24 February 2020

the mulloon institute
for environment, farming and society

Briefing – Landscape Rehydration Works

Topic	Legislative and regulatory reform to facilitate Landscape Rehydration Works in NSW.
Analysis	Landscape Rehydration Works have significant benefits for landowners and the environment. The NSW Government should amend legislation and regulations to facilitate these works.

Recommendations

That the NSW Government:

1 **Agree** to a definition of Landscape Rehydration Works;

2 **Agree** that Landscape Rehydration Works have significant benefits for landowners and the environment;

3 **Amend** the *Water Management (General) Regulations 2018* (NSW) to exempt Landscape Rehydration Works from requirements for controlled activity approvals (**CAAs**), water access licences (**WALs**) and water supply works approvals (**Works Approvals**);

4 **Amend** the *State Environmental Planning Policy (Infrastructure) 2007* (NSW) to make Landscape Rehydration Works a form of "complying development" under Division 25 Waterway or foreshore management activities;

5 **Amend**, by regulation, Schedule 2 to the *Water Supply (Critical Needs) Act 2019* (NSW) to include Landscape Rehydration Works in the Mulloon Community Landscape Rehydration Area (see Attachment A) as water supply development.

6 **Review** other legislation and regulations to amend as required, including:

(a) *Local Land Services Act 2013* (NSW);

(b) *Biodiversity Conservation Act 2016* (NSW);

(c) *Fisheries Management Act 1994* (NSW); and

(d) *National Parks and Wildlife Act 1974* (NSW).

Definition of Landscape Rehydration Works

The key element of this proposal is to introduce a definition of **Landscape Rehydration Works** into NSW legislation, such that they can be identified and exempt from various licensing and approval requirements.

Landscape Rehydration Works are physical works that are used as part of "Landscape Rehydration" or "natural sequence farming" to restore the natural flow of water through Australian landscapes. (See https://sdgs.org.au/project/mulloon-community-landscape-rehydration-project-mclrp/ for more information on the works and technique.)

Landscape Rehydration Works include **Leaky Weirs** and **Related Works** (**Embankments**, **Rock Ramps**, **Constructed Contour Banks** and **Watercourse Plantings**).

For the purposes of the legislative amendments in this proposal, we have suggested the following definitions that would be included in NSW legislation / regulation:

- **Leaky Weir** – means an in-stream or in-gully structure designed to contribute to the re-naturalisation of surface and near surface flow patterns.

  This includes the re-establishment of geomorphic features such as wetlands, chains of ponds, pond riffle sequences and/or swampy meadows.

  Intended outcomes/benefits include; slowing and spreading of flow pulses; raising the alluvial watertable; improved water quality; extended flow duration; restored instream, riparian and terrestrial habitat complexity; improved soil condition; and moderated micro-climate.

  Leaky weirs are engineered to a specific catchment context to ensure their immediate structural integrity. However, their long term integrity relies ultimately on vegetation establishment on and surrounding the structures.

  (Other terms used for similar structures include: - bed control structure, porous check dam, beaver dam.)

- **Related Works** (Embankments, Rock Ramps, Constructed Contour Banks and Watercourse Plantings) are defined in Attachment E.

For the purposes of the proposed legislative amendments, we understand that Related Works do not need NSW government approvals where they are exempt development under an environmental planning instrument.

Key Reasons for Recommendations

1 **Landscape Rehydration Works produce significant benefits for landowners and the environment.**

There is significant evidence that Landscape Rehydration Works produce the following results:

- increased soil hydration;
- improved soil health;
- increased and healthier vegetation;
- increased carbon sequestration;
- improved water quality;
- improved flow duration;
- decreased soil erosion;
- decreased need for dams;
- raised water table;
- improved flood control;
- improved agricultural productivity;
- increased biodiversity;
- long term weed reduction;
- drought resilient landscapes;
- decreased bush fire susceptibility;
- climate change mitigation; and
- improved human health.

See the "Compendium of Scientific Evidence for Landscape Rehydration" in Attachment B for evidence supporting each claim above.

To achieve the benefits listed above, facilitating Landscape Rehydration Works through legislative reform should be a key priority of the NSW Government.

2 The current approvals processes are inconsistent and unnecessarily burdensome

To implement Landscape Rehydration Works, including Leaky Weirs, landholders often need planning, water, environmental and other NSW Government approvals.

When seeking to repair whole catchments (which typically have multiple different landowners), current NSW legislation and regulations often requires:

- individual approvals for each structure;
- submissions from each separate landowner;
- different submissions to multiple departments; and
- the commissioning of expensive and time-consuming expert reports.

To implement Landscape Rehydration Works you often need to develop and submit:

- fully engineered designs for every structure in the system;
- site descriptions;
- hydraulic modelling reports;
- environmental impact assessments;
- development applications;
- Biodiversity Assessment Reports (the cost of which start at $15,000);
- WAL applications;
- vegetation management plans; and
- sediment and erosion control plans.

Portions of water catchments that are Crown Land (such as the middle of creeks in certain areas) require the concurrence of the other Control Authorities.

Compliance with these requirements is a significant administrative, legal and engineering process that costs significant amounts of time and money.

The compliance costs incurred by The Mulloon Institute for the first phase of the MCLRP was approximately $350,000 and took over 30 months before approval was granted to construct 7 Leaky Weirs and related works on a single property. The main reason for the delay was the time needed to engage with, and receive the confidence of, various NSW government agencies.

Once approval was granted, the cost of constructing the MCLRP works was approximately $100,000 and took 3 weeks to complete.

As a result of compliance costs and time, Landscape Rehydration Works are often delayed or not undertaken. Meanwhile our landscapes continue to dehydrate and erode.

The limited money and time of our farmers should be spent repairing their landscapes, not trying to understand and fulfil lengthy compliance processes.

Impediments and proposed reforms

1 **Water**

(a) Water - Impediments

Under the current water law framework, Landscape Rehydration Works typically require the following approvals:

- CAAs for instream and waterfront works;
- WALs for water 'take' (for example, overbank flow out of waterways into the floodplain) regardless of whether the water is used for irrigation or environmental purposes and regardless of whether the water is returned to its original source; and
- Works Approvals for the construction and use of a water supply work (for example, a weir, dam or pump) that extracts, diverts, stores water.

Landholders must also be aware of and comply with local Water Sharing Plans.

(b) Water – Proposed Reforms

Our preferred solution is to amend the *Water Management (General) Regulations 2018* (NSW) to exempt Landscape Rehydration Works from requirements for CAAs, WALs and Works Approval.

This will require the following amendments to Schedule 4:

- Part 1 Access licence exemptions –

  Insert Item **17AAA Landscape Hydration Works** – Any person constructing a Landscape Rehydration Work

- Part 2 Controlled activities exemptions –

  Insert Item **38 Landscape Hydration Works** – Any activity carried out in connection with Landscape Rehydration Work

This will also require the following amendments to Schedule 1 Excluded Works:

- Insert Item **10** works carried out in connection with Landscape Hydration Works

We note that item 12 of Part 1 of Schedule 4 ('Excluded works') links the exemption from the requirement for a Works Approval in Schedule 1 with an exemption from a corresponding WAL. Therefore, to the extent that Landscape Rehydration Works become exempt under Schedule 1, it may not be necessary to separately draft an exemption in Schedule 4.

2 **Planning – Impediments and Proposed Reform**

(a) Planning - Impediments

Under the current planning framework:

- Landscape Rehydration Works may require a development application (DA) under Part 4 of the EPA Act;

- even where no DA is required, works may still require environmental assessment under Division 5.1 of the EPA Act if any other approval is required to carry it out; and
- alternative pathways for obtaining planning approval are available (e.g. development permitted without consent) but these require the proponent to carry out the work on behalf of a public authority.

The planning requirements are not consistent across NSW, as they are a product of local planning instruments with different council requirements sometime even within the same catchment, water source or water sharing plan area.

(b) Planning – Proposed Reforms

Our preferred solution is to amend the *State Environmental Planning Policy (Infrastructure) 2007* to make Landscape Rehydration Works both development without consent if carried out by or on behalf of a public authority and complying development if carried out by any person in prescribed circumstances.

This will require the following amendments to Part 3 Division 25 Waterway or foreshore management activities of State Environmental Planning Policy (Infrastructure) 2007-;

- Clause 128 Definition

  Omit the definition of *waterway and foreshore management activities*.

  Insert the following definitions in alphabetical order –

  landscape rehydration works means -

  (a) riparian corridor and bank management, including erosion control, bank stabilisation, resnagging, weed management, revegetation and the creation of foreshore access ways, and

  (b) instream management or dredging to rehabilitate aquatic habitat or to maintain or restore environmental flows or tidal flows for ecological purposes, and

  (c) in-stream or in-gully structures designed to contribute to the re-naturalisation of surface and near surface flow patterns.

  waterway or foreshore management activities means -

  (a) riparian corridor and bank management, including erosion control, bank stabilisation, resnagging, weed management, revegetation and the creation of foreshore access ways, and

  (b) instream management or dredging to rehabilitate aquatic habitat or to maintain or restore environmental flows or tidal flows for ecological purposes, and

  (c) coastal management and beach nourishment, including erosion control, dune or foreshore stabilisation works, headland management, weed management, revegetation activities and foreshore access ways, and

  (d) in-stream or in-gully structures designed to contribute to the re-naturalisation of surface and near surface flow patterns; and

  (e) salt interception schemes to improve water quality in surface freshwater systems, and

  (f) installation or upgrade of waterway gauging stations for water accounting purposes.

- Insert Clause 125B ***Complying development*** –

  Development for the purpose of landscape rehydration works, carried out by or on behalf of any person on land is complying development if:

  (a) the development complies with clause 20B, and

  (b) the land is not in a heritage conservation area, and

  (c) [Mulloon Institute (in consultation with DPIE) to prepare development standards for landscape rehydration works as complying development including relevant applicable parameters for height, materials, engineering design certification, storage capacity, prohibition on pumping or other taking of water other than natural rehydration effect etc or other certification (eg engineering certification)]

  (d) [Mulloon Institute (in consultation with DPIE) to prepare a set of additional conditions to be imposed on a complying development certificate for landscape rehydration works].

3 **Other Legislative and Regulatory Reforms**

Depending on the nature of the Landscape Rehydration Words and the location of the works, approvals may also be required under a range of NSW legislation including:

- Local Land Services Act 2013;
- Biodiversity Conservation Act 2016;
- Fisheries Management Act 1994; and
- National Parks and Wildlife Act 1974.

We ask that the NSW Government review these acts and seek to introduce amendments that provide exemptions for Landscape Rehydration Works.

Supporting analysis

Sensitivities/contentious issues

Water is a sensitive issue but the evidence shows that LRW are net positives for water stakeholders as they provide consistent water flow, flood mitigation, cleaner water, etc. (see the attached Scientific Compendium for evidence of these claims).

Financial impact

The costs to the NSW Government to enact these reforms should be minimal – likely the time taken by NSW officers to review proposals and draft amendments.

There should be significant economic benefits to the rural and NSW economies from:

- the economic activity generated, and jobs created, in rural NSW once land owners hire teams to design and implement LRWs;
- rehydrated landscapes producing more profitable farms; and
- the cost savings from the decreased need for dams.

Consultation

These amendments will require approvals from a substantial number of NSW government departments and related bodies.

Communication

These reforms can be communicated with the following messages:

- supporting our farmers;
- providing regional jobs;
- increasing biodiversity;
- lowering bushfire risk;
- mitigating climate change; and
- improving water flow and quality.

The Mulloon Institute

The Mulloon Institute

The Mulloon Institute (**TMI**) is an independent not-for-profit research, education and advocacy organisation. TMI actively regenerates landscapes, while at the same time demonstrating and sharing regenerative methods of land management. Research results and education tools are used to create sustainable, resilient landscapes, to help provide Australia with long-term water and food security, and to create a model adaptable to other countries. TMI's research methodologies are recognised by the United Nations Sustainable Development Solutions Network and take a multi-dimensional integrated research approach which considers the environmental, economic and social impacts of landscape rehydration.

Current projects include the Mulloon Community Landscape Rehydration Project (**MCLRP**) and "100 Projects", a long term goal to facilitate 100 landscape rehydration projects across Australia and overseas in the next 10 years.

The Mulloon Community Landscape Rehydration Project

The Mulloon Institute (through the MCLRP) has undertaken instream works throughout the Mulloon catchment (NSW) including creek repair and erosion control using small interventions (leaky weirs) to slow and filter water flow in the catchment. So far, 14 creek structures have been installed across 3 adjoining properties and along 3.5 kilometres of Mulloon Creek.

Another 90 creek structures are planned to be installed throughout a further 25 kilometres of creek over the next 2 years. Through these land rehydration initiatives, the Institute aims to rebuild the natural landscape function of the entire Mulloon catchment and boost its resilience to climatic extremes, leading to more reliable stream flows, improved ecosystem functioning and enhanced agricultural productivity. By doing so, the MCLRP will demonstrate best practice in landscape restoration and will be used as a model to facilitate implementation of similar projects across Australia.

