

Monitoring water for the environment in Victoria

VEFMAP Stage 6 results 2016-2020



August 2020

Monitoring to improve the health of our waterways

Water for the environment is reinvigorating Victoria's waterways. Monitoring how river ecosystems respond to environmental water is improving our knowledge and giving us the information we need to make the most of every drop.

River regulation and climate change have affected many of the natural processes that native aquatic plants and animals need to survive, feed and breed. Since the early 1990s, the Victorian government has partnered with stakeholders and communities to manage water to balance social, economic and environmental outcomes. This has been achieved, in part, through the establishment of Victoria's Environmental Water Reserve.

Water released to rivers and wetlands through environmental entitlements can be actively managed to meet specific environmental needs. To be most effective, we need to release the right amount of water at the right time for the right duration. For example, at certain times of the year, higher flows are needed to maintain connectivity so fish can migrate and breed. At other times, lower flows are needed to retain pools that provide shelter and refuge.

The Victorian Environmental Flows Monitoring and Assessment Program (VEFMAP) helps us better understand how our waterway ecosystems respond to the release of environmental water, focusing on fish and vegetation, so we can manage environmental water more effectively.

TOP RIGHT: Releasing a Murray Cod, Mallee CMA
 RIGHT: Aquatic vegetation
 COVER: Murray-Darling Rainbowfish; a seedling; recording data in the field.

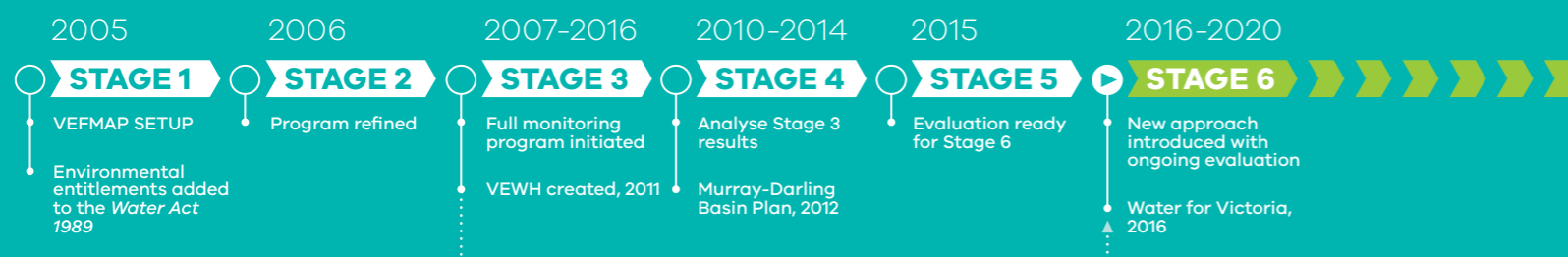
VEFMAP Stage 6 (2016 to 2020) was funded through the Victorian Government's \$222 million investment to improve the health of waterways and catchments under Water for Victoria.

A Victorian approach to monitoring and assessing environmental flows

VEFMAP monitoring began during the Millennium Drought, with annual surveys of fish, vegetation, water quality, macroinvertebrates and geomorphology conducted in eight regulated rivers from 2007-2016 (Stages 3 to 5).

Stage 6 of VEFMAP (2016-2020) called for a new approach, continuing the annual fish surveys and adding 'intervention' or 'flow-event' style monitoring to investigate native fish and vegetation responses to specific flows and watering events.

Researchers also started working more closely with waterway managers to make sure they had data as soon as possible to adapt and improve their planning and management of environmental water, on an annual and intra-annual basis. This data also informs Victoria's assessment of environmental outcomes in the Murray-Darling Basin.



Results from VEFMAP Stage 6 show not only that water for the environment is working, but that having the right data helps us get better results from this limited resource, leading to more efficient and effective use of Victoria's water resources.

Stage 6

Stage 6 of VEFMAP was developed in collaboration with waterway managers and scientists. It was based on the most up-to-date understanding of waterway management, using robust science to address key knowledge needs and incorporate effective monitoring and evaluation.

Core objectives

- ▶ For DELWP and its water delivery partners to demonstrate ecological outcomes of environmental water management to the community and water industry stakeholders.
- ▶ To fill knowledge gaps to improve planning, delivery and evaluation of environmental water management in Victorian rivers.
- ▶ To collect data needed for reporting under the Murray–Darling Basin Plan.

A new approach

To meet these objectives, Stage 6 was built on:

- ▶ A combination of both condition monitoring and intervention monitoring (specific responses to environmental flow releases), as well as experimentation.
- ▶ Closer relationships with waterway managers to understand and respond to their needs for short and long-term flow management and planning.
- ▶ Rigorous scientific standards for collecting and managing data.
- ▶ A simplified and 'adaptive' management structure.
- ▶ Regular reviews of progress and outcomes.
- ▶ Input from an independent panel of scientists.
- ▶ Collaboration with research institutes, universities, and government agencies across Australia.
- ▶ Sharing the benefits of environmental water with communities through their local CMAs.



Identifying key evaluation questions

Using sound science to improve our knowledge, management and planning for environmental water.

