

# Balancing water security and environmental biodiversity

A win-win for regional water supply and fish conservation



## Acknowledgements

Icon Water acknowledges the traditional custodians of the Canberra region, the Ngunnawal people and also recognises other people or families with connection to the ACT and region. We pay our respect to their Elders – past, present and emerging. We recognise and value their continuing culture and the contribution they make to the life of the city and the region. We also acknowledge the First Peoples of the broader region in which we live and work.



*Three Rivers* by Lynnice Church

Icon Water wishes to acknowledge the efforts of scientists and researchers from the University of Canberra, the Australian National University, University of Sydney, Griffith University and the ACT Government for their support and partnership with these projects at various times of the life of the research programs. Throughout this document, the term 'we' has been used to describe projects and actions by project teams to achieve positive environmental outcomes. In many instances, this term includes stakeholders from one or more of the organisations listed above, including Icon Water.



Old Cotter Dam wall pre-enlargement

When the enlargement of the Cotter Dam was being planned, many were uncertain about whether a major water security project could not only co-exist, but prioritise ecological protection.

This is the success story of one of the most significant infrastructure projects in Canberra's history, and how it managed this challenge.

Enlarging the Cotter Dam increased the community's drinking water supply while simultaneously supporting the conservation of the Australian Capital Territory's (ACT's) threatened native aquatic species in the Cotter Reservoir.

The project proved balancing water security and biodiversity conservation in managed freshwater systems **IS** possible – with effective collaboration. The project adopted an enduring adaptive management focus by three stakeholders in particular: ACT Parks and Conservation Service as the public land and water manager, Icon Water as the regional water utility and the University of Canberra as the aquatic ecology experts.

# WHO WE ARE

We are the ACT's supplier of essential water and wastewater services and have been part of the Canberra community for over 100 years.

We operate the region's network of dams, water treatment plants, wastewater treatment plants and water and sewage pipes and pumping stations.

Our purpose is to sustain and enhance quality of life. We provide safe and sustainable water and wastewater services that contribute to the health of our community and future security and prosperity of the region.

A major part of our role is protecting our environment. In all that we do, it is essential that we consider the impact of our actions on our catchments and freshwater environment and ecosystems, as depicted in our [Sustainability and Environment Policy](#).

Under the *Territory-owned Corporations Act 1990 (ACT)*, we are obligated to show a sense of social responsibility and integrate environmental and economic considerations into all our decision making.

We are committed to the United Nations Sustainable Development Goals (SDGs) and are a founding member of the Infrastructure Sustainability Council of Australia (ISCA). Our role directly contributes to SDG 15 'Life on Land' to ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services. We used the ISCA rating tool for the Cotter Dam project to ensure sustainability was threaded through the entire dam design and construction.



Sustainable Development Goals 6 and 15





The construction of the dam circa 1914  
 Source: National Library of Australia

## WATER SECURITY: PIVOTAL TO CANBERRA'S HISTORY

Having abundant, high-quality water is one of the main reasons Canberra, as Australia's national capital, is located where it is.

The ACT was officially established in 1911, and the shape of the territory was driven by the Cotter Catchment boundary. The build of the initial Cotter Dam started in 1912 to secure the area's water supply.

Since then, Canberra has become Australia's largest inland city, and the Cotter Dam (and Cotter Reservoir water supply) has been enlarged twice.

The dam was first enlarged in 1951, from a capacity of one gigalitre to four gigalitres. Then in 2013, following an extensive evaluation of water supply opportunities, the Cotter Dam was enlarged from four gigalitres to 78 gigalitres as the centrepiece of a comprehensive water security program for the ACT.

These enlargements catered for the needs of a growing region and provided a safe and secure water supply factoring in climate change and the risks arising from drought.

