT 2601
Office location Level 4, 51 Allara Street, Canberra City
Australian Capital Territory

Telephone (02) 6279 0100 international + 61 2 6279 0100
Facsimile (02) 6248 8053 international + 61 2 6248 8053
E-Mail info@mdba.gov.au
Internet http://www.mdba.gov.au

For further information contact the Murray-Darling Basin Authority office on (02) 6279 0100

This report may be cited as: The Living Murray Annual Environmental Watering Plan 2010–11

MDBA Publication No. 106/10

ISBN (on-line) 978-1-921783-60-9

CONTENTS

1. INTRODUCTION

The Living Murray (TLM) was established in 2002 in response to evidence that the health of the Murray River system[1] is in decline. In November 2003 the Murray–Darling Basin Ministerial Council announced its historic Living Murray First Step Decision. As part of this decision an additional average of 485 GL per year has been recovered for the environment and a structural works program is currently underway to deliver this water efficiently. The Living Murray's First Step focuses on the achievement of agreed ecological objectives at six 'icon sites' along the River Murray with a combination of 'water and works'. The six icon sites are:

- Barmah–Millewa Forest
- Gunbower–Koondrook–Perricoota Forests
- Hattah Lakes
- Chowilla Floodplain, Lindsay–Wallpolla Islands
- Lower Lakes, Coorong and Murray Mouth
- Murray River Channel.

This document is the Annual Environmental Watering Plan 2010–11 which focuses on the water delivery aspects of TLM. It has been jointly developed by the Murray-Darling Basin Authority (MDBA) and Environmental Working Group (EWG). The plan outlines the decision framework for prioritizing the use of TLM water for environmental watering actions across the Murray River system between 1 July 2010 and 30 June 2011.

The annual water planning process is responsive to changing water resource conditions, opportunities and environmental priorities throughout the season. Implementation of the TLM Annual Environmental Watering Plan 2010–11, including any changes to priorities or other aspects of the Plan, is recorded separately and reported at the end of the year.

For information about TLM go to http://www.mdba.gov.au/programs/tlm

1 Murray River system includes: the main course of the Murray River and all its effluents and anabranches downstream of Hume Dam to the sea including the Edward-Wakool River system, the Mitta Mitta River downstream of Dartmouth Dam and the Darling River and Great Darling Anabranch downstream of Menindee Lakes.

2. ENVIRONMENTAL WATERING ACTIVITIES 2009–10

In 2009–10 68.545 GL was allocated for environmental watering actions throughout the year from a total available allocation of 155.66 GL. These environmental watering actions were targeted at critical locations within icon sites that would provide a material benefit to achieving TLM objectives. A summary of these actions and the allocated water volumes is provided in Table 1.

Table 1: TLM environmental watering activities 2009–10

Icon Site	Locations within icon site	Volume committed (GL) (of 155.666 GL available)	Period of watering	Benefit
Barmah-Millewa Forest	Douglas Swamp, Walthours Swamp, Reed Beds, & Gulf Creek	2.37	Oct'09 – Dec'09	Facilitate the maintenance and recovery of wetland vegetation, and contribute to the maintenance of bird breeding and foraging habitat.
Chowilla Lindsay-Wallpolla	Punkah Creek, Twin Creeks, Coppermine, Werta Wert, Lake Littra, Monoman Island Horseshoe, Kulkurna, Pilby Lagoon, Wallpolla Island, & Lindsay Island	10.39	Nov'09 – Jun'10	Contribute to preventing the decline in health of long lived vegetation, including mature River Red Gum, Black Box and other high priority vegetation; provide a drought refuge.
Gunbower-Koondrook-Perricoota	Reedy Lagoon (Gunbower Forest)	2.201	Nov'09	Maintain drought refuge, and contribute to the maintenance of bird breeding and foraging habitat.
Hattah Lakes	Chalka Creek, Lake Lockie, Little Lake Hattah, Lake Hattah, Lake Bulla, & Lake Arawak	5	Apr'10 – May'10	To halt or reverse the decline of fringing River Red Gums in Hattah Lake and surrounding wetlands and to extend the duration of drought refuge.
Lower Lakes, Coorong and Murray Mouth	Narrung, Boggy Creek, Turveys Drain, & Lake Albert	48.585	Nov'09 – Dec'09 & Feb'10 – June'10	Maintain drought refuge for threatened waterbirds and fish species; and prevent loss of aquatic vegetation. Assist the process of recovery in Lake Albert through the inundation of high risk sediments reducing the risk of broad scale acidification and reducing salinity.
	TOTAL	**68.546**		

To facilitate future environmental water delivery, 4.45 GL was also committed to repay encumbrances attached to some TLM entitlements. The remaining 82.67 GL will be carried over to spring 2010–11 to maximize the environmental benefits from use of this water.

Table 2 presents the reliability class of entitlements held by TLM in 2009–10 with their associated entitlement, allocation and net use volumes and the volume remaining at June 30 2010–11. A total of 967.425 GL of entitlements are currently held on TLM Environmental Water Register across a range of security classes. A volume of 0.068 GL of River Murray Increased flows (RMIF) was not used in 2009–10. The interim RMIF rules allow for this water to be carried over for use until October 2010.

Table 2: TLM Entitlements 2009–10

Entitlement Type	Entitlement (GL)	Allocation available to TLM**(GL)	Environmental watering use (GL)	Volume remaining at June 30 2010 (GL)
NSW High Security	1.597	1.564	1.561	0.003
NSW General Security	205.796	91.545	48.84	26.508*
NSW Supplementary	363	0	0	0
VIC High Reliability	57.071	38.451	13.45	25.001#
VIC Low reliability	298.177	0	0	11.747*#
SA Water Licence	41.784	24.038	4.695	19.343
RMIF carried over from 2008–09***		0.068	0	0.068
TOTAL	**967.425**	**155.666**	**68.546**	**82.67**

* 4.45GL was used to pay back encumbrances. 11.747 GL was transferred to Victorian low reliability entitlements to reduce the risk of forfeiture of allocation in 2010–11.

** some water allocated to entitlements in 2009–10 has been utilised by the previous owner.

*** MDBA managed environmental water entitlement (not specifically TLM). This water is permitted to be carried over to October 2010.

5% transmission loss fee for carryover of allocation against some Victorian water entitlements.

3. FORECAST 2010–11

3.1 Inflows

Inflows for the 2009–10 water year (June 2009 to May 2010) were the highest since 2005–06, however still well below the long term average (Figure 1).

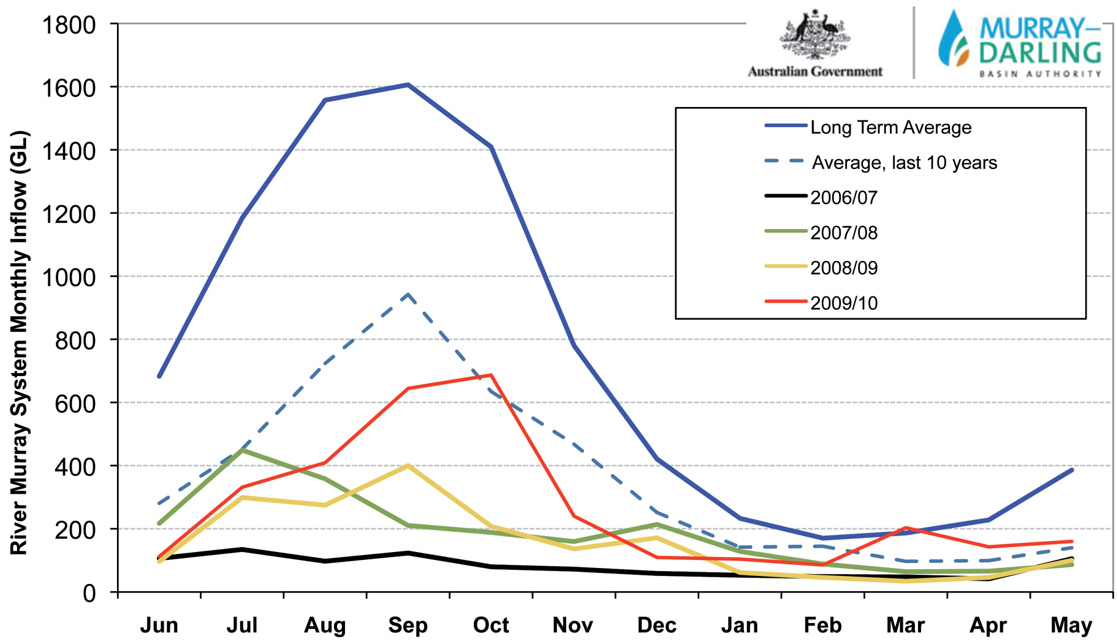


Figure 1: Comparison of inflows to River Murray system (excluding the Darling River and Snowy River) in selected years

3.2 Storage

Total MDBA active storage for the Murray system at the end of May 2010 was 2963 GL (34% of capacity) which is well below the end of May long term average of 4,670 GL (Figure 2). MDBA active storage was significantly increased in April 2010 when control of the Menindee Lakes system was transferred from NSW to MDBA control.

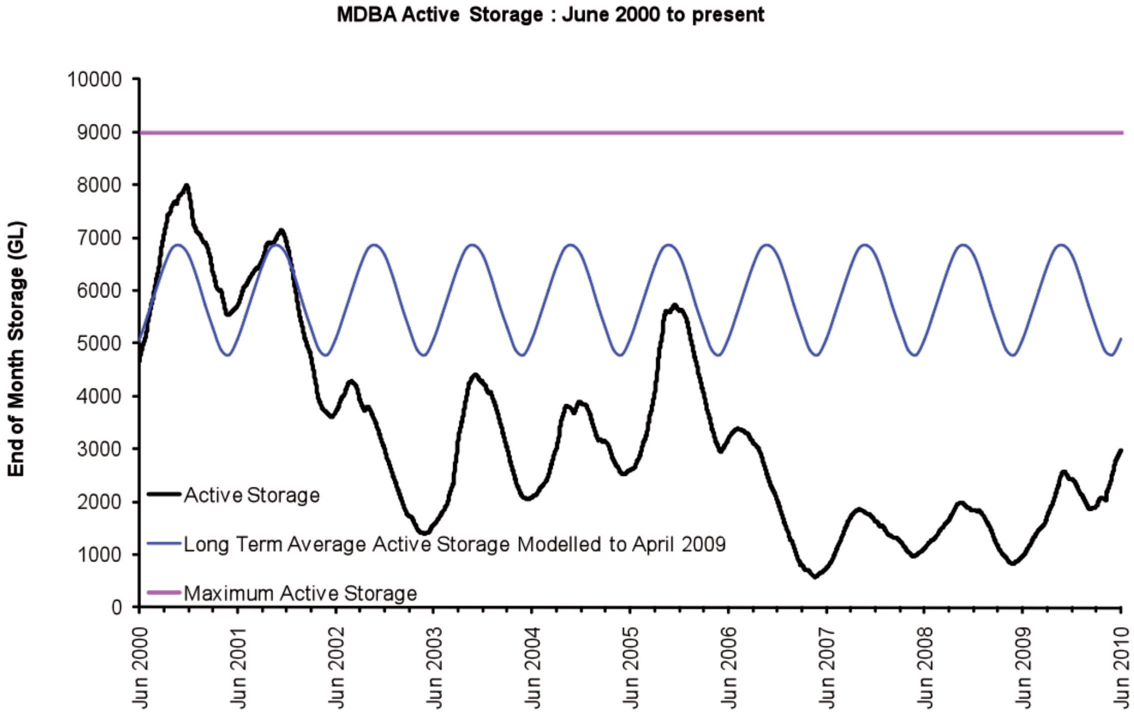


Figure 2: Comparison of active, long-term average and maximum storage levels in the River Murray system June 2000 to June 2009

3.3 Outlook

In early 2010, there were two flood events in the northern Basin and over 2,000 GL of water passed along the Darling River, much of which was stored in Menindee Lakes. As a result, Menindee Lakes will hold about 1,400 GL by the end of May 2010, having come under Authority control in mid-April 2010. This has provided a modest, but nonetheless very welcome, boost to the outlook for the River Murray System. With about 1,700 GL in Hume and Dartmouth storages, the opening season water availability will be the best since 2006.

There is sufficient water in the River Murray System in the 2010–11 water year to meet critical human water needs, basic evaporation and storage losses, basic distribution losses and private carry-over. However, without further improvements in inflows, opening allocations for irrigators are expected to be low or zero. Irrigation allocations in 2010–11 rely on the extent to which future inflows exceed the minimum levels used for planning.

The situation in the other large irrigation systems in the southern Basin is understood to be similar to or poorer than the Murray because they have not had the benefit of the Darling flows.

The prospects for floodplains in the River Murray System remain grim. Significant flooding, sufficient to first fill, and then spill depleted headwater storages, would be required to significantly improve environmental outcomes on these floodplains.

The levels in the Lower Lakes in South Australia have improved over the past year and are currently -0.45m AHD. However, it could take substantial unregulated flows to South Australia for the Lakes to fully recover.

In summary the drought for many irrigators and the riverine environment, particularly in the southern Basin, is not over. Recovery could still take multiple years of above average inflow.

3.4 Outlook for TLM water entitlements 2010–11

The majority of entitlements (97%) recovered by the TLM water recovery process have now been listed on the TLM Environmental Water Register. It is anticipated that a further 19 GL will be listed on the TLM Environmental Water Register in early 2010–11. Table 3 provides details of the estimated volumes and reliability classes of the entitlements to be listed in 2010–11.

Table 3. Entitlements expected June 2010–11

Reliability	Entitlement volume (GL)*
Low	0
General	4.94
High	14.88
TOTAL	**19.82**

* Approximate forecasts only. Note the volumes are not Long Term Cap Equivalents.

It is anticipated that flow conditions could be similar to 2009–10 based on current weather forecasts. Assuming similar allocation levels to 2009–10, an estimate of potential allocations to the TLM water portfolio in 2010–11 is given in Table 4. These estimates include 82 GL of carryover from 2009–10.

Table 4: Forecasted available TLM water 2010–11

Season	Forecasted allocation amounts (GL)	Carryover available (GL)	Cumulative Total (GL)
Spring 2010	20–45	81.12	100–125
Summer 2010–11	80–120	0	180–245
Autumn 2011	20–40	0	200–250

4. TLM WATER PLANNING 2010–11

4.1 Background

The TLM First Step decision in 2003 sought to achieve ecological objectives at six icon sites through a package of 'water and works'. These two core components of TLM provide some exciting challenges and opportunities that have been incorporated into the decision framework for water planning in 2010–11.

TLM water availability

The aim of the First Step decision was to recover an additional 500 GL average per year for the environment. To date 97% of this target has been achieved and is now available on the TLM portfolio. As the number of entitlements has gradually increased on the TLM portfolio, the volume of allocation has also risen. In 2009–10 EWG began to investigate opportunities to deliver larger volumes of environmental water in a manner that provided environmental benefits to multiple watering sites. Whilst this investigation highlighted a number of potential constraints including river operations and trade protocols, it was evident that multiple watering events could provide an efficient and effective use of environmental water.

By September 2010 it is anticipated that TLM will have a significant volume of water available due to the carryover of 82 GL from 2009–10. In order to use this water efficiently, EWG has recommended that TLM investigate the merits of trialing a multiple watering action at Barmah Millewa Forest and the Lower Lakes in spring 2010, including to ensure the feasibility of this proposal, assess its merits against the agreed criteria, assess the implications of River Murray operations and any approvals required from Basin Official's Committee..

TLM works

In 2010–11 the construction of infrastructure works designed to optimise the delivery of environmental water will be underway at most TLM icon sites. During the construction phase, environmental watering actions may be limited or not possible at some sites. During this phase and upon completion of the works, it will be necessary to undertake operations in a controlled manner that tests the functionality of the structures and builds an understanding of how the structures can deliver the best environmental outcomes to the floodplain.

4.2 Ecological watering objectives

In order to respond to the potential variability in water resources, EWG utilises a model that outlines management objectives for different water resource scenarios (Table 5). The ecological objectives for extreme dry/dry/median and wet scenarios outlined in the model provide guidance on how TLM water would be utilised under different flow and climatic conditions.

The increased number of entitlements held by TLM has led to a potentially greater range of allocation volumes available in 2010–11 depending on climatic variability. Due to the varying ecological condition of icon sites and the potentially greater range of allocation volumes, it is anticipated that the icon sites may be across a continuum of the water resource scenarios during 2010–11.

The forecasts for water availability for 2010–11 may provide the opportunity for some icon sites to utilise the objectives for the dry or median water resource scenarios, depending on flows within the River Murray system. However the serious decline in ecological condition of sites such as the Lower Lakes and the subsequent lag in recovery may need to be addressed by the management objectives for the extreme dry water resource scenario.

Table 5: Proposed ecological watering objectives under different water resource availability scenarios (*based on principles established by DSE Victoria and DEWHA*)

	Extreme Dry	Dry	Median	Wet
Ecological watering objectives	Avoid irretrievable loss of key environmental assets	Ensure priority river reaches and wetlands have maintained their basic functions	Ecological health of priority river reaches and wetlands have been protected or improved	Improve the health and resilience of aquatic ecosystems
Management objectives	Avoid critical loss of species, communities and ecosystems Maintain key refuges Avoid irretrievable damage or catastrophic events	Maintain river functioning with reduced reproductive capacity Maintain key functions of high priority wetlands Manage within dry -spell tolerances Support connectivity between sites	Enable growth, reproduction and small-scale recruitment for a diverse range of flora and fauna Promote low-lying floodplain-river connectivity Support medium flow river and floodplain functional processes	Enable growth, reproduction and large-scale recruitment for a diverse range of flora and fauna Promote higher floodplain-river connectivity Support high flow river and floodplain functional processes
Management actions	Water refugia and sites supporting species and communities Undertake emergency watering at specific sites of priority assets Use carryover volumes to maintain critical needs	Water refugia and sites supporting threatened species and communities Provide low flow and freshes in sites and reaches of priority assets Use carryover volumes to maintain critical needs	Prolong flood/high-flow duration at key sites and reaches of priority assets Contribute to the full-range of in-channel flows Provide carry over to accrue water for large watering events	Increase flood/high-flow duration and extent across priority assets Contribute to the full range of flows incl. over-bank Use carryover to provide optimal seasonal flow patterns in subsequent years
	Avoid catastrophic loss/maintain capacity for potential recovery	→ Improved capacity for recovery	→ Protect ecological health	→ Improved health and resilience

4.3 Ranking criteria

The primary objective of the Annual Environmental Watering Plan 2010–11 is to provide environmental benefit (in terms of the stated objectives for each site). In order to prioritise between individual watering actions throughout the year, EWG has agreed to use the following ranking criterion outlined in Table 6, regardless of climatic conditions.