Specific initiatives and intended outcomes of the MCRLP include:

- re-establishing the functional hydro-ecological connection between the creeks and floodplains of lower Mulloon and its tributaries through the further installation of approximately 90 in-stream structures to raise the water level and slow and spread water flow;
- exclusion of livestock from 50 kilometres of the Mulloon Creek;
- installation of nearly 100,000 plants;
- reinstatement of complex pond, wetland and riparian habitat for 11 rare and threatened bird species and 2 endangered frog species;
- sharing of ongoing research to provide benchmarks for stream and groundwater hydrology, water quality, biodiversity and landscape function for future projects;
- training and education delivered to the more than 20 landholders involved in the project.

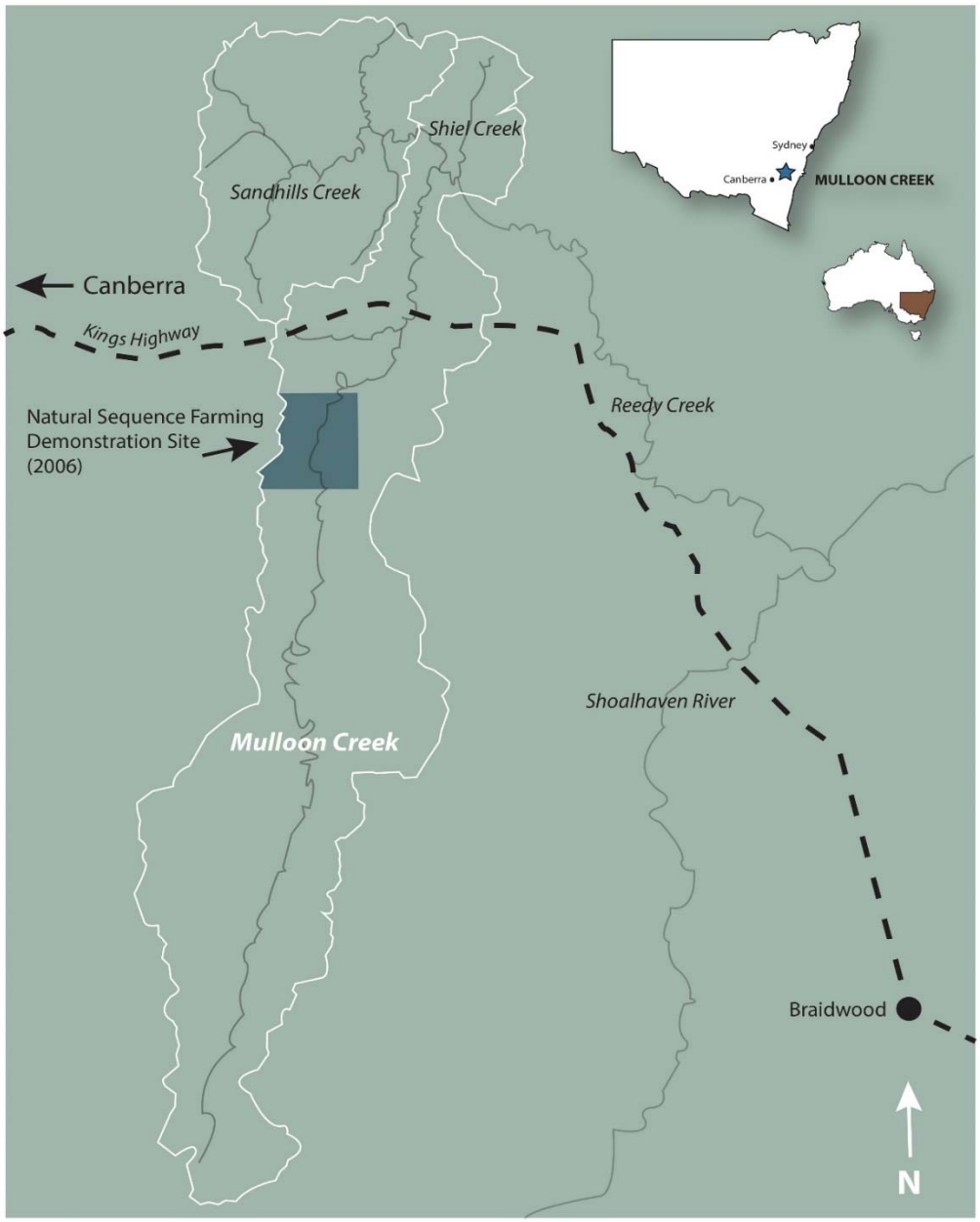
In April 2019, the MCRLP was awarded $3.8 million over 5 years by the Federal Minister for Agriculture and Water Resources for monitoring vital on-ground works in the MCLRP.

For more information on the MCLRP see https://themullooninstitute.org/projects/#mclrp-section

Attachments and references

Attachments / Reference	Title
A	Mulloon Community Landscape Rehydration Project Area map
B	Compendium of Scientific Evidence for Landscape Rehydration
C	Photographs of Mulloon Creek “Before and After”
D	MCLRP Project Construction Drawings
E	Definitions

Attachment A - MCLRP map



For more information on the MCLRP

- https://themullooninstitute.org/projects
- https://sdgs.org.au/project/mulloon-community-landscape-rehydration-project-mclrp/
- https://soilsforlife.org.au/mulloon-creek-catchment/

Attachment B - Compendium of Scientific Evidence for Landscape Rehydration

the mulloon institute
for environment, farming and society

Compendium of Scientific Evidence

for

Landscape Rehydration

24 February 2020

Contents

1. Introduction - Landscape Rehydration

1.1 Landscape Rehydration - Theory

"Landscape Rehydration" (also commonly known as "natural sequence farming") is a rural landscape management technique aimed at restoring natural water cycles.

Landscape Rehydration aims to re-establish the natural function, fertility and resilience of agricultural landscapes. It offers a low-cost, widely applicable method of reducing drought severity and boosting productivity on Australia's farms and landscapes. The technique is based on ecological principles, low input requirements and natural cycling of water and nutrients to make the land more resilient.

Unlike many other continents that have extensive river systems, Australia had wide floodplains in which water was absorbed and stored below the ground. Wetlands interrupted the main watercourses at regular intervals: rather than flowing rivers, Australia had a 'chain of ponds' system. In the past there was little evaporation loss in the floodplains, and landscapes were sustained through dry periods.

Modern western agriculture created incised creeks which rapidly removed water from landscapes. Significant areas of Australian land and water bodies have been seriously degraded.

The following video illustrates the degradation process -
https://www.youtube.com/watch?v=ylqR6u7xCjs

Landscape Rehydration aims to restore the natural flow of water through the landscapes, to produce landscapes that holds more water and to assist our landholders to use available water more effectively.

1.2 Landscape Rehydration Works

The physical works required to restore the natural flow of water ("**Landscape Rehydration Works**") involve Leaky Weirs and Related Works (Watercourse Plantings, Embankment Repair and Constructed Banks).

(a) Leaky Weirs

Leaky Weirs are soft engineered 'natural' eco-structures designed to raise the water level of the creek, slow water flow, rehydrate the floodplain and rebuild vital aquatic and riparian habitat. Leaky weirs trigger the natural regeneration of the landscape, and become part of a living, growing system.

Leaky Weirs use rocks, fallen trees and other natural debris to slow the flow of water down a catchment, but they do not prevent water from passing through the structures.

Leaky Weirs help restore the natural flow of water through the Australian landscape by reintroducing the "chain of ponds" system.

(b) Related Works

(i) Watercourse Plantings

The Landscape Rehydration technique involves the reintroduction of trees and vegetation into the catchment:

- Trees and vegetation slow water flow and energy (reducing erosion and increasing the chances of water hydrating surrounding paddocks);
- Trees and vegetation stabilise eroded banks – reducing erosion;
- Water plants filter and clean water;
- Tree and plant cover reduce evaporation;
- Tree and plant cover increases biodiversity.

(ii) Embankment Repair

Depending on topography and erosion levels, Landscape Rehydration techniques may involve earthworks to repair and reconstruct watercourse embankments to slow water flow, reduce erosion and provide appropriate ground for vegetation.

(iii) Constructed Banks

Landscape Rehydration techniques focus on water flow across landscapes, not just along watercourses.

On slopes above watercourses, Landscape Rehydration techniques involves constructing banks to break up slopes and reduce the depth and speed of runoff flow. The construction conveys water to a stable watercourse, water storage or water absorption area.

2. Scientific Claims and Evidence

The Mulloon Institute and supporters of Landscape Rehydration make the following 17 scientific claims about Landscape Rehydration techniques and the benefits of introducing Landscape Rehydration Works, including Leaky Weirs.

The aim of this compendium is to summarise these 17 claims and to provide evidence supporting each claims.

We believe further online research will find more evidence supporting Landscape Rehydration techniques – this document represents an introductory compendium.

Landscape Rehydration is a relatively new technique of land management in Australia. Its benefits are currently being studied and we expect more evidence will become available over the next decades as to its benefits. In the meantime we contend that enough evidence currently exists to prove the introduction of Landscape Rehydration Structures into Australian landscapes and watercourses will have immediate, significant, long lasting and sustainable benefits.

3. Increased Soil Hydration

3.1 Claim

As a result of Leaky Weirs and Related Works:

- water slows and banks up in a watercourse;
- this allows more water to seeps into the banks and surrounding pastures;

- this increases soil hydration;
- which improves soil health (see section below);
- which allows more water storage in the soil.

3.2 Evidence

(a) Landscape Rehydration significantly increases floodplain aquifer rehydration

(i) https://ro.uow.edu.au/cgi/viewcontent.cgi?article=1144&context=thsci

(b) Leaky weirs hydrate a thirsty landscape

(i) https://education.abc.net.au/home#!/media/1249433/

(c) "As you build soil, microbial diversity agro-ecosystems become more restored and hydrated. Fundamental to building this diversity is building soil carbon - every 1% organic carbon stores 140,000L of water per hectare of water. With most Australian soils now well below 1% and at the time of European arrival many soils exceeded 2.5%, it is no wonder dry periods, droughts and now desertification is effecting agricultural production so severely."

(i) https://www.theland.com.au/story/6275716/carbon-a-viable-option/

(ii) https://jwpm.com.au/industrial-marketing-blog/soil-carbon-farming

(iii) http://adamwillson.com.au/

4. Improved Soil Health

4.1 Claim

As a result of the installation of Leaky Weirs:

- adjacent paddocks become hydrated;
- hydrated soil encourages vegetation growth;
- vegetation growth encourages microbes and other animals;
- decomposing plant and animal material create "Topsoil" – dark spongy material rich in organic matter;
- Topsoil helps soil hold onto water and nutrients and supports soil microbes that recycle nutrients;
- Soil with better soil structure is less likely to erode;
- Improved soils allow for improved water infiltration;
- Increased Topsoil creation leads to greater soil depth.

4.2 Evidence

(a) Landscape Rehydration management led to increased soil moisture as a result of higher soil watertables and capillary rise and consequent increased biomass growth, nutrient cycling and organic turnover

(i) https://www.iuss.org/19th%20WCSS/Symposium/pdf/0597.pdf

(b) There are numerous positive benefits of installing leaky weirs, i.e. once the weirs backup water behind the structure, the floodplain upstream of the weir is stimulated. This in turn stimulates and influences: the resilience of the floodplain soil-landscapes to withstand severe climate events; soil physical properties by reducing soil compaction; soil hydrological properties by promoting soil permeability; soil chemical and nutrient recycling; soil biological activity; enhances plant productivity and plant growth i.e. biomass and photosynthetic material into dry seasons and periods of rainfall deficit.

(i) https://soilsforlife.org.au/wp-content/uploads/2020/01/VAST20Report20to20TMI_20190408_Final1.pdf

(c) Increased soil health in the Mulloon Creek property - "The soil is alive, with fungus and bacteria, earthworms, and they're all processing that organic matter and that litter. All you need to do is have a look under that brown stubble on the surface, and you can see plenty of resilience that will help this farm burst into life again in the spring."

(i) https://themullooninstitute.org/blog/2018/10/29/soaking-up-australias-drought

(d) Improved soils allow for improved water infiltration – the Mulloon property measured the rate water can be absorbed into soil at 10,000mm per hour. 1,000mm per hour of rainfall is equivalent to a torrential downpour."

(i) https://themullooninstitute.org/blog/2018/10/29/soaking-up-australias-drought

(e) Building up the soil carbon content meant more water stored in the soil, a critical factor when rain falls intensely across a short period in the tropics. "If you go around and measure the soil infiltration rates, some places are lucky to infiltrate half an inch (12mm) of rain an hour," he said.

(i) https://www.abc.net.au/news/rural/2020-01-07/landscape-rehydration-better-than-dams-in-improving-production/11834394?fbclid=IwAR2iwsSMwv0nvM8b-SNUALNyTmvcAs6R3ii4aziv9IIng8hnnJuExPEg7Ps

(f) "I know of people who can infiltrate 16 inches (406mm) of water an hour; if you can build your soil and organic matter to that sort of level, you can make more use of the rain.

