Mulloon Institute
For environment, farming and society.

Proposal for a

National Code of Practice for Landscape Rehydration & Restoration

Prepared by Dr Gerry Bates in consultation with the Mulloon Law Committee, for and on behalf of the Mulloon Institute[1].

EXECUTIVE SUMMARY

Proposal for National Code of Practice for Landscape Rehydration & Restoration:

This executive summary outlines a proposal aimed at restoring ecosystems, biodiversity, soil health and agricultural productivity in Australia. The proposed Code addresses the need for progressive regulatory reform to foster landscape rehydration initiatives and overcome current obstacles that hinder environmental restoration projects.

Introduction:

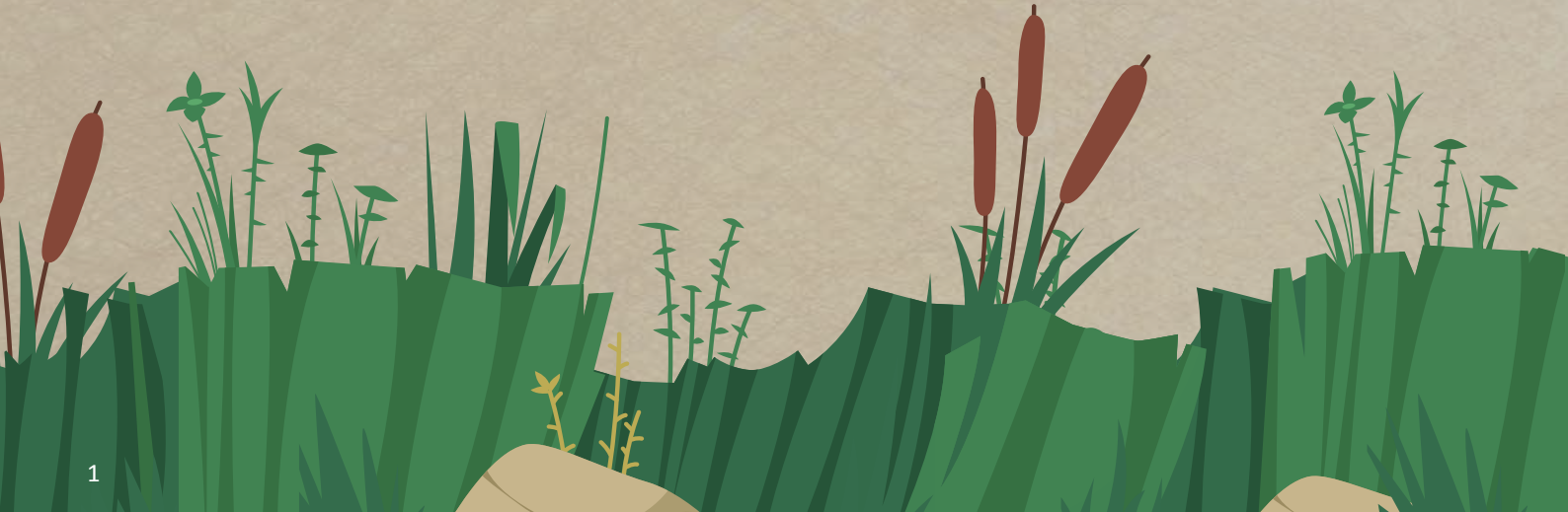
This proposal for a National Code of Practice is aimed at rejuvenating ecosystems, biodiversity, soil health and agricultural productivity through landscape rehydration and restoration. The proposal seeks to address the pressing need for comprehensive regulatory reform to expedite, expand and de-risk landscape rehydration and restoration projects across Australia.

Need for Ecosystem Recovery:

This proposal aligns with the United Nations Decade on Ecosystem Restoration's goal to reverse the loss of nature. Australia's environment faces significant challenges due to deforestation, agricultural activities and climate change. It acknowledges the need for resilient landscapes capable of withstanding climate extremes and the importance of water cycling and its critical role in ecosystem survival. Regulatory reform is urgently required to encourage landscape restoration and rehydration, fix the broken water cycle, restore biodiversity, improve soil health and increase agricultural productivity.

Landscape Rehydration Infrastructure (LRI):

The proposal advocates for natural infrastructure and landscape rehydration interventions to restore water cycles, improve water quality and support habitat restoration. These approaches, backed by scientific evidence, replicate nature's optimal water movement patterns, re-establishing functional water cycling crucial for regeneration.



Challenges in Environmental Regulation:

The current environmental regulation system in Australia presents barriers to restoration initiatives. Complex and time-consuming approval processes hinder eco-restoration projects, discouraging environmentally conscious landowners and experts. The focus on short-term risks rather than long-term outcomes impedes landscape restoration efforts.

Proposed solution:

Implementing a National Code of Practice is key to overcoming regulatory barriers. This Code aims to streamline approvals, create an outcomes-based regulatory approach, foster collaboration, de-risk investments, empower communities and create professional pathways for environmental leadership.

Function & benefits of Landscape Rehydration Infrastructure:

The proposal emphasises the positive impacts of LRI on landscape function, resilience to climate extremes, habitat restoration, water quality and soil health.

Alignment with Australian Government initiatives:

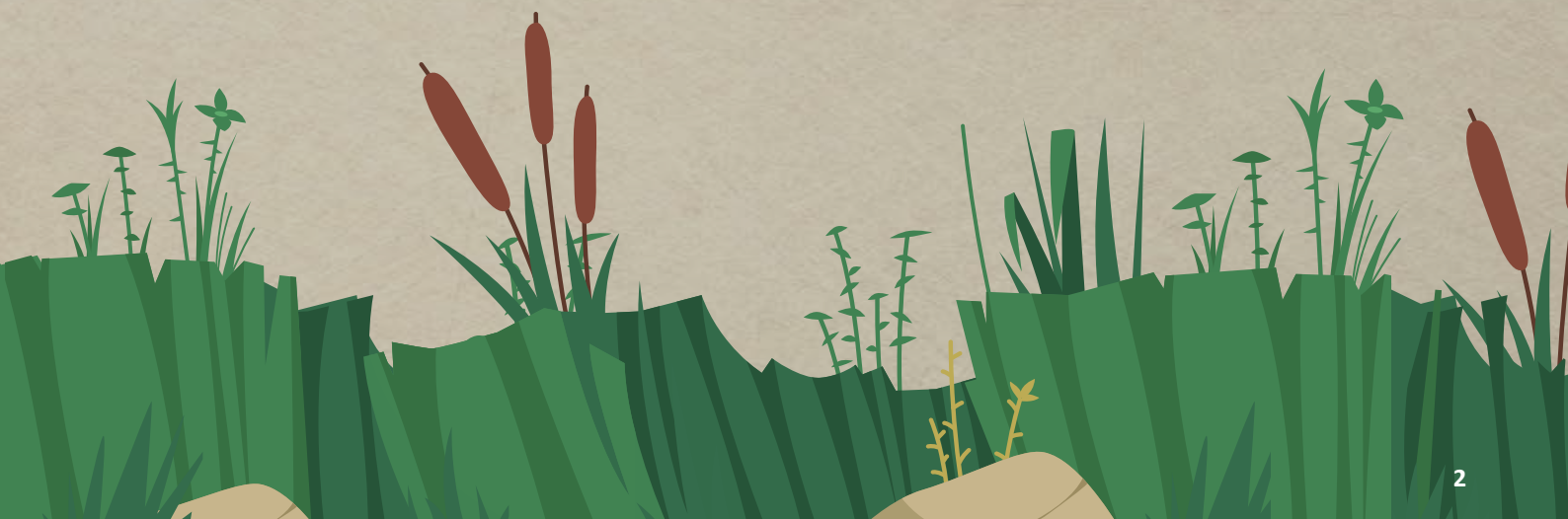
The proposed Code aligns with various government reviews and initiatives, emphasizing a shift toward a nature-positive approach, supporting biodiversity restoration and encouraging strategic planning and management of the environment at national or regional scales.

Implementation:

The Code creates a governance mechanism to replace the existing complex process-driven environmental regulation with an outcomes-based approach. It is designed to accelerate climate-resilient restoration projects and address threats posed by climate change.

Conclusion:

The proposed National Code of Practice for Landscape Rehydration and Restoration is a crucial step toward streamlining regulatory processes, encouraging ecosystem restoration and fostering a nature-positive approach.
By prioritising outcomes over processes, this initiative aims to unlock the potential of landscape rehydration and restoration for a more sustainable and resilient future.



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The Mulloon Institute acknowledges Aboriginal and Torres Strait Islander peoples as the First Australians and Traditional Custodians of the lands and waters where we live, learn and work.

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“Environmental law is failing in regulating environmental change.

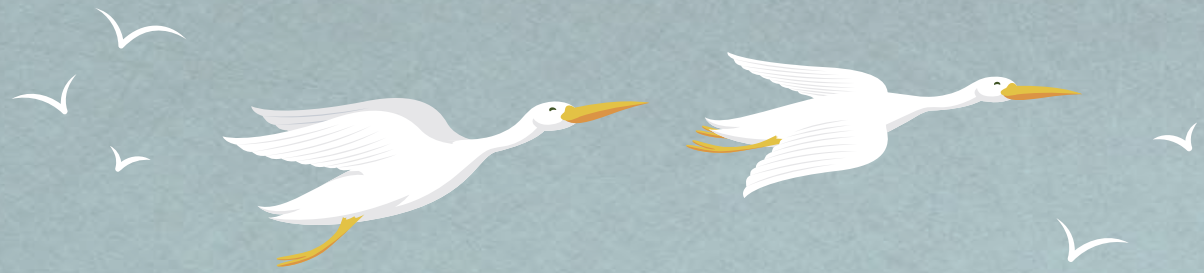
The state of the environment is getting worse. Albert Einstein is attributed with defining insanity as doing the same thing over and over again and expecting a different result.

With environmental law, we keep using the same legal techniques and approaches, and using the same knowledges, to address ever-changing environmental problems.

It is unsurprising, therefore, that we keep getting the same result, failing to address the environmental problems.

This suggests we need to change our approach to environmental law; we need to do things differently.”

Chief Justice Brian J. Preston,
Land & Environment Court of NSW (2022)[2]



PART A: THE NEED FOR A WHOLE-OF-GOVERNMENT APPROACH TO ECOSYSTEM RECOVERY

This document outlines a proposal aimed at restoring ecosystems, biodiversity, soil health and agricultural productivity. It addresses the need for comprehensive regulatory reform to accelerate, scale and de-risk landscape rehydration and restoration projects across the country.

Introduction & Background

Australia's environment is struggling. Deforestation and agriculture have caused widespread degradation of soils and waterways. Our landscapes cannot cycle the water needed for ecosystem survival and agricultural productivity. Climate change is amplifying these vulnerabilities. The Australian Government has committed to 'preventing, halting and reversing the loss of nature', signing up to The United Nations Decade on Ecosystem Restoration and publishing its Nature Positive Plan (2022).[3] As stated in the recently released Independent Review of the NSW Biodiversity Act 2016, it is time to move 'beyond biodiversity conservation to a "nature positive" framing that emphasises the need to repair past damage and to take urgent action to halt and reverse biodiversity loss, putting nature on a path to recovery, so that thriving ecosystems can support future generations.'[4]

To achieve this goal, we need resilient landscapes that can withstand climate extremes.
For landscapes to be resilient, they need to be functional, which means water, carbon, minerals and nutrients are cycling between different parts of the system supporting a variety of biological organisms. The most fundamental of all these cycles, the 'make-or-break' requirement, is water.

