KARUAH RIVER
Catchment Management Plan

Great Lakes
COUNCIL

Great Lakes Council 2015
Karuah River Catchment Management Plan

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Thank you to community members of the Karuah River Catchment for your input and willingness to contribute to the development of the Plan.

Thank you also to everyone who provided local photos for inclusion in the Plan.

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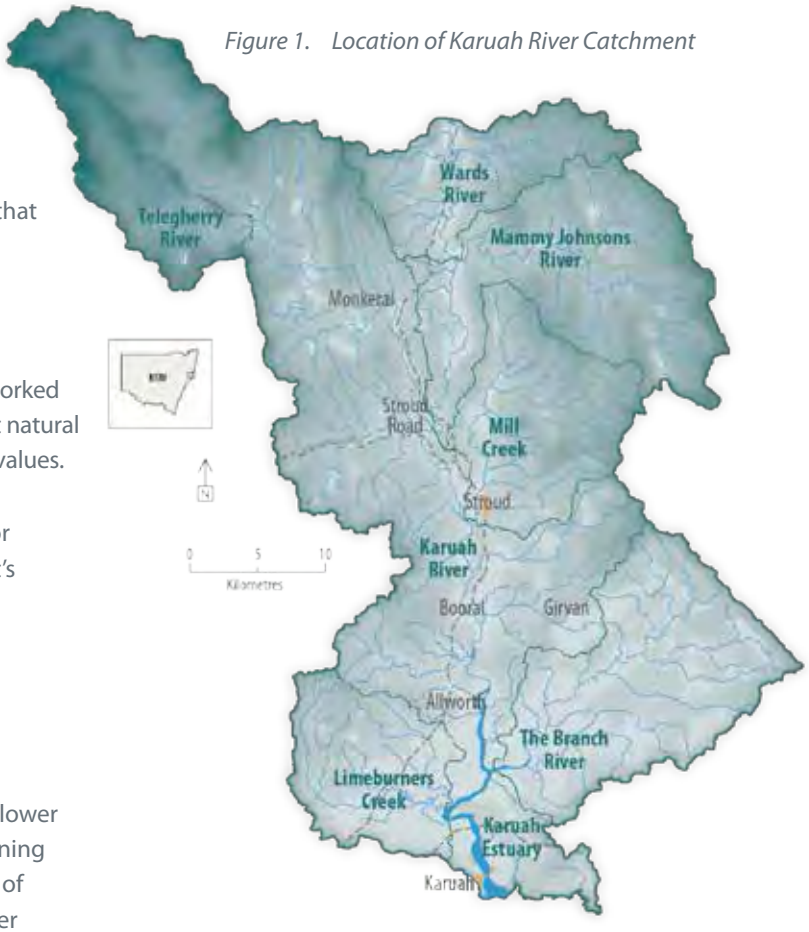
THE IMPETUS FOR CHANGE

The Karuah River Catchment Plan (KRCMP) has been developed to maintain and improve the health of the Karuah River Catchment's natural resources, so that they can support the sustained wellbeing of the catchment's community, its industries and its biodiversity. The term of the plan is ten years, that is 2015 to 2025.

The Plan has drawn on science and community to identify the catchment's economic, social, environmental and cultural values. It has also worked closely with the general community and expert natural resource managers to identify threats to those values.

The Plan identifies a set of desired outcomes or objectives for improvements in the catchment's health. These outcomes will flow from the implementation of a comprehensive set of recommended actions.

Figure 1. Location of Karuah River Catchment



The Karuah River Catchment

The Karuah River Catchment is located on the lower north coast of NSW. It is bordered by the Manning River Catchment to the north, the catchments of the Great Lakes to the east and the Hunter River Catchment to the south.

The catchment is located in a sparsely populated rural landscape. Its two main population centres are Karuah, which is located at the river mouth (pop. ~ 1,000), and Stroud (pop. ~700) which is located near the centre of the catchment.

Smaller settlements within the catchment include Allworth, Booral, Stroud Road, Girvan, Limeburners Creek, Monkerai and several others. Land use within the catchment comprises areas of State Forest, agriculture, National Parks, coal mining, aquaculture, private native forests and rural lifestyle properties.

The catchment is mostly located within the Great Lakes Council Local Government Area (LGA). A small proportion of the southern part of the catchment, around the township of Karuah, is located within the Port Stephens Council LGA. A very small portion on the western edge of the catchment is located within Dungog Shire Council and a small area on the northern boundary is within the Gloucester Shire Council's LGA.

The catchment's landscape and identity are strongly defined by the Karuah River, its tributaries and its river valley. The catchment's communities have a strong sense of place and a strong affinity with the landscape and the catchment's history.

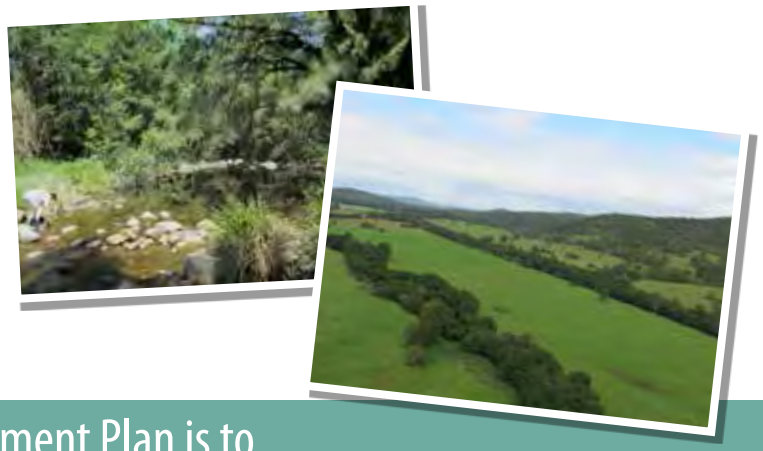
The plants and animals in the Karuah River Catchment are botanically significant and biologically diverse. The catchment's environment is influenced by tropical and temperate climatic influences, so a number of species are at the limit of their natural range and are therefore vulnerable to climate change.

The proportion of private land covered by remnant native vegetation is high compared to other regions. The catchment also has a comparatively large proportion of land held in public reserves. These reserves are also covered by intact remnant vegetation.

The headwaters of the Karuah River are located within the Barrington Tops National Park and occupy part of the *The Gondwana Rainforests of Australia World Heritage Area*. The catchment's estuary is located within the Port Stephens Great Lakes Marine Park.

The Need for a Whole of Catchment Approach

Catchment and landscape health are intrinsically linked to river water quality through a complex set of interrelationships between ecological systems, land and water use, and land and water management activities. Therefore, a whole of catchment approach - hill-slope to estuary - is required to understand the pressures and issues facing these complex and interlinked systems.



The purpose of the Catchment Management Plan is to maintain and improve the health of the Karuah River Catchment.

In 2011/12, scientists from the NSW Office of Environment and Heritage (OEH) undertook an ecological health assessment of the Karuah River. The assessment found that, overall, the Karuah River and its estuary were in moderate ecological condition; however, the assessment also revealed indicators of poor and degrading ecological condition. These indicators included:

- elevated water column turbidity and suspended solids
- elevated water column nutrient concentrations, in particular elevated total nitrogen and total phosphorus levels
- excessive growth of algae
- degraded riparian habitats
- seriously diminished seagrass habitats (almost 80% decline of seagrass, which is now almost non-existent)
- diminished saltmarsh habitats
- mangrove encroachment on other habitat types.

The economic and social viability of the catchment - including the viability of agriculture, oyster farming, timber production, lifestyle and tourism activities - is inherently linked to the condition and function of the natural environment and the sustained delivery of environmental services.

Great Lakes Council recognises the relationship between the ecological health of the catchment and social, economic and environmental well-being. It also recognises that the ecological assessment carried out by OEH indicates a decline in the catchment's health. It is for these reasons that Council has facilitated a collaborative effort between the general community, industry, and government agencies to complete the Karuah River Catchment Management Plan.

The Plan's Broad Framework and Its Connection to Other Plans and Strategies

The KRCMP will ensure the long-term health of the catchment. It will provide a framework to guide the future management actions required to deliver the desired outcomes that will restore the catchment's health. The Plan has separated these desired outcomes into the following three themes:

- Water
- Landscape, Production and Community
- Resilient Ecosystems

The KRCMP builds on, complements and expands on existing catchment management programs within the Great Lakes LGA to include the Karuah River Catchment. Related plans and strategies include:

- Great Lakes Water Quality Improvement Plan: Wallis, Smiths and Myall Lakes (2009)
- Wallis Lake Wetlands Strategy (2010)
- Tops to Lakes Initiative (2012)
- Community Strategic Plan (2012)
- Wallis Lake Estuary and Catchment Management Plan (2014)

The recommended management actions within the documents above overlap with those within the KRCMP. The key external document influencing the KRCMP is the Hunter-Central Rivers Catchment Action Plan (2013) developed by the Hunter Local Land Services.

Development of a Karuah River Catchment Management Plan

The Karuah River Catchment Management Plan incorporates science into catchment planning, but recognises that a catchment plan is ultimately about people.

Science

The ecological health assessment completed by OEH provides the KRCMP with a scientific baseline measurement of the catchment's condition. Other scientific information such as past research, monitoring, mapping and catchment management programs have also been used to inform the KRCMP.

Community

The historical use and management of the Karuah River Catchment's natural resources has yielded significant social and economic benefits to the people of the catchment and beyond. However, these benefits have resulted in the decline of some aspects of catchment health. It will be the actions of people today and in the future that will influence the catchment's health in the years to come.

Community and Stakeholder Participation in the Plan

In order to ensure that the community's values, insights and perspectives were incorporated into the Plan, considerable time has been spent on consultation and communication activities. These activities included informal one-to-one farm and industry visits, field days, workshops, presentations to groups and general communications.

To formally capture the views of the local community and other stakeholders, the Council hosted the Karuah Catchment Forum in Stroud on the 19th and 21st of June 2014. The Forum aimed to:

- seek ideas for a vision for the catchment and identify catchment values
- identify catchment pressures as well as its strengths
- identify potential management actions and activities.

Forum participants included representatives from government, industry and members of the general community. Specific groups and organisations represented included:

- Beef industry
- Poultry industry
- Oyster industry
- Dairy industry
- Tourism industry
- Absentee and small landholder sector
- Karuah and Great Lakes Landcare
- General community
- Private forestry sector
- NSW Farmer's Association
- Duralie Coal (Yancoal Australia)
- MidCoast Water
- Hunter Local Land Services
- NSW Office of Environment and Heritage
- Port Stephens - Great Lakes Marine Park
- National Parks and Wildlife Service
- Great Lakes Council staff and Councillor representatives

The Forum's outcomes are provided in Appendix 2. The information captured at the Forum has been incorporated into the Plan, along with quotes from Forum participants.

Format of the Plan

The Plan consists of the following sections:

Guiding Principles

The values and objectives that underpin the Plan. The underlying concepts and ideas for the guiding principles were developed at the Karuah Catchment Forum.

Karuah River Catchment

A brief outline of the biological, geomorphic and fluvial profile of the catchment.

The Past

An account of the history of the catchment in order to better understand the catchment of today.

The Present

A summary of what the science highlights about the current health of the Karuah River Catchment and the pressures on its health.

The Future

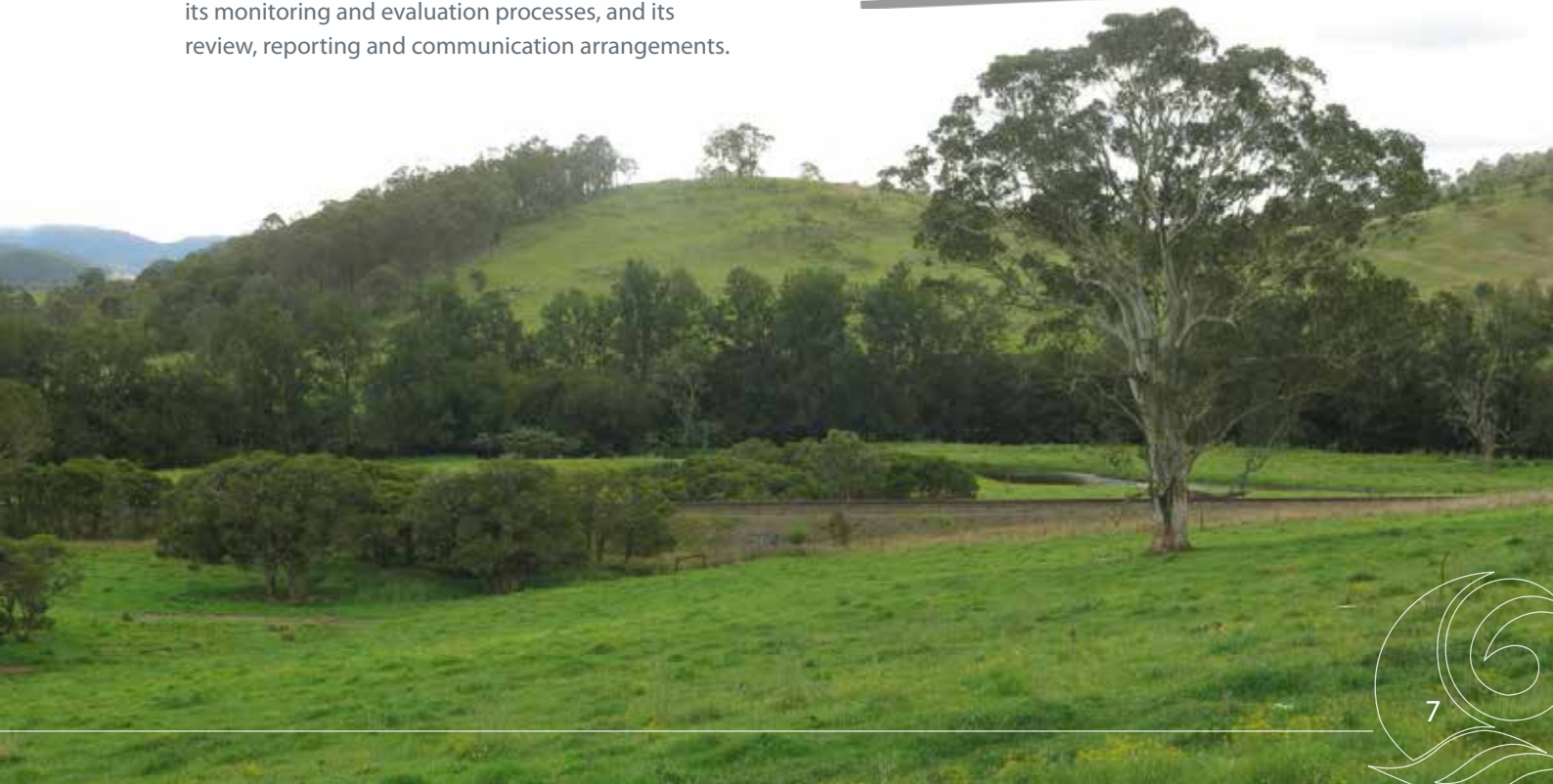
Outlines the desired outcomes of the Plan and the management actions required to deliver those outcomes.

Implementation

A summary of the Plan's coordination arrangements, its monitoring and evaluation processes, and its review, reporting and communication arrangements.

"Planning must account, as far as possible, for past, present and future conditions. An understanding of the history of the catchment, as well as the drivers of current condition is required if the planned rehabilitation measures are to match the nature and scale of the drivers of river condition"

(Cottingham, Bond, Lake, & Outhet, 2005)



GUIDING PRINCIPLES

The Source and the Purpose of the Plan's Guiding Principles

The Karuah River Catchment Management Plan is underpinned by four guiding principles which were developed from the Karuah River Catchment Forum. These principles encompass the following interconnected ideas: the importance of community participation in managing the catchment; the value of healthy rivers and river banks; the interdependence of the catchment's health and the local economy; and, the importance of ecosystem resilience.

These guiding principles form the basis of the themes for future action within the Plan. The themes are:

- **Water**
- **Landscape, Production and Community**
- **Resilient Ecosystems**

The Principles

An insight into each of the four guiding principles is provided below. Several quotes from Forum attendees have been included to provide the community's insight into each principle.

1 The **communities** of the Karuah River Catchment are **active partners** of the Catchment Management Plan.

This principle underpins each of the three management themes within the Plan and recognises that catchment management is ultimately about people.

Private landholders and companies manage the majority of the catchment, and therefore play a crucial role in the future health of the catchment's ecosystems. The Plan's priorities are to enhance and maintain the capacity and ability of the community to engage in planning, implementing and monitoring local actions to support the achievement of catchment targets.

A key and consistent message of the Karuah Catchment Forum was the desire of those present to actively participate in the implementation of the Plan.

"would like to see this community empowered"

"opportunities to exchange ideas with others in the valley"

"support and education for land owners"

2 **Healthy, clean rivers and riparian zones** are important to the long-term sustainability of the Karuah River Catchment.

The significance of the Karuah River to the local economy, environment and cultural values cannot be overestimated. MidCoast Water extracts water from the river to supply drinking water for Stroud and Stroud Road. The river also provides water for stock and domestic purposes in rural areas and is fundamental to commercial activities such as oyster production and tourism. The Karuah River is important socially. It provides sites for fishing, swimming, camping and enhances the aesthetics of the landscape.

Cultural and historic sites are also associated with the Karuah River providing a link to the catchment's indigenous and early European past.

"Without water there is no life"

3 **Catchment health** is fundamental to the economy and way of life of the Karuah River Catchment.

Living sustainably was a key principle that arose at the Karuah Catchment Forum. Discussions around this guiding principle focused on the management of natural resources to promote both production and environmental outcomes.

Values stated at the Karuah Catchment Forum:

"Productive value of our farm, also with the ability to improve water quality through the assimilation of nutrients"

"Great potential for sustainable timber production if forestry is done well. Great suite of species, timbers and wildlife values"

4 **Resilient ecosystems** are essential for catchment health.

Water cycling, food and fibre production, soil formation, pollination, scenic values and climate regulation are all services provided by a healthy and biodiverse ecosystem.

A resilient ecosystem has a greater capacity to recover from major disturbances such as floods, drought and pollution events. A resilient system will therefore be more able to continue to provide us with the goods and services that we require to support our quality of life (Walker & Salt, 2006).

It is evident that the community has a clear connection with the biodiversity of the catchment. At the Forum, the community showed great appreciation of species such as the platypus, and demonstrated a strong appreciation of the landscape. The desire to protect the unique landscape and the species that inhabit it was an important and recurring theme for many Forum attendees.

As stated at the Karuah Catchment Forum:

"Love the rich biodiversity including many endangered species and platypus"

"The trees on the hills"

"The continued vegetation along the Karuah River - it looks amazing compared to so many other rivers"

"We have a World Heritage site within the catchment"

KARUAH RIVER CATCHMENT

The Karuah River Catchment is located on the NSW lower north coast and is approximately 1,490 km2 in area. The river rises at an elevation of over 1,000 metres in the Barrington Tops and discharges into the wider Port Stephens Estuary adjoining the township of Karuah.

Major tributaries of the Karuah River include: Wards River, Mammy Johnsons River and Mill Creek in the north eastern reaches; Telegherry River and upper Karuah River in the north-west headwaters; The Branch River in the eastern estuary zone; and Limeburners Creek and Deep Creek in the western tidal zone of the lower reaches.

The river's tidal limit is approximately 4 km upstream of Allworth. A series of rapids between Allworth and Booral constitutes the tidal and navigable head of the river. The estuary of the Karuah River is located within the wider Port Stephens estuary. The Karuah River estuary is characterised by substantially longer flushing times than the main water body of Port Stephens Estuary (DPWS, 1999).

Owen (1991) describes four physiographic zones within the Karuah River Catchment:

1. *Coastal Riverine Plains Zone:* A complex system of sand dunes, wetlands, lagoons and other sand deposits, backed by a series of alluvial flats.
2. *Mid Valley Zone:* Extending from Port Stephens to about 10 km up The Branch River. This zone is characterised by wide river valleys up to 7 km wide in the lower areas, and around 1.5 km wide in the higher areas. It drains the extensive system of north-south ridgelines characteristic of this section of the Karuah River Basin, which rise steeply from the valley floors.
3. *Upper Valley Zone:* Within the upper reaches of the Karuah River, the valley floors are generally less than 1 km wide, and are surrounded by steeply sided ridges.
4. *Ridge Zone:* This section comprises the north-south ridgelines and dissected uplands of the Karuah Basin. The streams of this zone are characterised by small channel widths and sheer sided valleys.

Figure 2. Karuah/Port Stephens Estuary

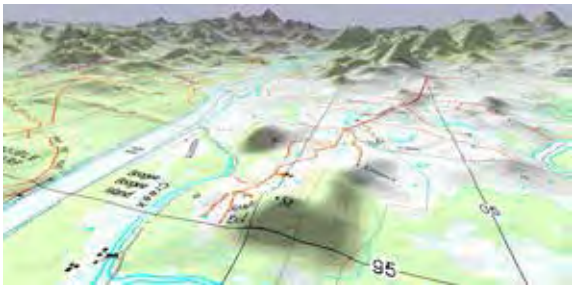


Figure 3. Branch Junction

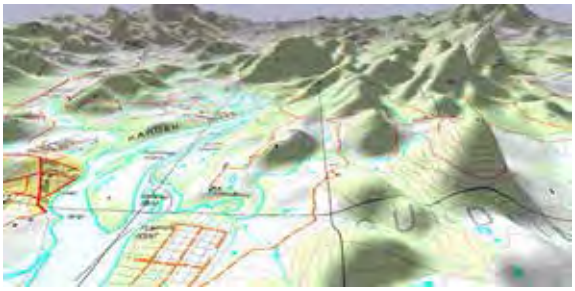


Figure 4. Allworth

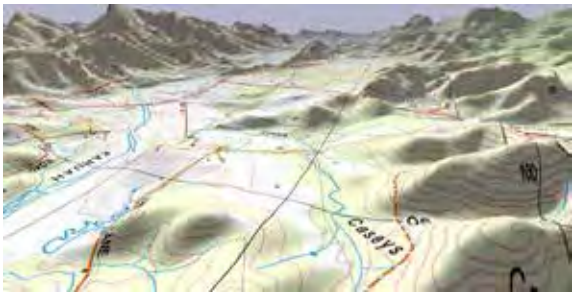


Figure 5. Booral

Figure 6. Stroud

Figure 7. Stroud Road/Mammy Johnsons River junction

Figure 8. Corner of The Bucketts Way and Monkerai Road

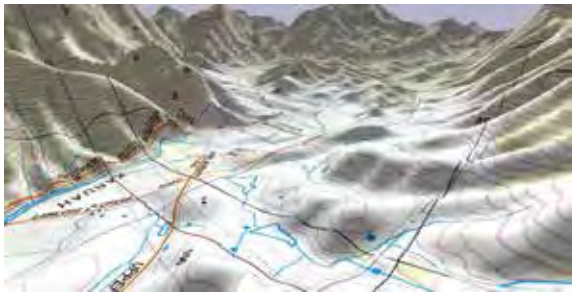


Figure 9. Upper Monkerai

Figure 10. Headwaters Barrington Tops

Figures 2-10 illustrate the landscape of the catchment.

The Stroud-Gloucester Syncline is a major influence on the characteristics of the Karuah River Basin. Alluvial plains are confined by steeper ridgelines on both the eastern and western boundaries of the catchment (Henderson, 2000). Inundation by the sea resulted in the deposition of fossiliferous sandstone and siltstone, which were overlain by extensive volcanic flows, and later extruded following uplift of the marine shelf. Further uplifting led to the deposition of terrestrial sandstone and conglomerate, followed by basaltic volcanism. Coal bearing sediments overlie these volcanics (Owen, 1991).

In many areas of the catchment, the duplex soils have been strongly leached and have dispersive sub-soils with an acidic profile. These soil landscapes are inherently at risk of gully and tunnel erosion, particularly on steep slopes (Owen, 1991). Narrow to moderately broad alluvial plains, terraces and alluvial fans, with numerous swampy areas, can be found along parts of the Karuah River. These soil types are typically highly erodible and susceptible to waterlogging and gully erosion (Henderson, 2000).

