

NORTHERN RIVERS JOINT ORGANISATION

ROUS COUNTY COUNCIL

Prepared on behalf of the region by Rous County Council

Northern Rivers Watershed Initiative

DISCUSSION PAPER

February 2019

Endorsed by:

ballina shire council

Byron Shire Council

Kyogle Council

lismore city council

Richmond Valley Council

TWEED SHIRE COUNCIL

DISCUSSION PAPER

Northern Rivers Watershed Initiative

1. INTRODUCTION

1.1 Context

The Northern Rivers region is recognised as having extremely high terrestrial, aquatic and marine biodiversity values with many species endemic to the region. However large portions of these catchment and estuarine areas have typically been extensively modified from (Pre-European) heavily timbered forests to a (current) mix of intensive agriculture, grazing and urban development (Cavanagh *et al*., 2006). As evidenced by the ecohealth status of the Richmond River, extensive modification of natural processes has placed significant stress on these Northern Rivers catchments and estuarine systems.

Pressure on ecosystems within the Northern Rivers will be heightened in the future through climate induced changes, with projections suggesting that there will be more hot days, bushfires, droughts and intense storms. These can all place human life, property and natural ecosystems at increased risk. Changes in rainfall and higher evaporation rates are likely to lead to less water for streams and rivers in the Northern Rivers catchments, which will place strains on water resources. Whilst changes in average temperature, rainfall and evaporation will have long-term consequences for the Northern Rivers catchments, the impacts of climate change are more likely to be felt through extreme weather events (CSIRO, 2007).

In summary, ecosystem health, water security and flood risk all therefore represent key water and catchment management issues for the Northern Rivers. Responding to ecosystem health, water security and flood risk in an integrated fashion requires solutions that can generate outcomes across a range of policy objectives.

The Northern Rivers Watershed Initiative (NRWI) is a catchment and estuary restoration program that has been specifically devised for the Northern Rivers Joint Organisation (NRJO) footprint to address ecosystem health, water security and flood risk issues across the Tweed, Brunswick, Richmond and Evans River systems in an integrated fashion. The NRWI is based on a holistic approach to the management of water within the catchments that will utilise modern, best practice approaches in catchment modelling and natural flood mitigation to target improvements in stream bank condition and river health that also contribute to reduced flood risk within the catchments.

1.2 Overview of the Northern Rivers Watershed Initiative

When rain falls on a catchment, the amount of rainwater that is converted via overland flow into surface water flow down waterways (and potential flooding) and the amount that is converted into longer term landscape storage (such as soil, groundwater and wetlands) depends on catchment characteristics. The NRWI is premised on the concept of natural flood management (NFM) that consists of a range of measures that aim to restore the natural functioning of river catchments, floodplains and rivers to retain water in the landscape in order to reduce downstream flood risks.

The NRWI would involve large-scale investment in catchment works in upper catchment areas that restore natural hydrologic functions that deliver both improvements in stream bank condition and river health and that also contribute to reduced flood risk within the catchment. In addition, it would also involve implementation of coastal zone management plan actions to address high priority estuarine health issues. These measures will deliver a range of environmental, social and economic benefits.

The area to be covered by the NRWI consists of the entirety of the Tweed River, Brunswick River Richmond River and Evans River catchments, covering an area of approximately 8,220 km^2 (refer Figure 1). The NRWI will cover the local government areas of Tweed, Byron, Ballina, Lismore, Richmond Valley and Kyogle. In this way, a truly regional solution to water security and catchment health will be achieved. Figure 1 shows the river catchments of the NRJO area, including these rivers systems that are the focus of the NRWI.

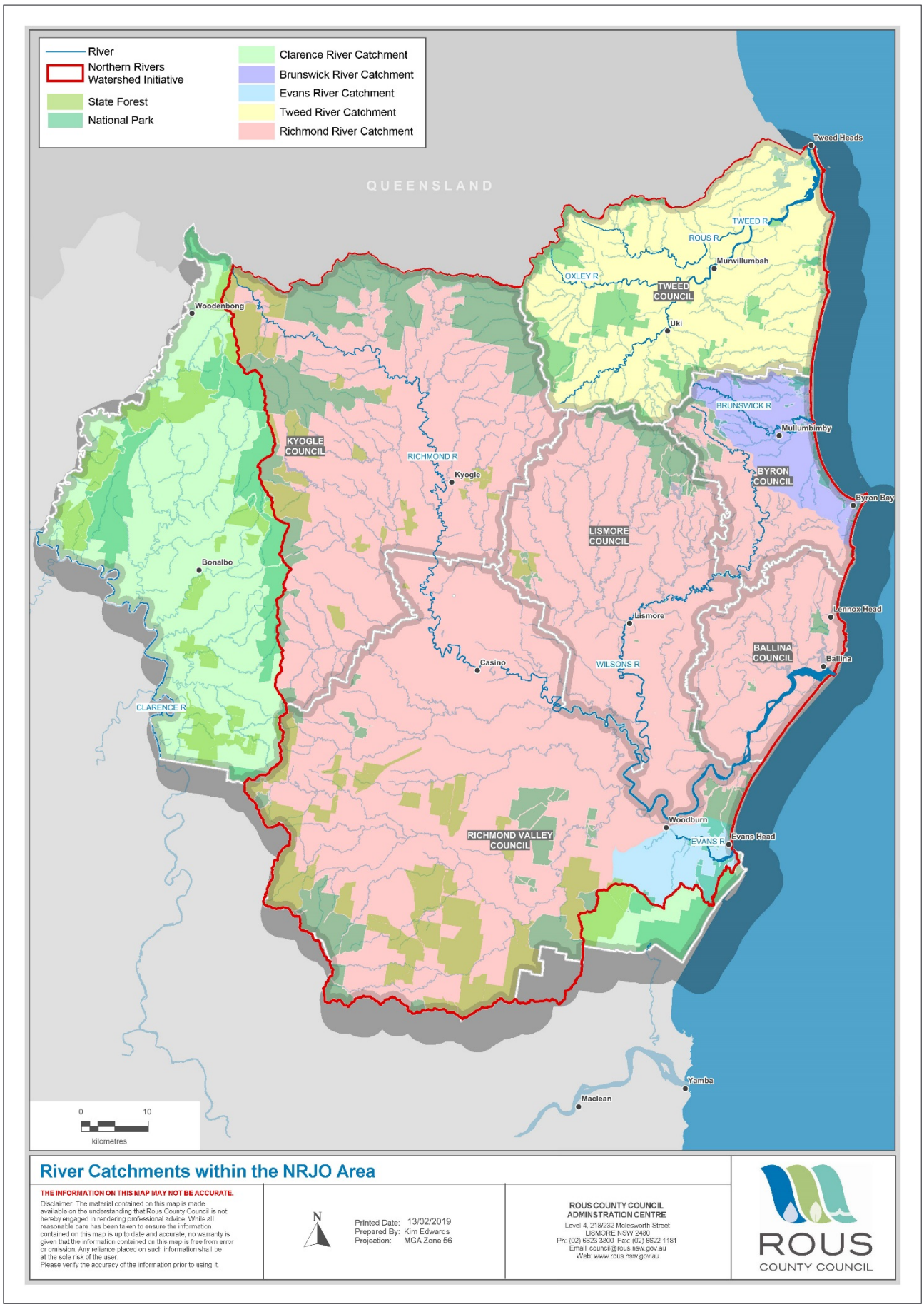

Figure 1: River catchments within the NRJO footprint

1.3 Structure of this report

This discussion paper is structured as follows:

Section 1..... introduces the NRWI.