To ensure a targeted and evidence-based approach, we worked with CMAs, MW and the VEWH to develop a set of key evaluation questions (KEQs) that would clearly demonstrate ecological responses to environmental flow events and fill important knowledge gaps.

KEQs were developed based on environmental water planning and the latest conceptual understanding of native fish and plant responses to managed water regimes. We also wanted KEQs that would be transferable across river reaches, so what we learned could easily be applied elsewhere.

TOP: Galaxiids

RIGHT: Vegetation survey on the Thomson River

A broad range of monitoring methods and locations were used to maximise results.

Fish surveys included electrofishing, netting and fishway trapping, as well as tagging fish to track their movement. Samples were also taken of some fish to enable genetic and otolith (earbone) analysis, which provides information on age, growth, recruitment, survival and where they were born.

Vegetation surveys included broad scale mapping and monitoring of cover, extent, richness and recruitment along transects, recording tree canopy cover, and use of photopoints. At some sites, soil moisture and instream hydrology were recorded. Fenced exclosures were also established to assess grazing and Carp impacts.



Monitoring locations map

- Fish
- Vegetation

51 vegetation sites have been monitored across nine rivers

174 fish sites have been monitored across 12 rivers





Demonstrating outcomes from Water for the Environment

The fish theme examined effects of environmental flows on the distribution, dispersal, recruitment, abundance and population trends of key species.



Attracting young fish into coastal rivers

Recruitment of some coastal fish species relies on the migration of juveniles from the ocean to freshwater river reaches.

Monitoring in Cardinia Creek and the Werribee, Bunyip, Barwon and Tarwin rivers has provided the first quantitative evidence that higher numbers of juvenile diadromous fish move into coastal rivers as spring flows increase. Peak movement times vary between species.

Use of environmental water to attract diadromous fishes into rivers will be most effective when natural spring flows are low. When spring flows are naturally high, very large numbers of fish are attracted into rivers and supplementary environmental flows are not needed. During these times, environmental water is best used to enhance the dispersal and survival of fish during summer.

Environmental flows can be timed to attract particular species of fish into coastal rivers, based on species' movement responses during different times of the year.

Great outcomes for fish in the Glenelg River

Environmental freshes (pulses of water that usually last for at least a few days) during summer and early autumn can greatly increase how many juvenile fish move upstream. Baseflows (continuous stable, sustained low level flows) are also critical to the survival of these juveniles through to adults. Surveys before and during environmental flow releases found almost six times as many juvenile Common Galaxias and Short-finned Eels and 40% more juvenile Tupong moving upstream during freshes compared to baseflow conditions.

Baseflows and freshes have been delivered each year since 2017, with population monitoring showing that the abundances of Tupong and Common Galaxias have increased by 16.0 and 5.8 times, respectively!



ABOVE: Tupong

Numbers of juvenile Tupong moving upstream increased by **40%**

Long-term monitoring provides valuable insights

Annual fish monitoring has been a key element of VEFMAP since 2005. Analysis of this data from Victorian rivers, combined with Stage 6 flow-event based monitoring, has helped identify how different flow and non-flow related factors have affected native fish populations.

Long-term trends identified include:

- ▶ A decline in the abundance of most fish species during the Millennium Drought, with fish abundance improving since 2012. Species that showed this trend were Murray Cod, Golden Perch, Murray-Darling Rainbowfish and Trout Cod. Trends varied across systems and species. For example, abundance of most species increased substantially in the Campaspe River, while the lower Loddon River saw very little change.
- ▶ Improved flow conditions, due to both natural flows and environmental water, have contributed to these improvements in fish abundance, with elevated flows during spring providing the most benefit.

These analyses provide the first quantified links between components of river flows and population dynamics for a number of native fish species.

Results indicate that delivery of spring flows that are >5 times the long-term daily average provide greater benefits to fish. They also support current flow management approaches already being used at some rivers to enhance fish populations.

Non-flow related factors also influence population trends and demonstrate the importance of delivering complementary measures together with water for the environment..

Understanding how other factors (e.g. fish stocking, angling and habitat condition) interact with flows to influence fish populations is important.

Population modelling is a powerful tool

In a novel approach, population modelling has allowed an assessment of how the abundance of some species changes under different managed flow scenarios over long time periods. This is particularly useful for long-lived species. It has also provided insights into the influence of other factors such as fish stocking.

Under the current flow recommendations in the Campaspe River the population of Murray Cod is predicted to improve in comparison to other flow scenarios. Murray Cod abundances are predicted to increase by an average of at least 7% from 2009 onwards.

Enhancing Silver Perch movements between rivers and habitats

Silver Perch can move 100s of km to access a variety of habitats in the mid-Murray and lower reaches of the Goulburn and Campaspe rivers. Both the volume of flow in rivers and the time of year greatly influence immigration and dispersal within and among habitats, and environmental flows contribute to these movements.

Moderate increases in environmental flows in spring and summer can be used to promote upstream movement of Silver Perch, with downstream movement occurring mainly during large flows.