(g) By fostering an efficient and active soil microbiome, you accelerate soil regeneration far beyond typical rates seen in nature.

(i) https://theconversation.com/to-restore-our-soils-feed-the-microbes-79616

(h) The most persistent forms of soil carbon are formed primarily from dead microbial bodies rather than from leftover plant parts. Adding efficient microbes to soils can enhance the percentage of plant carbon that is transformed into soil.

(i) https://www.nature.com/articles/srep09212

(ii) https://theconversation.com/to-restore-our-soils-feed-the-microbes-79616

(i) Soil structure, the arrangement of soil particles and aggregates, has a great impact on erodibility. In soils with good structure, soil particles are bound together in aggregates by organic gums, and iron and aluminium oxides. The larger aggregates are hard to break apart into individual particles, and harder to move by water or wind. In soils with poor structure, the individual particles are held together by pressure, so are easily detached by the force of wind or water. High humus levels in the soil helps soil particles aggregate into larger lumps that are heavier and more difficult for wind or water to move.

(i) https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0008/270881/saving-soil-complete.pdf

5. Increased and Healthier Vegetation

5.1 Claim

(a) Landscape Rehydration techniques increase soil hydration, improve soil health and improve soil depth which allows vegetation to grow quicker.

(b) More vegetation improves water retention in the landscape and watercourses.

(c) Improved groundcover protects topsoil from erosion and decreases evaporation in soil.

(d) Increased vegetation in and around watercourses lowers evaporation.

5.2 Evidence

(a) Without groundcover, up to 85% of rainfall from storms can run off into creeks and streams rather than soak into the soil and be available for plant growth. When groundcover is thin, patches of bare soil provide a path for runoff to build up speed and erode the soil.

(i) https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0008/270881/saving-soil-complete.pdf

(b) The most effective way to improve soil moisture capacity is to increase groundcover.

(i) https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0008/270881/saving-soil-complete.pdf

(c) Growing reeds in weirs increased humidity levels, while planting trees around them reduced wind, both helping to decrease evaporation, even with evapotranspiration from the plants.

(i) https://www.theland.com.au/story/6554043/weirs-flow-helps-firefighters/

6. Increased Carbon Sequestration

6.1 Claim

(a) Improved soils mitigate greenhouse gas emissions by capturing carbon.

(b) Increased and Healthier Vegetation takes carbon out of the atmosphere as vegetation funnels carbon into the soil.

6.2 Evidence

(a) Soil organic matter contains over 50 percent carbon. Globally, soils contain more carbon than plants and the atmosphere combined. Losing carbon-rich organic matter from soils releases carbon dioxide, a greenhouse gas, which can accelerate climate warming. But by regenerating our soils, we can sequester more carbon underground and slow climate warming.

(i) https://www.nature.com/articles/nature17174

(ii) https://theconversation.com/to-restore-our-soils-feed-the-microbes-79616

(b) The most persistent forms of soil carbon are formed primarily from dead microbial bodies rather than from leftover plant parts.

(i) https://source.colostate.edu/restore-soils-feed-microbes/

(c) Australian farms that practice Landscape Rehydration have large amounts of carbon in the soil.

(i) https://www.theland.com.au/story/6554043/weirs-flow-helps-firefighters/

7. Improved Water Quality

7.1 Claim

(a) Leaky Weirs act to filter out pollutants in the water producing livestock productivity and drinking water benefits.

(b) Leaky Weirs increase sedimentation which improves the re-vegetation of stream beds.

(c) Cleaner water flowing into drinking water catchment areas lowers costs to filter water.

(d) Less erosion and increased sedimentation reduces chemical and topsoil runoff into the Great Barrier Reef.

7.2 Evidence

(a) "The weirs are able to filter the water passing through, keeping it clean. "The reed beds in the system, catch and filter the water," Mr Royds said. "We measured the phosphorous coming in at 12 parts per million and when we measured it going out it was at four parts per million, so we've been able to strip phosphorous, a pollutant in the waterways, out of (the water). If you've got clean water you get a 12 per cent increase in productivity of your cattle straight off the bat."

(i) https://www.theland.com.au/story/6554043/weirs-flow-helps-firefighters/

(b) Leaky Weirs increase sedimentation which improved the re-vegetation of stream beds.

(i) https://www.publish.csiro.au/rj/rj12046

(c) Using cattle-grazing techniques where stock are moved from small paddocks on a regular basis and engineering works, the property's sediment runoff levels have reduced. Sam Skeat, grazing officer with NQ Dry Tropics, said remediating gully erosion was a key factor in keeping damaging topsoil out of the Great Barrier Reef

area. "Once water would get into this gully you wouldn't see it again, it'd end up in the Haughton (River) and end up in the sea," he said.

(i) https://www.abc.net.au/news/rural/2020-01-07/landscape-rehydration-better-than-dams-in-improving-production/11834394?fbclid=IwAR2iwsSMwv0nvM8b-SNUALNyTmvcAs6R3ii4aziv9IIng8hnnJuExPEg7Ps

(d) By focussing on water filtration upstream, New York is able to save US$10 billion to build a massive filtration plant, and at least another US$100 million annually on its operation.

(i) https://www.nytimes.com/2018/01/18/nyregion/new-york-city-water-filtration.html

8. Improved Flow Duration

8.1 Claim

(a) Watercourses on farms utilising leaky weirs flow year round.

(b) The installation of leaky weirs have no material impact on long terms flow into streams.

(c) Eroded watercourses allow water to travel quickly off the land before it hydrates the soil. Water heads quickly out to sea and is wasted as a precious resource.

8.2 Evidence

(a) Weirs continue to disperse water when eroded watercourses and dams are dry

(i) https://www.theland.com.au/story/6554043/weirs-flow-helps-firefighters/

(ii) https://themullooninstitute.org/blog/2018/10/29/soaking-up-australias-drought

(iii) https://themullooninstitute.org/blog/2019/11/6/braidwoods-secret-water-supply-waiting-in-weir

(b) The introduction of leaky weirs had no significant effect on water flow below the weirs – the Mulloon “leaky weirs”,raised the level of the creek with little impact on its flow. Only 0.2 of 1% of the creek’s flow fails to travel downstream as a result of the works.

(i) https://www.farmonline.com.au/story/3762033/un-eyes-on-mulloon-creek/

(c) The alluvial groundwater storage of the floodplain was important for maintaining base flow conditions. Alluvial groundwater discharge from the hyporheic zone to the channel occurred under base flow conditions.

(i) https://www.csu.edu.au/__data/assets/pdf_file/0008/748358/Keene_Annabelle_187.pdf

(d) Leaky weirs established from 2006 are paying dividends, as water continues to arrive despite no rain. “It is not coming in at the top of the system, it is coming from our storage in the floodplain,” Mr Fitzgerald said. “There is water just trickling over the rocks down at Peter’s Pond and Peter’s Weir. It is only just seeping through, but it is still moving and it is quite amazing there is still water.”

(i) https://the-riotact.com/braidwoods-secret-water-supply-waiting-in-weir/335126

(e) "Stream gauges were installed above and below the project site, piezometers were set up throughout the floodplain, and a weather stations were installed. Monitoring has shown an overall improvement to the creek's flow as it discharges from the project site with the creek maintaining its flow during dry times, even when most of Mulloon Creek dries up completely. This is vividly apparent during drought periods.

Generally, the same amount of water is flowing through the system but it's spread out over a greater area and over a longer time, allowing the water to soak in. This allows a greater diversity of creek habitat to develop including an abundance of flora and fauna. The increasing habitat complexity also captures and recycles nutrients more efficiently, which has created many benefits including improved water quality and a significant increase in the primary productivity of the floodplain.

(i) https://themullooninstitute.org/projects

(f) "This sponging-up of water by a well-vegetated farm does not rob downstream neighbours of water. It provides them with more. When water roars off land in a flood, it is lost to everyone. Caught and stored in fertile soils and leaky weirs, it still moves down the landscape, but slowly, releasing its benefits over time."

(i) https://landcareaustralia.org.au/wp-content/uploads/2016/05/LandcareInFocus_AnnualSpecialEdition_BuildingDroughtResilience_April2016.pdf

(g) "During its analysis of flow duration curves for a number of creeks in the Upper Shoalhaven (including Mulloon/Reedy Creek), the NSW Healthy Rivers Commission noted that the curve for Boro Creek was noticeably different from the curves for other sites….Boro Creek experiences significantly greater low flows and reduced medium to high flows.

The Commission concludes that the different flow duration characteristics of the Boro Creek gauging site are the result of the delaying effect the wetland has on medium flows. Medium flows entering the swamp are temporarily stored and released slowly over time, providing reliable flows over a long period."

(i) Independent Inquiry into the Shoalhaven River System – Final Report (1999) Healthy Rivers Commission of New South Wales.

9. Decreased Soil Erosion

9.1 Claim

(a) Leaky Weirs, Watercourse Planting and Embankment Repair slow the flow of water down watercourses, significantly decreasing water energy, power and velocity. This leads to less eroded landscapes and greater topsoil protection.

(b) Slow water allows sediment trapped in the water to settle, keeping soil on the property and removing solid particles from the water that can increase erosion.

(c) Increased groundcover prevents erosion and formation of gullies.

(d) Vegetation intercepts and slows water so that it has time to soak into the soil and infiltrate through the soil profile where it becomes available to plant roots.

9.2 Evidence

(a) As overland flows speed up they become more erosive.

(i) https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0008/270881/saving-soil-complete.pdf

(b) Groundcover prevents erosion and formation of gullies.

(i) https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0008/270881/saving-soil-complete.pdf

(c) Vegetation intercepts and slows water

(i) https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0008/270881/saving-soil-complete.pdf

(d) Structures and ponds in the flowlines reduce water velocity and prevent soil losses and downstream sedimentation.

(i) https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0008/270881/saving-soil-complete.pdf

10. Decreased Need for Dams

10.1 Claim

(a) Banking water in the landscape is more efficient then dams as there is much less evaporation.

(b) Leaky Weir water temperature is lower than dam water temperature significantly reducing evaporation.

10.2 Evidence

(a) Compared to farm dams, far less water evaporates from weirs. "There are four things that impact evaporation rates, temperature, humidity, wind and surface area," Mr Royds said. He said they'd measured the temperature of their dams and found the water was 15 degrees at deeper levels and 28 degrees on the surface, in the weirs the temperature was 18 degrees the whole way through. "If we can have it 10 degrees cooler than a farm dam on the same day, you have exponentially less evaporation," Mr Royds said.

(i) https://www.theland.com.au/story/6554043/weirs-flow-helps-firefighters/

(b) At ‘Jillamatong’,most of Mr Royds 34 dams (which he calls “evaporation dishes”) are bone dry. But 14 major weirs built over the past 10 years across erosion gullies are holding on to water. Some are brimful.

(i) https://the-riotact.com/braidwoods-secret-water-supply-waiting-in-weir/335126

(c) The potential for storing water in soil was significant. "We've been able to demonstrate in Mulloon, if we repaired and rehydrated the catchment through to the Sydney water supply, you could store the equivalent of Warragamba Dam," he said.

(i) https://www.abc.net.au/news/rural/2020-01-07/landscape-rehydration-better-than-dams-in-improving-production/11834394?fbclid=IwAR2iwsSMwv0nvM8b-SNUALNyTmvcAs6R3ii4aziv9IIng8hnnJuExPEg7Ps

11. Raised Water Table

11.1 Claim

Leaky Weirs act to significantly raise the water table providing water to soils and plant roots to help vegetation grow.

11.2 Evidence

(a) Studies show a significant rise in the Mulloon Home Farm water table – "The water table rise appears to have occurred due to the effectiveness of the weirs at altering stream level elevation."

(i) https://ro.uow.edu.au/cgi/viewcontent.cgi?article=1144&context=thsci

(b) Strong hydrological linkages existed between stream water and alluvial groundwater table depths. The key benefit of restoring hydrological connectivity of stream flows with alluvial groundwaters of the floodplain is increased groundwater storage, leading to increased stream base flow in dry seasons and enhanced ecological function of the hyporheic zone. The hyporheic zone is the saturated sediments below and adjacent to river channels, and in many streams it directly links surface water to permeable alluvial aquifers underlying the riparian zones and deeper regional groundwater

(i) https://www.csu.edu.au/__data/assets/pdf_file/0008/748358/Keene_Annabelle_187.pdf

(c) Landscape Rehydration management led to increased soil moisture as a result of higher soil watertables and capillary rise and consequent increased biomass growth, nutrient cycling and organic turnover

(i) https://www.iuss.org/19th%20WCSS/Symposium/pdf/0597.pdf

12. Improved Flood Control

12.1 Claim

(a) The impact of floods down the creek are neutralised because the water spreads, rather than being contained in the creek channel.

(b) Leaky Weirs create not only a hydrating system but a flood control system as well.