Section 2..... sets out the background to the NRWI, including the need to act, the current opportunity for funding, and the need for catchment-focussed action.

Section 3..... highlights the key ecohealth issues to be addressed by the NRWI.

Section 4..... outlines the key principles of natural flood management and how this would be applied within the NRWI.

Section 5..... outlines the key elements of the NRWI.

Section 6..... identifies considerations that need to be addressed as part of implementation of the NRWI.

Section 7..... lists the references used in compilation of this report.

2. KEY DRIVERS FOR THE NORTHERN RIVERS WATERSHED INITIATIVE

2.1 Need for Action

Ecohealth status

Ecohealth is an aquatic ecosystem monitoring program that measures how healthy our rivers and estuaries are for the plants and animals that live in them. Ecohealth looks at key environmental indicators including water quality, riparian vegetation, geomorphic (channel) condition, macroinvertebrates (waterbugs), fish (distribution and population sizes) and plankton, and reports on their condition. This information enables natural resource managers to determine where our rivers are under stress and where to invest in environmental management activities. It also helps Councils and State Government agencies meet local and state monitoring, evaluation and reporting requirements.

For the Richmond Ecohealth assessment (Ryder *et al*., 2014), 48 study sites were selected across the Richmond catchment (23 freshwater sites and 25 estuarine sites) - these were sampled monthly (estuarine) or bi-monthly (freshwater) over a 12-month period in 2014 to contribute to the assessment of the ecological condition of the catchment.

The Overall Grade for the Richmond catchment was D-, ranging from an F in the Wilsons River and upper Richmond estuary to a C in the headwater streams of the catchment. Twelve of the 17 river systems recorded a score of D or less.

The upper freshwater reaches of the Richmond catchment had better water quality, aquatic macroinvertebrates and geomorphic condition than the lower freshwater reaches, but no better riparian condition. The upper estuary (upstream of Woodburn) was consistently in the poorest condition, with very high nutrient concentrations, turbidity and algal biomass.

Whilst a comparable Ecohealth assessment has not been completed in the Tweed or Brunswick catchments, these catchments and estuaries share similar challenges to that in the Richmond and are also in need of attention.

Poor ecohealth outcomes across the Northern Rivers lead to compromised economic, social and ecological values within the catchment and estuarine systems.

Flood status

RCCs service delivery requirement in relation to flood mitigation in the rural environment involves the prevention and mitigation of the menace to the safety of life or property from floods and natural resource management issues arising therefrom. All local government authorities will have similar roles and responsibilities within their jurisdictions throughout the Northern Rivers.

Water security status

In relation to the long-term (50 year) bulk water supply demand forecast for the region, by 2060, the Northern Rivers water supplies are predicted to serve approximately 146,000 residential properties and 14,000 non-residential connections with a regional demand of approximately 40,000 ML/a, an increase of approximately 74%. Despite this increasing demand, the current secure yield of the region's water resources (approximately 32,000 ML/a) is expected to decrease with the impacts of future climate change by approximately 6,000 ML/a or 26% by 2060 (Hydrosphere (2013). Although there is some uncertainty with these predictions and there has also been some additional work conducted in the Tweed since the NOROC Bulk Water Strategy was prepared, there is little doubt that additional water supplies will be required due to population growth and the reduction in available water resources, meaning that water security is an important factor in the Northern Rivers.

2.2 Administrative arrangements

RCC is ideally positioned to lead this initiative given the regional footprint that it operates across its service delivery focus and given that it holds service level agreements with all Councils in the subject river basins. Whilst RCC is an organisation with the capacity to partner with all Councils within the Richmond River basin, the leadership role of Tweed Shire Council in the Tweed River, Byron Shire Council in the Brunswick River and Richmond Valley Council in the Evans River is also recognised and would be a key part of the NRWI. As the project is based on an emerging approach to flood mitigation with potential benefits for long term water security and natural resource management outcomes, the NRWI is considered to be consistent with the County's existing proclamation and organisational activities. This leadership may take a number of forms, from a lead organisation administering NRWI funding arrangements through to an on-ground project delivery agency.

It is also important to note that implementation of the NRWI will provide a key opportunity to work under the governance arrangements adopted through the *Richmond River Governance and Funding Framework*. Notwithstanding the Richmond River focus, this governance framework, which has been co-funded by both the Office of Environment and Heritage and local government with substantial involvement from catchment stakeholders provides a pathway to deliver the NRWI in an effective and collaborative manner in the Richmond, and would work in collaboration with existing arrangements in the other river systems.

Administrative arrangements for the management of NRWI grants and NRWI on-ground delivery would be subject to further consultation.

2.3 Funding requirements and funding criteria

Preliminary scoping of the scale of work needed to address this imitative indicates that a budget in the order of $150 million over 10 to 15 years would be required to affect the necessary changes across the landscape.

In promoting the NRWI, in addition to addressing the alarming Ecohealth trajectory of the Northern Rivers, RCC is also seeking to establish a regional solution that can generate outcomes across a range of policy objectives including:

- **Providing water security in priority catchments**: the Richmond River catchment has been identified as a high priority area for water security improvements through policy and infrastructure solutions.

  Implementation of the NRWI would improve the quantity and quality, and security of regional surface water and groundwater resources in the Richmond and is therefore well aligned with this priority area for investment. Restoring natural hydrologic functions in upstream catchments will have a positive influence on water resources by retaining water in the landscape for longer periods of time.

- **Activating regional locations for increased business investment:** providing attractive locations and conditions for targeted industries to invest in regional NSW.

  The subtropical climate and fertile soils within the region are suitable for growing a diversity of crops and the Northern Rivers has long been viewed as a potential 'food bowl' not just for our own region but for South-East Queensland and beyond. Sustainable agriculture generates substantial income for our region and employs many people, not to mention the numerous flow-on effects – for this reason, sustainable agriculture within the Northern Rivers is considered to represent an 'industry activation precinct' worthy of support. A key thread that runs throughout the NRWI is the need to foster sustainable behaviour and support farmers to adopt restorative farming practices and move towards sustainable agricultural enterprises, thereby providing attractive location and conditions for investment, and competitive advantages for key industries including both sustainable agriculture and nature-based tourism.