ABOVE: Releasing a juvenile Silver Perch
TOP LEFT: Releasing a Golden Perch
TOP CENTRE: Data recording during a fish survey
TOP RIGHT: Common Galaxias

Influencing fish movement in lowland rivers of northern Victoria

Environmental water plays a key role in improving the connectivity and availability of habitats for fish. This is particularly important in highly regulated systems such as the Loddon River in northern Victoria, where low flows and barriers can fragment populations.

Monitoring fish in northern Victorian rivers has improved our understanding of how both large- and small-bodied fish species respond to flows. We now know that environmental water can be used to:

- ▶ Stimulate fish to move to complete steps in their life cycle (spawning, dispersal and recruitment).
- ▶ Provide suitable hydraulic conditions for fish to move past barriers and through fishways.
- ▶ Maintain suitable habitat to encourage fish to remain in a river reach.

Monitoring before and during environmental flow releases showed the upstream movement of fish between river reaches increased substantially during freshes. This response was evident in both large-bodied species, such as Golden Perch, and small-bodied species such as Australian Smelt.

To achieve the greatest benefits for fish, management of environmental flows and fish passage should be considered together.

Numbers of small-bodied fish moving through fishways increased dramatically during environmental flow events. These are some of the first observations of small-bodied fish species increasing movement in response to flows.

Managing flows for the recruitment of Murray Cod

Long-term data for the Murray, Goulburn, Broken, Ovens and King rivers was used to examine effects of flow and environmental flow management on the recruitment of Murray Cod.

While specific links between river flows and recruitment varied across rivers, results provide strong evidence that managing flows in line with a more natural flow regime will significantly improve outcomes for Murray Cod. This is also likely to apply to species with similar breeding strategies, such as Trout Cod and River Blackfish.

For temperate regulated rivers, management of flows for Murray Cod should aim to:

- ▶ Be above the long-term annual average in winter and spring.
- ▶ Transition to below annual average levels through summer and autumn, while maintaining suitable water quality.
- ▶ Avoid extreme changes in flow rates during egg and larval periods for fish species.

To achieve recruitment success for Murray Cod, managers must consider the whole flow regime. Ideal flow conditions provided for reproductive success in spring can be offset by negative effects of high summer or low winter flows on juvenile fish.



ABOVE TOP: A juvenile Murray Cod
 ABOVE BOTTOM: An adult Murray Cod
 BOTTOM LEFT: Small-bodied fish species including Australian Smelt



Using environmental flows to support fish and vegetation outcomes in intermittent streams

Effects of environmental flows are usually examined on a species by species or group by group basis, but to manage a river for both fish and plant outcomes, it's important to understand how one species or group might affect another.

Several tributaries in the Wimmera River offered an ideal opportunity to jointly study fish and vegetation responses to flow management. These rivers and creeks included systems that flow intermittently, where evidence for outcomes from environmental flows is relatively limited.

Monitoring showed that environmental water is crucial to:

- ▶ Enhance habitat availability and connectivity in the upper MacKenzie River and Burnt Creek, resulting in a more extensive plant population and an abundant and wide distribution of fish species such as Southern Pygmy Perch.
- ▶ Maintain a diverse fish community and a broad extent of aquatic plants in the intermittent reaches of the lower MacKenzie River and Mount William Creek. Environmental flows provide opportunities for fish recruits and plant propagules to disperse. They also maintain soil moisture for aquatic plant survival and critical refuge pools when flow stops.

Correlations between flow, fish and aquatic plants suggested interactions and dependencies between taxa. This was particularly evident for Southern Pygmy Perch and aquatic plant species, where Southern Pygmy Perch abundance increased with greater aquatic plant diversity, suggesting the additional plant species provide better habitat for spawning, feeding or refuge from predation for these fish.

The results generated in this study can help guide the management of environmental flows in intermittent streams for better ecological outcomes.



Understanding how species interact, and when these interactions will affect responses to management actions, is key to developing management strategies that maximise biodiversity benefits while minimising the risk of unexpected adverse outcomes.

MIDDLE TOP: Southern Pygmy Perch
 MIDDLE BOTTOM: Aquatic plants are important for Southern Pygmy Perch
 BOTTOM LEFT: Lower Burnt Creek
 BOTTOM RIGHT: Upper MacKenzie River