Table 6: Ranking criterion for prioritization of TLM watering actions

Ranking criterion		Description
Significance of ecological outcome	An assessment of the predicted ecological outcomes provided by the watering. This should reflect the value and condition of the asset, threatened species and communities and magnitude of benefit, including:	
	Amount of benefit for the volume of water	An assessment of the predicted ecological benefit relative to the volume of water required. This may include the opportunity for return flows.
	Risk of not watering	An assessment of ecological risks of not watering. This may include the previous history and protection of previous investment.
	Certainty/likelihood of benefit	An assessment of the certainty of getting the predicted outcomes; whether the benefit of watering a site can be maintained in the short and long term and the implications for future management
Operational matters	Risks associated with watering	An assessment of any risks associated with the delivery of water including such as ASS, salinity spikes, black water events, algal blooms and the adequacy of mitigation measures.
	Cost effectiveness	An estimate of the overall costs of delivering the watering action (per ML) including delivery, pumping and associated infrastructural costs.

4.4 Framework for prioritization of regulated flows

In order to accommodate the potential range in water allocation volumes and varying icon site conditions, a flexible decision framework has been developed by TLM that will guide the prioritisation of environmental watering actions in 2010–11 (Table 7). This decision framework provides the focus for the prioritization of environmental watering actions, an assessment of the associated risks and the timeframes for the review of all other potential watering actions. These reviews will assess TLM water availability against the environmental benefit to all proposed watering sites using the ranking criteria.

To be event ready EWG have identified proposed watering actions that align with the decision framework (refer Schedule A, B, C & D). Schedules A, B, C and D provide a list of watering proposals for the extreme dry, dry, median and wet water resource scenarios, respectively. Watering proposals may be assessed across a range of schedules depending on the condition of icon sites and water availability at the review periods. As outlined in the framework, actions recommended for implementation throughout the year will not be limited to those identified in the schedules to this plan.

The watering proposals within the four schedules have been reviewed by EWG members to assess the watering opportunities over the next year, including multiple watering actions. Watering proposals have also been analysed to ensure that potential watering activities are compatible with the River Murray Operations Plan 2010–11.

The review periods during 2010–11 will assess the water availability against the environmental benefit to all proposed watering sites using the agreed ranking criteria. Real-time factors that may impact on the delivery of environmental water will also be considered during the review periods. These factors include the river operations, availability of other sources of environmental water, status of TLM works, status of delivery budget, opportunities for multiple site watering actions, conditions at the sites, antecedent and forecasted flows. EWG will then provide advice to the MDBA on whether any environmental watering actions should be implemented at that stage.

During the 2010–11 water year, EWG will review the schedules of environmental watering proposals at designated periods utilizing the process outlined in Figure 3. Based on the outcomes of the review, EWG will provide advice to the MDBA on whether any environmental watering actions should be implemented at that stage.

All watering actions will be implemented in accordance with the decision framework and prioritisation process outlined in the Annual TLM Environmental Watering Plan 2010–11. The approval of any watering actions recommended by EWG within icon sites is delegated to the Executive Director of Natural Resource Management, Murray-Darling Basin Authority.

Table 7: TLM Environmental Watering Decision Framework

Exceptions	Timing	Decision steps	Associated risks
Any exceptions that rise throughout the water year will be reviewed by EWG as required using the process outlined in the decision framework	June – September/ October 2010	Review of all watering actions against the agreed criteria*, including critical refuge sites and a multiple watering proposal at Barmah Millewa Forest and the Lower Lakes. This multiple watering proposal will be subject to an assessment of the implications of River Murray operations, any approvals required from Basin Official's Committee and a thorough assessment of the environmental benefits of this multiple watering proposal. Real-time factors to be considered at review periods include local site conditions / status of TLM works/ multiple site watering actions / other potential sources of environmental water / antecedent flows/forecasted flows.**	• Use of all available water could limit larger watering actions in the future
	October-November 2010	Review of TLM water availability against the environmental benefit to all proposed watering sites using the ranking criteria. Based on the review, EWG will either recommend: EITHER allocate all available TLM water to sites that may include, but not be limited to, those identified in the Schedules. OR bank any water allocation to enable a wider scope of watering actions to be considered in February OR a combination of banking and use of TLM water.	• Banking could limit the water available for water refugia and sites supporting threatened species and communities • Use of all available water could limit larger watering actions in autumn
	November-February 2011	Bank any water allocation to enable a wider scope of watering actions to be considered. Banking would not be considered if other proposed watering sites could be irretrievably lost during this period.	• Banking could limit the water available for water refugia sites
	February-June 2011	Review of TLM water availability against the environmental benefit to all proposed watering sites using the ranking criteria to recommend: Based on the review, EWG will either recommend: EITHER allocate water to proposed sites OR continue to bank water to enable wider scope of watering actions to be considered in following months OR carryover water to spring to maximize ecological outcomes	• Banking could limit the water available for water refugia and sites supporting threatened species and communities • Use of all water would limit larger watering actions in spring 2011 • Risk associated with carryover

* Watering actions will be prioritized within this framework using the ranking criteria outlined in this Plan

** The availability of other sources of environmental water will be considered for any proposed watering actions

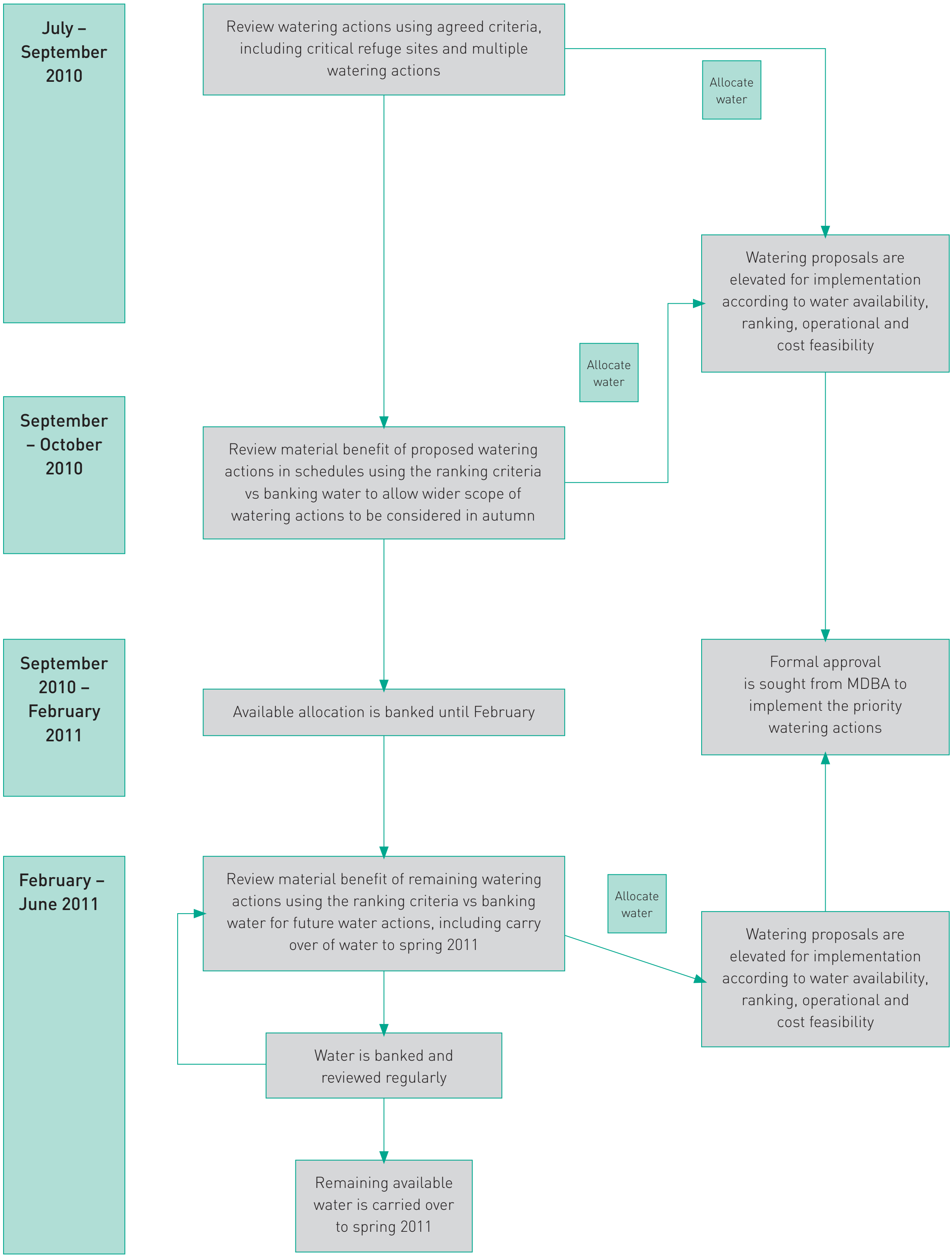


Figure 3: Flow chart of prioritization process for regulated flows

4.5 Framework for prioritization of River Murray Unregulated Flows

In 2008–09 EWG agreed to trial the prioritisation of environmental watering actions during a River Murray Unregulated Flows (RMUF) event. Although a simulation exercise was held in April – May 2009, there has been no opportunity to test this prioritisation process during a real-time RMUF event. Therefore it is proposed that this trial will continue during 2010–11.

As each RMUF event varies in location, duration and operational opportunities, it is not possible to prioritise watering proposals prior to a RMUF event. To be event ready EWG has prepared watering proposals for a range of water resource scenarios in 2010–11 (refer Schedules A-D, respectively). These actions will need to be reviewed/updated as an unregulated event occurs and supplementary information will be included so that filters such as location, magnitude and feasibility can be evaluated before the prioritisation of the environmental watering actions in real time.

The prioritisation of environmental watering actions during RMUF events in the River Murray system will in principle:

- be based upon a RMUF event declared by River Murray Operations
- be consistent with a one-river approach in that the areas of highest environmental need and benefit are given priority
- recognise existing obligations, initiatives and rights
- maximize/optimize environmental outcomes including integration with planned environmental water releases
- be based upon opportunity and relative environmental priority following ranking criteria agreed by the EWG; and
- be agreed on a case-by-case basis in real-time.

To assist in a real-time event, the ranking criteria adopted for the prioritisation of TLM regulated watering actions are also applied to the unregulated watering actions.

Figure 4 outlines the process for prioritising watering actions during a RMUF event. This process was refined during the RMUF simulation exercise in April – May 2009. The decision to implement a RMUF environmental watering action is the responsibility of the relevant jurisdiction in both physically implementing the agreed priority and in allowing the declared RMUF to be used according to the EWG agreed principles.

The environmental water volumes delivered during a RMUF event will be collated by the EWG and reported as part of TLM environmental water reporting. This will enable a more comprehensive understanding of environmental water delivered in the River Murray system.

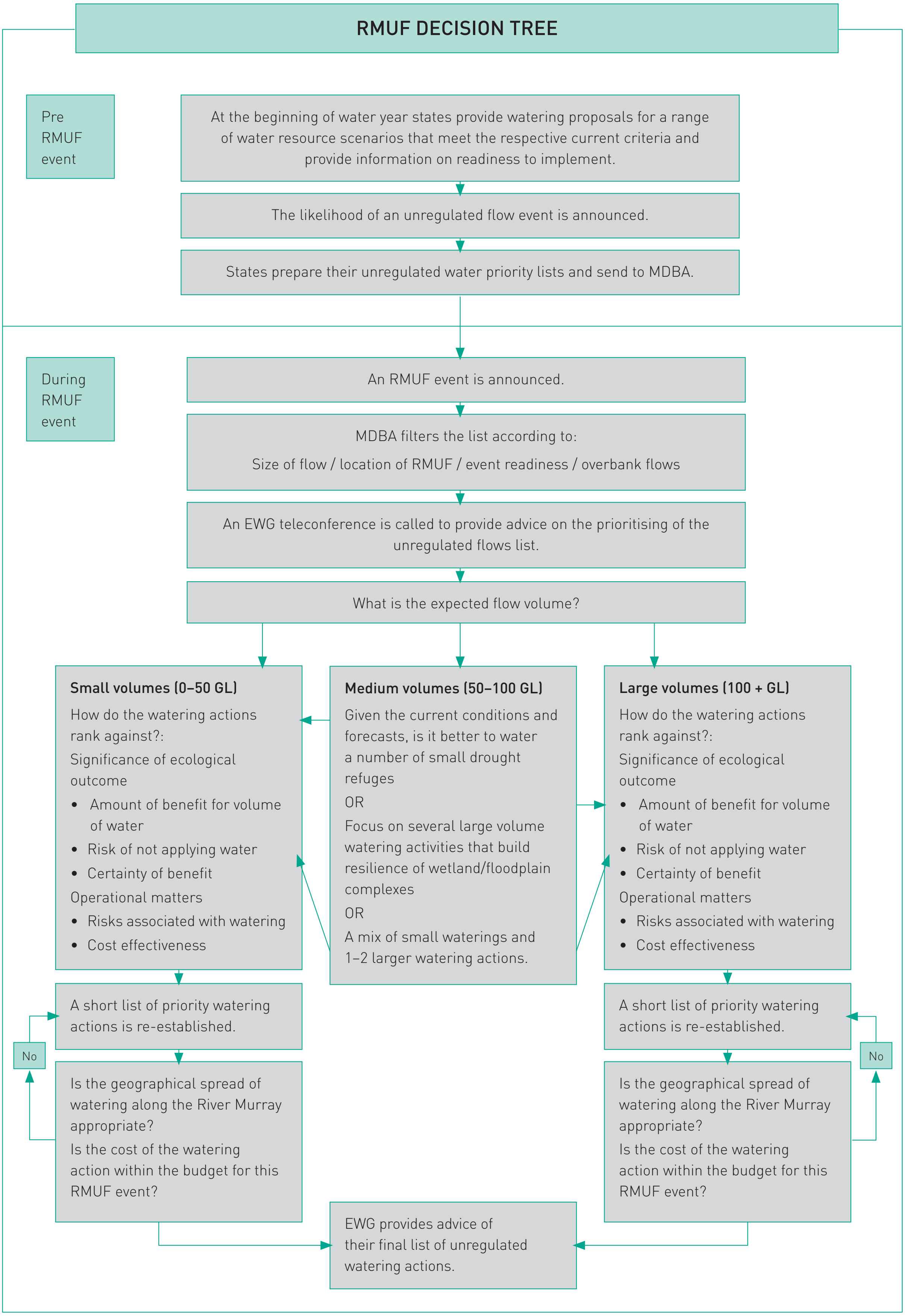


Figure 4: Prioritisation process for unregulated flows

5. ENVIRONMENTAL MONITORING FOR TLM

Monitoring and evaluating the achievement of the ecological objectives is part of the TLM Business Plan. A monitoring framework titled the Outcomes Evaluation Framework (OEF) has guided the development of monitoring arrangements and outlines the types of monitoring necessary to monitor progress toward the ecological objectives of TLM. The monitoring types listed in the OEF are River Murray system-scale monitoring, condition monitoring, intervention monitoring, compliance monitoring and knowledge generation. More detail on these monitoring types is provided below.

A key principle of TLM is to use information from monitoring in an adaptive management sense to optimise the approaches to achieving positive ecological outcomes at the Icon sites and thereby benefit the entire River Murray system. The current focus of TLM Environmental Monitoring is on condition, intervention (including monitoring specific watering events) and River Murray System-scale monitoring. Compliance Monitoring has been incorporated into Intervention monitoring.

The Living Murray Environmental Monitoring program coordinates with other MDBA programs including the Sustainable Rivers Audit, Native Fish Strategy and Natural Resources Information, to provide a coordinated approach to monitoring across the Murray-Darling Basin.

5.1 River Murray System-scale monitoring

Monitoring at the River Murray system-scale to determine if the health of the Murray River system improves following implementation of the First Step decision and its focus on the six Icon sites. The questions addressed by monitoring at this scale differ from those of the Sustainable Rivers Audit (SRA), which provides a condition assessment for the Murray-Darling Basin (i.e. the scale is different and hence the design is not tailored to address questions at the Murray River system scale). However, some data collected through SRA will be applicable to the Murray River system and where possible, monitoring at this scale will utilise data collected for the SRA. Currently the approach for fish, birds and vegetation are:

- A coordinated fish monitoring approach is being implemented to monitor fish response to TLM.
- The Annual Aerial Waterbird Survey has been implemented in October – November, linked to the Eastern Australia Aerial Waterbird Survey, so that geographical context is incorporated.
- A Red Gum and Black Box Stand Condition assessment is being implemented using remote sensing approaches to allow reporting annually on stand condition.

5.2 Icon site condition monitoring

Icon site condition monitoring will determine change in the environmental condition of individual icon sites resulting from water application and implementation of works programs under The Living Murray. Icon site condition monitoring is specifically tailored to determine if the objectives for each icon site are being met. Monitoring and evaluation at the icon site–scale is surveillance in type and typically undertaken on a medium frequency (months to years).

Condition monitoring activities planned for 2010–11 include ongoing monitoring as per the icon site condition monitoring plans that have been developed for each icon site. These plans detail the approaches and methods for monitoring the fish, bird and vegetation communities as they relate to the ecological objectives for the site. A core set of consistent approaches to monitoring the condition of fish, birds and vegetation has been developed and agreed across the icon sites. These approaches will be implemented during 2010–11 and include linkages to the system assessments identified in the system monitoring section. For example, the river red gum and black box on ground condition assessment will provide key support to the Red Gum and Black Box Stand Condition remote sensing assessments.

