Goulburn River

Seasonal Watering Proposal 2012 - 2013

Goulburn Broken Catchment Management Authority

GOULBURN BROKEN
CATCHMENT MANAGEMENT AUTHORITY

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Executive summary

This is a proposal to use available environmental and other water to maximise the environmental outcomes in the Goulburn River in 2012-2013 (and partly 2013-2014). The plan focuses on the Goulburn Rive between the Goulburn Weir and the Murray River, which has the most altered flow regime within the regulated reaches of the Goulburn River. Delivering flows to this reach can also provide benefits to the reach between Lake Eildon and Goulburn Weir in dry winters and springs.

The Goulburn River and its associated floodplain and wetland habitats support intact river red gum forest, and numerous threatened species such as Murray Cod, Trout Cod, Macquarie Perch, Squirrel Glider, and Eastern Great Egret. The river and its associated floodplain and wetland habitats also contain many important cultural heritage sites, provide water for agriculture and urban centres, and support a variety of recreational activities such as fishing and boating.

The conditions leading into the 2012-2013 year have been characterised by several years of extended drought with low river flows (particularly in the Goulburn River between Goulburn Weir and the Murray River) followed by extremely wet conditions in 2010-2011 where all environmental flow objectives have been met by natural catchment runoff. A summer flood and blackwater event resulted in a significant number of fish and crustacean deaths. In 2011-2012 flows were close to average in winter and drier in spring. Another flood occurred in March 2012 and an associated blackwater event. However, no fish deaths were observed. Importantly, terrestrial vegetation lost from the lower river bank during the 2010-2011 floods has not yet returned.

The focus for the 2012-2013 year is to continue to pursue fish, macroinvertebrate and vegetation ecological objectives established for the Goulburn River by implementing minimum and fresh flow recommendations, particularly in winter and spring. Fish objectives are pursued by providing a minimum flow of 500 and 540 ML/day at Murchison and McCoys Bridge respectively throughout the year as well as a spring fresh of 5,600 ML/day to stimulate Golden Perch breeding. Macroinvertebrate objectives are pursued by providing a minimum flow of 830 or 940 ML/day at Murchison and McCoys Bridge respectively and winter/spring and summer/autumn freshes of 5,600 ML/day. The terrestrial vegetation objectives are provided for by implementing the above fish and macroinvertebrate flow recommendations, particularly the duration of the spring fresh. Avoidance of environmental damage (bank slumping and biota stranding) from rapid falls in water level from environmental freshes or regulated water flows is provided by using environmental water to recue rate of fall.

Importantly, the proposal notes the difficulty in providing flow components in winter due uncertainty around environmental water availability and the need for environmental water in the coming season. Therefore, the continuation of the minimum flow recommendation of 500 and 540 ML/day at Murchison and McCoys Bridge respectively from July to September 2013 for native fish is seen as a higher priority than the macroinvertebrate driven higher minimum flows in the 2012-2013 year's summer and autumn. Reserving water for a 2013 winter fresh (July/August) is listed as the last priority for this proposal.

Overbank flows occurred in 2010-2011 and 2011-2012 and are therefore not required in 2012-2013. The feasibility of delivering overbank flows, including how best to deliver or supplement flows whilst avoiding damage to public and private assets requires further investigation. Therefore, overbank flows will not be delivered in the immediate future.

The proposal considers environmental water management under a range of possible climate scenarios from extremely dry to wet. Under the extreme and very dry scenarios, all of the environmental entitlements are used to provide improved winter/spring flows and progressively summer/autumn low minimum flows, while Inter-Valley Transfers help provide improved summer/autumn flows. However, unlike the drought years, Inter-Valley Transfers will not reliably provide all required summer flows and some environmental water will need to be reserved to fill gaps left in the flow regime. Under the average to wetter scenarios, winter/spring flow needs are mainly provided by catchment runoff, resulting in the environmental entitlements progressively transitioning to lower priority flow components later in the year.

The volumes of environmental water sought in 2012-2013 under each scenario are summarised in the following table, consisting of the water use possible under the existing Goulburn environmental entitlements and carryover if all water is allocated to the Goulburn River, plus additional water that could be used if available. The scenarios show how the additional water is proposed to be used, and the dry scenarios only list the next priority uses (and not the maximum possible use) given the limitations Inter-Valley Transfers puts on transferring additional water into the Goulburn catchment.

Summary of environmental water volumes required to support this proposal (GL)

REACHES 4 & 5	WORST DROUGHT	VERY DRY	DRY	AVERAGE	WET
Total environmental water planned	129	201	236	225	215
Additional water usable	73	100	50	111	85

In summary, the Goulburn Broken CMA is seeking access to, or be involved in the timing of releases of, all the water available under environmental entitlements in the Goulburn system (Commonwealth, Living Murray and Victorian), and preferably additional water, under all climates.

The proposal specifies bulk water volumes required to achieve various environmental objectives under specified climatic scenarios. However, climatic conditions do not follow one climate scenario throughout the year. Therefore, as the season unfolds the design of specific flow regimes to optimise outcomes will be required, requiring flexible and adaptive water deployment.

This proposal does not take account of competing needs for environmental water use from other river/creek systems or downstream along the Murray River.

As all of the flows proposed are well within the river channel, there is very low risk of adverse outcomes from releasing environmental water.

Water delivery through the lower Goulburn River to meet downstream consumptive and environmental targets is possible, but raises risks which need to be managed.

Contents

Glossary and acronyms

Bankfull - carrying capacity of the stream before spilling out onto adjacent land

Base flow – low flows sufficient to maintain fish passage, water quality, and pool and riffle habitats

Catchment management authority (CMA) – statutory authorities established to manage regional and catchment planning, waterways, floodplains, salinity and water quality

Channel - that part of a river where water flows at some time and includes the bed and banks, taken to mean the whole of the depression in which the water flows before it rises sufficiently to spill over onto adjacent lands as flood water

Commonwealth Environmental Water Holder (CEWH) – (part of the Department of Sustainability, Environment, Water, Populations and Communities) holds and manages the water entitlements purchased through the Restoring the Balance water recovery program

CMA – catchment management authority

Environmental flow regime – the timing, frequency, duration and magnitude of flows for the environment

Environmental flow study – a scientific study of the flow requirements of a particular basin's river and wetlands systems used to inform decisions on the management and allocation of water resources

Environmental water entitlement – an entitlement to water to achieve environmental objectives in waterways (could be an environmental entitlement, environmental bulk entitlement, water share, Section 51 licence or supply agreement)

Flow - movement downstream of water confined in the channel. The term **lotic** applies to flowing or moving water

Flow component – components of a river system's flow regime that can be described by timing, seasonality, frequency and duration (for example, cease to flow and overbank flows)

Flow regime - pattern of seasonal flow variations in any one year, usually consisting of periods of low flow during summer-autumn then high flows during winter-spring

Freshes - flows that produce a substantial rise in river height for a short period, but do not overtop the river bank. Freshes help maintain water quality and serve as life cycle cues for fish

GB CMA - Goulburn Broken Catchment Management Authority

Geomorphology - the physical interaction of flowing water and the natural channels of rivers including erosion and sedimentation

Gigalitre (GL) – one billion (1,000,000,000) litres

High flows - high flow within channel capacity. High flows allow full connection between all habitats in the river, which is important to fish passage during migration

High reliability entitlement – legally recognised, secure entitlement to a defined share of water, as governed by the reserve policy (full allocations are expected in most years)

Instream - refers to that area of a waterway below the surface of the water

Inter-Valley Transfers (IVT) – means bulk transfers of water from the Goulburn water supply system to supply water users in the Murray water supply system

Low reliability entitlement – legally recognised, secure entitlement to a defined share of water, as governed by the reserve policy (full allocations are expected only in some years)

Macroinvertebrates – aquatic invertebrates whose body length usually exceeds 1 mm (included insects, crustacean, aquatic worms and aquatic snails)

Macrophytes – an aquatic plant that grows in or near water and is either emergent, submergent, or floating

Megalitre (ML) – one million (1,000,000) litres

Overbank flow – flood flows that overtop the banks and spill onto the floodplain

Passing flow – water released out of storages to operate river and distribution systems (to deliver water to end users), provide for riparian rights and maintain environmental values and other community benefits

Planktonic algae – floating microscopic plants that are an important food source for aquatic fauna

Pool - a significantly deeper area in the bed of a river

Reach - a length of stream that is reasonably uniform with respect to geomorphology, flow and ecology

Riffle – a stream section with fast and turbulent flow over a pebble bed with protruding rocks (characterized by a broken water surface)

Riparian vegetation - vegetation growing on the water line, up the bank or along the very top of the bank. It is the vegetation which has the most direct affect on instream biota.

Seasonal allocation – the volume of water allocated to a water share in a given season, expressed as a percentage of total entitlement volume

The Living Murray (TLM) – an intergovernmental program, which holds an average of 500,000 ML of environmental water per year, for use at six icon sites along the River Murray

Unregulated entitlement – an entitlement to water declared during periods of unregulated flow in a river system, that is, flows that are unable to be captured in storages

Victorian Environmental Flow Monitoring and Assessment Program (VEFMAP) – assesses the effectiveness of environmental flows in delivering ecological outcomes

Victorian Environmental Water Holder (VEWH) – an independent statutory body responsible for holding and managing Victorian environmental water entitlements and allocations (Victorian Water Holdings)

Water entitlement – the right to a volume of water that can (usually) be stored in reservoirs and taken and used under specific conditions

Water Holdings – environmental water entitlements held by the Victorian Environmental Water Holder

Waterway manager – agency responsible for the environmental management of waterways (includes catchment management authorities and Melbourne Water)

Waterways – can include rivers, wetlands, creeks, floodplains and estuaries

1 Background and system overview

1.1 Background

The Environmental Water Reserve (EWR) is the legally recognised amount of water set aside to meet environmental needs. The reserve includes minimum river flows, unregulated flows and specific environmental entitlements.

Environmental entitlements can be called out of storage when needed and delivered to streams or wetlands to protect or enhance their environmental values and health. Environmental entitlements are held by the Victorian Environmental Water Holder (VEWH) the Commonwealth Environmental Water Holder (CEWH), and the Murray Darling Basin Authority (MDBA). Catchment Management Authorities (CMAs) are responsible for determining the environmental water requirements of streams and wetlands, developing and submitting seasonal watering proposals to the VEWH for consideration, and managing the delivery of environmental water in accordance with the VEWH's Seasonal Watering Plan.

The VEWH prepares seasonal watering plans based on each of the CMA's seasonal watering proposals. The plans describe the desired environmental water use for rivers and wetlands across Victoria in the coming year. To help facilitate the desired environmental water use outlined in the plans, the VEWH negotiates access to environmental water managed by the CEWH and the MDBA. The VEWH then prepares seasonal watering statements that authorises CMA's to undertake the agreed watering activities, including the use of CEWH and MDBA water. As more environmental water becomes available during the season the VEWH may prepare additional seasonal watering statements. Where possible, the VEWH, CEWH and the MDBA seek to coordinate the delivery and management of environmental water to maximise ecological benefits.

1.2 Purpose

The purpose of this Goulburn River Seasonal Watering Proposal is to:

- identify the environmental water requirements of the Goulburn River (below Lake Eildon) in the coming year under a range of climatic scenarios to protect or improve its environmental values and health; and
- inform the development of environmental water priorities in the VEWH's seasonal watering plan.

The proposal is informed by scientific studies and reports that identify the flow regimes required to meet the ecological objectives of the river. This proposal was prepared in consultation with key stakeholders and partners, and was approved by the Goulburn Broken CMA board.

1.3 System overview

The Goulburn River is 570 km long, flowing from the Great Dividing Range upstream of Woods Point to the Murray River east of Echuca. It has a mean annual discharge of approximately 3,040 GL representing 13.7% of the total state discharge (GB CMA 2005).

The Goulburn River has been identified as a high priority waterway in the Goulburn Broken Regional River Health Strategy due to its significant environmental values (GB CMA, 2005). The river and its associated floodplain and wetland habitats support intact river red gum forest, and numerous threatened species such as Murray Cod, Trout Cod, Macquarie Perch, Squirrel Glider, and Eastern Great Egret. The river and its associated floodplain and wetland habitats also contain many important cultural heritage sites, provide water for agriculture and urban centres, and support a variety of recreational activities such as fishing and boating.

1.3.1 Flow Regime

Flow along the Goulburn River has been modified by two major features, Lake Eildon and the Goulburn Weir. Lake Eildon is located in the river's upper catchment, immediately below the confluence to the Delatite River. It has a capacity of 3,334 GL. On average, 91% of water released from Lake Eildon is diverted for irrigation purposes and supplies about 60% of water used in the Goulburn Murray Irrigation District (G-MW website). With such a large storage capacity, operation of the lake fully regulates downstream flows in all but wet years (GB CMA 2008).

Lake Eildon and its operation have significantly affected the flow regime of the Goulburn River. Low flows in the mid Goulburn River (below Lake Eildon to Lake Nagambie) now occur in winter and spring due to harvesting, and high flows now occur in summer and autumn due to releases to meet irrigation and consumptive demands. However, below Lake Eildon flows do increase progressively moving downstream due to tributary inflows.

The Goulburn Weir is approximately 235 km downstream of Lake Eildon, and north of Nagambie. It holds 25 GL and is usually held close to full capacity to facilitate the diversion of water into irrigation channels and to supply Waranga Basin. Waranga Basin has a capacity of 432 GL and is used to store winter and spring flows from tributaries downstream of Lake Eildon (GB CMA 2008).

The Goulburn Weir and its operation have reduced the average annual downstream flow to 1,340 GL, less than half of the estimated pre-regulated flow (GB CMA 2005). In addition, significant flows may be released in summer and early autumn from the Goulburn Weir to the Murray River as Inter-Valley Transfers (IVT) to supply entitlements traded from the Goulburn River system to the Murray River system. However, below the Goulburn Weir the river does retain the natural seasonal flow pattern due to the influence of tributaries such as the Broken River and the Seven Creeks, and the diversion of irrigation water at the Goulburn Weir during summer and autumn. However, the flow is substantially reduced in volume from natural conditions.

The Goulburn River flow regime is also affected by a range of activities within the catchment, including alterations to vegetation, construction of small dams and drainage schemes. In addition, along the riverine plain downstream of Shepparton, artificial levees and other structures obstruct flood flows (Cottingham et al 2003).

1.3.2 Priority reaches and measuring points

An environmental flow study for the Goulburn River downstream of Lake Eildon to the confluence of the Murray River was completed in 2003 (Cottingham et al 2003). To facilitate the development of environmental flow recommendations the river was divided into five reaches with similar channel morphology, flow regimes, and ecological values (Figure 1). The reaches are:

1. Lake Eildon to Molesworth (63 km);
2. Moleswoth to Seymour (69 km);
3. Seymour to Nabambie (101 km);
4. Nagambie to Loch Gary (110 km); and
5. Loch Gary to the Murray River (125 km).