The climate of the Karuah River Catchment varies from humid sub-tropical on the coast to dry temperate for much of the catchment. The effects of the coastal influences are apparent in the south of the basin, and become less pronounced to the north and west due to the north-south aligned mountain ranges. The average rainfall on the coast is around 1300mm per year, and the headwaters of the catchment receive around 1500mm per year (Karuah Catchment Landcare Group and NSW Department of Land and Water Conservation, 1999).

The Karuah River Catchment contains great biological diversity. It is located in a landscape that receives influences from tropical and temperate bioregions and therefore includes a number of species that are at the limit of their natural range. It also includes coastal, estuarine, marine, riverine and slope/range landscapes, which support a great variety of species and ecological communities and a variety of productive land uses.

THE PAST

The Importance of an Historical Perspective

"It has been remarked that history has been slow to find its way into land management considerations. History can have a fundamental role where 'nature' and 'culture' are intertwined. Trees live longer than their managers, and natural or imposed forest cycles are greater than a lifetime"
(Griffiths, 1992.)

It is important to consider proposed catchment management actions within the context of both the historical and the present day use of the catchment. As Mika, et al., (2010) noted, "knowing the river's history is necessary to identify the causes, the spatial and temporal extents, and the intensities of disturbance to determine restoration priorities".

An historical understanding of the local landscape provides a context for analysing the past human occupation of an area. The analysis of the landscape contextualises and interprets patterns of past human behaviour.

Every catchment is subject to changes that influence its use, management and condition, and the Karuah River Catchment is no exception. With this in mind, the following chapter provides a brief historical context for the catchment. The context outlines some of the key changes in the major land uses and industries that have occurred over time. The context is not meant to be a comprehensive history of the Karuah River Catchment, but more a means to highlight the positive and negative impacts that past practices have had on the catchment's health and the landscapes that we see today.

Aboriginal History

The Worimi people are the traditional custodians of the Karuah River Catchment. Worimi country extends from Port Stephens northwards to meet the Biripi Country of the Manning Valley, another Kattang language group. Historical accounts mention various names for these groups, or family 'bands'. Bennett (1929), described a band as the 'Gringai' which means a group of the Wonnaruah people of the Hunter (Walsh, 1999) (see Figure 11). It is also known that there were relationships between the groups from the Williams River and Gloucester area through to Port Stephens, including the Karuah River Catchment in between the two.

There is a general correlation between cultural areas and major drainage basins. Water supply determines plant cover and the availability of food, and food supply impacts on Aboriginal population density (Petersen, 1986). Therefore, the Karuah River Catchment's characteristics, or more widely, the Port Stephens Catchment characteristics, defined the Aboriginal settlement and land use practices.

Figure 11. Map of Aboriginal Territorial Organisation (Horton, 1994)

Each family grouping of the Gringai lived about 12-15 km apart. They were not entirely nomadic; however, they did move from campsite to campsite on a rotational basis, mainly for reasons of hygiene (Bennett, 1929) and for seasonal access to food resources. Many of the paths they followed would have been along watercourses or from one water source to another.

The Gringai's extensive use of fire as a hunting tool modified the Australian vegetation. After firing, the bush would regenerate, and new grass would spring up, attracting prey including kangaroos and other animals. This form of hunting was called 'fire-stick farming'.

Fire also encouraged the regrowth of eucalyptus trees and edible plant roots. The ashes of fires provided nutrients that promoted the growth of new sweet, green shoots that would spring up after the first hard rain following the burn.

The fires were of low intensity, and only consumed the leaf litter and branches on the forest floors, while leaving the taller trees unharmed.

Similarly, in the Manning Valley to the north, Maiden (1895) wrote of the botanically rich areas of brush along the Gloucester River. Birrell (1987) also describes a similar pattern of vegetation distribution with rainforest along the river and some river flats giving way to more open grassy woodlands dominated by rough-barked apple.

The size and distribution of the Aboriginal population was, for the most part, determined by the food resources available, which in turn was related to rainfall; the area with the highest rainfall was generally the most rich in food. When food was difficult to obtain, the food quest simply required more time and effort rather than new strategies, so when times were hard, Aboriginal people simply moved more often and further afield. Unlike the European settlers, Aborigines in Australia were not vulnerable to famine because of the failure of one crop, because the diverse environment and landscape sufficiently provided for their needs.

The Australian Agricultural Company & Agriculture

The Karuah River was first surveyed by Europeans in 1795, when it was deemed not worthy of a return visit (Karuah Working Together Inc., 2010). It was not until nearly 1820 that the catchment began to be settled by Europeans.

The settlement of the catchment by Europeans is closely associated with the Australian Agricultural Company (AACo).

In 1824, AACo was established as a land development company with the assistance of the British Parliament. The British Parliament provided the company with a Crown Grant of 1,000,000 acres in the wider Port Stephens area (Australian Agricultural Company, 2014), including a large area of the Karuah River Catchment.

With the vision to produce fine wool and wheat, AACo established their headquarters at Carrington in 1826 and surveyed the estate. The estate included the land stretching from Port Stephens to the Manning River in the north and from the coast westward to include the Karuah River and Gloucester River Valleys (Department of Environment, 2014).

From 1826-1831, the saltmarsh areas to the east of the Karuah township were extensively cleared and drained in an attempt to turn the land into viable farming land (The Old AAco Road Sub-Committee of The Karuah Progress Association, 2014). Poor soils foiled determined attempts to make the area agriculturally viable. Eventually agricultural activities were moved north to the Booral and Stroud areas (Department of Environment, 2014).

Within a short time, the company headquarters were transferred to Stroud, which is one of the oldest planned settlements in Australia. Stroud township predates Adelaide and Melbourne (Stroud Heritage Conservation Inc, 2014).

Development progressed rapidly, and by 1834, 530 acres (including 278 acres of wheat) were under cultivation (Department of Environment, 2014), and sheep numbers had reached 124,000 (Stroud Historical Society, 2014).

Finding much of the original Port Stephens land grant unsuitable for sheep, AACo negotiated the surrender of the coastal region land in exchange for prime pastoral acreage on the Liverpool Plains, signalling the company's final withdrawal from Stroud in 1873 (Stroud Heritage Conservation Inc, 2014). Despite the withdrawal of AACo from the Karuah River Valley, agriculture, and in particular the grazing of livestock, remained within the Karuah River Valley.

In 1912-13, the North Coast railway line was constructed. The opening of the railway (which passes through the valley) was delayed by landslides caused by the fall of 250mm of rain in one week in December 1912 (Stroud Historical Society, 2014). The railway stimulated the expansion of the dairy industry in the 1920s by providing fast, reliable transport services (Department of Environment, 2014). The dairy industry peaked around 1960 (Stroud Historical Society, 2014).

The Karuah River Valley was part of the wider National and State post-war settlement scheme of the 1950s (Stroud Historical Society, 2014). This scheme set aside land for selection for use by serving or discharged members of the Defence Force. Ex-servicemen who took up the selections were expected to comply with the Government Standards for farming and land development. They were expected to 'improve' the land by clearing or draining it, and they were also required to abide by the 'use the land or lose it' principle.

The 1960s saw further change to the agricultural sector with the commencement of large-scale chicken production. This change resulted in a number of dairy farms converting to chicken or beef production. The poultry industry continued to expand, with significant increases in both egg and poultry meat production. Later deregulation of the dairy industry saw the number of dairy farms in the catchment decline further.

Today, agriculture within the Karuah River Catchment is dominated by both the poultry industry (both egg and broiler production) and the beef industry. The dairy industry remains in small numbers, along with the introduction of several other small boutique industries.

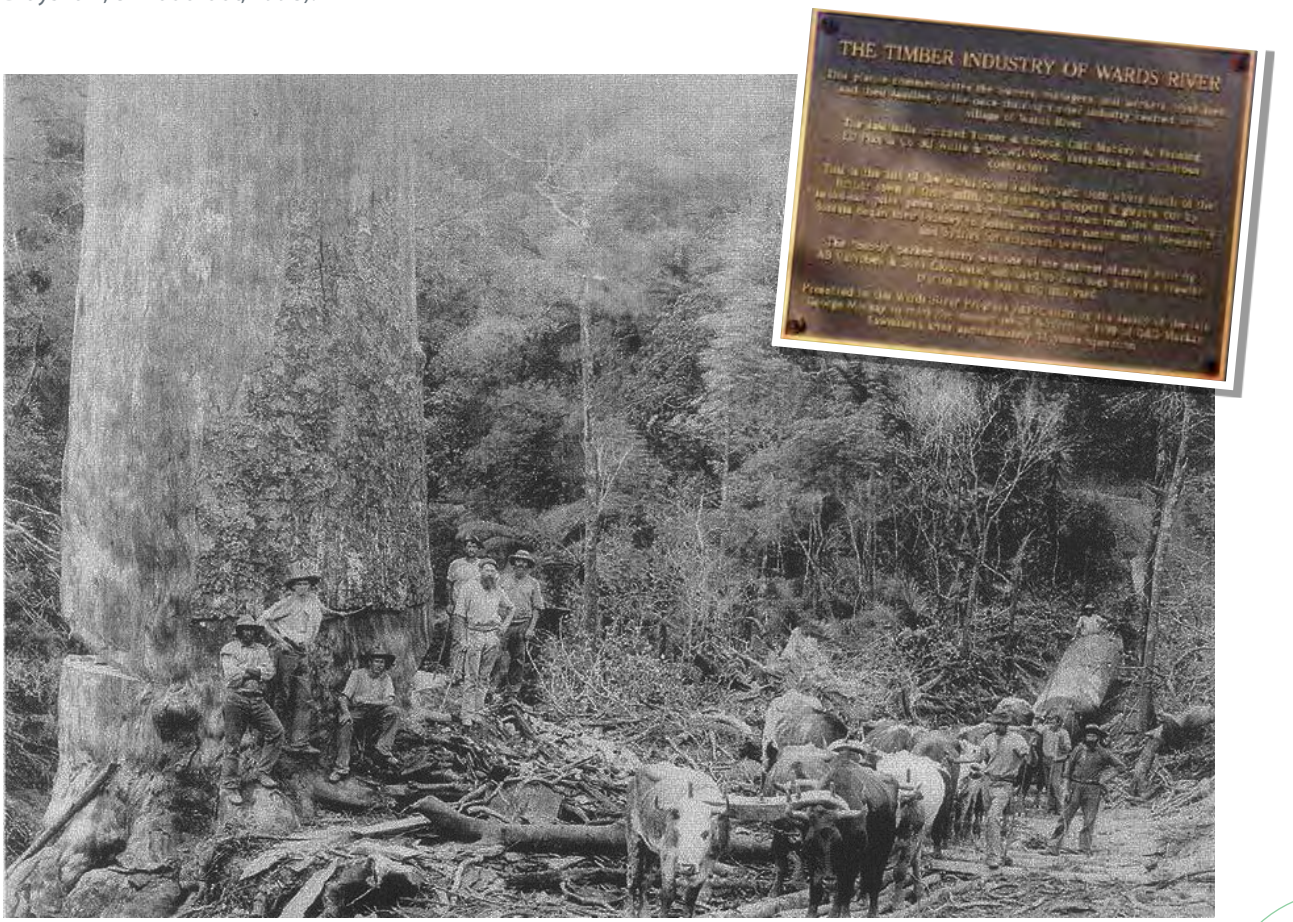
Timber Harvesting and Conservation

The timber industry has been a major feature in the landscape of the catchment since the very early days of European settlement. The first permit for timber cutting was issued for cedar harvesting in the Port Stephens area in 1816. The timber trade increased rapidly with rosewood as well as cedar being felled (Road Traffic Authority and Thiess, 2014). The timber was shipped from Sawyers Point on the western bank of the Karuah River in what is now the township of Karuah. The timber mill at Sawyers Point was not so much established because it was close to the timber source, but because it was on the 'shores' of Port Stephens, an ideal place for ships to load the finished product. Timber was brought to Sawyers Point from far and wide.

At first, the timber cutters with bullock teams , worked the river flats and brush gullies, and later penetrated deeper into the valley and rugged terrain of the catchment as the readily accessible and most prized timber from the lowlands was taken (Bickford, Brayshaw, & Proudfoot, 1998).

The timber industry continued to expand beyond the 1800s well into the 1900s. At a State level, the NSW Forestry Commission was established in 1916, whereupon crown lands containing forest resources were reserved as State Forests or Timber Reserves (Bickford, Brayshaw, & Proudfoot, 1998). Dedication of Crown Lands as State Forests permanently prevented these forests from being converted to freehold tenures and ensured that they were set aside for the preservation and regulation of timber harvesting. Poor utilisation, theft and unsustainable forestry practices were rife prior to this change.

Post World War II, timber demand for domestic purposes increased significantly. This, coupled with the advent of new technologies such as chainsaws, log trucks and bulldozers, saw many roads constructed in conjunction with the opening of new areas of forest for harvesting. Many of the existing state forests were extended and many new modernised sawmills appeared in the catchment area. Concurrently, there were conservation moves afoot within the wider community and in the political circles of both NSW and across the nation.



By the 1960s, the world of old timber-getters had almost vanished and forests were being recognised for values other than timber alone. In 1967, the National Parks and Wildlife Service of NSW was established with the intent to act as a management body for the conservation and protection of natural areas (Bickford, Brayshaw, & Proudfoot, 1998). A program of definition and gazettal of National Parks began, which included the gazetting in 1969 of 13,831 ha of plateau area to the north of the headwaters of the Karuah River to establish the Barrington Tops National Park (National Parks and Wildlife Service, 2010).

By the mid-seventies, many of the larger timber mills had disappeared from the landscape, and the principle of 'multi use forests' that recognised multiple values as well as preserving timber for the production of wood was seen as feasible (Bickford, Brayshaw, & Proudfoot, 1998). The move to recognise forests as places of recreation, education, ecological management and timber harvesting had been initiated.

The footprint from forestry was significant, covering a great percentage of the catchment, including the sub-catchments of Upper Karuah, Telegherry, Wards, Mammy Johnsons, Lower Karuah, Limeburners and The Branch.

Throughout the rest of the century, the transfer and reservation of large areas of forests for conservation was prominent. In 1983, the NSW State Government permanently ceased all logging in rainforests and in 1983-84 the *Forestry Revocation and National Parks Act* was introduced. A further 22,782 ha was added to Barrington Tops National Park, incorporating parts of the upper Karuah River Catchment (National Parks and Wildlife Service, 2010). An area of 39,120 ha of *Gondwana Rainforests of Australia*, within Barrington Tops National Park, was listed as a World Heritage Area by UNESCO in 1986 (UNESCO, 1991 - 2014). The area included the headwaters of the Karuah River.

With the advent of Interim Regional Forest Agreements in the late nineties, and the Comprehensive Regional Assessment (CRA) process, further additions were made to National Parks from State Forest Reserves under the *National Park Estate (Reservation) Act 2002*.

Within the Karuah River Catchment, this included the addition of 33,660 ha to Barrington Tops National Park; additions to the Myall Lakes National Park within The Branch sub-catchment; and the creation of several other parks and reserves including the Karuah National Park (3,534 ha), the Karuah State Reserve (74 ha), the Karuah Nature Reserve (824 ha) the Ghin-doo-ee National Park (4,819 ha), Black Bulga State Conservation Area (1,554 ha) and the Glen Nature Reserve (2,750 ha).

On the 1st January 2013, Forests NSW became a state owned corporation known as the Forestry Corporation of NSW. The focus of the new corporation is on sustaining the growth and harvesting of timber, while still providing ongoing recreational opportunities for the people of New South Wales.

The broader community - including the timber industry and the wider conservation movement alike - have developed a great knowledge of and affinity with the bush through the activities of the timber industry.

"The Australian experience of forests and their history is an important part of this country's ethos .... it has a tension between nature and culture, how the understanding has grown about the trees and ecology of the forest, how it might be used in the future"

(Bickford, Brayshaw, & Proudfoot, 1998, p.75).

Mining

As in other parts of Australia, the mining of various minerals has occurred or been attempted within the Karuah River Catchment. Many mines were unsuccessful because of the lack of capital and their location in difficult, steep and remote country.

Mining has been operational in various forms since early European settlement. Coal deposits were identified on AACo land north of Stroud in 1855 and pits were subsequently established in 1858 on Mammy Johnsons River. Despite the high quality of the coal resource, the mine was closed because the cost of extraction was prohibitive. Attempts were made to re-establish the venture in the 1870s; however, these attempts were unsuccessful (Stroud Heritage Conservation Inc, 2014).

The coal mining site north of Stroud Road on the Mammy Johnsons River remained dormant until March 2003, when Duralie Coal commenced operation on the site. Duralie is an open cut mining operation, which produces raw coal for export and domestic use. The coal deposit consists of two target seams: the Weismantel Seam and the Clareval Seam.

Some other notable mining operations include:

- In 1879, gold was discovered at Whispering Gully in the upper catchment.
- In 1890, a magnetite mine was established at Iron Stone Mountain near Allworth, and one ship carrying magnetite was sent to the United Kingdom.
- In 1894, the Karuah Valley's first commercial gold mine opened at Monkerai.

The Whispering Gully gold mine was first mentioned in records from the Department of Mineral Resources in 1894 and is described as being located in very rough and nearly inaccessible country. The main mining period (1895-97) appears to have been short lived, with some renewed interest occurring during the Great Depression (J Murray and the Forestry Commission of NSW, 1995).

Oyster Farming

Prior to European settlement, the local Aboriginal people included oysters as an important part of their diet (Karuah Working Together Inc., 2010). Oysters provided far more than food; their shells could be fashioned into tools such as effective fish hooks or cutting implements. Evidence of the value of the oyster to the local Worimi people can be found in the known sites adjacent to the river systems of Port Stephens (Clarke, 2013). Clarke noted "If you had sailed into Port Stephens Estuary at this time you would probably have seen more oysters than anywhere in the world - there were thousands of acres of them".

Throughout the early European settlement of Australia, natural resources were exploited to develop infrastructure. This exploitation has left lasting consequences on our natural resources, including the region's oysters. The early building industry relied heavily on lime for mortar for stone buildings and oysters were burnt to produce significant quantities of cheap lime (Clarke, 2013). Burning and crushing works were usually located on the bank of a creek, hence the derivation of the name of Limeburner's Creek (Clarke, 2013). Massive oyster numbers were taken, resulting in drastic declines in oyster populations from the 1850s to the late 1860s. To arrest the decline of the wild oyster resources, the NSW Government introduced legislation in 1868 prohibiting the burning of live oysters for lime (Clarke, 2013).

A decade or so later, legislation was developed to introduce oyster leases. In 1876, the first lease was granted within the wider Port Stephens Estuary (Clarke, 2013).

During this period, oysters were harvested by dredging the bottom of the watercourse (Clarke, 2013). Oyster farming at Karuah and the lower reaches of the Karuah River expanded, and by 1920, an average yield of about 15,000 bags were produced in the wider Port Stephens Estuary (Karuah Working Together Inc., 2010). Oysters were grown in the Karuah River, as far upstream as Allworth.

For someone living in Karuah at this time, it would have been difficult not to consider the possibilities of entering the developing oyster industry (Clarke, 2013).

Continual change and modification of the methods of harvesting and growing oysters was undertaken in an attempt to improve oyster production (Clarke, 2013). In the 1930s, long black mangrove sticks were used to farm oysters. Professional contractors cut out hundreds of thousands of mangrove sticks, firstly cutting out the local mangroves, before having to search further afield to supply the demand (Clarke, 2013). The use of black mangrove sticks was subsequently phased out in the mid-1940s with the introduction of sawn hardwood sticks (Clarke, 2013).

A portrayal of the Karuah River Estuary from the 1960s and 1970s as described by oyster growers of the time:

"Fish, mullet schools; the sizes you wouldn't believe. It sounded like a train coming, such was the noise they made and the water would be white with foam. Then there would be the loud crash as jewfish smashed the surface feeding."

This was also a time of great peaks in oyster production throughout the Port Stephens Estuary. It was estimated that over 70% of all oysters sold for human consumption in New South Wales during this time were from the Port Stephens stock (NSW Department of Primary Industries, 2014).

Production levels declined significantly in the mid 1980s with the introduction and proliferation of the Pacific Oyster at Port Stephens and the subsequent implementation of measures to control the spread of Pacific Oysters (NSW Department of Primary Industries, 2014). Pacific Oysters are endemic to Japan and are an invasive species that often displaces native intertidal species, modifying the habitat. The Pacific Oyster is declared as a Class 2 Noxious Fish in all New South Wales waters except for Port Stephens, incorporating the Karuah River Estuary. Due to the overwhelming numbers of wild Pacific Oysters present within the Port Stephens estuary, permission was granted for aquaculture permit holders to cultivate Pacific Oysters in the estuary in 1990 (DPI NSW, 2014).

Today, an area of the Karuah River estuary reaching to near Allworth - including sections of Deep Creek, Limeburner's Creek and The Branch River - is declared a priority oyster aquaculture area in the *NSW Oyster Industry Sustainable Aquaculture Strategy 2014*.

The Karuah River Estuary is used as a nursery for oysters, prior to moving them to other sites within the wider Port Stephens Estuary where they are grown out and undergo depuration before human consumption.

All oysters produced in New South Wales are harvested in accordance with the *NSW Shellfish Program*. This program incorporates the *Australian Shellfish Quality Assurance Program (ASQAP)* as a minimum standard. Administered by the NSW Food Authority, the *NSW Shellfish Program* oversees the open and closed status of harvest areas. Harvest areas may temporarily close for a number of reasons. For example, when localised rainfall produces runoff that pollutes the estuary. Shellfish are filter feeders and they can accumulate pollutants which can become a threat to human health (NSW Food Authority, 2014).

Community

There have been many changes within the landscape and in the communities of the Karuah River Catchment. The catchment has seen a tumultuous transition from the hunter - gatherer Aboriginal culture, to European settlement which focused on agriculture, the timber industry, oyster production and mining activities.

Over time, more complex and modern social structures have evolved. The Stroud Shire Council was established in1906, and eventually evolved into the Great Lakes Council and moved to offices in Forster in the 1980s. MidCoast Water was established as a county council in July 1997. The agency is responsible for reticulated water supply and sewerage systems and provides services to the North Karuah and Stroud communities (MidCoast Water, 2014). The Stroud Sewerage Treatment Plant and recycled water re-use system was commissioned in 2007. Treated water from the sewerage treatment plant is used by nearby farmers for irrigation.

Discharge of treated water to the river can only occur when all of the following conditions are met:

- the water cannot be used for irrigation
- the two large holding ponds are full
- the river is flowing at more than 2000 ML per day, i.e. after heavy rain.

In this scenario, the maximum amount of treated water that can be discharged is 2 ML per day. River discharge only occurred five times throughout 2012 and 2013. The reuse scheme has reduced nutrient loads and particularly *E. coli* levels in the Karuah River, and it also reduces the extractive pressure from irrigators in low flow conditions.

The move to a more sustainable approach to the management of the catchment has not only been evident at an agency or institutional level, but also within community sectors. One example of this is the Karuah River Rivercare Plan compiled in 1999 by the Karuah Catchment Landcare Group. The plan was developed in conjunction with the NSW Department of Land and Water Conservation, and its objective was to identify strategies to restore, rehabilitate and maintain the environment along a 42 km section of the Karuah River.

Further social transformation had begun to shape the valley in the 1970s. At this time, there were changes in the dairy and timber industries, and an expansion of tourism and lifestyle settlements. Today, tourism, rural lifestyle and absentee landowners are major components of the social and economic makeup of the catchment, which has created a mosaic of multiple land uses and community sectors. These sectors include:

- large scale commercial farms particularly within the poultry and beef sectors
- aquaculture e.g. oysters
- fishing
- forestry (both within the private and public sectors)
- conservation and cultural heritage e.g. national parks, cultural heritage sites
- small scale farms (often supported by off-farm income)
- rural lifestyle properties
- weekenders
- absentee landowners
- mining
- rural townships.