Water: We Cannot Restore Ecosystems Without It

We cannot underestimate the primacy of water cycling to all projects that aspire to conserve and regenerate natural systems. Our landscapes depend on intricate water processes that interlink aquifers, soils, plants, waterways, atmosphere and climate. These processes not only hydrate natural systems, they function in concert with plants to buffer and dissipate the colassal energy of the sun. Human impact, most significantly the mass removal of vegetation, has disrupted these water patterns.[5] As climate change quickens and amplifies the drought/flood cycle, we must ensure that our degraded catchments can manage rainfall effectively so that it heals and replenishes our landscapes and does not further erode them. With strategic interventions, we can do this. We have ample evidence from around the world that broken water cycles can be repaired.

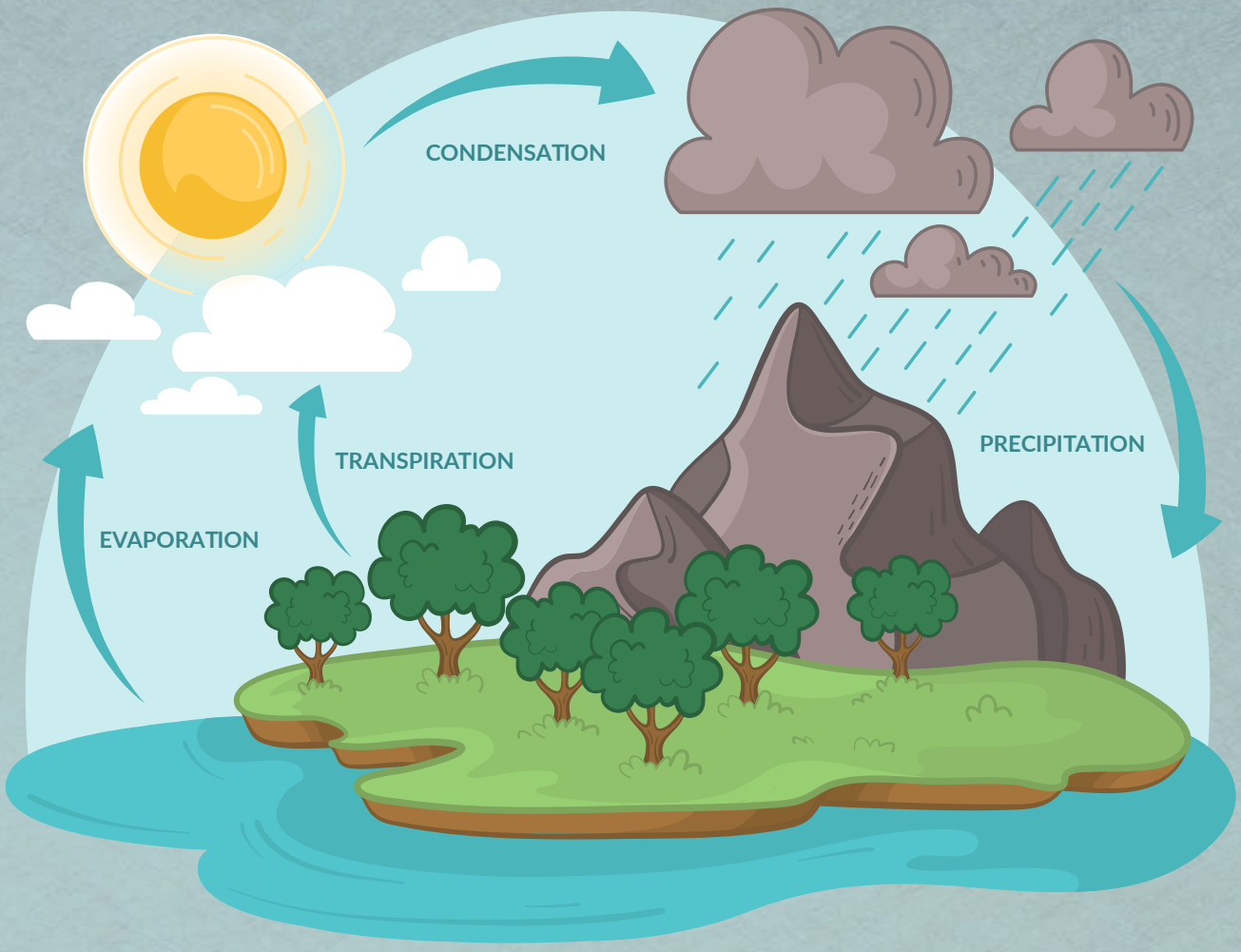


Figure 1: The Water Cycle.

Natural Infrastructure: The Best Tool for Water Cycle Repair

There are nature-based solutions, backed by science, that have succeeded at scale in regenerating desiccated landscapes and have vastly improved water quality, soil health and habitat.[6] These strategies revolve around natural infrastructure, or 'landscape rehydration infrastructure'.[7] These approaches mimic the templates provided by nature that have optimally guided the movement, infiltration and storage of water for millennia. Where recent land degradation has caused water to move too fast, draining our catchments rapidly after rain, these interventions reinstate water's slow phases.[8] Where human impact has severed hydrological connections between different parts of the landscape, these methods rebuild them. In short, these solutions re-establish the functional water cycling necessary for regeneration. They can be transformational at the scale of a single property, however they are most powerful when implemented at the sub-catchment or catchment scale, where they can catalyse whole-of-system change.[9]

Outdated Environmental Regulation is Impeding Restoration

The critical barrier impeding these strategies is, paradoxically, Australia's own environmental regulatory system. Activities on waterways are managed by multiple government agencies in each state and territory. This constellation of legal frameworks exists for understandable reasons: primarily to prevent developments from exacerbating environmental damage and to extract offsets where damage cannot be avoided or minimised. It was never designed to prevent

environmentally conscious landowners and expert eco-restoration practitioners from repairing degraded landscapes, yet this is exactly what is occurring across the country. Water-focused restoration projects are being stalled by complex approval processes that are prohibitively time consuming and expensive (see Part B: Inflexible Regulation, p15). The weight of process-driven regulation has made regulators risk-averse. A focus on short-term potential risk rather than long-term environmental outcomes, good or bad, has created a regulatory system geared to preserving damaged landscapes rather than restoring landscapes to functional resilience. We have no national environmental standards to guide proactive projects, and very little government funding directed to holistic catchment management.[10] In this vacuum, the implementation of environmental regulation is perversely hindering the systems-level environmental restoration we urgently need.

Proposed Solution: A Code of Practice

This paper proposes a simple, nationally led strategy to address this problem: a 'Code of Practice'. Codes currently work very well in many industries to provide integrated compliance frameworks. A National Code for Landscape Rehydration & Restoration could function in a similar way. With this mechanism, the financial costs incurred by those delivering land stewardship initiatives would be spent directly in pursuit of catchment rehabilitation works.

This Code could:

- streamline approvals processes and remove cost-barriers for eco-restoration
- create an outcomes-based approach to environmental regulation, in place of a process-driven approach
- foster collaboration between government agencies, First Nations groups, NGOs, universities and communities
- de-risk investment in restoration projects, accelerating the Nature Repair Economy
- empower communities to mitigate climate risk and enhance natural disaster preparedness and resilience
- create professional pathways for environmental leadership in agriculture, natural resource management and eco-restoration financing.

The NSW Crown Lands Commissioner recently suggested it was necessary to "simplify the assessment and approval requirements for environmental works to a single approval". A Code would go a long way to achieving this.[11] Indeed, as noted below, a Code would align with the recommendations of multiple government initiatives and inquiries that attest to the need for a cooperative, whole-of-landscape, outcomes-based approach to environmental governance. In the Schedule to this document, we suggest relevant criteria that could inform the development of this Code.

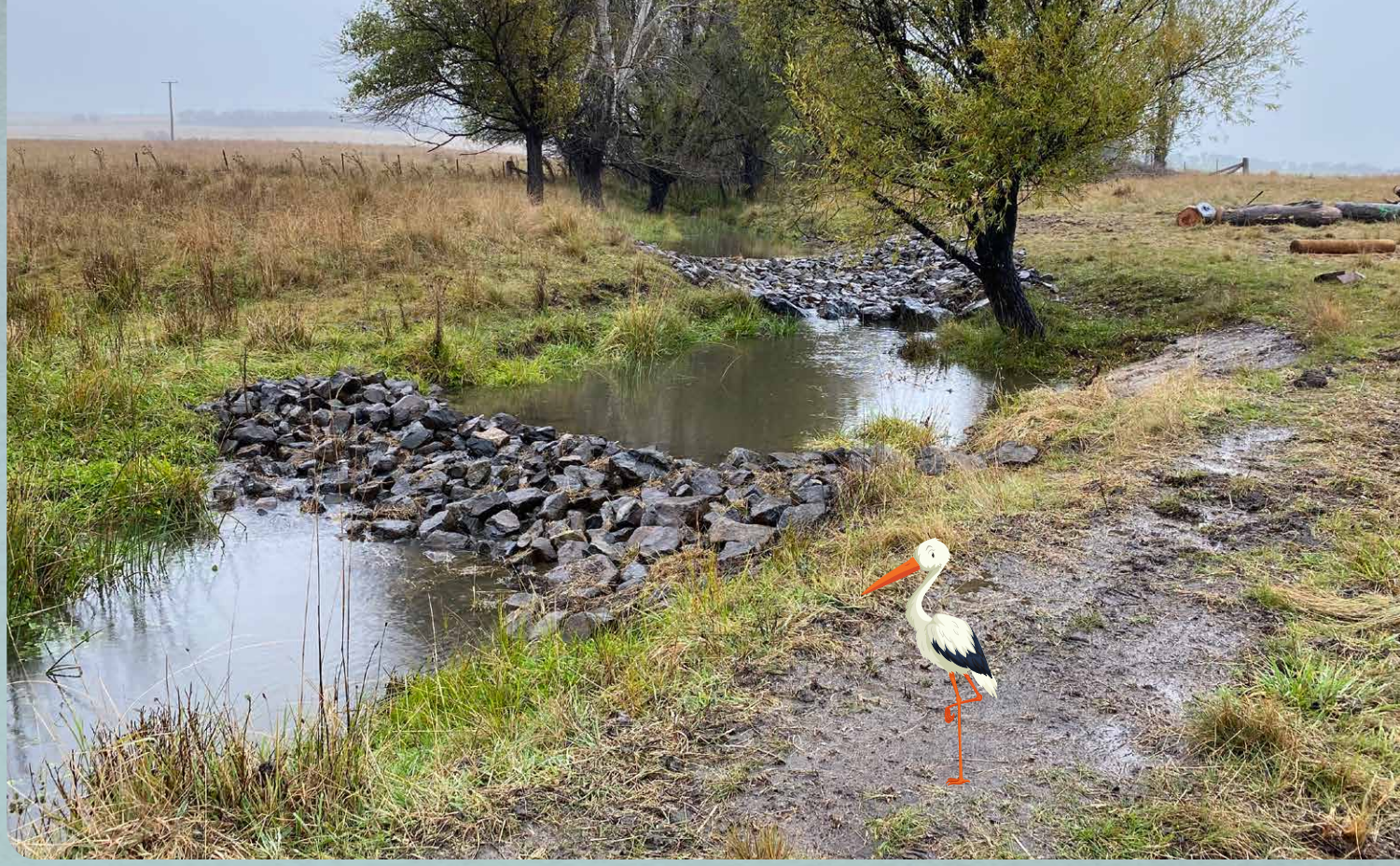


Figure 2: Landscape rehydration infrastructure (leaky weir) installed at 'Lorrina', Braidwood NSW, two days after construction, 2023.

