



Department of Planning and Environment

Annual plan for the Snowy and montane rivers increased flows 2022–23



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Abbreviations

Abbreviation	Term
ML	Megalitre
GL	Gigalitre
GWh	Gigawatt hours
SMRIF	Snowy montane rivers increased flows
SRIF	Snowy River increased flows
SWI	Snowy Water Initiative
SWIOD 2002	<i>Snowy Water Inquiry Outcomes Implementation Deed 2002</i>

Introduction

This watering plan was developed by the Environment and Heritage Group in the NSW Department of Planning and Environment (the department) and incorporates advice from the Snowy Advisory Committee, ecological experts and water managers.

This annual plan outlines the rationale and intention for use of water for the environment for the Snowy and Snowy montane rivers for the 2022–23 water year (1 May 2022 to 30 April 2023), and gives effect to the NSW Government’s commitment to implement the Snowy Water Initiative (SWI) on behalf of the partner governments.

The SWI was formally established in 2002 to significantly improve river health by releasing environmental water into the Snowy, upper Murrumbidgee and upper Murray river systems. Embodied in the *Snowy Water Inquiry Outcomes Implementation Deed 2002* (SWI OID 2002), the SWI is an agreement for water recovery and environmental flows between the NSW, Victorian and Australian governments (the partner governments) and Snowy Hydro Limited. The NSW Government is responsible for the implementation of the SWI.

Environment and Heritage Group manages water for the environment in the Snowy and Snowy montane rivers on behalf of the NSW Government. The SWI allows for the delivery of an average 212,000 megalitres (ML) (or 21% of average annual natural flows) to the Snowy River for environmental purposes. When low water allocations are available in the western Murray–Darling Basin water storages, there is less water available for the Snowy and montane rivers.

The SWI provides for 3 increased environmental water flow regimes to adjust for the diversion of river flows by the Snowy Hydro-electric Scheme:

1. **Snowy River** – environmental water to be released every day from Jindabyne Dam (Figure 1) as Snowy River increased flows (SRIF), to improve the health of the Snowy River in New South Wales and Victoria
2. **Snowy montane (higher altitude) rivers** – environmental water to be released continually or according to an annual schedule from a number of designated release points across certain rivers diverted by the Snowy Mountains Scheme (Figure 2) as Snowy montane rivers increased flows (SMRIF) in a quantity proportional to the amount allocated to the Snowy River below Jindabyne
3. **River Murray** – water allocation accruing up to 70 gigalitres (GL) in the Murray River system that is callable by environmental water holders as River Murray increased flows for delivery into the Murray River.

River Murray increased flows are managed in an integrated manner with other environmental water allocations by the Southern Connected Basin Environmental Water Committee and are not covered in this plan.

For the 2022–23 water year, 215,310 ML of water for the environment was allocated as SRIF. Of the allocation, a maximum of 212,000 ML is recognised by Snowy Hydro Limited for delivery. Environment and Heritage Group has sought advice from Department of Planning and Environment – Water on use of the remaining balance of 3,310 ML and this advice remains pending at the time of the finalisation of this plan.

A volume of water equivalent to 150 gigawatt hours (GWh) of foregone energy generation will be available as SMRIF.

There have been considerable inflows into the Jindabyne Dam with above average rainfall during November 2021 and the highest recorded rainfall in December 2021. This resulted in the Jindabyne Dam spilling on 20 December, followed by several pre-releases (controlled

spills) in December 2021, and January and April 2022. Tributary inflows have also resulted in multiple flooding events in the lower Snowy River.

The 2021–22 allocation was 201,077 ML, however ongoing wet conditions in the southern Murray–Darling Basin has resulted in water allocation for 2022–23 being 215,310 ML.