In summer and autumn there are limited opportunities to manage water for environmental purposes in reaches 1, 2 and 3 due to high flows to meet downstream irrigation and consumptive demands. During winter and spring, environmental flows delivered to reaches 4 and 5 also benefit reaches 1, 2 and 3. Therefore, the priority reaches for environmental water management are reaches 4 and 5.

The key measurement points for environmental flows are at Eildon for reach 1, Trawool for reach 2, Seymour for reach 3, Murchison and Shepparton for reach 4 and McCoys Bridge for reach 5 (Figure 1).

1.3.3 Delivery constraints

Delivery of environmental water down the Goulburn River is primarily constrained by the risk of flooding private and public assets. The minor flood levels at each flow measurement point along the Goulburn River are as follows:

- 14,500 ML/d at Eildon (reach 1);
- 21,700 ML/d at Trawool (reach 2):
- 22,800 ML/d at Seymour (reach 3):
- 29,200 ML/d at Murchison (reach 4): and
- 29,200 ML/d at McCoys Bridge (reach 5).

The availability of spare channel capacity may also constrain the timing of environmental water delivery.

1.3.4 Water sources

Environmental water available for use in the Goulburn River includes:

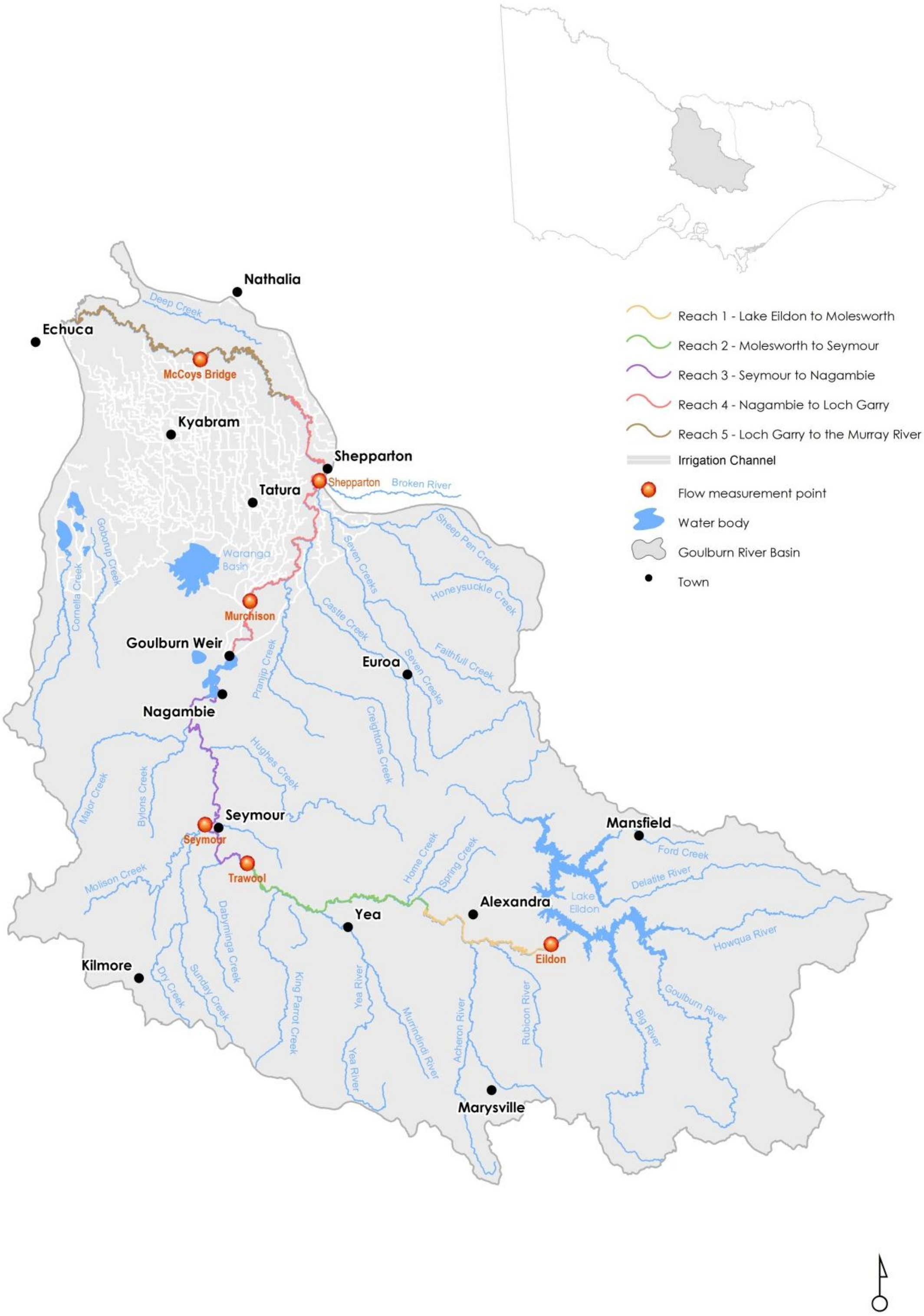
- minimum passing flows and a water quality allowance established in the Bulk Entitlement (Eildon – Goulburn Weir) Conversion Order 1995 and subsequent amendments;
- environmental entitlements held by the VEWH, the CEWH and the MDBA;
- unregulated flows; and
- Inter-Valley Transfers (Table 1)

Table 1: Environmental water available for use in the Goulburn River

ENVIRONMENTAL WATER	RESPONSIBLE AGENCY	DESCRIPTION	CONDITIONS
Bulk Entitlement (Eildon – Goulburn Weir) Conversion Order 1995			
Minimum Flow	G-MW	Minimum flow of 120 ML/d at Eildon Pondage Weir.	[1]
Minimum Flow	G-MW	Minimum average weekly flow of 250 ML/d at the Goulburn Weir.	The daily rate is to be no less than 200 ML/d.[1]
Minimum Flow	G-MW	Minimum average monthly flow of 350 ML/d from November to June inclusive at McCoys Bridge gauging station.	The daily rate is to be no less than 300 ML/d.[1]
Minimum Flow	G-MW	Minimum average monthly flow of 400 ML/d from July to October inclusive at McCoys Bridge gauging station.	The daily rate is to be no less than 350 ML/d.[1]
Goulburn Water Quality Allowance	G-MW	30 GL per year.	Maintenance of water quality.
Additional Passing Flow below Eildon Pondage Weir	G-MW	Minimum passing flows at Eildon Pondage Weir increased to 250 ML/d.	Inflows to Lake Eildon for previous 24 months must reach a specified volume.[1]
Additional Passing Flow below Eildon Pondage Weir	Secretary DSE	Up to 80 GL to provide up to 16,000 ML/d peak flow for 1 day.	Inflows to Lake Eildon from previous 12 and 24 months must reach specified volumes and the Secretary of DSE confirms the need for a release.[1]
Entitlements and Inter-Valley Transfers			
Victorian River Murray Flora and Fauna Entitlement	VEWH	27,600 ML high reliability entitlement.	
Goulburn Environmental Water Savings Supply Deed	VEWH	One-third of water savings created in the Goulburn System as a result of modernisation works completed as part of Stage 1 of the Northern Victorian Irrigation Renewal Project. 23GL is assumed to be available for 2012/13.	Volume based on works implemented and water losses saved in previous year's climate.
Environmental Entitlement (Goulburn-System – Living Murray) 2007	MDBA	49,625 ML high reliability entitlement and 156,980 ML low reliability entitlement, and 35 GL of carryover from 2011/12	Water allocated to this entitlement must be used for the Living Murray 'icon sites'. However, this water can provide environmental benefits in the Goulburn River en route to the Murray River.
Commonwealth Environmental Water Holdings	CEWH	146,418 ML Goulburn high reliability water share and10,654 ML Goulburn low reliability water share as at 29 February 2012.	Water use is subject to agreement with the CEWH.
Inter-Valley Transfers	MDBA (River Murray Water)	136,000 ML of high reliability water supply plus 120,000 ML of carryover.	As needed in the Murray system, with some flexibility on when and how this water is moved from Lake Eildon to the Murray system.
Shepparton Modernisation Project	VEWH	1,500 ML high reliability entitlement and 7,600 ML low reliability entitlement.	The entitlement is not yet available.

1 Minimum flows in the Goulburn Bulk Entitlement can be reduced under drought conditions and banked for later use.

Figure 1: Goulburn River Basin



2 Objectives and flow recommendations

This section outlines the environmental flow objectives established for the Goulburn River, and the corresponding flow recommendations including the volume, timing, duration and frequency of flow components.

2.1 Environmental flow objectives

An environmental flow study for the Goulburn River was completed in 2003 (Cottingham et al 2003) and another in 2007 (Cottingham et al 2007). The 2003 study was one of the earliest flows studies in Victoria and focused on the Goulburn River downstream of Lake Eildon to the confluence of the Murray River. The 2007 study was undertaken specifically to assess the impact and management of high summer flows resulting from Inter-Valley Transfers in the lower Goulburn River (i.e. from Goulburn Weir to the Murray River). Further studies were undertaken in the drought years between 2007 and 2010, including a fresh objectives study. Overbank flow recommendations in the Cottingham et al 2007 study were updated in a study by the Department of Sustainability and Environment in February 2011 (DSE 2011). These flows studies developed flow objectives and recommendations for the delivery of environmental flows in the five reaches of the Goulburn River as described in section 1.3.2.

The 2003 flows study is used in this proposal primarily for flow recommendations in Reaches 1 to 3 inclusive, and the 2007 study, the 2010 fresh objective study and the 2011 overbank flow study provide the flow objectives and recommendations in Reaches 4 and 5.

The 2003 flow study recommended targeting the following objectives:

- Vegetation:
  a) enhance the extent and diversity of aquatic vegetation;
  b) increased contribution to processes such as river productivity;
  c) maintain diversity of riparian vegetation;
  d) reduce the extent and impact of weeds; and
  e) maintain continuity and cover of riparian vegetation.

- Floodplain:
  a) enhance the extent and diversity of aquatic vegetation;
  b) increased contribution to processes such as river productivity;
  c) flood regime has all elements of a natural floodplain in terms of seasonality, frequency and duration; and
  d) connection of floodplain ecosystem components (e.g. grasslands, wetlands).

- Invertebrates;
  a) biomass and trophic structures closely resemble local tributaries;
  b) dynamic and diverse food webs; and
  c) diverse resilient communities through full range of physical conditions.

- Fish:
  a) suitable thermal regime for spawning, growth and survival stages;
  b) suitable in channel and off channel habitat for all life stages;
  c) fish passage for all life stages;
  d) cues for adult migration during spawning season;
  e) access to floodplain and off channel habitats for spawning/larval rearing;
  f) low flows for spawning and recruitment; and
  g) floodplain and bench inundation for exchange of food and organic material.

Based on these objectives, specific flows were developed to address channel attributes, reaches and flow components. In particular, the study focused on flow changes required to the then current regime, rather than on the total regime required. The study did not take into consideration social or economic constraints and has recommended flows based purely on achieving an environmental outcome.

In 2007, the second environmental flows study (Cottingham et al 2007) was completed for Reaches 4 and 5 (between the Goulburn Weir and Murray River). This study primarily looked at the issues and appropriate limits of high summer flows resulting from the potential need for large Inter-Valley Transfers, but also specified desirable environmental flow regimes for the whole year. The method used in the 2007 study altered significantly from that used in the 2003 study. The changes included:

- Specifying the flow required for each objective instead of identifying a single flow to meet several environmental objectives.
- Providing for inter-annual flow variability (dry, medium and wet years).
- Specifying two levels of environmental flow recommendations (the recommended environmental flow to achieve the environmental flow objective with a high degree of confidence (low risk) and a flow that represents a moderate risk to achieving the environmental flow objective. These two levels are provided in recognition of the inherent uncertainty in flow-ecology linkages and the need to trade of environmental risks with consumptive water use (Cottingham et al 2007).

As such, the 2007 study provides a complex range of flow recommendations for each environmental objective for different times of year, in different years, and with different levels of risk to the environmental outcomes. Environmental objectives are established for planktonic algae, macrophytes, terrestrial bank vegetation, macroinvertebrates, native fish and geomorphology.

Both studies made recommended a desirable maximum rate of rise and fall in river flows or water levels to minimise bank slumping and flushing or stranding of biota. These guide the shaping of flow freshes and intervention in impacts of water management.

In 2007, 2008, 2009, and 2010, the drought conditions and very low flows raised ecological questions not previously considered in the 2003 and 2007 flow studies. In response a panel of ecologists and hydrologists assessed the impact of low flows to the ecosystem and developed recommendations for water management to minimise the ecological risk in times of drought. These recommendations are included in a number of separate reports with recommendations specific to climatic conditions. Importantly, in Cottingham et al (2010), the panel provided additional advice on the objectives for flow freshes in the lower Goulburn River for 2010-2011. This report drew and expanded on the information provided in the 2007 flow study to design freshes. Further, the overbank flow study in 2011 (DSE 2011) set flow objectives for ecological features of the river and floodplain adapted from the 2003 flow study.

Table 2 outlines a selection of the environmental objectives and flow recommendation for all 5 reaches of the Goulburn River and the report they came from. In addition, environmental objectives met by the same flow recommendation (nested ecological objectives) are also listed. As outlined in section 1.3.2 there are limited opportunities to manage water in reaches 1, 2 and 3 for environmental purposes due to high flows to meet downstream irrigation demands in summer and autumn. Therefore, the priority reaches for environmental water management are reaches 4 and 5. In addition, the feasibility of delivering the overbank flow recommendations, including how best to deliver or supplement flows whilst avoiding damage to public and private assets is also an issue requiring further investigation. Therefore overbank flow recommendations are only provided by natural events. The selected environmental objectives and flow recommendations for reaches 4 and 5 are currently considered a priority. All of the environmental objectives and flow recommendations for reaches 4 and 5 set out in the 2007 study are listed in Appendix 1.

