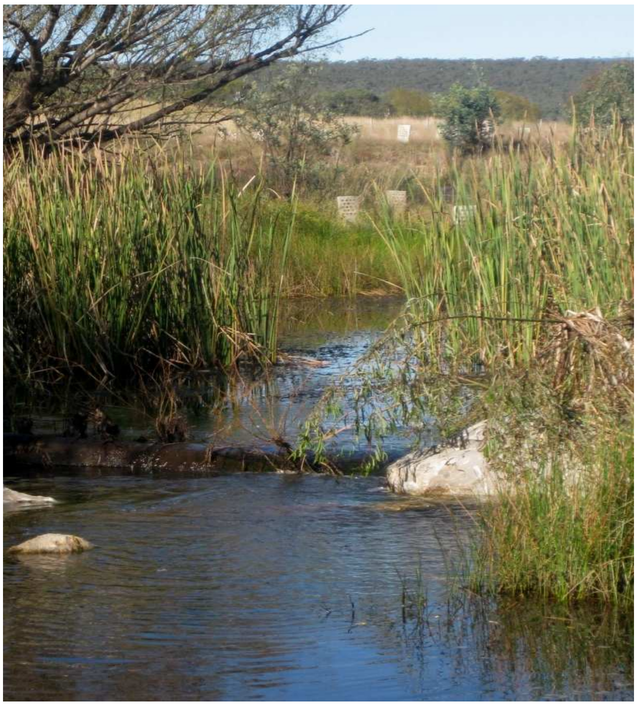

REPORT

SOUTHERN RIVERS CATCHMENT MANAGEMENT AUTHORITY

MULLOON CREEK NATURAL SEQUENCE FARMING TRIAL

A Project Summary and Proceedings of a Workshop (April 18 2011)

Catchment Management Authority Southern Rivers

Australian Government

Upper Shoalhaven & Upper Deua Landcare Network

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INTRODUCTION

This report provides an overview of the Natural Sequence Farming Trial established along Mulloon Creek near Bungendore NSW.

This project was a partnership between landholder Tony Coote (Mulloon Creek Natural Farms), Peter Andrews (Natural Sequence Farming), Southern Rivers Catchment Management Authority and the Upper Shoalhaven Landcare Council. The project trialed the application of Natural Sequence Farming techniques to a degraded waterway within a grazing system setting. The project commenced in 2006 with financial support provided by the National Landcare Program. Stage one of the project commenced in March 2006 and involved construction of eight structures. Stage two included 5 additional in-stream structures and bank shaping works. A range of materials and structure designs were incorporated into the project, most notably, rocks of varying sizes and gravel with vegetation playing a critical role in ensuring the structures remain stable during flow events.

This report is presented in two sections. Section One provides a detailed description of the project works, achievements and lessons learnt, from the Southern Rivers Catchment Management Authority's perspective. Section Two presents the outcomes of a workshop held to discuss the results of the trial and recommendations for the future, prepared by John Powell (Optimal ICM) and Michael Williams (Michael Williams & Associates Pty Ltd) in association with Southern Rivers Catchment Management Authority.

SECTION ONE – A DESCRIPTION OF THE MULLOON CREEK NSF TRIAL

1.1 MULLOON CREEK

The Natural Sequence Farming trial is located on "Mulloon Creek Natural Farms Home Farm", a property located approximately 10 km west of Bungendore on the Southern Tablelands of N.S.W. Mulloon Creek drains northwards from mountains of 1200-1330 m before flowing eastwards to the Shoalhaven River.

Mulloon Creek is part of the Reedy Creek catchment, a tributary of the Shoalhaven River and contributes to Sydney's drinking water supply.

The lower reaches of Mulloon Creek have historically undergone dramatic changes to hydrology including swamp and wetland drainage, channel straightening and catchment clearing. These activities have all contributed to moderate to severe bank erosion, significant channel incision, loss of in-stream sediment, loss of native biodiversity and a reduction in overall water holding capacity. The lower reaches of Mulloon Creek are now presented as a significantly incised channel, often isolated from adjacent floodplains with fragmented riparian vegetation.

During the 1970's and early 1980's the Shoalhaven River, Mulloon Creek and other tributaries were the focus of efforts of the Water Resources Commission to undertake 'River improvement works', including the removal of ti-tree and other 'snags' along with straightening channels to improve water flows. The table below demonstrates the schedule of works outlined for Mulloon Creek (Radke, 2003). Figure 1.1 and 1.2 show rehabilitation works undertaken on the property in the 1980s.

Table 1.1 – Schedule of 'River Improvement Works' Mulloon Creek

Mulloon Creek	*Mesh (metres)*	*Desnagging (metres)*
1971	5700	170
1974	410	-
1977	455	-
1978	1408	-
Jul 1980 – Jun 1981	570	-
Jul 1981 – Jun 1982	336	-
Jul 1982 – Mar 1983	343	-

Figure 1.1. Rock sausages placed along Mulloon Creek in 1980 at the site where Weatherstation crossing is now located (see Table 2 and Figure 3 for location).

Figure 1.2. Willow propagation via placement of tripods of willow canes at the site where Willows Crossing now occurs (see Table 1.2 and Figure 1.3 for location)

In 2003, the Upper Shoalhaven Landcare Council commissioned Bruce Radke to undertake a study to survey and map sites of streambed lowering within a number of tributaries of the catchment. Mulloon Creek was included in this study. Bruce Radke identified on average 1.9 erosion points per km within Mulloon Creek, with streambed erosion occurring at a similar rate in the other tributaries surveyed across the Upper Shoalhaven Catchment. During his survey of Mulloon Creek, Bruce Radke provided the following description for the area of Mulloon Creek Natural Farm:

"Above the gorge on *Mulloon Creek*, the stream stretches into a wider floodplain within a Silurian sequence of sediments and limestone, where meander engineering and willow revetments had been put in place in the 1970's. This reach exhibits a range of erosional features from SBL (*stream bed lowering*) (Mul 25-26) to predominant over-steepened riffles (Mul 25-29). A belt of exposed low limestone pinnacles across the width of the channel has acted as a partial bed structure, with gravels and flood debris accumulating upstream. Stream flow is intensified through narrowed channels between the limestone pinnacles. This has incised parts of the gravel deposits (Mul30). Upstream through a brief and narrow bedrock gorge, the stream has a wide and flat-bottomed channel, strewn with gravel and cobbles. Opposite willows established on the edge of the channel, root-stabilisation preserves the bed from complete erosion and subtle but steeper riffles have developed (Mul31). The stream again crosses the Mulloon Fault and gradually becomes bonier with increasing bedrock exposed, alternating with pools. (Radke, 2003)."

The upper reaches of Mulloon Creek are dominated by well vegetated areas of National Park and State Forest, however grazing is the major land use of the catchment downstream of (and including) Mulloon Creek Natural Farms where woody riparian vegetation is fragmented and rare (Mutendeudzi, & Haeusler, T. 2007).

The geomorphology of the reach of Mulloon Creek along which the NSF trial is located is described under the River Styles framework as a 'C*onfined Valley setting with a Discontinuous Floodplain'*. (Brierley *et. Al.,* 1999). It was further described in Johnson & Brierley, 2006, as a 'floodplain pocket, located 20.8 km from source'.

The project site is 2.4 km long and has a maximum width of almost 0.3 km. The channel is typically around 50m wide and comprises a bedrock-based, pool-riffle sequence with occasional mid-channel and bank-attached bars. Shallow levees are locally evident. Abandoned channels of moderate sinuosity and decreasing capacity can be traced along the floodplain. In locally wider sections of the valley, contemporary swamps have formed at floodplain margins' (after Johnson & Brierley, 2006). The Catchment area of Mulloon Creek upstream of the site is approximately 12,000 Ha with an average annual rainfall of approximately 650 mm.- 750mm.

Landholder, Tony Coote, was inspired by the work of Peter Andrews' on other similarly degraded properties and was seeking support of government agencies to undertake a trial of Peter Andrews NSF activities to rehabilitate this degraded reach of Mulloon Creek with the aim of re-hydrating the landscape and re-introducing vegetation and biodiversity to the area.