12.2 Evidence

(a) https://www.farmonline.com.au/story/3762033/un-eyes-on-mulloon-creek/

(b) https://www.austieca.com.au/documents/item/50

13. Improved Agriculture Productivity

13.1 Claim

Leaky weirs improve landscapes hydration and improved soils which leads to significantly improved agriculture productivity in the affected paddocks

13.2 Evidence

(a) The introduction of leaky weirs led to a 63% increase in production on the hydrated land.

(i) https://themullooninstitute.org/blog/2018/10/29/soaking-up-australias-drought

(ii) https://www.farmonline.com.au/story/3762033/un-eyes-on-mulloon-creek/

(b) On this floodplain we have increased our DSE (dry sheep equivalent) carrying capacity by 60 per cent (11 dse/ha to 17 dse/ha).

(i) https://themullooninstitute.org/blog/2019/11/6/regenerative-farming-model-paving-the-way-for-sustainable-agriculture

14. Increased Biodiversity

14.1 Claim

The rehabilitated water system leads to rising levels of biodiversity – encouraging threatened natural water and bird life.

As the natural landscape is established, native flora and fauna tend to outcompete introduced species creating a sanctuary for endangered native fauna.

14.2 Evidence

(a) Increased biodiversity

(i) https://www.farmonline.com.au/story/3762033/un-eyes-on-mulloon-creek/

(b) "Generally, the same amount of water is flowing through the system but it's spread out over a greater area and over a longer time, allowing the water to soak in. This allows a greater diversity of creek habitat to develop including an abundance of flora and fauna. The increasing habitat complexity also captures and recycles nutrients more efficiently, which has created many benefits including improved water quality and a significant increase in the primary productivity of the floodplain."

Over ten years later, the creek has become a healthy, vibrant ecosystem, filtering water through its extensive reed beds, capturing flood sediments, recycling nutrients and providing complex habitat for birds, mammals, reptiles, frogs, fish and invertebrates.

(i) https://themullooninstitute.org/projects

(c) Native fish return and outcompete introduced species

(i) https://static1.squarespace.com/static/5600deebe4b07aebe017c6d2/t/59ace7eaf7e0ab7ffc43f91c/1504503831373/Mulloon+Creek+fish+survey+Full+Report+final+2016.pdf

15. Long Term Weed Reduction

15.1 Claim

The long term effect of Landscape Rehydration is weed reduction without the need for agrichemicals.

15.2 Evidence

(a) Increased ground cover has assisted in reducing weed invasion.

(i) https://soilsforlife.org.au/gunningrah-shifting-mindset-from-animals-to-the-land/

16. Drought Resilient Landscapes

16.1 Claim

(a) The installation of leaky weirs allows water to bank in the natural floodplains upstream from the weir and this water is released into the stream during periods of drought.

(b) Water seeps into the floodplains which sustains the landscape in drought.

16.2 Evidence

(a) Farmers with leaky weir structures continued to have significant inflows of water during periods of drought

(i) https://www.theland.com.au/story/6554043/weirs-flow-helps-firefighters/

17. Decreased Bush Fire Susceptibility

17.1 Claim

A well hydrated landscape keeps plants lush and healthy and green, which in turn makes them less likely to burn.

17.2 Evidence

(a) A well hydrated landscape keeps plants lush and healthy and green, which in turn makes them less likely to burn.

(i) https://permaculturenews.org/2020/01/25/basic-design-techniques-and-plant-choices-for-growing-a-fire-break/

(b) "….the firefighters found water in ponds dotting the intact valley floor at Baarlijan (a property the subject of Landscape Rehydration Works) in a hydrated part of the landscape that proved much more resilient to the fires. The fire trucks were able to safely rewater in this green oasis, surrounded by a desiccated landscape just wanting to burn, before continuing to fight the fire…"

(i) https://themullooninstitute.org/blog/2020/1/16/j4vzo2ucp22nae9gf86ffe8dl86bw7

18. Climate Change Mitigation

18.1 Claim

Landscape Rehydration assists in mitigating climate change, as vegetated, rehydrated landscapes dissipate incoming solar thermal energy via the plant-driven photosynthetic process and the daily water cycle.

18.2 Evidence

(a) https://www.researchgate.net/publication/285734403_Sustainable_water_and_energy_management_in_Australia%27s_farming_landscapes

19. Improved Human Health

19.1 Claim

(a) Landscape Rehydration Farming leads to healthier soils;

(b) Healthier soil microbes play an essential role in building immune health;

(c) Degraded, low biodiversity land and soils tend to harbour more 'opportunistic' bacteria, while healthy, biodiverse ecosystems favour more stable and specialist bacteria.

(d) A more biodiverse ecosystem changed the bacterial composition towards more potentially immune-boosting microbial diversity.

(e) Biodynamically grown food had more diverse microbial populations when compared to conventionally grown food with conventional containing more potentially dangerous Enterobacters.

19.2 Evidence

(a) Healthier soil microbes play an essential role in building immune health.

(i) https://www.the-scientist.com/news-opinion/the-influence-of-soil-on-human-health-66885

(b) Degraded, low biodiversity land and soils tend to harbour more 'opportunistic' bacteria, while healthy, biodiverse ecosystems favour more stable and specialist bacteria. Bacterial communities more commonly found in degraded landscapes had "potential pathogenic character", with many in the same genera as prominent disease-causing bacteria Bacillus, Clostridium, Enterobacter, Legionella and Pseudomonas. A more biodiverse ecosystem, however, changed the bacterial composition towards more potentially immune-boosting microbial diversity.

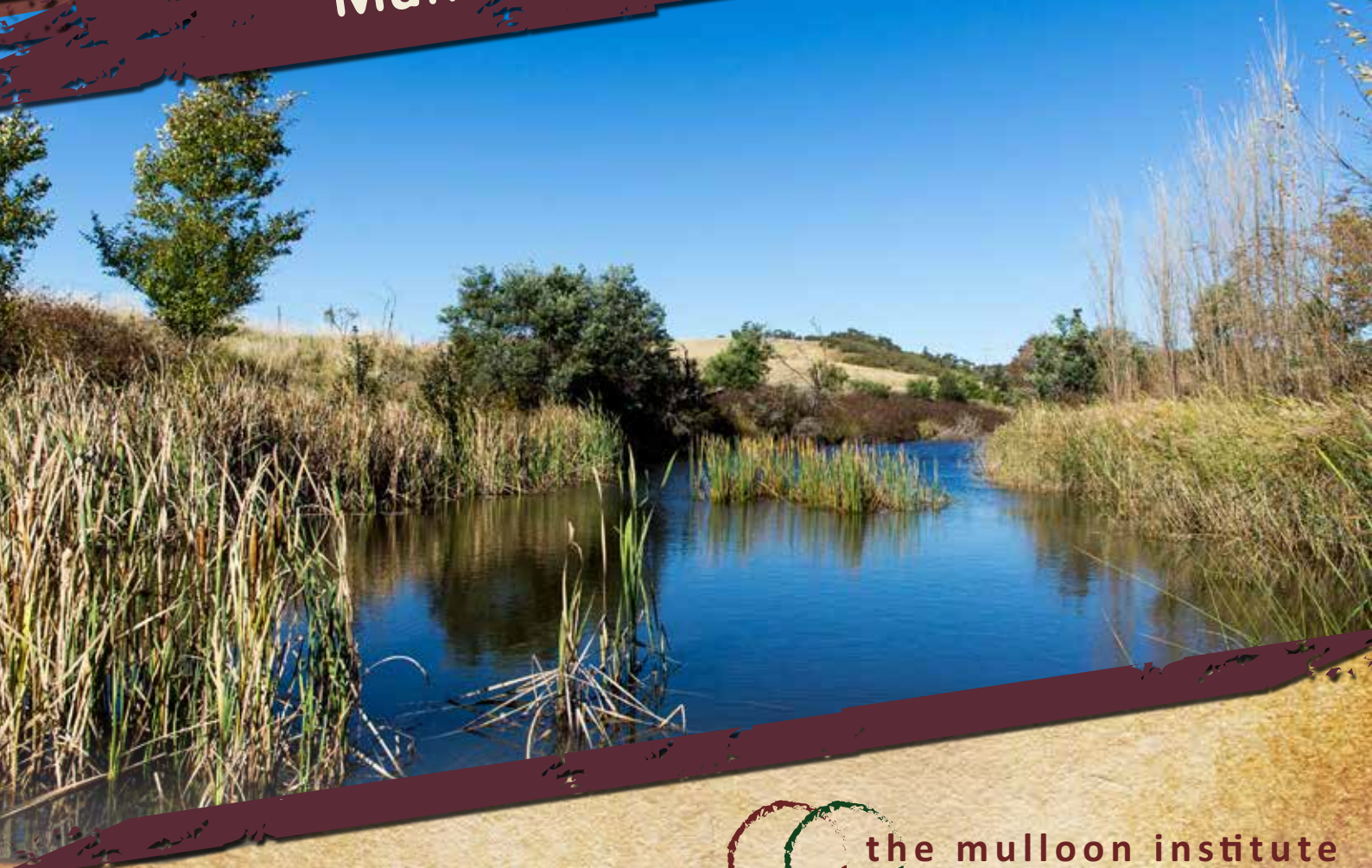
The researchers analysed soil bacterial communities from a restoration site with a progression of environments from cleared, degraded land to a restored, more biodiverse, natural reference ecosystem. They compared their findings with data from over 200 samples from across Australia which had been assigned as disturbed or natural soils, and found consistent patterns in the proportions of opportunistic versus stable bacteria.

(i) https://www.sciencedirect.com/science/article/pii/S0160412018331386?via%3Dihub

(c) Biodynamically grown apples had more diverse microbial populations when compared to conventionally grown apples with conventional containing more potentially dangerous Enterobacters.

(i) https://www.frontiersin.org/articles/10.3389/fmicb.2019.01629/full

Attachment C - Photographs of Mulloon Creek “Before and After”



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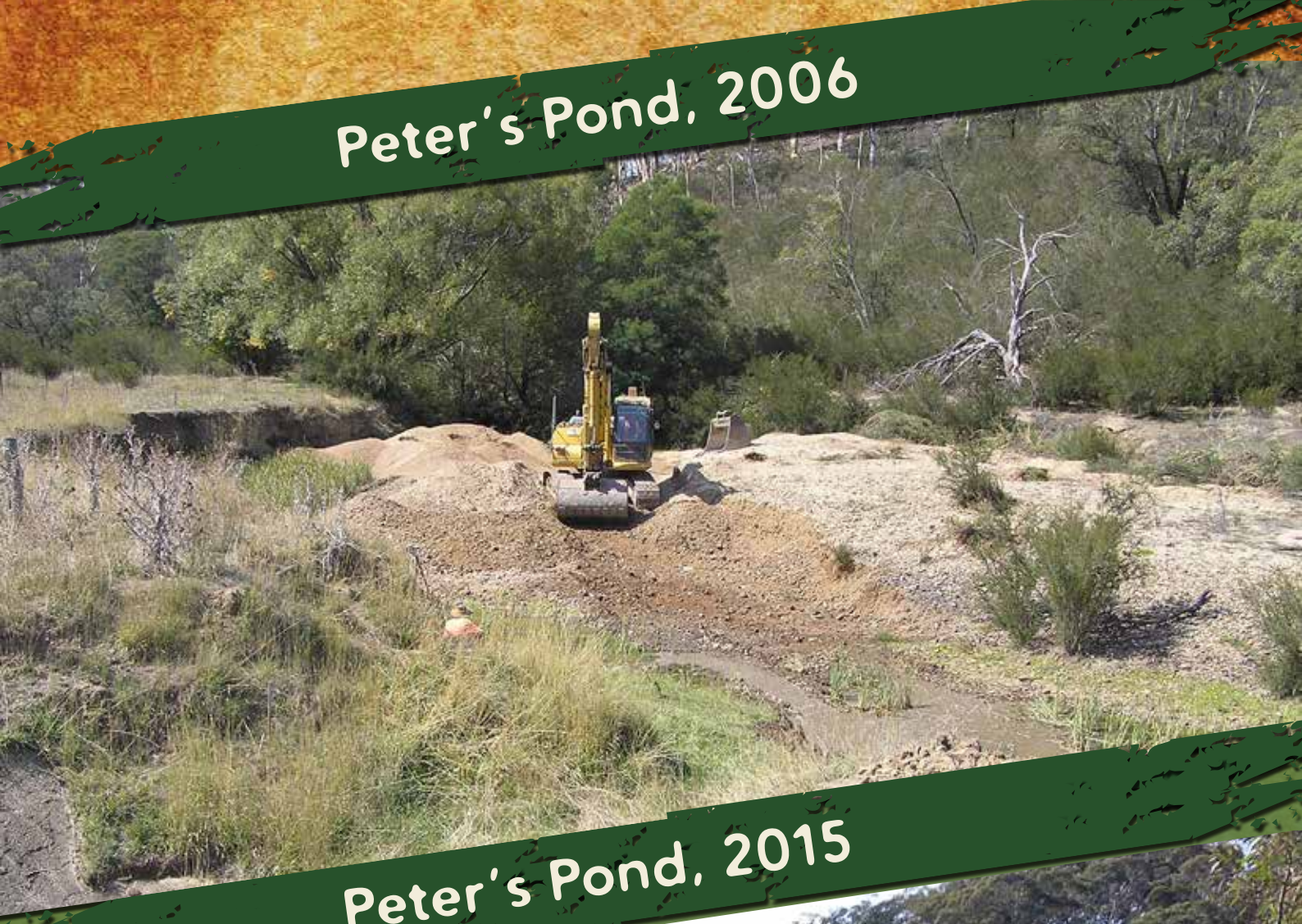