Table 2: Environmental objectives and flow recommendations for the Goulburn River (ML/day)

FLOW COMPONENT	ECOLOGICAL VALUE	ECOLOGICAL OBJECTIVES	NESTED ECOLOGICAL OBJECTIVES	SEASON	FLOW (ML/DAY)					REPORT
					Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	
Base flow	Macroinvertebrates	Provide near natural levels of riffle habitat for macroinvertebrates and small bodied fish	• Increase riffle habitat for macroinvertebrates and small bodied fish	Summer Autumn	<1,000	<1,000	<1,000	NA	NA	2003
Base flow	Macrophytes	Provide velocities suitable for in channel macrophyte recruitment and growth	• Provide velocities suitable for in channel macrophyte recruitment and growth	Summer Autumn	<3,000	<3,000	<3,000	NA	NA	2003
Base flow	Native fish	Provide suitable in-channel habitat for all life stages.	• Provide slow shallow habitat required for larvae/juvenile recruitment and adult habitat for small bodied fish	Summer Autumn Winter Spring	NA	NA	NA	400	540	2007
			• Provide deep water habitat for large bodied fish	Summer Autumn Winter Spring	NA	NA	NA	500	320	2007
Base flow	Macroinvertebrates	Provide habitat and food source for macroinvertebrates by submerging snag habitat within the euphotic zone	• Provide conditions suitable for aquatic vegetation, which provides habitat for macroinvertebrates • Provide slackwater habitat favourable for planktonic production (food source) and habitat for macroinvertebrates • Entrain litter packs available as food/habitat source for macroinvertebrates • Maintain water quality suitable for macroinvertebrates	Summer Autumn Winter Spring	NA	NA	NA	830	940	2007
Fresh	Native fish	Initiate spawning, pre-spawning migrations and recruitment of native fish (preferably late spring early summer for native fish)	• Maintain aquatic macrophyte, macroinvertebrate and fish habitat by mobilising fine sediments, submerging snags and replenishing slackwater habitat	Summer Autumn Winter Spring	NA	NA	NA	5,600 14 days (winter/ spring) 2-4 days summer/ autumn 1-4 events	5,600 14 days (winter/ spring) 2-4 days summer/ autumn 1-4 events	2010
Overbank (only provided by natural events)	Floodplain and wetland vegetation	Increase the extent and diversity of flood dependent vegetation communities	• Provide habitat for wetland specialist fish • Exchange of food and organic material between the floodplain and channel • Increase breeding and feeding opportunities for native fish, waterbirds and amphibians	Winter Spring	15,000+ Annual	15,000+ Annual	15,000+ Annual	25,000 5+ days 2-3 events in a yr 7-10 event yrs in10	NA	2003 2011

FLOW COMPONENT	ECOLOGICAL VALUE	ECOLOGICAL OBJECTIVES	NESTED ECOLOGICAL OBJECTIVES	SEASON	FLOW (ML/DAY)					REPORT
					Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	
Overbank (only provided by natural events)	Floodplain and wetland vegetation higher in the landscape	Increase the extent and diversity of flood dependent vegetation communities	• Provide habitat for wetland specialist fish • Exchange of food and organic material between the floodplain and channel • Increase breeding and feeding opportunities for native fish, waterbirds and amphibians	Winter Spring	60,000 Annual	60,000 Annual	60,000 Annual	40,000 4+ day 1-2 events in a yr 4-6 event yrs in 10	NA	2003 2011
Rate of flow rise	Native fish and macroinvertebrates	Reduce displacement of macroinvertebrates and small/juvenile fish		All year	Max rate 1.80 of previous days flow	NA	NA	Max rate of 0.38/0.38/1.20/0.80 metres river height in summer/autumn/ winter/spring	NA	2003 2007
Rate of flow fall	Geomorphology, native fish and macroinvertebrates	Reduce bank slumping/erosion and stranding of macroinvertebrates and small/juvenile fish		All year	Max rate 0.76 of previous days flow	NA	NA	Max rate of 0.15/0.15/0.78/0.72 metres river height in summer/autumn/ winter/spring	NA	2003 2007

3 Current situation

3.1 2011-2012 season review

Between autumn 2011 and autumn 2012 the mid and lower Goulburn River experienced a number of natural freshes, bankfull and overbank flows as a result of widespread and heavy rainfalls. In addition, environmental water was used to create a fresh in the lower Goulburn River and maintain minimum flows. As a result, the majority of the eight priority environmental flow components identified in the 2011-12 Goulburn River Seasonal Watering Proposal (GB CMA 2011) were met, with the exception of some base flows for short periods. A total of 155,061 ML of environmental water was used comprising 61,038 ML of TLM Program water (8,700 ML to increase minimum flows) and 94,033 ML of Commonwealth Water. The flows in the mid and lower Goulburn River during the 2011-2012 season are outlined in further detail below.

3.1.1 Mid Goulburn River (Reaches 1-3)

The Bulk Entitlement (Eildon-Goulburn Weir) Conversion Order 1995 provides for a minimum passing flow below Lake Eildon of 250 ML/day. Pre-releases from Lake Eildon from June 2011 until the end of August 2011, irrigation and consumptive demands and environmental water requirements below the Goulburn Weir ensured the minimum passing flow was met for the entire year. Conversely, the summer and autumn base flow recommendations of <1,000 ML/day and <3,000 ML/day only occurred for 11 days (10% of the time) and 32 days (30% of the time) respectively (Figure 2). These base flow targets have been set to provide shallow water habitat for native fish, macroinvertebrates and macrophytes. On the 10th March 2012, G-MW commenced pre-releasing from Lake Eildon. This may maintain flows in the mid Goulburn River at approximately 8,000 ML/day (plus tributary inflows) until the end of autumn.

The Goulburn Broken CMA provided advice to G-MW on how to best manage the June 2011 to August 2011 pre-release from Lake Eildon to improve environmental outcomes in the mid and lower reaches. This included reducing the rates of rise and fall in flows from Lake Eildon, and not maintaining a constant flow for more than a week. G-MW was able to implement these recommendations without impacting on reservoir and flood management. The Goulburn Broken CMA will also seek to provide similar advice to G-MW regarding the current pre-release from Lake Eildon.

As a result of widespread and heavy rainfalls the mid Goulburn River at Trawool and Seymour experienced a number of natural bankfull and overbank flows. Flows exceeded the recommended flood peak of 15,000 ML/day in July 2011, August 2011 and late February and early March 2012 (Figure 2). During July 2011 average daily flows were approximately 12,000 ML/day and peaked at over 15,000 ML/day at Trawool and 17,000 ML/day at Seymour.

The Bulk Entitlement (Eildon-Goulburn Weir) Conversion Order 1995 provides for the release of up to 80,000 ML in the month of November under certain inflow and release conditions. The provision was created to improve the watering of wetlands along the Goulburn River between Lake Eildon and the Goulburn Weir. The provision has only been triggered once before in 1996, and the Departmental Secretary decided a release was not required in that year. The provision was triggered for the second time in November 2011. However, it is unclear what flow rates downstream of Lake Eildon are required to inundate wetlands without impacting on public and private assets. Therefore, the Goulburn Broken CMA coordinated a trial release of the environmental water down the Goulburn River from Eildon. Flows were increased from 5,000 ML/day to 7,000 ML/day for two days from the 16th to the 18th November (Figure 2). Flows were then increased to 9,000 ML/day from the 21st to the 24th November (Figure 2). Flow and water elevation information was collected at 13 locations along reaches 1 and 2 during the release. This information will be analysed along with LiDAR and other spatial information to better understand the relationship between wetlands, private land and river flows.

3.1.2 Lower Goulburn River (Reaches 4-5)

The recommended winter/spring base flow target of 540 ML/day at McCoys Bridge was met throughout the year. The higher recommended winter/spring base flow target of 940 ML/day was also met throughout the year with the exception of 7 days in September 2011 and 10 days in October 2011 (Figure 3). However, the recommended winter/spring base flow target of 500 ML/day at Murchison was not met for approximately 22 days in September 2011 and 14 days in October 2011. The higher recommended winter/spring base flow target of 830 ML/day at Murchison was also not met for an additional 4 days in October 2011 and 6 days in September 2011 (Figure 3). No environmental water was available at the time to fill these gaps. The minimum flows were met as a result of pre-releases from Lake

Eildon, unregulated flows in response to rainfall events, CEW and TLM program water from November 2011 and IVTs from January to late February.

Four natural freshes occurred as a result of unregulated flows in early June 2011, late June/early July 2011, early July through to early September and early October 2011 (Figure 3). All the freshes reached the desired maximum flow of 5,600 ML/day. The freshes in late June/early July and early October were for short periods of less than 6 days. The fresh in early June 2011 was for approximately 15 days, exceeding the desired 14 day duration. The fresh from early July through to early September continued for approximately 59 days.

In early November both TLM Program and CEWH water were used on route to the Lower Lakes in South Australia to create a fresh. The fresh reached the desired maximum flow of 5,600 ML/day and was maintained for approximately 16 days.

As a result of widespread and heavy rainfalls in July 2011, a near bankfull flow occurred. Flows peaked at approximately 13,700 ML/day, 18,400 ML/day and 19,800 ML/day at Murchison, Shepparton and McCoys Bridge respectively (Figure 3). Further widespread and heavy rainfalls in August resulted in a short overbank event downstream of Shepparton. Flows peaked at approximately 14,100 ML/day, 25,300 ML/day and 21,000 ML/day at Murchison, Shepparton and McCoys Bridge respectively (Figure 3). The event was consistent with the overbank flow recommendations with the exception of the duration, which was for 3 days not the recommended 5+ days. Early March also experienced widespread and heavy rainfall. This resulted in further flood flows down the Goulburn River, peaking at approximately 17,000 ML/day at Murchison, 35,000 ML/day at Shepparton and 28,000 ML/day at McCoys Bridge for approximately 6 days (Figure 3). The flow and duration of the event was consistent with the overbank flow recommendations with the exception of the season. Goulburn-Murray Water has now commenced pre-releases from Lake Eildon which will maintain flows between 3,000 and 10,000 ML/day until May 2012.

ANZECC guidelines recommend dissolved oxygen concentrations should not fall below 5mg/L or 80-90% saturation to maintain suitable conditions for oxygen dependent aquatic species. Throughout most of the year dissolved oxygen concentrations in the lower Goulburn River have averaged between 5mg/L and 10mg/L at Shepparton (Figure 4). However, the flood flows in March 2012 entrained organic material from the floodplain increasing oxygen demand in the river. As a result, dissolved oxygen concentrations fell below 5mg/L at Shepparton and McCoys Bridge in early to mid March, dropping as low as 2 mg/L at McCoys Bridge. With the passing of the flood water dissolved oxygen concentrations rose above 5mg/L by late March. No fish deaths were recorded in this event.

3.2 Current ecological conditions

The floods and freshes experienced in 2010-2011 provided water to a system suffering drought effects. The floods provided input of nutrients, carbon and organic matter to the river and an exchange of sediments and biota between the channel, floodplain and wetlands. The floods and freshes connected floodplains that were not connected for 10-15 years and improved riparian vegetation health and stimulated native fish breeding including Golden Perch for the first time in eight years (since monitoring commenced). Although the floods and freshes improved many aspects of river health along the Goulburn River and its floodplain, there were a number of negative impacts. A blackwater event in December 2010 resulted in fish kills with exact numbers of fish killed unknown. Additionally, continuous inundation during the spring and summer months stripped the banks of riparian vegetation in Reaches 4 and 5.

The recent floods and freshes experienced in 2011-2012 have provided for the continued ecological recovery of the Goulburn River and its floodplain including:

- Establishment of floodplain and wetland seedlings set the previous year including stands of Common Reed (*Phragmities australis*) in Reach 4.
- Increasing the populations of aquatic dependent fauna including waterbirds, frogs and native fish by providing successive opportunities for breeding and feeding. Australian White Ibis (*Threskiornis molucca*) and Royal Spoonbill (*Platalea regia*) have bred at Reedy Swamp on the Goulburn River floodplain. Large numbers of waterbirds have also been recorded feeding and roosting at floodplain wetlands along Reaches 1-5 of the Goulburn River. A variety of native fish have been recorded in wetlands in Reaches 4 and 5 including the threatened Golden Perch (*Macquaria ambigua*), and 1,500 Carp gudgeons (*Hypseleotris* spp.) (SKM 2012). Murray Cod (Maccullochella peelii), which declined in numbers downstream of Shepparton following the blackwater event in December 2010, increased in spring 2011. There has been evidence of Golden Perch (*Macquaria ambigua*) recruitment with two juveniles (101 and 192 mm in total length) collected by ARI in November 2011. In addition, Golden Perch (*Macquaria ambigua*) eggs were collected in mid-November 2011, which coincided with

the fresh release (see 3.1.2) (ARI 2011). Finally there has been anecdotal evidence that the abundance and distribution of Freshwater catfish (*Tandanus tandanus*) have increased in reaches 3 and 4.
- Scouring pools and moving fine sediments.
- Removing the chronic need for flood events for the next two to three years.

Like the floods and freshes experienced in 2010-2011, the recent floods and freshes have also resulted in a number of negative ecological impacts. There has been strong recruitment of Common Carp (Cyprinus carpio) (ARI 2011). A similar response was recorded in 2010-2011. A number of wetlands (e.g. Reedy Swamp and Gemmills Swamp in Reach 4) and floodplain areas have been continually inundated since March 2010. This may have a detrimental impact on the diversity and structure of their vegetation by favoring species more adapted to prolonged flooding. Some species such as River Red Gum (Eucalyptus camaldulensis) may die from waterlogging. Aquatic and riparian vegetation stripped from the banks in Reaches 4 and 5 in 2010-2011 have not re-established in most areas. This may be a result of the extended high flows, particularly from early July 2011 through to early September 2011 when the average daily flow was approximately 12,000 ML/day. The current pre-releases from Eildon may further exacerbate this problem.

3.3 Flow components delivered

The key flow components for the lower Goulburn River include:
- Base flows to maintain native fish habitat and passage.
- Freshes to maintain water quality and habitat for macroinvertebrates; and provide cues for native fish migration and spawning.
- Overbank flows to increase the extent and diversity of floodplain and wetland vegetation; exchange of food and organic material; and increase breeding and feeding opportunities for native fish, waterbirds and amphibians.

These key flow component volumes at Murchison, Shepparton and McCoys Bridge gauging stations are outline in Table 3 below.

Table 3: Approximate flow component values for the lower Goulburn River (ML/day)

FLOW COMPONENT	MURCHISON	SHEPPARTON	MCCOYS BRIDGE
Base flow[1]	400/500	NA	540
Fresh[2]	5.600 (14 days or 2 days)	5.600 (14 days or 2 days)	5.600 (14 days or 2 days)
Overbank 1	NA	25,000 (5+ days)	NA
Overbank 2	NA	40,000 (4+ days)	NA

1 The Base flow figures are based on the minimum flow requirements for native fish identified in the 2003 Goulburn River Flow Study (Cottingham et al 2003). The Base flow figures are the same for each season accept for Reach 4 in autumn, which has a minimum flow requirement of 400 ML/day for native fish.

2 Freshes are 14 days duration in winter/spring and 2 days duration in summer/autumn

The key flow components that have occurred in the lower Goulburn River since 2001-2002 at Murchison, Shepparton and McCoys Bridge gauging stations as a result of delivering environmental water, and unregulated and regulated flows are outlined below in Table 4. In summary:
- Base flow targets at Murchison and McCoys Bridge have only been completely met in 2010-2011 and 2011-2012 respectively.
- Fresh targets at Murchison have only been completely met in 2005-2006 (summer), 2010-2011 (spring, summer and autumn) and in 2011-2012 (spring, summer, autumn and winter). They have occurred most frequently during summer (9 times) and spring (8 times).
- Overbank flows greater than 25,000 ML/day have only occurred in 2010-2011 (spring) and 2011-2012 (spring, summer, autumn and winter).
- Overbank flows greater than 40,000 ML/day have only occurred once in spring 2010-2011.