1.2 PROJECT PLANNING PROCESS

The Mulloon Creek Natural Sequence Farming Trial was a partnership between landholder Tony Coote (Mulloon Creek Natural Farms), Peter Andrews (Natural Sequence Farming), Southern Rivers Catchment Management Authority and the Upper Shoalhaven Landcare Council aimed to explore the opportunity of applying Natural Sequence Farming techniques to a degraded waterway and adjacent catchment, a grazing system setting. The project commenced in 2006 with financial support provided by the National Landcare Program. The project was established with the aim to:

- *establish a scientifically monitored demonstration of the Peter Andrews approach to landscape restoration in a grazing system setting*
- *develop an accredited learning process that allows others to implement the Peter Andrews approach under supervision or licence.*
- *provide an accessible and supportive environment for learning about the Peter Andrews system of landscape restoration*
- *develop a communication framework that is supportive of the catchment community, that engages key stakeholders and that clearly articulates the outcomes of each stage of the project.*
- *show that Natural Sequence Farming principles can be used in areas that do not have a creek or river.*
- *show how change in the landscape can be achieved with minimal or no cost.*
- *show how the method can improve the profitability of the farm.*
- *document Peter Andrews' theories and practices as the project advances for the benefit of those conducting further demonstrations.*

Preparing for the implementation of the Natural Sequence Farming Trial involved the following:

- Promotion and discussion of project objectives and activities with neighbouring property owners and the broader community.
- Meetings of project partners including Southern Rivers CMA, Mulloon Creek Natural Farms, Federal Government, NSW Fisheries, Office of Water, NSW Department of Lands and Upper Shoalhaven Landcare to agree on protocols for the development and implementation of the project;
- Field visits to other examples of Natural Sequence Farming in the Hunter Valley including 'Baramul', by various project participants;
- Successful application to the Australian Government National Landcare Program for financial assistance, along with negotiation of cost sharing arrangements between the Southern Rivers CMA, Federal Government and landholder, Tony Coote;
- Completion of a full survey of the reach of Mulloon Creek to aid in the design of in-stream structures;
- Several creek walks with Southern Rivers CMA staff, Federal Government staff , Tony Coote and Peter Andrews to discuss, debate and document project design;
- Discussion with Universities in the establishment of suitable project monitoring;
- Preparation of Review of Environmental Factors by Southern Rivers CMA, describing Peter Andrews' intended in-stream activities for the concurrence of the Department of Natural Resources (now Office of Water) and NSW Fisheries (now Department of Primary Industries).
- Coordination of on-ground works including several phases of earthworks under the guidance of Peter Andrews, fencing, revegetation and maintenance works following periods of water flows within Mulloon Creek; and

Once agreement had been negotiated by all parties involved, construction of the leaky weirs was undertaken in two stages, stage one being the construction of eight structures in April of 2006. Stage two included 5 additional in-stream structures and bank shaping works. During the construction of stage 2, additional structures were included in the project plan.

Southern Rivers CMA staff ensured that there was on-going communication of expectations between the landholder, Peter Andrews, Southern Rivers CMA, Department of Natural Resources and NSW Fisheries. The design of on-ground works emerged through an iterative process which was reliant on Peter Andrews interpretation of the landscape.

1.3 SUMMARY OF STRUCTURES

The in-stream structures installed at Mulloon Creek can be loosely described as one or more of the following:

- *Rock Weirs*
- *Log sills*
- *Rock/gravel sills*
- *Flow diffusing cobble bars*
- *Rock baffles*

A range of materials and designs were incorporated into the structures, most notably, rocks, gravel and vegetation play a critical role in ensuring the structures remain stable during flow events.

In an effort to implement 'low cost' solutions, all rock utilised in the construction of these structures was won on the property with an excavator, utilising tipper trucks to transport to the necessary locations. This is generally a cheaper option than purchasing rock from a quarry. Use of local rock is not always possible on private properties due to the impact of quarrying rock on potential habitat for native and threatened species or due to the absence of suitable rock.

Each structure, aside from the rock baffles, incorporates living vegetation that forms a crucial part of the structural integrity. The location, function and form of each structure was guided, and construction supervised, by Peter Andrews. Southern Rivers CMA staff were present to ensure the requirements the relevant authorities were considered, as per the agreed plans, and that changes were communicated. A summary of the final structures built within Mulloon Creek are listed in Table 1.2. An additional set of off-stream structures (The Fan) were constructed on a small flow line that enters Mulloon Creek from the west into Peter's Pond (LW2). Three, automatic flow monitoring devices were installed along Mulloon Creek and are discussed in Section 2 of this report.

Table 1.2 Summary of Mulloon Creek in-stream structures

Leaky Weir CODE	Name	Description
LW1	Goldney's Gate	Fifteen large boulders arranged to slow flow
LW2	Peters weir and pond	Rock weir supported by large willow tree and Cumbungi. Bank shaping and planting.
LW3/LW4	Weatherstation Crossing	Rock sills below rubble crossing.
LW5 LW6	Willows Crossing Complex	Three weirs, two constructed side channels, pond lengthening, two rock sills and a constructed pond. Bank tapering.
LW7a,b	Williams's Wallow	Two log and rock weirs, a constructed levy and pond.
LW8a, b, c	Triple Ponds	Series of three weirs. Bank battering.
LW9	Platypus Weir and pond	One weir made from rubble and willow branches. Bank battering.
LW10	Go Back Way Back Crossing	Large side-channel redirected against the creek flow. One constructed pond.
LW10a	Mitchell's Weir	Rock and rubble piled up around a felled willow tree.
LW11	Pokorney's pond and crossing	Rock, cobble, soil and vegetation weir.
	Hazellbank	Cobble, soil and vegetation bank. Further stages planned.
LW12	Poplars Crossing	Rock, logs, rubble and vegetation crossing. Low flow directed through pipe.
LW13	Wily's Ripl	Limestone outcrop with rock and earth added
LW14	Pump Shed Weir	Rock weir. Flow directed against bedrock.

1.3.1 Rock Weirs

Rock weirs are a common structure within the Mulloon Creek demonstration. A relatively simple construction, the rock weir has been built to slow water, creating a pond on the upstream side of the rock weir. Water is able to flow over the rock weir and slowly seep through the structures. Water velocities within the channel are noticeably reduced by reducing the slope and introducing roughness to the channel.

Peter Andrews refers to natural 'choke' points within the creek in locating rock weirs, relying on adjacent vegetation (such as willows) or natural rock bars to increase the stability of the structure and reduce the potential for outflanking by high water flows. It was also anticipated that revegetation within the structures with water plants such as *Phragmites* would provide additional stability.

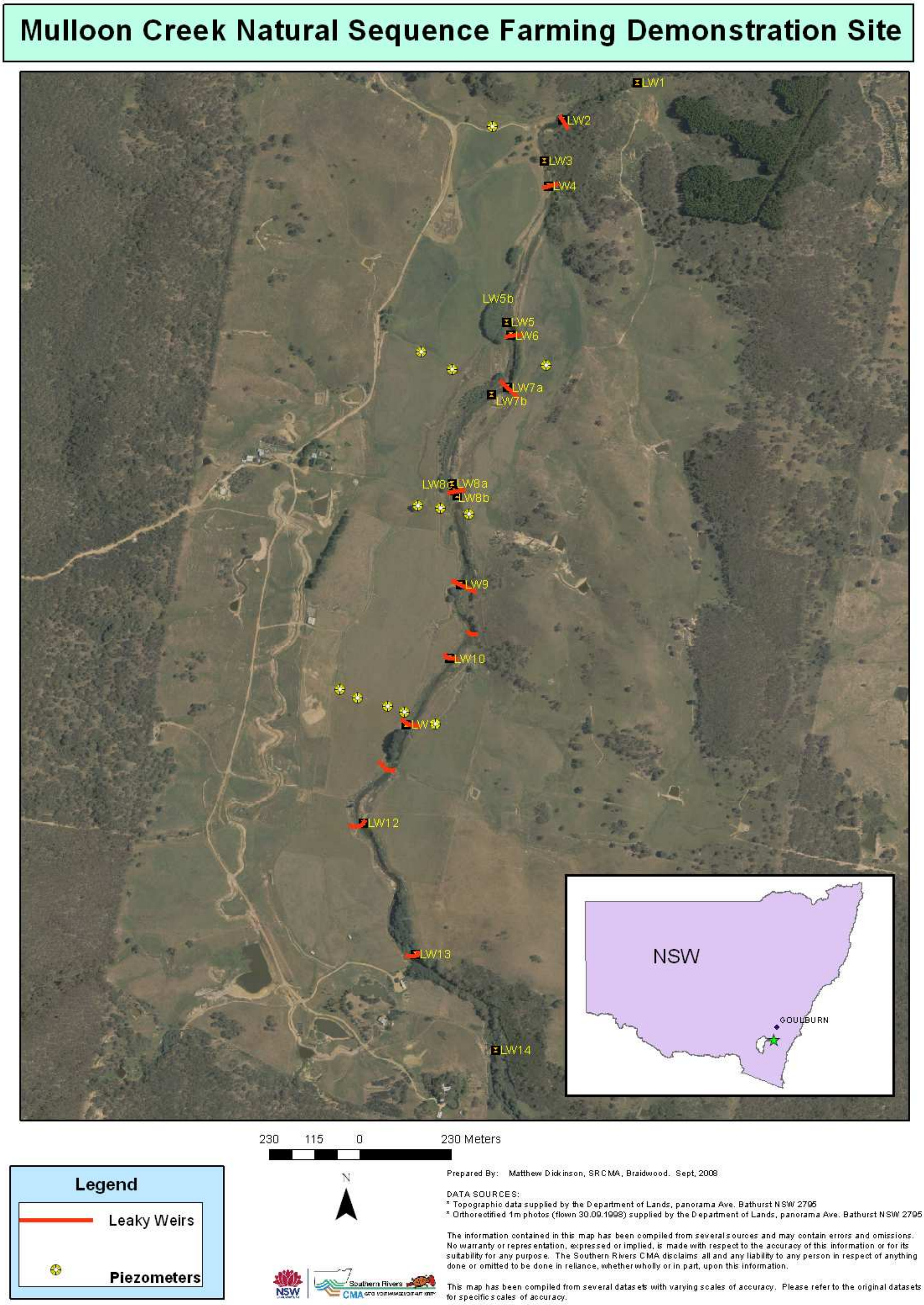

Figure 1.3. Sites on Mulloon Creek showing location of structures and piezometers

Water velocities anticipated across a variety of flow events at the proposed location of these structures informed Southern Rivers CMA recommendations on suitable rock size to optimise structure stability. These rock weirs have also been constructed to encourage sediment deposition up stream of the structure. It is recognised that this will likely take considerable time in a sediment-starved system such at Mulloon Creek.