Function & Benefits of Landscape Rehydration Infrastructure

The NSW Government's draft 'Landscape Rehydration Infrastructure Guide' details and acknowledges the benefits of carrying out natural infrastructure projects.[12] As it describes, these projects involve physical infrastructure built from natural materials that restore the natural flow of water through Australian landscapes. Works includes 'leaky weirs' and related projects such as rock ramps, contour banks and watercourse plantings. Terms used for similar structures in other jurisdictions include: 'bed control structure', 'porous check dam' and 'beaver dam' (see Appendix B). They contribute to the re-naturalisation of surface and near surface flow patterns, and lead to the re-establishment of geomorphic features such as wetlands, chains of ponds and/or swampy meadows. With respect to water cycling, these benefits may be summarised as:[13]

- reducing stream water velocity
- moderating stream discharge – lower peak flows and increased low flows
- protecting streambanks from erosion
- increasing the flows of currently intermittent streams
- creating moderated micro-climate
- increasing the amount of water available during dry periods
- raising the level of a lowered alluvial water table
- capturing sediment and filtering water
- optimising the cycling of nutrients and the capture of carbon.

The environmental benefits that flow from improved water cycling may be summarised as:

- improving landscape function and resilience to climate extremes
- restoring riparian and aquatic habitat
- reducing suspended sediment, benefitting aquatic biodiversity
- reducing the movement of pollutants and nutrients from agriculture through catchments
- re-establishing native vegetation
- providing more diverse biodiversity habitat.

The Guide concludes that landscape rehydration can:

- improve agricultural productivity by supporting actions that reduce soil erosion and hydrate soils
- facilitate best practice land management in the agricultural sector of the economy
- encourage ecological restoration works that can provide broad ecosystem benefits with respect to water quality and availability, soil health, biodiversity and native habitat.

Landscape Rehydration Infrastructure works are not a 'one size fits all' approach – they are engineered to a specific catchment context to ensure their immediate structural integrity. Their long-term integrity relies ultimately on vegetation establishment on and surrounding the structures. These solutions do not 'dam' water or prevent its transmission downstream. They are always permeable. They are designed to capture sediment, natural debris and organic matter (thus facilitating the re-establishment of the natural structure and functionality of streams and wetlands), while allowing water to filter through slowly. Hydrological data gathered by the Institute in relation to the functioning of the Mulloon Rehydration Initiative indicates no net loss of water to users downstream.[14]

Figure 3: Landscape rehydration infrastructure (leaky weir) installed at 'Palerang', Mulloon NSW, 2022.

How Australia's Inflexible Regulation Impedes Restoration

Currently, state and territory regulation exhibits the characteristics critiqued by the Independent Review of the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).[15]

- They rely heavily on detailed prescriptive processes that are convoluted and inflexible.
- They are too focused on the approval of individual projects rather than ecological protection.
- They sideline real engagement with environmental outcomes in favour of prescriptive and perfunctory considerations and checklist criteria.
- They focus on short-term risk rather than long-term outcomes.

These compliance processes actively deter landowners and eco-restoration professionals from carrying out projects that could restore our ailing catchments. The process of gaining government approval typically requires:

- individual approvals for each structure
- individual submissions for each separate landowner in a catchment
- separate and individual approvals from multiple government departments (water, planning, environment, fisheries, etc.)
- expensive expert reports.

To receive these approvals landholders are required to submit some, if not all, of the following documents:

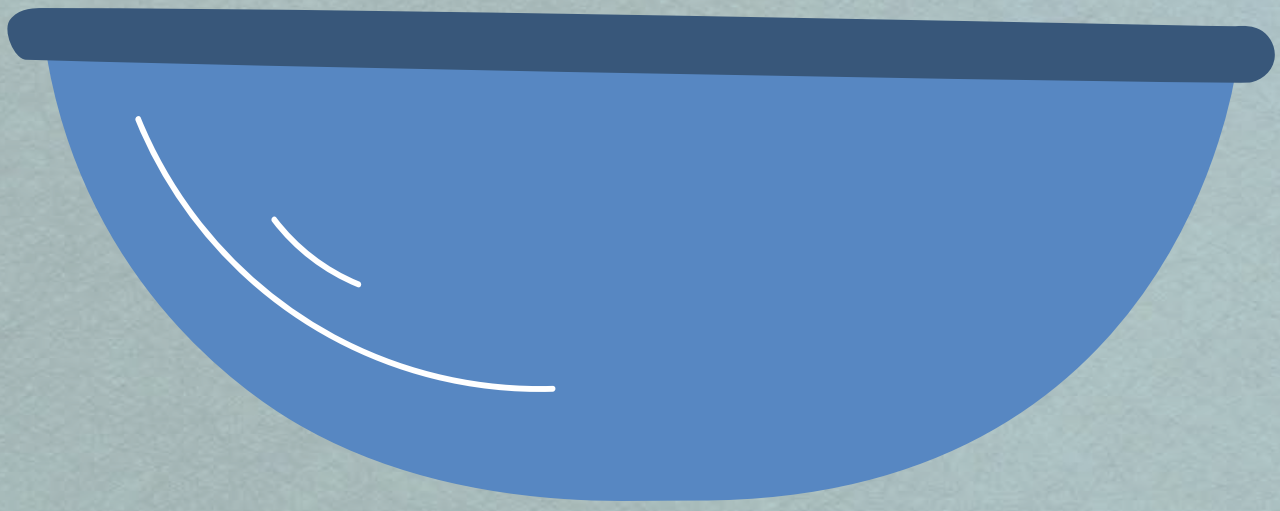
- environmental impact assessments
- development applications
- site descriptions
- engineering designs
- hydraulic modelling reports
- vegetation management plans
- sediment and erosion control plans
- biodiversity assessment reports
- fish studies and fish management reports
- water access applications
- cultural heritage assessment reports.

These approval steps were originally designed to prevent or lessen environmentally harmful impacts of development. Now they add enormous economic, administrative and time burdens to projects that are designed to be environmentally beneficial.

For example, the Mulloon Institute has spent over $450,000 and waited more than 36 months to receive final approvals to rehabilitate the Mulloon Creek catchment in NSW. The Institute and other eco-restoration practitioners have experienced similar costly and time-consuming regulatory hurdles right across Australia. Some examples are provided in Part B.

"Humanity's dependence upon the quality of the biosphere, in both social and economic dimensions, is as immutable as the laws of physics. The case for giving primacy to environmental repair is inescapable. Our future depends upon it."

Dr Ken Henry AC,
Foreword, Independent Review of Biodiversity Conservation Act 2016.[16]



Alignment with Government Reports & Initiatives

This proposal suggests how Australian governments can take shared responsibility for breathing new life into degraded landscapes. Its rationale and objectives are aligned with the recommendations of many government reviews and initiatives, including:

1. The **Independent Review of the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBCA)**:

   "The EPBC Act does not facilitate the maintenance or restoration of the environment. The current settings cannot halt the trajectory of environmental decline or manage cumulative impacts. The settings of the Act cannot mobilise the large-scale restoration needed and support future development in a sustainable way. Reversing this unsustainable trajectory will require planning to manage the environment on a national or regional (landscape) scale, as well as broad scale investment in restoration. To do this effectively and efficiently, a fundamental shift is required – from a transaction-based approach to one that is centred on effective and adaptive planning."[17]

   and

   We need *"National Environmental Standards... that focus on outcomes for matters of national environmental significance and on the fundamental processes for sound decision-making. Standards should prescribe that all activities contribute to national environmental outcomes... Ultimately, governments should shift their focus from individual project approvals to a focus on clear outcomes, integrated into national and regional plans for protecting and restoring the environment and plans for sustainable development."*[18]

2. The **National Statement on Climate Change and Agriculture** is committed to:

   "enhancing consistency and alignment of policies and programs, and sharing insights and capabilities across jurisdictions to advance best practice"

   and it supports initiatives that:

   - target increased productivity
   - improve resilience to a warming climate
   - connect with First Nations' communities.[19]

3. The **Report of the Royal Commission into National Natural Disaster Arrangements (2020)** recommended a ''whole-of-nation", "whole-of- government" and "whole-of-society cooperation and effort" to reduce disaster risk and increase disaster resilience.[20]

4. The **NSW Crown Land Commissioner's Review of the Implementation of the Crown Land Management Act 2016 (CLM Act) (2021)**

   "There is a need for a more proactive approach to achieving environmental outcomes on Crown land, which can be facilitated through the removal of legislative impediments. Currently environmental protection, restoration, rehydration or enhancement works require the approval or concurrence of multiple authorities and departments. Greater coordination and flexibility is required for future approaches to environmental management of Crown land."

   and:

   *"**Recommendations 26:** Simplify the assessment and approval requirements for environmental works to a single approval."* [21]

5. The **Independent Review of the Biodiversity Conservation Act 2016 (NSW)***:*

   "The focus of the Act should be shifted from threatened entities to strategic planning and management of biodiversity to ensure nature positive outcomes... A nature positive framing of the Act requires a substantial change in mindset, policy and program design, and dedicated resourcing. However, the Review Panel considers that nature positive is not only an environmental necessity, but crucial for underpinning future economic growth and wellbeing."

   *"**Recommendation 1:** ...the Act should commit to:*

   - *halting and reversing biodiversity loss and ecosystem collapse*
   - *restoring threatened species and ecosystems, ensuring the ecological and evolutionary potential of species and employing a landscape-level focus to building resilience and adaptive capacity, especially with respect to climate change."*

   *"**Recommendation 52:** Facilitate the investigation and development of instruments and methods that overcome barriers to participating in emerging nature markets and valuing and investing in natural capital."*

   *"**Recommendation 56**: Consider legislative reform to align relevant Acts with a nature positive outcome."*[22]

6. The proposed **Nature Repair Market** to "enable landholders who protect, manage or restore local habitat to receive biodiversity certificates which can then be sold to other parties"; and to "encourage projects with carbon sequestration and biodiversity outcomes."