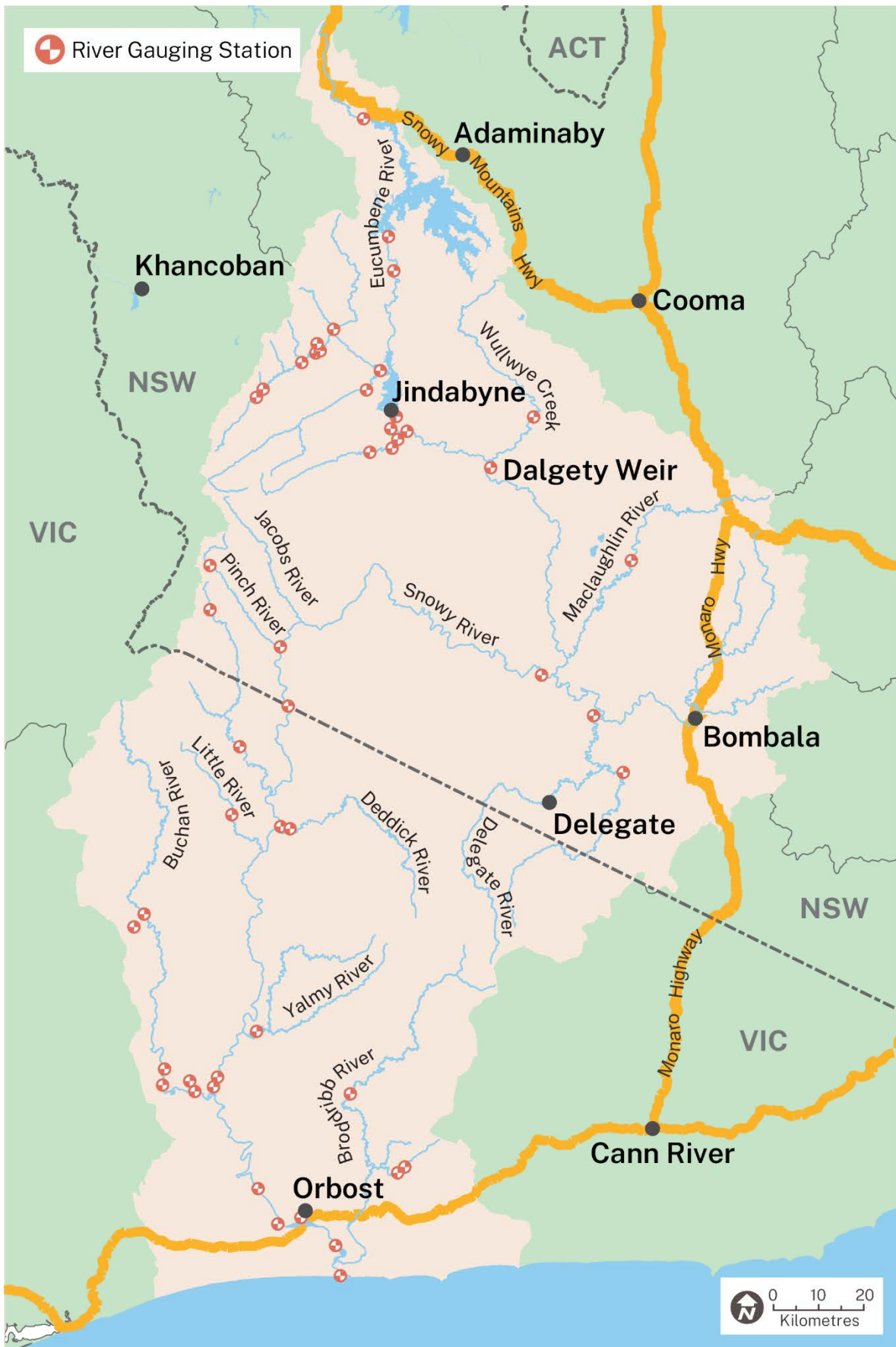


Figure 1 The Snowy River catchment in south-eastern Australia, showing the location of Jindabyne Dam, major tributaries and hydrological gauging stations

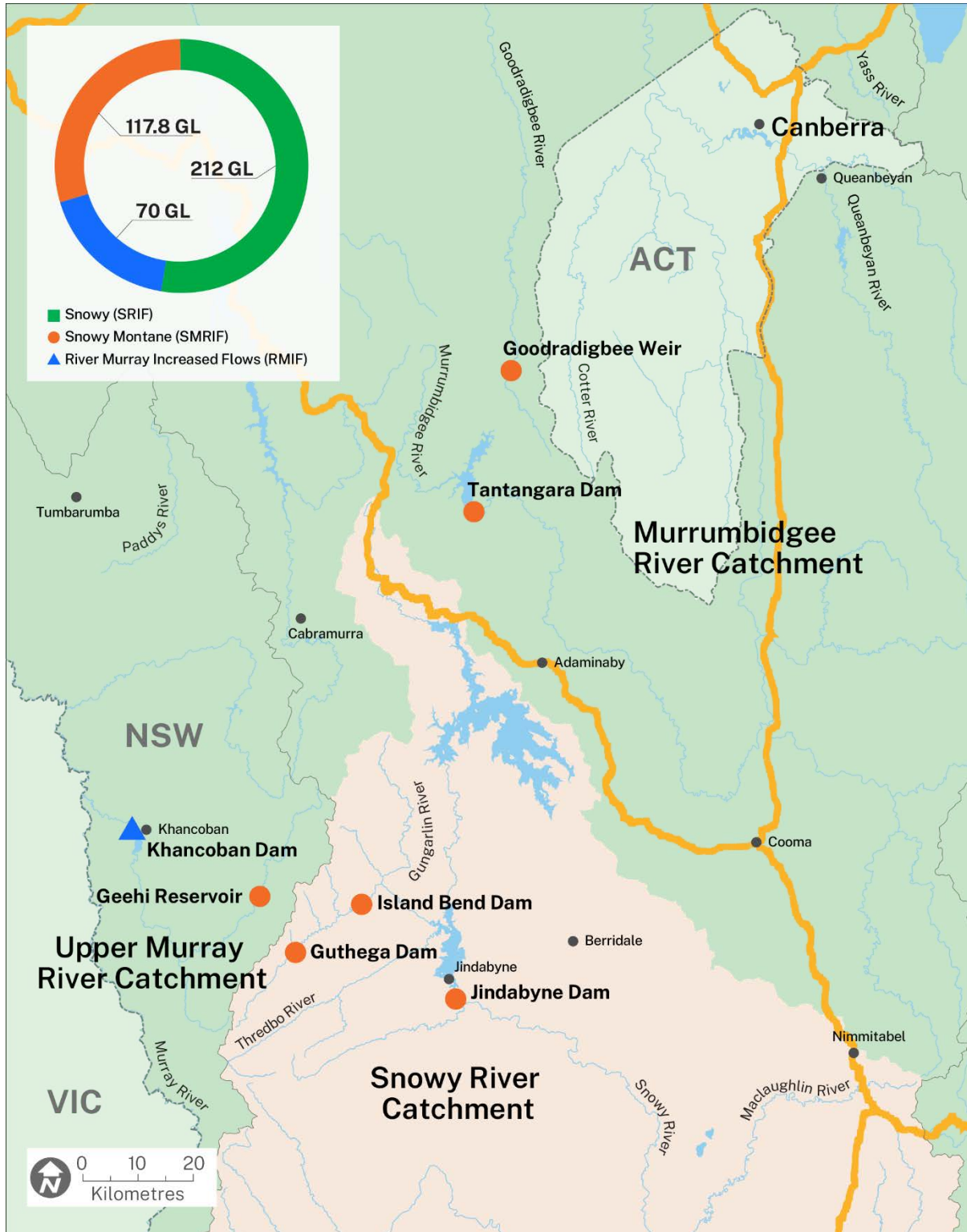


Figure 2 Locations of the Snowy montane rivers water release points, indicated by orange icons, and a pie chart of maximum annual flow volumes for the 3 increased flows

The volumes identified on the pie chart in Figure 2 represent the 212,000 ML allocation scenario (21% of the average natural flow). See ‘Snowy montane rivers increased flow’ section for detail.