5.3 Intervention monitoring

Intervention monitoring assesses the ecological response to types of interventions or environmental management actions implemented under The Living Murray. In doing so, it provides the major link to understanding how the ecological responses to specific environmental management actions result in changes at icon sites. It also provides the foundation information for adopting an adaptive-management approach to implementing The Living Murray.

During 2010–11, intervention monitoring will be focused around three broad areas.

- Monitoring the impacts of fishways and resnagging on fish populations throughout the Murray River.
- Monitoring the direct impacts of watering events at icon sites in relation to the event watering objectives.
- Addressing key information gaps on the response of vegetation, birds, habitat and fish recruitment to watering and works interventions.

Event monitoring has become important in managing the implementation of environmental watering activities during the drought to inform real-time decision making in relation to achieving ecological outcomes and minimising risks. This monitoring is focused on the specific objectives and risks of the environmental watering event and is targeted in both temporal and spatial scales. The process for event monitoring will be responsive to the environmental watering plan, including recognition that resourcing and implementation will require planning to ensure event-ready capacity is available. Event monitoring will be prioritised according to the water available for environmental watering and key knowledge gaps that may be addressed by specific watering actions. It is possible that events may not be monitored if resources are not available in appropriate timeframes. Reporting processes for event monitoring will recognise the level of monitoring undertaken.

Measuring the volume of water used at icon sites and the timing, volume and quality of any return flows etc is needed to account and report for the use and management of environmental water at the Icon sites. This area of monitoring was previously defined in Compliance monitoring; however it is now encompassed in intervention monitoring. This change has been made to ensure clear linkages between the various information requirements for managing successful watering events and informing the operation of works at Icon sites. This includes systems for water measurement and accounting, monitoring risks and ecological outcomes. Further detailed work in this area of monitoring is currently underway including water accounting needs for each icon site.

6. REPORTING ON TLM ENVIRONMENTAL WATERING

As noted in the previous section, environmental water accounting provides information on the volume of water released, delivered and used at each icon site, volume of water returned to the Murray River and the environmental water account figures. The Living Murray Business Plan requires these aspects to be reported on annually, consistent with The Living Murray Environmental Watering Plan.

Environmental water is accounted and reported for at an icon site and River Murray system scale throughout and at the end of the watering season. This information will be incorporated into the development of the National Standards for Water Accounting (Intergovernmental Agreement on a National Water Initiative 2004), the TLM Annual Implementation Report, TLM Annual Environmental Report and Murray-Darling Basin Authority Annual Report.

Schedule A: Extreme Dry (Possible TLM water available including carryover: 140 – 170 GL)

Watering Site	Reach- section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria: Amount of benefit for volume of water (High, Medium, Low)	Risk of not applying water (High, Medium, Low)	Certainty/ likelihood of benefit (High, Medium, Low)	Risks associated with watering (High, Medium, Low)	Cost effectiveness (High, Medium, Low)
Barmah-Millewa – Extreme Dry															
Duck Lagoon	5	Open Warrick regulator and allow flow in Warrick Creek to rehabilitate wetland vegetation and RRG forest	Enable recovery of wetlands vegetation following wildfire. Avoid critical loss or alteration of vegetation communities Maintenance of bird breeding and foraging habitat	2.0	2.0	Nil	August – December (this is an estimate as the capacity of the regulator is unknown at this stage)	Through Warrick regulator Warrick Creek	Prevent backflow out of system	$3,000	High	Medium	High	Medium	High
Clay Island	5	Use pumps to rehabilitate wetland vegetation and RRG forest	Avoid critical loss or alteration of vegetation communities Provide drought refuge Prevent critical loss of species	0.20	0.20	Nil	September – October	Pump or siphon direct from Edward River	Pump/siphon required	$8,000 (200ML @$40/ML)	High	Medium	High	Medium	High
Millewa – Toupna Creek	3	Open regulator to allow flows through Toupna Creek	Reinvigorating wetland vegetation Help maintain healthy vegetation Support a significant population of a threatened fish species – the Southern Pygmy Perch.	3.3	3.3	Nil	September – October Wet Creek & maintain low flow Sept til end January (10days 50ML then 140days 20ML)	Via Mary Ada regulator (>4700 ML/d @Toc.)	Installation of regulator or earth bank required at boundary to private property	$3,000	High	High	High	Low	High

Watering Site	Reach- section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria				
											Amount of benefit for volume of water (High, Medium, Low)	Risk of not applying water (High, Medium, Low)	Certainty/ likelihood of benefit (High, Medium, Low)	Risks associated with watering (High, Medium, Low)	Cost effectiveness (High, Medium, Low)
Barmah (various sites) – Top Island Boals Deadwoods Gooses Swamp Gulf Creek Smiths Creek	3	Open regulators to water small terminal wetland systems.	Provide drought refuge for water birds and other wetland dependent species, such as fish and turtles	4.05	4.05	Nil	September – November	Top Island - regulator Boals Deadwoods – regulator Gooses Swamp – regulator or pumping if Broken Creek flows are low Gulf Creek – regulator Smiths Creek – regulator	Nil	$25,000	High	Medium	High	Low	High
Wetlands, creeks and floodplain within the BMF	3	Consideration should be given to delivering all flows provided downstream of Barmah-Millewa via this icon site. the volume not used within the forest (= total – losses) will return to the River for reuse downstream.	Provide drought refuge for water birds and other wetland dependent species, such as fish and turtles	TBA		70 to 95%	August – December	Direct from the River Murray, via regulator or overbank flows	Over Bank	TBC $5,000 to $50,000 (for flow gauging to measure return flows)	High	Medium	High	Low	High

Watering Site	Reach- section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria: Amount of benefit for volume of water (High, Medium, Low)	Ranking criteria: Risk of not applying water (High, Medium, Low)	Ranking criteria: Certainty/ likelihood of benefit (High, Medium, Low)	Ranking criteria: Risks associated with watering (High, Medium, Low)	Ranking criteria: Cost effectiveness (High, Medium, Low)
Gunbower-Koondrook-Perricoota Forest – Extreme Dry															
Horseshoe lagoon (17 ha)	7	Pump to stressed wetland	Provide drought refuge within stressed forest Regeneration of vegetation and endemic wetland species Prevent irreversible loss of species Provide suitable habitat (feeding and nesting) for waterbirds	0.25	0.25	nil	August – October	Pumping required	Block bank	$13,000	High	High	High	Low	High
Swan Lagoon (37 ha)	7	Pumping to improve RRG fringing vegetation	Provide drought refuge within stressed forest Regeneration of vegetation and endemic wetland species Prevent irreversible loss of species Improve fringing red gum vegetation	0.5	0.5	nil	August – October	Pumping required	Block bank	$21,500	High	High	High	Low	High
Blackbox Lagoon (17 ha)	7	Pumping to improve RRG fringing vegetation	Provide drought refuge within stressed forest Regeneration of vegetation and endemic wetland species Prevent irreversible loss of species Improve fringing red gum vegetation	0.25	0.25	nil	August – October	Pumping required	Block bank	$11,500	High	High	High	Low	High

Watering Site	Reach- section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria				
											Amount of benefit for volume of water (High, Medium, Low)	Risk of not applying water (High, Medium, Low)	Certainty/ likelihood of benefit (High, Medium, Low)	Risks associated with watering (High, Medium, Low)	Cost effectiveness (High, Medium, Low)
390 mile lagoon (6 ha)	7	Pumping to improve RRG fringing vegetation	Provide drought refuge within stressed forest Regeneration of vegetation and endemic wetland species Prevent irreversible loss of species Improve fringing red gum vegetation	0.1	0.1	nil	August – October	Pumping required	Block bank	$5,500	High	High	High	Low	High
Black Charlie Lagoon (Gunbower)	4	Provide flows to wetland that's been dry for 5 years	Provide drought refuge for birds and fish in the upstream region of Gunbower Forest that would historically hold water 9 years out of 10 Avoid irreversible loss	1	1	Nil	September – October (Ideally during September – October 2010) no later than end October 2010.	Gravity fed from Torrumbarry weir pool, via Cameron's Creek and irrigation channel.	No complemen-tary works are required.	$0 ($70,000 if temporary pumping is required to deliver 1GL)	High	High	High	Low	High

Watering Site	Reach- section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria: Amount of benefit for volume of water (High, Medium, Low)	Ranking criteria: Risk of not applying water (High, Medium, Low)	Ranking criteria: Certainty/ likelihood of benefit (High, Medium, Low)	Ranking criteria: Risks associated with watering (High, Medium, Low)	Ranking criteria: Cost effectiveness (High, Medium, Low)
Gunbower Creek	4	This action will directly inform the detailed design for the Hipwell Road Channel Package of Works.	Calibrate the Gunbower Creek hydraulic model to inform the level requirements for the Hipwell Road Package of Works Calculate losses associated with delivering environmental water through Gunbower Creek Measure return flows to the River Murray Provide a spawning cue to native fish within Gunbower Creek.	17	5	12	July onwards	River gravity and Gunbower Creek		TBC					
Chowilla Floodplain, Lindsay and Wallpolla Islands															
Wallpolla Island	14	Water wetland to maintain breeding sites for waterbird species and habitat for other species.	Avoid irreversible loss/catastrophic event Provide drought refuge	3.2 (0.7GL in Spring + 2.5GL in Autumn)	3.2	Nil	September – October and March – June	Temporary Pumping	Nil	$160,000	High	High	High	Low	High

Watering Site	Reach- section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria				
											Amount of benefit for volume of water (High, Medium, Low)	Risk of not applying water (High, Medium, Low)	Certainty/ likelihood of benefit (High, Medium, Low)	Risks associated with watering (High, Medium, Low)	Cost effectiveness (High, Medium, Low)
Mulcra Island	14	Raise Lock 8 to generate flows through Potterwalkagee Creek using pumps	Increase the diversity of structural aquatic habitat Increase the diversity and distribution of native fish Provide occasional breeding and roosting habitat for waterbirds Provide habitat suitable for migratory waterbird species. provide drought refuge to various habitats	3	2.5	0.5	March – June	Temporary pumping Raising Lock 8 to generate flows through Potter-walkagee Creek;	Nil	$150,000 (3000ML @$50/ML)	High	High	High	Low	High
Mulcra Island	14	Raising Lock 8 to generate flows through Potterwalkage Creek; using newly completed TLM infrastructure to deliver water to the floodplain.	Increase the diversity of structural aquatic habitat; Increase the diversity and distribution of native fish; Provide occasional breeding and roosting habitat for waterbirds; Provide habitat suitable for migratory waterbird species.	20	5	15	March – June			$0	High	High	High	Low	High

Watering Site	Reach- section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria				
											Amount of benefit for volume of water (High, Medium, Low)	Risk of not applying water (High, Medium, Low)	Certainty/ likelihood of benefit (High, Medium, Low)	Risks associated with watering (High, Medium, Low)	Cost effectiveness (High, Medium, Low)
Lindsay Island	12	Pump water to wetlands to provide drought refuge and prevent critical loss of RRG.	Avoid irreversible loss/catastrophic event Provide drought refuge	2	2	Nil	March – June and September – October	Temporary pumping	Nil	$90,000 (2000ML @$45/ML)	High	High	High	Low	High
Coombool Swamp and Lake Limbra	15	Pumping to water to maintain Black box and lignum.	Prevent critical loss of species Provide drought refuge	9.15	9.15	Nil	March – June	Pumping		$352,500	High	High	High	Medium	High
Woolshed Creek and Chowilla Island Loop	15	Pump water to wetlands to improve RRG and Black box condition	Prevent critical loss of species Provide drought refuge	0.37	0.37	Nil	March – June	Pumping		$0	High	High	High	Medium	High
Chowilla Horseshoe, Lock 6 Depression, Monoman Depression, Punkah Island Depression	15	Pump water to wetlands to improve River red gum and Black box condition.	Prevent critical loss of species Provide drought refuge	1.27	1.27	Nil	September – November	Pumping		$0	High	High	High	Medium	High
Punkah Creek	15	Pumping to raise water levels in the anabranch to maintain water fringing vegetation.	Prevent critical loss of species Avoid irreversible loss/catastrophic event; Provide drought refuge	0.15	0.15	Nil	December	Aqua dam or Pumping		$39,000	High	High	High	Medium	Low

Watering Site	Reach- section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria: Amount of benefit for volume of water (High, Medium, Low)	Risk of not applying water (High, Medium, Low)	Certainty/ likelihood of benefit (High, Medium, Low)	Risks associated with watering (High, Medium, Low)	Cost effectiveness (High, Medium, Low)
Lower Lakes, Coorong and Murray Mouth															
Goolwa Barrage,	15	Pumping water from Lake Alexandrina into Goolwa weir pool and then released through Goolwa Barrage vertical slot fishway to allow recruitment and preservation Congolli species	Prevent critical loss of species Avoid irreversible loss/catastrophic event or Provide drought refuge	5.5	5.5	Nil	November – December	Pumping	Nil	$277,500	High	High	High	Low	High
Alexandrina & Lake Albert	15	Water to be gravity fed to Lake Alexandrina to maintain water levels. Decision regarding water sharing between Lake Alexandrina & Lake Albert subject to ongoing discussions re best ecological outcomes that can be achieved with available water	Maintain water levels objective: Maintain salinity levels within Lake Albert to within threshold tolerances of key species of fish. Ensure the high risk acid sulfate soils areas remain saturated Creating a 'pulse' of water down the River Murray channel which will provide ecological benefits to RMC icon site	170	170	Nil	TBA – subject to further modelling advice.	Water will be gravity fed to Lake Alexandrina	Nil	$0	High	High	High	Low	High

Watering Site	Reach- section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria				
											Amount of benefit for volume of water (High, Medium, Low)	Risk of not applying water (High, Medium, Low)	Certainty/ likelihood of benefit (High, Medium, Low)	Risks associated with watering (High, Medium, Low)	Cost effectiveness (High, Medium, Low)
Boggy Creek, Turvey's Drain and Dog Lake Channel	15	Pumping water from Lake Alexandrina, Goowla Weir Pool and current irrigation infrastructure to Boggy Creek, Turvey's Drain and Dog Lake Channel	To maintain a recruiting population of the nationally vulnerable Murray hardyhead at all sites and maintain recruiting population of Southern pygmy perch at Turvey's Drain. To maintain water quality within known thresholds for Murray hardyheads at the site. To maintain habitat (fringing and aquatic) at the sites)	0.084	0.084	Nil	Watering should be on-going throughout the year, starting in July 2010	Pumping	Mil	$58,950	High	High	High	Low	High
River Murray Channel															
Hume to Yarrawonga	1	Increase flows in channel to water adjacent wetlands to protect and enhance riparian ecosystems	Maintain ecological functions in adjoining anabranches and wetlands that received water in 2009/10.	Up to 3	Up to 3	0	Opportunistic watering action – most likely late spring/early summer	Gravity fed. Requires flow >or=12,000 ML/day in channel	Nil	$0	Medium	Low	Medium	Low	High
			TOTAL	246	219	27			TOTAL	$1,223,450 - 1,338,450					

Schedule B: Dry (Possible TLM water available including carryover: 200 – 250 GL)

Watering Site	Reach-river section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria: Likelihood of benefit (High, Medium, Low)	Risk of not applying water (High, Medium, Low)	Certainty/ likelihood of benefit (High, Medium, Low)	Risks associated with watering (High, Medium, Low)	Cost effectiveness (High, Medium, Low)
Barmah-Millewa - Dry															
Duck Lagoon	5	Pump to rehabilitate wetland vegetation and RRG forest	Facilitate maintenance and recovery of wetland vegetation Contribute to maintenance of bird breeding and foraging habitat	2.0	2.0	Nil	August – December (this is an estimate as the capacity of the regulator is unknown at this stage)	Warrick regulator via Warrick Creek		$3,000	High	Medium	High	Medium	High
Clay Island	3	Pump or siphon to rehabilitate wetland vegetation and RRG forest	Avoid critical loss or alteration of vegetation communities. Facilitate maintenance and recovery of wetland vegetation Contribute to maintenance of bird breeding and foraging habitat	0.2	0.2	Nil	September – October	Pump or siphon direct from Edward River	Pump/siphon required	$8,000 (200ML @$40/ ML	High	Medium	High	Medium	High
Toupna Creek	3	Wet Creek & maintain low flow Sept till end January	Support connectivity through the forest and maintain river function Water stressed RRG Improve health of wetlands ensuring maintenance of key functions eg nutrient cycling Provide drought refuge and restoration of vegetation.	4.6 (10days 50ML then 140days 20ML)	1.7	2.9	September – November and March to June	Via Mary Ada regulator (>4700 ML/d @Toc.)	Installation of regulator or earth bank required at boundary to private property	Earth bank $3,000	High	High	High	Low	High

Watering Site	Reach-river section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria: Likelihood of benefit (High, Medium, Low)	Ranking criteria: Risk of not applying water (High, Medium, Low)	Ranking criteria: Certainty/ likelihood of benefit (High, Medium, Low)	Ranking criteria: Risks associated with watering (High, Medium, Low)	Ranking criteria: Cost effectiveness (High, Medium, Low)
Douglas Swamp	3	Re-watering, to enhance health of vegetation and maintain nesting habitat	Facilitate recovery of wetland vegetation and waterbird nesting habitat. Site of importance for waterbird breeding and feeding habitat.	0.75	0.75	Nil	September – October	Via Nestrons regulator (>10,000 ML/d @Toc.)	Desilt inlet	Desilt = $1,500	High	Medium	High	Medium	High
Walthours/ Deadwood Swamps	3	Re-watering, to enhance health of vegetation and maintain nesting habitat	Facilitate recovery of wetland vegetation and waterbird nesting habitat. Site of importance for waterbird breeding.	0.30	0.30	Nil	September – October	Via Walt-hours regulator (>10,000ml/d @ Toc.) Or pumping to deliver water	Desilt inlet	Desilt = $1,500	High	Medium	High	Medium	High
St Helena		Re-watering, to enhance health of vegetation and maintain nesting habitat	Facilitate recovery of wetland vegetation and waterbird nesting habitat. Site of importance for waterbird breeding.	0.40	0.40	Nil	October – November	Via Crumps Regulator		$0	High	Medium	High	Medium	High
Barmah – Top Island Boals Deadwoods Goose Swamp Gulf Creek	3	Maintain several wetlands and creeks.	Provide drought refuge for waterbirds and water stressed vegetation including trees and wetland plants.	15.05	15.05	Nil	September – November	River gravity /Island and Sapping creek regulator		$45,000	High	Medium	High	Low	High