### Cotter Dam capacity

1GL 1912



4GL 1951



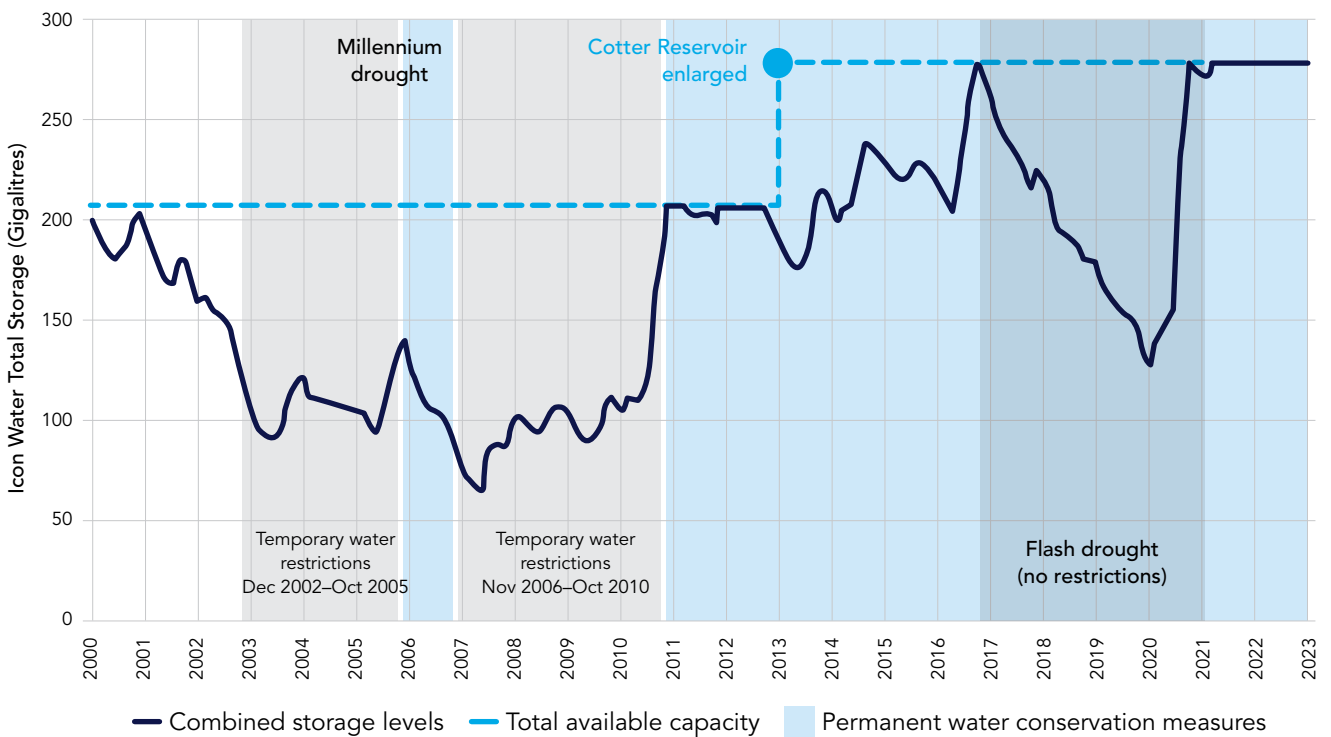
78GL 2013

Before the development of Australia's capital city there was an extended drought known as the Federation Drought (1895–1903). A century later, Canberra experienced the Millennium Drought (2001–2010) with devastating bushfires in 2003. A further flash drought followed between 2017 and 2019 concluding with the extensive Black Summer bushfires and three years of La Nina conditions.