   Notably, Environment Minister Tanya Plibersek stated when introducing the Nature Repair Market Bill 2023, that: "We're supporting landholders including farmers and First Nations communities to do things like... repair damaged riverbeds...." when in fact, state and territory regulation prevents them from doing this.[23]

7. The objectives of the Code are also consistent with the purpose of the **Future Drought Fund** to "support Australian farmers and communities to prepare for and become more resilient to the effects of future drought."[24]

8. The **Basin Plan Evaluation 2020** admits that, "the Basin Plan is unable to effectively support many floodplain and wetland ecosystems until implementation of critical improved water infrastructure and river operating rules are in place." It refers to the "complexity of the water policy and management system" and that, "the number of different government agencies involved is confusing and has worn down community confidence." It calls for "increased targeted investment and support for actions that complement water management including catchment soils and vegetation health….." [25]

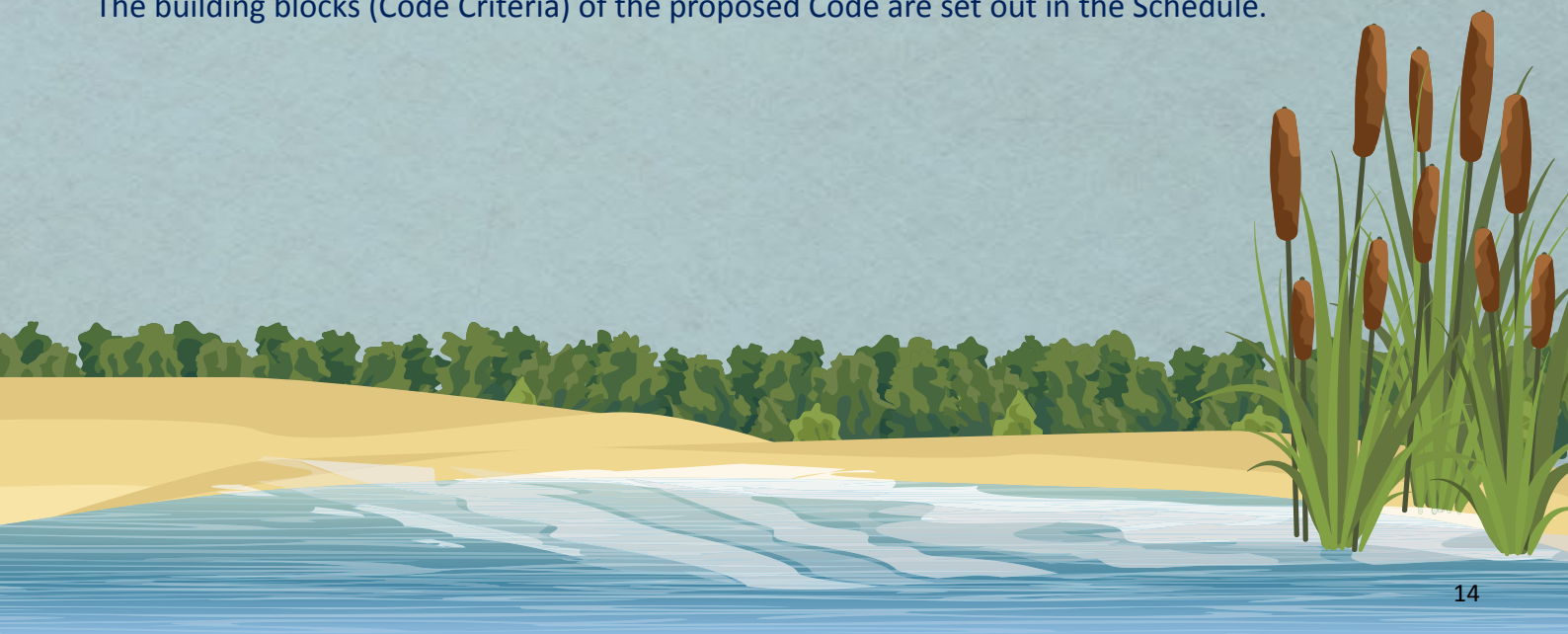
9. The **NSW Blue Carbon Strategy 2022–2027**:

   "There is an opportunity to streamline and simplify approvals for restoration projects to assist with reducing upfront costs and increasing investment certainty and project take-up."[26]

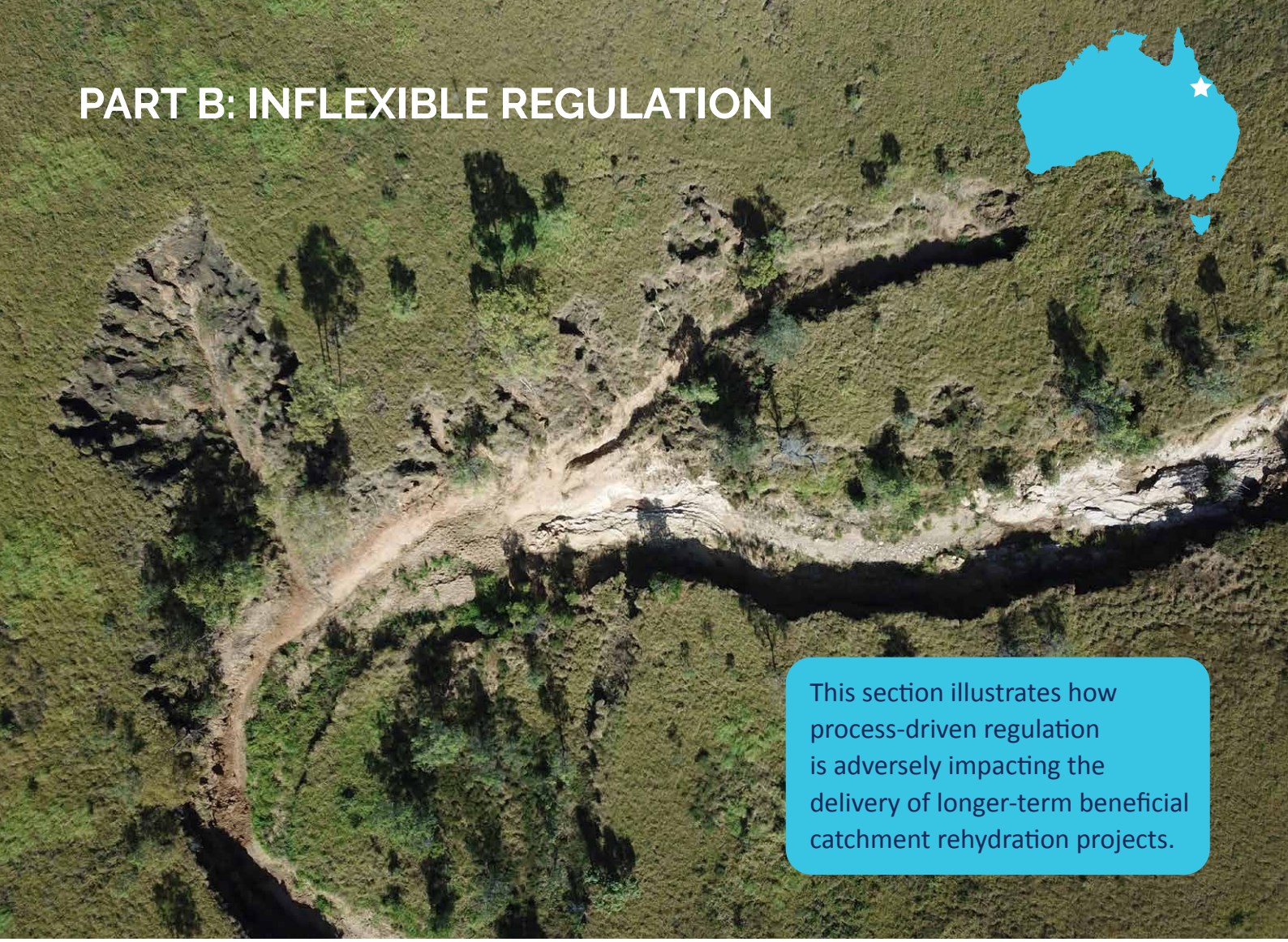
How Will It Work?

The Code creates a governance mechanism for taking a cooperative, whole-of-government approach to beneficial environmental projects.

By removing the expense and complexity of the current process-driven system of environmental regulation and replacing it with an outcomes-based approach for projects that will have proven or anticipated environmental benefits, this will assist us to meet the objectives of land rehydration and counter threats triggered by climate change by accelerating the uptake of climate resilient restoration projects. If predictions about the impacts of climate change are correct, we don't have much time left to fundamentally change how we re-think and apply environmental regulation. The building blocks (Code Criteria) of the proposed Code are set out in the Schedule.



PART B: INFLEXIBLE REGULATION



This section illustrates how process-driven regulation is adversely impacting the delivery of longer-term beneficial catchment rehydration projects.

Figure 4: Water formerly flowed through these incised gullies carrying sediments into the Great Barrier Reef lagoon, pictured here in 2021.

Case study:

WEETALABA STATION LANDSCAPE REHYDRATION DEMONSTRATION SITE (QLD)

Summary

The project (which would have improved fish stocks) was abandoned in its original location because it could not meet the regulatory requirements of the Fisheries Department.

Project

Weetalaba Station is a 20,800 hectare cattle station located near Newlands within the Whitsunday local government area in Northern Queensland. The Weetalaba Station Landscape Rehydration Demonstration Site aimed to showcase how Landscape Rehydration works can be used to reduce the amount of sediment reaching the Great Barrier Reef while achieving co-benefits of increased soil moisture, improved biodiversity and increased agricultural productivity.

NQ Dry Tropics engaged Mulloon Consulting as a subcontractor and funded the project through the Great Barrier Reef Foundation. The project was part of a $5 million water quality investment made in the Bowen, Broken and Bogie (BBB) catchment, a high priority catchment for fine sediment reduction into the Great Barrier Reef lagoon.

Problem

Current land degradation has resulted in:

- dehydration of the surrounding landscape
- threatened stands of remnant vegetation
- high rates of sediment export threatening impacts on the GBR lagoon
- reduced agricultural productivity
- flows in the gully that only run for one hour following a rain event.

Solution

To use a combination of a dam, leaky weirs and contour banks to:

- save at least 100 tonnes of sediment annually reaching the Reef
- protect remnant native vegetation
- rehydrate 600ha of landscape
- increase agricultural productivity.

Regulatory requirements

The proposed sites for the dam and leaky weir structures were located on a stream identified by the Queensland Government Department of Agriculture and Fisheries (DAF) as having “moderate fish passage values” which meant they required Development Approval (DA). This would lead to a significant increase in project costs through:

- time spent re-surveying and redesigning Landscape Rehydration interventions (>50 hrs)
- time spent preparing documentation for the DA process (>70 hrs)
- engaging external support from fisheries experts to approve the design ($6,800 + travel, accommodation and day rates for construction oversight)
- monitoring of fish in the system before and after by an accredited fish passage biologist
- increased construction costs to meet design requirements (>50% machine hours).

Result

Following a review of the project and the prohibitive costs associated with meeting DA requirements, it was clear Mulloon Consulting could not deliver the project on time and on budget. A solution that could have produced the desired result was forestalled by process-driven rather than outcomes-driven regulation. A new location on Weetalaba Station was then identified to continue the project.

Sedimentary savings and costs

At completion of the relocated project the total suspended sediment savings (TSS) was finalised by the Gully Erosion Control Assessment Tool at 257 tonnes per year. The cost of the erosion control measures as constructed was $602.55/tonne.

Commentary

In Queensland's current regulatory environment surrounding fish passage, the stipulations around "waterway barrier works" appear to be based around the current presence and scale of any landscape feature in which water moves, regardless of whether that feature is a result of agricultural land use (as is the case with gullies like this one).

This provides the regulator with limited scope to consider historic landscape condition or the trajectory of degradation, as well as the positive result of works that will reinstate landscape function and stabilise erosion sites. It is especially challenging when working in the Reef catchment area, as it impedes projects that have the potential to achieve huge sediment savings on eroded gullies that have recently formed.