Watering Site	Reach-river section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria				
											Likelihood of benefit (High, Medium, Low)	Risk of not applying water (High, Medium, Low)	Certainty/ likelihood of benefit (High, Medium, Low)	Risks associated with watering (High, Medium, Low)	Cost effectiveness (High, Medium, Low)
Wetlands, creeks and floodplain within the BMF	3	Consideration should be given to delivering all flows provided downstream of Barmah-Millewa via this icon site. the volume not used within the forest (= total – losses) will return to the River for reuse downstream.	To provide drought refuge in drought conditions and enable growth, reproduction and recruitment at various scales depending on the volumes available, seasonal conditions and River operations.	TBA		70 to 95%	August – December	Direct from the River Murray, via regulator or overbank flows.	Overbank flows	$5,000 to $50,000 (for flow gauging to measure return flows) TBC	High	Medium	High	Medium	High
Gunbower-Koondrook-Perricoota Forest – Dry															
Horseshoe lagoon (17 ha)	7	Pump to lagoon to improve RRG fringing vegetation	Support connectivity through the forest and maintain river function Water stressed RRG Improve health of wetlands ensuring maintenance of key functions eg nutrient cycling Provide drought refuge and restoration of vegetation	0.25	0.25	nil	Spring	Pumping required	Block bank	$13,000	High	High	High	Medium	High

Watering Site	Reach-river section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria: Likelihood of benefit (High, Medium, Low)	Risk of not applying water (High, Medium, Low)	Certainty/ likelihood of benefit (High, Medium, Low)	Risks associated with watering (High, Medium, Low)	Cost effectiveness (High, Medium, Low)
Blackbox Lagoon (17 ha)	7	Pump to lagoon to improve RRG fringing vegetation	Regeneration of vegetation and endemic wetland species that largely been absent through the drought Improve health of wetlands ensuring maintenance of key functions eg nutrient cycling Improve health of fringing RRG vegetation	0.25	0.25	nil	Spring	Pumping required	Block bank	$11,500	High	High	High	Medium	High
390 mile lagoon (6 ha)	7	Pump to lagoon to improve RRG fringing vegetation	Regeneration of vegetation and endemic wetland species that largely been absent through the drought Improve health of wetlands ensuring maintenance of key functions eg nutrient cycling Improve health of fringing RRG vegetation	0.1	0.1	nil	Spring	Pumping required	Block bank	$5,500	High	High	High	Medium	High

Watering Site	Reach-river section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria				
											Likelihood of benefit (High, Medium, Low)	Risk of not applying water (High, Medium, Low)	Certainty/ likelihood of benefit (High, Medium, Low)	Risks associated with watering (High, Medium, Low)	Cost effectiveness (High, Medium, Low)
Thule Creek	7	Inundate low-lying forest areas – improve vegetation health	Avoid irretrievable loss of key environmental assets – work towards achieving 30% of River Red gum Forest in a healthy condition and improve health of 80% semi-permanent wetlands through improving connectivity	10	10	nil	Spring	Pumping required	Block bank	$401,500	High	High	High	Medium	High
Unnamed Creek (near Clarkes Lagoon Rd junction)	7	Inundate low-lying forest areas – improve vegetation health	Support connectivity through the forest and maintain river function Water stressed RRG Improve health of wetlands ensuring maintenance of key functions eg nutrient cycling Provide drought refuge and restoration of vegetation	10	10	nil	Spring	Pumping required	Block bank	$401,500	High	High	High	Medium	High
Little Reedy Complex	4	Gravity fed from Gunbower creek via Yarran Creek regulator	A large area of permanent wetland would be flooded, providing feeding and breeding habitat for a range of waterbirds, fish, frogs and turtles.	5	5	Nil	Spring	Channel system	Yarran Creek regulator (uses Torrumbarry Irrigation System)	$0 (possibility of small cost being determined with G-MW)	High	Medium	High	Low	High

Watering Site	Reach-river section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria				
											Likelihood of benefit (High, Medium, Low)	Risk of not applying water (High, Medium, Low)	Certainty/ likelihood of benefit (High, Medium, Low)	Risks associated with watering (High, Medium, Low)	Cost effectiveness (High, Medium, Low)
Black Charlie Lagoon (Gunbower)	4	Water to replenish wetland dry for past 5 years	Provide drought refuge for birds and fish in upstream region of Gunbower Forest	2	2	Nil	September – October (ideally during September and October 2010); no later than end October 2010	River gravity, Torrumbarry weir and Cameron Creek/ channel		$0 ($140,000 to deliver 2GL if conditions change & temporary pumping required)	High	High	High	Low	High
Gunbower Creek	4	This action will directly inform the detailed design for the Hipwell Road Channel Package of Works.	The objectives are: Calibrate the Gunbower Creek hydraulic model to inform the level requirements for the Hipwell Road Package of Works Calculate losses associated with delivering environmental water through Gunbower Creek Measure return flows to the River Murray Provide a spawning cue to native fish within Gunbower Creek.	17	5	12	July onwards	River gravity and Gunbower Creek		TBC					

Watering Site	Reach-river section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria: Likelihood of benefit (High, Medium, Low)	Ranking criteria: Risk of not applying water (High, Medium, Low)	Ranking criteria: Certainty/ likelihood of benefit (High, Medium, Low)	Ranking criteria: Risks associated with watering (High, Medium, Low)	Ranking criteria: Cost effectiveness (High, Medium, Low)
Chowilla Floodplain, Lindsay and Wallpolla Islands															
Lake Wallawalla		Temporary pumping to wetland to established vegetation within the lakebed and maintain wetland habitat for waterbirds, frogs and turtles.	Increase the diversity of structural aquatic habitat Increase the diversity and distribution of native fish Provide occasional breeding and roosting habitat for waterbirds Provide habitat suitable for migratory waterbird species.	10 (5GL in Spring + 5GL in Autumn)	10	Nil		Temporary Pumps		$330,000 (10,000 @$33/ ML)	High	High	High	Low	High
Lindsay Island	12	Temporary pumping to wetland aquatic habitat and waterbirds.	Increase the diversity of structural aquatic habitat Increase the diversity and distribution of native fish Provide occasional breeding and roosting habitat for waterbirds Provide habitat suitable for migratory waterbird species.	2.8 (1.1GL in spring + 1.7GL in autumn)	2.8	Nil	September – October and March - May	Temporary pumping		$126,000 (2800 ML @ $45/ML)	High	High	High	Low	High

Watering Site	Reach-river section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria: Likelihood of benefit (High, Medium, Low)	Risk of not applying water (High, Medium, Low)	Certainty/ likelihood of benefit (High, Medium, Low)	Risks associated with watering (High, Medium, Low)	Cost effectiveness (High, Medium, Low)
Mulcra Island	14	Raising Lock 8 to generate flows through Potterwalkage Creek; using newly completed TLM infrastructure to deliver water to the floodplain.	Increase the diversity of structural aquatic habitat; Increase the diversity and distribution of native fish; Provide occasional breeding and roosting habitat for waterbirds; Provide habitat suitable for migratory waterbird species.	20	5	15	March – June			$0	High	High	High	Low	High
Anderson Creek	15	Pumping to water Black box, River red gums, lignum and bird species	Prevent critical loss of species Provide drought refuge	0.265	0.265	Nil	March – May	Pumping		$27,950	High	High	High	Medium	Medium
Twin Creeks, Monoman Creek Depression and Gum Flat	15	Pumping to water to maintain River red gums, Black box and lignum.	Prevent critical loss of species Provide drought refuge Provide breeding opportunities and refuge for waterbirds and frogs Maintain benefits from watering program to date	1.665	1.665	Nil	September – November	Pumping		$0	High	High	High	Medium	High

Watering Site	Reach-river section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria				
											Likelihood of benefit (High, Medium, Low)	Risk of not applying water (High, Medium, Low)	Certainty/ likelihood of benefit (High, Medium, Low)	Risks associated with watering (High, Medium, Low)	Cost effectiveness (High, Medium, Low)
Chowilla Oxbow (Anderson Creek)	15	Pumping to water to terminal wetland sites to maintain River red gum and Black box vegetation.	Prevent critical loss of species Provide drought refuge Maintain benefits from watering program to date	0.21	0.21	Nil	December – February	Pumping		$0	High	High	High	Medium	High
Lower Lakes, Coorong and Murray Mouth															
Fringing Wetlands of Lake Alexandrina	15	Pumping to enable wetlands to function and provide critical ecological services in the interim until Lake levels increase.	Prevent critical loss of species Avoid irreversible loss/ catastrophic event; or Provide drought refuge	1.8	1.8	Nil	September – November	Pumping		$160,000	High	Medium	High	Low	Medium
Lake Alexandrina, Lake Albert	15	Water to be gravity fed to Lake Alexandrina. Decisions re water sharing with lake Albert subject to ongoing discussion s regarding the best ecological outcomes to be achieved with available water.	Maintain salinity levels within threshold tolerance of key note species. Avoid acidification of water body by maximising volume and supporting the natural bacterial cycle to neutralise existing acidity. Provide drought refuge for wading birds Provide environmental pulse along River Murray Channel and stimulate fish breeding	250	250	Nil	TBA	Pumping		$0	High	High	High	Low	High

Watering Site	Reach-river section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria				
											Likelihood of benefit (High, Medium, Low)	Risk of not applying water (High, Medium, Low)	Certainty/ likelihood of benefit (High, Medium, Low)	Risks associated with watering (High, Medium, Low)	Cost effectiveness (High, Medium, Low)
River Murray Channel															
Hume to Yarrawonga	1	Increase flows in channel to water adjacent wetlands to protect and enhance riparian ecosystems	Maintain ecological functions in adjoining anabranches and wetlands that received water in 2009/10.	Up to 3	Up to 3	0	Opportunistic watering action – most likely late spring/early summer	Gravity fed. Requires flow >or=12,000 ML/day in channel	Nil	$0	Medium	Low	Medium	Low	High
			TOTAL	357	327	30			TOTAL	$1,543,950-1,588,950					

Schedule C: Median (Possible TLM water available including carryover: 310 – 380 GL)

Watering Site	Reach-section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria: Likelihood of benefit (High, Medium, Low)	Ranking criteria: Risk of not applying water (High, Medium, Low)	Ranking criteria: Certainty/ likelihood of benefit (High, Medium, Low)	Ranking criteria: Risks associated with watering (High, Medium, Low)	Ranking criteria: Cost effectiveness (High, Medium, Low)
Barmah-Millewa - Median															
Duck Lagoon	5	Open regulator to provide flow in Warrick Creek to rehabilitate wetland vegetation and RRG forest.	Provide for reproduction and recruitment of wetland species and River Redgums recovering from wildfire. Provide connectivity with other wetland areas within Moira, in particular Reed Beds that was watered twice in the last two years. Re-establish wet-dry phase to wetland	2	2	Nil	Spring/ Summer	Via Warrick Creek & Warrick regulator	Possible block banks required	TBC (approx $3,000 if block banks required)	High	Medium	High	Medium	High
Clay Island	5	Use pumps to rehabilitate wetland vegetation and RRG forest	Improve connectivity and connection with the river and between wetlands within site. Promote growth and recovery of River Redgums and wetland vegetation. Re-establish wet-dry phase to improve ecosystem function.	0.3	0.3	Nil	Spring	Pump or siphon direct from Edward River	Pump/siphon required	$12,000 (300ML @$40/ ML), less if siphoned	High	Medium	High	Medium	High

Watering Site	Reach-section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria				
											Likelihood of benefit (High, Medium, Low)	Risk of not applying water (High, Medium, Low)	Certainty/ likelihood of benefit (High, Medium, Low)	Risks associated with watering (High, Medium, Low)	Cost effectiveness (High, Medium, Low)
Millewa - Toupna Creek (Preferably water in conjunction with Douglas & Walthours swamps)	3	Open Mary Ada regulator to allow flows through Toupna Creek and reinvigorate wetland vegetation	Provide connectivity through low-lying areas of forest promoting growth and reproduction of River Redgums. Re-establish wet-dry phase to semi-permanent wetlands. Regeneration of wetland flora improving species diversity and abundance providing nesting and feeding habitat for waterbirds during future flood events. Broad scale watering may stimulate low scale colonial bird breeding event.	5.1	1.85	3.25	September – June	Via Mary Ada regulator	Block Bank	$3,000	High	High	High	Low	High
Douglas Swamp	3	Re-watering to enhance vegetation health and maintain nesting habitat	Build on improvements gained from prior watering (2009) and continue to restore vegetation health, reproductive capacity and key wetland processes. Provide connectivity through low-lying areas of forest promoting growth and reproduction of River Redgums. Re-establish wet-dry phase to improve ecosystem function.	0.75	0.75	Nil	Spring	Via Nestrons regulator (>10,000 ML/d @Toc.)	Desilt inlet	$1,500	High	Medium	High	Medium	High

Watering Site	Reach-section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria				
											Likelihood of benefit (High, Medium, Low)	Risk of not applying water (High, Medium, Low)	Certainty/ likelihood of benefit (High, Medium, Low)	Risks associated with watering (High, Medium, Low)	Cost effectiveness (High, Medium, Low)
Walthours/ Deadwood Swamps	3	Re-watering to enhance vegetation health and maintain nesting habitat	Build on improvements gained from prior watering (2009) and continue to restore vegetation health, reproductive capacity and key wetland processes. Provide connectivity through low-lying areas of forest promoting growth and reproduction of River Redgums. Re-establish wet-dry phase to improve ecosystem function.	0.4	0.4	Nil	Spring	Via Walthours regulator (>10,000 Ml/d @ Toc.)	Desilt inlet	$1,500	High	Medium	High	Medium	High
St Helena Swamp	3	Re-watering to enhance vegetation health and maintain nesting habitat	Build on improvements gained from prior watering (2009) and continue to restore vegetation health, reproductive capacity and key wetland processes. Provide connectivity through low-lying areas of forest. Watering action will enable wetland plants to mature and seed.	0.5	0.5	Nil	Spring	Via Crumps regulator	Nil	$0	High	Medium	High	Medium	High

Watering Site	Reach-section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria				
											Likelihood of benefit (High, Medium, Low)	Risk of not applying water (High, Medium, Low)	Certainty/ likelihood of benefit (High, Medium, Low)	Risks associated with watering (High, Medium, Low)	Cost effectiveness (High, Medium, Low)
Barmah (Top Island, Boals Deadwoods, Gooses Swamp, Gulf Creek, Smiths Creek)	3	Provide flows to maintain several wetlands and creeks	Provide drought refuge for waterbirds and other wetland dependent species, such as turtles. It would maintain key functions of several wetlands and creeks with icon site.	70	20	50	Spring	Gravity fed via overbank flows	Nil	$50,000 (modelling/ gauging costs)	High	Medium	High	Low	High
Wetlands, creeks and floodplain within the BMF	3	Provide flows to maintain wetlands creeks and possibly floodplain ecosystems	Provide drought refuge for water birds and other wetland dependent species, such as fish and turtles	TBA		70 to 95%	August – December	Direct from the River Murray, via regulator or overbank flows	Over Bank	TBC $5,000 to $50,000 (for flow gauging to measure return flows)	High	Medium	High	Low	High
Gunbower-Koondrook-Perricoota Forest – Median															
Horseshoe lagoon (17 ha)	7	Pump to lagoon to improve RRG fringing vegtation	Promote growth and reproduction of fringing Redgum vegetation. Promote regeneration of wetland flora species improving diversity and abundance. Re-establish wet-dry phase to wetland. Provide nesting and feeding habitat for waterbirds during future flood events.	0.3	0.3	nil	Spring	Pumping required	Block bank	$15,000 (pumping and block bank)	High	High	High	Low	High

Watering Site	Reach-section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria				
											Likelihood of benefit (High, Medium, Low)	Risk of not applying water (High, Medium, Low)	Certainty/ likelihood of benefit (High, Medium, Low)	Risks associated with watering (High, Medium, Low)	Cost effectiveness (High, Medium, Low)
Swan Lagoon (37 ha)	7	Pump to lagoon to improve RRG fringing vegetation,	Promote growth and reproduction of fringe RRG vegetation Allow re-establishment of wet-dry phase in semi-permanent wetlands that have been dry and stressed over last 10 years and stimulate nutrient cycling Promote regeneration of wetland flora, improving species diversity and abundance, and provide nesting and feeding habitat for waterbirds during future flood events.	0.5	0.5	nil	Spring	Pumping required	Block bank	$21,500 (pumping and block bank)	High	High	High	Medium	High
Swan Lagoon (37 ha)	7	Pump to lagoon to improve RRG fringing vegetation,	Promote growth and reproduction of fringing Redgum vegetation. Promote regeneration of wetland flora species improving diversity and abundance. Re-establish wet-dry phase to wetland. Provide nesting and feeding habitat for waterbirds during future flood events.	0.65	0.65	nil	Spring	Pumping required	Block bank	$27,500 (pumping and block bank)	High	High	High	Low	High

Watering Site	Reach-section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria				
											Likelihood of benefit (High, Medium, Low)	Risk of not applying water (High, Medium, Low)	Certainty/ likelihood of benefit (High, Medium, Low)	Risks associated with watering (High, Medium, Low)	Cost effectiveness (High, Medium, Low)
Blackbox Lagoon (17 ha)	7	Pump to lagoon to improve RRG fringing vegetation,	Promote growth and reproduction of fringing Redgum vegetation. Promote regeneration of wetland flora species improving diversity and abundance. Re-establish wet-dry phase to wetland. Provide nesting and feeding habitat for waterbirds during future flood events.	0.3	0.3	nil	Spring	Pumping required	Block bank	$13,500 (pumping and block bank)	High	High	High	Low	High
390 mile lagoon (6 ha)	7	Pump to lagoon to improve RRG fringing vegetation,	Promote growth and reproduction of fringing Redgum vegetation. Promote regeneration of wetland flora species improving diversity and abundance. Re-establish wet-dry phase to wetland. Provide nesting and feeding habitat for waterbirds during future flood events.	0.15	0.15	nil	Spring	Pumping required	Block bank	$7,500 (pumping and block bank)	High	High	High	Low	High