Natural flow scaling of Snowy River increased flows

A 'natural flow scaling approach' (Reinfelds et al. 2013) has been used to deliver environmental water to the Snowy River below Jindabyne Dam since 2013–14, when 212 GL of water entitlement for the Snowy River was achieved for the first time under the SWI.

The volume of water available for environmental flows in the Snowy River is approximately equivalent to annual natural flows in the Thredbo River. The Thredbo River is not regulated by dams, so its flow pattern is still close to natural. A practical interim objective using the natural flow scaling approach has been to deliver a flow regime that, over the long term, will drive the hydraulic geometry of the Snowy River below Jindabyne Dam to be more like the Thredbo River as river channel sediment is mobilised and redistributed.

The primary advantage of natural flow scaling is that the pattern of the flow regime is proportional to the volume of available environmental water. Peak flood magnitudes and duration can be tailored to achieve flow transmission and ecosystem objectives, while the flow regime mimics daily, seasonal and annual patterns in flow variability. This approach also provides a secure operational flow forecast that Snowy Hydro Limited can plan for and deliver.

The natural flow scaling approach recognises that with only 21% of the natural flow available, restoring any single aspect of the pre-regulation Snowy River flow regime could compromise other aspects of the flow regime and not optimise river health. Even the lowest annual discharge recorded in the Snowy River at Jindabyne before the dam and river diversion is approximately double the total volume of water available for environmental flows (Reinfelds et al. 2013).

Snowy River increased flows in 2022–23

Snowy River increased flows (SRIF) annual allocations are determined by inflows into the western catchment storages where Snowy water savings projects and market purchases were implemented to secure various water entitlements. These projects, funded by the NSW and Victorian governments, obtained water shares that were then transferred to Snowy environmental water licences. The water allocated to the SRIF licences in one year is then made available for environmental releases from Snowy storages in the following year. Planning for the forward year commences around November of each year, when the indicative volume of water available on the licences can be forecast with some certainty.

Of the 215,310 ML allocated in 2022–23, there is 212,000 ML of water available for use for the SRIF licences for 2022–23, which is 100% of the mean annual targeted release volume below Jindabyne Dam (Table 1). There is sufficient environmental water available to implement a **pre-planned** natural flow scaling pattern for the Snowy River.

Note: The SRIF amounts add to a 'base passing flow' amount of 8,500 ML released from Jindabyne Dam. Adjustments of the base passing flow amount are required when the amount of water released in the previous year was more than ('overs') or less than ('unders') the agreed flow volume. That amount is then corrected with changes to actual releases in the following year by reducing or increasing the 8,500 ML figure.

Note: The Jindabyne Dam spilt in December 2021 resulting in a borrow of 18,700 ML as per the SWIOID 2002. It has been agreed between the department and Snowy Hydro Limited to repay the full borrow amount from the 2022–23 SRIF available water.

Table 1 Summary of annual water allocation for the Snowy River for 2022–23

Water account	Annual volume (ML)
Snowy River increased flows	212,000
Base passing flow – Jindabyne	8,500
2021–22 Snowy River increased flows borrow	-18,700
Overs/Unders	1,200*
Total	203,000

* Final overs/under volume to be confirmed by Snowy Hydro Limited.

The 2022–23 water year will be the 10th consecutive year that the natural flow scaling approach has been used to develop the environmental water release strategy for the Snowy River below Jindabyne. The 2022–23 SRIF daily flow sequence is based on the May to December 2010 and the January to April 1993 water years in the Thredbo River. The 2010–11 water year was selected as the reference because it had a good range of peaks spread across winter, spring and early summer. However, by using the 2010–11 reference year there is not sufficient water available in 2022–23 to maintain the summer high flows while being able to provide variability for the remainder of the water year. Therefore, the 1993 water year data were used as a reference for planned releases for January to April 2023.

The 2022–23 flow plan is shown in the hydrograph below (Figure 3) and includes 5 high flow events with 8-hour peaks. These releases will require active management by Snowy Hydro Limited to generate the 8-hour peaks and reach the overall daily targets. The high peak flows of this regime will provide increased stream power to flush fine sediment from the stream bed, and the repeated pattern of several peaks is expected to help keep the sediment moving.

Fine sediment and sand are known to move at discharge rates of >1,000 ML/day in the upper reaches of the Snowy River (Williams 2010). While longer peak durations provide greater sediment movement than shorter peaks (Rose 2017), monitoring indicates that most of the fine sediment is moved in the first few hours of the releases (Coleman and Williams 2017; Coleman, unpublished data). The high flows for the Snowy River are therefore short in duration and in line with the natural Thredbo flows, with a maximum peak held for 8 hours for the majority of the highest flows.