Vegetation

Demonstrating outcomes from Water for the Environment

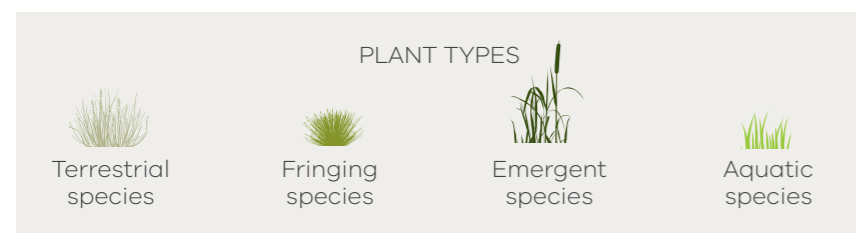
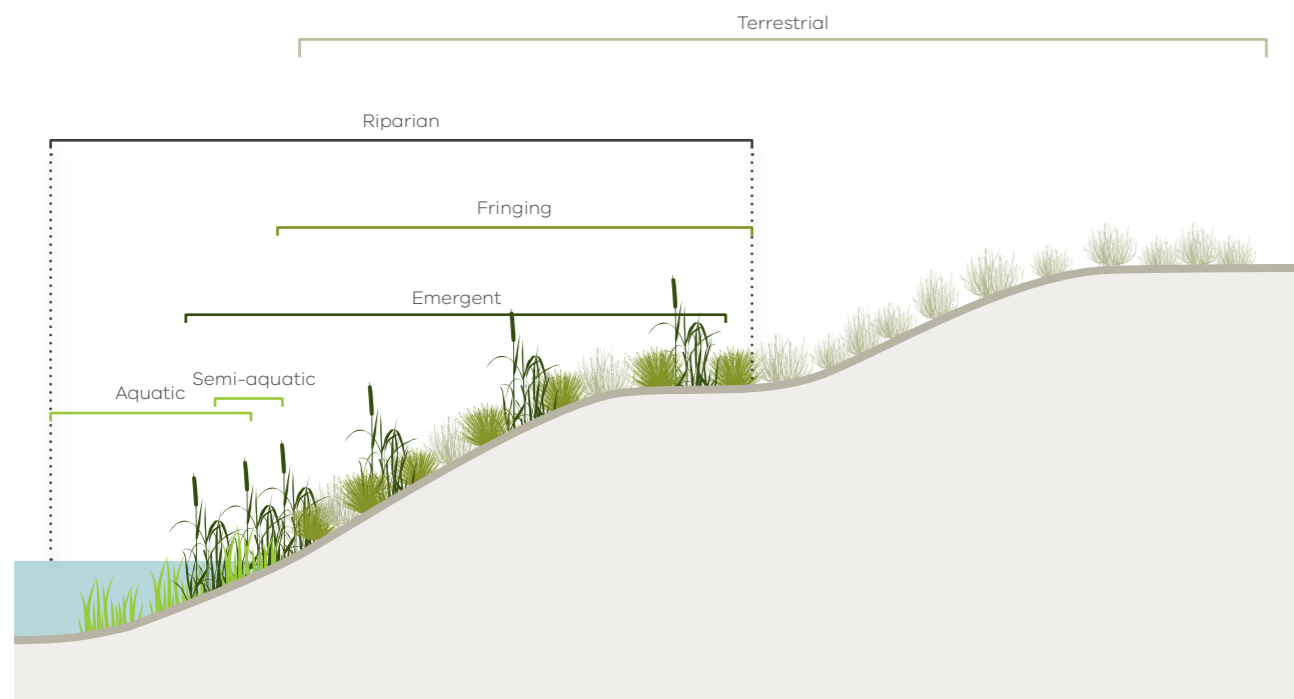
The vegetation theme examined effects of environmental flows on the distribution, foliage cover, diversity, recruitment and growth of riparian plant species.



Strategic delivery of environmental flows, when considered together with weed and grazing management, can maximise benefits to native riparian plants.

Riparian plants grow along river and stream banks and include aquatic plants within the water, right up to terrestrial plant species that live on the adjacent floodplain. Our monitoring focussed on filling knowledge gaps to better understand how riparian plants respond to flow as well as other factors such as livestock grazing, Carp, rainfall and soil moisture content.

Using an holistic approach to river management is important since plant survival is influenced by flow as well as a broad range of other factors.



TOP LEFT: Nursery trials of plant responses to inundation
 TOP CENTRE: Aquatic vegetation
 TOP RIGHT: Vegetation survey within a grazing enclosure on the Campaspe River
 FAR RIGHT: The Campaspe River



Managing flows for aquatic plants

Our monitoring has shown that environmental flows can successfully be used to promote growth and recruitment of aquatic plants.

Aquatic and semi-aquatic plants are most suited to sections of rivers with low to moderate flows. Environmental water has most impact for these species when it is delivered as essential baseflows or freshes within these low-flow systems.

Many of our regulated rivers are too deep, fast, or turbid for aquatic plants to establish and grow. However, even within these high-flow systems, we identified ways to manage environmental water to benefit the growth and recruitment of aquatic plants.



Plants along the riverbank - the effects of flow, rainfall and livestock grazing

Monitoring of riverbank vegetation showed baseflows provided by environmental water deliveries are critical to sustain fringing and emergent vegetation.

Spring freshes expand species distributions higher up the bank and sustain healthy plant populations. They increase riparian plant cover, seed dispersal, and germination, and provide water that young or shallow-rooted plants need.

In **higher rainfall** areas of south-eastern Victoria, exotic plant species are very common on riverbanks, often excluding native species. This illustrates the importance of delivering water for the environment together with complementary works, such as weed control.

In **lower rainfall** areas in north and western Victoria, exotic riparian species are less common, so environmental flows can simultaneously benefit the native

riparian plants while controlling the more common exotic terrestrial species. Environmental flows seem to have greater impacts in these systems, where water is more limited.

Livestock grazing significantly reduces native vegetation cover and results in higher numbers of exotic plants, particularly where grazing is heavy. This highlights the importance of delivering complementary measures together with environmental flows in order to benefit the environment.