Often these gullies are automatically mapped by the DAF as if they are streams that have fish passage value, even when assessments of the historic landscape indicate that there had formally been no stream.

This regulatory barrier is not only limiting investment into viable sediment saving projects to protect the Great Barrier Reef, but it will also limit future investment in activities such as nutrient or carbon storage in wetlands or landscape repair through Landscape Rehydration.

Figure 5: Conducting a site assessment of a five-metre deep erosion gully on 'Weetalaba Station' QLD, 2021.

Figure 6: Looking downstream at the lower end of the Carwoola floodplain in the Southern Tablelands NSW, 2020.

Case study:

MOLONGLO CATCHMENT REHYDRATION INITIATIVE CARWOOLA – STAGE 1 (NSW)

Summary

A project funded by a local landowner and the Mulloon Institute to restore the breeding habitat of the last population of the endangered Green and Golden Bell Frog on the Southern Tablelands has been delayed for years by the necessity to address regulatory requirements, which could include the need to provide $600,000 of biodiversity offset credits. If this requirement is enforced, it could see the project become financially unviable.

Project

The Molonglo Catchment Rehydration Initiative (MCRI) aims to restore the function of the upper Molonglo River floodplain to close to its natural state by implementing targeted interventions, including instream structures and floodplain earthworks. The MCRI will take place on two properties, Carwoola Station (Stage 1) and Foxlow Station (Stage 2), with a staged implementation. This project pertains to the Carwoola Station (Stage 1) component of the MCRI.

[Source: JJ Harrison, CC BY-SA 3.0 <https://creativecommons.org/licenses/by-sa/3.0>, via Wikimedia Commons]

Figure 7: Green and Golden Bell Frog.

Problem

The site supports an important population of the nationally endangered Green and Golden Bell Frog (GGBF), being the last known population in the Southern Tablelands. This project is seen as a critical step in improving the habitat to arrest the decline of that population.

Regular annual monitoring of this population since 2016 has been funded under the NSW Government's Saving our Species (SoS) program. Additionally, the SoS Program has provided funding to the Mulloon Institute to support the initial investigations and preparation of a scoping report for this project. The results of the SoS monitoring indicate that this population is in severe decline and expert advice of herpetologist, Sam Patmore, is that the population is at significant risk of localised extinction in the next few years in the absence of intervention (i.e. the "do-nothing" option).

Solution

The project includes the installation of eight in-stream structures on the Molonglo River channel, 16 earthwork interventions aimed primarily at restoring flood flows along secondary floodplain channels, and two constructed wetlands to enhance habitat for the GGBFs.

The Mulloon Institute has received grant funding of $170,000 through the NSW Environmental Trust's Environmental Restoration and Rehabilitation Program for contruction of the project up to 2025. The landholder and the Mulloon Institute have also contributed significant funds towards the project to support the completion of project investigations and preparation of detailed designs and legislative approvals.

The Institute has recently been successful in securing further grant funding of $170,000 through the NSW Environmental Trust's Environmental Restoration and Rehabilitation Program to progress design and approvals for the Foxlow Station (Stage 2) component of the MCRI.

Regulatory requirements

This project is subject to regulation under the following Commonwealth and state legislation and planning instruments:

- Environment Protection and Biodiversity Conservation Act 1999 (Cth)
- Biodiversity Conservation Act 2016 (NSW) (BCA)
- Environmental Planning and Assessment Act 1979 (NSW) (EPAA)
- Fisheries Management Act 1994 (NSW)
- Water Management Act 2000 (NSW)
- National Parks and Wildlife Act 1974 (NSW).

Biodiversity Conservation Act 2016 (NSW)(BCA)

To meet the requirements of the BCA, a Biodiversity Development Assessment Report (BDAR) is required for the project in accordance with the NSW Biodiversity Offset Scheme (BOS) and Biodiversity Assessment Method (BAM) if the project has a significant impact on the habitat of threatened species or endangered ecological communities. Up to 3.2ha of grasslands will be impacted during the construction phase. The BAM method assumes this impact is permanent and does not enable the broader biodiversity benefits of restoring the floodplain function across the project site or the expected re-establishment of grasslands in impacted areas to be considered.

Umwelt has prepared a draft BDAR on behalf of the Mulloon Institute, in which the BAM has determined that the following biodiversity credits would be required to offset the impacts of the Project:

- PCT 1110 River Tussock – Tall Sedge – Kangaroo Grass moist grasslands of the South Eastern Highlands Bioregion, 28 credits
- Green and Golden Bell Frog (*Litoria aurea*), 20 credits.

Figure 8: Carwoola floodplain on the Molonglo River, flanked by *Poa labillardierei* grassland – generally the dominant grass in this wet natural temperate grassland, 2020.

Figure 9: Looking upstream on the Molonglo River, Carwoola floodplain in 2020. Note: constructed levee bank adjacent to river channel from the 1970s.

Result

Based on recent project examples, Umwelt has advised that credits for PCT1110 are around $20,000/unit and GGBF credits are around $6,000/unit. In total, this would amount to over $600,000 in offsets.

The project, which is not being conducted for the commercial benefit of any party, may be abandoned if offsets are enforced.

Commentary

This is a perverse outcome given the intent of the project is to improve biodiversity outcomes by restoring the floodplain function, which in turn is expected to create an overall benefit in the longer term for both River Tussock and the Green and Golden Bell Frog.

More broadly, this has potentially significant consequences for the viability of future restoration projects aiming to reinstate landscape function and improve biodiversity outcomes. If the BOS is enforced, the Mulloon Institute is proposing to request a credit reduction for both threatened entities on the basis that this project will encourage greater biodiversity values in the long-term survival of both the Natural Temperate Grassland and the breeding and foraging habitats for the Green and Golden Bell Frog.

Figure 10: Landscape rehydration workshop for the Carboor Bobinawarrah Landcare Group conducterd in 2022.

Case study:

CARBOOR BOBINAWARRAH LANDCARE GROUP (VIC)

Project

The Mulloon Institute was engaged by the Carboor Bobinawarrah Landcare Group in early 2022 to run educational workshops and oversee a demonstration site, funded by a grant gained through the Murray Darling Healthy Rivers Program.

In March 2022, the Institute met with local landowners and completed designs for four structures. Mulloon's technical drawings, photos and other supporting information on the design and construction for ' leaky weirs' were forwarded to the North–East Catchment Management Authority (NECMA).

Regulatory requirements

NECMA initially advised that the project should be able to proceed through the Works on Waterways process with the Catchment Management Authority (CMA), but that Goulburn Murray Water (GMW) might consider these structures as dams and this would change the process for a permit.

If GMW determined that the structures were considered to be 'dams' then a 'take and use' component (licenced through GMW) would also include a requirement for GMW to issue a Licence to Construct Works. The definition of a dam under the Water Act 1989 (Vic) is, *"anything in which by means of an excavation, a bank, a barrier or other works water is collected, stored or concentrated" (s.3)*.

The CMA then deemed that these structures would function as online dams and that approval must be sought from GMW. After discussions with GMW, it was determined that the leaky weirs would constitute dams and would therefore be required to go through the Works on Waterway process through GMW.

This process could involve the following outlays and processes:

- $610 – fee for GMW to determine whether the stream was a 'waterway'
- completion of field surveys to determine the dimensions of levels/ gradients/waterways
- $1,530 – cost of permit application to GMW for approval, but at this point GMW unsure whether one permit would cover all four structures
- GMW to refer back to NECMA and the Department of Energy, Environment and Water for further consideration
- $4,000–5,000 – expenditure to date to get to this point, with process likely to take 8–12 weeks with uncertain outcomes
- $12–14,000 – estimated cost of running a two-day workshop on-site, however, the Group had no provision in the grant for this expenditure
- under the terms of the grant, the whole project had to be wrapped up and reported by 7 November 2022.

Results

The Landcare Group worked very hard to gain approvals to create the demonstration site, but were unsuccessful because with a limited budget they were unable to meet the regulatory demands.

Commentary

This project did not proceed because of perverse regulatory requirements that centred on definitions and processes that are out of date and did not engage with the beneficial outcomes that could be delivered by the project.

PART C: MULLOON REHYDRATION INITIATIVE[28]

Figure 11: Landscape rehydration infrastructure (leaky weir) at 'Westview', Mulloon Creek NSW, 2020. Two years after installation.

MULLOON REHYDRATION INITIATIVE

Figure 12: 'Home Farm', Mulloon Creek NSW, 2015.
Figure 13: 'Home Farm', Mulloon Creek NSW, 1977.

Case study:

Location:	Southern Tablelands, NSW
Size:	23,000ha, 50 kms creek
Participants:	23 landholders

Project Summary

This catchment-scale project aims to rebuild the natural landscape function of the Mulloon catchment and boost its resilience to climatic extremes for more reliable stream flows, improved ecosystem functioning and enhanced agricultural productivity. The project includes the development and implementation of a comprehensive Integrated Monitoring Plan.

The Mulloon Rehydration Initiative (MRI) is a model for landscape scale repair across Australia. It proves that properly devised interventions can lead to increased productivity, biodiversity and soil fertility and soil organic carbon, improved water quality and quantity and resilience to climatic extremes. The results of the project reflect healthier landscapes that enables the production of high quality, nutrient-dense food.

Australian Sustainable Communities Award

2020 Winners
'Response to Climate Change'

Mulloon Rehydration Initiative – Stage 1

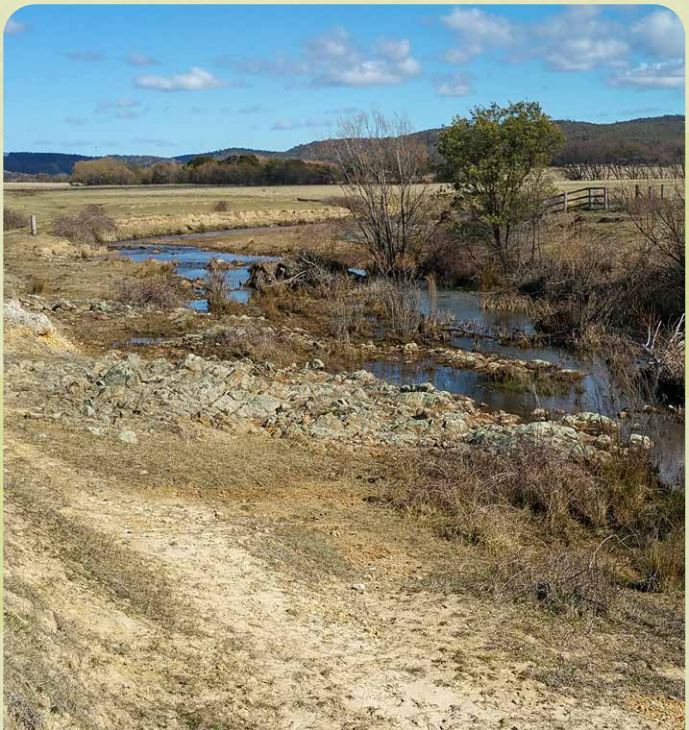
Figure 14: Landscape rehydration infrastructure (leaky weir) at 'Westview', Mulloon Creek NSW, 2020.