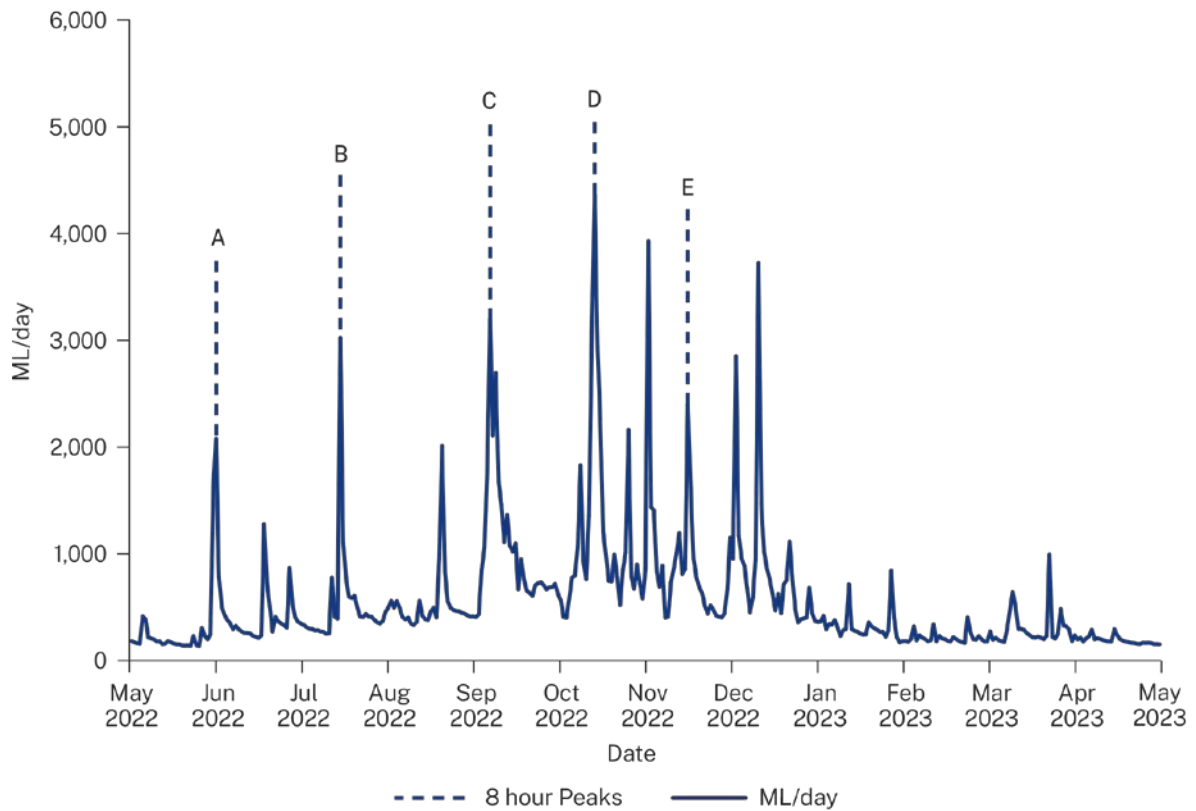
Coleman and Williams (2017) also found that the greater the increase in magnitude and interval since the previous high flow, the greater was the amount of sediment moved by the high flow. The proposed flow regime for 2022–23 provides a number of separate high flows, many with intervals of several weeks since the last event, and with a general trend of flows increasing up to the maximum peak of 5,000 ML in mid-October 2022.

Flushing flows are important to help develop a more defined river channel within the former riverbed to assist in achieving the long-term goal of returning the Snowy River to a smaller but healthy montane river. The Snowy Water Licence defines flushing flows as those exceeding 5,000 ML/day and can occur when the water year allocations exceed 100,000 ML. Flushing flows need to be delivered from the spillway gates of Jindabyne Dam, which requires high dam levels. Snowy Hydro Limited manage the dam levels to avoid potential spills, however, when wet conditions persist a spill cannot always be prevented, as occurred on several occasions during 2021–22. The Jindabyne Dam levels were at above 97% on 1 May 2022 and how any spills will be accounted for and which water accounts debited during the 2022–23 water year are yet to be confirmed. Due to this uncertainty, there is currently **no** flushing flow planned. Subject to the outcomes of the accounting arrangements, a flushing flow maybe incorporated into the SRIF plan at a later stage.

Figure 4 summarises the total monthly discharge patterns for 2022–23 below Jindabyne Dam. A pattern of higher flow rates over winter, spring and early summer reflects the rainfall/runoff patterns typical of a mixed rainfall and snowmelt river system characteristic of the Snowy Mountains.

Low flows with small flushes (less than 1,000 ML) will occur during the natural low-flow periods of summer and autumn, with higher-energy flows in winter and spring for river channel maintenance.

Natural tributary inflows below the junction with the Delegate River are expected to provide the most substantial contribution to the flow regime and ecosystem processes of the lower reaches of the Snowy River and its estuary in this water year.



Five flows with 8 hour peaks

- A = 31 May 2022 – Daily peak of 2,161 ML/d, 8 hour peak of 3,715 ML/d
- B = 14 July 2022 – Daily peak of 3,004 ML/d, 8 hour peak of 4,504 ML/d
- C = 5 September 2022 – Daily peak of 3,179 ML/d, 8 hour peak 4,979 ML/d
- D = 12 October 2022 – Daily peak of 4,339 ML/d, 8 hour peak of 5,000 ML/d
- E = 14 November 2022 – Daily peak of 2,383 ML/d, 8 hour peak of 4,189 ML/d

Figure 3 Snowy River below Jindabyne mean daily discharge pattern for 2022–23, with five 8-hour flow peaks