Table 4: Historical achievement of flow component values for the lower Goulburn River

Flow component	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12
Murchison											
Base flow											
Spring fresh											
Summer fresh											
Autumn fresh											
Winter fresh											
Shepparton											
Spring fresh											
Summer fresh											
Autumn fresh											
Winter fresh											
Spring overbank 1											
Summer overbank 1											
Autumn overbank 1											
Winter overbank 1											
Spring overbank 2											
Summer overbank 2											
Autumn overbank 2											
Winter overbank 2											
McCoys Bridge											
Base flow											
Spring fresh											
Summer fresh											
Autumn fresh											
Winter fresh											

No significant part of the flow component achieved (target flow met for less than 50% of the required duration)
Flow component partially provided (target flow met for more than 50% of the required duration)
Flow component completely provided (target flow met for the required duration)

3.4 Key observations and learnings from 2011-2012

In March 2012, another summer flood and blackwater event occurred (after the 2010-2011 event). Fortunately, dissolved oxygen levels did not fall as low as in 2010-2011 and no fish deaths were reported. This may have been due to lower water temperatures in March 2012.

The 5,600 ML/day 14 day fresh in spring 2011 appears to have had only limited success in stimulating golden perch breeding. Potentially this could have been caused by the late timing of the fresh and higher water temperatures. Any 2012 fresh should aim to be earlier at slightly lower temperatures. It may also be worth considering multiple, smaller duration freshes.

Unlike in the previous drought years the deployment of Inter-Valley Transfer water occurred later in the year, delivered over a shorter period, of modest flow rates, and was quite variable responding to changes in downstream demand. This change in behaviour was due to the Darling River floods changing Murray River system operation. Hence in 2012-2013, less reliance should be placed on Inter-Valley Transfer flows consistently meeting Goulburn River summer/autumn environmental demands.

The 2010-2011 floods removed all vegetation from the lower part of the river bank, but germination of new plants has yet to occur (despite being a target of the 2011 spring fresh). This should still be a target for the 2012 spring fresh, and the outcomes monitored.

3.5 Climatic outlook for 2012-2013

According to the latest weather outlook information from the Bureau of Meteorology the likelihood that the Goulburn and Broken Catchments will receive above average rainfall from April to June 2012 is 40-45% and there is 70-75% chance that there will be warmer than normal days. Lake Eildon is currently 93% full and G-MW is pre-releasing providing higher than average flows, which are likely to continue until early May 2012. Overall, other than the state of the water storages, the climate outlook provides no particular guidance for 2012-2013 flow management.

Figure 2: Mid Goulburn River flows for 2011-2012 at three measurement points downstream of Lake Eildon

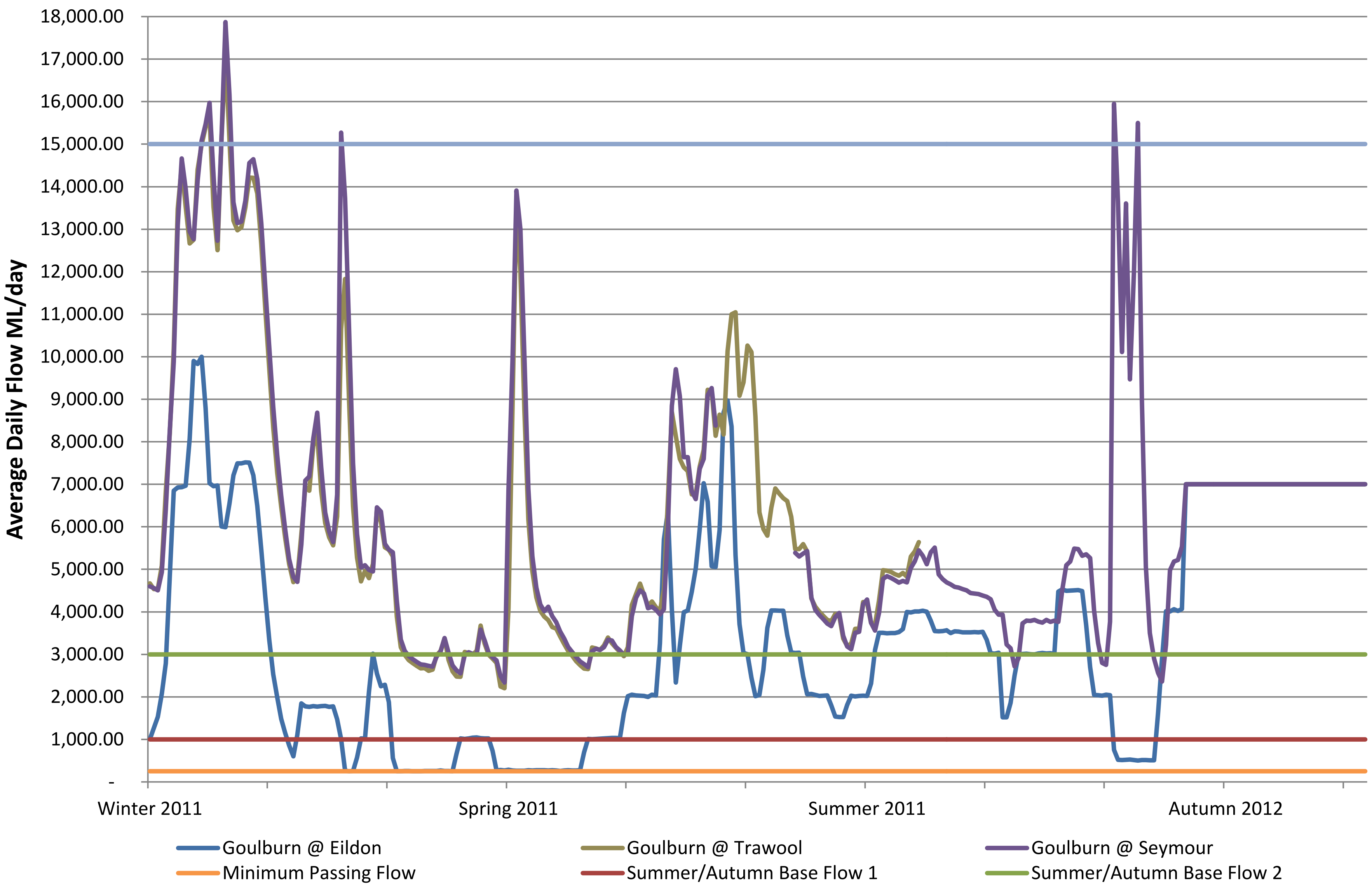


Figure 3: Lower Goulburn River flows for 2011-2012 at three measurement points downstream of Goulburn Weir

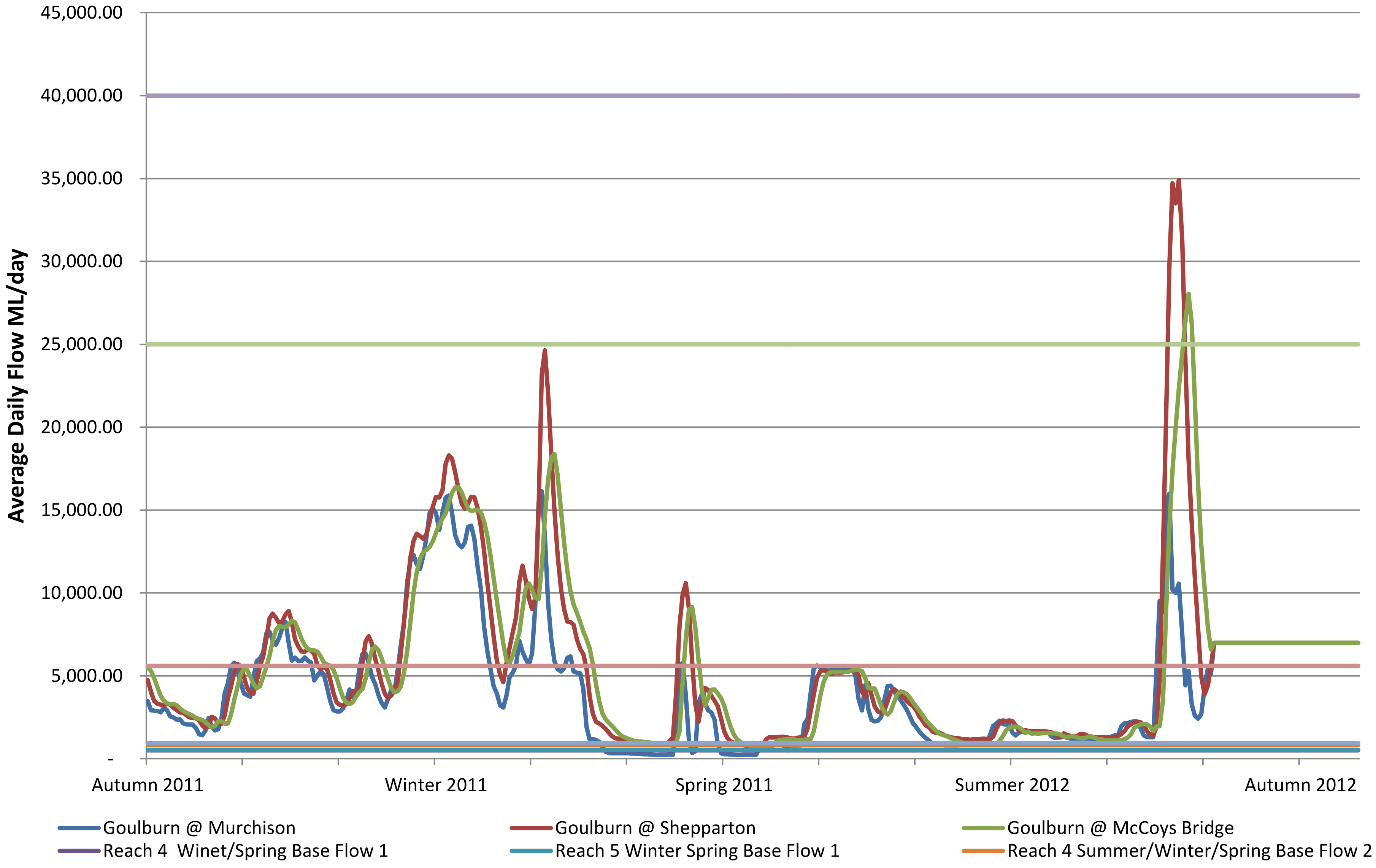
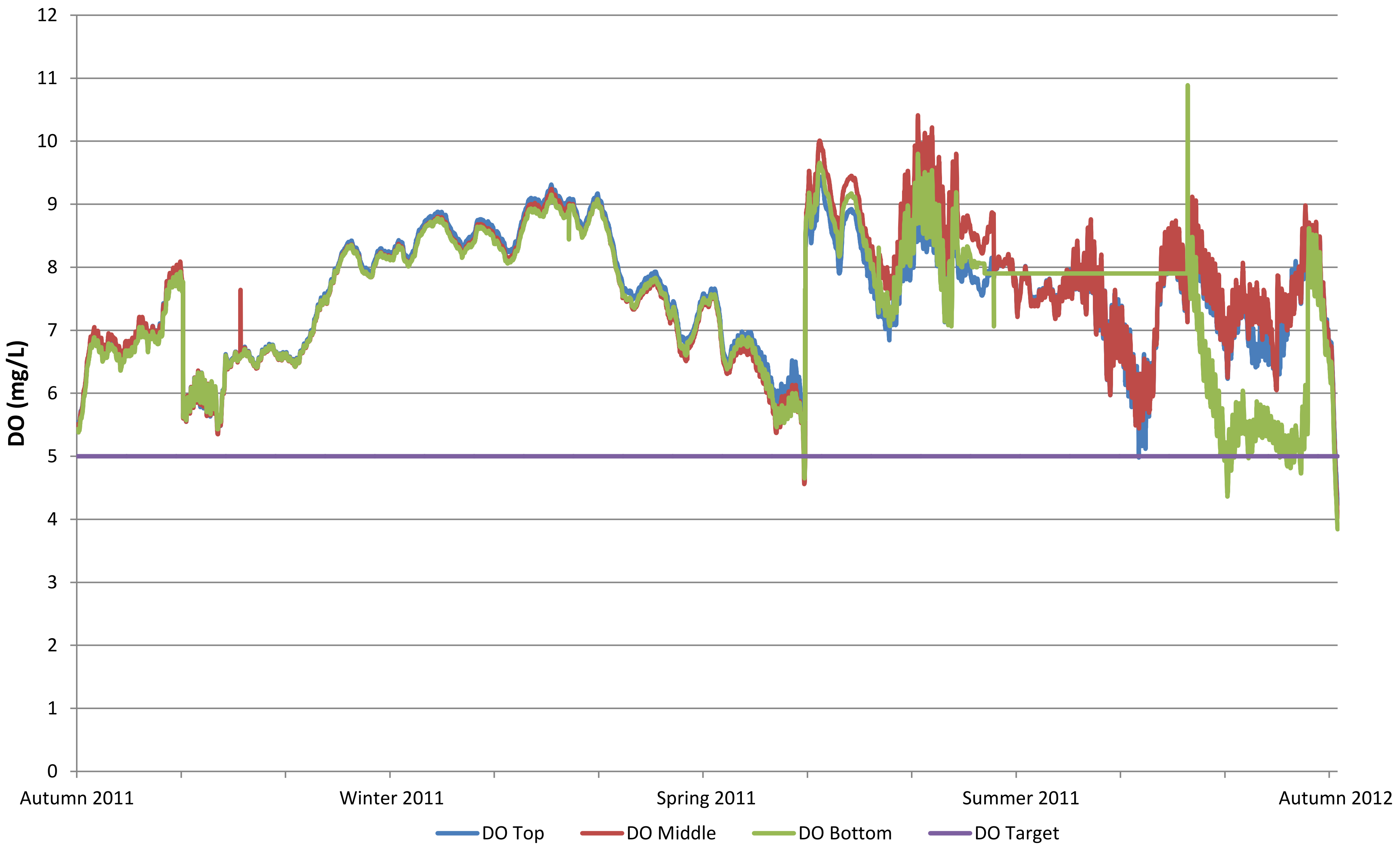


Figure 4: Dissolved oxygen concentrations for 2011-2012 at Shepparton.



4 Priority watering actions

For the purposes of this plan, the needs of the Goulburn River between the Goulburn Weir and the Murray River drive the plan, with reaches 1-3 between Lake Eildon and Goulburn Weir benefiting from flows being passed to the lower reaches 4-5 or being unaffected by them.

The Goulburn Weir to Murray River has two ecologically different reaches. Reach 4 upstream of Loch Garry and reach 5 downstream of Loch Garry. The key environmental water measurement point for reach 4 is Murchison (Shepparton for overbank flows) and the key environmental water measurement point for reach 5 is McCoys Bridge. As a general rule, the plan aims to meet flow targets for McCoys Bridge in spring, summer and autumn when there is limited tributary inflows and high extraction rates to meet irrigation and consumptive demands. This ensures adequate flow moves through Murchison to meet the targets for reach 4. Alternatively, in winter and spring when catchment runoff contributes more flow to reach 5, the plan aims to achieve flow targets for Murchison to ensure both reaches meet their flow targets.

The priority flow components are heavily driven by the recent flow history of the Goulburn River, characterised by 10+ years of drought with very low flows, and the last two years where all environmental flow targets were largely met. The 10+ years of drought significantly impacted on the health of instream and floodplain habitats and associated flora and fauna. The good flows in the last two seasons however, have started their ecological recovery. The summer flows in the last two years have tended to be high, and included stressful blackwater events, with the December 2010 event producing fish deaths.