Fringing grasses and herbs show strong growth after individual flow deliveries in spring. This effect is cumulative, with flow deliveries over many years' building on previous years' growth to significantly benefit plant populations.



An experimental approach

Nursery experiments investigated how terrestrial and riparian plant species respond to flooding duration, in different seasons, and with different water temperatures.



We looked at how plants respond to flows in:

- ▶ Late winter/early spring – when flows peak naturally, often supplemented by environmental water.
- ▶ Mid spring – when natural flows are often high and/or environmental flows are released.
- ▶ Late summer/early autumn – when brief environmental flows are released, or water is released for irrigation.

For most species tested, the seasonal timing of flooding significantly affected plant growth and survival. Many species survived long periods of flooding in the cooler conditions of late

winter/early spring. Flooding in late summer/early autumn reduced survival and growth, even when inundated for only two weeks.

Environmental flows in **late winter/early spring** cause limited damage to riparian plants.

Mid spring flows reduce plant survival and growth during their peak growing and reproductive period, and higher water temperatures increase plant stress.

Flows in **late summer/early autumn** should be carefully managed to reduce impacts on riparian plants; flow pulses of less than two weeks may reduce plant deaths.

Promoting recruitment and germination of native riparian plants

Recruitment is essential to maintain plant communities. Riverbank plants most commonly establish from seed germination. Seeds readily disperse within and between waterways. They are also stored in soil, lying dormant until conditions support their germination and growth.

Our monitoring showed:

- ▶ The timing and height of flows significantly influences how much germination occurs and the variety of species that germinate. Spring flows increase germination of native riparian species. Low flows in late summer are also important to promote aquatic and emergent plants.
- ▶ Rainfall supports germination of many riparian plants. With future hotter and drier conditions predicted, the role of environmental flows in maintaining riparian vegetation populations will become increasingly important.
- ▶ Many seeds that germinated in autumn are tolerant of long periods of cooler season flooding. However, many seedlings are killed by very high or long duration flows or during summer/early autumn flows. These results reflect what our nursery experiments found.

Other factors can affect the benefits of environmental flows

How environmental flows influence soil moisture for riparian plants

Increasing soil moisture through managed environmental flows is critical in drier waterways to support aquatic plants, as well as shallow-rooted or young plants growing along the banks. This is particularly important in waterways that experience long periods without flow or have poor connections to groundwater.

In years with natural floods that lead to large plant recruitment events, providing short-term freshes in late summer and autumn will increase soil moisture levels to benefit the survival of young plants.

Managing grazing impacts on riparian plants

Grazer exclusion trials confirmed livestock damage to riparian plants by trampling and eating them. At the edge of streams, cattle cause more damage than sheep, since they are heavier and enter the water. These trials also showed riparian zones typically recover quickly when livestock are excluded and environmental flows are delivered.

Environmental flows can:

- ▶ Play an important role in riparian plant recovery when grazing is removed.
- ▶ Support riparian plant condition in areas with light grazing intensity.

The influence of Carp and waterfowl on aquatic plants

Fenced exclusion trials showed how Carp and waterfowl grazing can damage plants. They also highlighted the potential to manipulate environmental flows to maximise aquatic vegetation growth and recruitment.

- ▶ Plots with Carp and waterfowl access had limited growth or establishment of aquatic vegetation.
- ▶ Plots where Carp and waterfowl were excluded showed signs of aquatic plant recovery, particularly at shallower sites, and where soils were briefly exposed to the air.
- ▶ Reductions in Carp are likely to improve the amount and variety of aquatic plants.

Environmental flow releases can promote the germination and recruitment of native plants in the riparian zone including on the floodplain.



THIS PAGE:

TOP: Setting up a nursery experiment

BOTTOM LEFT: A seedling

OPPOSITE PAGE

TOP LEFT: Setting up a soil moisture probe

TOP CENTRE: Cattle in the riparian zone

TOP RIGHT: Monitoring a fenced enclosure

BOTTOM RIGHT: Aquatic vegetation

Adaptive management

Constructive discussions between waterway managers and researchers are essential to environmental water planning and delivery. VEFMAP gives waterway managers the information they need for evidence-based decision making and adaptive management.

Types of flow management recommendations provided to CMA and MW waterway managers, based on Stage 6 monitoring results



Wimmera tributaries – providing a series of brief flow pulses

Advice: Provide a series of brief summer and autumn flow pulses to help maintain instream aquatic vegetation into the following year in intermittent waterways. This maximises the strategic use of available water with positive outcomes for vegetation.



Southern Victorian rivers – maintaining connectivity

Advice: Provide base flows together with short pulses of environmental water during summer to maintain river connectivity, suitable water quality and provide cues for movement of fish species, including Tupong, Short-finned Eels and Galaxiid species.



Campaspe River – changing the timing and duration of flow events

Advice: Re-schedule the delivery of a summer flow pulse, bringing it forward in the season, to assist the establishment of native riparian plant species and prevent introduced grasses from flowering.

ABOVE: Releasing a fish
TOP RIGHT: Plant recruits along the riparian zone

“Working with the VEFMAP researchers has allowed us to adaptively manage the North Central CMA’s flow releases in response to what we’re seeing on ground, driving better environmental outcomes. We’ve been each other’s sounding boards, allowing us to develop and test new ideas for monitoring..”