Problem

At Mulloon Creek, widespread land degradation has been caused by nearly 200 years of European-style land use, including agriculture, forestry and mining. The deep and chronic erosion of creeks and gullies has lowered the water-table, dried up wetlands and dramatically reduced the water holding capacity of the soils.

Solution

Reversing these threats through catchment-scale rehydration of the waterway and recreation of habitat by revegetating aquatic and terrestrial areas. Build whole-of-landscape resilience through increased and prolonged water and moisture levels, preventing future environmental damage, improving biodiversity and restoring and protecting habitat.



Restoring ecosystem function will improve soil health, as well as ground and surface water quality and availability through the filtering of sediments and recycling of nutrients. Increased soil moisture, combined with managed grazing approaches, can increase soil carbon levels. This, combined with the reinstatement of wetlands – traditional carbon sinks – can assist in sequestering carbon from the atmosphere and so contribute to addressing the global challenge of climate change.

Figure 15: Landscape rehydration infrastructure (leaky weir) at 'Westview', Mulloon Creek NSW, 2015.

Figure 16: Top contour pond installed at 'Duralla', Mulloon Creek NSW, 2021.

Regulatory requirements

This project is subject to various State regulatory requirements such as:

- Controlled Activity Approvals
- Site Descriptions
- Engineered Designs
- Hydraulic Modelling Reports
- Sediment and Erosion Control Plans
- Vegetation Management Plans
- Licence to work on NSW Crown Land
- Biodiversity and Cultural Heritage Assessments.

Figure 17: Top contour pond installed at 'Duralla', Mulloon Creek NSW, 2018.

Results

This initiative demonstrates the benefits of landscape scale repair and restoration works that have resulted in the sustained baseflow of Mulloon Creek. The waterway now has increased water quality and restored spongy wet floodplains which are more productive and provide valuable habitat for threatened and vulnerable species, including the Scarlet Robin, Diamond Firetail, and Dusky Wood Swallow.

A 'bringing the community along' approach has been developed to ensure all stakeholders, including landholders, regulators, researchers and the broader community, can engage with the catchment-scale project. This includes the education and capacity building of communities on the process of landscape rehydration and associated regenerative land management approaches.

Scientific baseline surverys were undertaken before the initiative was implemented and ongoing monitoring[29] is being done to record its impact on Mulloon Creek and surrounding catchment. An extensive monitoring framework looking at biophysical, social and economic factors has been developed, as outlined in the following peer reviewed paper:

> *Peel, L., Hazell, P., Bernardi, T., Dovers, S., Freudenberger, D., Hall, C., Hazell, D., Jehne, W., Moore, L., Nairn, G., 'The Mulloon Rehydration Initiative: The project's establishment and monitoring framework', Ecological Management & Restoration, Volume 23, Issue 1, 25-42, 2022*

This enables the impact of the restoration and rehabilitation works to be monitored in the long-term and demonstrates the crucial link between environmental, social and economic aspects of landscape repair. This valuable research will be shared publicly and the project will be used as a model of implementation in order to facilitate similar projects across Australia.

Further reading

https://themullooninstitute.org/projects#mri-section

https://themullooninstitute.org/s/2021Casestudy-MRI.pdf

https://themullooninstitute.org/case-studies

Acknowledgements

The Mulloon Institute has been recognised by the United Nations Sustainable Solutions Network as being one of five projects globally, as a demonstrator of sustainable, profitable and productive farming.

The Mulloon Rehydration Initiative is jointly funded through the Mulloon Institute and the Australian Government's National Landcare Program, with support from the NSW Government's Environmental Trust.

SCHEDULE:

CRITERIA FOR THE DEVELOPMENT OF A CODE OF PRACTICE FOR LANDSCAPE REHYDRATION AND RESTORATION

A Code provides an outcomes-based approach to decision-making that may be progressed through a co-operative relationship between landowners and regulators. This set of criteria and standards that will govern and guide the Code is not intended to be exhaustive; rather it focusses on the approach and principles needed to bring outcomes-based decision-making to fruition.

The Code criteria are based upon Standards that focus upon achieving the overall outcome of repairing the water cycle for the benefit of biodiversity, soil regeneration and agricultural productivity. Guidelines would be drawn up indicating how Code-compliant Landscape Rehydration Infrastructure (LRI) should be designed and structured.

Code compliant LRI would become exempt or complying development under the planning, environment, water, fisheries and heritage regimes of each state and territory. They would not need consent from any other state or local government entity.

The following standards, which we recommend should guide development of the Code, create both outcomes-based checklists for persons wishing to create Code compliant LRIs and also guidelines by which regulators can test compliance.

We anticipate that a final Code (containing these standards) will look similar to other Codes already operating in Australia (for example, the Building Code and the various codes for wind farm development).

For terms used, refer to Glossary (Appendix A, p39).

A. Demonstrated Competency Standard

1. When undertaking larger works or working in higher order streams, the relevant landowner or employees or contractor engaged to construct LRI works, ('the proponent') must have demonstrated competency to undertake the proposed LRI works. Alternatively, LRI works must be overseen by a person with such demonstrated competency.

2. Demonstrated competency may be shown by completion of a landscape rehydration course relevant to the complexity of the works proposed to be undertaken;[30] or the relevant person should be prepared in some other way to demonstrate competency to undertake or oversee the project.

   Experienced professional farmers often build their own bridges, roads and landscape engineering structures on their properties – it is expected these experienced professional farmers will have the competency to build LRI works to the Design Standard.

3. Competency may be demonstrated, for example, by proving understanding of the biophysical aspects of the landscape in which the work is proposed to be undertaken, including:
    - geology
    - geomorphology
    - soils
    - biodiversity (both terrestrial and aquatic)
    - catchment hydrology and hydraulics.

4. The Guideline could state that the level of competency required to implement an LRI scheme must be measured against:

    - size and landform of a catchment
      (larger waterways with significant flow will require persons with more specialised competencies)
    - catchment condition
    - annual catchment yield
    - 1% annual discharge exceedance probability (1% AEP).

For example, in an agricultural setting, an appropriately trained landholder or contractor could confidently undertake landscape rehydration works in a waterway with the following attributes:

- catchment size 1,000ha
- average slope of stream <2%
- 1% maximum discharge probably (1% AEP) 100 m^3/s
  (likelihood of any given event exceeding this volume in any given year).

5. The Nominated Government Authority (NGA) may ask the person or entity proposing to carry out LRI for proof of competency. If there is a dispute over proof of competency that cannot be resolved, the dispute must be referred to mediation in the nominated tribunal.

B. Compliance Standard

1. All LRIs must be constructed in accordance with the Code to receive exemption from state and territory consent requirements.

2. Before proceeding to construct LRI, the relevant landowner must inform the NGA of the intention to carry out a LRI on their land (Notice of Intent or NOI).

3. The NOI is intended to be a simple document in which the project proponent warrants that the LRI structure will be built in accordance with the Code. The NOI will include a map showing the proposed location of the works.

4. The NOI should be placed upon a public register available to other persons in the catchment (or available more generally). The NGA should be informed of any proposed material changes to the LRI or its location.

5. The NGA may choose to inform neighbouring and downstream landowners about the intention to proceed under the Code.

6. The NGA must release to the proponent all data held by any government instrumentality that is relevant to the proposed LRI.

7. The NGA may inspect the works as they proceed. The NGA may consult with other government agencies.

8. If there is a dispute about whether the proposed works are Code compliant and an agreement cannot be reached between the parties, the NGA must decide whether the works are Code compliant and may seek reasonable changes to improve the compliance of the structures. A dispute may be referred to mediation in the appropriate tribunal.

9. Breaches of the Code may be addressed by administrative remedies, such as stop work orders and soil conservation or land rehabilitation notices, as authorised under the relevant state and territory legislation.

10. Upon completion of works the landowner must inform the NGA (completion notice). The landowner must maintain the LRI according to the Maintenance Standard.

C. Design Standard

Landscape rehydration infrastructure is a leaky weir structure, located in-stream and where the structure partially slows and filters water flows. A fundamental feature of landscape rehydration infrastructure is that a leaky weir is part of a series of leaky weirs constructed along an entire stream, or part of a stream, in order to contribute to the rehydration of the landscape. Landscape rehydration infrastructure may include embankments, rock ramps, watercourse plantings, a fishway or a vehicle crossing on the top.

To be Code-compliant, the purpose of the LRI must be to:

- reduce the velocity of water flow by partially impeding the flow of a stream by an artificial obstruction
- maintain water in a stream and allow it to seep into adjoining soil in order to rehydrate the soil
- lift high flows out of an eroded stream and to revert that flow to the adjacent floodplain using embankments
- allow water to flow; it must be a permeable structure. The LRI must not be designed to stop the flow of water.

Leaky weirs

A leaky weir is often designed in the form of a log sill structure comprising logs placed in-stream and accompanied by a rock ramp/chute/rundown. Actively growing vegetation on and surrounding the leaky weir is also a key feature. The weir may also be designed in the form of a leaky gabion or wooden board structure, or a less formal structure using loosely placed woody materials.

- The design of the leaky weir must be compliant, as relevant, with:

  AS 1720:1—1997/Amdt 1—1998, *Timber structures (known as the SAA Timber Structures Code)—Design methods* if the structure is made of timber, and AS 3700—2011, *Masonry structures* and AS 3700 Supp 1—2004, *Masonry structures—Commentary (Supplement to AS 3700—2001)*.

Figure 18: Riparian vegetation being planted alongside leaky weir structures at 'Westview', Mulloon NSW, 2018.

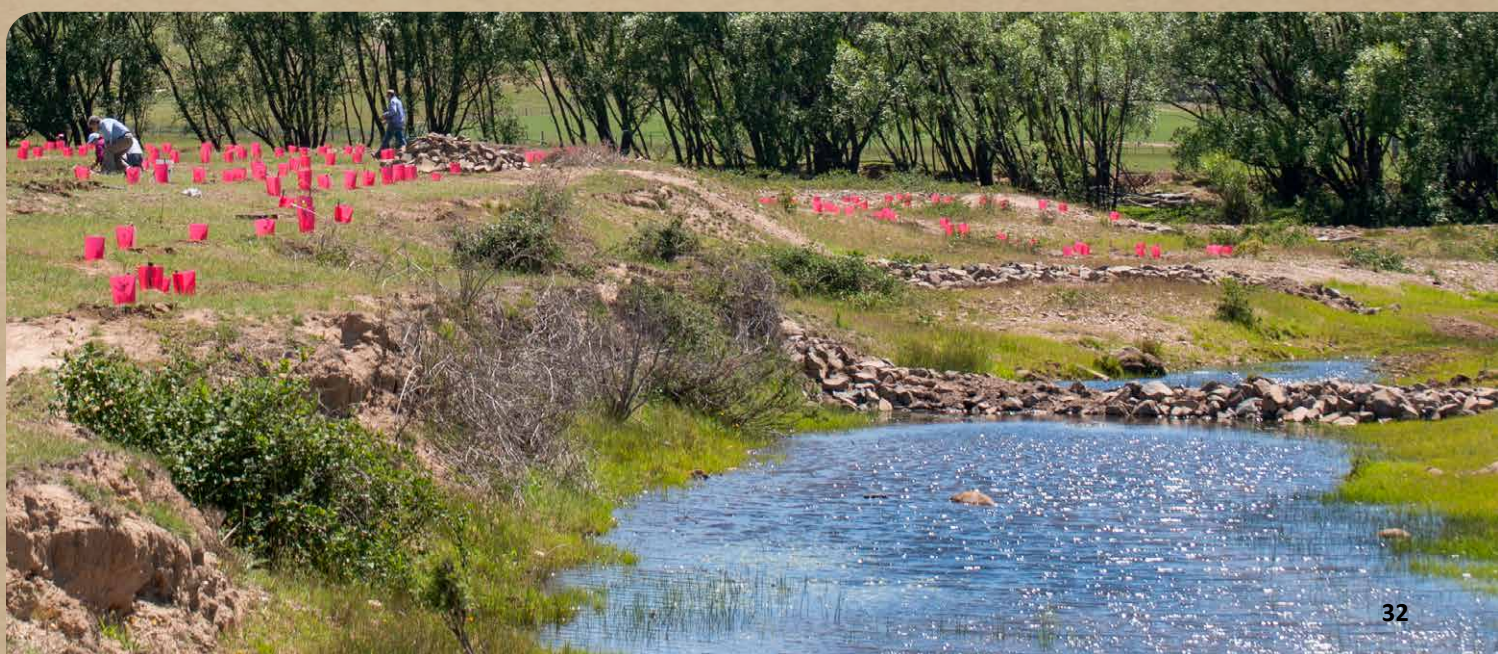


Figure 19: Example of a leaky weir using a log sill structure, under construction at 'Westview', Mulloon NSW, November 2018.