2.4 Catchment-wide science-based solution critical to long term ecohealth improvement regardless of the funding opportunity

Regardless of the momentum or subsequent success of the NRWI or other river health 'rescue package', it will be critical that additional prioritisation work be completed to guide any future catchment investment. This needs to target sediment sources and riparian condition and provide an integrated framework for moving forward. This does not exist at present. Therefore, regardless of the success of any NRWI funding application, there is an urgent need to undertake this prioritisation work to guide any subsequent catchment wide investment.

In addition to guiding investment through the NRWI project, this work is also critical at a catchment-scale to ensure that other substantial investments such as the targeted works being undertaken under the NSW Government's Marine Estate Management Strategy are contributing in an integrated manner to an agreed catchment vision and associated catchment-wide adaptive management and monitoring frameworks.

3. KEY ECOHEALTH ISSUES TO BE ADDRESSED BY THE NORTHERN RIVERS WATERSHED INITIATIVE

This section provides a brief summary of the ecohealth issues that would be the focus of the NRWI. This description is based on content reproduced from the *Estuary Management Study* for the Richmond River Estuary (Hydrosphere, 2011) and readers are referred to that document for additional information and references on this material.

Section 3 highlights key issues influencing river health in the Richmond River catchment and estuary – given comparable conditions within the Tweed, Brunswick, Richmond and Evans River catchments and estuaries, it is likely that these will apply in all locations.

3.1 Key Catchment-wide ecohealth issues

Diffuse pollutant loadings from agricultural land

Agriculture is an important contributor to the local economy and is a key component in the social fabric of the region. Agricultural land use and some management practices are also identified as one of the major causes of poor water quality in the catchment and contribute to a broad range of issues in both upstream catchment areas and the estuary including the contribution of significant sediment, chemical and nutrient loads to the estuary during runoff (rain) events. Agricultural fertilisers are reported as a major source of nutrients. Transportation of nutrients to waterways during rainfall events dominate annual nutrient budgets. Grazing is a dominant land use in the Richmond River catchment and unrestricted stock access to waterways creates issues of bank instability and erosion through trampling, damage to riparian vegetation and direct input of nutrients and contaminants from direct contact. Contaminant inputs and increased turbidity have flow-on effects to estuarine ecosystems and productivity in the immediate vicinity and downstream in the estuary.

Addressing the impacts of agricultural land use on both upstream catchments and the estuary, while continuing to enhance the local economy and protecting rural lifestyles, is one of the biggest challenges facing long-term management of the catchment/estuary.

Poor condition of the riparian zone

The riparian zone (the interface between land and waterways) bordering the Richmond River estuary and upstream tributaries is generally devoid of vegetation for much of the area. Where riparian vegetation is present it is generally degraded, with only a few examples of intact riparian vegetation in good condition.

The issues associated with the poor condition or lack of vegetation within the riparian zone are associated with the loss of the functions and values of this important zone. Riparian zone functions include fisheries habitat, terrestrial habitat, bank stability and maintenance of soil structural integrity, land use buffering, water quality filtering, lowering water temperature and reducing aquatic weeds as well as providing scenic amenity. This issue applies equally to headwater streams at the top of the catchment through to todal waterways in the estuary at the bottom of the catchment.

Vegetation management

Except for the Bungawalbin Creek sub-catchment and the Border Ranges, the majority of the Richmond River catchment has been extensively cleared of native vegetation. The effects of vegetation clearing include:

- Loss of vegetation and associated fauna species resulting in reduced biodiversity values of the Richmond River and its catchment;
- Fragmentation of habitats where fauna rely on vegetated “movement” corridors to move between remaining vegetation remnants. In many places these corridors do not exist;
- Increased sediment and nutrient loads to waterways and the estuary; and
- Changes in morphological (erosion, accretion) processes within both upstream areas and the estuary.

Any further clearing will exacerbate these issues and therefore remaining vegetation needs to be protected and enhanced wherever possible.

3.2 Key floodplain-specific ecohealth issues

Poor water quality episodes and fish kill events

The Richmond River estuary has a history of poor water quality episodes, particularly following flood events which are periodically associated with fish kills. There is now recognition of the significant detrimental impact of historic broad-scale land clearing and floodplain drainage and regulation on floodplain wetlands, acid sulfate soils (ASS) management and water quality affecting the overall health of the estuary. While fish kills are a periodically occurring natural phenomenon, research has indicated that their frequency and severity are greatly exacerbated by catchment and floodplain modification.

Floodplain vegetation clearing and modification

From early colonisation, European land clearing on the floodplain has replaced flood adapted native trees and shrubs with exotic grasses and crops which quickly die and decompose in summer when flooded. This was found to be a major factor in fish kill events in the Richmond River in the estuary process study and recent studies have offered greater insight into the nature and extent of blackwater events. Prolonged inundation of the floodplain during and immediately following flooding can cause the decay of the underlying vegetation and rapid decomposition of accumulated organic matter. The decomposition process strips oxygen from the overlying water, creating ‘blackwater’. The mass drainage of this ponded blackwater via the drainage network and tributaries as floodwaters recede can cause hypoxic (very low dissolved oxygen) conditions along large stretches of the estuary. Low dissolved oxygen levels in water causes stress to fish and other aquatic organisms and in extreme cases can result in widespread fish kills such as those observed in the Richmond River in 2001 and 2008.

Floodplain drainage infrastructure

The Richmond River floodplain has been extensively modified by a complex network of constructed drains, modified canals, artificial levee banks and floodgates. Installation of floodplain drainage channels began in 1888 and accelerated in the early 1900s for the purpose of draining wetlands for agriculture and for flood mitigation. Floodgates were installed to prevent back-flooding of drains, creeks and tributaries and subsequently the inundation of agricultural land on the floodplain during minor flood events or by salt water from high tides. The impacts of historical and on-going drainage works are now known to have significant environmental impacts on the estuary. These include the exposure and oxidation of ASS, formation of monosulfidic black ooze (MBO)

drainage providing a conduit to more effectively convey pollutants to the estuary and disruption of tidal flushing regimes affecting water quality and ecological processes.

Addressing the environmental impacts of floodplain drainage infrastructure whilst maintaining adequate protection against flooding is a key challenge for managing the on-going health of the estuary.

Acid Sulfate Soils (ASS) and Monosulfidic Black Ooze (MBO)

ASS is the common name given to naturally occurring sediments and soils containing iron sulfides. The exposure of these soils to oxygen by drainage or excavation leads to the generation of sulfuric acid often also releasing toxic quantities of iron, aluminium and heavy metals. Approximately 68,000 ha of the Richmond River floodplain is classified as having some level of ASS risk. Disturbance of these areas by historical and on-going drainage and agricultural practices has resulted in the oxidation of ASS resulting in chronic and acute discharges of acid and associated pollutants to adjacent waterways.

Five priority areas for the management of ASS in the study area have been identified and mapped during a state-wide study of ASS. These are Tuckean Swamp, Rocky Mouth Creek, Sandy Creek – Bungawalbin Creek, Maguires Creek - Emigrant Creek, and Newrybar Swamp-North Creek.