NSW Fisheries and Office of Water accepted these structures as part of a trial of Natural Sequence Farming, however, fish survey data is required to confirm that fish passage is not being impeded. Current legislation generally requires structures of this type to include a more gentle gradient on the downstream side to allow for fish passage, along with restrictions on height per structure. This would significantly increase the cost of the works, requiring additional rock and machinery time for their placement.

Figure 1.4. Peters Weir (LW2), August 14, 2007 on the left and April 4, 2011 on the right.

An example of this type of structure is 'Peters Weir (Figure 1.4). This leaky rock weir at Peter's Pond is designed to retard flows and retain a body of water that raises the level of groundwater in the adjacent floodplain.

- The height of this leaky weir is 1.2m;
- The structure consists of rocks between 0.25 m and 1 m diameter;
- The willow tree on the Western bank plays a critical role in stabilising the structure;
- A willow branch lodged in the centre of the structure has become established and is assisting to anchor the rock in place;
- This weir was repaired in 2008 by adding more limestone rocks.
- Vegetation established in the pond upstream of this structure is playing a role in enhancing its' stability.

The other large rock weir at Mulloon Creek is 'Pump Station Weir' (Figure 1.5). Large rocks were also incorporated into many of the other structures.

Figure 1.5. Pump-station Weir (LW14) in 2007.

1.3.2 Log Sills

Several log sills were constructed during the trial. These structures consist of logs placed on the bed of the stream in such a way as to direct flow in a specific direction. Log sills are designed to reduce up-stream gradients by raising the bed level by a predetermined amount at specific locations. Usually the log sills will direct flow toward the centre of the normal low flow channel. The logs need to be anchored in a way that prevents them from floating away.

Log sills are commonly used by the Southern Rivers CMA to address streambed erosion. Conventional methods applied by Southern Rivers CMA use large wooden 'pins' driven in to the bed of the stream to which the logs are attached with wire or cable. Logs are buried within the bed of the channel to secure the structure against a calculated potential scour depth and rock is then placed on the downstream side to prevent undercutting and allow for fish passage. A suitable height to raise the streambed with one log sill is considered to be 0.5 m.

At Mulloon Creek the logs were generally anchored by large rocks being placed on top of them and by vegetation growth, most typically willow trees. Logs were not buried within the channel, with stability anticipated as a result of vegetation being encouraged around the structure. It is important to note that rocks, gravel and vegetation form an integral part of these structures. Rock is used to prevent scouring by dissipating energy and anchoring the logs in place. Gravel is used to provide a medium for plant growth which armours the structure during high flow. As vegetation becomes more established the plants will take over the role of anchoring the logs and provide further roughness to the channel. Willows are clearly performing this function at Mulloon Creek in addition to *Lomandra, Phragmites* and *Typha*

Examples of log sills include: "Willows Crossing" (LW5), "Williams Wallow" (LW7), Poplars Crossing (LW12) and Triple Ponds Crossing (LW8) (See Figure 1.6 and 1.7).

Figure 1.6. Triple Ponds Crossing (LW8) under construction 2006 on the left and Oct 2009 on the right.

Figure 1.7. Upstream structure of Triple Ponds Crossing (LW8a) 2007 and a view of the three structures (2008).

1.3.3 Rock Sills

These structures act in a similar way to log sills but can be shaped to suit local site conditions. They are constructed as a row of rocks across the stream generally perpendicular to normal flow. The rock sills at Mulloon were designed and constructed to bring about the formation of ponds and to direct flow in specific directions with the intent of encouraging greater hydration of the adjacent riparian zone. Cobbles and gravels were used as part of their construction with aquatic vegetation being planted to provide stability in the long term. No excavation is undertaken to armour the structures from potential scour, relying on the establishment of in-stream vegetation to provide long term stability.

There are three rock sill structures on Mulloon Creek at Weather Station Crossing (Figure 1.8, 1.9 and 1.10) and a further three at Willows Complex Crossing (LW5).

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Figure 1.8. View downstream from Weather Station Crossing (LW3) soon after construction, 2006 (left) and Nov 2007 (right). The rock sill is identified by the red arrow. Note the establishment of in-stream vegetation.

Figure 1.9. Rock sill downstream of Weather Station Crossing (LW3) Jun 2007 (left) and Aug 2008 (right).

Figure 1.10. Weather Station Crossing (LW4) June 2006, this rock sill was constructed on a natural rock bar.

1.3.4. Flow Diffusing Cobble Bars

As noted by Bruce Radke in 2003, this section of Mulloon Creek included deposited cobble bars that had then become incised within the main channel. The principle behind this structure was to rehydrate these dry cobble bars by raising and directing water over or into the bar via an extended pool. A further aim of these structures is to reduce water energy by reducing overall stream gradient and increasing the accessible channel cross sectional area.

There are four of these structures along Mulloon Creek. Two larger examples of these at the site being Willows Crossing Complex, (Figure 1.11 and 1.12) and "Go Back, Way Back" (Figure 1.13).

The elongated pond at Willows Crossing Complex was excavated from the existing gravel bar and the material placed beside the pond forming a long levee (see Figure 1.11). Go Back Way Back has an additional function of introducing flow from an eroded floodplain channel into the main channel of Mulloon Creek in a direction counter to normal flow (see figure 1.13). This is intended to have the effect of reducing energy from both the flow in the flood channel and the main channel. The structure was built using soils and gravel excavated while battering the adjacent banks of the main channel.

Smaller versions of these structures were also built on the upstream side of Willows Crossing Complex (LW5) and at Poplars Crossing (LW12).

Rapid establishment of vegetation is considered critical to their stability due to the absence of large rock that may be stable during periods of high water flows. The structure at Willows Crossing Complex suffered some damage in 2007 and the resulting break in the bank was repaired with rock, forming a secondary rock sill that has since been colonised by willows, Typha and other plants (see Figure 1.12).

Figure 1.11. Downstream from Willows Crossing Complex (LW5b), Sept 2007 (left). Note rock sills to right of image in main channel. Also in May 2011 (right). Note the vegetation that has become well established in four years

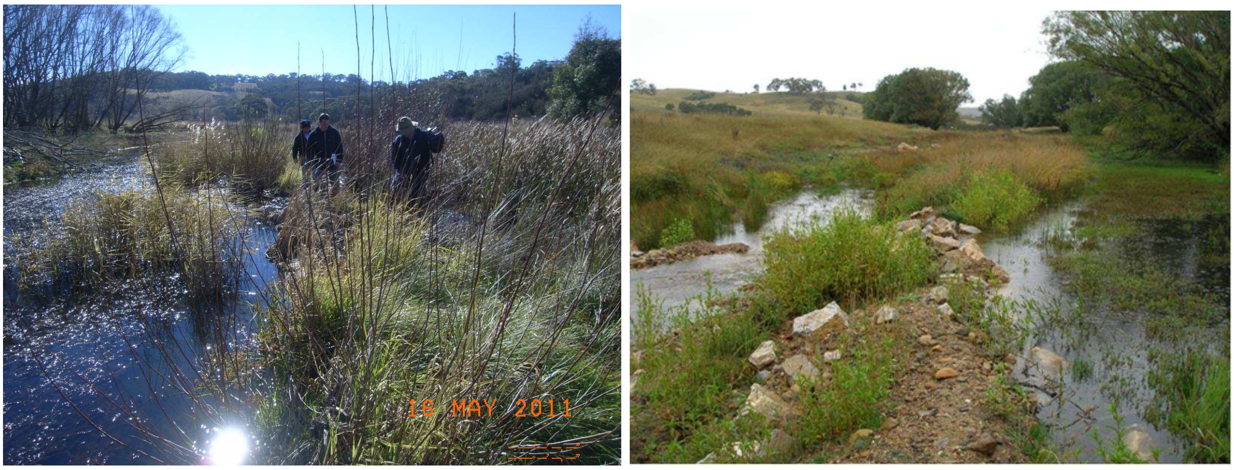

Figure 1.12. Downstream of Willows Crossing Complex (LW5b) at the upstream limit of the structure (left). Note extensive aquatic vegetation growing in main channel on RHS of image. Right photo - Downstream of Willows Crossing Complex (LW5b). Rocks were used to repair some flood damage creating an additional rock sill.