The Cotter Dam in 2017

### Historical storage levels





Macquarie perch in the Cotter Catchment

## PROTECTING FISH SPECIES

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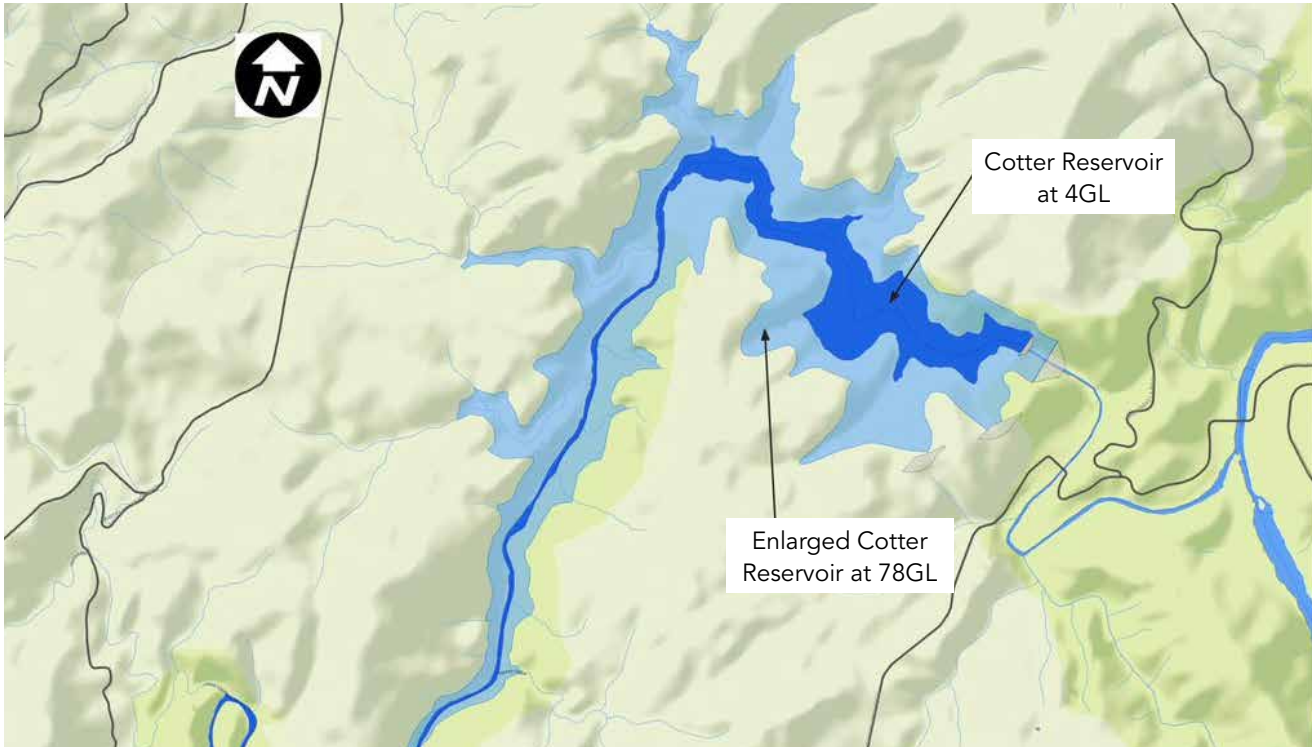
Endemic to the Cotter River are several threatened species – Macquarie perch, Two-spined blackfish, Trout cod and Murray crayfish.

Macquarie perch (*Macquaria australasica*) are endangered nationally and on the International Union for the Conservation of Nature (IUCN) red list. Once found widely across south-east Australia, especially in the Murray Darling Basin, their numbers have declined rapidly due to habitat destruction, over-fishing, river regulation, cold water pollution, disease and fish and bird predation.

Invasive species, like Rainbow and Brown trout, Redfin perch and European carp, create competition and are predators of the Macquarie perch.

Redfin perch are particularly concerning because they can carry the Epizootic Haematopoietic Necrosis (EHN) virus, known to cause liver and spleen problems that can lead to large fish kills.

The Cotter River system, above the dam wall, is the only place within the Murray Darling Basin that does not yet have carp or Redfin perch, which makes it quite unique. Both Redfin perch and carp exist directly below the Cotter Dam wall, so it's essential we manage the site in a way that keeps them excluded, so they can't impact the thriving Macquarie perch population.



Cotter Reservoir inundation zone

## OUR ACTIONS TO CONSERVE AND PROTECT

Threatened aquatic species are particularly vulnerable to changes in their environment.

Our challenge was to make sure they were protected when we were constructing the dam, inundating the reservoir, and from ongoing operational and maintenance activities.

The water security project involved enlarging the Cotter Reservoir by 4.5 kilometres in extended circumference, increasing the inundation zone from 50 hectares to 282 hectares and deepening the reservoir by 50 metres. This increased the Cotter Reservoir's accessible storage capacity to 76 gegalitres, 20 times its original size, and boosted the ACT's overall water storage capacity by 35 percent.

The inundated land comprised ex-pine forests which had burnt out in the 2003 bushfires and not rehabilitated.