The focus for the 2012-2013 year is to continue to encourage the long term improvement in the distribution, abundance and diversity of native fish, macroinvertebrates and vegetation. This will be achieved by implementing minimum and fresh flow recommendations, particularly in winter/spring as summer flows have been above average in the last two years.

For minimum flows, the priority is to provide for all of the fish objectives (flows of 500 ML/day and 540 ML/day at Murchison and McCoys Bridge respectively). The next priority is to provide for all macroinvertebrate objectives (flows of 830 ML/day and 940 ML/day at Murchison and McCoys Bridge respectively). Geomorphic objectives (aimed at maintaining pool depth) at higher flow rates are a much lower priority given the recent two years of high flows. Where water is limited, the 2012 winter/spring period is most important, followed by the 2012-2013 summer period (summer is potentially more biologically productive then autumn/winter) and then the 2013 autumn/winter period.

For freshes, the priority is to provide freshes in spring at the higher end of the flow range of 5,600 ML/day (for 14 days) to provide a significant ecological signal. The duration of the fresh is important in encouraging the germination of riparian vegetation on the stripped lower slopes of the bank and allowing macroinvertebrates to respond to the inundation of snags. A spring fresh is preferred as it has the added target of stimulating Golden perch breeding. The next priority is an earlier winter/spring fresh. However, it is unlikely the required volume of water will be available at this time. The next priority is for 1 fresh of 5,600 ML/day for two days in summer or autumn. Freshes have more complex environmental outcomes than shown here, and will need to be carefully designed to maximise outcomes.

A further element of freshes is to add environmental water to unregulated flows or managed flow releases. This could provide the desirable fresh with less environmental water, or merely to slow the flow recession to reduce ecological damage from rapid rates of fall. This may also allow more fresh events than planned.

The priority flow components are summarised in Table 5 and illustrated in Figure 5. This prioritises between minimum flows and freshes, with the spring fresh seen as a high priority for its multiple benefits, particularly riparian vegetation germination and golden perch spawning.

In considering priority flow components in 2012-2013, the potential needs for 2013-2014 were also considered (and whether any flow components would be foregone in 2012-2013 in preference for a flow component in 2013-2014). There is no major important need in 2013-2014 than in 2012-2013. The main trade-offs occur under the dry scenarios, and it is generally more important to maximise the ecological outcomes in 2012-2013 in a known dry year than hold water back in case 2013-2014 is also a dry year. The highest 2013-2014 priority would be to continue winter baseflows for fish objectives.

The movement of Inter-Valley Transfers and or environmental flows for the Murray River can create summer/autumn flows that are too high causing ecological damage to the lower Goulburn River, and the design of the summer and autumn flow regime will need to take this into account.

Having had major floodplain inundation in 2010-2011 and lower floodplain inundation in 2011-2012, no further floodplain inundation is required in 2012-2013. With the risk of flooding private land still unresolved, overbank flooding is not to be attempted in the immediate future in any case.

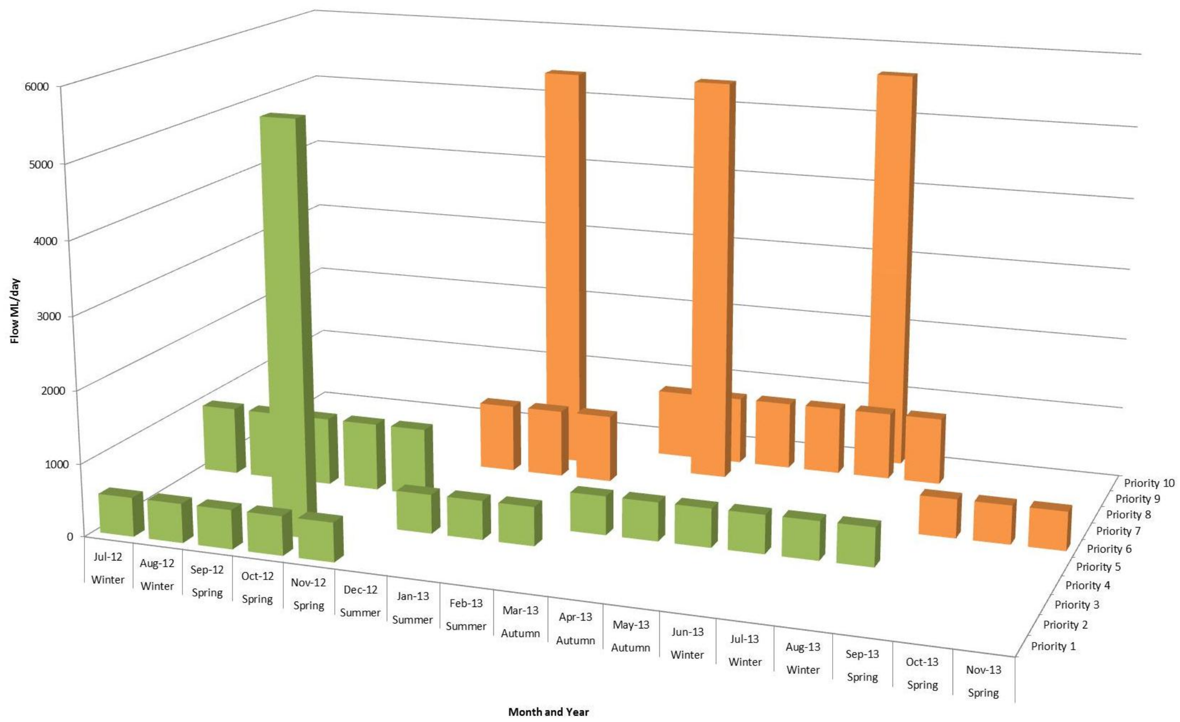
Table 5: Summary of priority environmental flow components

PRIORITY	FLOW COMPONENT	YEAR	SEASON	FLOW (ML/DAY)	
				REACH 4	REACH 5
1	Base flow	2012	Winter/spring	500	540
2	Fresh	2012	Spring	5,600 (or as high as possible[1]) for 14 days	5,600 (or as high as possible) for 14 days
3	Base flow	2012-2013	Summer	500	540
4	Base flow	2013	Autumn/winter	500	540
5	Base flow	2012	Winter/spring	830	940
6	Base flow	2013	Winter/spring	500	540
7	Base flow	2012-2013	Summer	830	940
8	Fresh	2012-2013	Summer/autumn	5,600 for 2 days	5,600 for 2 days
9	Base flow	2013	Autumn/winter	830	940
10	Fresh	2013	Winter	5,600 for 14 days	5,600 for 14 days

Note flow components shaded in green are high priorities. Delivery of components shaded in orange will depend on the seasonally adaptive allocation process.

1 If insufficient water available to provide full spring fresh, aim to provide a fresh of 14 days duration at as high a flow rate as the volume allows.

Figure 5: Priority environmental flow components



5 Scenario planning

The Goulburn River has a highly variable flow, depending on catchment runoff and on the operation of the water supply system to deliver water for consumption. Environmental flow planning aims to allow catchment runoff and water system operation to meet as many environmental flow objectives as possible, and then deploy water from environmental entitlements into the highest priority gaps that remain. However, under different possible climatic conditions (from very dry to very wet), the environmental flow gaps move dramatically, and the priorities for deployment of environmental water change.

Therefore, plans are prepared for a range of possible climatic scenarios to understand how the priorities and required volumes for deployment of environmental water change.

The scenarios are based on current conditions within the water supply system such as the volumes of water stored in the reservoirs. They then assume the availability of all environmental water entitlements and their associated water allocations in the Goulburn system, and determine how best to maximise the environmental outcomes from their use. They assume TLM water can be released precisely to meet Goulburn targets, whereas in practice TLM water will meet Murray targets and therefore be only partially effective in meeting Goulburn targets.

Importantly, the planning is not concerned with the probability of any particular climate scenario (or in picking the most likely scenario) – it merely ensures there is a plan if any scenario does occur. For the Goulburn system, while various indicators are available, predicting climatic conditions in the current autumn/early winter for the coming season (both winter/spring and summer/autumn) has little reliability.

The scenarios have been picked to highlight the key decisions that will need to be made about environmental water deployment for 2012-2013, and hence can change from year to year. Importantly, the actual management of water through the season needs to be adaptive, with water deployment decisions adjusting as the season unfolds, particularly in response to timing issues within the season. Table 6 outlines the range of scenarios for water use in the lower Goulburn River in the 2012-2013 year.

Table 6: Scenario summary descriptions for the Goulburn River

REACHES 4 & 5	SCENARIO 1 WORST DROUGHT 99% POE	SCENARIO 2 VERY DRY 90% POE	SCENARIO 3 DRY 70% POE	SCENARIO 4 AVERAGE 50% POE	SCENARIO 5 WET 30% POE
Water Supply	40% HRWS allocations Perhaps 100% available as private carryover	75% HRWS allocations Perhaps 100% available as private carryover	100% HRWS allocations Perhaps 60% available as private carryover	100% HRWS allocations Perhaps 40% available as private carryover	100% HRWS allocations Perhaps 10% available as private carryover
Expected River Flow and Water Management	Effectively no unregulated flows in winter/spring	One or two freshes (2000 to 14000 ML/d) in winter/spring of short duration	For most of period, strong baseflows, several freshes up to low overbank flows in winter/spring	For most of period, strong baseflows, several freshes and overbank flows in winter/spring	Very strong baseflows and one to three overbank flows (30,000 to 80000) in winter/spring
	Normal 400 ML/d minimum flow at McCoys Bridge from July to October	Normal 400 ML/d minimum flow at McCoys Bridge from July to October	Normal 400 ML/d minimum flow at McCoys Bridge from July to October	Normal 400 ML/d minimum flow at McCoys Bridge from July to October	Normal 400 ML/d minimum flow at McCoys Bridge from July to October
	Normal 350 ML/d minimum flow at McCoys Bridge from November to June	Normal 350 ML/d minimum flow at McCoys Bridge from November to June	Normal 350 ML/d minimum flow at McCoys Bridge from November to June	Normal 350 ML/d minimum flow at McCoys Bridge from November to June	Normal 350 ML/d minimum flow at McCoys Bridge from November to June
	170 GL of IVT available	220 GL of IVT available	220 GL of IVT available	183 GL of IVT available	147 GL of IVT available

REACHES 4 & 5		SCENARIO 1 WORST DROUGHT 99% POE	SCENARIO 2 VERY DRY 90% POE	SCENARIO 3 DRY 70% POE	SCENARIO 4 AVERAGE 50% POE	SCENARIO 5 WET 30% POE
WQ Reserve Volumes Available		30 GL of Water Quality Reserve available	30 GL of Water Quality Reserve available	30 GL of Water Quality Reserve available	30 GL of Water Quality Reserve available	30 GL of Water Quality Reserve available
Environmental Entitlement Volumes Available		CEWH – 56 GL VEWH – 23 GL TLM - 50 GL	CEWH – 113 GL VEWH – 23 GL TLM - 65 GL	CEWH – 146 GL VEWH – 23 GL TLM - 65 GL	CEWH – 146 GL VEWH – 23 GL TLM - 54 GL	CEWH – 146 GL VEWH – 23 GL TLM - 44 GL
Environmental Objectives		Maximise habitat and movement for large bodied and small adult fish and juveniles	Maximise habitat and movement for large bodied and small adult fish and juveniles	Maximise habitat and movement for large bodied and small adult fish and juveniles	Maximise habitat and movement for large bodied and small adult fish and juveniles	Maximise habitat and movement for large bodied and small adult fish and juveniles
		Improve macro invertebrate habitat and its availability	Improve macro invertebrate habitat and its availability	Improve macro invertebrate habitat and its availability	Improve macro invertebrate habitat and its availability	Improve macro invertebrate habitat and its availability
		Bench inundation for carbon-nutrient cycling & vegetation	Bench inundation for carbon-nutrient cycling & vegetation	Bench inundation for carbon-nutrient cycling & vegetation	Bench inundation for carbon-nutrient cycling & vegetation	Bench inundation for carbon-nutrient cycling & vegetation
		Stimulate Golden Perch breeding	Stimulate Golden Perch breeding	Stimulate Golden Perch breeding	Stimulate Golden Perch breeding	Stimulate Golden Perch breeding
Preferable Inter-Valley Transfer (IVT) Water Use		Release IVT water for as long as possible in December to March at 940 ML/d (61 GL)	Release IVT water for as long as possible in December to March at 940 ML/d (61 GL)	Release IVT water for as long as possible in December to March at 940 ML/d (36 GL)	Release IVT water for as long as possible in December to March at 940 ML/d (36 GL)	Release IVT water for as long as possible in December to March at 940 ML/d (36 GL)
		Possibly provide a low summer fresh	Possibly provide one or more low summer freshes	Possibly provide one or more low summer freshes	Possibly provide one or more low summer freshes	Possibly provide one or more low summer freshes
Preferable Environmental Water Use		Release Water Quality Reserve for emergency response to water quality problems (eg blackwater)	Release Water Quality Reserve for emergency response to water quality problems (eg blackwater)	Release Water Quality Reserve for emergency response to water quality problems (eg blackwater)	Release Water Quality Reserve for emergency response to water quality problems (eg blackwater)	Release Water Quality Reserve for emergency response to water quality problems (eg blackwater)
Priority watering actions	1	Increase minimum July to November flows to 540 ML/d at Murchison (44GL)	Increase minimum July to November flows to 540 ML/d at Murchison (44GL)	Increase minimum July to November flows to 540 ML/d at Murchison (44GL)	Increase minimum July to November flows to 540 ML/d at Murchison (44GL)	Increase minimum July to November flows to 540 ML/d at Murchison (44GL)
	2	Provide spring fresh to 5,600 ML/d for 14 days (85 GL)	Provide spring fresh to 5,600 ML/d for 14 days (85 GL)	Provide spring fresh to 5,600 ML/d for 14 days (75 GL)	Provide spring fresh to 5,600 ML/d for 14 days (75 GL) if required	Provide spring fresh to 5,600 ML/d for 14 days (75 GL) if required
	3		Increase summer minimum flows for 0.5 months to 540 ML/d at McCoys (3 GL)	Increase summer minimum flows for 0.5 months to 540 ML/d at McCoys (3 GL)	Increase summer minimum flows for 0.5 months to 540 ML/d at McCoys (3 GL)	Increase summer minimum flows for 0.5 months to 540 ML/d at McCoys (3 GL)
	4		Increase minimum April to June 2013 flows to 540 ML/d at Murchison (26GL)	Increase minimum April to June 2013 flows to 540 ML/d at Murchison (26GL)	Increase minimum April to June 2013 flows to 540 ML/d at Murchison (26GL)	Increase minimum April to June 2013 flows to 540 ML/d at Murchison (26GL)
	5		Increase minimum July to November 2012 flows to 830 ML/d at Murchison for part of period (got 48 of 69GL) 1*	Increase minimum July to November 2012 flows to 830 ML/d at Murchison (35GL)	Increase minimum July to November 2012 flows to 830 ML/d at Murchison (17GL)	Increase minimum July to November 2012 flows to 830 ML/d at Murchison (17GL)
	6			Increase minimum July to September 2013 flows to 540 ML/d at Murchison (26 GL) 2*	Increase minimum July to September 2013 flows to 540 ML/d at Murchison (26 GL)	Increase minimum July to September 2013 flows to 540 ML/d at Murchison (26 GL)