Darren White, Environmental Flows Project Manager, North Central CMA

Information gained through VEFMAP has filled key knowledge gaps and improved our understanding of environmental water requirements, drivers, processes and limiting factors that affect population and community outcomes for fish and plants.

“The relationship between the West Gippsland CMA and the VEFMAP team shows how managers and scientists can work together to improve environmental outcomes.”

Stephanie Suter, Environmental Water Officer, West Gippsland CMA

Regular sharing of results, discussions and on-site field visits with CMA and MW waterway managers have been an important feature of VEFMAP Stage 6.

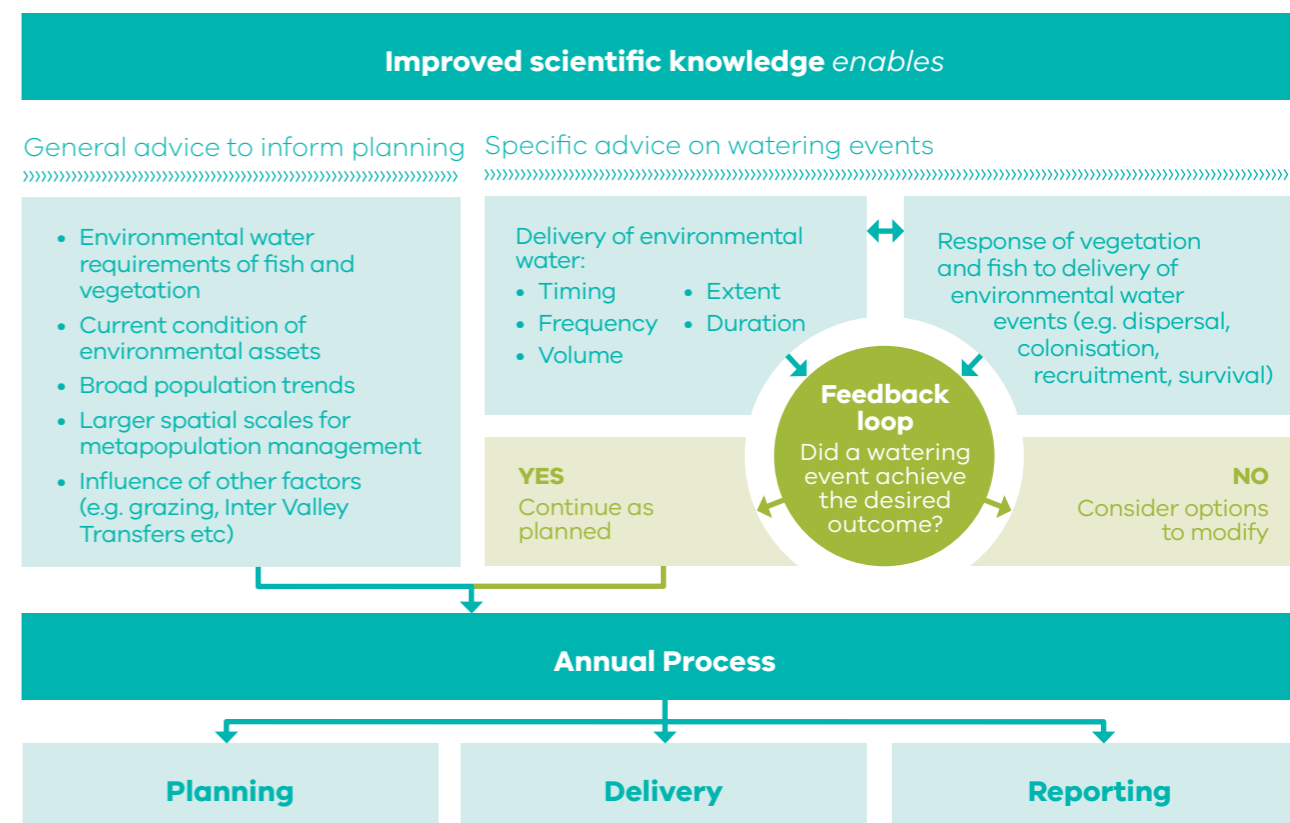
ARI scientists have worked closely with CMAs, MW, the VEWH and members of the community to help guide seasonal, annual and longer-term plans for environmental water delivery. Results from monitoring environmental water deliveries and natural flow events have then informed subsequent annual planning and continuous improvement, through an adaptive management approach.

For longer term planning, advice was provided on development of:

- ▶ Environmental objectives for long-term environmental flow studies.
- ▶ More specific vegetation and fish objectives to include in Seasonal Watering Proposals.

In the short term, timely advice from ARI researchers:

- ▶ Supported existing plans for environmental water releases.
- ▶ Recommended changes to plans for delivery of environmental water (timing, volume, duration of flows) to enhance fish and vegetation benefits.



Communication and engagement

Communication and engagement were an important focus for this program - we wanted to share accurate, clear and timely information with interested audiences, to support effective adaptive management of water resources and demonstrate the value of environmental water to stakeholders.