MBO is created by rotting organic matter in ASS environments and typically occurs on drain bottoms and sides. When disturbed and transported during flow events, MBOs have the capacity to rapidly deoxygenate water and severely disrupt the ecology of waterways. MBOs are known to occur in the Richmond River estuary and have been identified as a factor in fish kills. The Tuckean has one of the highest recorded concentrations of MBOs in the world.

3.3 Key catchment-wide structural or systemic-issues

Administration and Governance

The existing catchment and estuary management and governance model for the Richmond River estuary needs improvement. Key issues include the lack of a holistic approach to catchment and estuary management and poor coordination between the various management entities. It is believed that this presents a significant barrier to successful delivery of on-ground programs and effective catchment and estuary management. The issues have come about due to the large number of stakeholders with a range of responsibilities including local Councils, a County Council, and various government agencies and organisations. Current legislated responsibilities do not allow any one party to provide an over-arching governance and administration role. Community confusion about the role of the various local and state departments in catchment and estuary management has been identified as an issue.

Improved governance arrangements will rely on clearly defined responsibilities and adequate funding to implement these responsibilities. In the Richmond River catchment, these issues are currently being addressed through the *Richmond River Governance and Funding Framework*, a project that has been co-funded by the Office of Environment and Heritage and local government with substantial involvement from catchment stakeholders.

Climate change adaptation

The NSW Government's Sea Level Rise Policy (DECCW, 2009) states that sea level rise is inevitable and establishes planning benchmarks to be adopted in NSW. These benchmarks are an increase above 1990 sea levels of 40 cm by 2050 and 90 cm by 2100, an average increase of 0.8 cm per year.

Sea level rise in the Richmond River estuary is anticipated to result in a broad range of issues including tidal inundation and landward recession of low-lying ecosystems, increased salt penetration through the estuary and adjoining wetland systems, increased bank erosion and implications for drainage and flooding in urban and agricultural areas. This issue has broad implications, affecting most of the other estuary issues in some way and therefore needs to be considered as part of all management and planning for the estuary.

Monitoring and evaluation

Current monitoring does not provide a consistent approach over the catchment. It is generally carried out by a range of agencies and organisations for various reasons and over varying timescales. This means that there is currently no way to monitor the on-going health of the catchment and estuary over time or to compare relative sources of water quality degradation across the catchment. These are fundamental requirements to implement effective and on-going catchment and estuary management. Additionally, there is no integrated environmental monitoring and reporting system in place at a scale that is meaningful to determine the effectiveness of management and investment in programs and projects that affect the catchment and estuary.

4. CONCEPTUAL BASIS FOR THE NORTHERN RIVERS WATERSHED INITIATIVE

Natural flood management (NFM) embodies the broad range of efforts and is pursued in a number of countries over several decades to attenuate flood flows by restoring the natural hydraulic function of the floodplain, using a catchment-wide approach to flood control. It employs nature-based, bioengineering solutions including reintroducing woody debris to channel beds, encouraging channel sinuosity, and re-establishing riparian forest (Kemp *et al*., 2017).

A key aspect of the NFM approach is that whilst actively seeking to manage flood risks by undertaking action in catchment areas, these same measures will address river health issues, allowing multiple objectives to be met with the same investment. The NRWI aims to apply three main/broad NFM mechanisms/strategies to manage flood risk in rural catchments:

4.1 Increasing infiltration (changing agricultural practices to reduce soil compaction, improve soil quality and promote absorption of water)

How does this NFM measure work?

Soil types in a catchment are important as they control the amount of rainfall that can infiltrate into the soil, and hence the amount of rainfall which becomes flow.

Healthy soils are essential for good plant growth, increased crop yields, livestock carrying capacity and reducing pest and disease problems. Good soil structure increases water and nutrient infiltration and retention, making farms more resilient to drought and reducing run-off into waterways. Farms lose nutrients through natural processes such as denitrification, through soil cultivation, effluent from livestock, farm run-off and removal of animals and crops. There is potential to improve on-farm retention and re-use of nutrients, particularly in intensive industries such as dairying (Tweed Shire Council, 2016).

What would this NFM measure consist of?

In the Tweed, Brunswick, Richmond and Evans River catchments, many soils have been compacted through intensive farming practices for over 150 years. If de-compacted, improved soil structure has potential to take in and store considerably more of the incident rainfall.

Organic carbon is the basis of healthy and productive soils and has declined over time, impacting on the fertility and productivity of many Northern Rivers landscapes. Increased water infiltration can also be achieved by various means of increasing soil organic carbon levels.

4.2 Storing water (restoring functioning floodplains and wetlands)

How does this NFM measure work?

Natural storages such as wetlands and natural ponds or lakes have the capacity to store floodwater and release it slowly. Soil and land management techniques can reduce peak flow by slowing and storing surface water runoff and encouraging infiltration with the soil. Storing water can decrease the magnitude of the flood peak and reduce downstream flood depths especially for high frequency, low return period floods.

What would this NFM measure consist of?

This can include a wide range of different measures including floodplain restoration works that aim to restore the hydrological connectivity between the river and floodplain which encourages more regular floodplain inundation and flood water storage. There is also potential for the development of offline storage areas which are areas of floodplain which have been adapted to store and then release floodwaters in a controlled manner. They can provide temporary flood storage which can reduce peak flow. Strategies for retention of water on backswamp areas would potentially offer similar potential benefits, however the extent to which specific options will affect overall estuary health need to be carefully assessed.

Increasing the extent of woody riparian vegetation can also increase hydraulic roughness in the channels during floods, which has the combined effect of slowing the flow and reducing the amount of channel erosion. Slowing flows and increasing flood transmission time in the upstream catchment can lead to the attenuation of flood peaks in the lowland river reaches.

4.3 Slowing flows (restoring natural processes and landforms to the river corridor, riparian buffer strips, coarse woody debris)

How does this NFM measure work?

A portion of the rain that falls on a catchment is captured by soil and vegetation. Generally, the more vegetation there is in an area, the greater the amount of rainfall that is captured and the less water there is available to flow over the surface. Following the major flooding in South-East Queensland in 2011 and 2013, the Queensland Government invested considerable effort, funds and resources into understanding flood risk and improving flood resilience (refer Queensland Audit Office, 2016). The following extract from this report provides a useful overview as to how vegetation interacts with flows from catchments:

> *Empirical evidence has shown that deforestation increases both flood risk and severity.*
>
> *In 2012, the Queensland Government developed its own synthesis on the role of natural assets in flood resilience and concluded that the evidence that human changes to the landscape impact on flooding is overwhelming.*

This is because water flow speed is determined by the:

- *volume of water*
- *size of the channel*
- *slope of the landscape*
- *roughness of the landscape and channel.*

The presence or absence of vegetation affects the volume of water, speed of the water and roughness of the landscape and channel.

Vegetation affects the volume of runoff in two main ways. The presence of vegetation increases infiltration by aerating the soil and creating cracks and fissures which allow more rainfall to soak into the ground. Deep-rooted vegetation allows for water infiltration to a greater depth than shallow rooted plants.