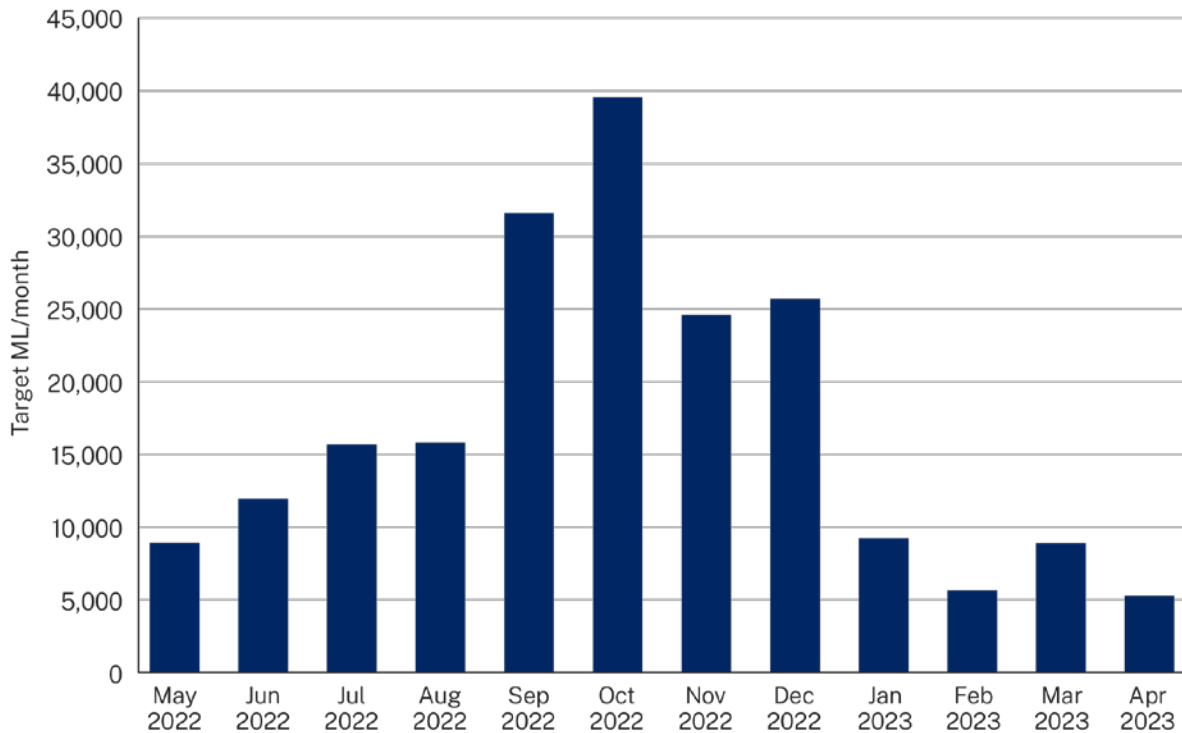


Figure 4 Snowy River below Jindabyne Dam total monthly discharge pattern for 2022–23

Objectives for Snowy River increased flows

In determining how to use water for the environment in the Snowy River below the Jindabyne Dam, the partner governments agreed that a primary ecological objective would be achieved by storing and then releasing sufficient volumes to provide annual flushing flows and occasional channel maintenance flows.

Flushing flows scour and transport finer sediment (sand, silt and clay) and improve the physical condition of the instream river channel habitat and overall river health. Channel-forming flows scour larger sediments (gravel and cobbles) and define a channel pathway within the overall riverbed. Over time it is expected that, as the river physically responds to these higher energy flows, the recovery process can transition to meet other secondary ecological objectives.

The SWIOID 2002 sets out 5 key environmental objectives for the SRIF:

1. improving the temperature regime of river water
2. achieving channel maintenance and flushing flows within rivers
3. restoring connectivity within rivers for migratory species and for dispersion
4. improving triggers for fish spawning
5. improving the aesthetics of currently degraded riverine environments.

The Department of Planning and Environment – Water redefined the SWIOID 2002 objectives incorporating new knowledge and scientific information to better define the aspects of riverine health that are key to the recovery of a geomorphologically confined Snowy River (Williams 2016a). As aquatic plants and animals are adapted to local climatic and hydrological conditions, being able to represent the varied characteristics of the local

hydrology is therefore a key driver to river recovery from flow diversion. The redefined overarching ecological objective is:

To facilitate the rehabilitation and evolution of the Snowy River below Jindabyne Dam into a smaller but healthy montane river.

The focus of the SRIF regime for 2022–23 is:

1. **Hydrology** – provide daily variable flows with higher release rates during winter and spring that are typical of a snowmelt river (daily variability)
2. **Riverbed maintenance** – improve channel condition by providing several high flow events, reducing fine sediment and algae smothering, and cleaning riffles, cobbles and gravel by mobilising sediment (multiple peak flow events)
3. **Basal resources** – enhance delivery of complex dissolved organic carbon and other basal resources and inundate lower in-channel river benches (multiple peak flow events)
4. **Riverine and aquatic vegetation** – limit the encroachment of terrestrial plants into the river channel (multiple peaks and flushing flow) and establish native aquatic and riparian vegetation (daily flow variability, multiple flows above 1,000 ML/day to inundate low benches, backwaters and connected ponds)
5. **Thermal regime** – provide a thermal regime similar to an unregulated montane river (daily flow variability)
6. **Macroinvertebrate communities** – increase the abundance of aquatic invertebrate fauna commonly found in unregulated Snowy montane rivers with gravel and cobble substrate (daily flow variability, multiple flow peaks)
7. **Fauna** – support habitat diversity and provide suitable habitats for water-dependent animals including macroinvertebrates, frogs, platypus, turtles and fish by increasing resource availability and productivity, and providing opportunities for breeding and recruitment. Inundate connected wetlands and ponds to provide breeding opportunities for frogs in the Snowy River (daily flow variability, multiple flow peaks, multiple flows above 1,000 ML/day to inundate low benches, backwaters and connected ponds)
8. **Platypus** – provide increased opportunities for movement and feeding (daily flow variability, multiple flow peaks)
9. **Dispersal of native fish** – increase opportunities for movement (multiple peak events and flushing flow)
10. **Channel morphology*** – develop a more defined river channel within the former river channel. *Only if a flushing flow is incorporated into the plan at a later stage.

Snowy montane rivers increased flows

The SWIOID 2002 also provides for environmental releases into a number of higher altitude (montane) rivers whose flows are significantly affected by the operation of the Snowy Scheme. These are known as the Snowy montane rivers increased flows (SMRIF) allocation. The environmental water is released from small weirs as a passing flow, or as managed releases from Tantangara Dam for the:

- Snowy River above Jindabyne Dam
- Goodradigbee River
- Geehi River
- Murrumbidgee River below Tantangara Dam.

Each water release point results in a different amount of foregone generation potential for Snowy Hydro Limited for each megalitre of water that is released, up to a maximum of 150 gigawatt hours (GWh) each year.

Each year, the degree to which generation is foregone by Snowy Hydro Limited is proportional to the volume of environmental water allocated to the Snowy River. If the average 212,000 ML target is available for the Snowy River, the full 150 GWh of generation potential equivalence will be allocated to the montane rivers. As the water is either reregulated by the Snowy Scheme, or by water supply storages in the western rivers, we do not need additional water savings to enable these releases.