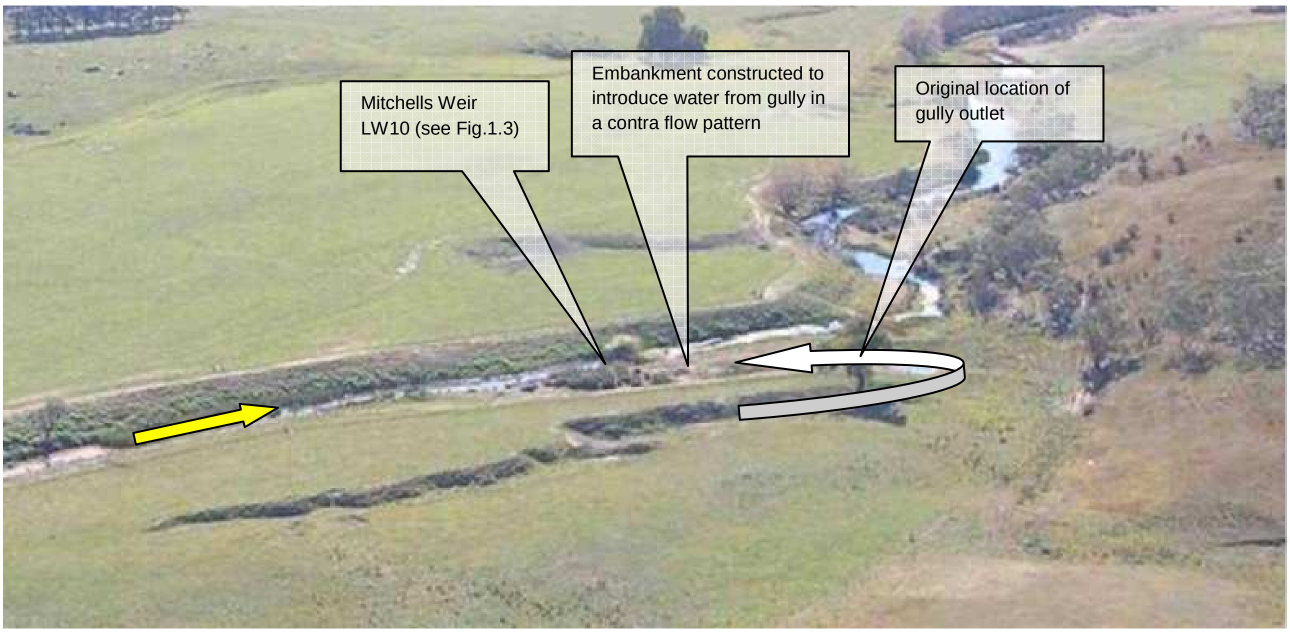

Figure 1.13. "Go Back Way Back" crossing from the air. Yellow arrow indicates direction of main flow and white arrow indicates contra-flow from secondary channel.

1.3.5 Rock Baffles

These structures include large boulders (minimum of 1 metre in diameter) that have been placed at 'strategic' choke points within the channel to reduce water velocity by the introduction of channel roughness. Significantly reducing channel capacity, their success relies on the strength of adjacent streambanks, located in places with excellent riparian vegetation and/or within a bedrock confined (or gorge) type channels.

There are two of these structures at the Mulloon Creek site although rocks have been used on nearly all of the structures to achieve different objectives (see Figure 1.14).

Figure 1.14 'Goldneys Gate' (LW1) (left) is a baffled structure which attenuates river flow. Willy's Ripl (LW13) (right) is a naturally occurring rock bar that was augmented with rock creating an extensive pool

1.3.6 Story of a Structure - Pokorney's Crossing (LW11)

Pokorney's Crossing was initially constructed as an earthen bank approximately 1m high. This bank was not secured with rock or logs, as per other structures, but relied on the successful establishment of vegetation to provide stability. After construction in August 2006 a high flow event early in 2007 broke through the earthen bank (Figure 1.15). The bank was reinforced with rock and a large willow tree was transplanted to the right bank to provide bank stability. Adjacent banks on both sides were also battered to encourage the establishment of vegetation and groundcover.

Before works 2005 *Structure when first constructed in August 2006*

January 2007

March 2007 showing impacts of a high flow event

August 2007 following repairs and addition of rock

February 2008 with vegetation well established

Figure 1.15 – Photographic log of Pokorney's Crossing (LW11).

1.3.7 Low cost structures

In 1993 a concrete flume was constructed at the 1993 level of Mulloon Creek on the western bank of the creek where Peters Pond is now located (LW2). This flume was constructed to stop active gully erosion working its way upslope into an alluvial fan. A channel still remained above the flume which directed water down the northern edge of the alluvial fan towards the flume (see Figure 1.16). When the NSF trial in-stream work commenced in 2006 this area was redesigned to slow and spread water pulses across the fan. An earthen bank was constructed at the top of the fan to redirect and spread irregular surface flows across the fan (Figure 1.17). The channel between the top of the fan and the flume was reshaped into a chain of ponds. This construction took about half a day of excavator time and required no importation of material. Through this simple intervention the area now supports ponds with good water quality and thick pasture cover (see Figure 1.18).

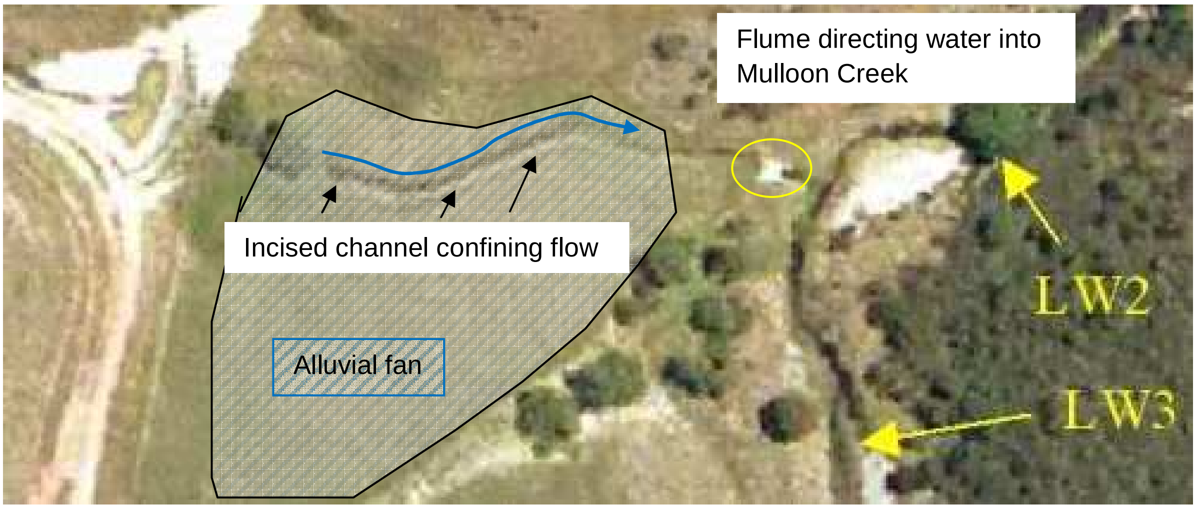

Figure 1.16. Site where gully erosion had confined western flow into Mulloon Creek within a shallow incised gully (flow shown in blue). Previously a concrete flume (circled in yellow) had been constructed to remove erosive energy associated with this flow.

Figure 1.17. Photo from May 2007 showing recovery after reshaping. Water has been directed away from the flume (circled in yellow) onto the fan (new flow shown in blue arrows) and the incised channel has been reshaped. Note that a new track has been constructed that was not present in the previous Figure.

Figure1.18. Area of previously incised channel now supports a small chain of ponds down to the flume (circled in yellow).

1.4 LESSONS LEARNT IN THE CONSTRUCTION OF IN-STREAM STRUCTURES DURING THE TRIAL

The experience of constructing a range of structures within Mulloon Creek and monitoring them during a range of rainfall and flow events has provided a few key messages for future application. These include:

- The location of structures plays a critical role in their success, taking into account the nature of materials used and identifying areas where the streambank is suitable to accommodate them. For example - will large rocks placed in-stream push water into adjacent banks? Are the streambanks suitably stable to compensate for lack of armouring in a structure?
- Materials of suitable size and weight should be incorporated into structures, particularly when vegetation establishment is going to be slow due to climate and/or lack of seed source and sediment within a system;
- Use of vegetation and promotion of vegetation growth is a key consideration in the success of many of the structures used in this trial;
- The use of soft materials for building in-stream structures increases the likelihood of maintenance being required following high flow events. Landholders considering the installation of such structures should ensure they have the capacity and/or budget available to undertake this maintenance prior to commencing works;
- The term ‘low cost’ structures can be misleading as the resources required to build the structures within this project were still substantial and may be beyond the capacity of an individual landholder (other than works described in Section 1.3.7);
- The implementation of the Natural Sequence Farming trial was an adaptive process, with construction often changing to suit different interpretations of the landscape in an iterative way. Such an approach is inconsistent with the standard state government approvals processes for construction of in-stream structures (ie. plan structures in detail, gain approval for plan, construct as per plan). In planning any future projects with an iterative planning process, project managers should ensure approval authorities are on-board with this approach and a set of agreed planning principles is developed prior to the project commencing.
- The Mulloon Creek NSF trial provided opportunity to demonstrate that general principles for structure design employed by the Southern Rivers CMA could be applied in combination with structure placement and design informed by Natural Sequence Farming;

1.5 ROLE OF VEGETATION

The establishment of vegetation is considered to be a vital component of the Mulloon Creek NSF trial. Trees, shrubs and aquatic plants, both native and introduced, are considered by Peter Andrews to be the key to providing long term stability to the structures. They add roughness and complexity to the channel that reduces erosive forces and stabilises the stream bed and banks (see Figure 1.19). They are considered to provide shade and shelter for wildlife, and generally improve the health and biodiversity of Mulloon Creek.