This chapter has attempted to provide an outline of the historical circumstances that have led to the present use of the catchment's natural resources and its overall health. The chapter highlights, that, like much of Australia, the Karuah River Catchment has had many human induced forces that have contributed to the catchment of today.

THE PRESENT

In order to provide a focus for the development of future management actions, the following chapter provides an overview of what we know about the current condition and health of the Karuah River Catchment. This chapter also provides an outline of the threats to catchment health and possible opportunities for catchment enhancement.

Research and Monitoring

To provide a scientific context and benchmarking for the development of the Plan, an ecological health assessment of the Karuah River was completed in 2011. The assessment found that, overall, the Karuah River estuary and catchment were in moderate ecological condition, although indicators of poor condition were evident (Office of Environment and Heritage, 2012). For simplicity of reading, the estuarine and catchment components have been separated, when, in reality, an integrated whole of catchment and estuary approach has been undertaken. An integrated approach (hill-slope to estuary) is required because the health of both the estuary and the river are a function of catchment inputs and estuarine processes.

Major issues of concern

Estuarine issues

- seagrass habitats have declined by approximately 80% and are now almost non-existent
- saltmarsh habitats have declined
- mangrove systems have encroached on other habitat types
- excessive algal recruitment on artificial pneumatophores
- elevated water column turbidity and suspended solids
- elevated water column nutrient concentrations, in particular total nitrogen and total phosphorus levels.

Catchment issues

- riparian habitats are degraded
- elevated water column turbidity and suspended solids
- elevated water column nutrient concentrations, in particular high total nitrogen and total phosphorus levels (Office of Environment and Heritage, 2012).

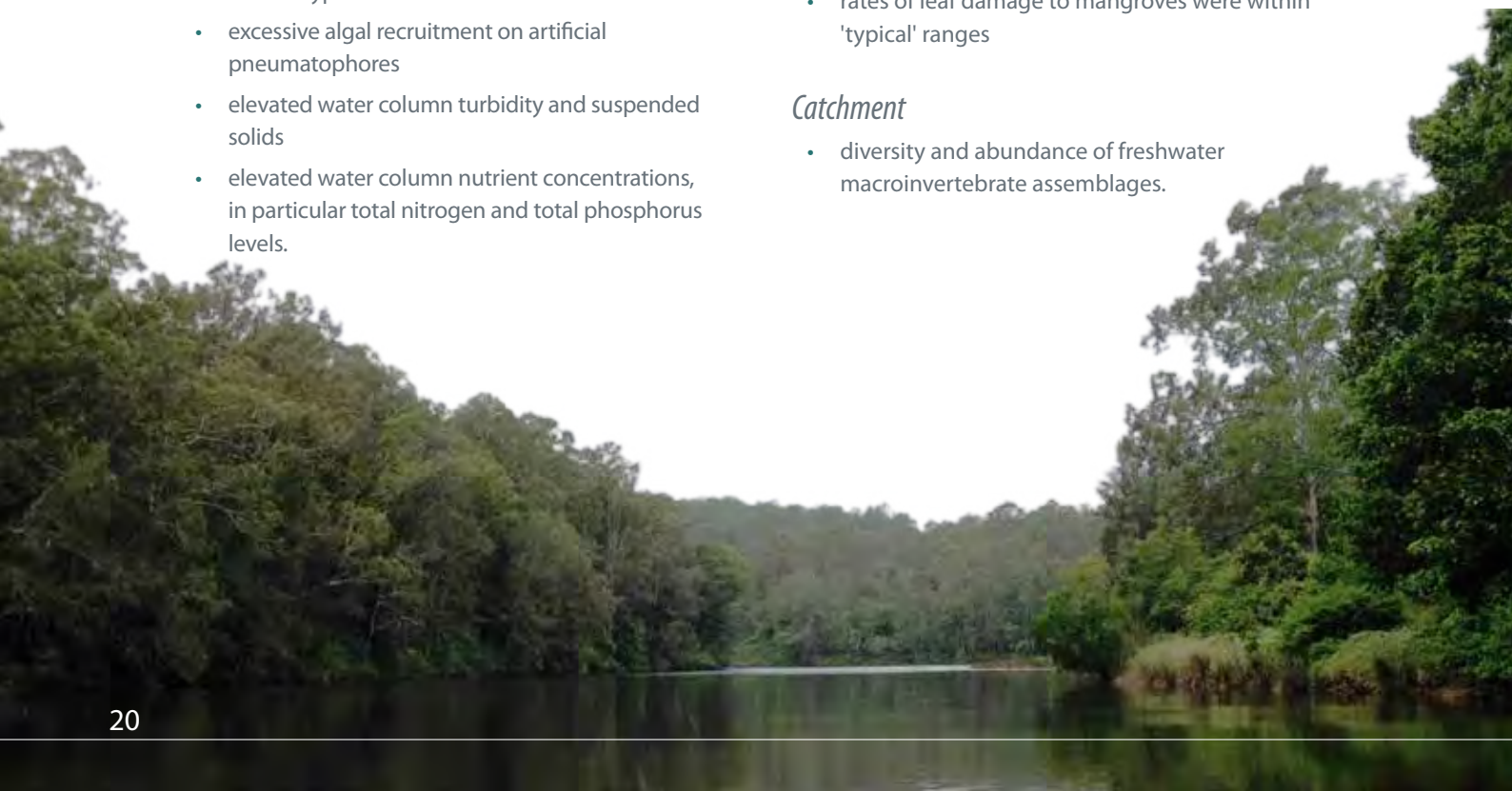
Positive findings of the Karuah ecological health assessment included:

Estuarine

- diversity of macroinvertebrate populations on intertidal flats
- estuarine fish assemblages
- shorebird abundance, with a healthy level of species richness
- Chlorophyll levels within phytoplankton and benthic microalgae typically below trigger values - excessive growth of Chlorophyll often leads to poor water quality, noxious odours, oxygen depletion, human health problems and fish kills, and it may also be linked to harmful (toxic) algal blooms
- algae growth on seagrass not excessive
- health and functioning of micro and macro-carnivore scavenger populations
- no ulcers observed on fish caught in the Karuah River
- rates of leaf damage to mangroves were within 'typical' ranges

Catchment

- diversity and abundance of freshwater macroinvertebrate assemblages.



Water Quality

Water quality monitoring is currently undertaken by MidCoast Water and Duralie Coal in accordance with their operational licence requirements. Monitoring sites are both upstream and downstream of the Stroud Sewerage Treatment Plant and Duralie Coal Mine. Results are consistent with the findings of the Ecological Health Assessment. Trends from this monitoring similarly display water quality parameters that are regularly in excess of Australian and New Zealand Environment and Conservation Council (ANZECC) water quality trigger levels.

Turbidity and nutrients including ammonia, total nitrogen, total phosphorus and faecal coliforms are regularly elevated. MidCoast Water 'State of the Environment' reports typically rate key environmental indicators within the Karuah River as fair to very poor due to elevated turbidity and/or faecal coliforms.

In addition, monitoring by Duralie Coal has occasionally observed total aluminium, total manganese and total zinc levels in excess of ANZECC water quality trigger levels. The water quality monitoring undertaken in the Karuah River Catchment by the Gloucester Water Study Project, Baseline Water Survey during 2014 likewise found elevated manganese, aluminium and iron levels, as well as elevated turbidity levels in Wards River and Mammy Johnsons River. These metals are naturally occurring within the landscape associated with the underlying geology and soils types of the catchment and a likely exported to the river bound to sediment.

Furthermore, in conjunction with Council's Waterway and Catchment Report Card, OEH undertook water quality monitoring in the estuarine zone of the catchment in 2007, 2011 and 2013. The monitoring has shown trends that partially correlate with weather conditions. The trends are outlined below:

1. Base flow turbidity and suspended solid levels tend to be lower and usually within the range of ANZECC trigger values. Following periods of intense rain events or higher than average rainfall (such as during the Ecological Health Assessment), turbidity and suspended solid levels spike considerably and climb into unacceptable ranges. This is also consistent with anecdotal evidence from oyster growers in the catchment, particularly for The Branch sub-catchment where storm events result in a significant pulse of sediment within freshwater flows. Silting of the lower estuary has also been observed by oyster farmers operating in the Karuah River.
2. Nutrient levels are regularly elevated, including ammonia, total nitrogen, total phosphorus and faecal coliforms. Algae need both light and nutrients to grow. Low turbidity can be a double-edged sword. During times of low turbidity, algae levels have typically been excessive - high levels of nutrients combined with clear and warm water stimulate the growth of algae. Conversely during periods of high rainfall, algae are failing to flourish due to limited light availability from turbidity / suspended solid levels.

A 'typical' algal bloom may not always be visually evident. If the growth of small algae population in the waterway continues, there is a risk that it will reach levels which are detrimental to fish, humans and aquaculture. This is consistent with the occasional blue-green algae high alerts issued by the NSW Office of Water (NoW).

Nutrients and sediments that enter waterways can be from point or diffuse (non-point) sources. Typically, point sources are easy to locate and often include urban discharges such as discharges from stormwater drains; however, it is more difficult to locate the origin of diffuse sources of nutrients and sediments.

Examples of diffuse sources of sediment and nutrients include erosion processes such as riverbank and bed erosion, gully, sheet or tunnel erosion, overland flow, and some land management operations e.g. poor fertiliser use, grazing practices and timber harvesting. Roadside runoff from gravel road networks throughout the catchment is also known to contribute significantly to sediment in the river.

Land Use

Figure 12 shows the composition of land uses within the Karuah River Catchment. Figures 13 and 14 illustrate the estimated proportional contribution to total phosphorus and total nitrogen loads of each land use using typical or average nutrient loads for each land use type. Whilst this is a useful tool, it should be recognised that nutrient export rates are inherently variable and are affected by climate, soils, management, distance to water sources and other factors.

Grazing occupies approximately 33% of the catchment; however, it is estimated to contribute 67% and 48% of the total phosphorus and total nitrogen loads, respectively. Grazing includes a mix of beef farms and rural lifestyle properties that also undertake some grazing.

Poultry production occupies less than 0.1% of the catchment and is estimated to contribute approximately 5% and 2% of the total phosphorus and total nitrogen loads, respectively. National Parks, forestry and tree and shrub cover combined account for approximately 64% of the land use within the catchment, but only contribute 18% and 45% of the total phosphorus and total nitrogen export loads, respectively. Rural residential and townships account for only 1% of the total land use within the catchment; nonetheless, they contribute 6% of the total phosphorus and 3% of the total nitrogen export loads, respectively.

Whilst these figures are only broad estimates, they do highlight the relationship between the intensive use of land and the potential for higher per hectare rates of nutrient export when unmanaged. Less intense land uses such as grazing still contribute a significant nutrient load to the catchment, as they occupy a larger percentage of the catchment.

These figures do not account for the movement of nutrients from one land use to another; the application of poultry litter as a fertiliser within the grazing industry is an example. Nitrate runoff has increased dramatically worldwide with increasing use of fertiliser in agriculture. Results of research indicate that fertilised land has the highest losses of dissolved inorganic nitrogen of any extensive rural land use and is typically related to application rates not matching plant requirements (Mitchell, Reghenzani, Faithful, Furnas, & Brodie, 2009).

Land use change within the catchment is always occurring. In most cases, this is driven by economic and social factors unrelated to natural resource management. For example, the improvement in transport and communication infrastructure has led to the movement of people into the catchment from the urban areas of Newcastle and Sydney. Within the land use chart, this demographic has largely been captured within the grazing land use category and may not effectively capture the relative nutrient contributions from this sector. The Karuah River Catchment is an ever-evolving and dynamic blend of multiple and sometimes conflicting land uses. There is a large variation in the way that land is managed, as well as the level of catchment management skills and knowledge levels across landholders.

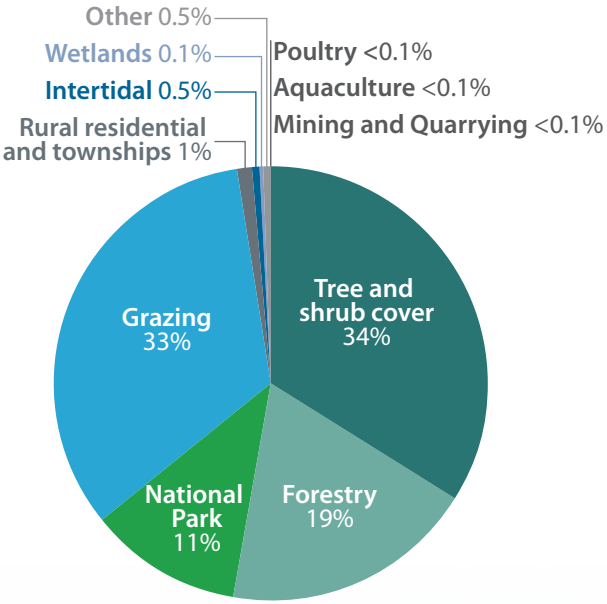


Figure 12. Composition of land uses by area in the Karuah River Catchment

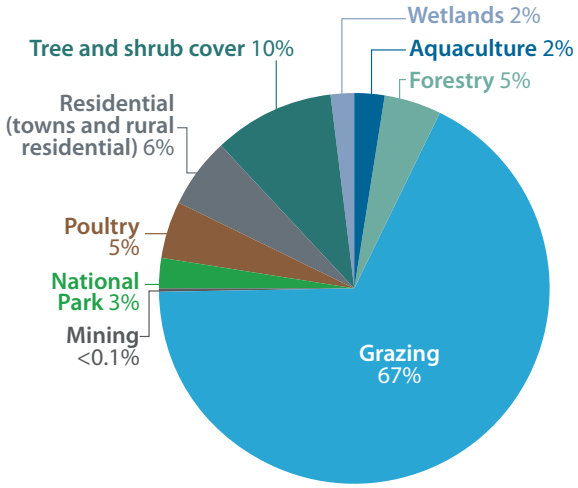


Figure 13. Proportional contribution to total phosphorus loads by various land uses in the Karuah River Catchment

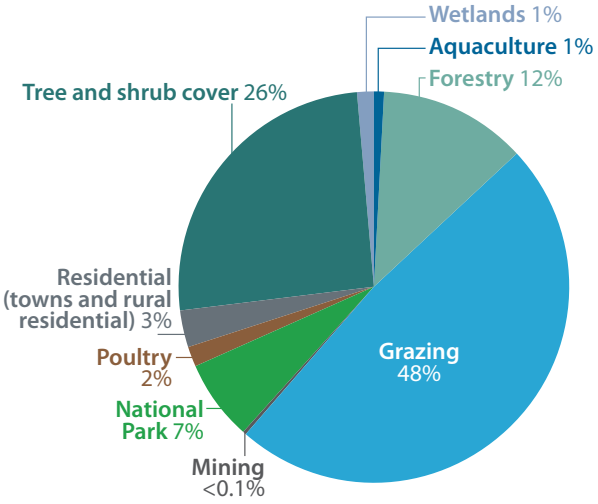


Figure 14. Proportional contribution to total nitrogen loads by various land uses in the Karuah River Catchment.

River Condition Index

The River Condition Index, including River Styles and the Aquatic Biodiversity Forecaster tool, is a useful tool to guide in-stream priorities for rehabilitation activities (See Appendix 4). River Styles is based on geomorphic considerations only, and does not take into account ecological, social or economic issues. The River Styles Fragility mapping for the Karuah River Catchment classifies the majority of the Karuah River (and its tributaries) as moderately fragile. This means that the geomorphic features of the river may adjust over short sections in response to catchment pressures, while major character changes can occur in response to a large scale event or pressures such as wide-spread clearing or major flooding. Limeburners Creek in the lower catchment has large reaches mapped as highly fragile with the potential for major changes to occur in response to catchment pressures. This is because the main protection in these areas is usually riparian vegetation. Any reduction in riparian vegetation can lead to river bed instability and channel widening (Brooks, Brierley, & Millar, 2003).

River Styles Recovery Potential is a measure of the capacity of a stream reach to return to a good condition or a realistic rehabilitated condition. There are a number of areas within the catchment that are mapped as 'Conservation', meaning they are in good geomorphic condition and do not require recovery actions, other than to protect the existing riparian zone and minimise threats. Typically, these reaches of the river are either located within vegetated areas of the catchment such as along the steeper ridge lines or in the estuarine zone of the river. Whilst the estuarine zone is largely mapped as 'Conservation', it is worth noting that water quality monitoring in areas such as The Branch sub-catchment has typically shown high sediment and nutrient levels. This suggests that catchment land use is the source of the problem rather than in-stream processes. From Booral through to Wards River, the river is mapped as having 'High Recovery Potential'. This means the river is in moderate geomorphic condition and has the potential to recover quickly if existing pressures such as livestock grazing are removed.

The Recovery Potential is also closely linked to the Action Priorities for Geomorphic Condition, where the catchment is mapped according to the priority level for rehabilitation and/or protection. As well, Action Priorities for riparian vegetation have been mapped for the catchment based on extent, not condition or quality and not taking weed extent into consideration. Figure 15 illustrates how River Styles is used for priority setting. Priorities for protection are based on maintaining high fragility reaches that are in good condition. Rehabilitation is a priority for reaches identified as:

- Strategic
- Rapid Recovery
- High Recovery

that also display moderate to high fragility.

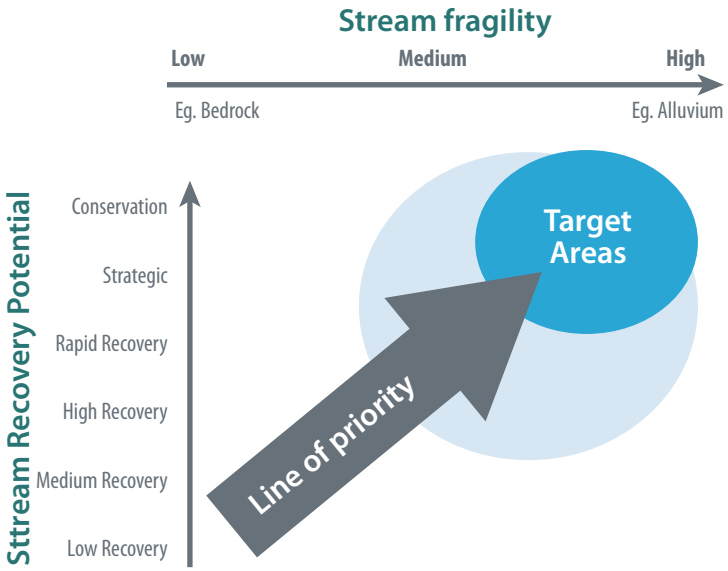


Figure 15. Use of River Styles for Priority Setting

Macroinvertebrates

Since 1994, macroinvertebrate monitoring in the Karuah River Catchment has been undertaken by the OEH approximately every two years. The monitoring has consistently found macroinvertebrate health (diversity and abundance) is similar to reference sites.

Monitoring of aquatic macroinvertebrates has also been commissioned by Duralie Coal Pty Ltd since the mine's commencement in 2002. Macroinvertebrates are currently sampled at seven separate sites. One site is on the Karuah River upstream of the junction with the Mammy Johnsons River and six sites are located within the Mammy Johnson sub-catchment; the sites are located both upstream and downstream of the mine. The results of the 2013 surveys indicate that both the Mammy Johnsons and Karuah Rivers are still in fair to healthy overall condition and possess a healthy, highly complex and diverse aquatic ecosystem (Invertebrate Identification Australasia, 2013).

Trends from the monitoring include:

- a general decrease in overall number of taxa following large rainfall and flow events
- consistency in overall community structure over time
- high number of sensitive taxa remaining within the river systems
- similarity of macroinvertebrate communities and trends between sites or location within the catchment
- some green filamentous algae present, mainly during sampling periods of low flow (Invertebrate Identification Australasia, 2013).

The Aquatic Biodiversity Forecaster Tool (see Appendix 4) was developed as a tool to predict and map where protection, restoration or conservation priorities should occur (Healey, Raine, Parsons, & Cook, 2012). Vast areas of the catchment are mapped as a high priority for macroinvertebrate conservation.

Water Quantity

The water in the Karuah River is regulated under the *Water Management Act 2000* via the Water Sharing Plan for the *Karuah River Water Source 2004*. The Water Sharing Plan allocates water for the environmental needs of the river and directs use and extraction of water from the river (NSW Department of Infrastructure, Planning and Natural Resources, 2005).

Landholders with direct river frontage are provided with basic landholder rights to extract water from the river for stock and domestic purposes without the requirement to be licensed. The basic landholder rights also provide for Native Title rights. Water access licences are issued for the following categories of use:

- Town water: MidCoast Water supplies approximately 500 households at Stroud and Stroud Road with domestic and drinking water. The water is pumped from the Karuah River to storage areas, where it is treated before use.
- Stock and domestic: Water supplied for those water users who cannot access water under basic landholder rights (i.e. their property does not directly front the river).
- Unregulated river: This category includes uses such as irrigation, industry, mining, recreation and general farming. Irrigation is the major use of water in the Karuah River (Department of Infrastructure, Planning and Natural Resources, 2005). The Karuah River Wateruser's Association was involved in the negotiations to secure irrigation as a licensed use within the Water Sharing Plan.
- Aboriginal culture: Water provided for Aboriginal people or communities for personal, domestic and communal purposes.
- Research: Water supplied for scientific research, experimentation or teaching.

Flow data is monitored by the NSW Office of Water via gauging stations on the River. The Water Sharing Plan highlights that the Karuah River is a stressed river; that is, if everyone pumped water at the same time, there would not be enough water for all existing water uses or enough water remaining to meet the environmental needs of the river (NSW Department of Infrastructure, Planning and Natural Resources, 2005). A very low flow 'cease to pump level' has been put in place and a long-term extraction limit has been set to manage growth.

Groundwater

The influence of groundwater, its quality and its flow characteristics remain relatively unknown and groundwater information is primarily gathered by the mining industry. The groundwater monitoring data collected by Duralie Coal Pty Ltd - in line with its licensing agreements - includes pH, electrical conductivity, heavy metals and the groundwater drawdown potentially associated with its open cut operation. Nutrients and the movement of groundwater through to alluvial systems have not been monitored.

Wetlands

Wetlands are an important feature of the Karuah River Catchment. Wetlands play a vital role in nutrient cycling, nutrient detention and trapping sediments by slowing the flow of water. They also contain a biodiverse range of species and provide a nursery for fish, crabs and prawns and a habitat for a wide range of plants and animals (Department of Environment, Climate Change and Water NSW, 2010).

In 1985, the State Environmental Planning Policy No14 - Coastal Wetlands (SEPP 14) was introduced with the aim to protect coastal wetlands. Within the estuarine reaches of the Karuah River Catchment, extensive areas of wetlands have been mapped as SEPP 14 wetlands. This includes around the mouth of the Karuah River, areas adjoining Limeburners Creek, Deep Creek, The Branch River, Little Branch Creek and along the Karuah River to approximately Allworth as shown in Figure 16.

The wetlands are typically within mapped areas of acid sulfate soils. In addition to the SEPP 14 wetlands, there are other wetlands distributed throughout the catchment.