In addition, vegetation temporarily impedes the flow of water across the landscape causing it to spread out and slow, thereby encouraging further infiltration until the point of saturation.

Vegetation increases the roughness of floodplains and channels, temporarily impeding the flow of water. Vegetation also reduces the amount of energy and the erosive and destructive power of floodwaters. High velocity water is a very hazardous aspect of flood risk and damage.

Vegetation, particularly riparian vegetation (i.e. within close proximity to creeks and rivers), delays the delivery of water into creeks and rivers. In doing so, it can reduce the size of the downstream flood peak by holding back the water so that it takes longer to flow downstream and arrives after the downstream water has drained away. Slowing and spreading the water will result in a minor or limited increase in localised flooding and is most suited to areas where there is reduced risk (that is, sparsely populated areas of the catchment).

The presence of vegetation also affects and protects the size of the channel. Riparian vegetation protects creek banks by binding soil and armouring the banks and bed of the stream, thereby preventing erosion and maintaining physical and ecological integrity.

Riparian vegetation also reduces the scour of valuable agricultural land on adjacent floodplains by slowing the flow of water and reducing the risk of channel avulsion (tearing away or eroding the river banks to create a new path). This reduces the amount of sediment that is carried downstream. This prevents drinking water supplies from becoming highly turbid (cloudy and thick with suspended matter) and protects the health of downstream environments.

Revegetation of other lands, particularly steep land, can also contribute a small but positive reduction in the rate of discharge into streams and the volume of sedimentation in water. Much of this land is privately owned and, in some cases, revegetation may negatively impact on the economic viability of the land. In such cases, government and council efforts are limited to land-owner engagement and education.

What would this NFM measure consist of?

There is increasing evidence that the additional channel roughness created by dense riparian and floodplain vegetation can provide significant benefits for flood mitigation - re-establishment of native vegetation in riparian areas and floodplains can slow flood flows and help reduce sediment delivery to the watercourse and reduce stream bank erosion. This can help reduce flood peaks, delay peak timing, desynchronise flood peaks and reduce peak height.

4.4 Notes on the Australian setting

The approaches described above (and presently being evaluated in the Hunter River catchment), centre on native revegetation of river corridors for flood and other benefits and can be described as a nature-based approach to river management.

Elsewhere in the world, nature-based river management has broad appeal as a potentially inexpensive approach with low costs for ongoing maintenance. It employs nature-based, bioengineering solutions including reintroducing woody debris to channel beds, encouraging channel sinuosity, and re-establishing riparian forest. However, it is thought that these efforts might be diffuse over the catchment or concentrated in certain areas, and their effectiveness depends on their hierarchy in the river network. Some empirical support for the effectiveness of NFM has been provided but the empirical evidence is not unequivocal. Theoretical considerations of tributary network configuration, vegetation characteristics, hydraulic geometry and sediment type, basin size, and the variability in storm patterns suggest that the effectiveness of NFM will be different in each river system. Its application in Australia needs to be carefully examined in relation to storm characteristics and vegetation type, flow variability, and the scale of the basin, before it can be recommended as a robust flood mitigation strategy (Kemp et al). This would occur as part of the NRWI.

5. OVERVIEW OF THE NORTHERN RIVERS WATERSHED INITIATIVE

The NRWI would integrate both NFM measures and implementation of high priority *Coastal Zone Management Plan (*CZMP) actions throughout the Tweed, Brunswick, Richmond and Evans River catchments and estuaries. By 2020, the CZMP will transition to a new framework consistent with the guidelines under the *Coastal Management Act 2016*. Any actions in a *Coastal Management Plan* (CMP) need to be implemented through a council's Integrated Planning and Reporting (IP&R) framework and land-use planning systems. The injection of external resources will be needed, otherwise high priority actions within future CMPs will be truncated to align with a council’s existing budgetary process.

The NRWI would consist of the following key modules:

5.1 Soil health improvement

The soil health program will restore essential ecosystem functions in soils such as nutrient cycling, water infiltration, carbon sequestration and biological pest control leading to healthy, more resilient agricultural landscapes. The program will be delivered through education, extension, research and on-ground activities that build land managers capacity to understand soil issues and adopt practices that improve soil function for productivity and ecosystem benefits.

5.2 Riparian restoration and catchment revegetation

The riparian restoration and catchment revegetation program will be based on an integrated approach to the management of river channels and riparian areas. Catchment-wide priorities and the locations to be targeted will be informed by leading scientific approaches (refer Section 5.6) – this will consist of both riparian restoration as well as broader scale revegetation programs. Within identified priority areas this program will seek to work with landholders to rehabilitate sections of river (river reaches) to achieve a desired *target condition. Target condition* would be defined at the outset of the program and is specific to a project reach/site. It would be defined based on:

- stock being excluded/ managed;
- achieving an appropriate width of riparian vegetation (e.g. minimum of 10 metres);
- achieving continuous native riparian vegetation;
- eradicating/reducing the extent of weeds (e.g. less than 10% of vegetation);
- addressing channel degradation (e.g. headcuts, bank erosion);
- removing/modifying artificial barriers to fish passage (e.g. pipe culverts, weirs etc.).

Reach-scale plans would be prepared identifying required rehabilitation works - this may include stock management, weed control, planting and erosion control works. All of the actions identified within the plan would be informed by the reach-scale assessments, with property-specific plans developed in consultation with participating landholders.

The NRWI recognises the valuable contributions being made by people and organisations who live and work in the respective catchments – the NRWI approach also understands the importance of working in cooperation with landholders in protecting water quality. As with other elements of the NRWI, landholders entering into property agreements would do so on a voluntary basis. Development of these plans do require a commitment from landholders to participate in the development of management options for their property and a willingness to be part of future project agreements to allow implementation of the plan. Key steps would involve:

- Completing project planning
- Co-ordinating reach-scale assessments of watercourse condition, focusing on bed and bank stability and channel sediment profiles.
- Preparation and implementation of reach-based rehabilitation plans addressing key river health threats (lack of riparian vegetation, emerging weeds, stock access, and bank erosion).
- In consultation with the subject landholders, preparation of and implementation of property-based rehabilitation plans addressing key river health threats.
- Preparation of scope of works for contractor engagement as required on a property-specific basis.

5.3 Agronomic best management practice

The NRWI aims to encourage sustainable agricultural enterprises and so a best management practice (BMP) scheme will be developed that aims to minimise transport of contaminants to waterways, maximise long-term farm viability and improve the natural environment. Key objectives of this program will be to identify and widely adopt efficient farm production practices that support long-term farm viability and improve the natural environment; reduce contaminant loads from agricultural land to appropriate levels that protect water quality; provide incentives, information and support across rural industries to encourage farm practices that protect water quality and improve environmental outcomes. This will be implemented across the catchment with a focus on:

- Sugar cane
- Macadamias
- Livestock grazing
- Dairying.