Figure 1.19. Mitchells Weir showing the integration of vegetation with rocks that make up this structure.

Through the course of this project extensive riparian revegetation has been completed. In addition, many aquatic plants have either been planted from purchased stock or relocated from other parts of the Reedy Creek catchment. It is clear that there is significantly more native vegetation growing within the channel than was the case prior to this project being implemented (see Figure 1.20 and 1.21). Another key to the success of vegetation establishment has been stock management from the waterway, with the landholder replacing all riparian fencing to ensure this occurred.

Figure 1.20. Overview of Peter's Pond (P2) prior to works in 2006 April 2011.

Figure 1.21. View downstream from Weather Station Crossing (LW4) June 2006 and November 2008.

Figure 1.22. Example of planting on the river bank near Poplars Crossing (LW12) in Oct 2008.

Willows (*Salix fragilis*) are a common feature of the structures installed at the site and occur extensively along this reach of Mulloon Creek, with existing willows (many planted during previous government programs) incorporated into structures and occasionally transplanted to other locations within this reach of Mulloon Creek. It is highly likely that willows will colonise more of this section of Mulloon Creek and there is evidence of this is already occurring. This is particularly the case in shallower areas where willow branches have taken root. The increased availability of water within the reach has also made conditions more favourable to willow growth. It is recognised by the land manager that willow management is an important ongoing consideration as a watercourse dominated by willows is likely to have a negative impact on the water quality and quantity.

Blackberry (*Rubus fruiticosus*) is also present on the site in significant densities. This is particularly the case in the upstream sections. Mulloon Creek Natural Farms is a registered organic farm and the use of herbicides is not an option for the farm. They will need to actively manage this plant to ensure it does not spread. The use of vegetation as a management tool to suppress blackberry growth is a viable option when used with other more labour intensive methods.

1.6 ACHEIVEMENT OF PROJECT AIMS

The Natural Sequence Farming Demonstration at Mulloon Creek Natural Farms contained many specific aims:

1. To establish a scientifically monitored demonstration of the Peter Andrews approach to landscape restoration in a grazing system setting;
2. To develop an accredited learning process that allows others to implement the Peter Andrews approach under supervision or licence;
3. To provide an accessible and supportive environment for learning about the Peter Andrews system of landscape restoration;
4. To develop a communication framework that is supportive of the catchment community, that engages key stakeholders and that clearly articulates the outcomes of each stage of the project;
5. To show that Natural Sequence Farming principles can be used in areas that do not have a creek or river;
6. To show how change in the landscape can be achieved with minimal or no cost;
7. To show how the method can improve the profitability of the farm; and
8. To document Peter Andrews' theories and practices as the project advances for the benefit of those conducting further demonstrations.

The extent to which these aims were achieved warrants discussion.

- It is important to note that the emphasis in the project proposal was on *landscape restoration* whereas the actual project was limited to activities in-stream and within the riparian environment.
- This project has been successful in establishing a demonstration of Peter Andrews approach to riparian and in-stream restoration in a grazing system setting. Monitoring has been established as part of the project including measurements of surface water flows, groundwater levels and extensive photo monitoring. However, due to the enthusiasm of project partners to commence on-ground works, more thorough collection of baseline data was not collected, resulting in limited 'before' data to compare with data collected once the works were completed;
- An accessible and supportive environment has been created to learn about Peter Andrew's system of landscape restoration. Many field days and opportunities for community members have been provided to allow for exposure to the works, following the completion of construction (see Figure 1.23). These field days delivered on aims 3 & 4 listed above. However, due to many considerations, including safety, there was not opportunity for access to the site by community members during the construction phases of the project, therefore limiting community members understanding of the process to create these works;
- This project has not resulted in the development of an accredited learning process. It is anticipated, however, that the Mulloon NSF trial will be instrumental in informing the development of NSF learning processes and in the planning of future NSF projects. This issue is discussed further in Section 2 of this report.
- This project did not result in the documentation of Peter Andrew's theories and practices. The project has more-so resulted in the documentation of a compromise position in constructing instream works which represents a mix of Peter Andrew's theories and practices and current NSW government standards for the construction of in-stream works (see Figure 1.24). The need for this aim to be fulfilled is discussed further in Section 2 of this report.
- Whilst the project aimed to achieve landscape restoration at minimal or low cost this outcome was not achieved. Implementation of all aspects of this project required significant investment of money in use of earthmoving machinery, Peter Andrews time, purchase of fencing materials and revegetation costs. In addition to these resources, the landholder, Upper Shoalhaven Landcare and Southern Rivers CMA invested considerable amount of labour in the maintenance of structures and the project site along with undertaking the project monitoring. The reality of the costs involved in this project would be beyond the capacity of a majority of individual landholders. It is important to note however, that the scale of this project (ie. 2.4km of stream) greatly exceeds the size of a project likely to be undertaken by a single landholder.

- The project aimed to demonstrate that Natural Sequence Farming principles can be applied away from creeks and rivers (ie landscape restoration). Whilst some, low cost, off-stream activities were undertaken during the Mulloon trial they received minimal attention from a monitoring perspective and were not a focus for field days subsequently held. Such off-stream activities may include relocating floodplain biomass to less fertile areas and improving soil water-holding capacity. Such activities may be more applicable to individual landholder than much of the Mulloon in-stream works. Such activities are more likely to be low cost, with opportunity to learn from mistakes and trial and error with minimal negative impact from unintended consequences. Such activities warrant further consideration.
- The documentation of how on-farm profitability can be achieved through the application of natural Sequence Farming was not an outcome of this project and may be something that could be considered in the future.

Figure 1.23 Mulloon Creek NSF field days have drawn large crowds.

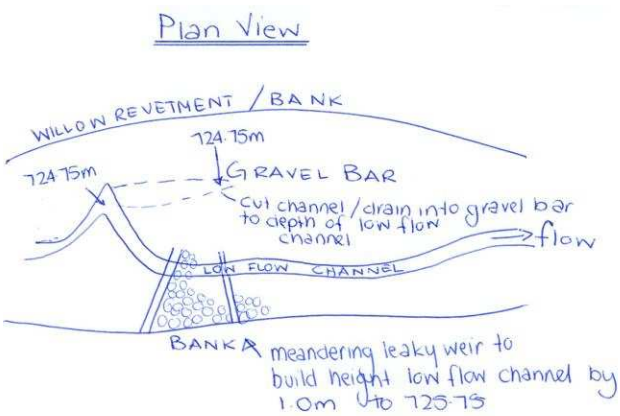

Figure 1.24. Schematic of construction plans for in-stream works

1.7 RIVER HEALTH

The installation of the physical structures has re-instated a pool and riffle sequence that has enormous benefits for aquatic wildlife. Sections of creek that were previously dry a majority of the time are now often wet. This has had the effect of dramatically increasing the area of available habitat to aquatic and semi aquatic plants and animals.

It should be noted that none of the structures act independently of the others. There is a marked connectivity between the structures, where each structure would seem to be reliant on those both upstream and downstream for hydraulic control.

The improvement in habitat diversity and complexity has clearly benefited the general river health in this reach of Mulloon Creek. Bio-monitoring using aquatic macro-invertebrates suggests that stream health is improving. Improvements in biodiversity on the site are likely to have a much broader benefit to catchment wide biodiversity such as provision of drought refuge, increased availability of food and increased habitat diversity.

This project demonstrates the value in rehabilitating a whole reach of stream by improving ecological resilience, creating greater connectivity and enhancing biodiversity. While many of the river rehabilitation projects completed by the Southern Rivers CMA achieve the same outcomes, it is rare to be able to deliver them on a whole 2.4km reach.

The structures created at the Mulloon Creek site are considered to be dynamic and it was never the intention of Peter Andrews that these structures may be left alone following construction. Maintenance and ongoing attention by the landholder is a requirement of these and any structures built in this way. When undertaking river rehabilitation works Southern Rivers CMA applies industry accepted best practice risk management approaches to design and construction. Movement of material associated with in-stream structures is considered unacceptable and viewed as structural failure. Due to the use of unconsolidated materials in many of the structures installed in the NSF trial there is a greater risk of structural damage than would be the case with a standard Southern Rivers CMA project. Landholders adopting the methodologies of Peter Andrews will need to be aware of these risks and the likely costs associated with on-going maintenance.

The work at Mulloon Creek has been a compromise between industry accepted standards and Peter Andrew's concepts and methods. Southern Rivers CMA is impressed with the result of the trial so far and will continue to work with the landholder to ensure that the trial provides benefits well into the future.