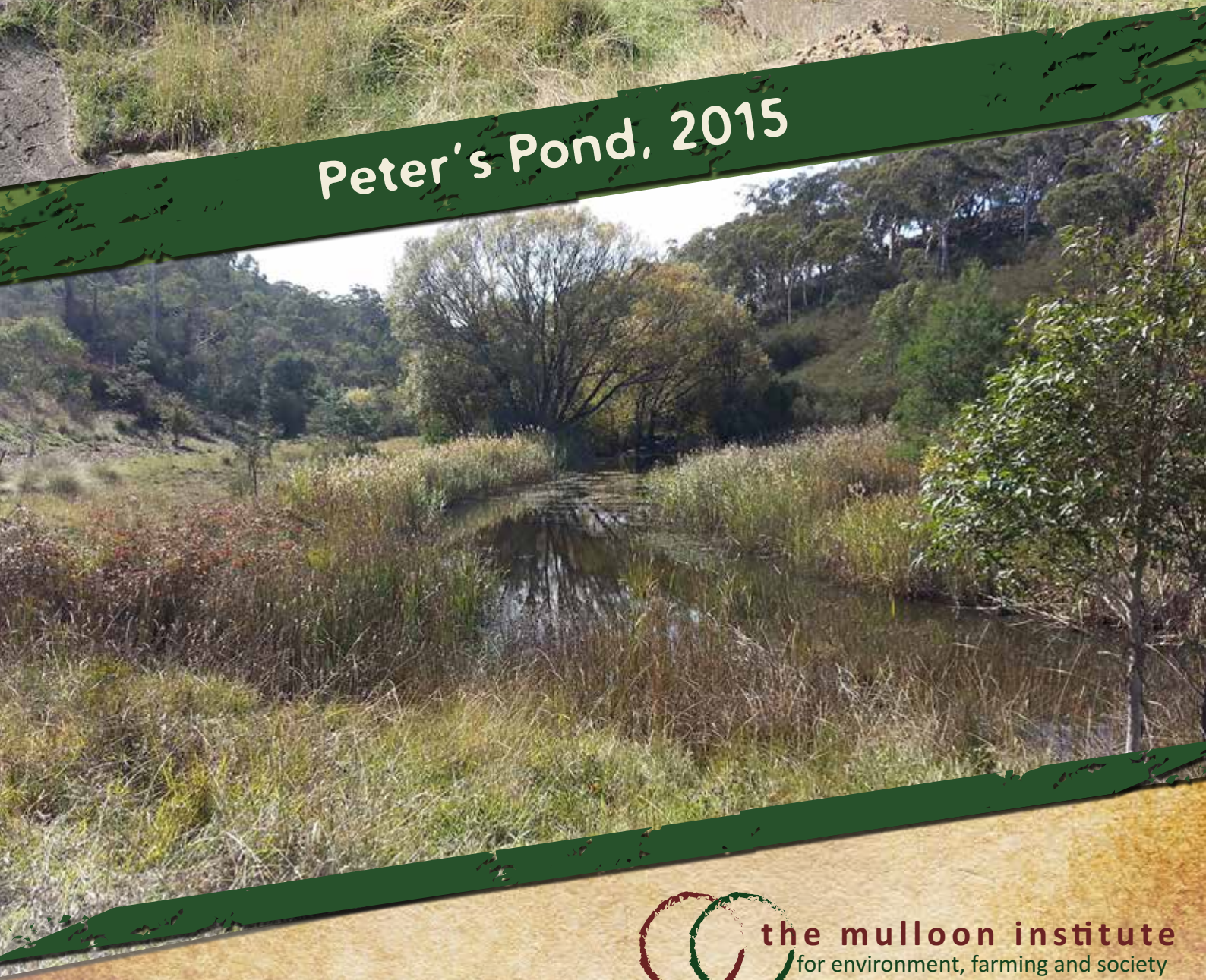

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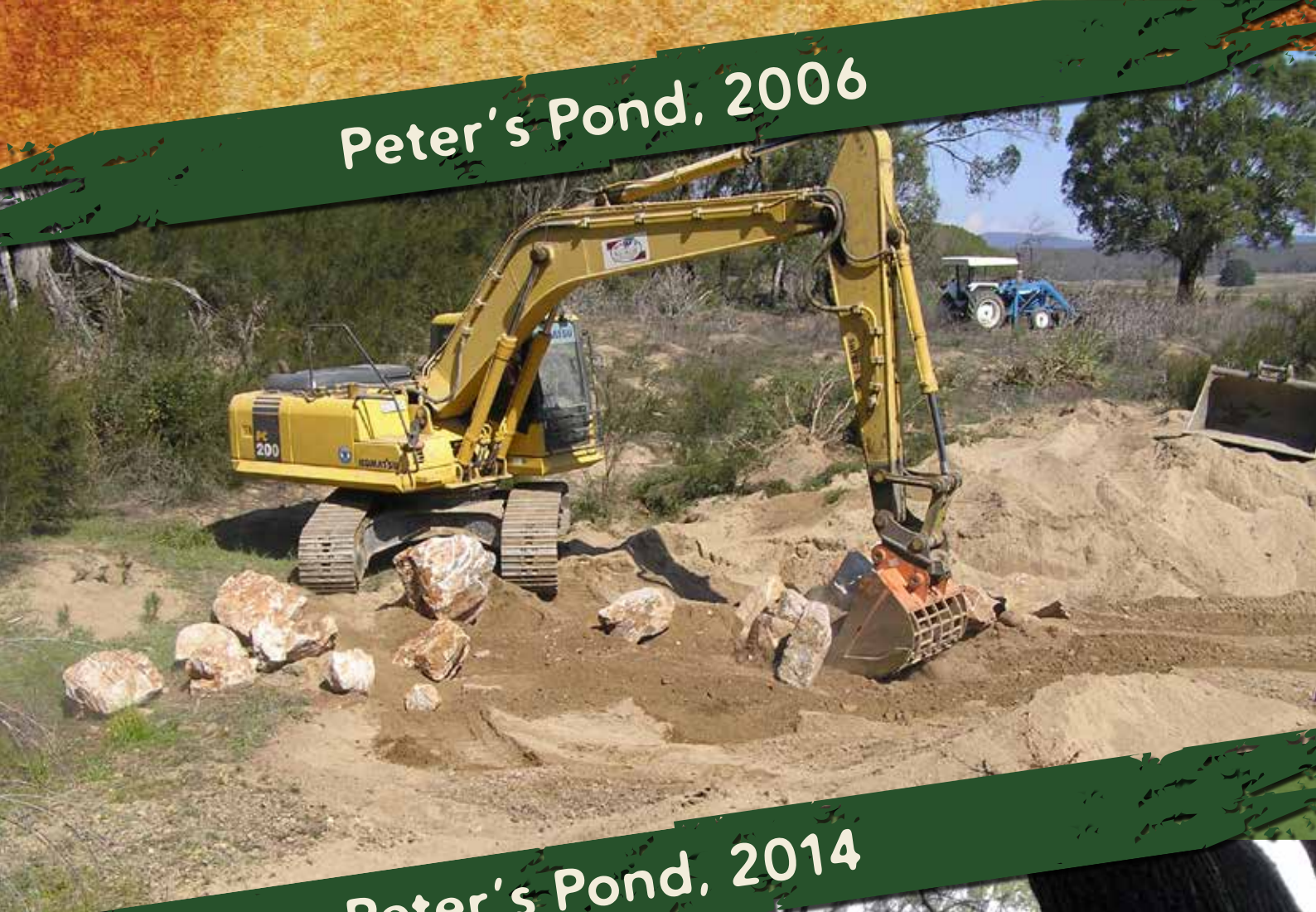
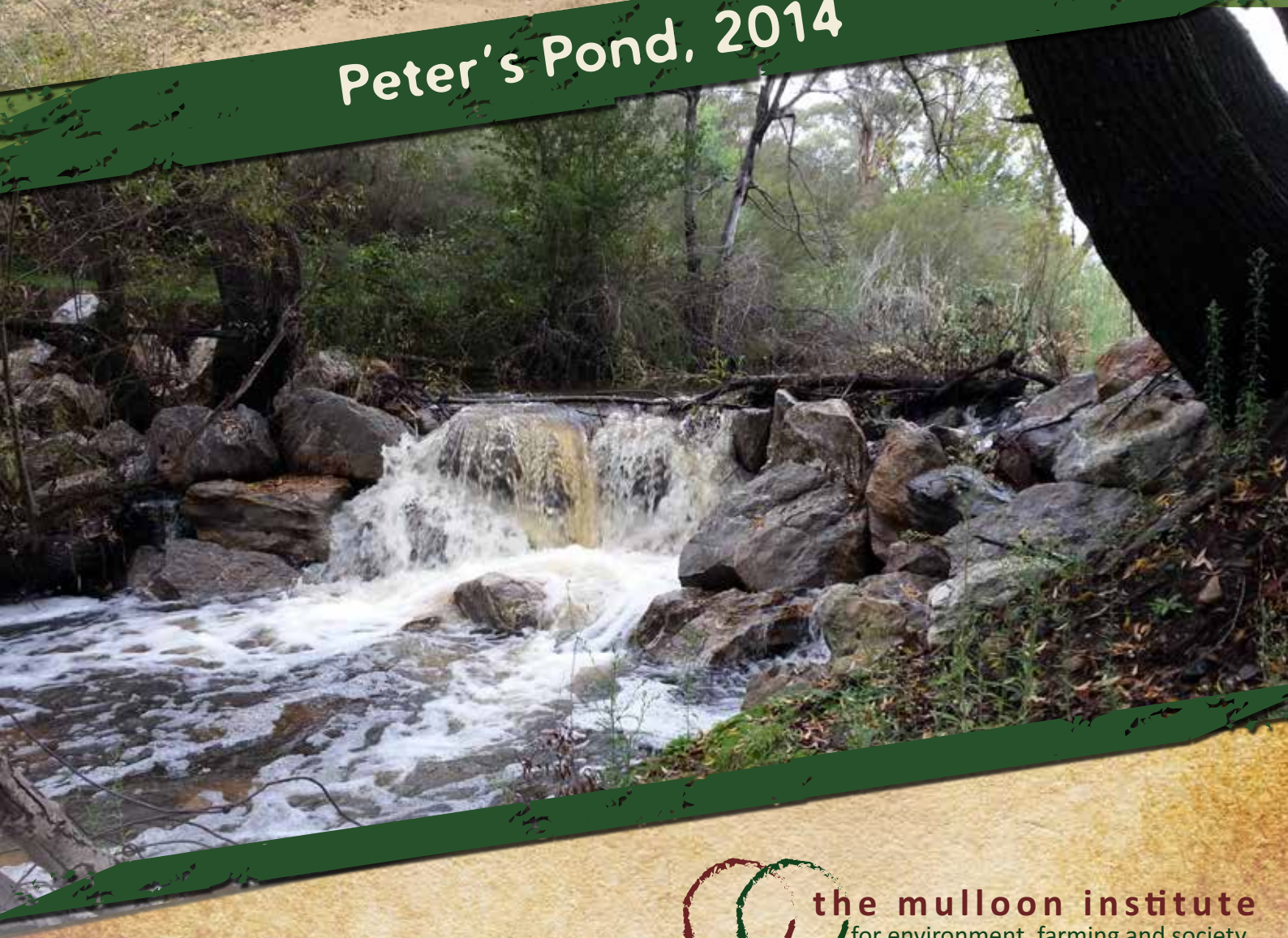
Peter's Pond, 2006