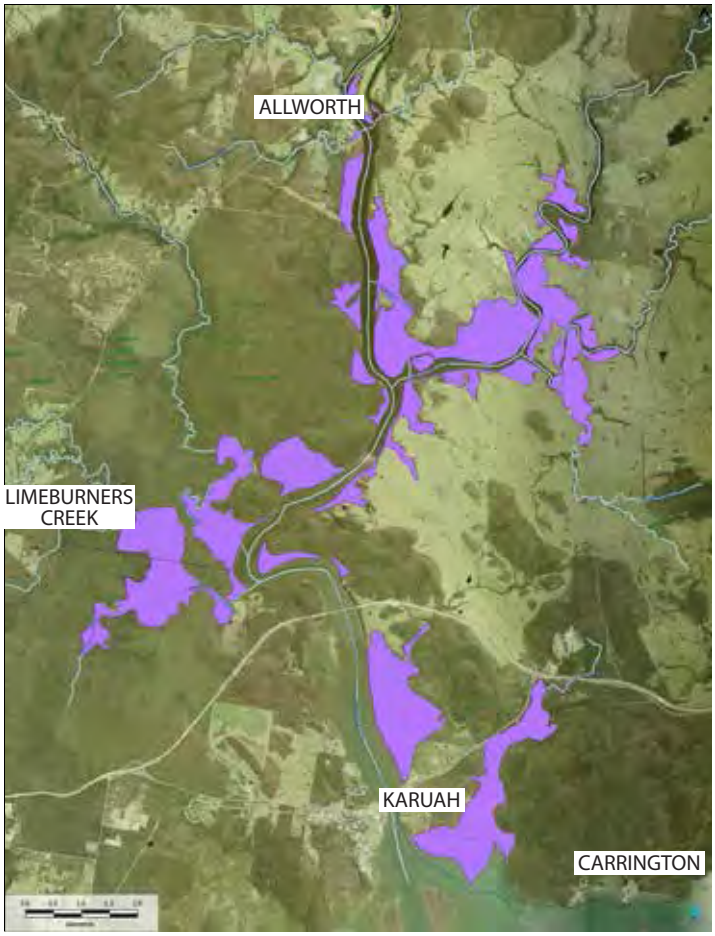


Figure 16. SEPP 14 Wetlands within the Karuah River Catchment

Biodiversity

The Karuah River Catchment contains a diverse range of significant plant and animal species. The catchment is located in a landscape that receives influences from tropical and temperate bioregions, so several species are at the limit of their natural range. The catchment also includes a range of habitats: coastal, estuarine, marine, riverine and slope / range landscapes.

The *Port Stephens Great Lakes Marine Park (PSGLMP)* was declared on 5th December 2005, and the zoning plan came into effect on 21st April 2007. The purpose of this relatively large marine park is to ensure representation of the ecosystems, habitats and marine life in the Manning Shelf Bioregion and to contribute to the national and global system of marine protected areas (Marine Parks Authority, 2010). The PSGLMP is approximately 98,000 ha and is the largest Marine Park in New South Wales. Port Stephens is the largest drowned river valley in New South Wales and the only tide dominated drowned river valley in the Bioregion.

The waters of the Karuah River, upstream of the Pacific Highway Bridge, are classed as Habitat Protection Zone. Two areas of Sanctuary Zones exist, one located in the Little Branch Creek and the other upstream of Allworth to the end of the tidal zone. The waters of the Marine Park extend up to the mean high water mark. The Park encompasses a diverse range of habitats including intertidal and subtidal reefs, soft sediments, beaches, seagrass beds, mangroves, saltmarsh and open waters, which all support distinct and diverse groups of plants and animals. The Marine Park is a unique environment where tropical, subtropical and temperate marine fauna and flora co-exist (Marine Parks Authority, 2010).

Monitoring of fish populations in the Karuah River since 1983 has shown a progressive increase in the number of fish species within the river. Gambusia was the only 'alien' species recorded (Howell & Creese, 2010). The most abundant species were Sea Mullet, Long-finned Eels, Australian Smelt, Australian Bass, Flat-head Gudgeon and Empire Gudgeon (Howell & Creese, 2010). In 2007 the NSW Department of Primary Industries mapped the Karuah River and estuary as Key Fish Habitat for its importance to the sustainability of the recreational and commercial fishing industries, the maintenance of fish habitats generally and the survival and recovery of threatened aquatic species (Department of Primary Industries, 2014). Fish biodiversity hotspot analysis by NSW Fisheries has also highlighted very high fish biodiversity in the reaches of the Upper Karuah (see Appendix 4 for mapping).

Stream connectivity and habitat diversity are critical components of healthy rivers; many fish have evolved to be reliant on a range of habitat types throughout their life cycle (NSW Department of Primary Industries, 2005). Fish passage, bed stability, bank stability and the quality of riparian habitats play an important role in the rehabilitation of New South Wales waters (Sarah Fairfull, Fisheries NSW, 2013). A number of activities aimed at improving fish passage in the Karuah River have been undertaken. These activities include the removal of The Branch River Crossing and the restoration of the fish passage at Stroud Weir. NSW Fisheries currently have seven known fish barriers within the Karuah River Catchment.

There are substantial areas of mangrove and saltmarsh habitats in the Karuah River estuary that provide food sources and nursery areas for fish, but only very small areas of seagrass exist. The PSGLMP contains the largest extent of mangroves and saltmarsh in New South Wales and 5% of the State's seagrass. The estuary has 30% of the saltmarsh community in the Manning Shelf Bio-region (Breen, Avery, & Otway, 2004). Seagrass extent has decreased by almost 80% between 1985 and 2009 (Office of Environment and Heritage, 2012). Low light availability due to high turbidity, and/or nutrient enrichment are the most likely reasons for the decline of seagrass in the Karuah River estuary. The loss of seagrass results in loss of critical habitat and food resources for many species. The extent of saltmarsh over this time has also reduced, while the extent of mangrove has increased. Similar to many estuaries in New South Wales, it appears that mangroves have increased at the expense of saltmarsh.

The headwaters of the Karuah River are within the Wold Heritage Area known as the *Gondwana Rainforests of Australia* within Barrington Tops National Park. Few places on earth contain so many plants and animals, which remain relatively unchanged from their fossilised ancestors. The outstanding geological features and the high number of rare and threatened species are of international significance for science and conservation. Much of this area is also declared as Wilderness Area under the *NSW Wilderness Act (1987*).

State Forests are the largest land use managed by a single land manager within the catchment. The landscape has significant ecological values which are managed through the Integrated Forest Operations Approval, which must comply with the NSW *Threatened Species Conservation Act 1995*. The Forestry Corporation is required to implement many permanent harvest exclusions based on ecological values such as rainforest, ridge and headwater habitat, old growth forest and threatened species habitats.

Approximately 34% of the catchment is tree and shrub cover located on private land. The largest areas of intact native vegetation mostly occur in the less developed and more inaccessible steep slopes of the catchment. It is probable that this vegetation contains unmanaged significant biodiversity and ecosystem values.

With some exceptions, the lower to mid-slopes and floodplains are cleared, in particular along the Karuah River Valley floor, the lower Monkerai district and The Branch sub-catchment. Riparian zones are characteristically narrow strips of vegetation along the waterways, although there are some exceptions to this. Fragmentation of habitat is a well-recognised pressure on ecosystem resilience. Despite the large areas of native vegetation within the catchment, connections between habitat and habitat types are in some cases lacking.

There are many recorded occurrences of threatened flora, fauna, and ecological communities throughout the catchment; however, a broad, systematic analysis of the locations, trends and status of threatened biodiversity has not been carried out. The number of threatened entities as listed on State and Commonwealth legislation known to occur in the Great Lakes LGA are provided below:

- 3 endangered populations
- 12 endangered ecological communities
- 32 threatened plants
- 28 threatened mammals (15 terrestrial / arboreal species, 13 bats)
- 6 threatened frogs
- 1 threatened reptile (excluding marine turtles)
- 45 threatened birds (excluding oceanic species)

It is anticipated that the majority (but not all) threatened species and ecological communities known to be present in the Great Lakes LGA are also likely to exist within the Karuah River Catchment.

An example of the significance of the threatened species within the catchment is the Giant Barred Frog (*Mixophyes iteratus*) which is listed at both a State and Federal level. The Giant Barred Frog is known to occur in the Mammy Johnsons River and Mill Creek (including the tributary Saggers Creek). These frog populations are relatively isolated from other known populations in the south and north. Given the overall distribution of the Giant Barred Frog, the populations in the Karuah River Catchment are of regional significance (Duralie Coal Mine, 2012).

Beyond threatened species, there are a number of iconic Australian species that are known to occur within the catchment such as platypus, koalas, gliders, possums, antechinus, wallabies, kangaroos, pademelons and echidnas.

Pressures and Threats

There are many threats to threatened species, ecological communities and biodiversity. Both the State and Federal biodiversity conservation laws formally list the key threatening processes.

A key threatening process is listed under legislation if it threatens or may threaten the survival, abundance or evolutionary development of a native species or ecological community. Currently, there are 35 separate key threatening processes listed on the New South Wales legislation and a further 16 key threatening processes recognised by the Commonwealth. There is considerable overlap between the State and Commonwealth lists. Examples of key threatening processes within Federal legislation are:

- *loss of climatic habitat caused by anthropogenic emissions of greenhouse gases*
- *predation by feral cats.*

Within State legislation, some examples of key threatening processes are:

- *alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands*
- *high frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition*
- *predation and hybridisation of feral dogs.*

In addition to the legislated prescribed lists of key threatening processes, there are many other unlisted pressures on biodiversity and catchment health. Weeds can have a significant impact on biodiversity, agriculture and community values. Within the Karuah River Catchment widespread Weeds of National Significance (WoNS) include Madeira Vine, Lantana, Alligator Weed, Cats Claw Creeper and Blackberry. Widespread noxious weeds within the catchment include Giant Parramatta Grass, Privet (small and broad leaf varieties), Camphor Laurel, Green Cestrum, St John's Wort, Fireweed, Coolatai Grass (giant & dwarf), Noogoora Burr, Crofton Weed, Bathurst Burr and Willows. There is also a number of WoNS and noxious weeds known to be present within the catchment, but are limited in their distribution.

Feral animals , like weeds, cause a range of actual or potential negative impacts on the health, productivity and biodiversity of the catchment. There is, however, limited knowledge and systematic monitoring of feral animal status, distribution, abundance and population trends in the catchment. Within the catchment, it is known or expected that some 15 different species of introduced mammals and at least 8 species of introduced birds are residents. Introduced frog and reptile species (Cane Toad and Asian House Gecko) may reside in the catchment, or have a high likelihood of invading the catchment in the future. The feral species with perhaps the greatest level of public concern is the wild dog; wild dogs are efficient predators that predate on livestock and native fauna. Other species such as foxes, feral cats and rabbits also have significant impacts on biodiversity and other catchment values.

The relationship between fire and biodiversity is highly complex. Fire is a crucial component of a healthy functioning ecosystem, and yet altered fire regimes can threaten biodiversity in multiple ways. Altered fire regimes are associated with the loss of diversity, changes in distribution and abundance of species and changes to species' structure and composition.

Fire related impacts on biodiversity can result from either too frequent or infrequent burning and/or inappropriate fire intensities.

Climate change has the potential to impact on the present condition of the Karuah River Catchment. We know that the catchment receives influences from tropical and temperate bioregions and accordingly a number of species within the catchment are at the limit of their natural range. Any change in climate will reduce the area of preferred habitat and conditions required for the survival of many species.

Turbidity and suspended solid concentrations increase following storm events and during extended periods of higher than average rainfall. Without alternative mitigation or adaptation strategies, the increase in storm events and intensity predicted from climate change will create elevated risks of increasing sedimentation in the catchment.

Notwithstanding the many things we do not know, we do know that the Karuah River Catchment has a sound foundation on which to continue to build ecological resilience. That is, we know there are hotspots of biodiversity where threatened species of flora and fauna remain and there are still considerable areas of native vegetation present.

THE FUTURE

This section outlines the Plan's desired outcomes for the catchment and the program of recommended actions required to deliver those outcomes. The Plan is intended to provide an integrated approach to catchment management. For planning purposes, the desired outcomes and actions have been presented within the following three themes:

- **Water**
- **Landscape, Production and Community**
- **Resilient Ecosystems**

In reality, there is a complex set of interactions between all themes, for instance, the proposed management of sediment and nutrients has been split into two themes. End of pipe solutions are primarily contained within the Water Theme, while source controls and mitigation are mostly included within the Landscape, Production and Community Theme.

- *End of pipe solutions* provide buffers to the output of nutrient and sediment from the terrestrial environment. These buffers include the use of wetlands and riparian zones to trap sediment and nutrients.
- *Source controls and mitigation* aim to prevent runoff of nutrient and sediment at their source. Options include the use of groundcover and improved fertiliser management.

The Plan aims to deliver the best possible outcomes within the prevailing environmental and socio-economic conditions.

Understanding and adapting to climate change is also an overarching issue embedded within the Plan. Whilst there are some actions that directly reference climate change, most actions do not. However, by their nature each action considers the potential impacts of climate change and its potential impact on catchment health, and identifies how best to adapt to its impacts. For example, climate change is anticipated to increase the frequency and severity of storm events.

The multiple benefits of riparian buffer zones are well documented and those benefits include stabilisation of stream bank erosion, capture of sediment and nutrients, slowing the flow of water and enhancement of biodiversity. These multiple benefits will all assist the catchment to adapt to the effects of climate change.

In addition to the actions identified within the Plan, there are numerous legislative or statutory requirements that are relevant to the KRCMP. In the main, these have not been included or discussed, as the Plan aims to complement these requirements and achieve changes beyond them.

WATER

Desired Outcomes

1. Water quality and the ecological values of waterways, wetlands and groundwater are protected, maintained and restored.
2. The export of pollutants, including nutrients, sediments and effluent to the waterways of the Karuah River is reduced.
3. The landscape has an increased ability to slow the flow of water and protect water quality during high inflow periods.
4. Developments on greenfield sites achieve a neutral or beneficial effect on water quality and ecological values of waterways.
5. The health and functioning of water systems, including groundwater, are better understood within the Karuah River Catchment.
6. A scientific adaptive management approach underpins management of water resources in the catchment.

Key Issues

- surface water quality (nutrients, sediments, effluent and other pollutants) and quantity
- condition and extent of riparian zones
- weed invasion within riparian zones
- degradation of wetlands
- risks and impacts of acid sulfate soils
- groundwater quality and quantity
- understanding of the inter-relationship between surface and groundwater
- impact of high intensity rainfall and extended wet periods
- erosion - terrestrial and in-stream
- sedimentation from erosion of unsealed roads and tracks
- protection and management of ecosystem services e.g. riparian vegetation, vegetated steep slopes, wetland management, estuarine vegetation communities
- mining
- climate change
- knowledge gaps, for example groundwater functionality and nutrient hotspots

Management Actions	Participating Partners
Wetland and Acid Sulfate Soil Management	
1 Map the occurrence and condition of wetlands. Identify priorities for management and action	GLC, LLS
2 In collaboration with private landholders, utilise incentives and engagement mechanisms to protect and rehabilitate wetlands within the Karuah River Catchment	GLC, PSC, LLS, DPI (Fisheries) Local Landholders
3 Investigate and pursue the strategic purchases of priority wetlands to improve water quality and biodiversity values	GLC
4 Continue to engage and inform the community about the value of local wetlands and associated issues	GLC, OEH, LLS, DPI (Fisheries)
5 Investigate the potential for the establishment, re-establishment or enhancement of wetlands in sub-catchments with high nutrient and sediment inputs	LLS, GLC
6 Manage wetlands in the Karuah River Catchment in accordance with the principles and actions of the Wallis Lake Wetland Strategy	GLC
7 Adopt and implement a model NRM clause for wetlands in the Great Lakes Local Environmental Plan (LEP)	GLC
8 Improve community knowledge and management of acid sulfate soils in the estuary zone of the catchment	LLS, DPI (Fisheries), GLC

Management Actions	Participating Partners
Water Pollution Management	
9 Conduct works to protect and rehabilitate riparian zones, incorporating the establishment of native vegetation. Works to be carried out opportunistically and in line with priorities. Where possible, develop synergies between works on both public and private land. Priorities to include: • areas with medium hydraulic soils • areas where current land use results in high rates of nutrient or sediment export to the river • high quality native vegetation • areas where links can be created to nearby patches of native vegetation • priorities identified by the Riverstyles mapping and framework.	LLS, GLC, PSC, DPI (Fisheries), Local Landholders
10 Phase out grazing of stock in riparian zones in identified foreshore Crown Reserves and manage Crown Foreshores for conservation purposes. Zone identified Crown Foreshores for Environmental Protection within the relevant Local Environmental Plan	DPI (Crown Lands), GLC
11 Map and identify areas at high risk of erosion. Implement an incentive program to prevent and remediate soil erosion within priority areas, including the management of steep slopes	LLS, DPI (SCS), DPI (Fisheries), GLC, DPI (NoW), Local Landholders
12 Improve community knowledge of the methods available to both prevent and mitigate soil erosion, including the value of riparian vegetation	LLS, DPI (SCS),DPI (Fisheries), GLC
13 Identify and prioritise areas of sediment export to the Karuah River from unsealed roads, tracks and creek crossings and undertake mitigation activities according to priorities	NPWS, Forestry Corporation, GLC, PSC, Local Landholders
Water Pollution Management continued	
14 Expand GLC Sediment and Erosion Control Environmental Management System (SECEMS) to address management of sediment and erosion control of Council managed unsealed roads	GLC
15 Assess road network needs for operational and fire management purposes. Close and rehabilitate roads surplus to requirements and install locked gates as appropriate to minimise erosion from recreational vehicles	Forestry Corporation, NPWS
16 Ensure future developments comply with GLC's Water Quality Objectives to: (a) ensure re-development and infield developments achieve a load reduction, and (b) all greenfield developments achieve a neutral or beneficial effect on water quality	GLC
17 Review and update the Karuah section of the Port Stephens Urban Stormwater and Rural Water Quality Management Plan.	PSC
18 Ensure all future developments in the Karuah area address the objectives of the Port Stephens Urban Stormwater and Rural Water Quality Management Plan	PSC
19 Develop a stormwater management plan for Stroud	GLC

Management Actions	Participating Partners
20 Continue to implement the Great Lakes Council Onsite Sewerage Management Strategy, including the following recommendations: • all systems are inspected to determine if they are operating satisfactorily • inspect more frequently systems identified as high-risk or that are operating poorly • pump-out records are monitored to ensure systems are not overflowing or being illegally emptied • aerated Wastewater Treatment System (AWTS) reports are monitored to ensure owners are aware of maintenance that is required • approval and ongoing monitoring of AWTS contractors to ensure qualified technicians are carrying out quality services.	GLC
21 Continue to initiate and support campaigns to reduce the reliance on plastic bags and other single-use plastics in the community that contribute to roadside litter and rural rubbish	GLC
22 Ensure compliance with the Karuah River Water Sharing Plan	DPI (NoW)
23 Include water quality, water sharing legislation and environmental flow information in rural landholder extension and education programs	DPI (NoW), GLC, DPI (Ag), LLS
Groundwater	
24 Investigate the current status of groundwater quality and quantity; develop and implement programs to mitigate any significant impacts	OEH, DPI (NoW), Miners and other large users of groundwater
25 Implement the Groundwater and Drinking Water Catchment Clause in the Great Lakes Standard Local Environment Plan (LEP)	GLC, MCW
26 Ensure that any future or current developments comply with the Great Lakes WQIP and do not adversely impact groundwater resources and ground water dependant ecosystems through development assessments	GLC, PSC
Research, Monitoring and Evaluation	
27 Investigate nutrient and sediment loads in order to identify 'nutrient and sediment hotspots' within the catchment. Use this information to determine priority areas for action and, in particular, assess nutrient and sediment source 'hotspots' during storm events	OEH, GLC, Research Institutions
28 Within GLC's Waterway and Catchment Report Card, undertake for the Karuah River Catchment: (a) water quality monitoring every two years, and (b) a catchment wide assessment of riparian and instream aquatic health, including seagrass, saltmarsh and mangrove habitat every five years. Investigate and pursue collaborations and potential partnership opportunities for completing the Report Card and riparian and instream aquatic health assessment	GLC, OEH, Duralie Coal, Forestry Corporation, NPWS, MCW, DPI (NoW), DPI (Fisheries), Research Institutions

LANDSCAPE, PRODUCTION AND COMMUNITY

Key Issues

- soil erosion, nutrient loss and water use efficiency associated with agriculture
- waste management practices for intensive agriculture
- biosecurity for agriculture
- weeds and feral animals
- large scale industry and mining as potential risks to catchment health
- adequacy of planning and management mechanisms
- soil health, including organic carbon
- climate change
- co-ordination, collaboration and communication with relevant stakeholders
- awareness and understanding of indigenous culture and values
- best management practices for rural lifestyle properties and absentee landholders
- knowledge gaps, e.g. soil health, nutrient management, land use planning

Desired Outcomes

1. Improved capacity of the agriculture, forestry and aquaculture sectors to manage the landscape for productive returns, whilst also improving the ecological health of the catchment.
2. The export of pollutants, including nutrients, sediments and effluent from production landscapes to the waterways of the Karuah River Catchment is reduced
3. Mining and industry is responsive to the needs of the environment, community and health.
4. Potential impacts and opportunities associated with the economic development of land, land use and demographic change are understood, planned for and managed to ensure catchment health, the maintenance of productive land use and community wellbeing.
5. An adaptive management and continuous improvement approach underpins the management of landscapes and the productive land use, using scientific, community and cultural knowledge.
6. Management of catchment health is underpinned by community awareness, understanding and shared responsibility.