The landholder is proposing the implementation of a stage 3 to this project. This would involve additions to several structures along with additional in-stream structures. Southern Rivers CMA is continuing to work with Mulloon Creek Natural Farms to further develop this project.

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SECTION TWO – MULLOON CREEK, KEY OUTCOMES OF A NATURAL SEQUENCE FARMING WORKSHOP, BUNGENDORE NSW, 18 APRIL 2011

Prepared by John Powell, Optimal ICM & Michael Williams, Michael Williams & Associates Pty Ltd in association with Southern Rivers Catchment Management Authority

EXECUTIVE SUMMARY

The Mulloon Creek Natural Sequence Farming (NSF) Workshop brought key NSF stakeholders together to consider outcomes of the Mulloon Creek NSF trial, share the learnings and identify next steps. In addition to Peter Andrews (developer of NSF), key stakeholder groups included the Fenner School of Environment and Society (FSES) from the Australian National University (ANU), the Mulloon Creek Institute, and the Natural Sequence Farming Association. The workshop was developed by the Southern Rivers Catchment Management Authority (CMA), generously hosted by Tony and Toni Coote the owners of Mulloon Creek Natural Farms and independently facilitated by Michael Williams of Michael Williams & Associates Pty Ltd, Sydney.

2.1 RESULTS AND LEARNINGS OF MULLOON CREEK NSF TRIAL

Dr John Field and Nathan Weber from FSES ANU concluded, subject to caveats, that no detrimental effects on downstream users have been identified from preliminary data. More specifically: there appears to be no reduction in discharge volume from the catchment; works undertaken as part of the Mulloon Creek NSF trial appear to be storing water during stormflow events and releasing sustained baseflows; the connection between water levels in Mulloon Creek and groundwater under the floodplain is complex and is not yet well understood; and a comparison of water quality at Mulloon Creek with a relatively intact ‘chain of ponds’ suggests that Mulloon Creek meets water quality baselines (standards).

Amongst workshop participants, there was general agreement that:

- works undertaken as part of the Mulloon Creek NSF trial have stabilised erosion, improved water quality, diversified in-stream habitats, and re-established ecological function;
- within the trial site, Mulloon Creek is holding more water with no apparent negative impacts on downstream water availability.
- the works have withstood high-flow events, and can hold more water in the riparian zone with no apparent impacts on downstream water;
- in-stream and riparian zone revegetation is particularly important in stabilising the system;
- NSF as applied at Mulloon Creek can be viewed by landholders as the riparian component of their landscape management ‘jigsaw’; and
- the transferability of NSF techniques applied at Mulloon Creek is dependent on the site-specific context and the capacity of managers to design and maintain structures..

2.1.2 Unanswered Questions

Participants identified questions that could be addressed by future investigations, including:

- although it appears as though the NSF practices cause no loss of water to downstream users, it is possible that additional groundwater is entering the catchment;
- due to the poor understanding about connectivity between in-stream water levels and water levels under the floodplain, it is unclear whether there has been higher productivity from ‘rehydrating’ the floodplain;
- utilising any increased water stores under the floodplain, especially during drought, may reduce water available to downstream users; and
- the revegetation required for a successful long-term ecological succession is unknown.

In addition to the unanswered questions, workshop participants considered that key issues are impeding NSF adoption, including: defining and documenting NSF, legislative impediments, and NSF delivery.

2.1.3 Next Steps

The workshop developed next steps to accelerate NSF adoption and attract investment, including:

- create NSF/CMA/government partnerships to support NSF adoption, and to create an enabling policy and legislative framework;
- produce a 'design and construct' manual documenting core NSF principles and practices and how to apply them;
- consider formalised training in NSF leading to accreditation; set up an NSF training camp, where aspiring NSF practitioners can be mentored by Peter Andrews;
- continue monitoring the Mulloon Creek trial to provide data over longer timeframes and conduct additional investigations including economic analyses;
- broaden the objectives of CMA programs, for example to increase ponding in streams and enhance in-stream habitat diversity.

2.2 BACKGROUND

Natural Sequence Farming (NSF)

NSF principles

- Recreate a functional floodplain that drives high levels of productivity (i.e. usable and accessible farm biomass);
- Address and cost-effectively repair significant land degradation within valley floors (e.g. soil erosion, bank collapse, gully formation, floodplain stripping, saline leakage, saline scalds etc);
- Functionally reconnect the hydrology of drainage lines, creeks and rivers with their adjacent floodplains;
- Enable the underground storage of significant volumes of water along the floodplain thereby allowing plant production to continue during drought conditions (i.e. drought-proofing);
- Ameliorate deleterious energy fluxes [slow down damaging water flows];
- Redistribute nutrients to all parts of a valley system; and
- Create stable platforms that functionally mimic pre-European 'chain of ponds-swampy meadows' complexes once prevalent in valley systems.

NSF practices

- Physically intervene in the floodplain to create small-scale leaky structures in the stream bed to slow down water flow and facilitate water recharge in the floodplain, and to create one or more additional channels through the floodplain running approximately parallel with the stream bed;
- Harness natural freshes or flooding to initiate sedimentation and plant succession across the floodplain, above and below the leaky structures;
- Adaptively manage the [NSF implementation] process to achieve the stated goals, and to fine-tune structures, assess sediment build-up and biomass production, check piezometer levels where appropriate to assess the volume and dynamics of stored water in the floodplain, check salinity levels where appropriate, manipulate vegetation through targeted replanting and/or removals; and
- Harvest productivity through cropping, haymaking, grazing and encouraging appropriate wildlife, with the latter two activities facilitating nutrient reallocation across the valley from the riparian zone to valley tops.

Adapted from: *Natural Sequence Farming* (NSF), by P Andrews, D Goldney, D Mitchell and P Newell in Proceedings of the 20th Annual Conference of the Grassland Society of NSW Inc, Orange NSW, 19-21 July 2005.

Figure 2.1. A log and limestone leaky weir at Mulloon Creek. L-R: Martin Royds (Chair, Natural Sequence Farming Association), Peter Andrews (Developer, Natural Sequence Farming) and Brad Davies (NSW Land and Property Management)

2.2.1 Workshop Participants

Participants included: Mulloon Creek Natural Farms property owner Tony Coote; Chair Southern Rivers CMA Ms Pam Green; former Australian Government Natural Resource Management Facilitator Peter Hazell; other leading NSF practitioners and advocates including NSF developer Peter Andrews; New South Wales Natural Resources Commissioner Professor John Williams; and representatives of Southern Rivers CMA Board and staff, Mulloon Institute, Fenner School of Environment and Society (FSES) from Australian National University, Charles Sturt University, and local, NSW and Australian Governments. A full list of participants appears at Appendix 1.

2.2.2 Workshop Purpose

The workshop agenda appears at Appendix 2. Its five objectives were to:

1. bring stakeholders together and capture their contributions to, and feedback on the outcomes of the Mulloon Creek trial;
2. determine if the knowledge gained can inform future CMA-managed projects;
3. determine if there is scientific data not yet collected that is essential in determining key trial outcomes;
4. document the recommendations and learning from the workshop; and
5. document the next steps proposed by workshop participants.

The workshop format comprised a field walk/drive in the morning to inspect most of the NSF structures at Mulloon Creek, followed by an independently facilitated workshop that included presentations and discussion about the trial structures, the lessons and outcomes, and next steps.

2.2.3 Mulloon Creek NSF Trial

The on-ground activities completed during this project have been described in section1.

The NSF 'leaky weirs' can be viewed as 'soft engineered' structures. They are perceived to be inexpensive, using naturally-available stone, timber and vegetative materials. They seek to slow down rather than impound stream flows, and their aim is to re-create functioning riparian ecosystems and re-connect streams with the broader landscape. They have a low visual impact, appearing after a few years as though they are natural features. On the other hand, 'hard engineered' structures more traditionally supported by CMAs focus on erosion and sediment control. They typically involve construction of concrete flumes to stabilise active gully heads, and construction of in-stream impoundments that can be lined with geotextile fabric to prevent water leaking through the impoundment wall. Planting exotic plants such as willows is not encouraged.

The Mulloon Creek NSF trial's objectives were to:

1. establish a scientifically-monitored demonstration of NSF;
2. provide an accessible and supportive environment for learning about NSF;
3. show how NSF principles can be applied in areas that do not have a creek or river;
4. show how change can be achieved at minimal or no cost;
5. show how NSF can improve farm profitability; and
6. document Peter Andrews' theories and practices for the benefit of further demonstrations.

Objectives 3 and 5 have not yet been addressed by the trial. Southern Rivers CMA supported the trial, acknowledging the high level of landcare and broad community support for the trial, and the high level of interest in NSF by landholders nationally. The trial was consistent with the CMA's aim of supporting innovation in riparian zone rehabilitation, and property owner Tony Coote was motivated and committed to the trial.