There will also be investigation of potential 'river health' marketing and branding advantages that could be realised by individual farmers or industry groups that actively support implementation of these programs.

5.4 Redesigned floodplain drainage to meet contemporary standards

As recognised in the CZMP (Hydrosphere, 2011a), the management of agricultural lands both in the catchment and on the floodplain has a major influence on water quality and riparian vegetation condition within the estuary. The CZMP identifies actions involving development of farm management plans for priority properties. These plans will identify estuary-friendly land management practices and document farm-by-farm implementation strategies which aim to preserve the economic benefits of agriculture in the catchment while meeting the needs of the estuary.

The component of the NRWI would involve the redesign and retrofitting of floodplain drainage to meet contemporary standards, backed by contemporary understanding of the associated issues. The key aspect of this module would involve minimising environmental impacts associated with floodplain drainage infrastructure whilst maintaining flood mitigation levels of service.

For example, infilling, shallowing and reshaping drains can be an effective means of reducing acid discharge and other negative impacts of over drainage, particularly in ASS-affected backswamps. Raising drain invert levels, while maintaining the effective drain cross-sectional area, acts to reduce acid seepage and maintains the drainage capacity of the existing system. These drains are commonly referred to as 'swale drains' and are depicted in Figure 2 below (WRL, 2018)

Narrow, deep drains are ideal candidates for drain reshaping, as the drain cross-sectional area required to provide efficient drainage can be maintained by conversion to a shallow, wide swale drain. Conversely, a wide, deep drain would require a significantly wider swale drain to be constructed to maintain the effective cross-sectional flow area. This strategy is applicable where the acid soil layer is sufficiently deep enough to enable an efficient drainage slope from the back swamp to the estuary without the drain invert disturbing the acid layer.

There are a range of approaches that could be applied to redesign and retrofit the floodplain drainage network to meet 2018 standards. This module would work together with other NRWI modules including the implementation of best management practices (refer Section 5.3) and the sustainable agriculture reform package (refer Section 5.5).

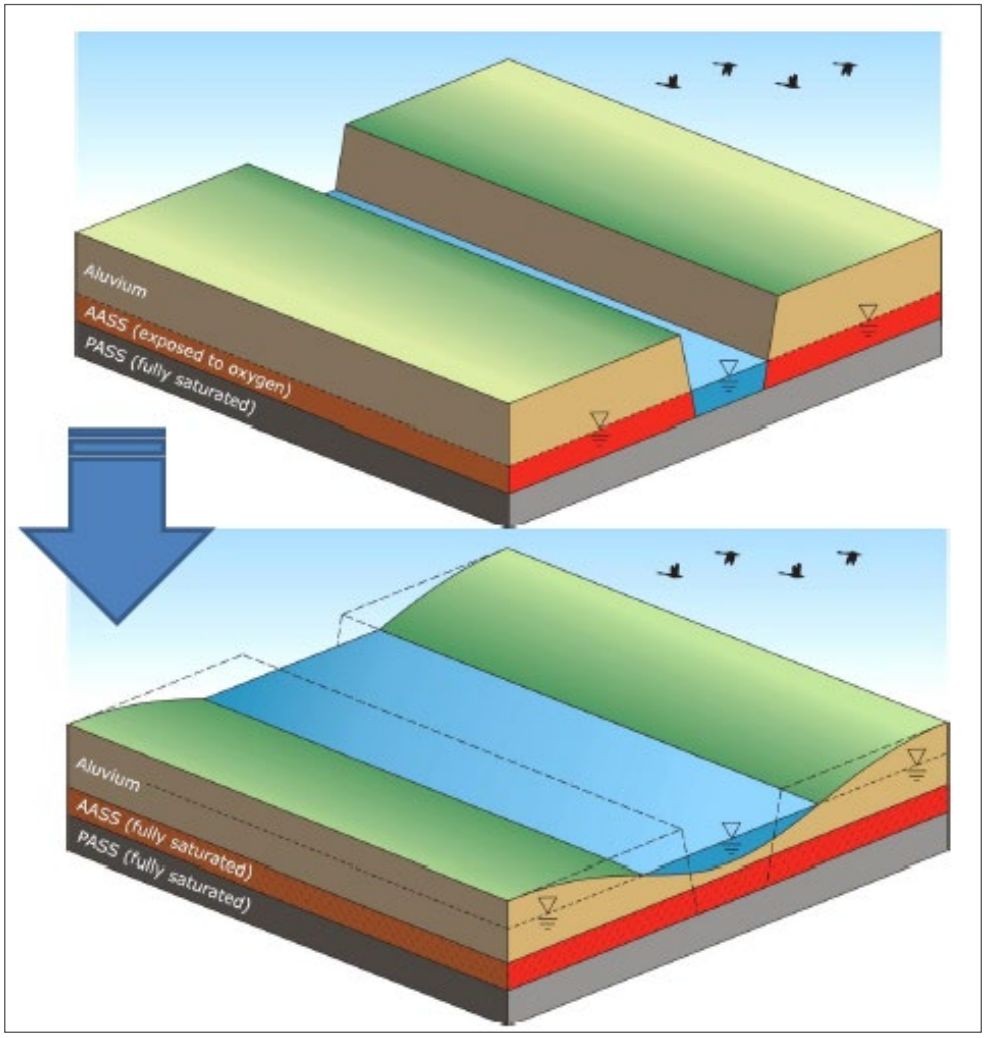

Figure 2: Before and After Swale Drain Construction (WRL, 2018)

5.5 Sustainable agriculture reform package (including buy backs)

Where farming is being undertaken in marginal country (challenged by issues associated with farming at or near sea level, or adjacent to or nearby major acid hot spot areas and extreme riverbank erosion areas), the NRWI will provide landholders with opportunities to access a reform package to get out of farming marginal lands – this will be on a strictly voluntary basis.

In the absence of any meaningful stewardship scheme to recognise landholder efforts for the provision of 'ecosystem services', a scheme will be developed that will provide landholders in designated priority restoration zones the opportunity to access a land buyback program that will allow landholders to sell parcels of land, access funds and continue farming profitable country. This will allow marginal land to be taken out of production, land that can then be placed into restoration. This reform package is an acknowledgement that in some instances and farming situations, remediation of chronic environmental problems such as blackwater and acid drainage while continuing existing farming practices is unlikely to be successful, and a less costly option would be to undertake strategic buyback, undertake suitable land restoration, and then return land to the market or place suitable environmental management covenants on it. Lands which may be considered for the buy backs include:

- heavily modified backswamp areas prone to blackwater generation
- acid hot spot areas
- extreme riverbank erosion zones.

Landholders will not be 'punished' if choosing not to participate in buy backs but will be supported to continue with improved land management practices. Lands that are bought back from landholders would be managed for river health outcomes, as demonstrated by numerous similar successful actions undertaken along the NSW coast in recent years.