Since the inundation zone was known to contain a viable population of Macquarie perch,

this project posed several potential threats to this fish species, like flow alterations, loss of refuge, potential increased predation, loss of food sources, invasion or expansion of alien fish species, loss of riverine spawning habitat as used for breeding (or access to it) and the introduction of disease.

In 2008, in partnership with various universities, government agencies and leading specialists, we started a collaborative and comprehensive research and management program during the early planning phase. The aim was to manage the threats to these aquatic species and determine the environmental impact of enlarging the Cotter Reservoir. We engaged an independent fisheries scientific advisor and established stakeholder steering and working groups to help in this process, including the Commonwealth and ACT Governments, the University of Canberra and Icon Water.



This award-winning fish management program comprised 18 research projects (within the Cotter Reservoir and upstream reaches of the Cotter River) to understand the issues in real time and enable timely adaptive management action. This included regular surveys and long-term aquatic monitoring, which started during the construction phase, through the filling period, and remains ongoing through the operation of the dam as a water supply reservoir.

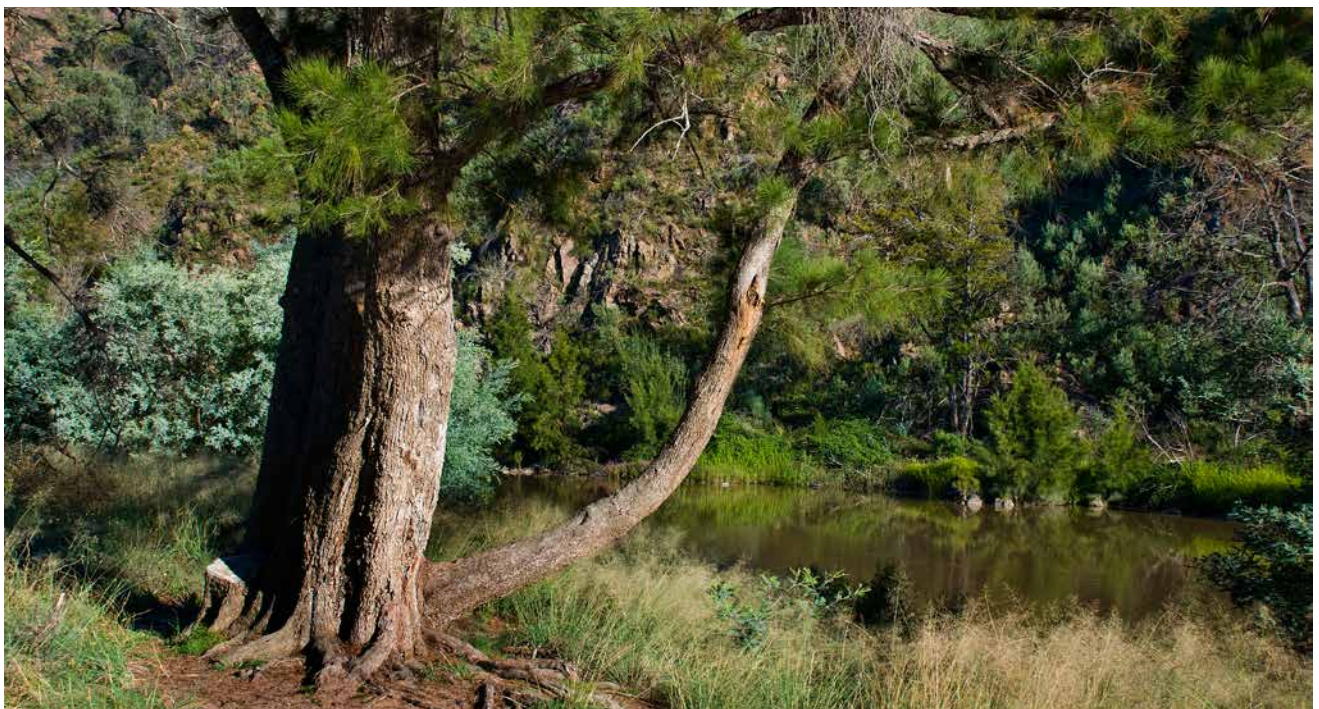
We undertook extensive environmental impact assessments, consultation, commitments and conditions of approval with ACT and Commonwealth regulators to gain the necessary permits for the enlargement.