Figure 19 above shows a log sill structure under construction. The materials used include hardwood logs, pins to hold the logs in place, geofabric such as coir or jute, tie wire, coarse and fine sediment fill, rock, sod and topsoil, mulch, seeds and plants. More details of an example construction technique and methodology of a typical log sill structure can be found in Appendix B on page 42 of this proposal.

As the name 'leaky' weir implies, during normal flow conditions the weir is not a barrier to flow. During drought-like conditions, water would continue to flow under and through the weir. The design and construction technique ensures that slow moving water can filter through the rock and coarse sediments of the weir or the bed below. The pool of slow-moving water backed up behind the weir soaks into the ground on either side of the stream, providing more moisture for plant growth.

Figure 20: Design of a log sill structure by the Mulloon Institute.

Figure 21: Log sill structure after construction at 'Westview', Mulloon NSW, December 2018.

The ponds of water upstream restore natural aquatic habitat for fish, frogs and numerous bird and insect species and can re-establish geomorphic features such as wetlands, chains-of-ponds, pond riffle sequences and/or swampy meadows.

Typically, more than one leaky weir is needed to be placed in a stream to meet the objectives of landscape rehydration and to recreate a more natural stream that would contain a chain-of-ponds. In practice, to create a chain-of-ponds would mean the first weir is constructed at the lowest point in the stream, then the next weir to be constructed is upstream of the first weir, and so on. The location of the second leaky weir is designed so that the water flowing from the second weir meets the backwater (pond) of the first leaky weir.

Figure 22: Plants take hold in the rock ramp to provide stability to the structure at 'Westview', Mulloon NSW, December 2020.

The purpose of this fundamental landscape rehydration infrastructure design parameter is that the water does not drop onto the stream bed. By designing to ensure 'water meets water' or 'water onto water' means that the water velocity reduces through this process and thus reduces potential erosion forces in-stream.

The design may include embankments, rock ramps and watercourse plantings. Embankments would direct the flood waters to flow overbank to the floodplain on higher ground. The long-term integrity relies ultimately on vegetation establishment on, and surrounding, the structure. The leaky weir has the result of encouraging the natural processes of vegetative debris and mulch accumulation to occur immediately upstream from the infrastructure, with vegetation then being able to take hold in and around the stream.

Embankments

In some circumstances, embankments can accompany leaky weirs within a rehydration scheme. As with leaky weirs, they are strategically placed and are generally constructed of earthen banks. Embankments lift high water flows out of an eroded stream/gully and revert that water flow to the adjacent floodplain. In so doing, the high flow event is transformed from a high energy, erosive gully flow into a low energy, spreading, depositional floodplain flow. Stream sediment is deposited on the floodplain thus improving fertility.

Rock ramps

Rock ramps are constructed in conjunction with leaky weirs and embankments or in any situation where a high-flow needs to spill back into a stream to prevent head cutting/erosion. Rock ramps allow high flows to safely fall from one level to another, for example from a floodplain surface to a gully floor or from one pond to the next. Long-term sustainability of a rock ramp requires armouring vegetation to grow over the ramp.

Watercourse plantings

For any leaky weir to be sustainable it needs to be a 'living structure.' Plantings in and around the structure need to be actively managed for several years to ensure that the plantings are contributing to, and not adversely affecting, the integrity of the structure or the broader system. Plantings contribute to the short, medium and long-term armouring of the structure and its surroundings.

Other catchment works

Other works may need to be undertaken throughout the water catchment to reduce the velocity and quantity of water flow across the land, and thus the velocity and flow of the water entering gullies and streams. Fast-flowing water has the effect of sweeping away the natural forms of streams together with much of its flora and fauna. Slow flowing water has less erosion ability and has time to seep into the soils.

Other catchment works such as overland water flow control works including constructed contour banks, and in-gully works including head-cut protection works, would not need development consent or other approvals.

An example of LRI Design Parameters is included in Appendix B on page 42.

D. Erosion and Sediment Control

All erosion and sediment control measures should be effectively maintained for the duration of the construction works and until such time as all ground disturbed by the works has been stabilised and rehabilitated so that it no longer acts as a source of sediment.

Figure 23: Triple Ponds structure, Mulloon Creek NSW – just after installation in 2006.

Figure 24: Triple Ponds structure, Mulloon Creek NSW – covered and stabilised by plant assemblages in 2013.

Figure 25: Planting native vegetation to support regeneration of the surrounding landscape, 'Westview', Mulloon NSW, 2018.

E. Biodiversity Standard

1. The LRI should be designed to avoid and minimise biodiversity impacts. Any short-term construction impacts should be significantly outweighed by longer term net gain to, or enhancement of, biodiversity values.

2. Re-establishment of plant assemblages along a stream where leaky weirs are constructed should be planned to:

    - stabilise and eventually completely cover the in-stream infrastructure
    - slow and spread stream flow
    - filter sediments and nutrients
    - improve water quality
    - rebuild the geomorphic structure of the stream
    - contribute energy (including sequestered carbon) to drive complex ecosystem processes.

3. LRI infrastructure should be designed to encourage the passage of native fish species upstream.

    We note that:

    - LRI that meets the Design Standard already provides excellent natural fish passages with full fish mobility during high flow events.
    - Evidence shows that the reversion of catchments to their natural 'chain-of-ponds' sequence encourages native fish species and discourages invasive species.

F. Heritage Standard

Impact of Below Ground (Sub-surface) Works – Non-Aboriginal Relics

- If any previously unidentified archaeological relics are uncovered during the course of the work, then all works shall cease immediately in that area and the landholder must contact the relevant government Heritage Unit. Depending on the possible significance of the relics, an archaeological assessment and an excavation permit may be required for further works in that area. Works shall not recommence until the applicant receives written authorisation from the Heritage Unit.

Impact of Below Ground (Sub-surface) Works – Aboriginal Relics

- If any previously unidentified Aboriginal archaeological relics are exposed during construction works, the Applicant shall immediately cease work and notify the nominated local Aboriginal Heritage Advisor. Works shall not recommence until an appropriate strategy for managing the objects has been determined in consultation with the Aboriginal Heritage Advisor.

G. Water Standard

Leaky weirs or any other LRI works must not impound water unless justified within the Scheme.

H. Maintenance Standard

- The LRI must be inspected at regular intervals, including immediately following an extreme climatic event.
- Where necessary, maintenance or repair work should be carried out promptly.
- Maintenance or repair works must comply with the Code.

Appendix A – Glossary

A guide to the terminology used in this Code, or terminology that may be useful.

Aquatic habitats

Includes all areas of land submerged by water, permanently or intermittently, and include both artificial and natural bodies of water. It includes wetlands, rivers, creeks, lakes, dry riverbeds and estuaries.

Biodiversity

The variety of living animal and plant life from all sources and includes diversity within and between species and diversity of ecosystems.

Biodiversity values

(a) vegetation integrity – the degree to which the composition, structure and function of vegetation at a particular site and surrounding landscape may be altered from a near natural state.

(b) habitat suitability – being the degree to which the habitat needs of threatened species are present at a particular site.

(c) biodiversity values – prescribed by regulations.

Chain-of-ponds

At the time of European settlement in Australia, a valley landform feature, recognised by the relative absence of trees, vegetative cover of grasses, rushes and sedges, and at times disconnected pools, was commonly ascribed as chain-of-ponds and swampy meadows.

Contour

A line along one elevation measurement. It is a line directly perpendicular to the slope (up and down).

Ecological community

An assemblage of species occupying a particular area.

Grade control structures

Leaky weirs are grade control structures. Grade control structures are designed to create a minor barrier to water flow, forming a pool on the upstream side under flow conditions and reduce the gradient of the channel for a section of the stream. A reduction in the gradient subsequently reduces the energy of water flow and provides an enhanced opportunity for sediment-capture and vegetation establishment.

Gullies

Channels deeper than 30 cm that cannot be removed by normal cultivation. Gullies occur when smaller water flows concentrate and cut a channel through the soil. Most gullies extend upslope as a result of the head of the gully being continually undercut and collapsing. However, collapse and slumping of sidewalls usually contribute a greater proportion of soil loss.

Habitat	*(a)* an area periodically or occasionally occupied by a species or ecological community, and *(b)* the biotic and abiotic components of an area.
Nominated government authority	Government authority nominated by a state or territory to whom reference should be made about competency and Code compliance matters.
Nominated tribunal	Tribunal or court nominated by a state or territory to whom appeals should be directed about competency and Code compliance matters.
Overbank flow	Flood condition where water flows beyond and sub-parallel to the main channel of a river, but within the bounding floodplain.
Riffle zone	Riffles are short segments of the stream where water flow is agitated by rocks. The rocky bottom provides protection for fish from predators, food deposition and shelter. Riffle depths vary depending upon stream size but can be as shallow as 2.5 cm or as deep as 1 m. The turbulence and stream flow results in high dissolved oxygen concentration.
Riparian	An area or zone within or along the banks of a stream or adjacent to a watercourse or wetland; relating to a riverbank and its environment, particularly the vegetation.
River 	*(a)* any watercourse, whether perennial or intermittent and whether comprising a natural channel or a natural channel artificially improved, and *(b)* any tributary, branch or other watercourse into or from which a watercourse referred to in paragraph (a) flows, and *(c)* anything declared by the regulations to be a river, whether or not it also forms part of a lake or estuary, but does not include anything declared by the regulations not to be a river.
Species	*(a)* a defined subspecies, and *(b)* a taxon below a subspecies, and *(c)* a recognisable variant of a subspecies or taxon, and *(d)* a population of a particular species (being a group of organisms, all of the same species occupying a particular area).

Strahler System

Method of determining the stream order of a watercourse shown on a topographic map.