Our products and approaches included a mix of annual monitoring reports, fact sheets, workshops, presentations, online content, social media presence, newspaper articles, a poster and videos. Participation in CMA Environmental Water Advisory Groups provided a successful way to communicate and engage directly with communities, as has an Angler Citizen Science Project in northern Victoria.

"The key researchers from ARI ...have been able to provide innovative and complex science information and data in a very clear and easily understood manner. They regularly present this information to the CEWAG. All the partners in this project value the ability to interact with the scientists and to be involved..."

Ted Gretgrix - Chairperson, Campaspe Environmental Water Advisory Group (CEWAG)

Bringing datasets together

A system-scale approach to manage Golden Perch

A multi-jurisdictional study of Golden Perch genetics made use of samples from across the Murray-Darling Basin, including otolith and fin clip samples from VEFMAP.

This broad-scale approach is particularly valuable and relevant for this species, which travels large distances and requires coordinated management of environmental water across multiple river systems.

Collaborators - La Trobe University, University of Melbourne, North Central and Goulburn Broken CMAs, South Australian Research and Development Institute and New South Wales Department of Primary Industries



We created a VEFMAP database early in Stage 6 to maintain high scientific standards in managing our data. A clear, transparent process was set up for data collection, rigorous checking and data entry.

An accessible online tool was also created so that waterway managers can access information from their area while they wait for our annual report, which has a full analysis and interpretation of each year's data.

The VEFMAP database model has since been adopted for Victoria's Wetland Monitoring and Assessment Program for environmental water (WetMAP).

Citizen science - working with anglers

Citizen science projects help ARI scientists connect with communities across Victoria. We help community members learn more about environmental water and they help us collect more data. Anglers are particularly interested in increasing fish numbers and improving waterway health. During 2018-19, a group of avid fishers helped us collect otoliths (fish ear bones), to discover more about the lives of Murray Cod and Golden Perch.

Anglers who catch and eat these fish species sent ARI the otoliths from their catches and received a fish profile in return. Together they collected 84 Golden Perch and 25 Murray Cod from 12 rivers, creeks and lakes.

Otoliths tell us how old the fish was, how quickly it grew, whether it bred naturally in the river or was stocked, and even which rivers it swam in. This information helps us understand how flow events affect the way fish move, breed and survive.

Otoliths collected from the Campaspe River showed us that Murray Cod have been breeding successfully there and that stocked Golden Perch are surviving and growing well - when combined with our other research, this shows that flow management is working well in this river.

Some of the Golden Perch had travelled more than 1000 km from where they were born. We've seen evidence of these large-scale movements in other studies, highlighting the importance of managing and coordinating flows, as well as fish passage, for Golden Perch in multiple rivers.

"We really enjoyed being involved in this study and couldn't wait to find out how old our fish were and where they came from. The results led to some great discussions around the campfire!"

Graeme Anderson, Angler Scientist



ABOVE: A tagged Golden Perch
 TOP RIGHT: Angler citizen scientists learn how to remove an otolith
 CIRCLE: an otolith
 BOTTOM LEFT: Data recording during plant survey
 BOTTOM RIGHT: Zeb Tonkin, ARI talking to angler citizen scientists at a field day

Collaborating with other key monitoring and research programs

The results from VEFMAP Stage 6 have been significantly improved by close collaborations and sharing of knowledge, data and learnings with a broad range of scientists, research institutes and government agencies.

VEFMAP is one of several long-term environmental water monitoring programs in south-eastern Australia – others include the Commonwealth Environmental Water Office (CEWO's), Flow-MER Program (Monitoring, Evaluation and Research), The Living Murray Program, Melbourne Water's river and wetland monitoring programs and DELWP's Wetland Monitoring and Assessment Program for environmental water (WetMAP).

Partnerships with these and other programs and organisations have allowed us to:

- ▶ Use funds more efficiently by sharing effort, expertise, equipment and results.
- ▶ Work with other environmental water programs in Victoria and across the Murray-Darling Basin to make sure we are sharing knowledge and results, and not duplicating monitoring and research.
- ▶ Combine datasets to create bigger sample sizes for analyses.
- ▶ Create multi-disciplinary teams, to make use of diverse and targeted expertise.
- ▶ Contribute to student development.

"VEFMAP is critical for demonstrating outcomes of Victoria's environmental watering program and helps us make more informed and responsive decisions about managing this precious resource for the future."