REACHES 4 & 5		SCENARIO 1 WORST DROUGHT 99% POE	SCENARIO 2 VERY DRY 90% POE	SCENARIO 3 DRY 70% POE	SCENARIO 4 AVERAGE 50% POE	SCENARIO 5 WET 30% POE
	7			Increase summer minimum flows for 2 months to 930 ML/d at McCoys (36 GL)	Increase summer minimum flows for 2 months to 930 ML/d at McCoys (36 GL)	Increase summer minimum flows for 2 months to 930 ML/d at McCoys (36 GL)
	8				Enhance IVT to provide summer fresh (<50 GL) [1,2]	Enhance IVT to provide summer fresh (<50 GL) [1,2,3]
	9					Increase minimum April to June 2013 flows to 830 ML/d at Murchison (26GL)
Environmental water carried over into 2013/14		Nil	Nil	Nil	Committed 26 GL plus possibly more	Committed 26 GL plus likely more
Desirable priority watering actions	**3**	Increase half month of summer minimum flow to 540 ML/d (3 GL)				
	4	Increase April-June 2013 minimum flows to 540 ML/d (26 GL)				
	5	Increase 2012 July to November minimum flow to 830 ML/d (45 GL)	Complete increase of 2012 July to November minimum flow to 830 ML/d (21 GL)			
	6		Provide 540 ML/d in July to September 2013 (26 GL)			
	7		Increase summer 2012-2013 minimum flows to 940 ML/d (3 GL)			
	8		Provide summer fresh to 5,600 L/d (<63 GL)	Enhance IVT to provide summer fresh (<50 GL)		
	9				Increase minimum April to June 2013 flows to 830 ML/d at Murchison (26GL)	
	10				Provide 2013 winter fresh of 5,600 ML/day for 14 days (85 GL)	Provide 2013 winter fresh of 5,600 ML/day for 14 days (85 GL)

1 The timing of water availability may not allow this component to be provided, in which case it would be deployed to the desirable additional uses (which occur after the spring).
2 Significant demand in this scenario is after the 2012 winter/spring and it may not be possible to usefully use the TLM water.
3 Many flow components may not be required, hence carryover likely.

6 Adaptive management

This Goulburn Broken CMA proposal is based on using the carryover and allocations of all environmental entitlements expected to be available in the Goulburn system in 2012-2013, as outlined in Table 1. Of these, the Commonwealth Environmental Water Holder water volumes are the major driver of this proposal.

The highest priority is to meet all fish related flow targets for the whole year, and particularly those in the 2012 winter/spring.

Under drier conditions, much of the available water is targeted to the 2012 winter/spring. As conditions become wetter and unregulated flows increase, most of the water is best deployed after the 2012 winter/spring. Inter-Valley Transfers offer the opportunity to meet some of the summer/autumn flow needs, particularly minimum flows.

Given the potential for dry conditions to occur, it is proposed that in July 2012 water would be deployed to maintain a 540 ML/day minimum flow, with additional water saved for a spring fresh (October/November).

If the winter/spring is wetter and unregulated flows provide winter/spring flow components, the water saved would be reserved for the 2013 summer/autumn/winter 540 ML/day minimum flow components. Even in wet conditions, water would continue to be reserved for the spring fresh until after an appropriate event occurs at the right time to stimulate fish breeding.

In October/November, the need for and timing of the spring fresh needs to be determined.

A key issue is the deployment of The Living Murray water, which aims to provide environmental outcomes in the Murray River, not the Goulburn River. How well this Murray deployment meets Goulburn needs is a critical issue for how many Goulburn priorities can be achieved.

Given the uncertainty about available water for Goulburn outcomes early in the 2012-2013 year, it is unlikely water will be available early enough to deploy as a 2012 winter flush, or as an increased winter (and maybe spring) minimum flow (to 830 ML/day at Murchison). These events in future will probably only occur if planned for in the prior year (as they have been in this proposal for 2013-2014).

The proposal prioritises provision of a minimum flow in July to September 2013 before a summer fresh, and a 2013 winter fresh only when all 2012-2013 needs have been met.

In October/November/December, the potential availability of Inter-Valley Transfers will become clearer, but given the supply conditions likely in the Murray, it will provide a useful but unreliable supply of environmental flow needs. Hence it will be important to have clarified the environmental water available to fill flow gaps in the Inter-Valley Transfers.

Over the summer months, unseasonal floods onto the floodplain (as in 2012-2011 and 2011-2012) could be an issue requiring a response to flush out the water remaining after any blackwater event.

From March/April onwards when Inter-Valley Transfers cease, maintaining minimum flows at 540 ML/day would occur.

The provision of these flows should be quite feasible as they are well within the sort of flows normally regulated within the Goulburn system.

The environmental flows leaving the Goulburn system have potential to be used again for downstream environmental benefits in the Murray system, including the Lower Lakes.

Importantly, the Goulburn environmental flow study defines a range of flow components that need to be optimised. The proposal specifies bulk water volumes required to achieve various environmental objectives. However, as the season unfolds, the design of specific flow regimes to optimise outcomes will be required, requiring flexible and adaptive water deployment. In particular, adding to existing freshes and slowing flow recessions will respond to circumstances at the time.

In summary, this proposal suggests the use of the available environmental entitlements held in the Goulburn water supply system, the seasonal allocations and any carryover associated with those entitlements. Table 7 below outlines the environmental water required to support this proposal under a range of climatic scenarios. It assumes the Commonwealth holding is 146 GL of High Reliability Water Shares (HRWS) and 10 GL of Low Reliability Water Shares (LRWS), Living Murray holding is 40 GL of HRWS and 157 GL of LRWS, and NVIRP savings of 25 GL. The volumes of water assumed to be available and useful under those entitlements are given in Table 1. Additional water can be used if available and this is also listed in Table 1. However, given the lower volumes of Inter-Valley Transfer water available, any proposal for water to be traded into the Goulburn system would need to be assessed for the potential impacts of reduced summer flows. Less water can be used than proposed by not delivering flow components under each scenario in Table 6.

Table 7: Summary of environmental water volumes required to support this proposal (GL)

REACHES 4 & 5	WORST DROUGHT	VERY DRY	DRY	AVERAGE	WET
Planned environmental water use	129	201	236	225	215
Additional water use	73	100	50	111	85

The 80 GL additional passing flows available from Lake Eildon under the Goulburn Bulk Entitlement for a flush to 16,000 ML/day for one day is only available in a narrow window of climatic conditions and is called out at the discretion of the VEWH. In 2012-2013, it would appear that the conditions do not occur where it is possible for a release to be triggered. In any event, there is currently no need for its deployment.

Under the Goulburn bulk entitlement, minimum flows specified in the bulk entitlement can be reduced under drought conditions, with the water saved banked for later use. There is no scenario in 2012-2013 that would require this to be undertaken.

7 Implementation arrangements

7.1 Notice and time required

A notice period of one to two days minimum and preferably four days is required for environmental water orders from Goulburn system storages. If constraints in making environmental water available are foreseen by G-MW, the Environmental Water Manager will be advised accordingly. Releases from Lake Eildon take approximately 2½ days to reach Goulburn Weir. Releases from Goulburn Weir take one day to reach Murchison, four days to reach Shepparton, and seven to eight days to reach McCoys Bridge (near the Murray River). However this can be influenced by existing conditions in the river channel and seasonal conditions. If flows are being harvested at Goulburn Weir into Waranga Basin, releases can be made from Goulburn Weir by reducing harvesting, hence saving travel time from Lake Eildon.

7.2 Costs

The Environmental Water Manager does not have to make any payment for headworks costs relating to the environmental entitlements or the Goulburn Bulk Entitlement. If chargeable, these costs are met by the entitlement holders. There are no water delivery costs.

8 Risk management

8.1 Environmental Water Delivery

The risks associated with the proposed water delivery of each flow component include: current environmental flow recommendations are inaccurate which may result in ecological objectives not been met; improving conditions for non-native species such as European carp; environmental water releases causing flooding of private land; unable to provide evidence environmental objectives were met from the environmental water releases; and key stakeholders not supportive of environmental water releases. These have been assessed as a medium risk while remaining risks have been assessed as low (Table 8). The flow components and associated risks and risk ratings are the same for each season.

Table 8: Risk assessment of the proposed Goulburn River water delivery

RISK CATEGORY	Risk #	Risk type	FLOW COMPONENT	
			Low flow	Fresh
Quality issues lead to non-achievement of objectives	1.0	Release volume is insufficient in meeting required flow at target point	Low	Low
	1.1	Current recommendations on environmental flow inaccurate	Medium	Medium
	1.2	Storage operator maintenance works affect ability to deliver water	Low	Low
	1.3	Resource manager cannot deliver require volume or inflow rate (outlet/capacity constraints, insufficient storage volume)	Low	Low
Time	2.0	Limited CMA resource to deliver environmental release	Low	Low
Cost	3.0	Cost of delivery exceeds available funding	Low	Low
Human	4.0	Environmental release cause personal injury to river user	Low	Low
Environmental	5.1	Releases cause water quality issues (e.g. blackwater, low DO, mobilisation of saline pools, ASS etc.)	Low	Low
	5.2	Improved conditions for non-native species (e.g. carp)	Medium	Medium
Compliance	6.0	Environmental water account is overdrawn	Low	Low
	6.1	Environmental releases causes flooding of private land	Low	Medium
	6.2	Environmental releases causes flooding to public infrastructure	Low	Low
	6.3	Environmental releases causes flooding of Crown land	Low	Low
Reputation	7.0	Unable to provide evidence in meeting environmental objective	Medium	Medium
	7.1	Key stakeholders not supportive of environmental water release	Low	Medium

Table 9 below outlines the mitigation strategies that will be employed by the Goulburn Broken CMA to address the medium risks identified above.

Table 9: Mitigation action plan

RISK #	RISK TYPE	FLOW COMPONENT	RISK MITIGATION STRATEGY	IMPACT OF MITIGATION RISK
1.1	Current recommendations on environmental flow in inaccurate	Low flow and fresh	Keep focus on monitoring outcomes from flow management and reassess recommendations as necessary	Adaptively improves recommendations and lowers risk over time
5.2	Improved conditions for non-native species (e.g. carp)	Low flow and fresh	None available	
6.1	Environmental releases causes flooding of private land	Fresh	Consider potential catchment runoff from forecast rainfall in deciding when to commence releases and whether to prematurely cease releases	Becomes low risk
7.0	Unable to provide evidence in meeting environmental objective	Low flows and freshes	Seek involvement, contributions and results from monitoring and research programs	Progressively lower risk over time
7.1	Key stakeholders not supportive of environmental water release	Freshes	Keep key stakeholders aware of fresh plans and timing	Lowers risk somewhat now, and increasingly over time

The key management activity with immediate outcomes includes:

- to manage reduce flooding risk associated with delivering freshes by considering potential catchment runoff from forecast rainfall events in deciding when to commence releases and whether to cease releases prematurely.
- To keep key stakeholders advised of flush release plans.

Importantly risks associated with our current level of knowledge need attention now, but will take time to reduce the associated risks.

8.2 Other Water Delivery

While this proposal focuses on how to use available water to maximise environmental benefits to the lower Goulburn River, water supply and environmental releases can be made to the Murray River for other purposes. In particular, The Living Murray water is targeted at environmental outcomes at the six Murray icon sites, and Inter-Valley Transfers are targeted at meeting consumptive water demand in the Murray River. These releases can pose a risk to the Goulburn River environment and increase the risk of flooding private and public infrastructure.

Releases of water in winter/spring generally pose little risk to the environment, provided flow rates are not varied at greater rates than specified in the Cottingham et al 2007 environmental flows study. Cottingham recommended maximum rates of river level rise in reach 4 of 1.2 and 0.80 metres/day for winter and spring respectively, and maximum rates of river level fall of 0.78 and 0.71 metres/day for winter and spring respectively.

Releases is summer/autumn can pose a significant environmental risk from persistent high flows as defined in the Cottingham et al 2007 environmental flows study. Key impacts are: bank notching and erosion; bank slumping; filling of pools from transported sand; loss of macrophytes; reduced phytoplankton production; and reduced macroinvertebrate growth. Essentially this limits the maximum flow to 5,240 ML/day at McCoys Bridge for a maximum of 2 days to pose a low risk to the environment, with greater durations allowable for lower flow rates. As a guide, flows of greater than approximately 2,500 ML/day can occur for less than 50% of the time. Rates of rise and fall also pose a risk, and Cottingham recommended maximum rates of river level rise of 0.38 metres/day for summer, and maximum rates of river level fall of 0.09 metres/day for both summer and autumn.

The risk of flooding arises from rainfall-induced runoff adding flow on top of an environmental release. The key issue is the unpredictability of the amount of rainfall and the associated runoff. Flooding of land occurs at a flow of approximately 18,000 ML/day at Shepparton, although inundation of some assets (such as irrigation pumps) occurs at much lower flows.

Management of the risk of flooding is a balance of how much spare capacity is left in the river to carry the rainfall runoff and the reduction/suspension of environmental releases when rainfall is forecast to increase the river's spare capacity to carry rainfall runoff. The highest flow that could be provided is 9,000 to 10,000 ML/day under dry conditions, as this is the river capacity downstream of Lake Eildon, and assumes no irrigation water supply demand. This leaves 9,000 to 8,000 ML/day of spare river capacity in the lower Goulburn to carry runoff from rainfall on a dry catchment. Under wet conditions, lower releases (with higher spare river capacity) would be needed to deal with the potentially higher runoff downstream of Lake Eildon. The higher the flow rate, the more likely the flow would be reduced or ceased due to the uncertain response to rain, making provision of the environmental or water supply flow erratic and potentially unreliable.

9 Monitoring and reporting

9.1 Current monitoring programs

A number of programs are currently conducted by the Goulburn Broken CMA to monitor environmental flow and river and ecological conditions. The main program for environmental flow monitoring is the Victorian Environmental Flows Monitoring and Assessment Program (VEFMAP). This program is being undertaken at 12 sites in the Goulburn River from Goulburn Weir to the Murray River and is monitoring vegetation, fish, macroinvertebrates, channel features, physical habitat. Not all parameters are measured at each site. These assessments are carried out on a range of timeframes (varying from annually, to when a channel changing event occurs) and are a long term assessment (5 - 10 years) of the impacts of and changes from environmental flows. The analysis of this data is based on statistical methods rather than before-after style monitoring. Monitoring has been occurring since 2008 (i.e. four years) and to date no data analysis has occurred. Additionally, 2010/11 was the first year of the monitoring to have significant flows, and hence the first year that any response to flows may occur with previous years providing base line data only.