Then, before filling the enlarged reservoir (and based on research and expert advice), we completed various construction projects to mitigate the risks of the inundation and provide a more protective environment for these threatened fish populations.

Some of these projects are summarised over the page.



Downstream of Vanity's Crossing



Casuarina tree below the Cotter Dam

# CONSERVATION PROJECTS

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## Rock reef habitat

We built a seven kilometre artificial freshwater rock reef in the inundation zone – the first of its kind – as a substitute for the fringing aquatic plants used by the Macquarie perch to shelter from cormorants.

The custom-designed habitat was made by positioning over 52,000 tonnes of rock close to the shoreline to provide shelter at a range of reservoir depths.

We also left native hardwood and woody debris within the inundation zone in-situ to provide supplementary shelter habitat for the Macquarie perch, particularly during the filling phase.

## Installing fishways

Before we filled the reservoir, we constructed fishways (also known as fish ladders) above the dam to open a substantial area in the Cotter River as spawning habitat for the Macquarie perch. We discovered that, although the swimming speed of Macquarie perch was faster than previously understood, the culverts at Pipeline Road Crossing were generating flow speeds even faster and beyond the capacity of the fish. To manage this, we designed the fishway at the crossing to slow the water velocity, allowing the fish to swim freely upstream.

## Controlling erosion and sediment

The area has highly erodible soils and an extensive network of ex-forestry trails, which meant a lot of sediment was entering the Cotter Reservoir when it rained, impacting not only the quality of the drinking water, but the quality of fish habitat.

To mitigate this, we installed more than 50 large scale erosion and sediment control structures around the dam, including restoring native vegetation cover, stabilising drainage lines with rocks and limiting activities that cause erosion and sedimentation.

## Clean up projects

We extensively salvaged the waterways during the project to ensure they remained free of obstacles and so the area was left in a better state than before we started the project. This included removing ten dumped vehicles from the Cotter River, which were compromising water quality and biodiversity health.



Helicopter used in 2013 to remove abandoned car bodies before the new Cotter Reservoir was inundated



Icon Water and University of Canberra conducting fish passage assessments at differing dam levels

# KEY RESEARCH AND MONITORING PROJECTS

This biodiversity conservation program included six prominent research and monitoring projects.

## 1 Environmental flows and spawning

Macquarie perch need flowing water and rock riffle habitat to spawn. When we surveyed the Cotter River upstream of the Cotter Reservoir before filling, we found several spawning habitat sites, but also some natural barriers (like large boulders) that could prevent the fish from migrating upstream from the inundation zone. We determined that we could make some barriers more passable by releasing water flows from Bendora Dam upstream. This information was critically important in understanding the population movement as the reservoir filled.

We monitored adult Macquarie perch spawning movements through different reservoir levels to find out if the flow releases from Bendora Dam did improve access to their spawning habitat. This information together with ongoing monitoring of spawning behaviour is used to adapt our dam and environmental flow management processes.

## 2 Disease prevention

The native EHN virus is known to occur in the Canberra region, but we did not know if it was present in the Cotter catchment upstream of the Cotter Dam. A research project did not detect the EHN virus in sampled fish from the Cotter Reservoir or tributaries upstream of the reservoir.

This information informed measures to ensure the virus didn't enter the reservoir when constructing the new Cotter Dam wall (125 metres downstream of the original dam wall) – including relocating Macquarie perch trapped between the old and new walls and removing invasive fish. We also established strict requirements for all personnel working near or in the water to avoid contamination and disinfected the stream bed to kill the EHN virus and other potential pathogens. This sterilisation process was effective; no invasive fish were transferred above the wall and neither Redfin perch nor Carp have been found upstream.



Relocating Macquarie perch trapped between the old and new walls and removing invasive fish



New Cotter Dam (under construction) and old Cotter Dam

### 3 Fish population

Our research found that Macquarie perch adult numbers boomed during the filling phase, on the back of high spawning yields during baseline years and an abundance of food as the reservoir filled. However, as the filling progressed, the headwater of the reservoir met with in-stream obstacles, which we believe prevented the spawning of Macquarie perch during the 2014 and 2015 seasons.