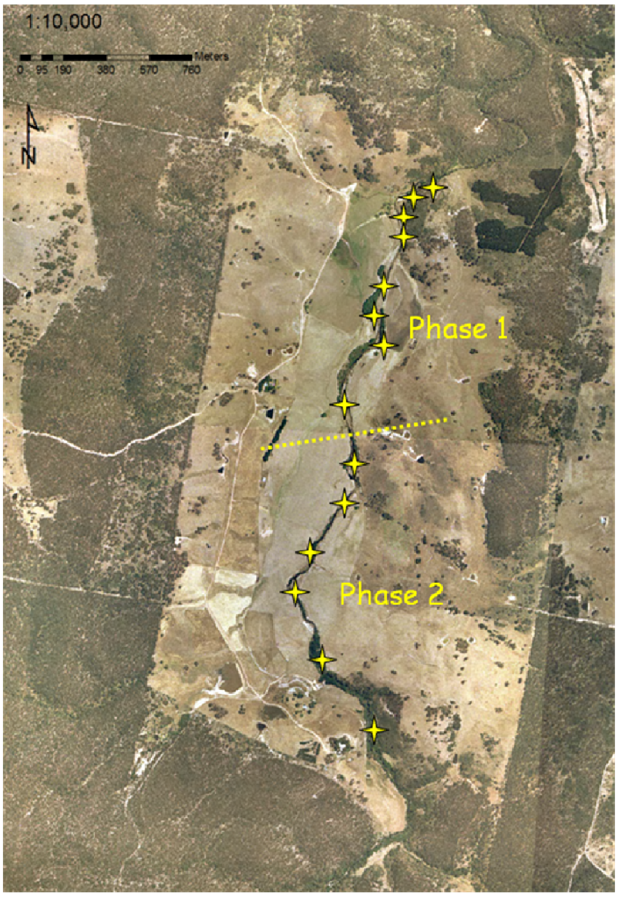

Figure 2.2
Aerial view showing locations of the 14 NSF structures constructed along Mulloon Creek on *Mulloon Creek Natural Farms – shown by yellow crosses*. The photo also shows the extensive floodplain (directly to the west of the creek and pale green in colour) on *Mulloon Creek Natural Farms*. The NSF trial site catches water from 6.7 percent of the Mulloon Creek catchment, and is in the upper one-third of the catchment. Phase 1 of the trial commenced in May 2006 and Phase 2 commenced in October 2007.

2.2.4 Monitoring

Monitoring to-date has included: pond depths; discharge volume; groundwater levels; water quality; climate; pond ecology. In addition, a photo and video log have been made.

Dr John Field and Nathan Weber from FSES ANU are carrying out scientific monitoring of the trial. Discharge volume is being monitored at three sites (see Figure 2.3 and 2.4). The first site is upstream of the NSF trial site, and measures discharge from the upper 23 percent of the Mulloon Creek catchment. The second discharge monitoring point is near the lower end of the NSF trial site and measures discharge from about 30 percent of Mulloon Creek catchment. The third monitoring site is near the northern-most (downstream) end of Mulloon Creek, and measures discharge from nearly 100 percent of the catchment). Groundwater levels are being monitored through a network of 12 piezometers located on the NSF trial site floodplain.

Data collected and analysed by the FSES ANU comprises four years of discharge quantity data, which enables changes in the discharge quantity of Mulloon Creek to be examined over time. The FSES ANU has ten months of water quality data, comprising pH, electrical conductivity, turbidity, and aquatic invertebrate data. Ten months of groundwater level data is available as well as a comprehensive climate record.

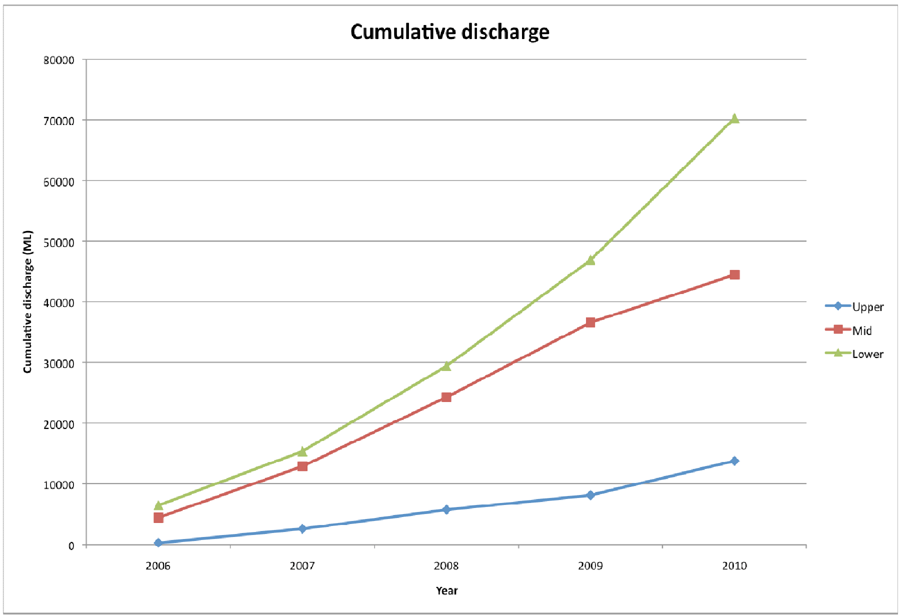

Figure 2.3. This graph shows the volume of water being discharged from the top 23% of the catchment (shown in blue), the additional volume discharged from the next 7% of the catchment (shown in red), and the volume of water discharged from the remaining 70% of the catchment (shown in green).

The graph shows that the volume of water being discharged from the mid (red) and lower (green) catchment areas is increasing over time in comparison with volumes discharged from the upper catchment area (blue). The difference in discharge between the mid-catchment monitoring point and the upper catchment is surprising, given that only an extra 7% of the catchment is contributing to discharge at the mid-catchment monitoring point. The Mulloon Creek NSF structures are situated immediately upstream of the mid-catchment monitoring point. The discharge data suggests that over time, the NSF in-stream structures are increasing the amount of water stored in the mid-catchment area and allowing this water to be slowly released.

2.3 RESULTS AND WHAT WE HAVE LEARNT

After five years, the visual impact of the NSF structures applied at Mulloon Creek can be seen in the photos below. They were taken at *Peter's Pond*, named after NSF developer Peter Andrews. Peter's Pond is the furthest downstream of the 14 NSF leaky weirs constructed at *Mulloon Creek Natural Farms*.

Figure 2.4. Peter's Pond before construction of leaky weir (ca. 2006) and in 2011

2.3.1 ANU conclusions - based on FSES ANU scientific monitoring

FSES ANU representative Dr John Field cautioned that funding constraints had precluded pre-trial monitoring of the NSF trial site to collect baseline data. The constraints had also prevented setting up a paired catchment comparison (for example comparing the eroded NSF trial site prior to commencement of the trial with a similarly degraded system where NSF works were not to be undertaken). Dr Field indicated that the floodplain regolith (the layer of loose soil and rock material above bedrock) is a complex sedimentary system of alluvial in-stream gravel and sand deposits, levee sand deposits, floodplain clays and back water clay and organic deposits interbedded with complex alluvial fan deposits. This sedimentary complexity makes it most difficult to gain a clear understanding of ground water flow and ground water levels within the floodplain sedimentary sequences. The FSES ANU representatives indicated that their study results should be interpreted in the context of these data and site limitations.

On the basis of preliminary data analysed to-date, the FSES ANU representatives concluded that the NSF trial on Mulloon Creek has not resulted in any identified detrimental effects on water quality or quantity that might impact on downstream users. More specifically:

- there appears to be no reduction in discharge as a result of the in-stream NSF structures. A detailed water balance (an estimate of the amount of surface and groundwater entering and leaving the catchment) needs to be conducted in order to determine if the considerable additional water discharge into Mulloon Creek contributed by the additional 7% of the catchment (see Figure 2.3) is a function of ground water input;
- the NSF structures at Mulloon Creek appear to be successfully storing water during stormflow events and subsequently releasing more sustained baseflows. In some instances, Mulloon Creek continues to flow out of the furthest downstream NSF structure when surface flows upstream of the NSF trial site have stopped;
- the connection between water levels in Mulloon Creek and groundwater under the floodplain is either absent or very tenuous, but the complexities of the floodplain sedimentary sequences may explain the lack of connection; and
- Mulloon Creek meets chemical water quality baselines (Australian standards). A comparison of aquatic invertebrates in Mulloon Creek with those in a relatively natural, undegraded 'chain of ponds' system, indicated that Mulloon Creek supports a greater diversity and abundance of aquatic invertebrates than the 'chain of ponds'.

2.3.2 Workshop Participants’ Views – Based on the Workshop Presentation and Field Inspections.

There was general agreement that:

- in a short timeframe, activities associated with the NSF trial at Mulloon Creek have stabilised streambed and bank erosion, improved water quality, created a wide range of in-stream habitats, and re-established ecological function;
- within the trial site, Mulloon Creek is holding more water with no apparent negative impacts on downstream water availability. The volume of baseflow appears to be increasing since commencement of the trial;
- in-stream and riparian zone revegetation including willows, is particularly important in stabilising the system. Excluding livestock is critical to successful riparian revegetation. It was noted that willows can shade out other species and that willows require active management (e.g. pruning) to ensure they provide a net benefit to the system;
- once established, the ‘soft engineering’ NSF structures have withstood high-flow events;
- the transferability of NSF techniques applied at Mulloon Creek as part of the NSF trial is dependent on the site-specific context and the capacity of managers to design and maintain structures;
- the Mulloon Creek trial has provided an accessible and supportive environment for learning about NSF, with 2,000-3,000 people visiting the site to-date;
- NSF is now a nation-wide social movement, with the establishment of the *Natural Sequence Farming Association*.