River flows are currently monitored through the North East Monitoring Partnership at Lake Eildon, Killingworth, Trawool, Seymour, Murchison, Shepparton and McCoys Bridge. Goulburn-Murray Water also monitors releases from Goulburn Weir.

Water quality monitoring on the Goulburn River has been in place for a number of years. This monitoring includes continuous monitoring (i.e. 30 minute intervals) that has been occurring for approximately 2½ years (primarily in response to drought) and monitoring on a monthly basis that has been occurring for more than 10 years. Table 10 lists the sites, frequency and parameters that are used for environmental flow monitoring. This monitoring is used frequently (sometimes daily) in short term management of environmental flows to assist decision making in terms of minimising the risk of dissolved oxygen sags and potential fish kills or other water quality issues.

Table 10: Monitoring sites on the Goulburn River

Site	Parameter
Continuous monitoring	
Goulburn River@McCoys Bridge	Dissolved oxygen, electrical conductivity, temperature, pH
Goulburn River@Shepparton STP	Dissolved oxygen, electrical conductivity, temperature, pH, level
Goulburn River@Trawool	Turbidity, level
Goulburn River@Goulburn Weir	Dissolved oxygen, temperature, turbidity
Goulburn River@Tabilk	Dissolved oxygen, temperature, electrical conductivity
Non continuous monitoring	
Goulburn River@Murchison	Dissolved oxygen, temperature, turbidity, EC, suspended solids, TP, TN
Goulburn River@Trawool	Dissolved oxygen, temperature, turbidity, EC, suspended solids, TP, TN
Goulburn River@Eildon	Dissolved oxygen, temperature, turbidity, EC, suspended solids, TP, TN

Turbidity and water level is monitored continuously on a number of Goulburn River tributaries located between Lake Eildon and Seymour (i.e. reaches 1 and 2) affected by the 2009 bushfires. Goulburn-Murray Water monitors dissolved oxygen and turbidity in Goulburn Weir.

Additional fish monitoring has also been carried out in the lower Goulburn River for the last eight years. This monitoring includes boat electrofishing, drift net surveys, including larval drift sampling and acoustic tracking. This monitoring provides extra data on fish assemblages, fish movement and recruitment. Where feasible this has been undertaken to coincide with flow events such as freshes and overbank flows. However, its implementation is dependent upon annual funding.

An investigation of fish assemblages and populations in floodplain wetlands has also recently been completed. This project identified what fish are currently in the wetlands, why they go into some types of wetlands and not others, and how long do fish remain in the wetlands.

9.2 Monitoring 2012-2013 environmental flow outcomes

In 2012-2013 the VEFMAP will monitor fish, macroinverebrates and vegetation along the lower Goulburn River (reaches 4 and 5). However, as stated above the program generally aims to detect environmental improvement over some years and the frequency and timing does not necessarily coincide with flow events to assess the effect of environmental water in isolation. If funds are available the Goulburn Broken CMA will continue to monitor fish assemblages, movement and recruitment in the lower Goulburn River (reaches 4 and 5). Where feasible this will be coordinated to coincide with planned freshes to test the hypothesis that they initiate spawning, pre-spawning migrations and recruitment of native fish.

9.3 Reporting

The first level of reporting is on use of environmental entitlements. Weekly reporting is planned to advise environmental entitlement holders of progressive water use, and on any adaptive water deployment decisions made. The second level of reporting is on flows occurring in the river system. Weekly reporting is planned to advise environmental entitlement holders of current flows and the effectiveness of environmental water deployed in achieving desired flows. The third level of reporting is on environmental outcomes achieved. This will tend to more anecdotal in nature and is planned to be reported fortnightly. An annual report will be prepared after the end of the 2012-2013 year to collate all information on the use of environmental water, the river flows achieved, and the environmental outcomes recorded.

9.4 Knowledge gaps

There are two key knowledge gaps associated with the environmental water management in the Goulburn River. The first is there are no ecological objectives and flow recommendation for reaches 1-3 for winter and spring. The 2003 flow study only made summer and autumn flow recommendations and following studies did not make any recommendations for reaches 1-3. Secondly, current monitoring programs do not assess whether a number of key ecological objectives are met by the recommended flows in reaches 4 and 5. These are listed below in Table 11.

Table 11: Ecological objectives not assessed

FLOW COMPONENT	ECOLOGICAL VALUES	ECOLOGICAL OBJECTIVES	FLOW (ML/DAY)	
			Reach 4	Reach 5
Base flow	Macroinvertebrates Planktonic algae	• Provide habitat and food source for macroinvertebrates by submerging snag habitat within the euphotic zone Provide conditions suitable for aquatic vegetation, which provides habitat for macroinvertebrates • Provide slackwater habitat favourable for planktonic production (food source) and habitat for macroinvertebrates • Entrain litter packs available as food/habitat source for macroinvertebrates • Maintain water quality suitable for macroinvertebrates	830	940
Fresh	Native fish Macrophytes Macroinvertebrates	• Initiate spawning, pre-spawning migrations and recruitment of native fish (preferably late spring early summer for native fish) • Maintain aquatic macrophyte, macroinvertebrate and fish habitat by mobilising fine sediments, submerging snags and replenishing slackwater habitat	5,600	5,600

10 Stakeholder engagement and communication

In developing the proposal, discussions have been held with Goulburn-Murray water on the seasonal outlook and the deliverability of the proposal.

There are two key audiences for communications under the proposal. The primary audience is the agencies involved in delivering the proposed flow management and included Goulburn-Murray Water, River Murray Water, the Victorian Environmental Water Holder and the Commonwealth Environmental Water Holder.

Goulburn-Murray Water is the key water delivery agency. When the final proposal for 2012-2013 is agreed, communications with Goulburn-Murray Water are aimed at making clear what the intended environmental flow release plans are and their intended purpose. Then, throughout the season, there will be regular communications (phone, email) directly with the water resource management group to understand unregulated flows, Goulburn-Murray Water planned consumptive use releases, and to organise environmental flow releases.

River Murray Water is responsible for calling out Inter-Valley Transfers. Communications (phone, email) will be aimed at initially planning Inter-Valley Transfers to achieve Murray system operational objectives and lower Goulburn River environmental objectives, and then regularly throughout the season, adjusting the plans to conditions as they unfold.

The Victorian Environmental Water Holder will use this proposal as the basis (in whole or part), in developing the Seasonal Watering Plan. Water allocated is to be delivered in accordance with the plan and the plan is used to seek agreement from other water holders for the use of their water. Routine communication (phone, email) will report on deployment of water under the plan, and seek to modify release plans to align with downstream site needs as the year unfolds.

Commonwealth Environmental Water Holder may have allocated water to the Seasonal Watering Plan which is based on this proposal, and are responsible for achieving further benefits from the water at downstream environmental sites. The Murray Darling Basin Authority is responsible for delivery of TLM water to the Murray River, with potential benefit to the Goulburn River. Routine communication will be via the Victorian Environmental Water Holder, particularly highlighting risks of summer releases and optimising achievement of lower Goulburn River and Murray River environmental objectives.

The secondary audience is those potentially affected by or interested in environmental flows and/or the health of the river environment. This includes Parks Victoria and Department of Sustainability and Environment (public land managers), water users along the river (Goulburn-Murray Water diversion licence holders), campers and recreation users, local government, environment groups, and the general public. As the effect of the proposal on these groups is expected to be minimal, the communication objective is to provide information about the decision to provide environmental flows and what it is trying to achieve. A secondary objective is to build a public understanding of the change from past flow regimes to a future one managed to achieve improved river health. These communications will be through media articles of newsworthy actions, and potentially through talks and local newsletters directly with special interest groups.

To assist with the environmental water management program, the Goulburn Broken CMA is establishing a Goulburn Environmental Water Advisory Group to provide advice on planning environmental water use (including seasonal watering proposals and water management plans) and on any environmental health trends occurring in the rivers, creeks and wetlands. The focus of the group will be the Goulburn River from Lake Eildon to the Murray River and wetlands supplied from the Goulburn system (including wetlands close to and away from the river).The group is expected to be established by the end of April 2012 and will comprise 6 members (including Chair), who will come from a range of geographic locations along the Goulburn River or adjacent to wetlands. Representatives from key agency partners (such as the Department of Primary Industries, Department of Sustainability and the Environment, and Goulburn-Murray Water) and indigenous groups will be consulted.

Table 12 outlines the consultation process the Goulburn Broken CMA has undertaken during the development of this seasonal water proposal and the consultation/communication process that will be implemented following its approval.

Table 12: Seasonal watering proposal development and implementation consultation process

STAKEHOLDER	PURPOSE	ENGAGEMENT TYPE	METHOD	TIMING
		Proposal development		
G-MW	Seek information on water system outlooks and river management, and feasibility of proposal	Involve/consult	Personal discussion with key staff	March – April 2012
CMA Board	Approval of the proposal	Approve	Board Meeting Paper/Presentation	13 April 2012
		Proposal implementation		
Indigenous Groups	Inform Indigenous Groups on the proposal and seek advice on indigenous related issues	Inform/consult	Personal discussion with key staff	May 2012 – April 2013
Goulburn Environmental Water Advisory Group	Inform the Goulburn Environmental Water Advisory Group on the proposal and seek advice on community and river health related issues	Inform/consult	Meetings	April 2012 – April 2013
VEWH	Report on deployment of water under the plan, and seek to modify release plans to align with downstream site needs as the year unfolds	Inform/consult	Telephone and email	May 2012 – May 2013
River Murray Water	Planning Inter-Valley Transfers to achieve Murray system operational objectives and lower Goulburn River environmental objectives, and adjusting the plans to conditions as they unfold	Inform/consult	Telephone and email	May 2012 – May 2013
G-MW	To understand unregulated flows, planned consumptive use releases, and to organise environmental flow releases	Inform/consult	Telephone and email	May 2012 – May 2013
Interest Groups	Build understanding of environmental flow objectives and changes in flow regime	Inform	Media, possibly newletters and talks	May 2012 – May 2013
General public	Build understanding of environmental flow objectives and water management to achieve objectives	Inform	Media	May 2012 – May 2013

11 Approval and endorsement

I, the authorised representative of the agency shown below, approve the Seasonal Watering Proposal for the Goulburn River 2012-13.

SIGNED FOR AND ON BEHALF OF THE GOULBURN BROKEN CATCHMENT MANAGEMENT AUTHORITY

Signature of authorised representative

Name of authorised representative

Date:

12 References

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Appendix 1: Reach 4 & 5 flow recommendations

The following provides the flow recommendations outlined in Cottingham et (2007).

Flow duration bounds identified for Reach 4 ecological objectives.

Note: The values in the table represent the proportion of time that discharge may exceed a particular bound (e.g. 0.85 = 85%). The various percentile years provide opportunities for inter-annual variability, providing different exceedence levels for dry (min, 10th and 30th percentile years) median and wet years (70th, 90th and max years).

			RECOMMENDED						
Ecological Objective	Flow Element Code	Discharge (ML/day)	Minimum	10th percentile year	30th percentile year	median year	70th percentile year	90th percentile year	Maximum
Summer - Lower Bound									
MI4	F003b	540		0.90	0.95	0.95	0.98	0.99	
MI1	F007a	310	0.70	0.80	1.00	1.00			
MI3	F007a	310	0.99	0.99	0.99	0.99	0.99		
MI2	F008b	400	0.90	0.93	0.95	0.98	0.98		
n. fish	F008b	400	0.74	0.95	0.99	0.99	0.99		
n. fish	F007b	500	0.97	0.98	0.99	0.99	0.99		
MI6	F003b	540		0.80	0.90	0.95	0.99	0.99	
MI2	F008c	830	0.70	0.93	0.95	0.98	0.98		
Geo3	F026i	856	0.36	0.71	0.94	1.00	1.00	1.0	1.00
Geo3	F026h	1186	0.11	0.57	0.75	0.88	0.96	1.0	1.00
MI1	F007c	1500		0.10	0.30	0.45	0.75		
MI3	F007c	1500		0.15	0.30	0.40	0.70		
Geo3	F026g	1660		0.30	0.47	0.63	0.74	0.94	1.00
Geo3	F026f	2223		0.11	0.25	0.40	0.60	0.71	1.00
Geo3	F026e	3142		0.01	0.06	0.20	0.43	0.55	0.86
Geo3	F026d	4490				0.05	0.24	0.37	0.64
Geo3	F026c	6590					0.08	0.16	0.42
Geo3	F026b	10700						0.04	0.27
Geo3	F026a	19000							
Summer Upper Bound									
Geo3	F026i	856	0.36	0.71	0.94				
Geo3	F026h	1186	0.11	0.57	0.75	0.88	0.96		
MI1	F007c	1500			0.70	0.90	0.90		
Geo3	F026g	1660	0	0.30	0.47	0.63	0.74	0.94	
Geo3	F026f	2223	0	0.11	0.25	0.40	0.60	0.71	
Geo3	F026e	3142	0	0.01	0.06	0.20	0.43	0.55	0.86
Geo3	F026d	4490	0	0	0	0.05	0.24	0.37	0.64
Geo3	F026c	6590	0	0	0	0	0.08	0.16	0.42
Geo3	F026b	10700	0	0	0	0	0	0.04	0.27
Geo3	F026a	19000	0	0	0	0	0	0	0.07
Autumn Lower Bound									
MI2	F008b	400		0.90	0.93	0.95	0.98	0.98	

			RECOMMENDED						
Ecological Objective	Flow Element Code	Discharge (ML/day)	Minimum	10th percentile year	30th percentile year	median year	70th percentile year	90th percentile year	Maximum
n. fish	F008b	400		0.99	0.99	0.99	0.99	0.99	
MI4	F003b	540		0.70	0.90	0.95	0.98	0.99	
MI6	F003b	540		0.70	0.90	0.95	0.99	0.99	
MI2	F008c	830		0.50	0.65	0.80	0.95	0.98	
Winter Lower Bound									
n. fish	F008b	400		0.99	0.99	0.99	0.99	0.99	
n. fish	F007b	500		0.80	0.86	0.88	0.90	0.96	
MI4	F003b	540		0.85	0.90	0.95	0.98	0.99	
MI6	F003b	540		0.80	0.90	0.95	0.99	0.99	
MI2	F008c	830		0.90	0.93	0.95	0.98	0.98	
Spring Lower Bound									
n. fish	F008b	400		0.99	0.99	0.99	0.99	0.99	
MI2	F008b	400		0.90	0.93	0.95	0.98	0.98	
n. fish	F008b	400		0.99	0.99	0.99	0.99	0.99	
n. fish	F007b	500		0.81	0.85	0.91	0.95	0.99	
MI4	F003b	540		0.70	0.90	0.95	0.98	0.99	
MI6	F003b	540		0.70	0.90	0.95	0.99	0.99	
MI2	F008c	830		0.90	0.93	0.95	0.98	0.98	
n. fish	F027a	24000				0.05	0.13	0.31	
Spring Upper Bound									
n. fish	F027a	24000		0	0	0.08	0.19	0.47	

Flow duration bounds identified for Reach 5 ecological objectives.