The Cotter Reservoir filled during the winter of 2016, overtopping these in-stream barriers, at which point we found reasonable numbers of juvenile Macquarie perch – the species was achieving successful reproduction rates.

This trend has largely continued since the reservoir filled, and we continue to have a healthy and self-sustaining Macquarie perch population.

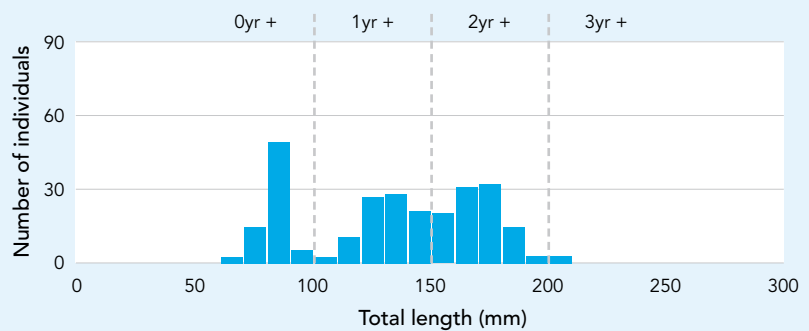


Fish monitoring in the upper Cotter River reaches post 2019–2020 fires



Juvenile Macquarie perch examined during fish monitoring programs

#### Macquarie perch population in 2019



### 4 Monitoring food

We regularly monitored (and continue to monitor) food sources along the shoreline and instream to make sure there is an abundance of food available for the Macquarie perch. Typically, they feed on shrimp and small aquatic species. Our findings confirmed that Macquarie perch are opportunistic feeders and during the filling stages they transitioned to eating small terrestrial species such as worms, with plentiful food sources available during gradual shoreline inundation.

## 5

## Managing predators

Cormorants are key predators for Macquarie perch. Our monitoring of cormorant species found their greatest numbers occur in spring and summer when the surface water is warmer. This is because reduced oxygen in the lower reaches of the reservoir can force fish closer to the surface. We addressed this risk by operating destratifiers in the reservoir to mix the water column with oxygen at various water depths, so Macquarie perch can stay deeper in the water.

Cormorants also prey on Macquarie perch when they migrate upriver to spawn. To manage this, we now have a control plan in place with ACT Parks and Conservation Service, as the public land custodian, based on a set of trigger levels. If dissolved oxygen levels in the reservoir drop to certain levels, or if certain cormorant numbers are reached, they activate a range of on-ground control measures to deter cormorants.

Fortunately, our ongoing monitoring indicates that although natural predation continues, the cormorant threat from the Great Cormorant hasn't changed significantly, and Macquarie perch are successfully finding refuge via aquatic plants around the edge of the reservoir and within the rock reef.

Brown trout predation is also a threat to Macquarie perch, particularly to juveniles. Brown trout numbers have increased in the past five years, so we are now developing new investigations including genetic testing of gut contents of trout, and triggers and actions for managing adult trout populations.



Greater Cormorant – a predator of Macquarie perch

## 6

## Macquarie perch translocation

Between 2008 and 2019 we translocated more than 1,000 Macquarie perch to the Molonglo River, upper Cotter River reaches and to Paddy's River, and an additional 300 to the Upper Cotter and Molonglo sites in subsequent years.

This program mitigates the risk of local extinction and helps maintain genetic diversity. It has had mixed success, and we are continuing to monitor these areas to inform future translocation efforts for Macquarie perch. Watch more about the translocation [here](#).



View from the northern side of the reservoir looking west across the Brindabellas



Satellite image of the rock reef artificial habitat constructed within the Enlarged Cotter Dam

## WORLD FIRST DISCOVERIES

The project teams made several discoveries that have improved scientific understanding, dispelled globally held assumptions and assisted the management of this endangered species:

- While it was commonly understood that Macquarie perch are a quiet and docile species, our movement tracking identified that Macquarie perch are faster swimmers than previously known. They can swim against flows and pass instream barriers more easily than previously understood, including in our own laboratory trials.
- Macquarie perch are largely nocturnal, occupying well-defined home sites during the day. Our research found they predominantly migrate upstream between dusk and dawn, a characteristic not previously known. Because of this, we no longer conduct daytime monitoring for spawning.
- Our comprehensive assessments allowed us to answer specific questions about predation. We found that Macquarie perch are prey to Brown trout and cormorants, neither of which had been confirmed previously.
- When new ground was inundated, there was concern that dissolved oxygen levels in the reservoir may become too low for Macquarie perch due to the breakdown of all the organic matter. In reality, this process occurred much more quickly and was less severe than anticipated – a phenomenon that hadn't been well studied in temperate regions.