Management Actions	Participating Partners
Agriculture - production and environment	
29 In collaboration with landholders build understanding and capacity to increase the adoption of best management practices which address catchment degradation and encourage profitable farms. Opportunities for focused action may include focus farms, group mentoring programs, on-farm trials, farm sector advisory groups, demonstration sites, landholder champion programs, and property management planning activities	LLS, DPI (Ag), DPI (Fisheries), GLC, KGLL, Local Landholders
30 Targeting sediment and nutrient hotspots, work in collaboration with landholders to improve grazing/groundcover management, soil health (including organic carbon) and water use efficiency	LLS, DPI (Ag), DPI (Fisheries), GLC, KGLL, Local Landholders
31 In collaboration with the poultry industry explore and implement appropriate options for improved management of poultry litter throughout the whole poultry litter supply chain e.g. Fertcare	DPI (Ag), NSW Farmers Association, LLS, GLC, Local Landholders
32 Expand and implement a best practice fertiliser storage and application program, targeting hotspots of nutrient loss within the catchment	LLS, DPI (Ag), GLC, Local Landholders
Oyster Production	
33 Support the development of business plans and environmental management systems within the oyster industry	LLS, DPI (Fisheries), DPI (Food Authority), GLC, PSC, Oyster Industry
34 Encourage the sharing of knowledge and understanding between oyster growers, other primary producers and other users of the catchment's land and water resources	LLS, DPI (Fisheries), DPI (Food Authority), GLC, PSC, KGLL, Local Landholders, Oyster Industry
35 Continue to support the implementation of the NSW Oyster Industry Sustainable Aquaculture Strategy (OISAS)	Oyster Industry, DPI (Fisheries), DPI (Food Authority), GLC, PSC
Mining and Large Scale Extractive Industry	
36 In recognition of the high quality and sensitive catchment values, encourage new or existing large-scale extractive industry to achieve a beneficial effect on catchment health through: • contributing to the Karuah Catchment improvement fund • contributing to improved understanding of catchment functioning and health • adopting best practice catchment management procedures on mine owned land.	GLC, LLS, Extractive Industry, MCW

Management Actions	Participating Partners
Planning	
37 In collaboration with the poultry industry, review and update the development control requirements for new poultry sheds taking into consideration: • the export of nutrients • odour and visual impacts • land use buffering to reduce conflict with neighbouring landuses • potential adverse effects to farm biosecurity.	GLC, NSW FA, Poultry Farmers, Research Institutions
38 In collaboration with the poultry industry investigate and implement incentive mechanisms for voluntarily retrofitting of existing poultry farms to achieve best practice. Potential improvements could include: • practices to reduce the export of nutrients • wetland systems • riparian buffers • waste disposal • landscaping and screening practices • odour management.	GLC, NSW FA, Poultry Farmers, LLS, DPI (Ag), Research Institutions
39 Enforce provisions in the Great Lakes Standard Local Environment Plan as they pertain to rural land use. The key environmental provisions in the GLC LEP (2014) include: • Acid Sulphate Soils (Clause 7.1) • Earthworks (Clause 7.2) • Stormwater Management (Clause 7.5) • Drinking Water Catchments (Clause 7.6) • Riparian Land and Watercourses (Clause 7.7) • Wetlands (Clause 7.8) • Limited Development on Foreshore Area (Clause 7.10) • Significant Extractive Resources (7.14)	GLC
40 Evaluate the merits of preparing and implementing an Agriculture Strategy for the Karuah River Catchment	GLC

Management Actions	Participating Partners
Research, mapping and monitoring	
41 Research the long-term impacts of regular applications of chicken litter on pastures in high rainfall areas and their influence on soil condition	Research Institutions
Education & Awareness	
42 Continue catchment management education programs, such as Water Watch, with local primary schools and community groups	LLS, GLC, Community
43 Continue to use communication and social marketing tools such as newsletters, extension, field days and websites to promote an understanding and awareness of catchment management within the community	LLS, DPI (Ag),DPI (NoW), DPI (Fisheries), GLC, KGLL, MCW
44 Explore and implement opportunities to build the capacity of rural lifestyle and absentee landholders to protect, maintain and restore catchment health. Opportunities could include: • the introduction of mentoring programs, the promotion of local champions and the development of focus groups • development of NRM information packages for rural lifestyle properties • encouragement of real estate agents to provide a package of 'Small Property Management' to potential buyers of rural lifestyle land • provision of information to new property owners through the Council's rating system	LLS, DPI (Ag), DPI (Fisheries), GLC, KGLL, Local Landholders
Heritage and Culture	
45 Where activities are being proposed or undertaken, identify, monitor and protect sites of known significant Aboriginal and European heritage, and where there is uncertainty about the value of culture and heritage, adopt a precautionary approach	GLC, NPWS, DPI (Crown Lands), LLS, OEH, KLALC
46 Engage with local Aboriginal communities to identify key water and landscape related environmental, social, cultural and economic values and priorities for protection	KLALC, OEH, NPWS, LLS, DPI (Marine Parks), GLC
47 Incorporate information regarding local Aboriginal people's cultural history and their connections to land and water into educational material—the material to be used by the local community and visitors to the catchment	KLALC, OEH, NPWS, LLS, DPI (Marine Parks), GLC
48 Engage with local Aboriginal communities to incorporate, where appropriate, traditional land management knowledge into NRM programs	OEH, GLC, KLALC

RESILIENT ECOSYSTEMS

Key Issues

- loss and degradation of vegetation communities and habitat, particularly populations of priority and threatened species and ecological communities
- landscape and habitat connectivity
- quality / condition of native vegetation areas
- weed invasion
- impacts of feral animals
- altered fire regimes
- climate change
- incentives and mechanisms for conservation
- comprehensive, adequate and representative reserve systems
- sustainable forest practices
- illegal fishing within sanctuary zones of the Port Stephens-Great Lakes Marine Park
- barriers to the movement of aquatic species
- key threatening processes
- knowledge gaps, e.g. species distribution & population dynamics, effects of climate change & mitigation strategies, strategic biodiversity knowledge, vegetation mapping

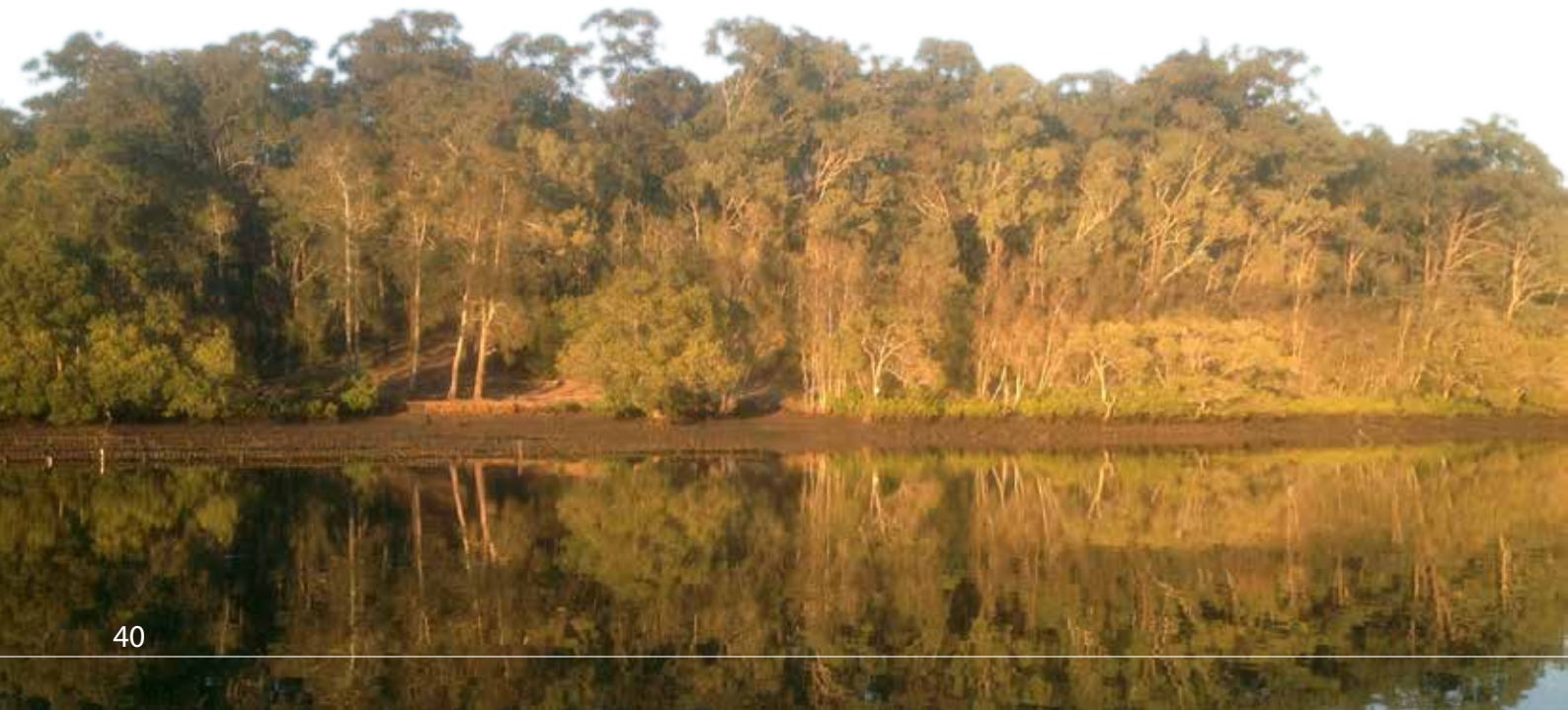
Desired Outcomes

1. Natural ecosystems and biodiversity are strategically conserved, restored, linked and managed within a productive landscape to maintain and improve resilience.
2. An adaptive management approach underpins natural ecosystems and biodiversity actions based on scientific and community knowledge.
3. Forestry areas are managed in order to maintain and improve a range of ecosystem services, biodiversity, water quality and cultural heritage values.
4. Pressures on biodiversity, natural ecosystems and habitat are reduced.

Management Actions	Participating Partners
Landscape & habitat connectivity	
49 Implement the Tops to Lakes Initiative; monitor and report on outcomes; review and update, as necessary	GLC, LLS
Protect , maintain and restore native vegetation	
50 In collaboration with private landholders, utilise incentive and engagement mechanisms to protect and rehabilitate threatened species, ecological communities, areas of high biodiversity values, and to create vegetation corridors	LLS, DPI (Fisheries), GLC, KGLL, Local Landholders
51 Continue to investigate and implement opportunities to protect, restore and rehabilitate ecological values of State Forest	Forestry Corporation
52 Investigate and implement opportunities to foster the active management of native vegetation on private land for multi-use outcomes, which include the maintenance and restoration of biodiversity and protection water quality values. Opportunities could include carbon farming and timber production	LLS, Local Landholders, DPI (Ag) Hunter Farm Forestry Network
53 Support management of private native forests in accordance with Forest Stewardship Council Codes of Practice. Develop and implement an ecological thinning code of practice for even-aged derived forests to optimise production and biodiversity outcomes	LLS, DPI (Ag), GLC, Local Landholders

Management Actions	Participating Partners
Pest Plants and Animals	
54 Eradicate weeds of national significance and environmental weeds that have a limited distribution within the Karuah River Catchment	MNCWCC, GLC, PSC, LLS, Forestry Corporation, NPWS, Duralie Coal, Hunter Water, Local Landholders
55 Continue to work with local landholders and the community to strategically control and reduce weed impacts on farming land and in the natural environment	MNCWCC, GLC, LLS, Local Landholders
56 Work collaboratively with multiple landholders and agencies to establish a prioritised and cross-tenure approach to monitoring and managing terrestrial vertebrate pests within the Catchment (and across the Great Lakes LGA). The approach should be consistent with state and regional management plans and priorities	MNCWCC, GLC, LLS, OEH, DPI (Ag), Forestry Corporation, NPWS, Crown Lands, Local Landholders
57 Work collaboratively with multiple landholders and agencies to establish a prioritised and cross-tenure approach to managing invasive weeds within the Catchment (and across the Great Lakes LGA). The approach should be consistent with state and regional management plans and priorities	MNCWCC, GLC, PSC, LLS, OEH, DPI (Ag), Forestry Corporation, NPWS, Crown Lands, Local Landholders
Estuarine and instream habitat	
58 Protect, maintain and restore habitat adjoining marine sanctuary areas within the Karuah River Catchment to complement aquatic and terrestrial biodiversity conservation	DPI (Marine Parks), LLS, DPI (Fisheries), OEH, NPWS, Forestry Corporation, NPWS, GLC, PSC, Crown Lands
59 Install and maintain effective fish-ways that are in line with identified DPI (Fisheries) priorities	DPI (Fisheries), GLC
60 Investigate options for the monitoring of the recreational fishing catch	DPI (Fisheries), Fishing Clubs
61 Undertake a platypus community awareness program and platypus status assessments	MCW, Manning Great Lakes PACT, GLC, OEH, Local Landholders
62 Promote the importance of seagrass, saltmarsh, mangrove and other aquatic habitats, and promote their protection to stakeholders and the general community	DPI (Marine Parks), DPI (Fisheries), GLC
Inappropriate Fire Regimes	
63 Encourage landholders to undertake bushfire management training, such as the 'Hotspots Program', to encourage burning regimes sensitive to ecological needs	NSW Rural Fire Service, Nature Conservation Council NSW, LLS, Lower Hunter BFMC, Local Landholders
64 Maintain ecological burning programs to promote critical ecological processes and minimise the risk of high intensity wildfire	Forestry Corporation, NPWS

Management Actions	Participating Partners
Roadside management	
65 Improve the capacity and mechanisms within Council to facilitate improved environmental management and rehabilitation of roadside environments	GLC, PSC, HCED
Biodiversity	
66 Develop and implement an over-arching biodiversity strategy for the Great Lakes LGA. Monitor and report on the implementation of the strategy and coordinate reviews and updates	GLC, HCED, NPWS, OEH, DPI (Fisheries)
67 Ensure that native vegetation clearing on private land (including private native forestry) complies with statutory controls and regulations	OEH, LLS
68 Adopt and implement a model NRM clause for terrestrial biodiversity in the Great Lakes Local Environment Plan (LEP)	GLC, HCED
Research, mapping and monitoring	
69 Progress the development of a Great Lakes vegetation classification scheme and fine-scale, accurate vegetation community mapping. Review and update as necessary	GLC, HCED
70 Explore and implement collaborative opportunities to expand and co-ordinate flora, fauna, and endangered ecological community monitoring to be undertaken by individual stakeholders	GLC, HCED, Forestry Corporation, NPWS, Duralie Coal, OEH, Research Institutions
71 Develop and implement a strategic biodiversity and assessment program to monitor and assess the effectiveness of pre-harvesting ecological mitigation strategies. Amend ecological management programs as appropriate	Forestry Corporation
72 Develop a Great Lakes Catchment Landscape Report Card: (a) utilising tools such as Land for Wildlife and native vegetation condition assessments, and (b) report on Landscape Condition to the community and stakeholders every five years.	GLC, HCED, LLS
73 Continue to investigate the threats posed to different landscapes and ecosystems by climate change and sea level rise, as well as the implementation of mitigation and adaptation options	LLS, NPWS, OEH, Crown Lands, DPI (NoW), DPI (Fisheries), DPI (Marine Parks), Research Institutions



KRCMP IMPLEMENTATION

For the Plan to achieve its stated purpose '*to maintain and improve the health of the Karuah River Catchment*' it is imperative that not only the Plan's management actions are implemented, but that their effectiveness is monitored and evaluated. The monitoring and evaluation will be used to determine what is working and what is not, and programs will be amended as required.

Jones (2009) poses a set of questions for environmental planners and managers to consider as Natural Resource Management Plans progress through their implementation:

1. '**What would you expect to see if management was working well?**' And the converse question: '**What would you expect to see if management was NOT working well?**'
2. '**What could we monitor or measure (photograph, map, or survey, etc.) to reveal the outcomes that are being delivered?**'
3. '**Where would we realistically expect to see improvements or changes if management was working well?**' And the converse question: '**Where would we realistically expect to see things getting worse or changing if management was not working well?**'
4. '**How will the findings of monitoring and evaluation be reported and/or used?**' The process of adaptive management relies on the findings and recommendations of evaluation to influence improvements in ongoing management.
5. '**Who will be responsible for doing the monitoring, evaluation and reporting?**'

Realistic levels of resourcing and priority for effectiveness monitoring, evaluation and reporting are essential ingredients of sound adaptive management.

The implementation of an adaptive management framework will ensure that the Plan is not a static document. Rather, the Plan will continually respond to new information, changes in approaches to catchment management, community expectations, new science and major environmental events. The following section outlines the arrangements put in place in response to Jones' questions for environmental planners and managers.

Coordination

The KRCMP has many stakeholders and many people will be required to work in unison during the Plan's implementation. Without clear leadership, the Plan will fail; therefore, it is essential that a lead agency is nominated to: (a) take the overall responsibility to coordinate and manage the Plan's implementation, and (b) negotiate and facilitate collaborative solutions with agencies and stakeholders who are responsible for the implementation of specific management actions.

The Great Lakes Council is the largest key coordinating land manager in the Karuah River Catchment, so it is best placed to lead, coordinate and facilitate the management and governance of the Plan's implementation. This role will not be undertaken in isolation. As per the Plan's Guiding Principles a collaborative approach will be taken to management and governance of the Plan, particularly when consulting and engaging with the community and key stakeholders.

Monitoring and Evaluation Program

Implementation of management actions

This component of the monitoring and evaluation program will focus on the achievement of outputs within the Plan and is framed by two key questions:

- Are the actions within the Plan being implemented? If not, why not?
- Are strategies in place to address why actions are not achieved, such as the sourcing of funding?

A conscious effort has been made within the Plan to steer away from assigning priorities to each action because funding opportunities and priorities vary over time, and the ability of stakeholders to implement actions will vary accordingly.

Monitoring the implementation of management actions will reveal if there are significant or urgent actions that are not being undertaken, and options will be put in place to rectify the issue.

Management action evaluation

Reviews of the implementation and effectiveness of management actions and projects will take place at regular intervals. The following key questions will form the basis of these reviews:

- What were the key elements of the management action(s) or project? Is that what happened? If not, why not?
- What worked well? What were the strengths?
- What did not work well? What were the weaknesses?
- Were there any gaps in project management, for example monitoring?
- What changes occurred as a result of the management action(s) or project?
  Note: consider management, environmental, social and economic or productive changes.
- Were these the changes expected prior to implementing the management action(s) or project? If not, what are the key differences found and why?
- Did the management action or project achieve its objective(s)? If not, why not?
- What are the key insights or learning's gleaned from management action(s) or the project?
- Is there anything that could have been done differently?
- What recommendations or changes can be applied to future management actions? Are there any amendments to management actions required within the Plan?

Evaluation of management actions will be undertaken in multiple ways depending on their complexity:

- Simple short term management actions will be evaluated once implementation has been completed.
- Complex management actions, that have multiple projects within the one management action, will be evaluated progressively as each individual project is concluded. A final overall evaluation of the management action will also be undertaken once the entire management action has been completed.
- Multi-year management actions, such as monitoring programs, will be evaluated during the mid-term review of the Plan scheduled for 2020.

Monitoring of desired outcomes

An important principle underpinning the Plan is that its actions should be based on sound scientific evidence in conjunction with community observations and knowledge.

Questions considered in the development of monitoring and research management actions within the Plan include:

1. What catchment management patterns and information are observed by the community?
2. Is there scientific understanding?
3. Is there data and information?
4. Are there analytic tools?
5. What gaps in knowledge and understanding exist?
6. What scientific research and monitoring actions should be included within the Plan?

This component of the monitoring and evaluation program focuses on monitoring the ecological health of the Karuah River Catchment to ultimately determine the effectiveness of the Plan in achieving its aim to maintain and improve the health of the catchment.

Monitoring of environmental condition has been built into the management actions, rather than through a separate stand-alone program.

The aim of monitoring ecological health is to assess the success of the Plan; however, it should be recognised that there can be a long lag time between the completion of actions and a measurable improvement in ecological health. Chapter Four discussed the incremental impacts of catchment use over the past 200 years on ecological health. Likewise our expectation of rehabilitation should be realistic. We should recognise that measurable results will not be achieved overnight and that it will not be possible to reinstate the catchment's ecosystems to their pristine state.

Plan Review

A mid-term partial review of the Plan will be undertaken in five years and a full review and update will be completed in ten years' time. The review will utilise information from monitoring and evaluation activities and will use adaptive management principles as part of a cycle of continuous improvement.

Reporting and Communication

Council will coordinate the completion and distribution of management action reports from key agencies and stakeholders on the Plan's implementation. Reports will include:

- results of monitoring and evaluation
- results of management actions and projects
- Council will directly report to the community, agencies and key stakeholders on:
  - » management actions that Council is directly responsible for
  - » results of monitoring and evaluation, in particular ecological health, where applicable
  - » the overall progress of implementation of the Plan.

As part of the commencement and implementation of the Plan, a template for achievement and implementation reporting and adaptive feedback will be developed. As with any project, the Plan recognises the importance of celebrating successes, and recognising and responding to barriers.

DEFINITION OF TERMS AND LIST OF ACRONYMS

ANZECC Trigger Values	Australian and New Zealand Environment and Conservation Council Water Quality Guidelines provide a set of trigger values for concentrations (loads) of key physical and chemical water quality parameters that infer an environmental problem when exceeded.
Chlorophyll	Chlorophyll a is the main green photosynthetic pigment found in all plants. The concentration of chlorophyll a in estuarine, coastal or marine waters (in the water column) is used as an indicator of phytoplankton and benthic microalgae.
DCP	Development Control Plan
DPI (Ag)	NSW Department of Primary Industries - Agriculture NSW
DPI (Fisheries)	NSW Department of Primary Industries - Fisheries NSW
DPI (Food Authority)	NSW Department of Primary Industries - NSW Food Authority
DPI (NoW)	NSW Department of Primary Industries - NSW Office of Water
DPI (Crown Lands)	NSW Department of Primary Industries - NSW Trade & Investment: Crown Lands
DPI (SCS)	NSW Department of Primary Industries - Soil Conservation Service
DPI (Marine Parks)	Department of Primary Industries - Port Stephens Great Lakes Marine Park
GLC	Great Lakes Council
Habitat connectivity	refers to the connections between patches of habitat that are suitable for a particular species and the ability of species to move between them.
HCED	Hunter Councils Environment Division
KGLL	Karuah and Great Lakes Landcare
KRCMP	Karuah River Catchment Management Plan
Landscape connectivity	refers to the physical connections between habitat areas across a landscape.
LEP	Local Environment Plan
LGA	Local Government Authority
LLS	Local Land Services
Lower Hunter BFMC	Lower Hunter Bush Fire Management Committee
MCW	MidCoast Water
Manning Great Lakes PACT	Manning Great Lakes Platypus Awareness and Conservation Team
MNCWCC	Mid North Coast Weeds Co-ordinating Committee
NPWS	NSW National Parks and Wildlife Service
OEH	NSW Office of Environment and Heritage
PSC	Port Stephens Council
Resilience	is the ability of individuals of groups of people, native species, ecosystems or landscapes to withstand or recover from an impact or other shock and quickly restore core functions and capacities.
RIRDC	Rural Industries Research and Development Corporation
SECCEMS	Sediment and Erosion Control Environmental Management System
SEPP14 Wetlands	State Environmental Planning Policy No. 14 – Coastal Wetlands. The aim of this policy is to ensure that the coastal wetlands are preserved and protected in the environmental and economic interests of the State of New South Wales.
Turbidity	Turbidity is a measure of water clarity, associated with suspended material in stream. Suspended material can include clay, silt, algae, microbes and other substances.

BIBLIOGRAPHY

Australian Agricultural Company. (2014). *About Us / Our History*. Retrieved 08 06, 2014, from AACo: http://www.aaco.com.au/about-us/our-history/

Australian and New Zealand Environment Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand. (2000). *Australian and New Zealand guidelines for freshwater and marine water quality: Volume 1 - The Guidelines.* Retrieved from http://www.environment.gov.au/resource/australian-and-new-zealand-guidelines-fresh-and-marine-water-quality-volume-1-guidelines

Beaglehole, J. C. (1995). The Journals of Captain James Cook on his Voyage of Discovery. London: Hakluyt Society.

Bennett, G. (1929). *The Earliest Inhabitants.* Dungog: Chronicle Print.

Bickford, A., Brayshaw, H., & Proudfoot, H. (1998). *Thematic Forest History and Heritage Assessment (Non-Indigenous) UNE/LNE CRA Regions - A Report Undertaken for the NSW CRA/RFA Steeering Committee, Project Number NA 29/EH.* Unpublished.

Birrell, W. K. (1987). *The Manning Valley: Landscape and Settlement 1824-1900.* Milton, Qld: Jacaranda Press.

Bishop, D. K. (1996). *Development of Strategic Water Quality Monitoring in the Karuah River Catchment.* Karuah & Great Lakes Total Catchment Management Committee.

Bishop, K. A. (1995). *Review of existing water quality and land/water use data from the Karuah River Catchment: Prerequisite for the development of strategic water quality monitoring.* Karuah & Great Lakes Total Catchment Management Committee.

Breen, D. A., Avery, R. P., & Otway, N. M. (2004). *Broad-scale biodiversity assessment of the Manning Shelf Marine Bioregion.* NSW Marine Parks Authority.

Brooks, A. P., Brierley, G. J., & Millar, R. G. (2003). The long-term control of vegetation and woody debris on channel and floodplain evolution: insights from a paired catchment study in south-eastern Australia. *Geomorphology*, pp. 51: 7-29.

Carbon Based Environmental Pty Ltd on behalf of Duralie Coal Pty Ltd. (2013). *Duralie Coal Annual Review Year Ending 2013.* Duralie Coal Pty Ltd.

Clarke, J. (2013). *The Oystermen "The World's Biggest Oyster Farm".* Singapore: Tien Wah Press.

Cottingham, P., Bond, N., Lake, P., & Outhet, D. (2005). *Recent Lessons on River Rehabilitation in Eastern Australia. Technical Report.* Canberra, ACT: CRC for Freshwater Ecology.

Cui, G. (2000). Rainfall runoff model improvements incorporating a dynamic wave model and synthetic stream networks. *Thesis: PhD Doctorate, University of Newcastle*. unpublished.

Department of Environment. (2014). *Australian Heritage Database*. Retrieved July 31, 2014, from Australian Government, Department of Environment: http://www.environment.gov.au/cgi-bin/ahdb/search.pl?mode=place_detail;search=state%3DNSW%3Bplace_id%3D106194%3Blatitude_1dir%3DS%3Blongitude_1dir%3DE%3Blongitude_2dir%3DE%3Blatitude_2dir%3DS%3Bin_region%3Dpart%3Bkeyword_PD%3D0%3Bkeyword_SS%3D0%3Bkeyword_

Department of Environment and Primary Industries. (2013, April 26). *What is Community Engagement*. Retrieved from Department of Environment and Primary Industries, State Government of Victoria: http://www.dse.vic.gov.au/effective-engagement/introduction-to-engagement/what-is-community-engagement

Department of Environment, Climate Change and Water NSW. (2010). *NSW Wetlands Policy.* Sydney: State of NSW.