CEO VEWH

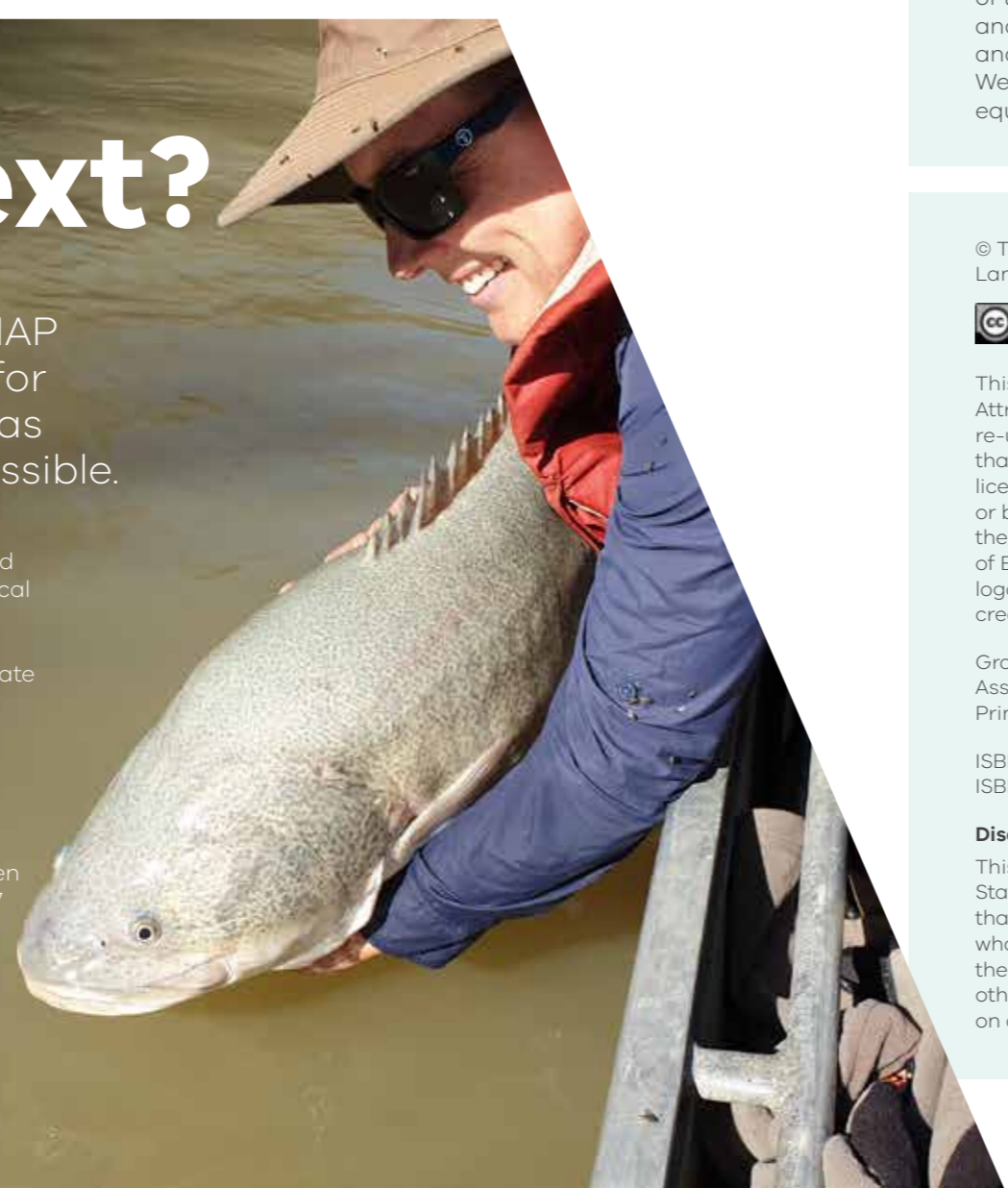
BELOW: Releasing a Murray Cod
All images are courtesy of the Arthur Rylah Institute (ARI) except where specified.

What's next?

Monitoring programs like VEFMAP are key to ensuring that water for the environment is being used as efficiently and effectively as possible.

VEFMAP Stage 6 has shown us and our communities that water for the environment is working. We've learned more about how environmental water supports ecological outcomes and built the relationships needed to get even more out of environmental water management in Victorian rivers. VEFMAP data are also helping us evaluate environmental outcomes in the Murray-Darling Basin.

We know from our ongoing review and adaptive management approach that VEFMAP Stage 6 was well designed and produced some valuable results. This leaves us well placed to continue onto Stage 7 (2020-2024), where we can build on these results and work even smarter with this limited and precious resource. Stage 7 will include a growing focus on sharing our results with communities and interest groups, as well as building further scientific collaborations.



Acknowledgment

The Victorian Government proudly acknowledges Victoria's Aboriginal community and their rich culture and pays respect to their Elders past and present. We acknowledge Aboriginal people as Australia's first peoples and as the Traditional Owners and custodians of the land and water on which we rely. We recognise and value the ongoing contribution of Aboriginal people and communities to Victorian life and how this enriches us. We embrace the spirit of reconciliation, working towards the equality of outcomes and ensuring an equal voice.



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Waterway management partners



Members of the independent review panel

Commonwealth Scientific and Industrial Research Organisation (CSIRO), Griffith University, La Trobe University, University of Melbourne

Organisations who have collaborated with VEFMAP

CSIRO, the Commonwealth Environmental Water Holder, Murray–Darling Basin Authority, Department of Primary Industries New South Wales, Victorian Fisheries Authority, Jacobs, Streamology, Austral Ecology, Dja Dja Wurrung Clans Aboriginal Corporation, Deakin University, La Trobe University, University of Melbourne, Goulburn–Murray Water, Lower Murray Water, South Australian Research and Development Institute.