Watering Site	Reach-section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria				
											Likelihood of benefit (High, Medium, Low)	Risk of not applying water (High, Medium, Low)	Certainty/ likelihood of benefit (High, Medium, Low)	Risks associated with watering (High, Medium, Low)	Cost effectiveness (High, Medium, Low)
Thule Creek	7	Pump into creek to inundate low-lying forest areas – improve vegetation health	Provide connectivity of low-lying forest promoting growth and reproduction of fringing Redgum vegetation. Promote regeneration of wetland flora species improving diversity and abundance. Re-establish wet-dry phase to wetland. May stimulate low-scale colonial bird bereeding event. Provide nesting and feeding habitat for waterbirds during future flood events.	10	10	nil	Spring	Pumping required	Block bank	$401,500 (pumping and block bank)	High	High	High	Low	High
Unnamed Creek (near Clarkes Lagoon Rd junction)	7	Pump into creek to inundate low-lying forest areas & improve vegetation health	Provide connectivity of low-lying forest promoting growth and reproduction of fringing Redgum vegetation. Promote regeneration of wetland flora species improving diversity and abundance. Re-establish wet-dry phase to wetland. May stimulate low-scale colonial bird bereeding event. Provide nesting and feeding habitat for waterbirds during future flood events.	10	10	nil	Spring	Pumping required	Block bank	$401,500 (pumping and block bank)	High	High	High	Low	High

Watering Site	Reach-section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria				
											Likelihood of benefit (High, Medium, Low)	Risk of not applying water (High, Medium, Low)	Certainty/ likelihood of benefit (High, Medium, Low)	Risks associated with watering (High, Medium, Low)	Cost effectiveness (High, Medium, Low)
Swan Lagoon into Burrumbury system	7	Pump into lagoon which will then flow through creek system to inundate low-lying forest areas & improve vegetation health	Provide connectivity of low-lying forest promoting growth and reproduction of fringing Redgum vegetation. Promote regeneration of wetland flora species improving diversity and abundance. Re-establish wet-dry phase to wetland. May stimulate low-scale colonial bird bereeding event. Provide nesting and feeding habitat for waterbirds during future flood events.	10	10	Nil	Spring	Pumping required	Block bank	$401,500 (pumping and block bank)	High	High	High	Low	High
Horseshoe Lagoon into Burrumbury system	7	Pump into lagoon which will then flow through creek system to inundate low-lying forest areas & improve vegetation health	Provide connectivity of low-lying forest promoting growth and reproduction of fringing Redgum vegetation. Promote regeneration of wetland flora species improving diversity and abundance. Re-establish wet-dry phase to wetland. May stimulate low-scale colonial bird bereeding event. Provide nesting and feeding habitat for waterbirds during future flood events.	10	10	Nil	Spring	Pumping required	Block bank	$403,000 (pumping and block bank)	High	High	High	Low	High

Watering Site	Reach-section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria: Likelihood of benefit (High, Medium, Low)	Ranking criteria: Risk of not applying water (High, Medium, Low)	Ranking criteria: Certainty/ likelihood of benefit (High, Medium, Low)	Ranking criteria: Risks associated with watering (High, Medium, Low)	Ranking criteria: Cost effectiveness (High, Medium, Low)
Gunbower Forest Wetlands and Creeks	4	Gravity fed flows through Gunbower Creek, water delivered via the new Lower Landscape works	A large area of wetlands and River Redgum grassy woodland would be flooded, providing feeding and breeding habitat for a range of waterbirds, fish, frogs and turtles.	15	12	3	Autumn – Spring 2011	Channel system and Gunbower Creek and regulator	New Lower Landscape Regulators (uses Torrumbarry Irrigation System)	$0 (possibility of small cost being determined with G-MW)	High	Medium	High	Low	High
Gunbower Creek	4	This action will directly inform the detailed design for the Hipwell Road Channel Package of Works.	Calibrate the Gunbower Creek hydraulic model to inform the level requirements for the Hipwell Road Package of Works Calculate losses associated with delivering environmental water through Gunbower Creek Measure return flows to the River Murray Provide a spawning cue to native fish within Gunbower Creek.	17	5	12	July onwards	River gravity and Gunbower Creek		TBC					

Watering Site	Reach-section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria: Likelihood of benefit (High, Medium, Low)	Risk of not applying water (High, Medium, Low)	Certainty/ likelihood of benefit (High, Medium, Low)	Risks associated with watering (High, Medium, Low)	Cost effectiveness (High, Medium, Low)
Chowilla Floodplain, Lindsay and Wallpolla Islands															
Mulcra Island	14	Raising Lock 8 to generate flows through Potterwalkage Creek; using newly completed TLM infrastructure to deliver water to the floodplain.	Increase the diversity of structural aquatic habitat; Increase the diversity and distribution of native fish; Provide occasional breeding and roosting habitat for waterbirds; Provide habitat suitable for migratory waterbird species.	20	5	15	March – June			$0	High	High	High	Low	High
Lower Lakes, Coorong and Murray Mouth															
Lake Alexandrina, Lake Albert and Murray Mouth	15	Maintain salinity levels and provide critical waterbird habitat	Prevent critical loss of species Avoid irreversible loss/ catastrophic event; or Provide drought refuge Maintain river functioning with reduced reproductive capacity Enable growth, reproduction and small-scale recruitment; and Promote low-lying floodplain connectivity	360	360	Nil	TBA	Water will be gravity fed to Lake Alexandrina			High	High	High	Low	High
			TOTAL (with small volumes at Swan & Horseshoe Lagoons')	512	429	83			TOTAL	$968,500-$1,013,500					
			TOTAL (with large volumes at Swan & Horseshoe Lagoons')	530	447	83			TOTAL	$1,704,500-1,749,500					

Schedule D: Wet (Possible TLM water available including carryover: 460 – 520 GL)

Watering Site	Reach-section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria				
											Likelihood of benefit (High, Medium, Low)	Risk of not applying water (High, Medium, Low)	Certainty/ likelihood of benefit (High, Medium, Low)	Risks associated with watering (High, Medium, Low)	Cost effectiveness (High, Medium, Low)
Barmah-Millewa – Wet															
Toupna Creek	5	Water delivered through regulators then disperse through forest via interlinked runners and inundating wetlands	Extended period of inundation promoting growth reproduction and large-scale recruiting. Large volume may reach vegetation higher on the floodplain, including Box communities. High flood levels would enhance river and floodplain functioning and provide greater connectivity throughout the forest. Support threatened Southern Pigmy Perch population. Re-establishment of a wet-dry phase in semi-permanent wetlands.	120	20	100	Spring	Via Mary Ada regulator. (Flow at Yarrawonga >9000ML/ day)	Nil	$0	High	High	High	Low	High
Barmah (85 % Barmah forest floodplain)	3	Overbank flows to enable significant growth, reproduction and recruitment of vegetation & associated biota	Would enable growth, reproduction and large-scale recruitment of vegetation and associated biota throughout the forest.	180	9	171	Spring	Gravity fed via overbank flows	Nil	$80,000 (modelling/ gauging costs)	High	Low	High	Low	High

Watering Site	Reach-section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria: Likelihood of benefit (High, Medium, Low)	Risk of not applying water (High, Medium, Low)	Certainty/ likelihood of benefit (High, Medium, Low)	Risks associated with watering (High, Medium, Low)	Cost effectiveness (High, Medium, Low)
Wetlands, creeks and floodplain within the BMF	3	Consideration should be given to delivering all flows provided downstream of Barmah-Millewa via this icon site.	Provide drought refuge for water birds and other wetland dependent species, such as fish and turtles	TBA		70 to 95%	August – December	Direct from the River Murray, via regulator or overbank flows	Over Bank	TBC $5,000 to $50,000 (for flow gauging to measure return flows)	High	Medium	High	Low	High
Gunbower-Koondrook-Perricoota Forest – Wet															
Horseshoe lagoon (17 ha)	7	Pump to lagoon to improve RRG fringing vegtation	Extended period of inundation promoting growth reproduction and large-scale recruiting. Increase species diversity and abundance, and stimulate nutrient cycling.	0.4	0.4	nil	Spring	Pumping required	Block bank	$19,000 (Pumping and block bank)	High	High	High	Low	High
Swan Lagoon (37 ha)	7	Pump to lagoon to improve RRG fringing vegetation,	Extended period of inundation promoting growth reproduction and large-scale recruiting. Increase species diversity and abundance, and stimulate nutrient cycling.	0.75	0.75	nil	Spring	Pumping required	Block bank	$31,500 (Pumping and block bank)	High	High	High	Low	High

Watering Site	Reach-section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria				
											Likelihood of benefit (High, Medium, Low)	Risk of not applying water (High, Medium, Low)	Certainty/ likelihood of benefit (High, Medium, Low)	Risks associated with watering (High, Medium, Low)	Cost effectiveness (High, Medium, Low)
Blackbox Lagoon (17 ha)	7	Pump to lagoon to improve RRG fringing vegetation,	Extended period of inundation promoting growth reproduction and large-scale recruiting. Increase species diversity and abundance, and stimulate nutrient cycling.	0.4	0.4	nil	Spring	Pumping required	Block bank	$17,500 (Pumping and block bank)	High	High	High	Low	High
390 mile lagoon (6 ha)	7	Pump to lagoon to improve RRG fringing vegetation,	Extended period of inundation promoting growth reproduction and large-scale recruiting. Increase species diversity and abundance, and stimulate nutrient cycling.	0.2	0.2	nil	Spring	Pumping required	Block bank	$9,500 (Pumping and block bank)	High	High	High	Low	High
Thule Creek	7	Pump into creek to inundate low-lying forest areas – improve vegetation health	Extended period of inundation promoting growth reproduction and large-scale recruiting. Large volume may reach vegetation higher on the floodplain, including Box communities. High flood levels would enhance river and floodplain functioning and provide greater connectivity throughout the forest.	10	10	nil	Spring	Pumping required	Block bank	$401,500 (Pumping and block bank)	High	High	High	Low	High

Watering Site	Reach-section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria				
											Likelihood of benefit (High, Medium, Low)	Risk of not applying water (High, Medium, Low)	Certainty/ likelihood of benefit (High, Medium, Low)	Risks associated with watering (High, Medium, Low)	Cost effectiveness (High, Medium, Low)
Horseshoe Lagoon into Burrumbury system	7	Pump into creek to inundate low-lying forest areas – improve vegetation health	Extended period of inundation promoting growth reproduction and large-scale recruiting. Large volume may reach vegetation higher on the floodplain, including Box communities. High flood levels would enhance river and floodplain functioning and provide greater connectivity throughout the forest.	10	10	nil	Spring	Pumping required	Block bank	$403,000 (Pumping and block bank)	High	High	High	Low	High
Unnamed Creek (near Clarkes Lagoon Rd junction)	7	Pump into creek to inundate low-lying forest areas & improve vegetation health	Extended period of inundation promoting growth reproduction and large-scale recruiting. Large volume may reach vegetation higher on the floodplain, including Box communities. High flood levels would enhance river and floodplain functioning and provide greater connectivity throughout the forest.	10	10	nil	Spring	Pumping required	Block bank	$401,500 (Pumping and block bank)	High	High	High	Low	High

Watering Site	Reach-section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria				
											Likelihood of benefit (High, Medium, Low)	Risk of not applying water (High, Medium, Low)	Certainty/ likelihood of benefit (High, Medium, Low)	Risks associated with watering (High, Medium, Low)	Cost effectiveness (High, Medium, Low)
Swan Lagoon into Burrumbury system	7	Pump into lagoon which will then flow through creek system to inundate low-lying forest areas & improve vegetation healt	Extended period of inundation promoting growth reproduction and large-scale recruiting. Large volume may reach vegetation higher on the floodplain, including Box communities. High flood levels would enhance river and floodplain functioning and provide greater connectivity throughout the forest.	10	10	nil	Spring	Pumping required	Block bank	$401,500 (Pumping and block bank)	High	High	High	Low	High
Gunbower Creek	4	This action will directly inform the detailed design for the Hipwell Road Channel Package of Works.	Calibrate the Gunbower Creek hydraulic model to inform the level requirements for the Hipwell Road Package of Works Calculate losses associated with delivering environmental water through Gunbower Creek Measure return flows to the River Murray Provide a spawning cue to native fish within Gunbower Creek.	17	5	12	July onwards	River gravity and Gunbower Creek		TBC					

Watering Site	Reach-section of River Murray	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria				
											Likelihood of benefit (High, Medium, Low)	Risk of not applying water (High, Medium, Low)	Certainty/ likelihood of benefit (High, Medium, Low)	Risks associated with watering (High, Medium, Low)	Cost effectiveness (High, Medium, Low)
Chowilla Floodplain, Lindsay and Wallpolla Islands															
Mulcra Island	14	Raising Lock 8 to generate flows through Potterwalkage Creek; using newly completed TLM infrastructure to deliver water to the floodplain.	Increase the diversity of structural aquatic habitat; Increase the diversity and distribution of native fish; Provide occasional breeding and roosting habitat for waterbirds; Provide habitat suitable for migratory waterbird species.	20	5	15	March – June			$0	High	High	High	Low	High
Lake Alexandrina, Lake Albert and Murray Mouth	15	Maintain salinity levels and provide critical waterbird habitat	Prevent critical loss of species Avoid irreversible loss/ catastrophic event; or Provide drought refuge Maintain river functioning with reduced reproductive capacity Enable growth, reproduction and small-scale recruitment; and Promote low-lying floodplain connectivity	360+	360+	Nil	TBA	Water will be gravity fed to Lake Alexandrina			High	High	High	Low	High
			TOTAL (with small volumes at Swan & Horseshoe Lagoons')	718	420	298				$955,000 - $1,000,000					
			TOTAL (with large volumes at Swan & Horseshoe Lagoons')	736	438	298				$1,709,000 - $1,814,000					

Australian Government

MURRAY–DARLING BASIN AUTHORITY

Australian Government

MURRAY–DARLING BASIN AUTHORITY

MURRAY–DARLING BASIN AUTHORITY

The Living Murray

Annual Environmental Watering Plan 2011-12

August 2011

The Living Murray

Annual Environmental Watering Plan 2011-12

Published August 2011

Copyright

Published by the Murray-Darling Basin Authority

Postal Address:	GPO Box 1801, Canberra ACT 2601
Office location:	Level 4, 51 Allara Street, City ACT
Telephone:	(02) 6279 0100 international + 61 2 6279 0100
Facsimile:	(02) 6248 8053 international + 61 2 6248 8053
Email:	info@mdba.gov.au
Internet:	www.mdba.gov.au

This report may be cited as: *The Living Murray Annual Environmental Watering Plan 2011-12*

MDBA publication no. 170/11

ISBN (online) 978-1-921914-52-2

Cover image: *Young cormorants, Barmah Forest* (Photo by Keith Ward © MDBA)

Contents

1 Introduction

The Living Murray (TLM) was established in 2002 in response to evidence of the declining health of the River Murray system. In November 2003 the Murray–Darling Basin Ministerial Council announced its historic The Living Murray First Step Decision. This decision was to recover an average of 500 GL per year for the environment. As at 30 May 2011, 477.8 GL had been recovered. This volume is expected to increase to 486 GL in 2011–12. A structural works program is currently underway to deliver this water efficiently.

The Living Murray's First Step focuses on achieving a set of agreed ecological objectives at six 'icon sites' along the River Murray through a combination of 'water and works'. The six icon sites are:

- Barmah–Millewa Forest
- Gunbower–Koondrook–Perricoota Forest
- Hattah Lakes
- Chowilla Floodplain and Lindsay–Wallpolla Islands
- Lower Lakes, Coorong and Murray Mouth
- River Murray Channel.

This document, The Living Murray Annual Environmental Watering Plan 2011–12, outlines the decision framework for prioritising the use of recovered TLM water for environmental actions across the River Murray system in 2011–12. The Plan has been jointly developed by the Murray–Darling Basin Authority (MDBA) and Environmental Watering Group (EWG) which consists of the partner governments for The Living Murray Initiative.

The annual water planning process is responsive to changes in water resource conditions, opportunities and environmental priorities throughout the season. Implementation of The Living Murray Annual Environmental Watering Plan 2011–12, including any changes to priorities or other aspects of the Plan, is recorded separately and reported at the end of the year in The Living Murray implementation report.

For information about The Living Murray go to www.mdba.gov.au/programs/tlm.

[1] The River Murray system includes: the main course of the River Murray and all its effluents and anabranches downstream of Hume Dam to the sea including the Edward–Wakool River system, the Mitta Mitta River downstream of Dartmouth Dam and the Darling River and Great Darling Anabranch downstream of Menindee Lakes.

Water access entitlement: a perpetual or ongoing entitlement, by or under law of a State, to exclusive access to a share of the water resources of a water resource plan area.

Unregulated flows: water that cannot be captured in Lake Victoria and is, or will be, in excess of the required flow to South Australia.

River Murray Unregulated Flows: unregulated flows in the River Murray occurring after jurisdictions have exercised their existing rights.

Water resource scenarios: the extreme dry, dry, median and wet resource scenarios are based on anticipated inflows to River Murray system and the associated climate conditions.

2 Environmental watering activities 2010–11

2.1 Inflows 2010–11

Inflows for the 2010–11 water year (June 2010 to May 2011) were among the highest on record, with the highest rainfall on record occurring in the southern half of the Basin and in parts of south-east Queensland (figure 1).

Although similar inflow volumes have occurred historically the inflow pattern in 2010–11 was very unusual. Inflows until the end of November were modest, however inflows over the summer period were about 6,700 GL, which was more than double the previous highest of about 2,980 GL recorded in the summer of 1992–93.

The dramatic increase in inflows resulted in floods occurring multiple times along parts of the Murray, Barwon–Darling, Murrumbidgee, Goulburn, Ovens, Campaspe, Loddon and many other rivers in the Basin. The extent of this flooding varied across the River Murray system due to the pattern of rainfall and the nature of the floodplain.

2.2 Environmental watering activities 2010–11

At the beginning of 2010–11, the outlook for inflows into the River Murray system still looked grim. Opening allocations were expected to be very low and the drought in many areas of the southern basin was not over. The Living Murray had carried over environmental water from the previous water year to provide sufficient water to trial a large multiple watering in spring at the Barmah–Millewa Forest and the Lower Lakes, Coorong and Murray Mouth.