Department of Environment, Water, Heritage and the Arts. (2009). *Chapter 5: Threats to Australian Biodiversity, In: Assessment of Austrralia's Terrestrial Biodiversity 2008.* Canberra, ACT: Report prepared by the Biodiversity Assessment Working Group of the National Land and Water Resources Audit for the Australian Government.

Department of Infrastructure, Planning and Natural Resources. (2005). *A Guide to the Water Sharing Plan for the Karuah River Water Source (as amended 1 July 2004)*. Taree: Department of Infrastructure, Planning and Natural Resources.

Department of Primary Industries. (2014). *Fishing and Aquaculture; Protecting Habitats*. Retrieved 08 20, 2014, from NSW Department of Primary Industries: http://www.dpi.nsw.gov.au/fisheries/habitat/protecting-habitats#KFH

Department of Sustainability and Environment, Victoria. (2005). *Effective Engagement: building relationships with community and other stakeholders, Version 3*. Melbourne: Victorian Government Department of Sustainability and Environment.

DPI NSW. (2014, October 30). *Pacific Oyster (Crassostrea gigas)*. Retrieved from NSW Department of Primary Industries: http://www.dpi.nsw.gov.au/fisheries/pests-diseases/marine-pests/nsw/pacific-oyster

DPWS. (1999). *Port Stephens/Myall Lakes Estuary Processes Study.* Manly: NSW Department of Public Works and Services. Manly Hydraulics Laboratory.

Duralie Coal Mine. (2012). *Giant Barred Frog Study.* Duralie Coal: Part of Gloucester Coal.

Ecotone Ecological Consultants and Forestry Commission of New South Wales. (1995). *Fauna Survey of Gloucester and Chichester Management Areas.* Pennant Hills, NSW: State Forests of New South Wales.

Fawcett, J. W. (1898). Notes on the Customs and Dialects of the Wonah-ruah Tribe. *Science of Man*.

Gordos, M., Nichols, S., Lay, C., Townsend, A., Grove, C., Walsh, S., & Copeland, C. (2007). *Audit and Remediation of Fish Passage Barriers in Coastal NSW. Proceedings of the 5th Australian Stream Management Conference. Australian Rivers: Making a Difference.* Thurgoona, NSW: Charles Sturt University.

Grant, T. C. (1988). *History of Forestry in New South Wales 1788 to 1988.* Sydney: Forestry Commission of NSW.

Great Lakes Council. (2009). *Garden Escapees & Other Weeds of Bushland & Reserves 2nd Edition.* Forster: Mid North Coast Weeds Advisory Committee.

Great Lakes Council. (2012). Community Strategic Plan. Forster, NSW: Great Lakes Council.

Griffiths, T. (1992). *Secrets of the Forest.* Sydney: Allen and Unwin.

Harris, G. (2001). *A Nutrient Dynamics Model for Australian Waterways: Land Use, Catchment Biochemistry and Water Quality in Australian Rivers and Estuaries, Australia State of the Environment Second Technical Paper Series.* Canberra, ACT: Department of the Environment and Heritage, Commonwealth of Australia.

Healey, M., Raine, A., Parsons, L., & Cook, N. (2012). *River Condition Index in New South Wales: Method development and application.* Sydney: NSW Office of Water.

Henderson, L. E. (2000). *Soil Landscapes of the Dungog 1:100 000 Sheet Report.* Sydney: Department of Land and Water Conservation.

Horton, D. (1994). *Encyclopedia of Aboriginal Australia.* Aboriginal Studies Press.

Howell, T., & Creese, R. (2010). *Freshwater Fish Communities of the Hunter, Manning, Karuah and Macquarie-Tuggerah Catchment: a 2004 Status Report.* Cronulla, NSW: Industry and Investment NSW (now incorporating NSW Fisheries).

Invertebrate Identification Australasia. (2013). *Duralie Coal Project: Biological Monitoring of the Streams Adjacent to the Duralie Coal Mine. Study 1, Survey 23, March 2013.* Duralie Coal Pty Ltd.

J Murray and the Forestry Commission of NSW. (1995). *Report on Historical Sites: Gloucester and Chichester Forestry Management Areas.* Taree NSW: State Forests of NSW.

Jones, G. (2009). The adaptive management system for the Tasmanian Wilderness World Heritage Area - Linking Management Planning with Effectiveness Evaluation. In C. Allan, G. Stankey, & (eds), *Adaptive Environmental Management. A Practitioners Guide* (p. Chapter 13). Dordrecht, The Netherlands and Collingwood, Australia: Co-published by Springer and CSIRO Publishing.

Karuah Catchment Landcare Group and NSW Department of Land and Water Conservation. (1999). *Karuah River Rivercare Plan: Companion Booklet.* Unpublished.

Karuah Working Together Inc. (2010). *About Karuah*. Retrieved July 2014, from Karuah: http://www.karuah.net/pages.php?id=2

Land & Water Australia. (2005). *Australia's Farmers: Past, Present and Future.* Canberra: Land and Water Australia.

Lindenmayer, D., & Burgan, M. (2005). *Practical Conservation Biology.* Collingwood: CSIRO Publishing.

Macquarie University, The University of Auckland, New Zealand, Land and Water Australia, NSW Office of Water. (2014, October 09). *Scientific and management values of the River Styles® framework*. Retrieved from River Styles: http://www.riverstyles.com/outline_scientific.php

Maiden, J. H. (1895). Notes on a trip to the North-Central Coast Forests of New South Wales. *Agricultural Gazette*, 6(9): 583-612.

Marine Parks Authority. (2010). *Port Stephens - Great Lakes Marine Park Operational Plan.* Sydney: NSW Marine Parks Authority.

Marr, N. (1995). Aboriginal History of the Great Lakes District. unpublished.

MidCoast Water. (2014). *History*. Retrieved 08 11, 2014, from MidCoast Water: http://www.midcoastwater.com.au/site/history

Mika, S., Hoyle, J., Kyle, G., Howell, T., Wolfenden, B., Ryder, D., . . . Spink, A. (2010). Inside the "Black Box" of River Restoration: Using Catchment History to Identify Disturbance and Response Mechanisms to Set Targets for Process-Based Restoration. *Ecology and Society*, 15(4):8.

Mitchell, A., Reghenzani, J., Faithful, J., Furnas, M., & Brodie, J. (2009). Relationship between land use and nutrient concentrations in streams during a 'wet-tropics' catchment in northern Australia. *Marine and Freshwater Research*, 60: 1097-1108.

National Parks and Wildlife Service. (2010). *Barrington Tops National Park, Mount Royal National Park and Barrington Tops State Conservation Area, Plan of Management.* Nelson Bay: Department of Environment and Climate Change.

New South Wales National Parks and Wildlife Service. (1998). *Wilderness Assessment Project - UNE and LNE. A project undertaken as part of the NSW Comprehensive Regional Assessments. Project number NA 33/EH.* Sydeny: State of New South Wales and Commonwealth of Australia.

NSW Department of Infrastructure, Planning and Natural Resources. (2005). *A Guide to the Water Sharing Plan for the Karuah River Water Source.* Taree: NSW Department of Infrastructure, Planning and Natural Resources.

NSW Department of Primary Industries. (2005). *Reducing the impact of road crossings on aquatic habitat on coastal waterways - Hunter/Central River, NSW. Report to the New South Wales Environmental Trust.* Flemington, NSW: NSW Department of Primary Industries.

NSW Department of Primary Industries. (2014). *NSW Oyster Industry Stustainable Aquaculture Strategy 2nd ed.* NSW Department of Primary Industries.

NSW Department of Public Works and Services: Manly Hydraulics Laboratory. (1999). *Port Stephens/Myall Lakes Estuary Processes Study. Report No. MHL913.* Manly, Australia: NSW Department of Public Works and Services, Manly Hydraulics Laboratory.

NSW Food Authority. (2014, 10 16). *NSW Shellfish Program*. Retrieved from NSW Food Authority: http://www.foodauthority.nsw.gov.au/industry/industry-sector-requirements/shellfish#.VD7tXaO4ZaR

NSW Office of Environment and Heritage. (n.d.). *Threatened Species found in Karuah Manning CMA sub-region*. Retrieved September 09, 2014, from NSW Office of Environment and Heritage: http://www.environment.nsw.gov.au/threatenedSpeciesApp/cmaSearchResults.aspx?SubCmaId=76

Office of Environment and Heritage. (2012). *An Ecological Health Assessment of the Karuah River.* Forster, NSW: Great Lakes Council.

Office of Environment and Heritage, NSW. (2012). *An Ecological Health Assessment of the Karuah River.* Forster, NSW: Great Lakes Council.

Owen, G. (1991). *Catchment Management Issues in the Karuah River Basin - A Survey of Community Perceptions.* Sydney: NSW State Catchment Management Coordinating Committee.

Petersen, N. (1986). *Australan Territorial Oganisation.* Sydney, NSW: University of Sydney Press.

Road Traffic Authority and Thiess. (2014). *Project Overview: Karuah History*. Retrieved July 31, 2014, from Karuah Bypass: http://karuah.thiess.com.au/html/history.html

Roads and Traffic Authority and Thiess. (n.d.). *Project Overview: Karuah History*. Retrieved July 31, 2014, from Karuah Bypass: http://karuah.thiess.com.au/html/history.html

Sarah Fairfull, Fisheries NSW. (2013). *Policy and Guidelines for Fish Habitat Conservation and Management (2013 Update)*. Sydney, NSW: NSW Department of Primary Industries, a part of the Department of Trade and Investment, Regional Infrastructure Services.

Stroud Heritage Conservation Inc. (2014). *A Brief History*. Retrieved 08 06, 2014, from Stroud Heritage Conservation Inc: http://www.stroudheritage.com.au/stroudnsw-herit7.html

Stroud Historical Society. (2014, 06). Karuah Valley Catchment Timeline. Stroud, NSW, Australia: unpublished.

The Old AAco Road Sub-Committee of The Karuah Progress Association. (2014). *The Old AAco Road*. Retrieved 08 06, 2014, from The Old AAco Road: https://aacoroad.com/

UNESCO. (1991 - 2014). *Gondwana Rainforests of Australia*. Retrieved 08 05, 2014, from UNESCO World Heritage Centre: http://whc.unesco.org/en/list/368/multiple=1&unique_number=422

Walker, B., & Salt, D. (2006). *Resilience Thinking: Sustaining Ecosystems and People in a Changing World*. Island Press: DC, USA.

Walsh, B. (1999). *Tocal's First European Settler James Phillip Webber*. Tocal, Paterson, NSW: CB Alexander Foundation.

Walsh, B., & Archer, C. (2000). *Maitland on the Hunter*. Tocal, Paterson, NSW: CB Alexander Foundation.

Wilcock, R. J., Monaghan, R. M., Quinn, J. M., Srinivasan, M. S., Houlbrooke, D. J., Duncan, M. J., . . . Scarsbrook, M. R. (2013). Trends in water quality fo five dairy farming streams in response to adoption of best practice and benefits of long-term monitoring at the catchment scale. *Marine and Freshwater Research*, 64, 401-412.

APPENDIX 1

Community and Stakeholder Engagement

From the Council's perspective, catchment management is ultimately about people, because people have the greatest positive or negative impacts on catchment health. The Council also recognises that people hold valuable local knowledge and recognition of their knowledge and values is an important aspect of catchment planning.

There are a range of diverse groups, individuals, government agencies and companies that play a role in the management of the catchment. Within the community, this includes agricultural industries, oyster farming, rural lifestyle property owners, indigenous communities, mining industry, absentee landowners, Landcare, private forestry, tourism and 'general' community members.

Government agencies that have a role in the catchment include:

- Local Land Services
- Office of Environment & Heritage
- National Parks and Wildlife Service
- Forestry Corporation NSW
- MidCoast Water
- DPI (Marine Parks)
- NSW Farmers Association
- DPI (Agriculture)
- DPI (Crown Lands)
- DPI (Fisheries)
- DPI (Food Authority)
- DPI (NoW)
- DPI (SCS)
- Environment Protection Agency
- Port Stephens Council
- Great Lakes Council
- NSW Safefood Authority

Approach to Community and Stakeholder Engagement

The processes used to develop the KRCMP aimed to be as inclusive as possible; however, the level of engagement varied according to the stakeholder's role in the catchment. An analysis of stakeholder impact or influence within the catchment was evaluated against the complexity of communicating with each stakeholder group to determine the level of engagement. The evaluation was carried out in line with the International Association for Public Participation Model (Department of Sustainability and Environment, Victoria, 2005).

A multi-staged approach and philosophy was developed for the community and stakeholder engagement program:

Setting the Scene

This stage was primarily focussed on informal one-on-one landholder visits, informal small group meetings, phone calls, emails, presentations and general discussion with community members and stakeholders. The purpose of this stage was to gain an insight into the catchment from the community and stakeholders' viewpoints, and to raise awareness of the catchment management plan.

Awareness

The aim of this stage of the engagement was to create awareness and discussion of catchment management issues within the community. The focus was on participatory processes, including:

- a three day pasture and grazing management workshop for commercial producers
- ABC's of grazing and fertiliser management for small properties workshops
- a platypus spotting evening
- the Monkerai Weed and Riparian Management Program
- attending the Poultry Enterprise Network, Tamworth, Technical Think Tank with three poultry farmers from the Karuah Catchment
- presentation and facilitation at the Karuah Oyster Growers field day.

Karuah Catchment Forum

The Great Lakes Council hosted the Karuah Catchment Forum on the 19th & 21st of June 2014 in Stroud. The Catchment Forum was a critical component in the process of developing the Karuah River Catchment Management Plan. The Catchment Forum provided an opportunity for a diverse range of community members and stakeholder organisations to work together on the development of the KRCMP.

The purpose of the Forum was to:

- seek ideas for a vision for the catchment and identify catchment values
- identify key catchment threats/pressures and key strengths and opportunities for the catchment
- seek ideas for key management actions and activities
- raise understanding of different perspectives and values regarding catchment management.

Participants from the following sectors, stakeholder groups and organisations were involved in the Forum:

- Poultry industry
- Oyster industry
- Beef industry
- Tourism
- Absentee and small landholders
- General community
- Private forestry sector
- Karuah Great Lakes Landcare
- Great Lakes Council
- MidCoast Water
- Hunter Local Land Services
- Office of Environment and Heritage
- Port Stephens - Great Lakes Marine Park
- National Parks and Wildlife Service
- Duralie Coal (Yancoal Australia)
- NSW Farmers Association

Approximately 80 people attended on June 19th and approximately 55 on June 21st.

The Forum outcomes are reported in Appendix 2. The information captured at the Forum has been incorporated throughout the Plan, along with quotes from Forum participants.

APPENDIX 2

Karuah Catchment Forum Outcomes Report

PCB Consulting - July 2014

Introduction

The Karuah River Catchment is located on the NSW lower north coast and it is bordered by the Manning River catchment in the north and the Hunter River catchment in the south and west. The topography of the Karuah Basin is characterised by an extensive system of north-south ridges lines, which is reflected in the river's formation.

The Karuah River drains a catchment of approximately 1,490 km2. It rises in the north in the Barrington Tops at an elevation of over 1,000 metres and discharges to the south into the Port Stephen's Estuary adjacent to the township of Karuah. In its higher regions, the catchment is characterised by narrow valleys which widen out in the river's mid to lower reaches.

The Karuah River has a number of major tributaries, including the Telegherry River, the Mammy Johnsons River, Mill Creek, The Branch River, Deep Creek and Limeburners Creek, plus the Upper Karuah River itself. The rivers and creeks in the Karuah River Basin are not regulated by major storages that capture or control river flows. As in most unregulated rivers, flows are most affected during relatively dry times, when water flow is diminished and demand is high.

Land use within the catchment includes large areas of State Forest, agricultural production (particularly poultry farms and beef cattle), National Park Estate, coal mining and lifestyle properties. The main population centres within the catchment are Karuah (pop. ~1000) at the mouth of the river and Stroud (pop. ~700) which is located in the centre of the catchment.

The majority of catchment is located within the Great Lakes Council LGA; however, a small area to the south, around the township of Karuah, is located within the Port Stephens Council LGA.

In recognition of the need to protect the natural environment, not just for its environmental value, but also for its economic, health and lifestyle values, the Great Lakes Council has been developing and implementing a catchment management program within the LGA. In keeping with this work, Council has commenced the development of a Catchment Management Plan for the Karuah River Catchment.

On the 19th & 21st of June in Stroud, the Great Lakes Council hosted the Karuah Catchment Forum. The Forum was a critical component of the process of developing the Karuah River Catchment Management Plan. The purpose of the Forum session was to:

- seek ideas for a vision for the catchment and identify catchment values
- identify key catchment threats/pressures as well as key catchment strengths and opportunities
- identify the key management actions and activities that need to be implemented in each of the sub-catchment areas.

Forum participants included representatives from government, industry and members of the general community. Specific groups and organisations represented included:

- Great Lakes Council staff and councillor representatives
- Mid Coast Water
- Hunter Local Land Services
- Office of Environment and Heritage
- Port Stephens - Great Lakes Marine Park
- National Parks and Wildlife Service
- Duralie Coal (Yancoal Australia)
- NSW Farmers Association
- Private Forestry Sector
- Oyster Industry
- Poultry Industry
- Beef / grazing industries
- Tourism Sector
- Absentee and Small Landholder Sector
- Karuah Great Lakes Landcare
- General Community

Approximately 80 people attended the Forum on June 19th and approximately 55 attended on June 21st 2014.

This report summarises what was said and written at the Forum and also provides an outline of the Forum's central outcomes. There have been no judgements made on the merit of the ideas or comments made at the Forum; however, the perspectives provided will play a valuable role in informing the final catchment plan.

The agenda for the Forum can be found in Appendix 3 of this report.

Our Vision

Forum participants were asked to contribute ideas to help construct a vision for the Karuah Catchment. Their responses have been compiled under the four key themes below.

Theme 1: Engaged Community, Involved In Activities

- Platypus Watch
- Water Watch
- *"Healthy Catchment, healthy community (that works together)"*
- Education on flora and fauna
- Tree planting days
- Regular community working bees
- Monitoring the catchment health
- Land restoration projects
- Groups working for biodiversity conservation outcomes

Theme 2: Healthy, Clean Rivers and Riparian Zones

- Direct access to the rivers to enjoy swimming, fishing, canoeing and camping
- *"Good quality riparian zone, and land management"*
- Improvement works on the river
- *"Is it a river or a sewer, your actions will decide?"*
- Fenced off riparian zones - intact riparian vegetation - continuous vegetation along the Karuah River
- *"Clean rivers mean a well-managed catchment regardless of diversity of activity"*
- Stable resilient stream banks
- Support and education for land owners to undertake riparian Landcare - including help with costs, labour, knowledge, weed control and ongoing management

Theme 3: Living In Harmony with the Beautiful Area

- Better farming methods
- *"I like how farmers in this area haven't cut down trees off the steep hills"*
- Wildlife corridors - continuous and cohesive not fragmented
- There is a holistic balance between economics, environment, and social matters
- Consolidated approach to further growth - limiting further subdivision to the periphery of existing residential areas

Theme 4: Healthy Catchment and Resilient Ecosystems

- Environmental flows
- *"Good water quality"*
- The gullies and riverbanks have native plant species - introduced feral weed/animal species are eradicated
- *"Introduced feral species - lantana, blackberry …… need to be eradicated. Also feral animals - wild dogs, rabbits need to be eliminated"*
- Fire management
- Conservation of vegetation on the high hills

What we love about our Karuah River Catchment

Participants discussed and listed what they love about the Karuah River Catchment. A summary of the discussions is provided below.

What the Forum's participants love about the Karuah Catchment.

- *"When in drought the springs open up and there is plenty of clean water"*
- Wildlife - platypus - endangered species
- The rivers and creeks of the Catchment
- The utility of the river to be able to support the range of industry activity
- Vegetation - the trees on hills
- The lifestyle
- The catchment's ability to adapt to change - socially or economically
- The naturalness - the scenic values and the areas you can go for peace and quiet
- Not many people live here
- The productive landscape
- Rich biodiversity including many endangered species and platypus
- The diversity of landforms
- The 'utility' of the river - it's got a whole raft of functions
- The good water quality
- *"It's a complete system - connecting with Port Stephens & the rest of Great Lakes"*
- *"The continued vegetation along the Karuah River - looks amazing compared to so many other rivers"*

What we hope for from the Karuah River Catchment Management Plan

Participants identified what they hoped might flow from the process of developing a Catchment Management Plan. A summary of their hopes is provided below.

What the Forum's participants hope for the catchment

- *"Would like to see this community empowered"*
- Biodiversity measures to reduce the animal carnage on roads
- Understanding how the plan sits from a statutory point of view
- *"That the area is preserved and improved upon"*
- Plan can become a guiding document - will it be policed?
- Community projects e.g. Wards River Mammy Johnsons River Landcare Project
- Local Landcare groups developed to help each other
- Empower community politically - talk with one voice
- Linkages to surrounding catchments - the Williams, Myall, Avon and Gloucester
- *"Opportunities to exchange ideas with other people in the Valley"*
- Integration with Council's other plans and its Local Environmental Plan (LEP) - alignment of actions
- There has been much study of the estuary but little focus on the upper catchment - hope that the catchment management plan will go some way to balance the attention by an increased emphasis on the upper catchment

Our Catchment Values

Participants were asked to identify, value and document specific sites or catchment assets that were important to them. These asset valuations were guided by the following prompts:

- Where is the valued asset located?
- Provide a general description of the asset.
- Why is the asset of high value?
- What is its current condition?
- What community/social value does it provide?
- What is its economic value?
- What is its environmental value?
- What are the known threats to the asset's value?
- What management ideas could help protect the asset's values?

Common values identified across the catchment

- platypus
- agriculture / primary industries
- clean water
- the river
- landscape / natural beauty
- biodiversity / world heritage / wildlife / plants & animals
- production and conservation
- history / sense of place.

Forum participants were asked to assign key words to describe the community, social, economic and environmental values for each important catchment asset. A summary of the results from the activity are provided below.

Community / Social Value

- Healthy, productive, biodiverse natural systems
- Community
- Areas for people to enjoy
- *"It has been my home for 35 years"*
- Employment for families
- *"Full of good community and social values"*
- Water quality
- *"Lifestyle"*
- *"More areas for people to enjoy"*
- History
- Water
- Employment
- *"Aboriginal pre-settlement environment"*
- Provides both a profession & a lifestyle
- *"Tourism swimming, boating, fishing"*
- Views
- Aesthetic: *"It is beautiful"*
- Tourism potential
- Biodiversity
- *"Rainforest gullies close to the road"*
- Water quality
- Good community & social values
- *"Healthy catchment = resilience = healthy community"*

Economic Value

- Long term prosperity
- *"High value in terms of lifestyle"*
- *"Employs people"*
- Tourism
- *"Biodiversity"*
- *"Supports a huge variety of industries, for example largest dolphin watching fleet in the southern hemisphere and worth over $20million"*
- Self-sufficiency
- *"Livelihood of family & some employment"*
- Water quality

- Supports a range of industries, e.g. oyster growing, beef grazing, poultry production, tourism, forestry, mining etc.
- *"Great potential for sustainable timber production if forestry done right"*
- *"Keeps cattle alive"*
- Recreation
- *"Multimillion $ investment"*
- Wood growing
- *"Fish stock"*
- Canoeing
- *"Critical to local economy"*

Environmental Value

- *"Clean pristine environment"*
- Water quality / clean water
- Essential
- Riparian zones
- *"Magnificent wildlife, particularly bird life"*
- Sea grass
- Beautiful setting & outlook
- Great lifestyle
- *"Provides a corridor between existing vegetation"*
- Habitat
- Land, views, aspect
- Vegetation & clean air
- Forests - significant species & wildlife corridors
- High conservation value
- *"Ecosystem functioning"*
- Corridors of vegetation & wildlife
- *"Biodiversity"*
- *"Oysters are filter feeders to help keep the system clean"*
- *"High conservation & ecological significance"*
- *"Range of plants, birds and animals"*
- Plants and wildlife

Our Past

A timeline (outlined below) summarising the history of the region was provided by the Stroud Historical Society. The timeline was placed on the Forum venue's wall and participants were given the opportunity to include additional historical events to the summary. Participants' additions to the timeline are presented in italics.