All of the targeted release points have the required modifications to existing diversion works to allow us to make the releases. This was undertaken progressively as the SRIF water licences accrued up to 212,000 ML.

Releases to the upper Murrumbidgee River are made from Tantangara Dam, a much larger structure than the other release points. Tantangara releases usually comprise 2 components: a SMRIF amount, plus a required annual base passing flow.

The Tantangara base passing flow has 2 key operating rules required by the Snowy Water Licence:

- 32 ML/day minimum river discharge maintained at Mittagang Crossing, near Cooma
- 2,000 ML/year volume on average is targeted over the longer term.

Montane releases from the other, smaller weirs reflect the catchment inflows to each weir pool and it is not practical to prescribe a daily flow target. The downstream flow from the smaller weirs reflects the hydrology of their inflows where, in wetter years, the flow will exceed the long-term target and, in drier years, the annual volume will be less than the target.

The SMRIF sets an annual yield so that over the long term the annual volume will approximate the nominated increased flow target. To achieve the long-term target, each weir has been modified to either allow all water to pass downstream (known as ‘transparent releases’), or in the case of the Goodradigbee River, allow a proportion of the daily inflows to pass downstream (known as ‘translucent’ releases). This is so that the flow characteristics downstream of the modified weirs will reflect the hydrology of a smaller mountain river or stream.

Figure 2 provides a pie chart of maximum annual flow volumes for the 3 increased flows which represent the 212,000 ML allocation scenario (21% of the average natural flow).

Snowy montane rivers increased flows in 2022–23

The SRIF allocation for 2022–23 will lead to a foregone generation value of 150 GWh for SMRIF. There is sufficient allocation to operate all the weirs of the montane program and provide 35,773 ML of environmental water to be released from Tantangara Dam into the upper Murrumbidgee River. This includes allowing full flow over Middle Creek Weir and the maximum flow over the Goodradigbee Weir.

The SMRIF allocations for each river reach and the works to deliver the environmental water are identified in Table 2.

Table 2 Snowy montane rivers increased flows allocations and settings for the 2022–23 water year

River reach/ catchment	Modified works	Conversion factor (GWh per GL)	Forgone electricity generation (GWh)	2022–23 volume (GL)	SWI OID annual target (GL)
Murrumbidgee River	Tantangara Dam outlet	1.94	69.4	35.8	27
Goodradigbee River	Goodradigbee River Weir	1.94	23.3	12	12
Geehi River	Middle Creek Weir	1.85	32.4	17.5	20
	Strzelecki Creek Weir	1.85	9.6	5.2	
Snowy River – Island Bend to Lake Jindabyne	Tolbar Creek Weir	0.71	6.7	9.5	20
	Diggers Creek Weir	0.71	6.7	9.4	
Snowy River – Guthega to Island Bend	Falls Creek Weir	0.57	1.9	3.4	30
Total			150	92.8	118

Similar to the Snowy River, when there is sufficient environmental water available, a modified ‘flow scaling’ approach has been applied to the Murrumbidgee River to assist in providing natural seasonality and daily variability. This approach uses historical flows from the gauge on the Murrumbidgee River above Tantangara as a reference. For the 2022–23 water year, the May to October 2022 daily flows used the 2016–17 flow patterns as a reference, and the November 2022 to May 2023 daily flows used the 1992–93 flow patterns as a reference. These water years were used a reference because they include a good range of flow peaks across the winter–spring season. The proposed flows have been scaled down to approximately 20% to fit within the available SMRIF equivalent 35,773 ML.

The natural flow pattern of the upper Murrumbidgee River varies from that of the Snowy River, as there are strong climatic gradients across the Snowy Mountains. Typically, the upper Murrumbidgee River catchment is lower in elevation than the Snowy River catchment and has substantially less catchment area above the snowline, therefore snowmelt flow is not as pronounced as in the Snowy River.

There will be no environmental flow released from Tantangara for 20 periods totalling 140 days as there is insufficient water available to maintain the flow regime for every day of the year that includes multiple high peaks. During this time, Snowy Hydro Limited is required to make releases to maintain flows at or above 32 ML/day at Mittagang Crossing if tributary flows do not provide this level of flow.

Two flow scenarios were considered for the Tantangara releases in 2022–23:

1. **Keep it wet** – provide continuous daily flows for the entire year
2. **Keep it clean** – provide daily variability and higher peaks to flush sediment and clean riffles.

The Snowy Advisory Committee expressed a preference for a ‘keep it clean’ scenario with multiple peak flows and several small flushes rather than providing persistent base flows. Maintaining the minimum deliverable flow of 30 ML/day for the full year requires 11,000 ML and is not possible to return permanent flows to the 27-kilometre stretch of river from Tantangara Dam to the Yaouk River confluence every year.

The planned upper Murrumbidgee flow pattern set out in Figure 5 includes:

- some daily flow variability to reflect a scaled natural flows pattern
- 13 flows above 500 ML/day across 7 peak events, including 3 daily high flow peaks above 1,000 ML to move fine sediment and inundate low lying benches. The highest of these is 1,500 ML/day. Although the peaks are accentuated, they are still smaller than the ‘pre-scaled’ size of the original Murrumbidgee above Tantangara flows (highest peak in 2016–17 reference year was 4,823 ML/day on 4 October)
- the 20 cease-to-flow periods ranging from 2 to 21 days, with the shorter cease-to-flow periods during the summer months
- flows are continuous between 2 June and 15 November 2022
- there are a series of small freshes provided from December 2022 to April 2023.