The enlargement of the Cotter Reservoir is an extraordinary example of how industry, science and government can work together to achieve major solutions to declining water supplies while continuing to protect threatened native fish species.

This environmental program is the largest ecosystem protection project in the ACT. It represents a benchmark for other infrastructure projects worldwide, particularly projects that threaten riverine fish. As such, there have been over 50 scientific papers on the program and it has received a number of national awards. It is a model we can replicate when looking at future water security projects.



Indigenous grass tree (*Xanthorrhoea* spp.) relocated to Cotter catchment

## BROADER SUSTAINABILITY OUTCOMES

The Cotter Reservoir project achieved many additional environmental outcomes:

- We reused resources wherever possible. A million tonnes of excavated aggregate were retained on-site to be crushed and reused in the construction of the dam wall. This saved nearly three million kilometres in construction vehicle journeys and prevented extraction of virgin materials.
- We planted a mix of over 30,000 Eucalyptus, Acacia and other shrubs and grasses endemic to the region, over more than 200 hectares across the Lower Cotter area.
- We relocated Indigenous grass trees (*Xanthorrhoea* spp.) from the inundation zone to nearby areas of the Cotter catchment and donated some plants to the Australian National Botanic Gardens and the National Arboretum.
- To offset the biodiversity impact of constructing the dam and enlarging the reservoir, we accelerated the natural recovery from the 2003 fires with native plantings across 420 hectares of land in the Lower Cotter Catchment.
- We planted a carbon forestry offset to ensure that the entire project lifecycle was carbon neutral.



Cotter Dam Discovery Trail entrance

We also undertook a comprehensive heritage program:

- Traditional land custodian representatives collected around 4,000 artefacts including stone cutting tools and axe heads at the construction and inundation site, and carefully placed them in a selected site overlooking a reach of the reservoir in a Return to Country ceremony. Watch our [video](#) on our indigenous archeology program.
- We recorded Aboriginal and European artefact material including artworks, photography and video footage of the past and present.
- In consultation with the local Yurung Dhaura Indigenous working group, we planted a nursery of bush medicine and traditional food species.
- We built the Cotter Dam Discovery Trail (1.4 kilometres) and Honyong-Cotter Walking Track (2.6 kilometres) to showcase the history and heritage of the area and its significance to the Canberra community. Find out more about the tours we run at the Discovery Trail [here](#).



The Cotter Dam was officially opened on 12 October 2013.

ACT Parks and Conservation Service planting grasses to restore habitat in Pierces Creek in the Lower Cotter Catchment, an area badly damaged in the 2003 bushfires



Aboriginal heritage stone cutting tools and artefacts returned to Country



To find out more about Macquarie perch in the ACT and Icon Water's conservation efforts see the following references:

- [Operational compliance reports for the Cotter Dam \(Icon Water\)](#)
- [Macquarie perch nature conservation factsheet \(ACT Government\)](#)

## OUR SUSTAINABILITY PRINCIPLES



Enrich our neighbourhood



Respect resources



Care for tomorrow

### Principal Registered Office

Level 5, ActewAGL House  
40 Bunda Street  
Canberra ACT 2600

### Mitchell Office

12 Hoskins Street  
Mitchell ACT 2911

### Postal address

Icon Water  
GPO Box 366  
Canberra ACT 2601

**ACN:** 069 381 960

**ABN:** 86 069 381 960

### TTY for Hearing Impaired

133 677

### Language assistance

13 14 50, 24 hours

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### Talk to us

**E** [talktous@iconwater.com.au](mailto:talktous@iconwater.com.au)

**T** (02) 6248 3111



@iconwater



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