Historical Time Line for the Development of the Karuah Catchment

- **Pre 1826**: Area inhabited by the Gringai and Worimi Aboriginal tribes.
- **1826**: Australian Agricultural Company (AACo.) set up headquarters at Carrington, Port Stephens. Port Stephens estate encompasses 1,000,000 acres, including the Karuah Valley Catchment, with the vision to produce fine wool and wheat.
- **1832**: Rock pens constructed to wash sheep in the Karuah River, known as 'Washpool'.
- **1834**: Sheep numbers reach 124,000.
- **1841**: Eight underground brick silos are built at Stroud to store wheat.
- **1849**: Land subdivision for private settlement in Stroud.
- **1850-56**: Stroud becomes the AACo. Headquarters.
- **1858**: Coal pits opened by AACo. On Johnsons Creek, but costs proved prohibitive.
- **1877**: Timber truss bridge constructed over the Karuah River at Monkerai. Today it is the oldest truss bridge in NSW. *Bridge in need of repair.*
- **1880's**: Timber truss bridge over the Karuah River at Booral.
- **1890**: *Iron Stone Mountain mined - 1 ship of magnetite sent to the United Kingdom.*
- **1891**: Timber truss bridge over the Karuah River at Washpool.
- **1894**: Karuah Valley's first commercial gold mine opens at Monkerai.
- **1896**: Huge flood in the Karuah Valley.
- **Early 1900's:** Timber industry gains momentum (and starts to diminish by the 1980's).
- **1906**: Stroud Shire Council established.

- **1912-13**: North Coast railway line passes through the Karuah Valley. The opening of the railway was delayed due to 250mm of rain falling in one week in December 1912, causing landslides.
- **1920's**: Dairy industry evolves, (peaking in 1960).
- **Approx. 1928**: *Flood washes 2 houses away on Cromarty Creek.*
- **1950's**: *Post war settlement scheme, including subdivisions and land development incentives.*
- **1955**: Karuah Catchment encounters huge flooding.
- **1957**: New bridge constructed over river at Karuah, changing the Pacific Highway route.
- **1960's**: Large scale chicken production commences. A considerable amount of dairy farms switch to chicken and beef production.
- **1964-65**: Devastating drought reduces cattle numbers.
- **February 1978**: *Big floods in the Karuah Valley.*
- **1980's**: Stroud Shire Council changes to Great Lakes Council and offices move to Forster.
- **Early 80's**: *Drought - the river stops flowing.*
- **1986**: *Floods in the Karuah Valley.*
- **1992**: *Drought and the river stops flowing.*
- **1998**: *Regional Forest Agreement implemented - some State Forests were converted to National Parks, State Conservation Areas and Nature Reserves. Changes were made to the timber industry associated with this.*
- **2000**: *Dairy deregulation - the number of dairies decline further throughout the catchment.*
- **2003**: Duralie open cut coal mine commences production on the earlier Johnsons Creek site.
- **December 2005**: *Port Stephens - Great Lakes Marine Park officially declared.*
- **2007**: *Commissioning of the Stroud Sewerage Treatment plant and re-use of recycled water system, reducing nutrient loads to the river.*

Our Current Situation

A panel of technical experts and representatives from key industries spoke briefly at the forum providing participants with an overview of the current situation in the catchment.

Presentations were given by the following:

1. Dr Peter Scanes, Water Scientist, NSW Office of Environment and Water
   Karuah River and Catchment Health Ecological Health
2. Mat Bell, Senior Ecologist, Great Lakes Council
   Biodiversity of the Karuah River Catchment
3. Michael Barberie, Senior Land Services Officer - Land and Soils, Hunter Local Land Services
   Soils of the Karuah Catchment
4. Debbi Delaney, Karuah Catchment Officer, Great Lakes Council
   Changes in the Social and Economic Makeup of Rural Australia - Karuah Valley. Implications for Catchment Management
5. Chris Hall
   Outline of Chris's beef enterprise and catchment management opportunities challenges he faces
6. Brett Howard
   Outline of the Howard Family egg and beef enterprises and the catchment management opportunities and challenges faced by the business
7. Dean Cole: Cole Bros. Oysters
   Due to last minute work commitments, Dean could not attend and tendered his apology

SWOT Analysis of Catchment Condition

Small groups of participants were asked to use one of the five themes as a focus for further analysis of the current catchment situation. These themes included:

- biodiversity
- water
- soils and land
- community
- industry.

For their particular theme, each group was asked to brainstorm the following elements of a SWOT analysis:

- strengths (what is currently working well in the catchment?)
- weaknesses (what is currently not working well in the catchment?)
- threats (what might impact on catchment health?)
- opportunities and new ideas to consider.

Notes from each theme table describing the strengths, weaknesses, threats and opportunities for catchment health are provided below:

Biodiversity Theme

Our Strengths What is currently working well?	Our weaknesses What is currently not working well?
• residual high biodiversity • community values—network, communication, collaboration • relatively good rainfall—reliable • interested council • relatively high representation of natural vegetation • we have reserve areas—national parks, reserves, state conservation areas • adjoin world heritage area • private conservation areas • current legislation—native vegetation controls, threatened species	• fragmentation of wildlife corridors • too much clearing • lack of resources and funding • lack of resources to implement legislation • Council too Wallis focussed • lack of understanding of biodiversity regrowth • lack of supervision / enforcement of regulations and consent conditions • ignorance and don't care attitude • lack of knowledge • lack of awareness e.g. Catchment Action Plan • no focus on biodiversity hot spots - biodiversity is not uniform • complexity of regulators and bureaucracy • narrow funding • lack of coordination and collaborative effort • lack of landuse controls • animal mortality - road kill and chemicals • limited strategic biodiversity knowledge • limited use of natural resilience
Threats / Concerns to catchment condition	**Opportunities and new ideas to consider**
• ongoing funding commitment to NRM • politics • lack of recognition of the links between biodiversity values and production and land management • maintaining momentum • mining impacts	• education and awareness—in schools • applied research and training opportunities—using tertiary institutions • developing relationships—with Local Land Services and local Landcare groups • developing relationships with Councils—LEP/DCP • response to known threats—e.g. Lower the speed limits and wildlife signage—Booral Road • research of biodiversity hotspots—signage and management • lower the Council rate charges for private conservation areas • developing relationships with mining—off set areas, funding, community support, sharing data • developing guidelines for corporate social responsibility—commercial entities need to respond to the damage caused with funding and action

Water Theme

Our Strengths What is currently working well?	Our weaknesses What is currently not working well?
• existing Landcare groups • Great Lakes Council resources, attitude, policy • strong community structures • good appreciation of the importance of the water in the catchment • existing knowledge of interdependence of nature and people • water quality is high • no major industry in the Karuah Catchment • marine habitat is good fish habitat - fresh water mussels • marine park allows for management of extractive industries • Mammy Johnson's River is cleaner • riparian vegetation • free flowing rivers • in-stream biodiversity	• small landholdings—affordability, time, difficulty to address land management issues • large landholders face many issues, high cost lower incomes • aging and limited labour on farm • difficult to gain coordinated action • them and us divide in the community • fear of regulation and loss of freedom and income • pollution—disease • mine discharging to river via creeks • animal grazing impact • high turbidity during wet weather • major industry impacts—mining • limited seagrass habitat and increasing mangrove habitat • altered state of Mammy Johnsons River • riparian weeds—transferred from further up stream
Threats / Concerns to catchment condition	**Opportunities and new ideas to consider**
• turbidity and nutrients identified as a major problem • erodible soils causing problems • climate change—threat to river flows and levels • mining—diversion of creek (2) and broken into aquifer • riparian damage • policing the mining discharges to river • erosion from concentration of flow • flow variability—drought impact and the impact of land managers keeping water on property • council road maintenance practices—increases sediment and concentrated flows • unfenced sections of streams • dust entering the waterways from coal trains	• slow the rate of water entry into water courses • bring people together to take action on issues - to raise awareness and meet one another and establish Landcare groups and expand existing groups • communication to the community on opportunities and issues • draw out and use existing skills and knowledge to share with other landholders • address fears with knowledge and mediation • extend the marine park sanctuary zone • protect riparian vegetation • protect forested hills • encourage river walks for recreational walkers • the Wards River—Mammy Johnsons River Landcare Project proposal • fence creeks and riparian zones—revegetation of riparian zones

Soils and Land Theme

Our Strengths What is currently working well?	Our weaknesses What is currently not working well?
• Great Lakes Council - information and facilitation • community sense of need for action	• absentee landowners • weed management—particularly lantana, privet, camphor laurel • weed management needs follow up action—follow up weed management and increasing ground cover • unsure about the value of previous mapping studies—what have been the actions or outcomes resulting from this
Threats / Concerns to catchment condition	**Opportunities and new ideas to consider**
• weeds • erosion • commercial pressures to reduce native pasture and biodiversity • rabbits—create the holes that start tunnel erosion • mining • climate change—more extreme weather events e.g. storm events	• improve soil management knowledge • improve weed education and pasture management techniques • vegetate river stream banks with improved diversity of species • improve the soil water infiltration potential

Community Theme

Our Strengths What is currently working well?	Our weaknesses What is currently not working well?
• improved sewage and water treatment in Stroud • ability of Great Lakes Council to provide communication via Creek to Coast newsletter and Stroud community web • increased access to a variety of views through inward migration • proud social history of Stroud with lots of community activities—a very friendly town • we are located close to Newcastle • Great Lakes Council environmental specialists	• sewage and water treatment • lack of coordinated communication about the catchment management issues • fear and divisiveness between industry sectors within the community • lack of real engagement with young people • constant change of government departments and roles and responsibilities— leaving communities not knowing who to contact about issues • really needing advocacy, political savvy, statesmanship and leadership at a local level
Threats / Concerns to catchment condition	**Opportunities and new ideas to consider**
• contamination by industry—self regulation by industry • lack of monitoring of obvious sources of pollution in general • poor design of earthworks and road works engineering design and the quality of gravel on unsealed roads and other earthworks • divisiveness between industry sectors	• physical and scenic attractiveness of the valley • collaborative usage of experience brought in by in migration to the area • Great Lakes Council could target land holders with information on the current position of the catchment and possible impacts on the rivers

Industry Theme

Our Strengths **What is currently working well?**	**Our weaknesses** **What is currently not working well?**
• planting trees (the right sort) for erosion control • fences • monitoring soil quality at least annually • how to establish a riparian zone • water quality has improved in the last ten years • no one clears the hills • the people in the catchment • a proactive community • farming is still hanging on in the catchment	• floods—and the flood colour • deep holes in the river silting up • cleaning up post flood e.g. Oaks • fast running and fast rising river • springs running "hot"—changes in temperature • jellyfish 10 years ago were at Allworth has now decreased—is this good or bad?
Threats/concerns to catchment condition	**Opportunities and new ideas to consider**
• extremist views causing division within the community—us and them—need to balance the views—industry not raping the system and "greenie" views • hobby farmer and newcomers to the area can lead to unnecessary clearing—they are untrained, and they don't need to make money from the land • weed invasion e.g. lantana • water tanks and dams • recreational bush racing tracks • fish levels (Monkerai) • platypus levels • carp and catfish on the rise • waste disposal—littering • potential for gas and mining expansion • burning—too often or not enough • mining impacts—weeds, regeneration, koalas	• using electric fencing for riparian zone fencing • slow the water speed • options to reduce erosion—chicken litter can act as a soil stabiliser, kikuyu also helps to stabilise soil • getting neighbours to work together on local issues—helps to educate newcomers • field days—to provide local information on local issues • recreational anglers—could be interested in helping with bank stabilisation and fish stock monitoring projects • expanding garbage collection service

Key Management Actions Ideas

Forum participants were asked to identify management actions that could be included in the Karuah Catchment Management Plan. Participants were asked to focus on management actions that would protect the value of water, biodiversity, land and soils, the community and industry. The participants' ideas are provided in Appendix 2 of this report.

The management actions developed within the Forum are grouped into three main themes: education, awareness and community capacity building; provision of incentives; and communication and community engagement. The aggregation of identified activities within each theme also forms the basis of a number of catchment based projects (See Appendix 2).

The key actions within each theme are provided below.

Education, Awareness and Community Capacity Building Actions

- Implement a network of water sampling/ monitoring sites in the many streams and rivers of the catchment
- Regular reporting of monitoring results in local media.
- Involve schools, universities and TAFEs in the monitoring program—flora and fauna surveys to be included
- Hold workshops and field days on priority catchment management issues for all land managers—farmers learning Best Practice from other farmers
- Establish a network of demonstration sites and trial sites of best practice for each industry
- Establish a network of best practice local champions for each industry.

Incentive based actions

- Provide access to resources and funds to assist landholders to fence riparian zones and establish off stream watering systems
- Provision of one soil test per property as an incentive to attend a workshop, followed by another workshop on how to use the soil test results to determine chicken manure or fertiliser requirements
- Reduction in rates for land that is managed to promote biodiversity outcomes

Communication and community engagement based actions

- Using a range of communication tools such as the media and newsletters, ensure that the community is aware of catchment issues that need to be addressed
- Encourage community input and feedback on the plan, by establishing a Karuah Catchment Management Plan webpage that is linked to other appropriate internet sites such as the Great Lakes Council website, groups, blogs and Facebook pages.
- Establish a few key areas in the catchment for focused community action such as weed control, stream bank stabilisation work, establishment of biodiversity corridors, fencing and clean up days, and encourage the participation of a broad range of community members in the "Community Action" days.

Where Next?

This report summarises the results of the Karuah Catchment Forum hosted by Great Lakes Council on the 19th and 21st June 2014 at Stroud. The report records the views of a wide cross section of the catchment's stake holders in a non-judgemental and unqualified manner; however, the information contained within the report will play an important role in informing the development of the Draft Karuah River Catchment Management Plan.

A brief study of the Forum's SWOT analysis clearly indicates that the community perceives that there are a number of common threats to the catchment's values. These threats are identified in each of the four themes: water, biodiversity, land and soils and community and industry. A list of these perceived threats is provided below:

Perceived threats to catchment values identified by the Forum, included the following:

- ongoing funding commitment to natural resource management (NRM)
- politics
- lack of recognition of the link between productive and NRM values
- mining impacts
- industry practices
- commercial pressures
- knowledge levels
- lack of co-ordinated communication
- absentee landowners
- turbidity and nutrients
- erodible soils
- road management practices
- weeds
- feral animals
- climate change
- lack of monitoring of obvious sources of pollution
- divisiveness between industries
- potential for gas expansion / fracking
- burning practices - too often or not enough
- habitat decline (e.g. riparian zones, threatened species)
- lack of monitoring / data (e.g. fish, platypus, seagrass, threatened species, water quality hotspots)
- land use controls & regulations
- potential issues from fracking.

During the wrap up discussion at the conclusion of the Forum, it was agreed to undertake three actions during the development of the Draft Karuah River Catchment Management Plan. The three actions are to:

1. Establish an email list, 'Karuah Updates', as a mechanism for Council to update community members on the progression of the Catchment Plan and to promote action within the catchment.
2. Establish a webpage on the Council's website to provide a central location for background information, information links and significant issues relating to the Karuah River Catchment Management Plan.
3. Conduct a bus trip from the Karuah Catchment to the Durness and Nerong Park properties to see the work that has been undertaken on these properties.
4. In conclusion, the Great Lakes Council would like to thank the people who participated in the Forum for the contribution of their ideas, their commitment, their knowledge and enthusiasm, and their concern for the health of the catchment.

APPENDIX 1 Karuah Catchment Forum: Potential Ideas for Management Actions by Theme

Biodiversity Theme

Management Action	Contributing Ideas
Education/knowledge development	• Education—particularly schools and applied education • Landholder workshops—identification, awareness, management, techniques • Proactively encourage increased membership of local wildlife groups • Program to identify biodiversity hotspots. • Encourage natural farming techniques and practices— education and workshops • Involve universities and tafe—flora and fauna surveys and assessments • Creek to coast newsletter
Funding and Resources	• Local Land Services funding should be strategic—focus on sub-catchments rather than on individual owners. • Catchment Management Plan to identify funding needs from commonwealth
Roadsides	• Encourage landholder and agency slashing of roadsides to reduce road kill • Road side vegetation management implementation. • Continued maintenance of the road side corridor environment • Change roadside vegetation practices—train council road crews • Better/programmed improved roadside slashing in fauna hotspots • Identify ability to reduce road speed in appropriate locations • Examine ability to provide signage for road hotspots
Community engagement	• Measures to foster voluntary community biodiversity conservation
Council actions	• Council to finalise vegetation mapping and biodiversity strategy • Limit future "rural" lifestyle growth to the periphery of existing urban areas • Consider relationships with councils LEP to rezone or not—DCP considerations
Corridors/Linkages/ connectivity	• Drive 'Tops to Lakes Initiative' in the community and link to Great Eastern Ranges Project • Create biodiversity link from Gloucester to coast and in return reduce rates and dollars • Facilitate conservation of wildlife corridors (statutory and non statutory mechanisms alike)
Climate Change	• Strategy to cope with global warming
Soil	• Consider soil biology
Management	• seedbank for restoration program • weed control—burning and spraying • fence off riparian zones and manage weeds • holistic management of the area—not small sector by sector • LLS to focus on regeneration and not just planting

Water Theme

Management Action	Contributing Ideas
Incentives	• Re-introduce subsidies for installing dams away from gullies and the river • Have the authority—Council, State or Federal—to contribute to the landowners' cost of fencing off the river and construction of the alternative water supply for stock
Education and Awareness	• Water Watch community school groups—Wards River—Mammy Johnsons River • On purchasing rural land an information pack riparian maintenance/pasture control be given • Engage all landholders in land management education to prompt action • Resources for private landowners to fence riparian areas • Local workshops on managing riparian vegetation • Weed control using control burning • Document case studies of best on-farm water management practices • Encourage local Landcare groups to help drive awareness and action • River access for community river walks • The Wards River—Mammy Johnsons River Landcare project proposal • If river access is important buy your own property with it
Monitoring	• Water tests on Wards River Mammy Johnson's river—to monitor for petrochemicals and heavy metals • Support water monitoring by the community • Independent water testing on Wards River Mammy Johnsons River
Regulatory Controls on Industry	• Stricter control of mining activities • No gas exploration in upper catchment—management of impacts • Investigate broader off site use of stored mine water (say on ridge tops) to prevent irrigation on small areas that increase hotspots • Council to be flexible in dam and swale construction to alleviate run off • Encourage best practice on mining land
Rehabilitation	• Rebuild swales to reduce run off • State fisheries to fund the stabilisation of river banks and create nursery for crustaceans and fish out of licences • Fence off riparian zones

Soils and Land

Management action	Contributing Ideas
Education/capacity building	• Detailed identification of worst runoff sites • Fire management • Establish a Landcare group in local areas where none exists at the moment • Educate for better stock management • Field days • Subsidies • Absentee land owners must have set up to keep minimum standards for their property • Conduct trial water management pond system as a demonstration model to extend to other areas and educate • Increase understanding of catchment system and relationships • Education on weed control, erosion, pasture management and water infiltration • Regrowth— swales and wetlands • Education on avoiding set stocking arrangements and how to implement a rotational grazing system to enable pasture growth to reduce run off • Minimum standards for landownership
Feral Controls	• Feral dog eradication campaigns on a continuous basis with an LLS officer present before, during and after • More intensive LLS campaigns for rabbit eradication now
Remediation	• Dung beetles and worm farms to reduce manure on the surface of soils • Worm farms can be fed exclusively with manure to produce the most rich compost
Incentives	• Funding for fencing in riparian zones on private property • More affordable soil testing available to landholders
Riparian	• Further promote riparian management techniques
Weeds	• Have community workshops for weed management techniques • Camphor Laurel elimination program reintroduced • Inform landowners on what to plant and what to use for weed control • Encourage weed management by volunteer groups which is much more efficient
Council	• Adopt and implement Hunter Council's roadside vegetation strategy and practices • Council education for new landowners on weed control and soil type issues • Rebuild the 'Man in the Stocks' at Limeburners Creek as an educational tool against littering • Offer subsidy or cheaper price on goods we need and require to maintain land/soil

Community Theme

Management action	Contributing Ideas
Education	• Start involving the younger generation by approaching local schools for involvement and feedback from students • Share the historical information
Community Action	• Community projects such as River Care and Landcare projects and Water Watch. • Pool resources for environmental action—work with volunteer groups in a few key locations in the catchment.
Communication	• Identify and define the problems and issues in the catchment and then publicise these to the broader community • Establish a website and Facebook site to continue the forum discussion and exchange ideas
Funding	• It is essential that funds are found for the implementation of the Catchment Management Plan • Coordinate and focus all government authorities' action in the catchment area—rather than individual effort. • Please tar the gravel roads

Industry Theme

Management action	Contributing Ideas
Education	• Council and EPA Industry training and education sessions • Set up best practice examples for each industry/industrial activity and publish on the web • Effective use of chicken litter workshops for graziers • Demonstrate sustainable pond management and conservation works • Provide one free soil test per rural property or information on a Council web site that gives hints and links for grants to help in river health
More Industry Controls	• Nil discharge from any mining site into creeks, gullies, rivers • More controls on mining activities e.g. drilling • Mandatory detention for water run-off and recycle to pasture
Incentives for Industry	• Incentives for industry relocation for economic benefit • Council and EPA environmental incentives programs • Sustainable forestry in top steep parts of catchment—maintain biodiversity corridors • Utilise the government's "green army" for improving industry environmental projects • Employing the unemployed on farms—salary funding minus the extras (super, insurances) • Farming industry in the valley is very important for local jobs • Private forestry opportunities—promote native areas on farms for connectivity and on-farm timber

APPENDIX 2 Karuah Catchment Forum: Detailed Management Actions by Theme

Biodiversity Theme

Issue to be addressed:	**Education and Knowledge**
Location e.g. catchment wide, sub-catchment, specific site etc.	Catchment wide - but use a focus on particular sub-catchments or localities for topical issues
Proposed actions / project to address the Issue List key activities and objectives of the project	Objectives: • Changed behaviour • Foster understanding • Provide a path to sustainable long-term management • Increased awareness • Promote interconnectedness • Bringing the community together • Reducing "fear of the unknown" • Applied knowledge to inform strategic landuse planning • Intergenerational continuity of effort Project Activities: • Field days with local groups—range of topics • Expand and develop local Landcare groups • Schools' education • Scientific investigation of biodiversity hotspots—publish • Understand/tailor programs to funding • Shared knowledge from other regions/agencies

Water Theme

Issue to be addressed:	**Education, Awareness and Monitoring**
Location e.g. catchment wide, sub catchment, specific site etc.	Catchment wide
Proposed actions / project to address the Issue List key activities and objectives of the project	Objective: • Raise awareness to enable ongoing action to improve water quality Key Project Activities: • Implement water measurement/monitoring sites in many streams and rivers • Regular reporting of monitoring results in local media and through groups using a visible indicator site • Involve schools in awareness and monitoring • More land management and environmental information on local website • Develop stories for local issues/initiatives for media • Support new and existing Landcare and river care groups • Hold workshops on priority issues for all land managers—farmers learning best practice from other farmers • Demonstration sites, trial sites

Issue to be addressed:	**Incentives**
Location e.g. catchment wide, sub- catchment, specific site etc.	Catchment wide
Proposed actions / project to address the Issue List key activities and objectives of the project	Objective: • Fencing of riparian areas Key Project Activities: • Funds for fencing materials and for off stream watering • Coordinated approach to weed management within the newly fenced area • Need to ensure it is flexible on where the fence line goes to account for floods • Incentives for soil testing • Using soil tests to determine chicken manure or fertiliser requirement

Soil and Land Theme

Issue to be addressed:	Education and Capacity building
Location e.g. catchment wide, sub-catchment, specific site etc.	Catchment wide—on a sub-catchment basis
Proposed actions / project to address the Issue List key activities and objectives of the project	Objective: • Education of land managers on best management practices Key Project Activities: • Media, newsletters, publication of a weed calendar • Field days with hands on activities • Establish a network of local champions in the catchment • Establish a network of best practice demonstrations with community groups

Community Theme

Issue to be addressed:	Education
Location e.g. catchment wide, sub- catchment, specific site etc.	Catchment wide
Proposed actions / project to address the Issue List key activities and objectives of the project	Objective: • Uniting and engaging all the community through education, communication and action Key Project Activities: • Identification and communication of the catchment's issues and problems to all in the community including schools • Landholder workshops addressing the key catchment management issues e.g. erosion, riparian vegetation and fencing • Involve students in identification of catchment issues and involve students in the Landcare process e.g. students to visit a farm with erosion issues • Establish a webpage on the Karuah River Catchment Management plan linked to the Great Lakes Council website: • with links to local groups; • include blog or Facebook feature so community can provide input and feedback.