Peter's Pond, 2014



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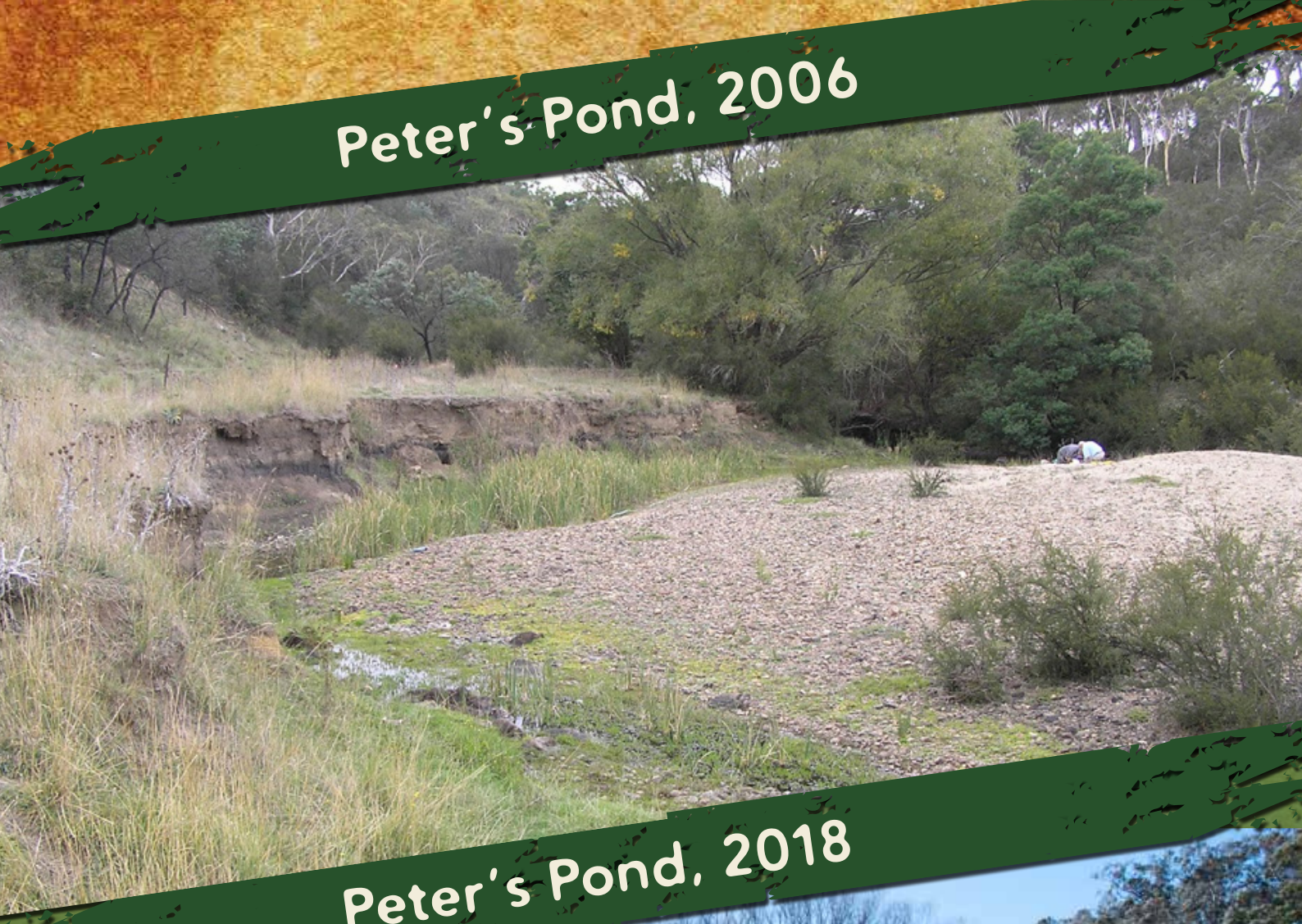

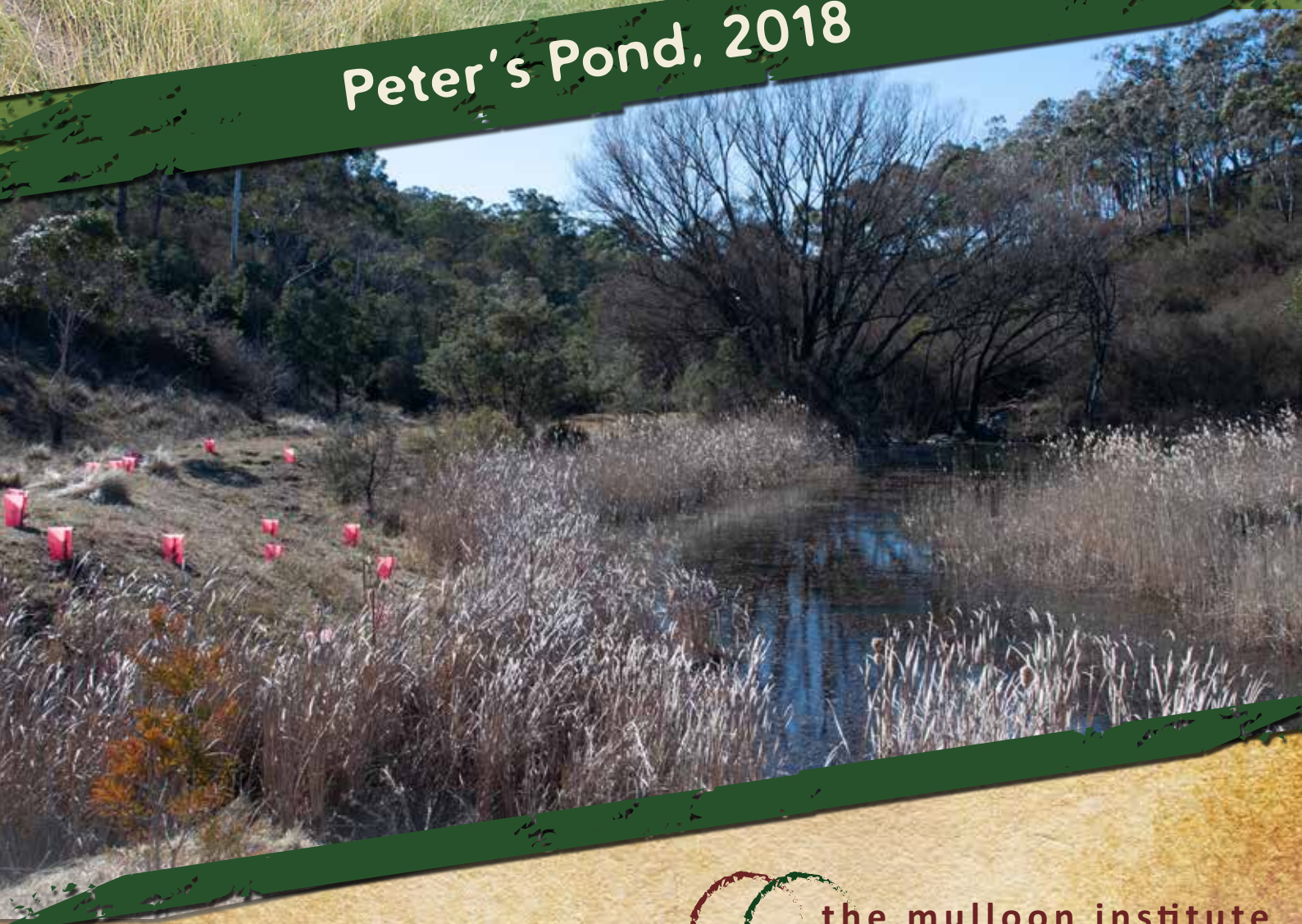

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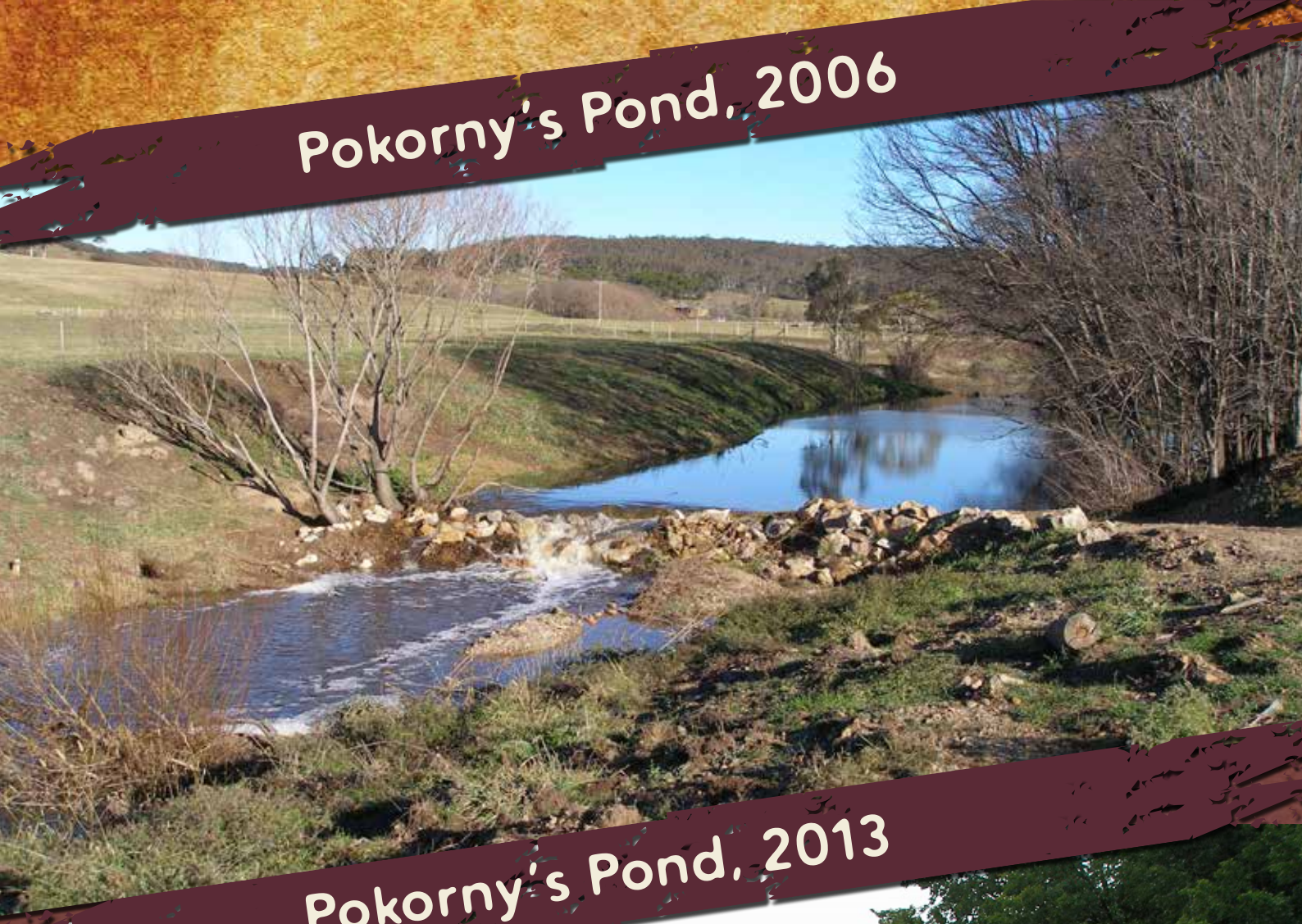
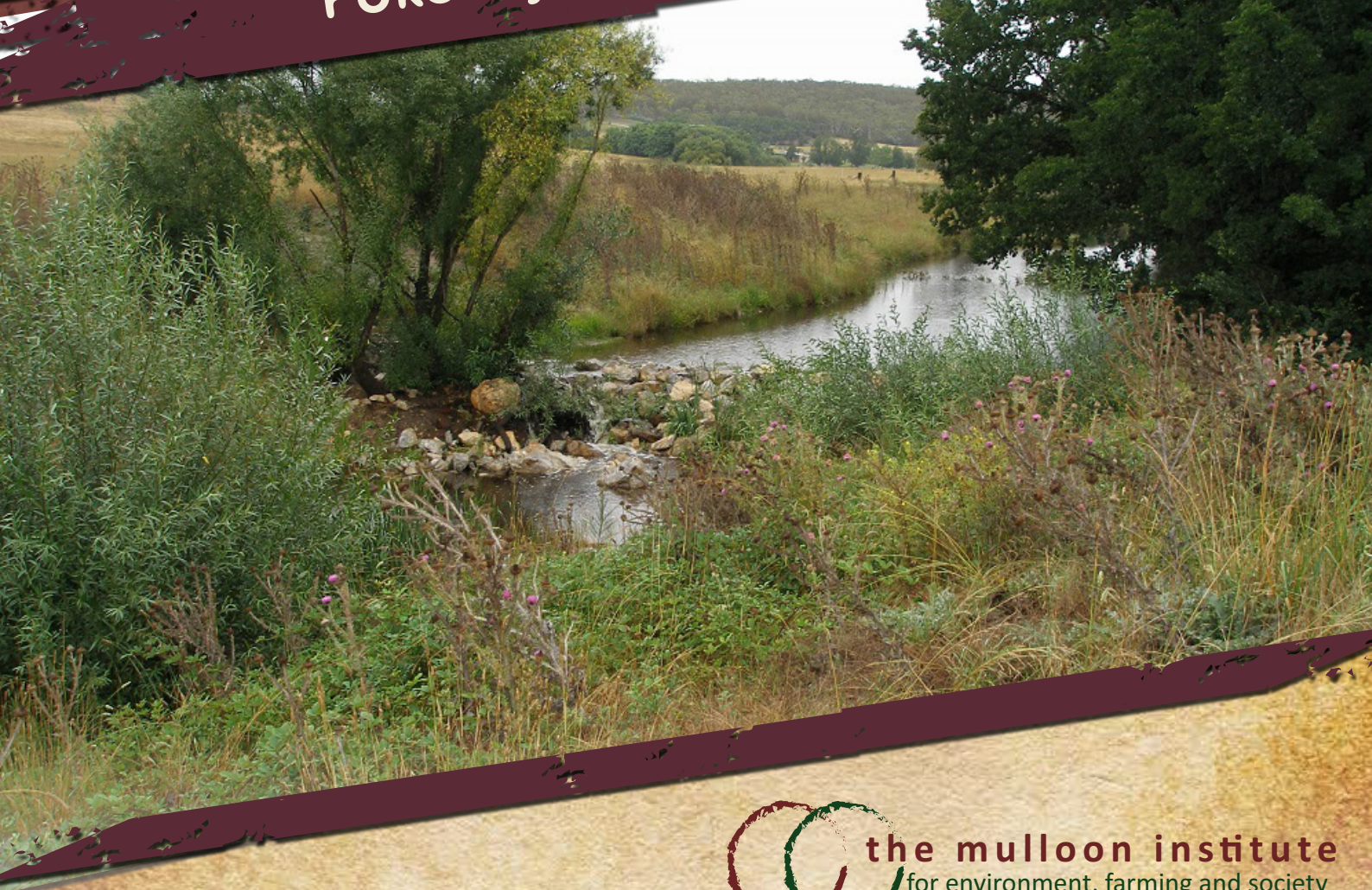
Pokorny's Pond, 2006