(a) Any watercourse that has no other watercourses flowing into it is classed as a first order stream.

(b) If two streams join, the resulting stream is:

(i) the same order as the highest order of the two streams, or

(ii) if the two streams are of the same order, the order greater than that of the two streams.

For example, in the diagram below:

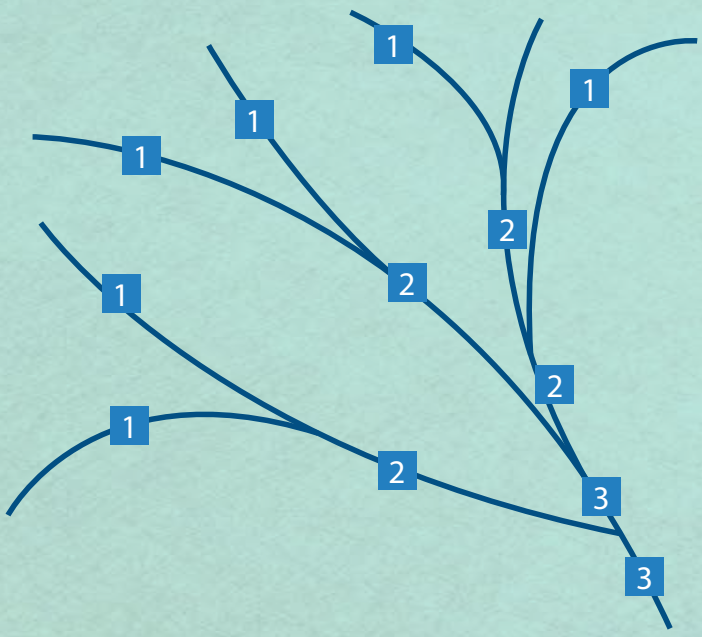


Figure 26: Strahler System illustrating first, second and third order streams.

(a) If two first order streams join, the stream becomes a second order stream (2).

(b) If a second order stream is joined by a first order stream, it remains a second order stream.

(c) If two second order streams join, they form a third order stream (3).

(d) If a third order stream is joined by a first or second order stream, it remains a third order stream.

(e) If two third order streams join, they form a fourth order stream.

Note: a 'river' is a third, fourth or higher stream order under the Strahler System.

Water table

Upper surface of a body of groundwater occurring in an unconfined aquifer. At the water table, pore water pressure equals atmospheric pressure.

Appendix B – Example design parameters of a leaky weir

Constructing a leaky weir is not a 'one size fits all' project. The placement and design of a LRI depends on context. For explanatory purposes, the design below reflects the construction of a typical structure.

Leaky weir using a log sill structure

- structure height 300–1500mm
- relative height above downstream structure no more than 400–500mm
- spill point – should be between 100–300mm lower than the edges with a cross-sectional gradient of no more than 2%
- gradient on face/spill side – no greater the 25% or 1:4
- gradient on back/pond side – no greater than 17% or 1:10
- rock size – determined based on the hydraulic forces acting on the structure at its final height. Rock should be sized based on the following formula. Rock should extend at least 1m up the bank on either side of structure.

Figure 27: Calculations from *Catchments & Creeks (2010) Gully Erosion – Part 3, Design of Rock Chutes for Gully Stablisation*.

Equation 1 represents the recommended design formula for sizing rock on the bed and banks of chutes. Tables 6 & 7 provide mean rock size (based on Equation 1 and rounded up to the next 0.1m unit) for safety factors of 1.2 and 1.5 respectively.
where:

$$d_{50} = \frac{1.27 \cdot SF \cdot K_1 \cdot K_2 \cdot S_O^{0.5} \cdot q^{0.5} \cdot y^{0.25}}{(s_r - 1)} \qquad \text{(Eqn 1)}$$

d_{50} = nominal rock size (diameter) of which 50% of the rocks are smaller [m]

K_1 = correction factor for rock shape
= 1.0 for angular (fractured) rock,
1.36 for rounded rock (i.e. smooth, spherical rock)

K_2 = correction factor for rock grading
= 0.95 for poorly graded rock ($C_u = d_{60}/d_{10} < 1.5$),
1.05 for well graded rock ($C_u > 2.5$),
otherwise $K_2 = 1.0$ ($1.5 < C_u < 2.5$)

q = flow per unit width down the embankment [$m^3/s/m$]

s_r = specific gravity of rock

S_O = bed slope = tan (θ) [m/m]

SF = factor of safety (refer to Table 1)

y = depth of flow at a given location [m]

Wherever practical, the unit flow rate 'q' ($m^3/s/m$), flow velocity 'V' (m/s), and flow depth 'y' (m) used to determine rock size should be based on 'local' flow conditions (i.e. unit flow rate, flow depth and flow velocity at the location of the rock), rather than values averaged over the full cross-section.

Typical relative densities (s_r) of various types of rock are provided in Table 2.

Table 1 – Recommended safety factor (SF) for use in determining rock size

Safety factor (SF)	Recommend usage	Example site conditions
1.2	• Low risk structures. • Failure of structure is most unlikely to cause loss of life or irreversible property damage.	• Rock chutes located within most rural gullies and low-risk urban gullies. • Permanent rock chutes that are likely to experience significant sedimentation and vegetation growth before experiencing high flows.
1.5	• High risk structures. • Failure of structure may cause loss of life or irreversible property damage. • Gullies where failure of the chute is likely to cause ongoing, severe gully erosion and/or damage to assets.	• Rock chutes in urban gullies located close to homes. • Rock chutes designed for a storm frequency less than 1 in 10 years.

Table 2 – Typical relative density (specific density) of rock

Rock type	Relative density (s_r)
Sandstone	2.1 to 2.4
Granite	2.5 to 3.1 (commonly 2.6)
Limestone	2.6
Basalt	2.7 to 3.2

Figure 28: Hardwood logs securely fixed in leaky weir at 'Tidbinbilla Station' ACT, 2023.

Log sill structure – materials

- **log sill** – sustainably sourced, untreated hardwood logs, of no less than 300mm diameter at the butt end
- **pins** – sustainably sourced, untreated hardwood pins, of no less than 200mm diameter and no less than 2.1m in length
- **geofabric** – durable biodegradable fabric such, as coir or jute mesh, at no less than 900gsm
- **tie wire** – 3mm low to medium tensile fencing wire
- **fill** – underneath can be fine stream sediments. Surface should be course stream sediments – course sand and gravel if possible
- **rock** – as per Figure 27
- **sod & topsoil** – scalped from site in preparation for construction
- **mulch** – any organic, hay-like material
- **seeds** – appropriate cover mix
- **plants** – appropriate riparian and aquatic plants.

Log sill structure – construction

- **log sill**
  - ➤ construct in a v-notch configuration with the apex of the ‘v’ facing upstream, with the acute angle of the v between 140 and 165 degrees
  - ➤ key into bank by at least 1m.
- **pins**
  - ➤ drive into the bed of the stream, in front of the logs, to a depth of 1m.
- **each log in the sill**
  - ➤ tie to pins with fencing wire and nail fencing wire to both the log sill and the pins.
- **area on the pond side of the logs**
  - ➤ fill with sediment to the bottom of the top log.
- **area on the downstream side of the log sill**
  - ➤ fill with sediment up to the bottom of the top log.
- **pond side of the structure**
  - ➤ fill with sediment to the top of the log sill.
- **geofabric**
  - ➤ nail to the top of the top log, then drape down the back of the log sill, to cover voids between the logs
  - ➤ nail to the pond side of the top log, then drape over the entire log, and on top of the sediments on the downstream side of the log sill
  - ➤ should extend 4m downstream of the log sill and 1m up each bank.

Figure 29: Geofabric in place on leaky weir installed at ‘Tidbinbilla Station’ ACT, 2023.

Figure 30: Rocks placed over geofabric in leaky weir at 'Tidbinbilla Station' ACT, 2023.

- **rock**
  - ➤ place D_{50} 400mm rock over geofabric and press in, so final level is the top of the log sill.
  - ➤ place an apron of rock sized to the formula in Appendix B (p42), immediately downstream of the D_{50} 400mm rock and extending 1m up each bank.
- **sod & topsoil**
  - ➤ spread over rock ramp and press into voids.
- **structure & surrounds**
  - ➤ mulch, seed with a cover mix, plant with appropriate riparian and aquatic plants, then water in well.

Construction methodology

- Preparation and implementation of a construction environmental management and safety plan.
- Each site would be pegged out as per a design plan based upon the design parameters.
- Materials should be stockpiled within 40m of the work site and adjacent to the defined site entry point to minimise machinery impact.
- Typically, construction and heavy lifting work will be undertaken with an excavator.
- Rock should be sourced onsite or imported, preferably from a local source.
- A bulldozer can be used to batter the upstream banks of the stream, following the completion of structures.
- Earth will be won from the banks adjacent to structures that require it.
- Around the structure sites, topsoil should be stripped off, stockpiled and respread where required once earthworks are complete.
- Hardwood logs should be sourced from the site or salvage grade hardwood logs will be sourced locally; for example Forestry Corporation of NSW.
- Native tubestock should be supplied by local nurseries.
- Transplanted plants may be sourced from within the stream.
- Mulch may be cut on farm using a tractor and slasher and used to mulch bare earth.
- Along with unrecoverable vegetation disturbed during the works, hessian may be laid out underneath and between the logs to prevent undermining of the structure.
- Upon completion of the structures, experienced persons should immediately plant out the site with reeds, sedges, shrubs and trees at a density of at least 2,500 plants per hectare. Canopy plants should be planted at 400 plants per hectare.
- Upon completion of the bank battering work, the banks should immediately be sown with a local pasture mix and watered in to quickly establish groundcover. In the meantime, and if possible, the banks should be mulched. It is expected that, close to the banks, the sown grasses would be supplanted by perennial wetland vegetation and native grasses within 2–3 growing seasons.
- If the battering of the banks causes significant compaction of the topsoil, the disturbed areas should be harrowed before seeding.
- Fishway – rock would be placed around the spill point of each structure in such a way to facilitate the passage of native fish.
- All of the stream should be fenced to exclude livestock.
- Rock should be deposited near the left or right bank of the proposed structure. The excavator should then be used to excavate and shape the banks and to build the core of the control structure. The excavator should place the rocks on and around the structure. Following completion of the structure, the planned bank battering should be conducted in the upstream reach.

Endnotes

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The Mulloon Institute is an independent not-for-profit research, education and advocacy organisation https://themullooninstitute.org/ dedicated to building the capacity of rural communities to improve the health and resilience of their landscapes and waterways. Mulloon implements a range of strategies that optimise the cycling and retention of water for the benefit of both agricultural enterprises and the natural environment, to help provide Australia with long-term water and food security, and to create a model adaptable to other countries. Mulloon's methods are recognised by the United Nations Sustainable Development Solutions Network and are grounded in strategic collaborations with University researchers, Landcare groups, Natural Resource Management organisations and government and industry partners. The Mulloon Institute takes a multi-dimensional research approach to catchment remediation which considers the environmental, economic and social impacts of landscape rehydration and builds resilience to climate extremes.

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28 See https://themullooninstitute.org/monitoring

The Mulloon Institute acknowledges Aboriginal and Torres Strait Islander peoples as the First Australians and Traditional Custodians of the lands and waters where we live, learn and work.

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