5.6 Scientific framework for landscape design and monitoring

Integrated management of river channels and riparian areas

Recommendations arising from the Richmond Ecohealth assessment are summarised in the box below:

- *Geomorphic condition:* Strongly linked to riparian condition, the active restoration of riparian zone vegetation as a long-term action for improving geomorphic condition must be a priority in the Richmond catchment. The poor geomorphic condition is directly linked to low scores in water quality, macroinvertebrates and riparian vegetation. Improving geomorphic condition, particularly in the mid and lower (including estuary) reaches will lead to an improvement in all other indicators.

- *Riparian condition:* Restoration of the riparian revegetation must be a priority in the Richmond catchment. The lack of streambank vegetation is linked to poor bank condition and localized erosion, sediment deposition and benthic habitat smothering throughout rivers, reduced habitat for biota, and poor water quality (evidenced by high nutrients and turbidity throughout the year).

- *Water quality:* Total and available nitrogen was consistently high throughout the catchment and should be a focus for future water quality monitoring. The highest concentrations of nutrients were not associated with increased flows (freshes) in the Wilsons or Richmond Rivers, suggesting the channels contain high loads of nutrients at all times, either transported with sediment in high flows or released during low oxygen conditions under low flows. Reducing nutrient concentrations in the channel may require a reduction in catchment inputs over the long term.

- *Water quality:* The clear longitudinal pattern of increasing turbidity and nutrients with distance downstream highlights the need to improve riparian and bank condition throughout the catchment as a management priority. Improvement of water quality in the Richmond catchment therefore requires significant investment in reducing diffuse sources of fine sediments and their associated nutrients. Reducing stock access to the steep and fine-grained banks in the upper reaches would be an important step, as would vegetating those riparian zones to increase their buffering capacity for terrestrially derived nutrients.

- *Water quality:* The poorest water quality was recorded from the sites closest to the tidal limit, highlighting their role as depositional environments for both freshwater and estuarine contaminants, and the importance of this zone as a focal point for future monitoring programs. Low DO concentrations, low pH and high Chlorophyll a (algal biomass) and nutrient concentrations were a feature of estuarine reaches. Focal reaches for future monitoring are from upstream of Tatham on the Richmond River and upstream of Lismore on the Wilsons River, as well as North Creek in the lower estuary.

- *Aquatic macroinvertebrates*: Macroinvertebrate scores were low throughout the catchment. This reflects poor water quality and habitat conditions, particularly the geomorphic change to channels (U-shaped channels) and smothering of habitat with fine sediment. The potential for localized increases in macroinvertebrate condition (e.g., upper Richmond, Rocky Creek) suggest habitat restoration (e.g., riparian zone, woody and organic debris, macrophytes, riffles) and therefore food availability, disturbances such as sediment smothering, and water quality (nutrients and turbidity) must be targeted to improve macroinvertebrate condition.

These recommendations emphasise the significance of riparian restoration, stabilisation of erosion and sedimentation processes and habitat restoration works across the catchment areas. The CZMP includes strategies to implement these types of works.

Whilst the CZMP provides an effective framework of strategies and supporting actions and describes in detail the associated tasks, these are described at a fairly high level - neither the CZMP itself nor any supporting document provides a specific defined set of tasks and on-ground works, with an accompanying budget. Whilst the CZMP does provide indicative funding requirements, this is not based on a specific understanding of the overall quantum of work to 'fix' the river, but an estimate of a reasonable investment.

Without a defined, costed and mapped schedule of works, there is the risk that projects will be undertaken in a manner that is inconsistent with the priority/intentions of the CZMP as described above. A prescribed and mapped 'schedule of works' and associated costs would allow projects to be rolled out in a prioritised manner and in a way that progress can be accurately tracked.

Whilst the need to undertake additional planning/riparian restoration work is not always a popular thing to do when the need for urgent on-ground work is apparent, this is also a required critical element of any future catchment rehabilitation plan such as the NRWI.

There has been excellent research on sediment yields and transport in the Richmond catchment and some prioritisation work completed, and there are also some known areas for high priority works. Nevertheless, it is critical that any significant investment in river health into the Tweed, Brunswick, Richmond and Evans River catchments and estuaries be based on a detailed understanding of the primary sources of sediment delivered to waterways and the interactions with riparian and floodplain vegetation.

“Erosion mitigation measures differ depending on the erosion process being treated it is important to correctly identify the dominant source of erosion before attempting local or catchment-wide management to control it” (Olley et al. (2013). Therefore, a key element of the NRWI is considered to be a detailed investigation of vegetation change and geomorphology in the catchments, including detailed riparian condition assessments and associated sediment tracing studies.

This approach has been applied in the Hunter Catchment (Pietsch et al., 2017) and is now being applied in the Manning Catchment in a refined form using catchment-wide LiDAR data. This allows the current riparian vegetation condition to be precisely quantified and a strategy developed for prioritising the implementation of riparian works. These data then enable detailed plans to be developed and costed. They also provide a basis for monitoring the progress of the program implementation and measuring the success of the program in achieving the core goals, such as reducing bank erosion. Examples of these outputs are provided in Figure 3 and Figure 4.