Pokorny's Pond, 2013



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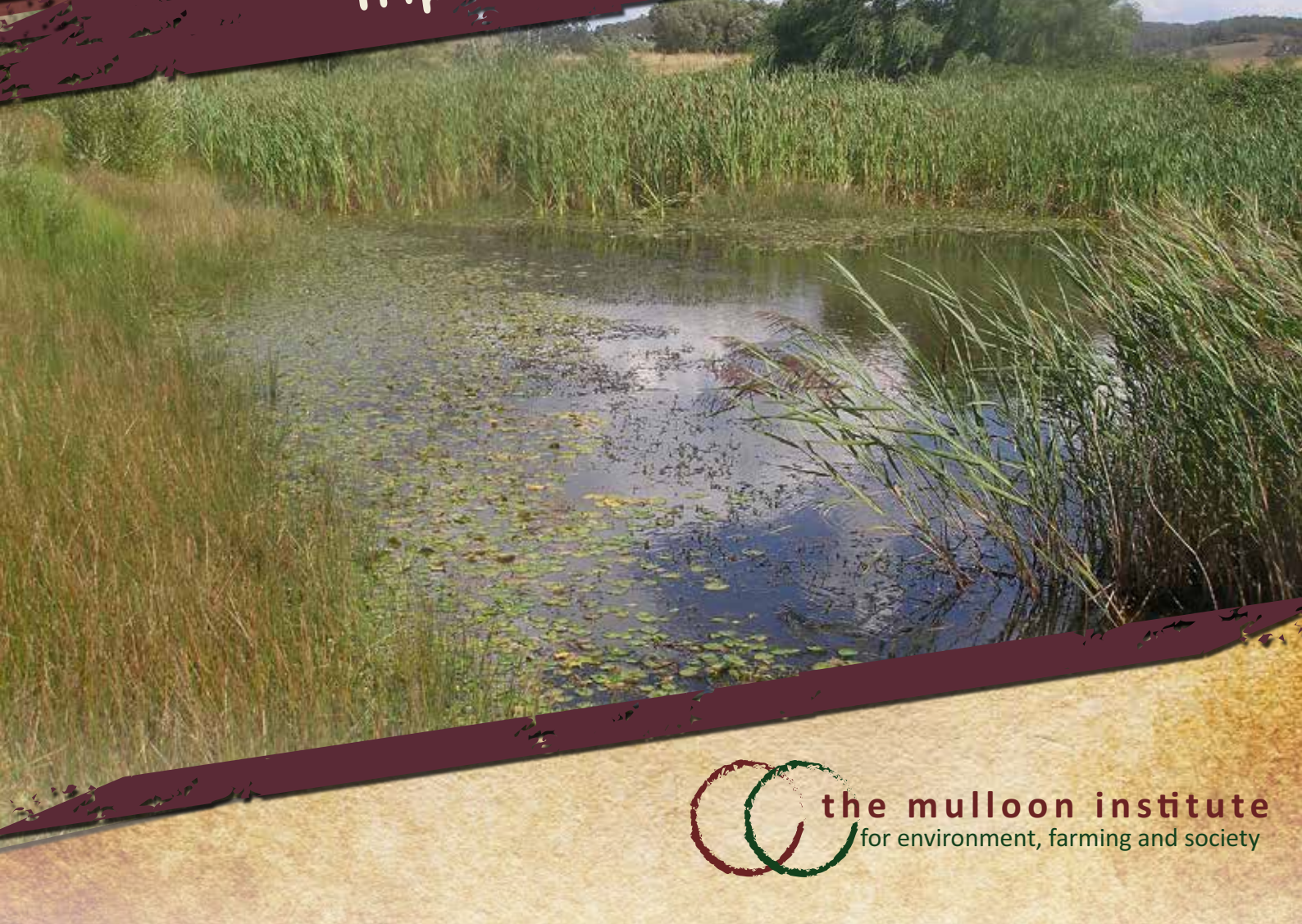

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Attachment D - MCLRP Project Construction Drawings

MULLOON COMMUNITY LANDSCAPE REHYDRATION PROJECT (MCLRP)

STAGE 1

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WESTVIEW CONSTRUCTION DRAWINGS

BEFORE AND AFTER PHOTOS CONSTRUCTION

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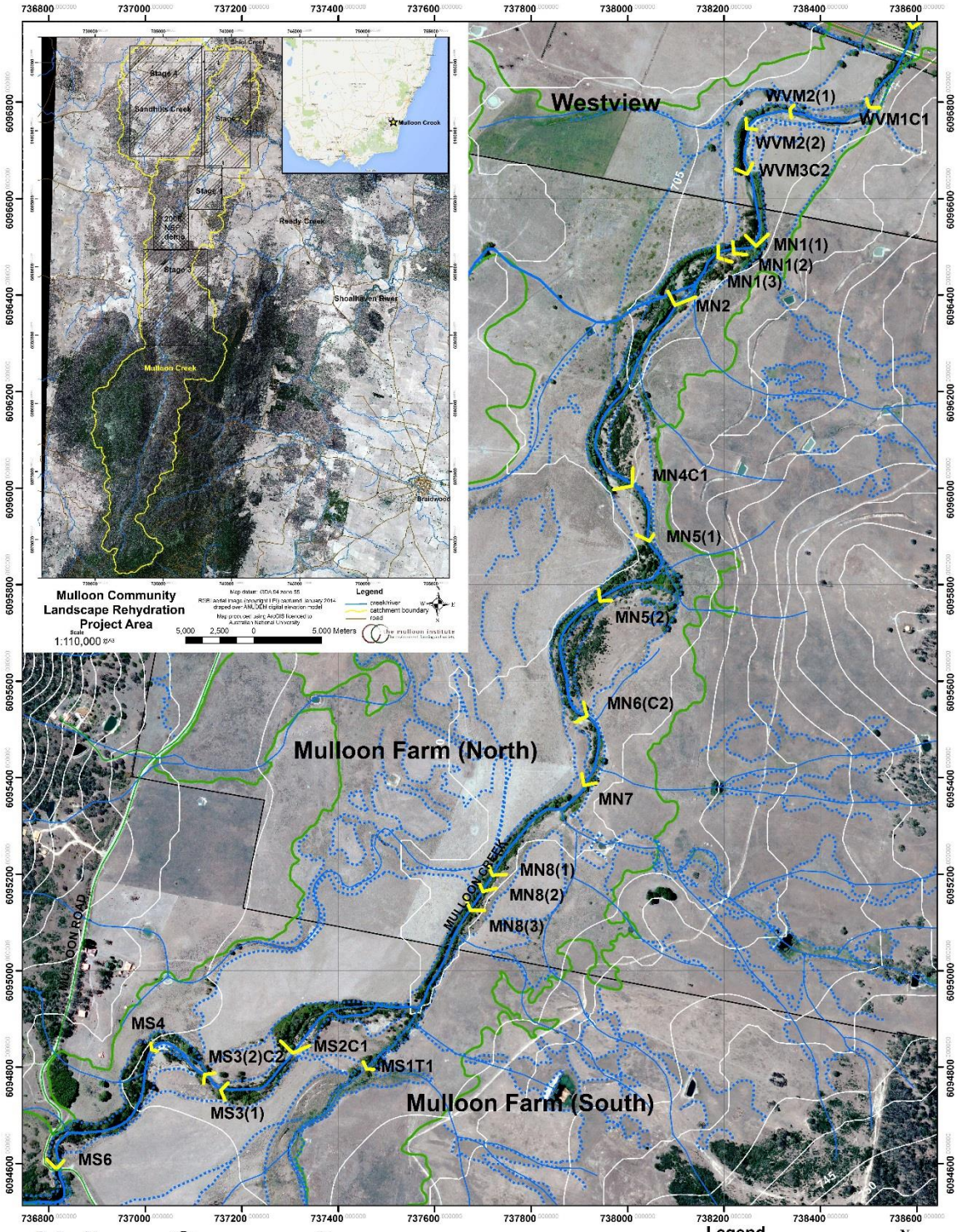

Mulloon Community Landscape Rehydration Project - Stage 1

Scale 1:7,000 @A3

Map datum: GDA 94 zone 55

RGBI aerial image (copyright LPI) captured January 2014 draped over ANUDEM digital elevation model

Map produced using ArcGIS licenced to Australian National University

400 200 0 400 Meters

Legend

- creek
- minor flowline
- floodplain boundary
- property boundary
- proposed ecostructure

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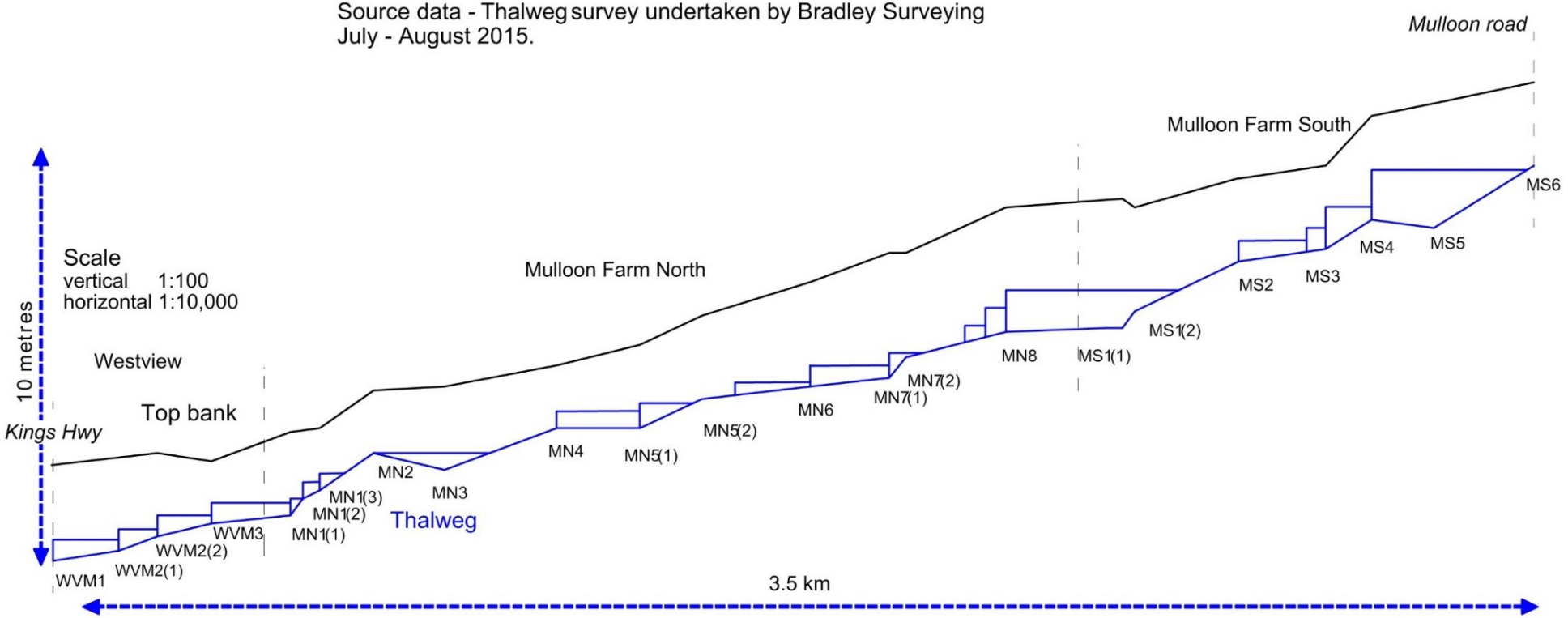
Mulloon Creek long-section - Kings Highway to Mulloon Road crossing with proposed structures

Source data - Thalweg survey undertaken by Bradley Surveying
July - August 2015.