Whilst environmental water was initially allocated to a small number of watering actions, the high inflows in late spring, with the accompanying increase in allocations provided the opportunity to increase both the number and size of environmental watering actions. This included the release of 428 GL of environmental water (comprised of 10 GL of entitlements held by NSW, 199 GL from The Living Murray and 219 GL from the Barmah–Millewa Environmental Water Account) from Hume Reservoir.

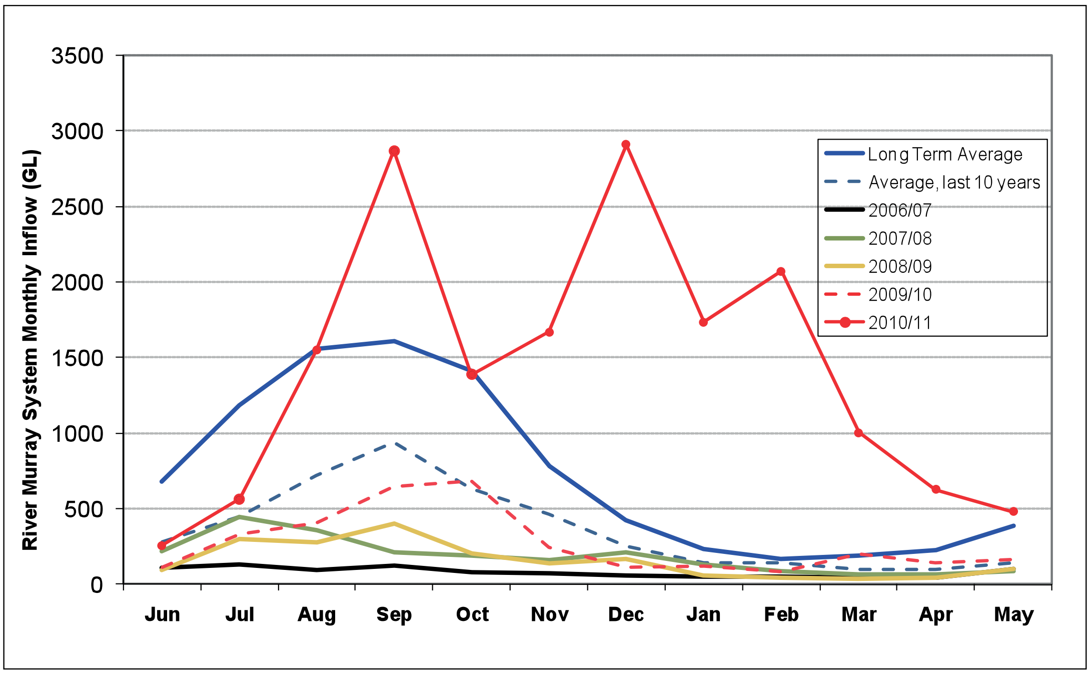


Figure 1 Comparison of inflows to the River Murray system (excluding the Darling River and Snowy River) in selected years

These releases were timed to maintain water levels in key colonial waterbird breeding areas and other wetlands in the Barmah–Millewa Forest during periods of lower flow rates so that fledgling chicks were not abandoned.

Whilst 317 GL of TLM allocation was committed by November 2010 for environmental watering activities, the subsequent higher inflows meant that some of these watering actions were partially or fully met by the floods. For example, TLM, New South Wales and the Commonwealth initially provided environmental water to the Lower Darling Anabranch which was then extended by the flooding. Although flows are now receding in the Anabranch, most billabongs and lakes have now been inundated for the first time in ten years and the landscape continues to flourish.

In 2010–11 a total of 270.175 GL of allocation was delivered to sites within the River Murray system. A summary of these actions and the allocated water volumes is provided in table 1.

2.3 River Murray Unregulated Flow event

The high inflows in 2010–11 resulted in a prolonged period of unregulated flow being announced for the River Murray and Lower Darling systems from spring 2010 until June 2011. The availability of River Murray Unregulated Flows (RMUF) allowed the Environmental Watering Group to trial the prioritisation of environmental watering actions during RMUF for the first time. For the purposes of the trial, the Environmental Watering Group ensured that water was made available to watering actions with the best potential environmental outcomes, including the consideration of certainty of outcome and risks which are also considered for regulated watering actions.

The trial showed that during the early stages of the event when smaller volumes of RMUF water was available, the process undertaken by the Environmental Watering Group to review and coordinate environmental watering actions was beneficial. However as larger amounts of unregulated water became available, this coordination was not required as flows naturally inundated most of the priority environmental watering sites. .

Table 2 provides a summary of the environmental watering actions prioritised by the Environmental Watering Group in the early stages of the RMUF event.

2.4 Combined impacts of inflows and environmental watering activities

The flooding in 2010–11, combined with targeted environmental watering activities, has been critically important for many species recovering from the recent unprecedented drought sequence experienced over the past decade. For example, the environmental watering action at Barmah–Millewa Forest has resulted in the largest bird breeding event in 60 years.

The Central Murray Floodplain, including the Barmah–Millewa Forest, Gunbower–Koondrook–Perricoota Forests and the Edward–Wakool system experienced prolonged, but relatively low level, flooding (that would generally occur on average once every ten years). Over 90% of the Barmah–Millewa Forest was inundated and approximately 27,000 hectares of Koondrook–Perricoota and 9,000 hectares of Gunbower Forest were also estimated to have been inundated. At the Hattah Lakes icon site, most of the lakes were inundated naturally and water was pumped to Lake Kramen for the first time since 1993.

Menindee Lakes was effectively spilling for eight months with releases into the Lower Darling River of up to 34,000 ML/day. The flooding has provided much needed water to floodplains along the Darling River and Great Darling Anabranch as well as the River Murray in South Australia.

The high inflows that entered the River Murray system in the 2010–11 water year have improved condition in the River Murray Channel. The removal of locks and weirs during the floods allowed fish to move freely and helped to flush saline water out of the system. It also provided connectivity between the channel and adjacent billabongs and wetlands, thereby improving the condition of vegetation and providing habitat for a range of species.

These flows continued throughout the River Murray system. By the end of May 2011, the total annual flow across the South Australian border was approximately 14,000 GL, which was the highest since 1975–76. The high River Murray flows and increased local rainfall have resulted in more than 60% of the Chowilla Floodplain being inundated. This has mainly watered river red gum and wetland areas, and has also reached some black box communities for the first time in over ten years.

Table 1 The Living Murray regulated environmental watering activities 2010–11

Site	Locations within site	Volume delivered (GL)	Period of watering	Benefit
Multiple site watering	Barmah–Millewa Forest (NSW and Vic)/ Lower Lakes, Coorong and Murray Mouth (SA)	199.000	September–February	Facilitate the recovery and maintenance of wetland vegetation, and contribute to a successful bird breeding event.
	Murrumbidgee River (NSW)/Lower Lakes, Coorong and Murray Mouth (SA)	23.039	May–June	Improve water quality in the Murrumbidgee River and River Murray as well as provide and prolong inundation of the river red gum forest and associated wetland systems. Benefits of flows at the Lower Lakes include continued fishway releases through winter 2011. Continued barrage releases also helped reduce salinity in the Lower Lakes and Coorong.
	Goulburn River (Vic)/ Lower Lakes, Coorong and Murray Mouth (SA)	33.000	November–December	Provide a dilution flow from the Goulburn River to the River Murray to help mitigate an emerging blackwater event. Flows to Lower Lakes contribute to fishway and barrage releases.
	Lower Darling Anabranch (NSW)/ Lower Lakes (SA)	15.000	September–October	To improve the health of drought stressed vegetation communities, improve native fish stocks, provide habitat and food production for bird species and other fauna such as frogs.
Chowilla Lindsay–Wallpolla Islands	Chowilla Horseshoe, Lock 6 depression, Monoman Depression, Punkah Island Depression	0.045	September–November	Facilitate the recovery and maintenance of floodplain vegetation, and maintain habitat for birds and frogs, including threatened species such as the southern bell frog.
	Punkah Creek Floodrunner, Punkah Creek aquadam, Punkah Creek Depression (Chowilla)	0.034	December	Contribute to improving the health of long lived vegetation, including mature river red gum, black box and other high priority vegetation. Provide habitat for frog populations, including the threatened southern bell frog.
	Twin Creeks, Monoman Creek Depression, Gum Flat (Chowilla)	0.057	September–November	Contribute to improving the health of fringing wetland vegetation. Provide breeding opportunities for waterbirds and frogs including the southern bell frog.
	Total	**270.175**		

Table 2 The Living Murray RMUF environmental watering activities 2010–11

Icon site	Locations with in site	Volume delivered (GL)	Period of watering	Benefit
Gunbower–Koondrook–Perricoota Forest	Gunbower Creek	6	To be advised	To facilitate the recovery and maintenance of native fish populations in wetlands.
Hattah Lakes	Lake Kramen	3	To be advised	To maintain habitat for native fish and waterbirds and provide occasional breeding for waterbirds.
Chowilla Lindsay–Wallpolla Islands	Wertawert Wetland, Lake Littra, Coppermine Waterhole and Monoman Island Horseshoe	2.13	December 2010–March 2011	Facilitate the recovery and maintenance of floodplain vegetation, and maintain habitat for waterbirds and frogs.
Lower Lakes, Coorong and Murray Mouth	Lake Alexandrina, Coorong estuary and Murray Mouth	34.3	December 2010–March 2011	TEnhance migratory water bird habitat to allow for greater fish passage across the barrages between the Coorong/Murray Mouth and Lake Alexandrina.
River Murray Channel	Reid Flat and Morgans East Lagoon	0.265	December 2010–March 2011	Maintain and improve health of long-lived vegetation for regent parrot habitat. Promote successful breeding events in frog and threatened water bird communities.
	16 wetlands located along the River Murray Channel	3.7	November–December 2010	Improve groundwater conditions surrounding the wetlands. Provide habitat for frog and waterbird species. Improve condition of vegetation.
	Total	**49.395**		

The levels in Lake Albert and Lake Alexandrina have returned to the 'normal' range after significant flows entered the system in 2010–11. Lake levels in March 2011 were around +0.7 m AHD (Australian Height Datum) after experiencing levels below sea level. These lake levels are now well above the critical acidification threshold water levels. The large flow volumes arriving in Lake Alexandrina from the River Murray have generated a range of ecological benefits. The flows have enabled extensive connectivity between Lake Alexandrina and the Murray Mouth estuary, facilitating movement of diadromous fish; increased the extent of the Murray Mouth estuary; and opened and enlarged the Murray Mouth. The flows have also raised the level of the Lower Lakes, increasing habitat for threatened birds, fish and frogs.

As all the icon sites received significant volumes of water during the spring/summer period, the Environmental Watering Group decided to carryover the remaining 90 GL of allocation available in The Living Murray portfolio to spring 2011 to maximise the environmental outcomes that could be achieved.

2.5 Adaptive management

The trial of a larger multi-site watering at Barmah–Millewa Forest and the Lower Lakes, Coorong and Murray Mouth in spring 2010 raised several operational and water accounting issues that meant that TLM could not deliver environmental water in the manner proposed initially. The Living Murray is currently working to resolve these issues with the jurisdictions. Some of the issues included:

- challenges in the ability to deliver and protect environmental flows
- challenges in identifying and tracking the different flows which made up the event
- challenges to deliver and protect environmental flows under historical river operations practice.

A set of principles to guide multi-site watering have been agreed by the Basin Officials Committee as:

1. The efficient use of environmental water which optimises beneficial environmental outcomes:
    - in an accountable and transparent manner
    - in accordance with the rights of the underlying environmental water portfolio
    - without creating unacceptable material third party impacts.
2. The efficient use of environmental water which optimises beneficial environmental outcomes will be achieved by:
    - adaptively applying learnings from trials
    - using a method which is as simple and cost effective as possible.

The Basin Officials Committee has agreed that achieving multi-site environmental watering on the River Murray will require short-, medium- and long-term solutions. A limited number of practical options are being explored in the short term to achieve the best possible environmental outcomes.

The extensive overbank flooding in the River Murray system this year also resulted in large areas being affected by blackwater. Blackwater events occur naturally due to the rapid breakdown of leaf litter on the forest floor causing water discolouration and at times low dissolved oxygen levels.

Although this blackwater event resulted in fish deaths being reported in several rivers, it also provided positive impacts by providing nutrients back into the river system thereby promoting the growth of many aquatic organisms. Several actions were implemented jointly by TLM parties and MDBA with the aim of diluting the blackwater event. This included the release of 33 GL of TLM water in the Goulburn River.

The collaboration undertaken by a range of state agencies to monitor this event and provide information to the public has provided a process for monitoring and reporting that could be utilised if similar events arise in the future.

Monitoring during the drought has shown that it takes a number of watering activities to build up resilience following periods of severe ecological stress. Although the drought has broken, some areas of the floodplain will require several flood events to fully recover.

2.6 The Living Murray portfolio summary

Table 3 presents the reliability class of entitlements held by TLM in 2010–11 with their associated entitlement, allocation, net use volumes and the volume remaining at June 30 2011. A total of 982.7 GL of entitlements are currently held on The Living Murray Environmental Water Register across a range of reliability classes.

Higher flows within the River Murray system in 2010–11 meant the threshold for the repayment of Snowy Borrow Encumbrances attached to some TLM entitlements was met in 2010–11. A total of 7.153 GL was repaid, thereby removing all remaining encumbrances on TLM licences. The remaining 90 GL of unused allocation will be carried over to spring 2011–12 on TLM entitlements in the Goulburn Valley that have spillable water accounts. A 5% transmission fee for water carried over in Victoria reduces the volume to 85 GL. If there is a likelihood of spills in Eildon Reservoir, carryover held in these accounts will not be made available immediately.

Table 3 The Living Murray entitlements 2010–11

Entitlement Type	Entitlement (GL)	Long Term Cap Equivalent (LTCE)[6]	Allocation available to TLM[2] (GL)	Environmental watering use (GL)	Volume remaining at 30 June 2011[5] (GL)
Regulated water entitlements					
NSW High Security	1.887	1.792	1.887	1.877	0.01
NSW General Security	212.927	165.81	209.593	182.873	19.966[1]
VIC High Reliability	62.979	62.908	87.899	75.0604	33.093
VIC Low Reliability	263.877	127.805	19.222	11.1597	8.062
SA Water Licence	43.765	41.528	49.697	0.1368	29.36
RMIF carried over from 2008–09[3]			0.068	0.068	0
Unregulated/supplementary water entitlements					
NSW Supplementary	350	40.9	tba[4]	tba[4]	0
NSW Unregulated	12.965	9	tba[4]	tba[4]	0
VIC Unregulated	34.3	28.1	34.3	34.3	0
Total	**982.7**	**477.843**	**402.666**	**305.4759**	**90.491**

[1] 17.153 GL was used to pay back encumbrances.

[2] This volume includes carryover and allocation to Victorian unregulated entitlement. Note: some water allocated to entitlements in 2010–11 was utilised by the previous owner.

[3] MDBA managed environmental water entitlement (not specifically TLM). This water was permitted to be carried over to October 2010.

[4] NSW unregulated and supplementary entitlements for TLM do not receive allocation; rather, they increase the size of existing unregulated flow events in the River Murray. To gain an understanding of the volume of water that these entitlements have contributed to the total volume of unregulated flows, modelling will have to be undertaken retrospectively once the unregulated flow event has been completed and as annual accounts are finalised.

[5] Throughout the 2010–11 water year a number of water allocation trades were completed. For this reason allocation remaining does not necessarily reflect the volume allocated to that specific type of licence.

[6] The Long Term Cap Equivalent is the long term average volume per year.

3 The Living Murray water planning 2011–12

3.1 Storage

Total MDBA active storage for the River Murray system at the end of May 2011 was 6,886 GL (80% of capacity) which is above the end of May long-term average of 5,089 GL (figure 2). Whilst high inflows have contributed to storage levels, it is also partly due to new carryover provisions in Victoria.

Hume Reservoir is currently at around 93% capacity. The situation in the Goulburn and Murrumbidgee catchment is similar to the Murray, with many water storages at near to full levels. If there is average inflow conditions throughout winter and spring of 2011 there could be significant releases from Hume Reservoir. If these releases are combined with high inflows from the Kiewa, Ovens and Goulburn Rivers, this could result in another significant flood event along the River Murray in 2011–12. Figure 3 provides preliminary flow forecasts for different water resource scenarios in 2011–12.

3.2 Outlook for The Living Murray entitlements

The aim of the First Step Decision was to recover an additional 500 GL average per year for the environment. To date 477.843 GL has been recovered and this figure is expected to increase to 486 GL average per year in 2011–12.

MDBA active storage levels are significantly higher than any other water season since TLM was established. It is anticipated that TLM will have a significant volume of environmental water available in early spring from carry-over and early season allocations. Table 4 provides estimates of potential allocation to TLM water entitlements, including carryover from 2010–11.

With high storage levels, there is also a high risk of spills. This may delay the availability of water carried over in spillable water accounts. The volume of carryover in these accounts may also be reduced in 2011–12 if spills occur before this carryover is made available.