2.3.3 Unanswered Questions

In discussing results presented by the FSES ANU and what has been learnt, participants identified unanswered questions that could be addressed in future investigations:

- it appears there is no loss of water to downstream users from the in-stream NSF structures, but it is possible that additional groundwater is entering the catchment and hence is adding to the amount of water being held in the catchment, as well as increasing baseflow;
- there is poor understanding about connectivity between in-stream water levels and ground water levels under the floodplain, hence it is unclear whether there has been higher agricultural productivity from ‘rehydrating’ the floodplain;
- utilising any increased water stores under the floodplain to increase agricultural productivity, or to sustain a high level of productivity in drought, may reduce water available to downstream users;
- re-vegetation is a critical part of stabilising the in-stream and riparian areas, but some willows are dying, others are proliferating downstream, some exposed stream bank sediments appear to favour weeds, and the number and diversity of plants in the ecological succession is unknown;
- the effect of vegetation in increasing the total amount of available moisture in the system (for example additional moisture from dew and fog) needs to be investigated in the Australian landscape;
- the cumulative effects of up-scaling implementation of NSF works to the entire Mulloon Creek catchment, or multiple catchments, is unknown;
- the efficacy of raising the existing structures to further increase water levels in the landscape is unknown;
- the effect of the structures on native fish movement, behaviour and breeding is unknown.

Figure 2.5. Leaky weir comprising rocks, mulch, sediment, plants and micro-organisms.

2.3.4 Issues impeding NSF adoption

Participants raised issues impeding wider adoption of NSF. These are outlined below.

- *Defining and documenting NSF*

Although Peter Andrews has authored two books and Peter and others have authored a number of papers about NSF, participants remain confused about NSF terms and the differences between NSF and other stream rehabilitation principles and practices. They want to know what is uniquely NSF, and they want detailed guidance on how to design and implement NSF practices.

- *Legislative impediments*

Professor John Williams (Commissioner, NSW Natural Resources Commission) noted that existing NSW legislation perpetuates the notion that incised and degraded streams, which have become that way since settlement, are the norm and as a corollary it is therefore in the public interest to maintain the flows and resultant sediment loads delivered by those incised and degraded streams. This is in contrast to NSF structures that affect the flows by slowing water down, reducing sediment movement, restoring ecological function, and re-connecting the streams to the wider landscape and thus may be inconsistent with current NSW legislation. The legislation could be reviewed to provide more certainty to landholders in relation to restoration of landscape function. A representative of the NSW Office of Water indicated that the Office can assist CMAs and landholders in interpreting the legislation with a view to obtaining the necessary approvals for construction of NSF structures.

- *NSF Delivery*

At present there is no formal delivery mechanism for NSF, as there is for other approaches that assist landholders with improving landscape function and management (for example time-control grazing or pasture cropping). Once NSF has been defined and documented, an education and training program could be developed. The importance of learning to 'read the landscape' was emphasised by Peter Andrews as something that requires 'time in the paddock'. This expertise cannot be gained solely from a text or classroom.

2.3.5 Recommended Next Steps

Participants developed the following list of actions that a range of stakeholders needs to take to accelerate NSF adoption and attract increased investment:

- create NSF/CMA/government partnerships to promote and support NSF adoption, and to create an enabling policy and legislative framework. A specific task force, informed by outcomes from NSF research and development, may also be warranted to review legislation;
- produce a 'design and construct' manual documenting the core principles and practices of NSF and how to apply them, to underpin education, training and NSF application;
- consider formalised training leading to Certificate III, IV or Associate Diploma accreditation, for example through a partnership between FSES ANU and the Canberra Institute of Technology
- set up another property as a facilitated NSF 'training camp' where aspiring NSF practitioners could participate in a multi-day residential course, mentored by Peter Andrews;
- continue monitoring the Mulloon Creek trial to provide data over longer timeframes and conduct additional investigations including economic analyses at Mulloon Creek and other case study sites, to answer questions raised at the workshop;
- broaden the objectives of CMA stream rehabilitation programs, for example to increase ponding in streams and enhance in-stream habitat diversity; and
- incorporate NSF principles into farm planning courses supported by CMAs.

2.4 CONCLUDING COMMENTS

Comments made by key partners directly involved in the Mulloon Creek NSF trial reinforced views expressed by other workshop participants. For example:

- a consistent theme of the workshop is the need to document NSF in a manual and invest more in NSF education and training. The NSF Association is to produce the outcomes of a NSF Workshop held in late 2006 and intends to produce an NSF manual with assistance from workshop participants;

- Ms Pam Green, Chair of Southern Rivers CMA, indicated that rehydration of the landscape is an important part of our future. The CMA intends to package NSF learnings to-date from this workshop into a communication product for other interested stakeholders and commit to continuing the monitoring at Mulloon Creek, along with development of Stage 3 of the Mulloon Creek trial in conjunction with the landholder;

- NSF integrates ecology, geology and geomorphology and needs to be part of mainstream science. We need to have a teaching facility that provides certification in NSF. We also need to ensure that legislation is framed around the way in which the Australian landscape has evolved and should function, not as it is framed currently around a non-functional and degraded landscape;

- as a community, our expectation that leading figures will change legislation and promote NSF on the basis of the knowledge they have at present, is unrealistic. As more information from NSF sites becomes available, participants from this workshop need to take responsibility for keeping leading figures and other stakeholders appraised of NSF.

APPENDIX 1 WORKSHOP PARTICIPANTS

Amanda Herringe	Licensing Cadet, NSW Office of Water
Brad Davies	NSW Land and Property Management Authority
Cam Wilson	The Mulloon Institute
Chris Presland	Landscape Manager, Southern Rivers CMA
Colin Maclean	Chair Upper Shoalhaven Natural Sequence Association
Danny O'Brien	CEO The Mulloon Institute
David Anthony	Strategic Planner, Palerang Council
David Zerafa	Senior Licensing Officer, NSW Office of Water
Donna Hazell	Catchment Coordinator Upper Shoalhaven, Southern Rivers CMA
Frank Exon	Catchment Officer (Sustainable Landuse) Southern Rivers CMA
Jim Gilfoyle	The Mulloon Institute
John Field	The Fenner School of Environment and Society, Senior Lecturer
John Fry	Landholder, Natural Sequence Proponent
John Powell	Optimal ICM - scribe
John Williams	Commissioner NSW Natural Resources Commission
Kerry Pfeiffer	Southern Rivers CMA Board
Lyall Bogie	Catchment Officer (River Rehabilitation)Southern Rivers CMA
Martin Royds	Chairperson Natural Sequence Association (National Body)
Matt Dickinson	Catchment Officer (River Rehabilitation) Southern Rivers CMA
Michael Cheetham	Research Associate Southern Cross University
Michael Williams	Michael Williams & Associates Pty Ltd – independent facilitator
Michael Wilson	Manager, Living Murray Initiative, Murray Darling Basin Authority
Michelle Jones	Fenner School of Environment and Society, (M.Sc. student) ANU
Nathan Weber	Fenner School of Environment and Society (PhD student) ANU
Pam Green	Southern Rivers CMA Board, Chairperson
Paul Dann	Community Landcare Representative
Paul Newell	Landholder, Natural Sequence Proponent
Peter Andrews	Natural Sequence Farming author and proponent
Peter Hazell	Land Steward
Prof David Goldney	Adjunct Professor, CSU, Orange
Stuart Little	Sydney Catchment Authority
Sue Ogilvy	The Mulloon Institute
Tim Cohen	Fluvial Geomorphologist, Lecturer, University of Wollongong
Todd Maher	Natural Resources Analyst, NSW Natural Resources Commission
Tony Coote	Landowner Mulloon Creek
Wayne Ryan	Licensing Officer, NSW Office of Water

APPENDIX 2 NATURAL SEQUENCE FARMING AT MULLOON CREEK – WHERE TO FROM HERE?

Workshop agenda

7:45 am	**Welcome & Introduction**, **Tony Coote**
8:00 am	**Creek tour**
9:15 am	**Morning tea**
9:30 am	**Introduction and purpose of workshop** **Presentations**
9:45 am	**Project background, objectives and key lessons** Peter Hazell Chris Presland
10:30am	**Review of data collected and results thus far** Dr John Field Nathan Weber
11:45 pm	**Discussion of key lessons and further questions from the floor**
12:30pm	**Lunch Break**
1:00 pm	**Discussion and synthesis** What are the key things we have learnt? Bio-physical and social considerations What are the critical unanswered questions? Where to from here for all partners?
3:00pm	**Afternoon Tea**
3:15pm	**Conclusions**
4:00pm	**CLOSE**

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