Section G1: Westview

Location and layout: see Figures B1 & B2

What work will be undertaken?

A series of 4 streambed control structures are proposed to be constructed along approximately 580 m of Mulloon Creek from the northern to the southern boundary of Westview (Figures B1 & B2).

Site WVM1: log sill and rock baffle grade control structure

Refer to: Figures B5, B6, & B7

WVM1 Site summary

Top bank to top bank	50m	Primary overflow height to backwater	0.4m
Control structure width	22m	Gradient on face	1:4
Control structure cross-section area	8.9m^2	Approx. Impoundment	0.8 ML

WVM1 Works description

Site WVM1 will be raised 700mm above the existing streambed using a combination of hardwood log sill (Figure B7) and an imported rock baffle (Figure B3). The final spill height will be 400mm above the backwater created by an existing rock ramp built in 2004 on the neighbouring property. A 400mm hardwood log will be pinned to the bed using 200 mm diameter hardwood uprights and keyed into the left bank. If bedrock prevents adequate pin penetration in the centre of the channel, the log will be anchored using 900 mm rock (Figure B4). On the right side of the channel, 650 mm granite boulders will be keyed into the upstream side of an existing bedrock bar to create a rock baffle.

Undermine protection will be achieved via a 400mm bed of knitted brush mattressing and Poa tussock mulch. Streambed gravel will be placed against the upstream side of the structure, into which Typha and Phragmites will be transplanted. For scour protection, a 200 mm deep rip rap apron will be installed on the downstream side (where bedrock is absent), extending to one metre above the low flow channel on both flanks.

The banks and bed above and below WVM1 will be extensively planted with native vegetation comprising reeds, sedges, shrubs and trees (See vegetation plan for more details).


Figure B3: Example of an imported rock baffle in place on Mulloon Creek upstream of Westview.


Figure B4: Example of a log sill with large rock anchors.

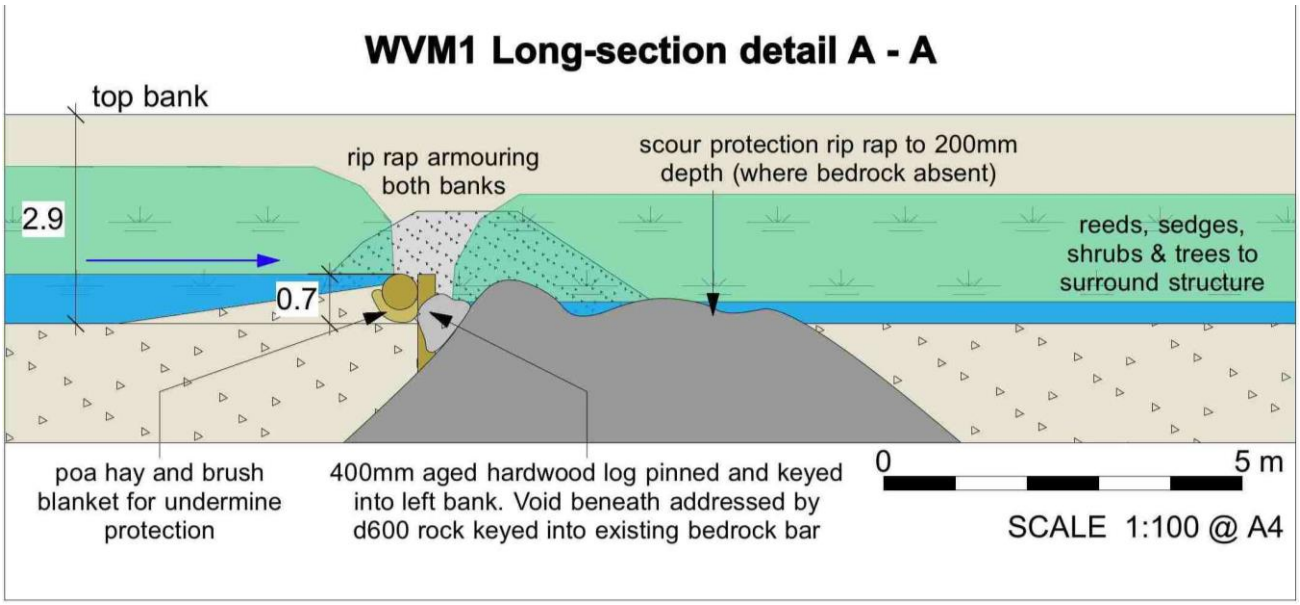


Figure B5: WVM1 long-section. See Figure B4 for section location

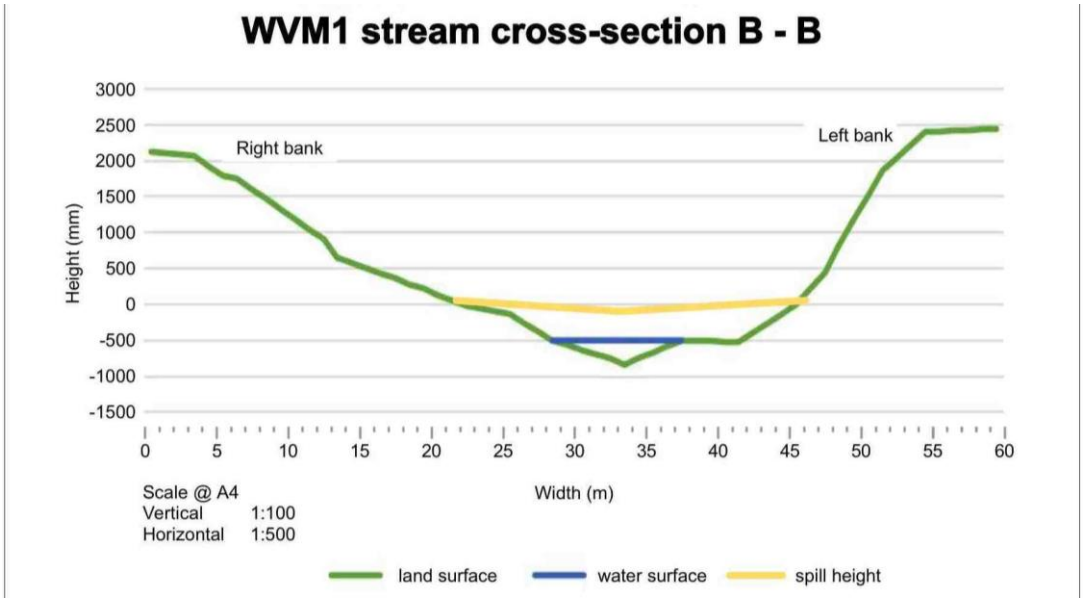
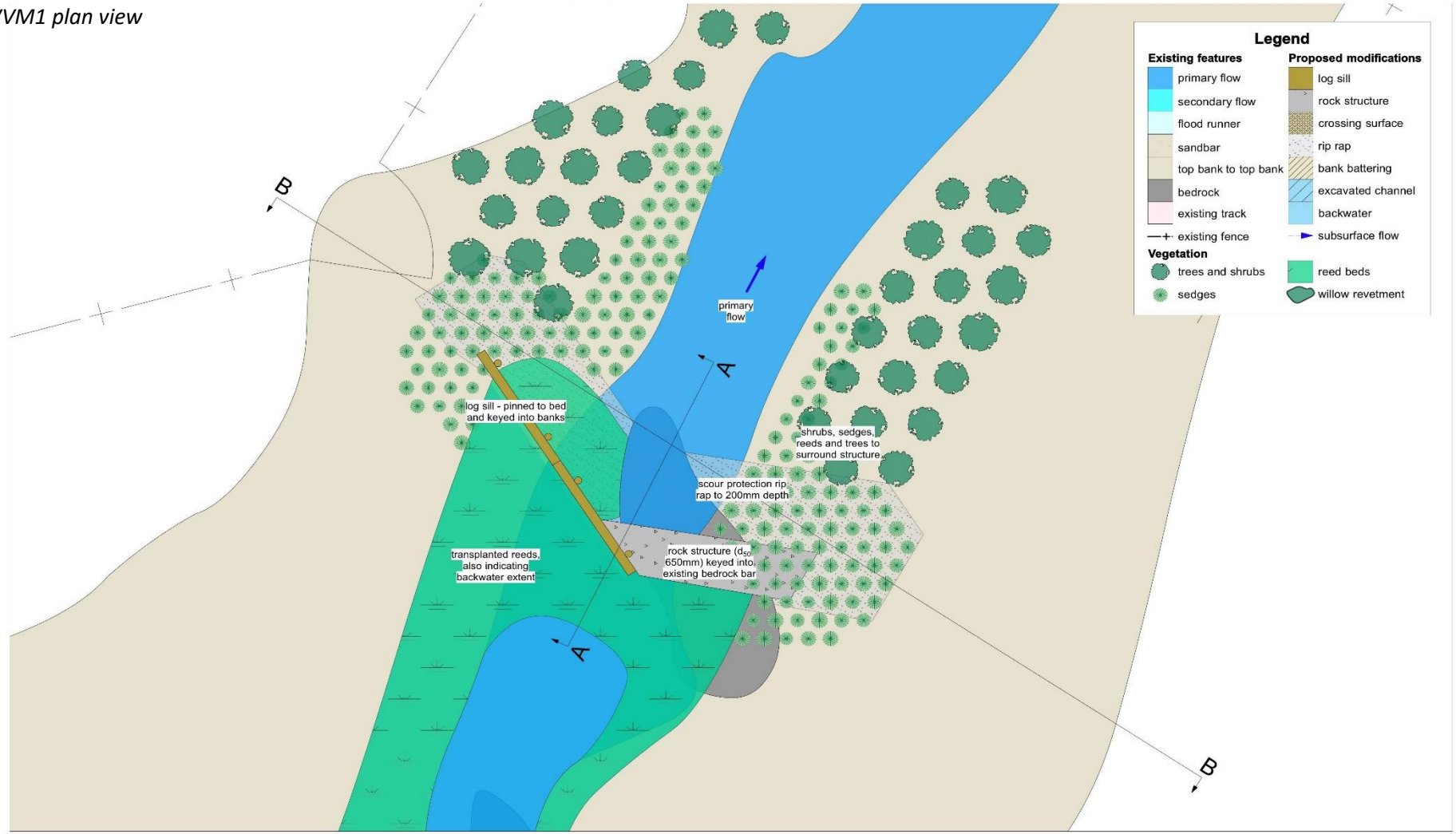


Figure B6: WVM1 cross-section. See Figure B4 for section location

Figure B7: WVM1 plan view



Project: Mulloon Community Landscape Rehydration Project
Property: Westview
Owner: John West
Site: WVM1
Drawing: Structure Detail
Drawn by: Campbell Wilson
Date: 20/2/18

SCALE
1:200 @ A3

0 5 10 15 20 m

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Attachment E - Definitions

Leaky Weir – means an in-stream or in-gully structure designed to contribute to the re-naturalisation of surface and near surface flow patterns.

This includes the re-establishment of geomorphic features such as wetlands, chains of ponds, pond riffle sequences and/or swampy meadows.

Intended outcomes/benefits include; slowing and spreading of flow pulses; raising the alluvial watertable; improved water quality; extended flow duration; restored instream, riparian and terrestrial habitat complexity; improved soil condition; and moderated micro-climate.

Leaky weirs are engineered to a specific catchment context to ensure their immediate structural integrity. However, their long term integrity relies ultimately on vegetation establishment on and surrounding the structures.

(Other terms used for similar structures include: - bed control structure, porous check dam, beaver dam.)

Related Works - consists of Embankments, Rock Ramps, Constructed Contour Banks and Watercourse Plantings.

Embankments – means, taking account of the surrounding geomorphology, strategically placed generally constructed earthen banks, the aim of which is to lift high flows out of an eroded stream or gully and to revert that 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. Reverting high flows to the floodplain creates similar outcomes/benefits to those described in the definition for leaky weirs, with the additional benefit of encouraging broad areas across the floodplain of vigorous vegetation growth.

Rock Ramps – means rock ramps constructed in conjunction with embankments or in any situation where a high flow needs to spill back into a watercourse or gully 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. Long term sustainability of a rock ramp, as with other structures described herein, requires armouring vegetation to grow over the structure.

Constructed Contour Banks – means constructed contour banks that intercept excessive surface flow before it reaches a watercourse allowing it time to either soak into the soil or to spread out on the ridges, rather than that water concentrating in the gullies and increasing potential for erosion. Contour banks are constructed exactly perpendicular to a slope at carefully identified locations within the slope called steps. The banks are designed to take into account local conditions such as slope, soil type, catchment size and climate.

Watercourse Plantings means plantings undertaken in conjunction with the construction of any of the above structures. The primary aim is to contribute to the short, medium and long term armouring of that structure and its surroundings, therefore, ensuring the sustainability of that structure. For any structure described above to be sustainable it needs to be a ‘living structure.’ Plantings in and around structures need to be actively managed for several years to ensure that they are contributing to, and not adversely affecting, the integrity of the structure or the broader system.