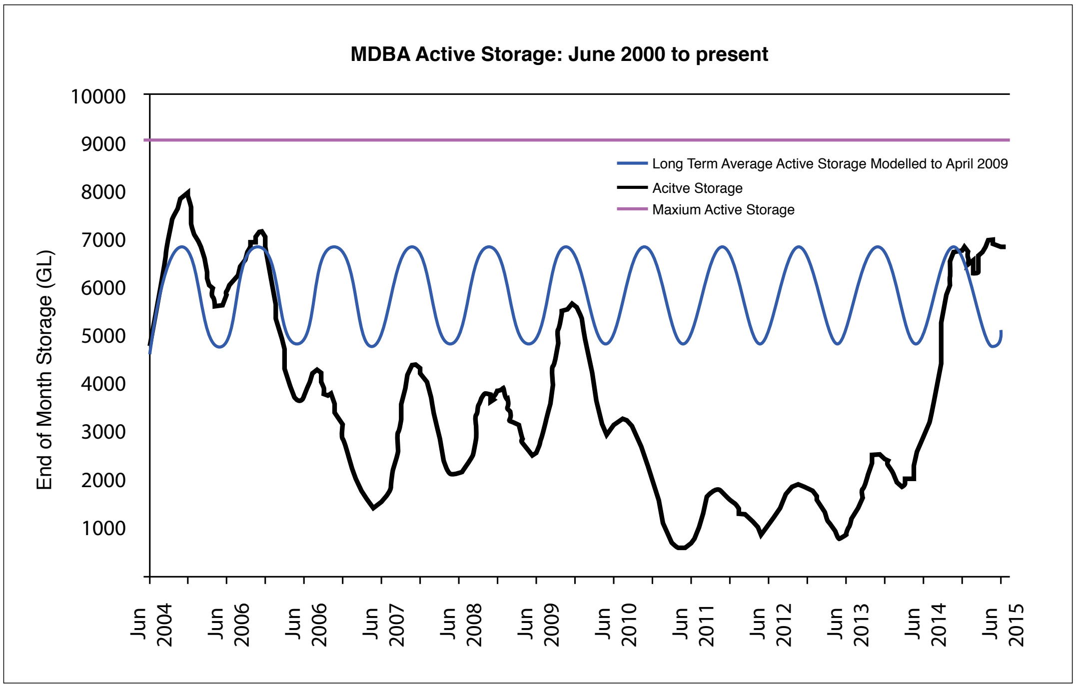


Figure 2 Comparison of active, long-term average and maximum storage levels in the River Murray system June 2000 to June 2011

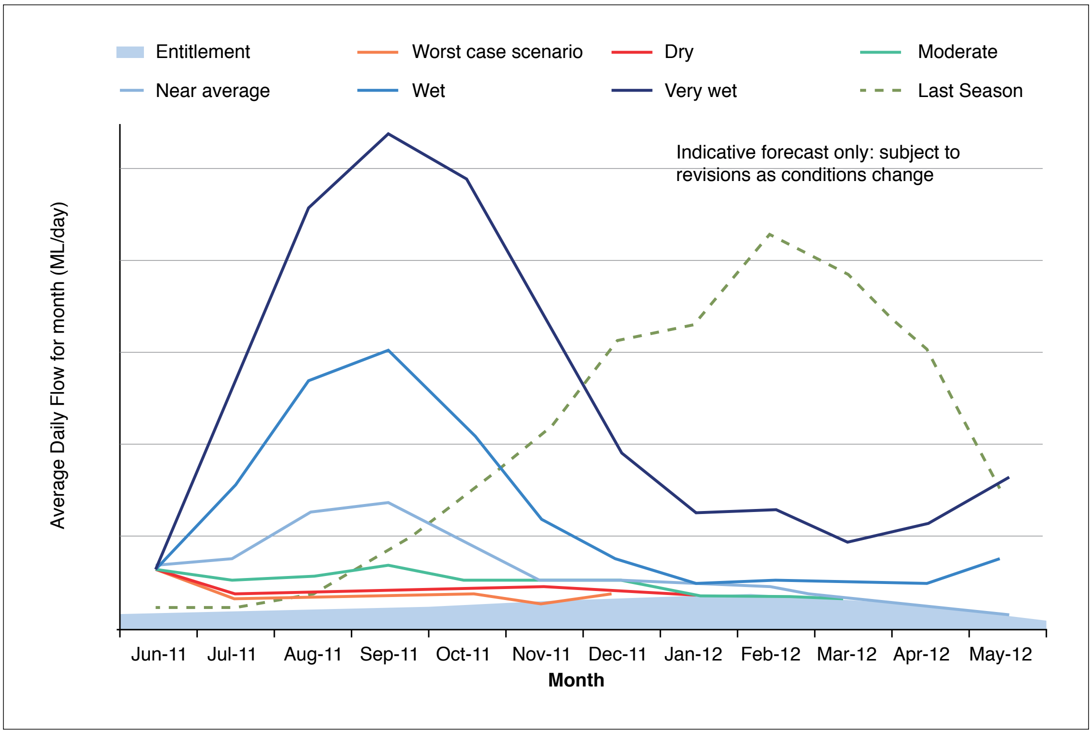


Figure 3 Preliminary flow forecasts for different water resource scenarios 2011–12 as at 30 May 2011

Table 4 Forecasted available The Living Murray water 2011–12

Season	Forecasted allocation amounts (GL)	Carryover available (GL)	Cumulative Total (GL)
Spring 2011	180–200	50	230–250
Summer 2011–12	80–100	35	345–385
Autumn 2012	10 –20	0	355–405

With allocations expected to reach similar levels to 2010–11, it provides the opportunity to consider larger watering actions at multiple sites. The high storage levels also increase the likelihood of uncontrolled flooding occurring at icon sites.

3.3 The Living Murray works

The Living Murray environmental works are designed to optimise the delivery of environmental water at icon sites. Following high river flows in 2010–11, the construction of infrastructure works was extensively delayed. Works are currently planned for completion in 2011–12 at Koondrook–Perricoota Forest, the lower landscape of Gunbower Forest and Mulcra Island in the Chowilla Lindsay–Wallpolla icon site.

During the construction phase, environmental watering actions may be limited or not possible at some sites. During this phase and upon completion of the works, it will be necessary to undertake operations in a controlled manner that tests the functionality of the structures and builds an understanding of how the structures can deliver the best environmental outcomes to the floodplain.

The volume and timing of inflows into the River Murray system will determine the ability to undertake construction and other activities at icon sites. If these sites are inundated by large unregulated flows in 2011–12 these activities could be limited and therefore provide an opportunity to provide environmental water to these sites.

Table 5 Proposed ecological watering objectives under different water resource availability scenarios (based on principles established by DSE Victoria and DEWHA)

	Extreme dry	Dry	Median	Wet
Ecological watering objectives	Avoid irretrievable loss of key environmental assets	Ensure priority river reaches and wetlands have maintained their basic functions	Ecological health of priority river reaches and wetlands have been protected or improved	Improve the health and resilience of aquatic ecosystems
Management objectives	Avoid critical loss of species, communities and ecosystems Maintain key refuges Avoid irretrievable damage or catastrophic events	Maintain river functioning with reduced reproductive capacity Maintain key functions of high priority wetlands Manage within dry-spell tolerances Support connectivity between sites	Enable growth, reproduction and small-scale recruitment for a diverse range of flora and fauna Promote low-lying floodplain-river connectivity Support medium flow river and floodplain functional processes	Enable growth, reproduction and large-scale recruitment for a diverse range of flora and fauna Promote higher floodplain-river connectivity Support high flow river and floodplain functional processes
Management actions	Water refugia and sites supporting species and communities Undertake emergency watering at specific sites of priority assets Use carryover volumes to maintain critical needs	Water refugia and sites supporting threatened species and communities Provide low flow and freshes in sites and reaches of priority assets Use carryover volumes to maintain critical needs	Prolong flood/high-flow duration at key sites and reaches of priority assets Contribute to the full-range of in-channel flows Provide carry over to accrue water for large watering events	Increase flood/high-flow duration and extent across priority assets Contribute to the full range of flows including over-bank Use carryover to provide optimal seasonal flow patterns in subsequent years
Overarching objective	Avoid catastrophic loss/maintain capacity for potential recovery	Improved capacity for recovery	Protect ecological health	Improved health and resilience

3.4 Ecological watering objectives

In order to respond to the potential variability in water resources, the Environmental Watering Group uses a model that outlines management objectives for different water resource scenarios (table 5). The ecological objectives for extreme dry, dry, median and wet scenarios outlined in the table provide guidance on how TLM water is utilised under different flow and climatic conditions.

The anticipated strong opening allocations plus allocation carried over from 2010–11 means TLM is likely to have between 230–250 GL of environmental water available in spring 2011. This suggests that the median water resource scenario should be utilised initially for planning the use of environmental water in 2011–12. The water resource scenario will be reviewed through the year to take into account any significant changes to conditions at the icon sites and inflows into the River Murray system.

3.5 Ranking criteria

The primary objective of the Annual Environmental Watering Plan 2011–12 is to provide environmental benefit consistent with the stated objectives for each icon site. In order to prioritise between individual watering actions throughout the year, the Environmental Watering Group has agreed to use the following ranking criterion outlined in table 6, regardless of climatic conditions. Further details on the method for applying the criteria is provided at appendix A.

3.6 Framework for prioritisation of regulated flows

In order to accommodate the potential range in water allocation volumes and varying icon site conditions, a flexible decision framework has been developed by TLM that will guide the prioritisation of environmental watering actions in 2011–12. This decision framework provides the focus for the prioritisation of environmental watering actions and the timeframes for the review of all other potential watering actions. These reviews will assess TLM water availability against the environmental benefit to all proposed watering sites using the ranking criteria.

To be event ready the Environmental Watering Group has identified and ranked watering proposals that align with the decision framework (refer appendix B). These watering proposals have been identified to assess watering opportunities over the next water year, including multiple watering actions, and ensure that potential watering activities are considered during the development of the River Murray Operations Plan 2011–12. Further consideration of proposals will still be required before a commitment is made to undertake the watering actions in 2011–12.

The broad strategy for 2011–12 is to prioritise those watering actions that are most likely to deliver the best environmental benefits, given water availability and operational constraints. This is likely to be larger watering actions that maximise opportunities to deliver environmental water to multiple sites.

Table 6 Ranking criterion for prioritisation of TLM watering actions

Ranking criterion		Description
Significance of ecological outcome	An assessment of the predicted ecological outcomes provided by the watering. This should reflect the value and condition of the asset, threatened species and communities and magnitude of benefit, including:	
	Amount of benefit for the volume of water	An assessment of the predicted ecological benefit relative to the volume of water required. This may include the opportunity for return flows.
	Risk of not watering	An assessment of ecological risks of not watering. This includes the previous history, desired watering frequency, resilience period and protection of previous investment.
	Certainty/likelihood of benefit	An assessment of the certainty of getting the predicted outcomes; whether the benefit of watering a site can be maintained in the short and long term and the implications for future management.
Operational matters	Risks associated with watering	An assessment of any risks associated with the delivery of water such as acid sulfate soils, salinity spikes, black water events, algal blooms, operational constraints and the adequacy of mitigation measures.
	Cost	An estimate of the overall costs of delivering the watering action (per ML) including delivery, pumping and associated infrastructure costs.

Smaller watering proposals will also be considered a priority where the ecological health of high value sites needs to be consolidated and maintained.

During the 2011–12 water year, the Environmental Watering Group will review the schedule of environmental watering proposals at designated periods utilising the process outlined in figure 4. These review periods will assess the water availability against the environmental benefit to all proposed watering sites. Depending on the conditions at the review periods, watering proposals may be assessed across a range of water resource scenarios.

Multiple watering proposals will be subject to an assessment of the implications for River Murray operations, any approvals required from Basin Officials' Committee and a thorough assessment of the environmental benefits.

Real-time factors that may impact on the delivery of environmental water will also be considered during the review periods. These factors include river operations, availability of other sources of environmental water, status of TLM works, status of delivery budget, opportunities for multiple site watering actions, conditions at the sites, antecedent and forecasted flows.

Based on the outcomes of the review, the Envrionmental Watering Group will provide advice to the MDBA on whether any environmental watering actions should be implemented at that stage. The approval of any watering actions recommended by the Environmental Watering Group is delegated to the Executive Director of Natural Resource Management, Murray–Darling Basin Authority.

All watering actions will be implemented in accordance with the decision framework and prioritisation process outlined in the Annual TLM Environmental Watering Plan 2011–12. Any other watering proposals that are developed throughout the water year will be reviewed by the Environmental Watering Group as required using the process outlined in figure 4.

3.7 Framework for prioritisation of River Murray Unregulated Flows

In 2008–09 the Environmental Watering Group agreed to trial the prioritisation of environmental watering actions during a River Murray Unregulated Flows (RMUF) event. The Environmental Watering Group had its first opportunity to prioritise environmental watering actions during a RMUF event in 2010-11. Following this successful trial, the Basin Officials Committee has agreed that the Environmental Watering Group should continue the trial prioritisation of environmental watering actions during RMUF events to maximise the environmental benefits.

As each RMUF event varies in location, duration and operational opportunities, it is not possible to provide precise information on watering proposals prior to a RMUF event. To be event ready the Environmental Watering Group plans to develop potential unregulated flow management scenarios at the beginning of 2011–12. These scenarios will be subject to an assessment of the implications for River Murray operations, any approvals required from Basin Officials' Committee and an assessment of the environmental benefits.

Watering proposals will need to be reviewed as an unregulated event occurs and supplementary information will be included so that filters such as location, magnitude and feasibility can be evaluated before the prioritisation of the environmental watering actions in real time.

The prioritisation of environmental watering actions during RMUF events in the River Murray system will in principle:

- be based upon a RMUF event declared by River Murray Operations
- be consistent with a one-river approach in that the areas of highest environmental need and benefit are given priority
- recognise existing obligations and rights
- maximise environmental outcomes including integration with planned environmental water releases
- be based upon opportunity and relative environmental priority following ranking criteria agreed by the Environmental Watering Group
- be agreed on a case-by-case basis in real-time.

To assist in a real-time event, the ranking criteria adopted for the prioritisation of TLM regulated watering actions are also applied to the unregulated watering actions.

Figure 5 outlines the process for prioritising watering actions during a RMUF event. The decision to implement a RMUF environmental watering action is the responsibility of the relevant jurisdiction in both physically implementing the agreed priority and in allowing the declared RMUF to be used according to the Environmental Water Group agreed principles.

During a RMUF event it is possible that unregulated flows may be substituted for TLM allocation if approved watering actions have not yet been completed. This ensures that watering actions are undertaken in the most effective manner.

The volumes and benefits of water prioritised by the Environmental Watering Group and delivered during a RMUF event will be collated and reported as part of TLM environmental water reporting. This will enable a more comprehensive understanding of environmental water delivered in the River Murray system.