The values represent the proportion of time that discharge may exceed a particular bound (e.g. 0.85 = 85%). The various percentile years provide opportunities for inter-annual variability, providing different exceedence levels for dry (min, 10th and 30th percentile years) median and wet years (70th, 90th and max years).

			RECOMMENDED						
Environ. Objective	Flow Element Code	Flow Threshold (Ml/day)	Minimum	10th percentile year	30th percentile year	median year	70th percentile year	90th percentile year	Maximum
Summer - Lower Bound									
MI1	F007a	240		0.70	0.80	1.00	1		
MI3	F007a	240		0.99	0.99	0.99	0.99	0.99	
n. fish	F007b	320		0.90	0.90	0.99	0.99	0.99	
MI2	F008b	540		0.90	0.92	0.95	0.98	0.98	
n. fish	F008b	540		0.99	0.99	0.99	0.99	0.99	
MI4	F003b	770		0.90	0.95	0.95	0.98	0.99	
MI6	F003b	770		0.80	0.90	0.95	0.99	0.99	
MI2	F008c	940		0.70	0.92	0.95	0.98	0.98	

			RECOMMENDED						
Environ. Objective	Flow Element Code	Flow Threshold (Ml/day)	Minimum	10th percentile year	30th percentile year	median year	70th percentile year	90th percentile year	Maximum
Geo3	F026i	1096	0.38	0.75	0.88	0.96	1.00	1.00	1.00
Geo3	F026h	1505	0.17	0.53	0.64	0.82	0.94	1.00	1.00
Geo3	F026g	1993	0.02	0.17	0.40	0.60	0.73	0.97	1.00
Geo3	F026f	2711	0	0.09	0.21	0.35	0.60	0.87	1.00
Geo3	F026e	3800	0	0	0.05	0.20	0.40	0.66	1.00
Geo3	F026d	5240	0	0	0	0.02	0.22	0.43	0.71
Plankt. Algae	F002c	6060				0	0.17		
Geo3	F026c	7560	0	0	0	0	0.08	0.18	0.47
Geo3	F026b	13000	0	0	0	0	0	0.03	0.38
Geo3	F026a	23900	0	0	0	0	0	0	0.09
Summer - Upper Bound									
Geo3	F026i	1096	0.38	0.75	0.88	0.96	1.00	1.00	1.00
Geo3	F026h	1505	0.17	0.53	0.64	0.82	0.94	1.00	1.00
Geo3	F026g	1993	0.02	0.17	0.4	0.60	0.73	0.97	1.00
Geo3	F026f	2711	0	0.09	0.21	0.35	0.60	0.87	1.00
Geo3	F026e	3800	0	0	0.05	0.20	0.40	0.66	1.00
Geo3	F026d	5240	0	0	0	0.02	0.22	0.43	0.71
MI2	F004c	5610		0.01	0.01	0.02	0.30	0.50	
MI4	F004c	5610		0.01	0.01	0.02	0.25	0.45	
Plankt. algae	F002c	6060					0.19	0.30	
Geo3	F026c	7560	0	0	0	0	0.08	0.18	0.47
MI2	F002b	8910		0.01	0.01	0.01	0.05	0.15	
Geo3	F026b	13000	0	0	0	0	0	0.03	0.38
Geo3	F026a	23900	0	0	0	0	0	0	0.09
Autumn - Lower Bound									
n. fish	F007b	320		0.99	0.99	0.99	0.99	0.99	
MI2	F008b	540		0.90	0.92	0.95	0.98	0.98	
n. fish	F008b	540		0.99	0.99	0.99	0.99	0.99	
MI4	F003b	770		0.70	0.90	0.95	0.98	0.99	
MI6	F003b	770		0.70	0.90	0.95	0.99	0.99	
MI2	F008c	940		0.50	0.65	0.80	0.95	0.98	
Autumn - Upper Bound									
MI2	F004c	5610		0.01	0.01	0.02	0.30	0.60	
MI4	F004c	5610					0.03	0.10	
MI2	F002b	8910		0.01	0.01	0.01	0.01	0.05	
n. fish	F007b	320		0.99	0.99	0.99	0.99	0.99	
n. fish	F008b	540		0.99	0.99	0.99	0.99	0.99	
MI4	F003b	770		0.85	0.9	0.95	0.98	0.99	
MI6	F003b	770		0.8	0.9	0.95	0.99	0.99	
MI2	F008c	940		0.9	0.92	0.95	0.98	0.98	
Winter - Upper Bound									
MI2	F002b	8910		0.2	0.3	0.65	0.8	0.9	
n. fish	F007b	320		0.99	0.99	0.99	0.99	0.99	
MI2	F008b	540		0.9	0.92	0.95	0.98	0.98	
n. fish	F008b	540		0.99	0.99	0.99	0.99	0.99	

			RECOMMENDED						
Environ. Objective	Flow Element Code	Flow Threshold (Ml/day)	Minimum	10th percentile year	30th percentile year	median year	70th percentile year	90th percentile year	Maximum
n. fish	F008b	540		0.99	0.99	0.99	0.99	0.99	
MI4	F003b	770		0.70	0.90	0.95	0.98	0.99	
MI6	F003b	770		0.70	0.90	0.95	0.99	0.99	
MI2	F008c	940		0.90	0.92	0.95	0.98	0.98	
Plankt. algae	F002c	6060							
MI4	F004c	5610		0.42	0.70	0.85	0.95	1.00	
Plankt. algae	F002c	6060		0.35	0.66	0.73	0.86	1.00	
MI2	F002b	8910		0.10	0.40	0.65	0.80	1.00	
n. fish	F027a	24000		0	0.05	0.13	0.26	0.54	

Flow stressors and their components

CODE	DESCRIPTION	ELEMENTS
F001	Mean hydraulic residence time (hours/km)	-
F002	Proportion of time when euphotic depth is less than n times the mean depth	n = 0.2, 0.25, 0.3
F003	Proportion of time when mean shear stress is less than n N/m2 - leading to deposition of fine sediments	n = 1, 2, 3
F004	Proportion of time when mean shear stress is more than n N/m2 – leading to possibly biofilm instability	n = 5, 6, 7
F005	Water level fluctuation characterised by the amphibious habitat index calculated at euphotic depth for the n% exceedence flows (in the pre-regulation regime)	n = 10, 20, 30, …, 90
F006	Maximum inundation duration at heights up the bank corresponding to the water surface levels for the n% exceedence flows (in the pre-regulation regime)	n = 10, 20, 30, …, 90
F007	Proportion of time when there is less than n m2/m slow shallow habitat (d<0.5 m, v<0.05 m/s).	n = 1, 2, 3, …, 5
F008	Proportion of time when there is less than n m2/m deep water habitat defined as d>1.5 m	n = 5, 10, 15, 20
F009	Maximum continuous rise in stage (m)	-
F010	The distribution of daily change in stage characterised by the n th percentile values (m)	n = 10, 90
F011	mean illuminated volume of water (m3 per m length of channel)	-
F012	mean ratio of euphotic depth to mean water depth	-
F013	mean ratio of fall velocity (n m/s) to mean water depth	n = 0.2, 0.4 and 0.94
F014	mean illuminated area of benthos (m2 per m length of channel)	-
F015	mean illuminated area of benthos with velocity less than n m/s (m2 per m length of channel)	n = 0.2, 0.3, 0.4 and 0.9
F016	proportion of time when benthos has been in euphotic zone for at least n days, calculated for water surface levels corresponding to the m% exceedence flows (in the pre-regulation regime)	n = 14 and 42 m = 10, 20, 30, …, 90
F017	Number of independent events when benthos has been in euphotic zone for at least n days, calculated for water surface levels corresponding to the m% exceedence flows (in the pre-regulation regime)	n = 14 and 42 m = 10, 20, 30, …, 90
F018	Mean water depth (m) during periods when benthos is in euphotic zone for at least n days calculated for water surface levels corresponding to the m% exceedence flows (in the pre-regulation regime)	n = 14 and 42 m = 10, 20, 30, …, 90
F019	proportion of time benthos is in the euphotic zone, calculated for water surface levels corresponding to the m% exceedence flows (in the pre-regulation regime)	m = 10, 20, 30, …, 90
F020	Proportion of time benthos is below the euphotic zone, calculated for water surface levels corresponding to the m% exceedence flows (in the pre-regulation regime)	m = 10, 20, 30, …, 90
F021	number of overbank events	
F022	The distribution of daily rises in stage characterised by the n th percentile values (m)	n = 10, 90
F023	The distribution of daily falls in stage characterised by the n th percentile values (m)	n = 10, 90
F024	The distribution of daily falls in stage characterised by the n th percentile values (m) for flow	n = 10, 50, 90

CODE	DESCRIPTION	ELEMENTS
	bands defined by the flows Qi ML/day	= 0, 4000, 100000
F025	Proportion of time water level is within a range defined by water surface levels corresponding to the m% exceedence flows (in the pre-regulation regime)	m = 10, 20, 30, …, 90
F026	Proportion of time water level is above a specified depth above bed corresponding to the m% exceedence flows (in the pre-regulation regime)	m = 10, 20, 30, …, 90
F027	Proportion of time flow exceeds 24000 Ml/day	

Summary of relationships between flow-related objectives and flow stressors (see Appendix 1 and 2 for further details of flow objectives)

Ecological Value	Code	Ecological Objective	Stressor code(s)	Seasons	Stressor mechanism
Source of food for fish and invertebrates and influence on river nutrient and chemical conditions	Planktonic algae	Production rates, biomass levels and community composition more resembling un-impacted sites and dynamic diverse food webs	F001	Su, Sp	Increased channel retention due to reduced water velocity and/or hydraulic retention zones allows accumulation of biomass if growth rates exceed loss rates.
			F002	Su, Sp	Proportion of time planktonic algae spend in the euphotic zone determines whether net production is possible or not
			F012	Sp	Proportion of time planktonic algae spend in the euphotic zone multiplied by mean surface irradiance determines the relative level of production
			F013	Su, Sp	Water depth influences the rate of depostion of planktonic algae (It takes longer for settling in deeper water)
Source of food for fish and invertebrates, habitat, and influence on river nutrient and chemical conditions	Periphytic algae	Production rates, biomass levels and community composition more resembling un-impacted sites and dynamic diverse food webs	F014	Su, Sp	Bethic production is restreicted to wetted perimeter within the euphotic zone (i.e. where light penetrates to the channel bed and banks)
			F015	Su, Sp	High velocities influencing biofilm stability. Area of colonization determined by extent of light zone - use euphotic depth, but limited by velocity.
			F016	Sp	Establishment of biofilms requires that the wetted surface remains wet and within the euphotic depth for a period of some time. Drying and submersion below the euphotic depth will advsersely affect biofilms
Contributes to primary production, habitat for macroinvertebrates and native fish	Macrophytes	Production rates, biomass levels and community composition more resembling un-impacted sites and dynamic diverse food webs	F014	Su, Au, Wi, Sp	Bethic production is restreicted to wetted perimeter within the euphotic zone (i.e. where light penetrates to the channel bed and banks)
			F015	Su, Au, Sp	High velocities influencing biofilm stability. Area of colonization determined by extent of light zone - use euphotic depth, but limited by velocity.
			F016	Su, Au, Sp	Establishment of aquatic macrophytes requires that the wetted surface remains wet and within the euphotic depth for a period of some time. Drying and submersion below the euphotic depth will advsersely affect macrophytes
Natural gradient of native terrestrial vegetation up the river banks	Terrestrial bank vegetation	Maintain native terrestrial cover at top of banks and reduce cover of terrestrial vegetation in areas of the bank influenced by flow regulation	F006	Dec-Apr	Duration of submergence (inundation) has potential to drown out terrestrial vegetation, due to carbon and oxygen starvation; critical values for duration tolerance expected to vary between seasons, being much longer in cool (autumn-winter) than in warm growing (spring-summer) season.
Diverse and resiliant aquatic macroinvertebrate fauna	MI1	Provision of conditions suitable for aquatic vegetation, which provides habitat for macroinvertebrates	F007	Su	Slow shallow velocities required for establishment of aquatic vegetation
			F010	Wi	Short-term flow fluctions can adversely effect aquatic vegetation growing along the channel margins
			F022	Su, Au, Wi, Sp	Short-term flow fluctions can adversely effect aquatic vegetation growing along the channel margins
			F023	Su, Au, Wi, Sp	Short-term flow fluctions can adversely effect aquatic vegetation growing along the channel margins
	MI2	Submersion of snag habitat within the euphotic zone to provide habitat and food source for macroinvertebrates	F002	Su, Au, Wi, Sp	Quantity and variety of snags dependant on volume (possibly modified by biodiversity and productivity of snag biofilm - depth and variability of light climate).
			F004	Su, Au	High shear stresses can lead to biofilm instability

Ecological Value	Code	Ecological Objective	Stressor code(s)	Seasons	Stressor mechanism
			F008	Su, Au, Wi, Sp	Loss of pools
			F025	Dec-Apr	Reduction in flpw result in drying of large woody denris
	MI3	Provision of slackwater habitat favourable for planktonic production (food source) and habitat for macroinvertebrates (MI3)	F007	Su	Increased flow velocity and rapid rates of rise and fall affect availability of shallow, slackwater habitat for macroinvertebrates.
			F023	Su, Au, Wi, Sp	daily fall in stage
			F024	Dec-Apr	daily fall in stage
	MI4	Entrainment of litter packs available as food/habitat source for macroinvertebrates (MI4)	F003	Su, Au, Wi, Sp	Shear stress required to disrupt (refresh) biofilms and entrain organic matter.
			F004	Su, Au, Sp	Shear stress required to disrupt (refresh) biofilms and entrain organic matter.
			F021	Su, Au, Wi, Sp	Overbank events may entrain organic matter
	MI6	Maintenance of water quality suitable for macroinvertebrates	F003	Su, Au, Wi, Sp	Temperature, nutrients and salinity assumed not significant, pollution effects (toxicants) not known. Sediment deposition noted and known to remove susceptible taxa.
Diversity of native species, naturally self-reporducing populations of native fish, threatened and iconic native species.	Native Fish	Suitable in-channel habitat for all life stages	F007	Su, Aut, Wi, Sp	Slow shallow habitat required for larvae/juvenile recruitment and adult habitat for small bodied fish
			F008	Su, Au, Wi, Sp	Deep water habitat for large bodied fish
		Cues for adult migration during spawning season	F022	Su, Sp	Flow variation required as a cue for migration and spawning
			F023	Su, Sp	Flow variation required as a cue for migration and spawning
		Suitable off-channel habitat for all life stages	F027	Sp	Inundation of floodplain required by some species and for transport of nutrients and organic matter to drive food webs
Natural Channel Form and Dynamics	Geo1	Avoid notching	F025	Dec-Apr	Long duration of stable flow followed by rapid draw-down. Impact likely to be exacerbated by loss of bank side vegetation.
	Geo2	Avoid slumping	F023	Su	Excessive rates of fall in river level.
	Geo3	Maintain pool depth	F026	Su	Unseasonal events that fill pools with sediment but do not flush them.
	Geo6	Maintain natural rates of geomorphic disturbance	F006	Dec-Apr	High velocity discharge increases disturbance of sand substrates and aquatic macrophytes.