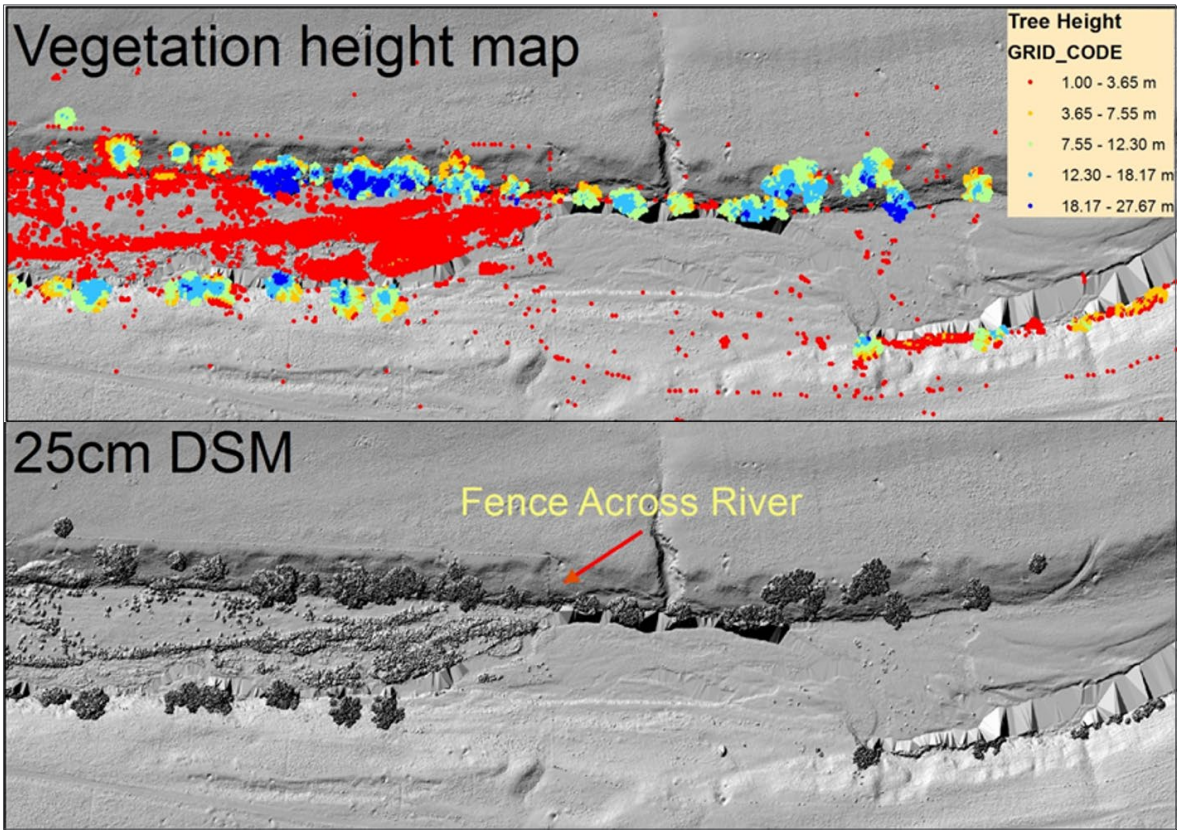

Figure 3: Example of the LiDAR data in the Hunter catchment and how it is used to quantify riparian vegetation cover and community structure (Pietsch et al., 2017)

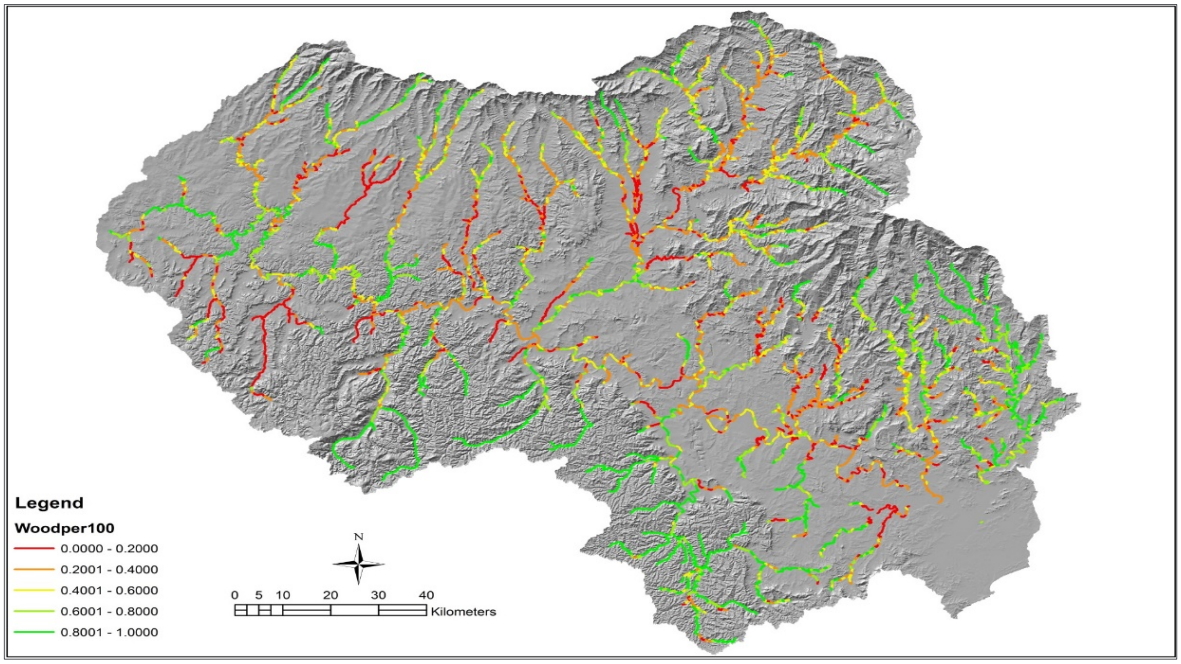

Figure 4: Example of the catchment scale woody riparian vegetation assessment undertaken in the Hunter Catchment. Red = low cover green = high cover (Pietsch et al., 2017)

Potential Research Program - *Will blending natural and physical capital strengthen flood resilience*?

Southern Cross University (SCU) has developed an ARC linkage grant proposal, which will bring together a number of issues relating to land management in the catchment, and flood mitigation under the auspices of the National Centre for Flood Research with affiliated researchers. Potential elements would include:

- landholder communications
- hydrological modelling
- vegetation planning and assessment
- soil and topography
- livelihood opportunities and financial assessment
- river governance and flood risks
- building nature into engineering.

In designing this research program, it will be important to learn from the experience that has been gained in the Great Barrier Reef catchments involving the management of agricultural fertiliser and pesticide runoff. Recent policy development has involved the development of ReefCredits (https://www.reefcredit.org/) – a market-based approach that is being applied to encourage farmers to minimise the application rates of fertilisers and pesticides. It can also provide financial incentives for implementing riparian revegetation works. A program such as *"Exploring environmental market-based mechanisms for reducing fertilizer and pesticide application rates, and riparian management"* will be considered in the design of the NRWI.

6. IMPLEMENTATION

Implementation of the NRWI would be based on the following:

6.1 Consultation

This report provides an outline of a **potential program only**. This will now be subject to additional consultation with a range of stakeholders including constituent councils, industry groups, community organisations, and leading researchers.

Any subsequent model pursued needs to be developed with the input of leading researchers to ensure that any subsequent investment is well targeted and is focussed on achieving multiple outcomes.

Development of the initial concept has been informed by discussions between the Rous County Council Chair, and a number of industry, university, community, government representatives regarding the progression of initiatives to address river health and flooding in the Richmond River catchment.

Additional consultation has been undertaken at officer-level with representatives from constituent councils, NSW Government agencies and the research community.

6.2 Integration

A key aspect of the further development of the NRWI will be to integrate with existing initiatives across all stakeholder groups in each river system. This includes coordination with the rollout of the NSW Government Marine Estate Management Strategy and the *Richmond River Governance and Funding Framework* that has been co-funded by the Office of Environment and Heritage and local government.

6.3 Early wins / planning for the future

Whilst the need to undertake additional planning work is not always a popular thing to do when the need for urgent on-ground work is apparent, this is also a critical element of the governance/administration that is required and so whilst any such initiative needs to deliver some 'early wins', it will be equally important that any subsequent investment is well targeted and informed by science.

6.4 Landholder involvement

As emphasised throughout this document, works undertaken on the NRWI would be done so on a voluntary basis executed through property agreements with landholders.

6.5 Timeframe

The approach outlined in this discussion paper has been endorsed as a key regional initiative by Rous County Council in late 2018, and by the NRJO in early 2019. The NRJO and RCC are ready to work with government to progress this initiative to the next stage of development.

Implementation of the NRWI would involve expenditure of the $150 million package over a 10-year or 15-year program of works.

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