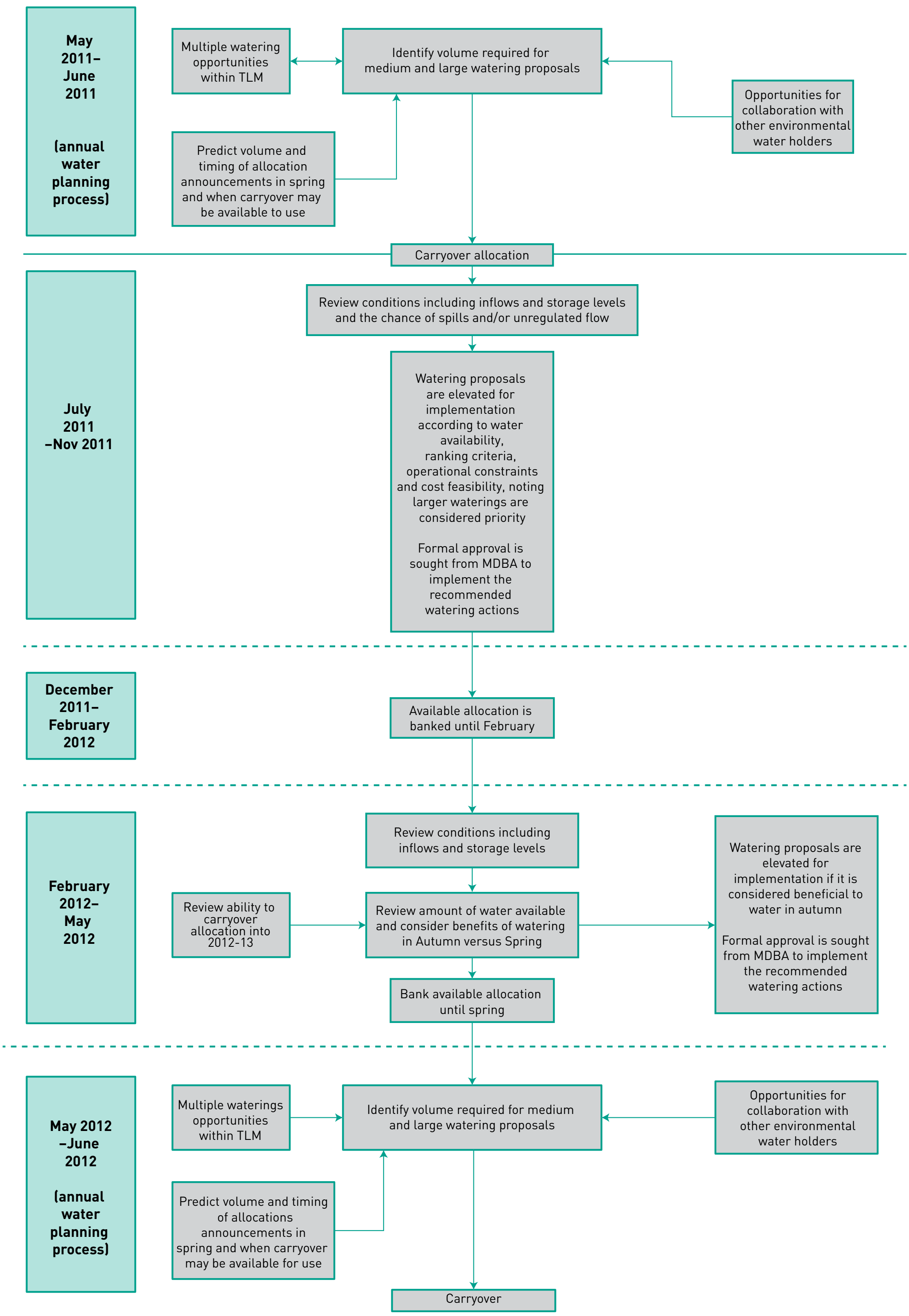


Figure 4 Flow chart of prioritisation process for regulated flows

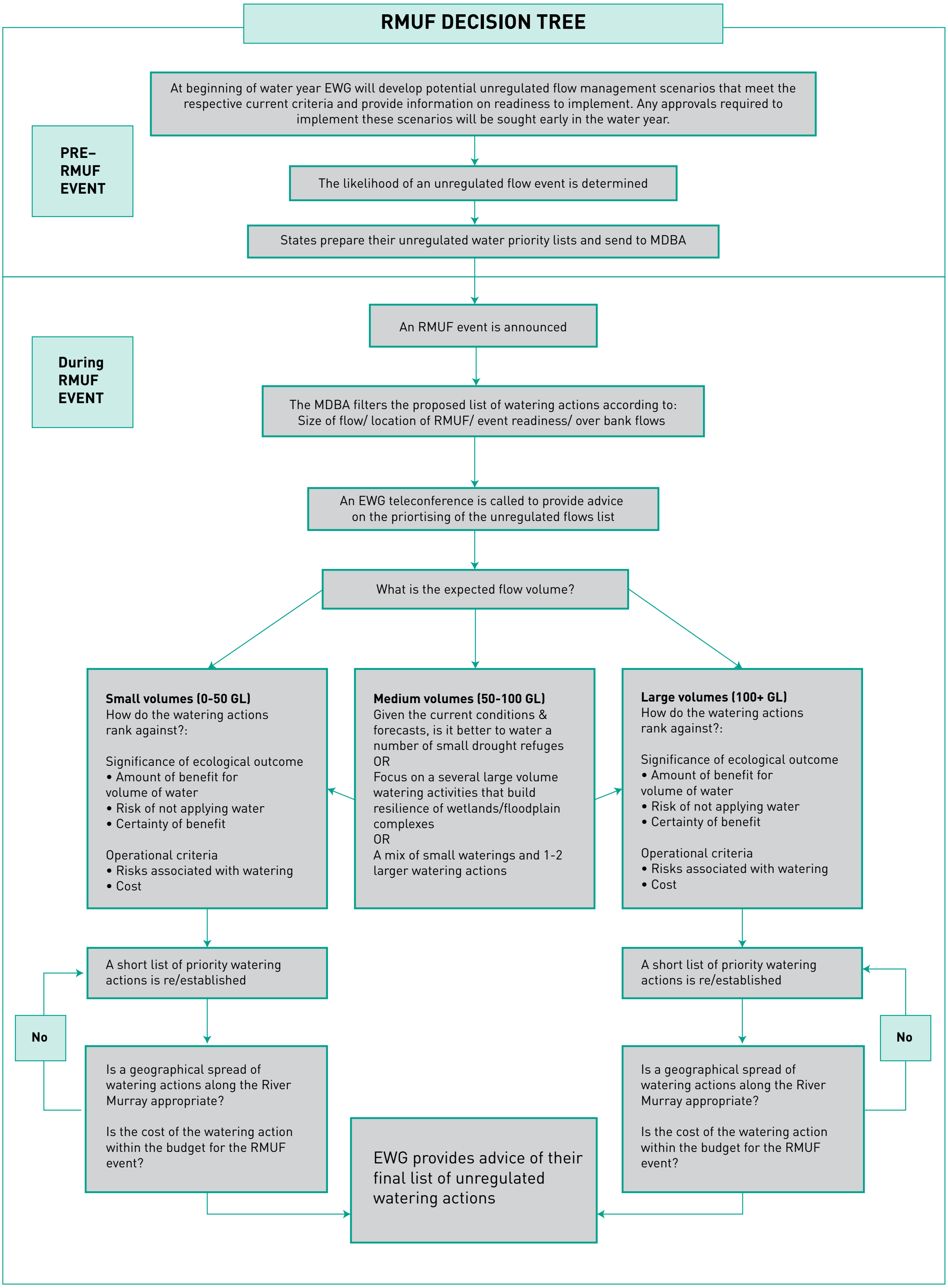


Figure 5 Prioritisation process for unregulated flows

4 Environmental monitoring for The Living Murray

Monitoring and evaluating the achievement of the ecological objectives is part of The Living Murray Business Plan. A monitoring framework titled the Outcomes Evaluation Framework has guided the development of monitoring arrangements and outlines the types of monitoring necessary to monitor progress toward the ecological objectives of TLM. The monitoring types listed in the Outcomes Evaluation Framework are River Murray system-scale monitoring, condition monitoring, intervention monitoring, compliance monitoring and knowledge generation.

A key principle of TLM is to use information from monitoring in an adaptive management sense to optimise the approaches to achieving positive ecological outcomes at the icon sites and thereby benefit the entire River Murray system. The current focus of TLM environmental monitoring is on condition, intervention (including monitoring specific watering events) and River Murray system-scale monitoring. Compliance monitoring has been incorporated into intervention monitoring.

The Living Murray Environmental Monitoring Program coordinates with other MDBA programs including the Sustainable Rivers Audit (SRA), Native Fish Strategy and Natural Resources Information, to provide a coordinated approach to monitoring across the Murray–Darling Basin.

4.1 River Murray system-scale monitoring

Monitoring at the River Murray system-scale is designed to determine if the health of the River Murray system improves following implementation of the First Step Decision and its focus on the six icon sites. The questions addressed by monitoring at the River Murray system-scale differ from the objectives of the Sustainable Rivers Audit, which provide a condition assessment for the entire Murray–Darling Basin, whereas the design of River Murray system-scale monitoring is specifically tailored to address questions at the river system scale only. However, some data collected through SRA is applicable to the River Murray system, for example, fish data collected for the SRA and icon site condition monitoring in the River Murray adjacent to the icon sites, has been used to develop a River Murray Community Fish Assessment.

The current River Murray system-scale projects are:

- The annual aerial waterbird survey of The Living Murray icon sites, which was implemented in 2007, and will be conducted in October–November 2011. The survey will be linked to the Eastern Australia Aerial Waterbird Survey so that geographical context is incorporated. The survey will also be conducted in cooperation with the on-ground waterbird surveys conducted as part of icon site condition monitoring to ensure cryptic species not easily identified by the aerial survey, are also assessed.
- A red gum and black box stand condition assessment, which has been implemented using remote sensing approaches to allow reporting annually on stand condition.
- An approach to a system-scale assessment of the fish community, in development, will provide an overall indication of the fish response to the implementation of TLM. The approach draws on data collected as part of fish condition monitoring at the icon sites and may include data collected for the Sustainable Rivers Audit . A trial of the fish community analysis approach is planned for the second half of 2011–12 and will be reported in June 2012.

4.2 Icon site condition monitoring

Icon site condition monitoring will determine change in the environmental condition of individual icon sites resulting from water application and implementation of works programs under The Living Murray. Icon site condition monitoring is specifically tailored to determine if the objectives for each icon site are being met. Monitoring and evaluation at the icon site–scale is surveillance in type and typically undertaken on a medium frequency (months to years).

Condition monitoring activities planned for 2011–12 include ongoing monitoring per the icon site condition monitoring plans that have been developed for each icon site. These plans detail the approaches and methods for monitoring the fish, bird and vegetation communities as they relate to the ecological objectives for the site. A core set of consistent approaches to monitoring the condition of fish, birds and vegetation has been developed and agreed across the icon sites. These approaches will be implemented during 2011–12 and include linkages to the system assessments identified in the system monitoring section. For example, the river red gum and black box on ground condition assessment will provide key support to the red gum and black box stand condition remote sensing assessments.

4.3 Intervention monitoring

Intervention monitoring assesses the ecological response to types of interventions or environmental management actions implemented under The Living Murray. In doing so, it provides the major link to understanding how the ecological responses to specific environmental management actions result in changes at icon sites. It also provides the foundation information for adopting an adaptive-management approach to implementing The Living Murray.

During 2011–12 intervention monitoring will be focused around three broad areas:

- monitoring the impacts of fishways and resnagging on fish populations throughout the River Murray
- monitoring the direct impacts of watering events at icon sites in relation to the event watering objectives and the management of risks
- addressing key information gaps on the response of vegetation, birds, habitat and fish recruitment to watering and works interventions.

Event monitoring has become important in managing the implementation of environmental watering activities during the drought to inform real-time decision making in relation to achieving ecological outcomes, quantifying and minimising risks. This monitoring is focused on the specific objectives and risks of the environmental watering event and is targeted in both temporal and spatial scales. The process for event monitoring will be responsive to the environmental watering plan, including recognition that resourcing and implementation will require planning to ensure event-ready capacity is available.

Event monitoring will be prioritised according to the water available for environmental watering and key knowledge gaps that may be addressed by specific watering actions. It is possible that events may not be monitored if resources are not available in appropriate timeframes. Reporting processes for event monitoring will recognise the level of monitoring undertaken.

Measuring the volume of water used at icon sites and the timing, volume and quality of any return flows etc is needed to account and report for the use and management of environmental water at the icon sites. This area of monitoring was previously defined in compliance monitoring; however it is now encompassed in intervention monitoring. This change has been made to ensure clear linkages between the various information requirements for managing successful watering events and informing the operation of works at icon sites. This includes systems for water measurement and accounting, monitoring risks and ecological outcomes. Further detailed work in this area of monitoring is currently underway including water accounting needs for each icon site.

The Living Murray Environmental Monitoring Program works with The Living Murray Environmental Watering Group to plan and prioritise monitoring activities prior to the start of each financial year. This involves jurisdictions documenting the monitoring needs for icon sites, then the Environmental Watering Group considering the identified requirements with regard to:

- The Living Murray works and measures coming on-line that year and the associated specific information needs for adaptive management, such as water measurement, risks and ecological response
- monitoring around specific planned watering events to inform knowledge gaps and document outcomes from watering
- knowledge generated from previous monitoring projects that may be extrapolated to future waterings
- long-term agreed priorities (e.g. fishways monitoring).

This cooperative approach ensures that the highest priority monitoring needs are resourced each year and that resources available for monitoring are used in the most efficient manner.

5 Reporting on The Living Murray environmental watering

Environmental water is accounted and reported for TLM at the end of the watering season. Information reported includes the volume of water released, delivered and used at each icon site, volume of water returned to the River Murray and environmental water account figures.

The Living Murray Business Plan requires all aspects of water accounting be reported on annually consistent with The Living Murray Business Plan. This information will be incorporated into the development of:

- The National Standards for Water Accounting (Intergovernmental Agreement on a National Water Initiative 2004)
- The Living Murray Annual Implementation Report
- The Living Murray Annual Environmental Watering Report
- Murray–Darling Basin Authority Annual Report.

The timeframes for these reports vary, but will be completed within six months of the new water year.

6 Communications and consultation

The Living Murray Communication and Consultation strategy 2011–12 provides the framework for implementing a coordinated, consistent approach to communicating the achievements, progress and future direction of The Living Murray across all jurisdictions. One of the key objectives that will direct communication and consultation activities in 2011–12 is to promote the use of The Living Murray water portfolio to achieve environmental outcomes through proactive media and communication products.

The icon site consultation reference groups provide an opportunity to seek input from community members and also inform them about the use of TLM water.

Appendix A Methodology for applying ranking criteria

The ranking of watering proposals by the Environmental Watering Group provides a basis and starting point for discussions on the prioritisation of watering proposals by Environmental Watering Group members and does NOT constitute the final decision on which proposals will be recommended for implementation. It is acknowledged that these ranking criteria are a decision support tool and that other factors will contribute to the final decision including water availability and operational feasibility.

Amount of environmental benefit for the volume of water

High	• contribution to key site values and/or TLM site management objectives is high (for example breeding event) • total area of target community or site watered • major outcomes at River Murray system-scale • outcomes of the watering (for example maintenance of habitat) can be sustained for a lengthy period of time (e.g. greater than 12 months)
Medium	• able to contribute partially (approximately half) to key site values and/or to TLM site management objectives • important outcomes at icon site scale • at least half of target community or site watered • outcomes of the watering is sustainable for a reasonable length of time (e.g. 6–12 months)
Low	• minor contribution to key site values and/or TLM site management objectives • outcomes at localised scale • will require follow up watering within short term (e.g. 3–6 months) in order to sustain outcomes

Risk of not applying water

High	• not watering would result in a catastrophic risk to a species or key habitat component or site value that would have a long recovery time • high loss of previous watering investment (ecological, volume or $) • site is reaching end of resilience period
Medium	• high risk of loss of a local population of a species, but limited scope for recovery (i.e. poor recolonisers) or long recovery time • loss of key habitat components that have a short recovery time • moderate loss associated with previous watering investment • may not be able to fully deliver minimum regime
Low	• risk of loss of a local population (of a common species) but scope for recovery within short term • minor loss associated with previous watering investment • may not be able to fully deliver optimum watering regime

Environmental risks associated with watering

High	•	no discernable risks (for example liability, flooding, salinity spikes, blackwater events and other water quality risks) associated with watering. Mitigation strategies ensure no short or long-term impacts
Medium	•	high localised risks associated with watering. Mitigation strategies may ensure no long-term impacts but may have negative short term impacts
Low	•	major widespread risks associated with watering. Mitigation strategies may not be able to prevent long-term negative impacts on ecosystem health

Certainty/likelihood of benefit

High	•	considerable evidence, sound conceptual model with rigorous scientific underpinning, done successfully before at this site
Medium	•	anecdotal support, sound conceptual model supported by good understanding of the processes that would lead to the outcome
Low	•	limited understanding, unsure of outcome, lack of consensus on likely outcome

Cost

High	•	total delivery costs* 0 – $30/ML
Medium	•	total delivery costs $30 – $60/ML
Low	•	total delivery costs →$60/ML

*this includes all delivery costs such as pumping charges, infrastructure costs (e.g. levee banks) and irrigation channel fees

Appendix B Watering proposals

Watering site	Brief action description	Objectives of watering. Relate to TLM objectives or water resource scenario management objectives	Resource scenario under which watering action will be considered (dry, median, wet)	TLM volume needed to be ordered (GL)	TLM estimated volume of use (GL)	TLM estimated return flow volume (GL)	Beneficial timing window (range)	Water delivery mechanism	Complimentary works required	Costs (water delivery and complimentary works)	Ranking criteria (high, medium, low): Amount of benefit for	Risk of not applying water	Certainty/ likelihood of	Risks associated	Cost
Barmah Forest															
Top Island, Boals Deadwoods, Gooses Swamp, Gulf Creek, Smiths Creek, other small regulators and creeks which receive water under 15,000 ML/day	Provide spring flows to build on improvements made by 2010–11 event and provide for colonial waterbird breeding event improvements made by 2010–11 event and provide for colonial waterbird breeding event	Healthy vegetation in at least 55% of the area of the forest including virtually all of the giant rush, moira grass, river red gum forest, and some river red gum woodland	Median	273–450 GL depending on flow levels	28–49%	51–72%	Sept–Nov	Flows through regulators in Barmah under 15,000 ML/day	None	$0	High	Low	High	Low	High
Gunbower–Koondrook–Perricoota Forest															
Black Charlie Lagoon, Reedy Lagoon, Little Gunbower Creek Complex, Little Reedy Complex	In event of unregulated flows, water may be required to support bird breeding	Successfully recruit wetland and floodplain vegetation and to provide suitable habitat for wetland and floodplain dependant fauna. Successful waterbird breeding events Suite of waterbirds present Contribute to population recovery of threatened waterbird species	Median Wet	21.8	11.8	10	July–Dec	Delivery through TLM regulators	None	$170,040	Medium	Low	High	Low	Low
Gunbower Creek	Water provided through TLM regulators	Increase in the abundance of native fish species and restore the presence of locally extinct fish species to Gunbower Island. Allow movement of native fish in and out of habitat types	Dry Median Wet	50–80 depending on inflows	30%	70%	July–Dec	Water provided through TLM regulators	None	$390,000–$624,000 depending on volume delivered	Medium	Low	High	Low	Low
Hattah Lakes															
Lake Kramen	Pump water to Lake Kramen	Restore mosaic of hydrological regimes Maintain and restore, where possible, ecological character of the Ramsar site Restore macrophyte zone around at least 50% of the lakes Maintain habitat for freckled duck, grey falcon and white-bellied sea-eagle	Dry Median Wet	3	3	Nil	Spring	Pumping	None	$135,000	Low	Medium	High	Low	Medium

Chowilla Floodplain and Lindsay–Wallpolla Islands															
Lake Wallawalla	Watering to improve populations of threatened flora and fauna that are flow dependent	Provide a diversity of structural aquatic habitats Increase diversity and abundance of wetland aquatic vegetation Maintain and improve the populations of threatened flora and fauna that are flow-dependent Restore productivity linkages between river and floodplain habitats Increase abundance, diversity and extent of distribution of native fish	Dry Median Wet	8	8	Nil	July–Dec	Pumping as recent floods have damaged levees		$280,000	Low	Low	High	Low	Medium
Mulcra	Low level watering autumn to improve connectivity between river and floodplain	Provide a diversity of structural aquatic habitats Maintain and improve the populations of threatened flora and fauna that are flow-dependent Restore productivity linkages between river and floodplain habitats Increase abundance, diversity and extent of distribution of native fish	Median Wet	2	2	Nil		Delivery by raising Lock 8 and operating Mulcra regulators	None	$0	Low	Low	High	Low	Low
Chowilla wetlands: Lake Limbra, Gum Flat, Coombool Swamp, Punkah Depression, Andersons Creek, Kulkurna Black Box site, Monoman Creek depression	Pumping to high value floodplain wetlands	High value wetlands maintained. Current area of river red gum maintained At least 20% of original area of black box vegetation maintained	Dry Median Wet	11.1	11.1	0		Pumping		$200,000	Medium	Medium	High	Low	Low
Lower Lakes, Coorong and Murray Mouth															
Lower Lakes, Coorong and Murray Mouth	Gravity fed to Lake Alex along RMC and then to barrages and fishways to the estuary, Murray Mouth and Coorong	Enhanced migratory water bird habitat in the Lower Lakes and Coorong More frequent estuarine fish spawning and recruitment Maintain an open Murray Mouth	Median Wet	240–300	240–300	Nil	Sept–	Gravity fed	None	$0	Medium–high	Medium	High	Low	Low
River Murray Channel															
Great Darling Anabranch	Water delivered through regulators into Anabranch	Improve native fish stocks by providing a trigger for breeding upstream of the River Murray. Improve health of drought stressed vegetation communities, particularly river red gum. Provide habitat and food production for bird species and other fauna such as frogs	Dry Median Wet	Tp to 47	TBA	TBA		Water provided through regulators		$20,000	High	Low	High	Medium	Low
			Total	**655.9–922.9**	**367.3 – 580.4**	**185–390**			**Total**	**$1,195,040 – $1,429,040**					

Australian Government

MURRAY–DARLING BASIN AUTHORITY