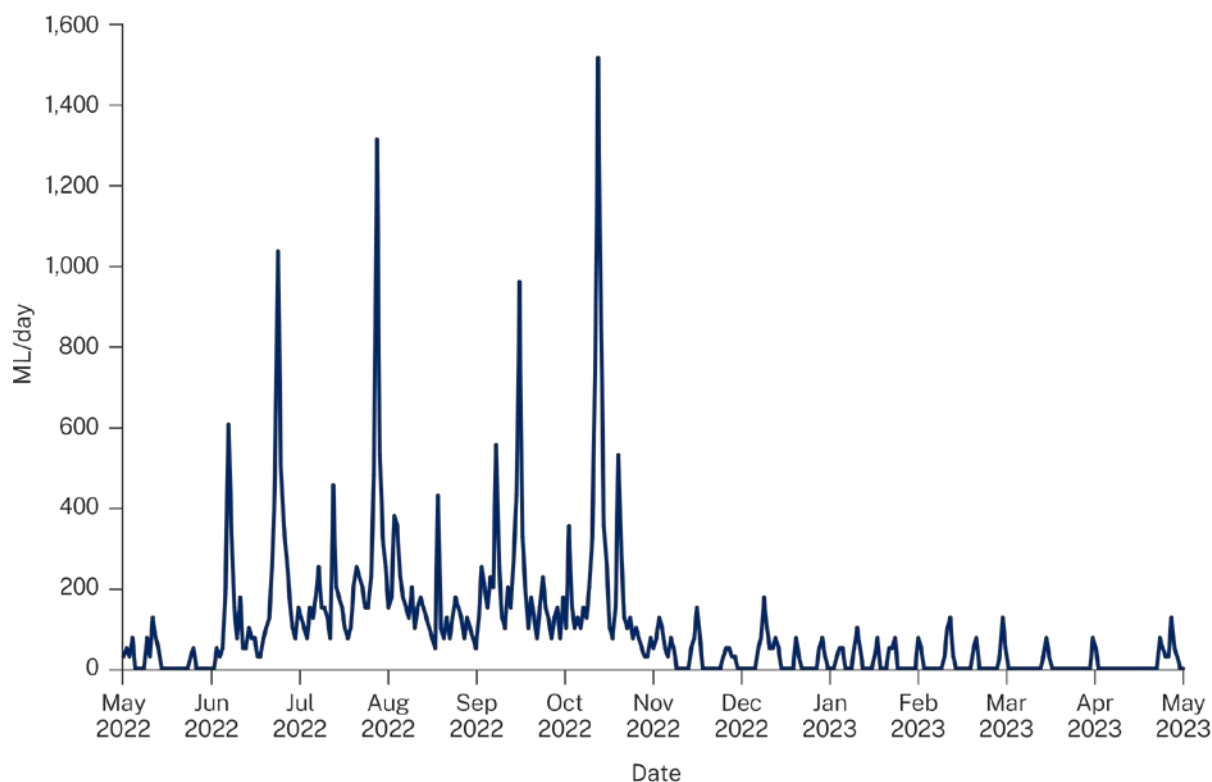


Figure 5 2022–23 Snowy montane rivers increased flow pattern for the upper Murrumbidgee River below Tantangara Dam

Objectives for Snowy montane rivers increased flows

The SWIOID 2002 set the following ecological objectives for the Snowy montane rivers:

1. to protect endangered/threatened species
2. to maintain natural habitats
3. to maintain wilderness and national parks values.

Using newly available knowledge and scientific information, the Department of Planning and Environment – Water refined the objectives (refer to Williams 2016b).

For the Murrumbidgee River specifically, the following overarching objective has been identified:

To facilitate the rehabilitation and evolution of the Murrumbidgee River below Tantangara Dam into a smaller but healthy river.

The focus of the Tantangara flow regime for 2022–23 is:

- **Hydrology** – provide some variability that has higher flow rates during winter and spring that are typical of a snowmelt river
- **Channel morphology and riverbed maintenance** – the release plan provides 3 peaks of 1,000 ML/day or greater to help move sediment, clean riffles and reduce encroachment of vegetation. These peaks are provided with increasing magnitude and with an interval between events to allow each to provide greater sediment movement
- **Fish (Macquarie perch)** – the endangered Macquarie perch is present downstream of Yaouk. Macquarie perch spawn from October to December and their eggs lodge in gravel and cobble in riffles (Lintermans 2007). The 3 high flow releases in 2022–23 are timed to flush gravels and cobbles prior to the breeding season to provide a better

substrate for the eggs. Very high flows should be avoided during October to December to reduce the likelihood of eggs being displaced or stranded with spawning not seen when flows exceed 2,500 ML/day (Prue Haantjens, NSW Fisheries, email 28 January 2021). Some variation in flow is required during the breeding season, because Macquarie perch have been found to lay their eggs in riffles on the recession of freshes

- **Flora and fauna** – flow variability and inundation of connected ponds aims to provide habitat and increase productivity, providing benefits for a range of biota including macroinvertebrates. Improved populations of macroinvertebrates will in turn provide food for platypus, fish and other animals
- **Frogs** – high flows will inundate low-level connected ponds and slack water areas during late winter, spring; and freshes in summer will provide opportunities for flow-dependent frog species. The higher flows above 500 ML/day are also highly likely to provide habitat and recruitment opportunities for the flow-stream species such as stony creek frog (unpublished data E Wilson, 2021).
- The alpine tree frog, a subspecies of the broadly distributed whistling tree frog, is nationally vulnerable and endangered in New South Wales. The alpine tree frog occurs in the south-eastern NSW and Victorian high country (alpine and sub-alpine zones) generally above 1,100 metres, mostly located within Kosciusko National Park (OEH 2022). The species was detected at multiple locations along upper Murrumbidgee and connected ponds, including metamorphosed juveniles in December 2021 (unpublished data, E Wilson, 2021). The releases from Tantangara Dam will assist in providing suitable habitat conditions and potential breeding opportunities for the alpine tree frog
- **Productivity** – the higher peaks are expected to wet lower streamside channels and provide organic matter to help encourage productivity and drive food chains
- **Connectivity** – continuous flows during the wetter months with several small freshes to assist with maintaining connectivity.

Monitoring of SRIF and SMRIF

Monitoring, evaluation and reporting will inform planning and use of Snowy and montane environmental water.

In 2000, the NSW Government established the Snowy Flow Response Monitoring and Modelling program to assess the changes in river condition attributed to the environmental flows. The monitoring parameters included hydrology, geomorphology, macroinvertebrates, aquatic vegetation, water quality, productivity (biofilm, algae, carbon) and fish.

Elements of the program were initially funded by the NSW, Victorian and Australian governments. A large portion of the monitoring effort until 2012 primarily focused on the Snowy River and included geomorphology, water quality, hydrology, fish and macroinvertebrate studies. In the montane rivers the focus was on macroinvertebrate response to environmental flows.

Smaller biannual macroinvertebrate studies in the Snowy and montane rivers have been continued, with other monitoring undertaken opportunistically, including studies on fine sediment mobilisation and assessment of changes to the Snowy River channel and vegetation.

Table 3 is a framework for monitoring of outcomes against SRIF and SMRIF objectives that will be developed by Environment and Heritage Group with the advice of relevant experts. With the annual watering plan complete, the monitoring framework can be refined with input from the Snowy Advisory Committee and experts.

Table 3 Framework example for monitoring outcomes against SRIF and SMRIF objectives

Parameter	Site	SWIOD objective: Snowy	SWIOD objective: montane	Williams (2016a): objectives for Snowy	Williams (2016b): objectives for montane rivers
Fish	Upper Murrumbidgee		Objective 1		Objective 6
Frogs	Snowy River (Dalgety Plains), upper Murrumbidgee River				Objective 6
Geomorphology	Snowy River	Objective 2	Objective 2	Objectives 2 and 3	
Hydrology (water volumes delivered, tributary inflows)				Objective 1	
Macroinvertebrates	Montane rivers, Snowy River			Objective 7	Objectives 4 and 6
Vegetation	Snowy River, upper Murrumbidgee River		Objective 2	Objective 5	
Water quality (electrical conductivity, pH, temperature)	Montane, Snowy River	Objective 1		Objective 6	

Social, cultural and economic considerations

The Snowy and montane rivers are of great significance for their connection to a range of communities and people. This has remained a driving force behind the actions that have led to their ongoing recovery.

It is important the key linkages and dependencies of communities and people to the mountain rivers are recognised and, where possible, nurtured by the effective use of environmental water. These understandings will grow with increased knowledge of traditional and contemporary practices of the First Peoples' movements following seasonal travel routes and the availability of food and resources.

The Snowy Advisory Committee established by the NSW Government will be a primary source of advice to water managers on these relationships: cultural, social or economic. The committee has resolved to develop a framework for future advice that will support decisions that are broader in application than annual flow scaling.

Consistent with the statutory basis of the committee, it will seek to provide advice for the SRIF and SMRIF allocations that is first and foremost about what is best for the environment, but that can also achieve cultural, social and economic benefits where they are compatible with achieving environmental outcomes. The committee considers that multiple benefits should be sought when providing its advice. Most importantly, the committee considers that the framework must be inclusive of Aboriginal culture and heritage and this aspect will be included in all advisory considerations.

Over time, the committee considers that integrating these objectives will guide more detailed and nuanced flow management and monitoring activities. These understandings will grow around the central concepts of the rivers and their First Peoples, with an intention to provide for healthy rivers that support a diversity of cultural, social and economic activity.

Healthy rivers recovered from a history of water diversion will remain the primary purpose of water use. The direction set by the committee will, however, lead to better identification of river-use constraints with the intention that water managers will better communicate plans and, where possible, optimise multiple benefits for river-use objectives such as the availability of water for recreational activities.

References

- Coleman D and Williams S (2017) 'Mobilising fine sediment in a highly regulated upland snowmelt river using hydrological scaled experimental floods', *Marine and Freshwater Research*, 68:146–158.
- Lintermans M (2007) *Fishes of the Murray-Darling Basin: an introductory guide* [PDF 3.8MB], Murray–Darling Basin Authority, Canberra.
- OEH (Office of Environment and Heritage NSW) (2022) *Alpine tree frog – profile*, OEH website, accessed 1 May 2022
- Reinfelds I, Williams S, Russell M, and Haeusler T (2013) *Scaling environmental flow releases in the Snowy River to unregulated snowmelt rivers of the Snowy Mountains* [PDF 1.6MB], Snowy Flow Response Monitoring and Modelling program, NSW Office of Water, Sydney.
- Rose T (2017) *Processes, rates and pathways to recovering river channel functions through geomorphically effective floods: a case study of the highly regulated Snowy River downstream of Jindabyne Dam, Australia* [PhD thesis], University of Newcastle.
- Williams S (2010) 'Assessing recovery in the Snowy River below Jindabyne Dam: 2000–2010', Snowy Flow Response Monitoring and Modelling Program, *Australian Society for Limnology 49th Annual Congress*, Thredbo 29 November – 3 December 2010.
- Williams S (2016a) *Revised strategy for the Snowy River increased flows, 2016–17* [PDF 1.4MB], Snowy Flow Response Modelling and Modelling program, NSW DPI Water, Sydney.
- Williams S (2016b) *Strategy for the Snowy montane rivers increased flows 2016–17* [PDF 1.2MB], Snowy Flow Response Modelling and Modelling program, NSW DPI Water, Sydney.

More information

- [Snowy Flow Response Monitoring and Modelling program](#)
- [Snowy Water Initiative](#)
- [Snowy Water Inquiry Outcomes Implementation Deed 2002](#)

Hale J (2020) *Snowy River estuary and wetlands: summary of existing recommendations* [unpublished report for East Gippsland Catchment Management Authority], February 2020.

MDBA 2020, [Basin-wide environmental watering strategy](#), Murray–Darling Basin Authority, Canberra website.