Industry Theme

Issue to be addressed:	Education and Incentives
Location e.g. catchment wide, sub-catchment, specific site etc.	Catchment wide
Proposed actions / project to address the Issue List key activities and objectives of the project	Key Project Activities: • Bringing the older farmers and the new farmers together to generate new ideas for more productive farms/industries. • Develop a database of all farms in the catchment using the rates notices and the email lists of all of the local associations e.g. the brick throwing group, the historical society, the Show Committee. • Provide funding for one soil test per year to every participant at a farming industry workshop - link this back to education with "how to interpret a soil test" session and "how to calculate how much fertiliser or chicken litter to apply" session.

APPENDIX 3 Karuah Catchment Forum: Karuah Catchment Forum - Agenda

Session 1	Thursday 19th June
6pm	Arrive- Registration desk
6.10	Welcome
	Background and context - why we need a plan?
	Workshop Objectives
6.20	Workshop Agenda and Process
	Introductions
6.40	The Karuah River Catchment Management Plan
7.05	Identify areas of high value in the catchment from your perspective
	When our Karuah River Catchment is at its best..... What does that look like? What is happening?
8.20	Next Steps
8.30	Thanks and Close

Session 2	Saturday 21st June
10.00 am	Arrive- Registration desk
10.15am	Welcome
	Workshop Objectives
10.20	Workshop Agenda and Process
10.25	The Karuah River Catchment Management Plan - recap
10.35	Current Condition of the Catchment - Technical Panel
11.55	Current Landuse and Agricultural Practice - Industry Panel
12.15	Small group work at Tables (within your theme)
	Key catchment strengths and opportunities to improve catchment condition
	Key threats/pressures or challenges to catchment condition
12.50	When our Karuah River Catchment is at its best..... What does that look like? What is happening?
1.00	Lunch
2.20	Small groups
	ideas for management actions
3.45	Next steps/thanks
4.00pm	Close

APPENDIX 3

An Ecological Health Assessment of the Karuah River

A copy of the Ecological Health Assessment can be found at:
http://www.greatlakes.nsw.gov.au/Environment/Plans_and_Strategies

APPENDIX 4

NSW River Condition Index

The NSW River Condition Index was developed by NoW to allow spatial reporting of long-term river health and to integrate water allocation and catchment planning. Other spatial products developed alongside the River Condition Index enable spatial representation of in-stream values, as well as the risk to in-stream value or resilience from physical disturbance and water extraction.

The approach aims to provide a consistent method for riverine condition assessment, incorporating fish, macroinvertebrates, physical form, riparian vegetation, catchment disturbance and hydrological disturbance in a single measure. This is based on the National Framework for Assessing River and Wetland Health.

Rivers show diversity of character and behaviour in any catchment. The River Styles framework is used to interpret river character, behaviour, condition and recovery potential. The River Styles framework:

- Provides a baseline survey of river character and behaviour throughout a catchment. Downstream patterns and connections among reaches are examined, demonstrating how disturbance impacts in one part of a catchment are manifest elsewhere over differing timeframes.
- Evaluates recent river changes in the context of longer-term landscape evolution, framing river responses to human disturbance in context of the 'capacity for adjustment' of each River Style.
- Provides a basis to compare stream type-with- stream type and from this, geomorphic condition of the river is assessed.

Further information is available at http://www.water.nsw.gov.au/Water-management/Monitoring/Catchments/Catchments

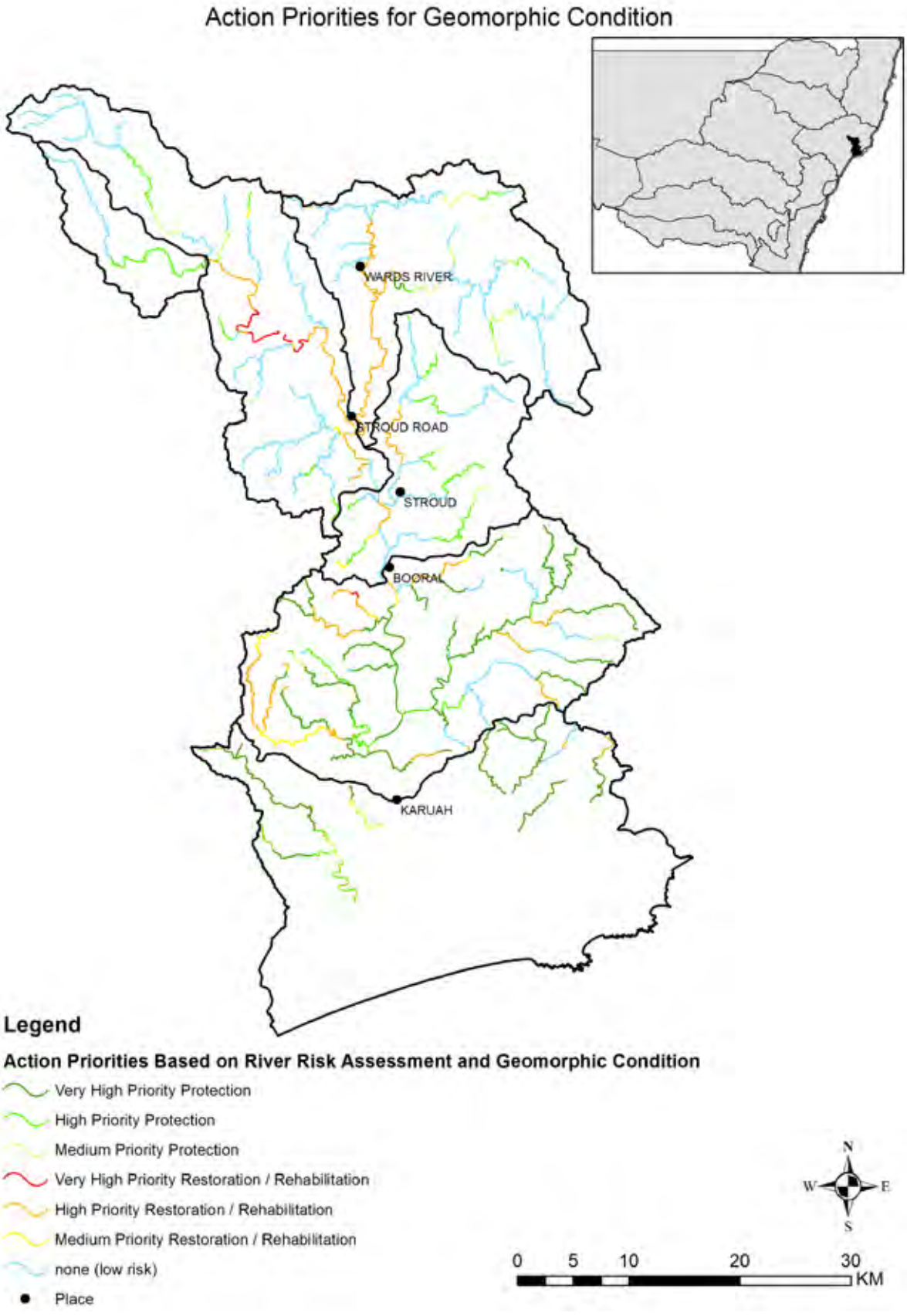


Figure 17. Karuah River Action Priorities for Geomorphic Condition

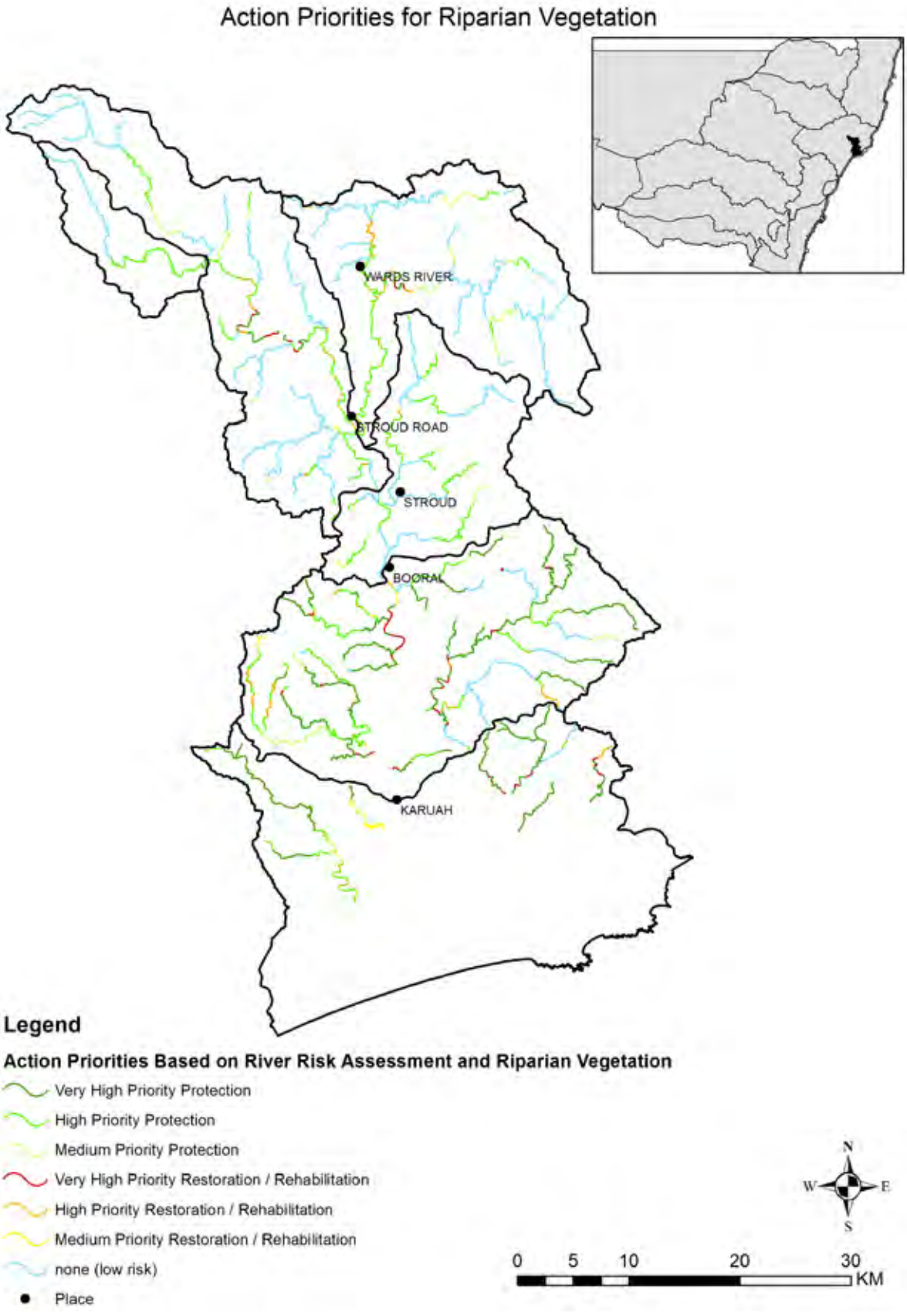


Figure 18. Karuah River Action Priorities for Riparian Vegetation

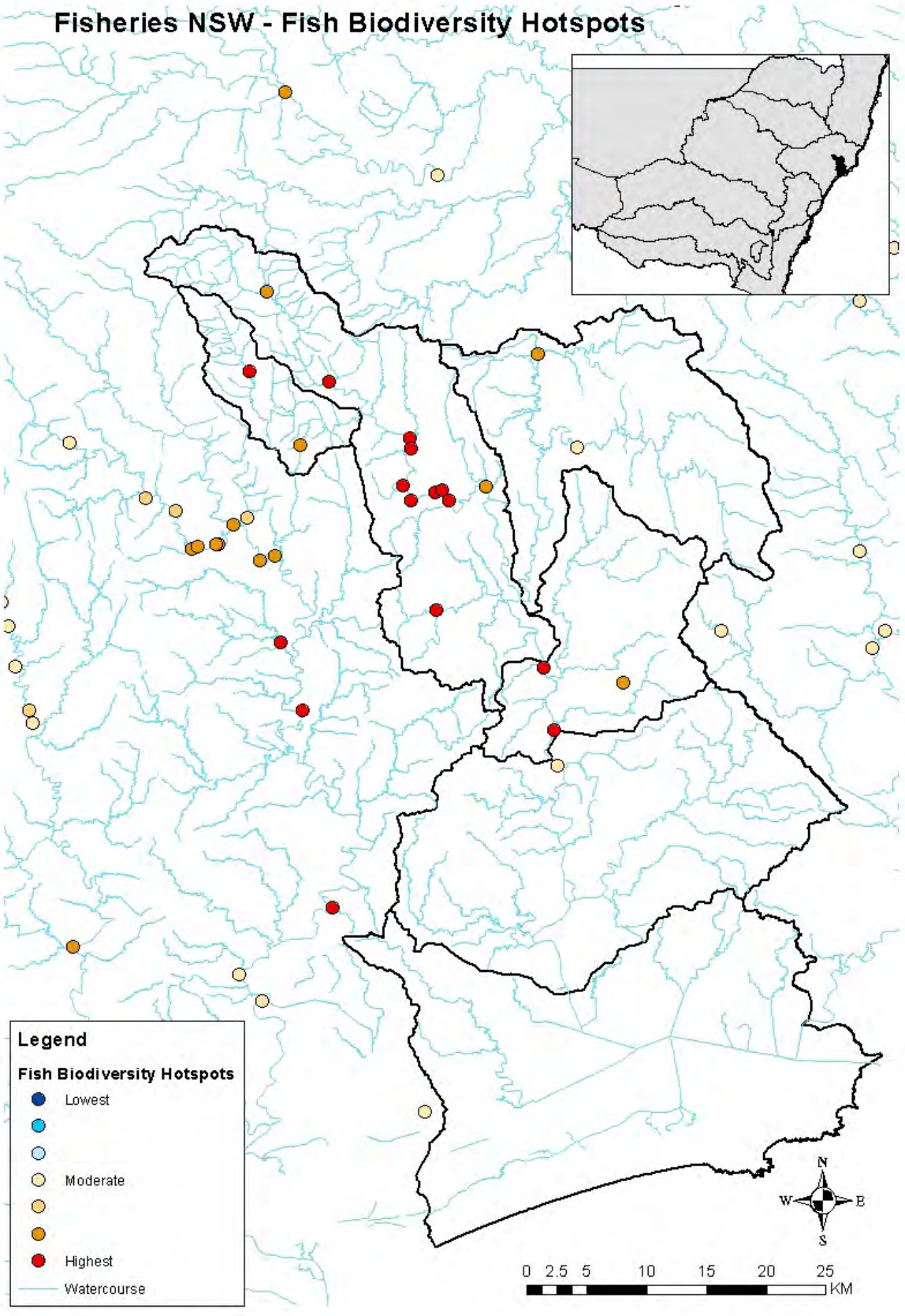


Figure 19. Fisheries NSW, Karuah River Fish Biodiversity Hotspots

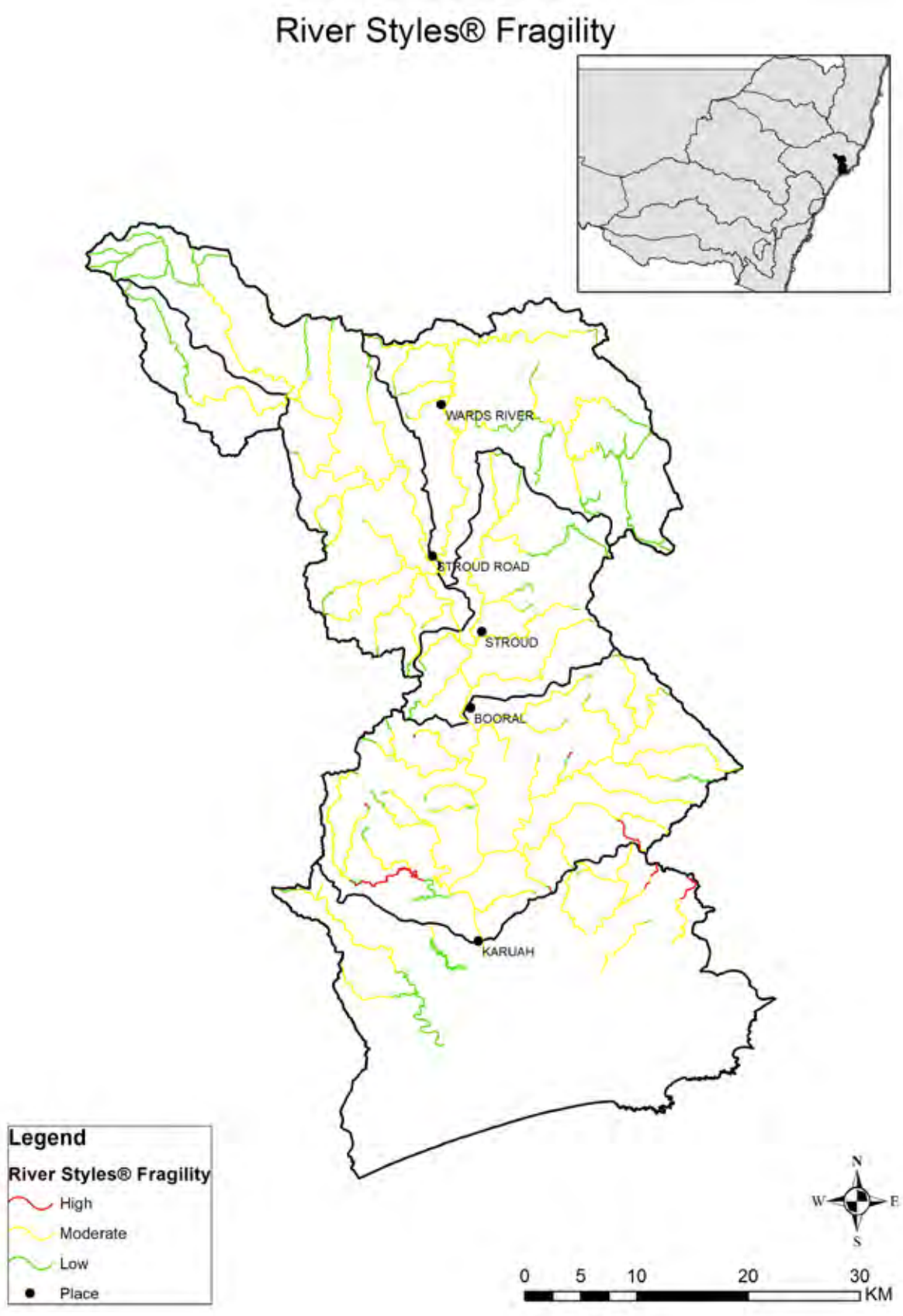


Figure 20. Karuah River Styles Fragility

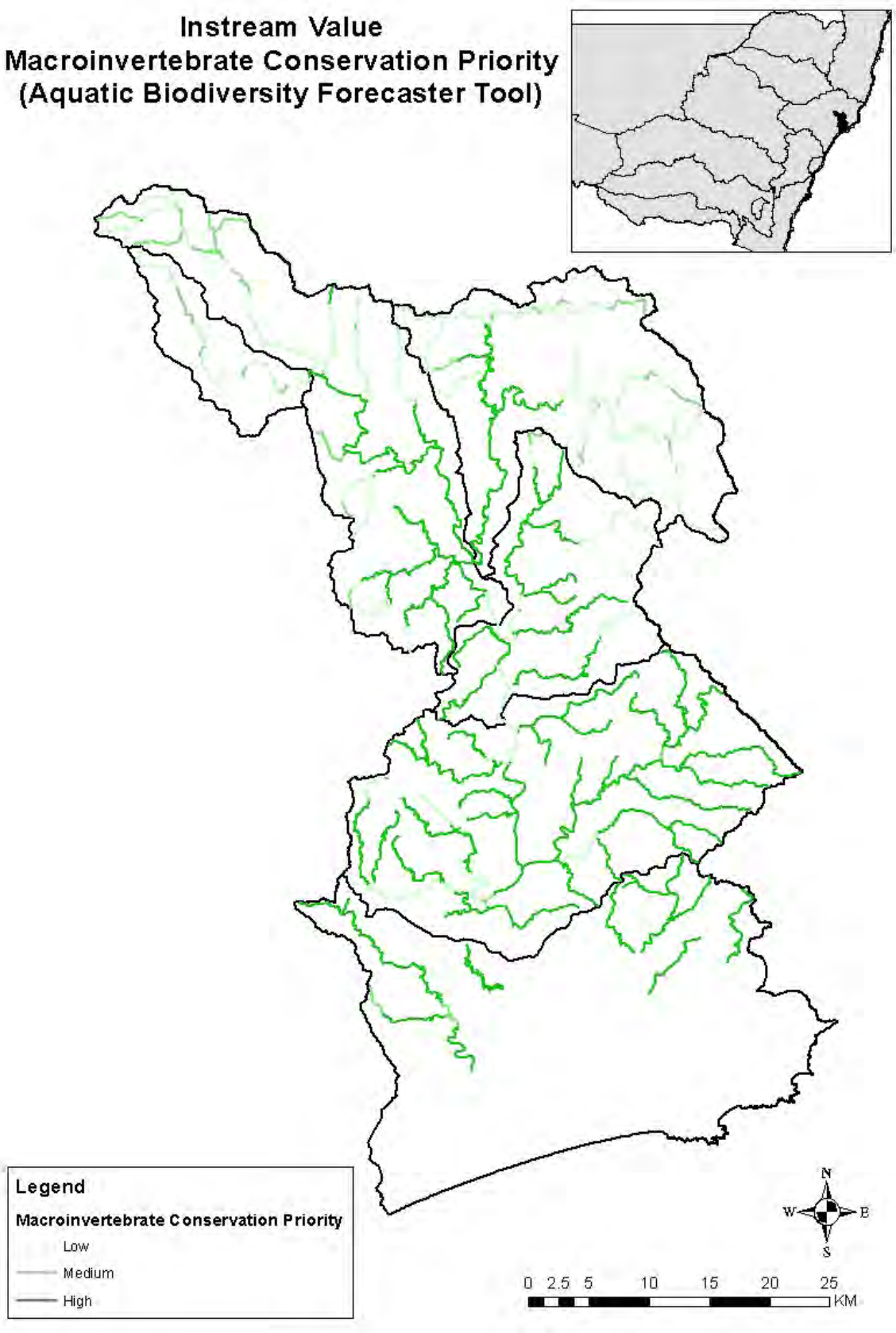


Figure 21. Karuah River In-stream Value Macroinvertebrate Conservation Priority (Aquatic Biodiversity Forecaster Tool)

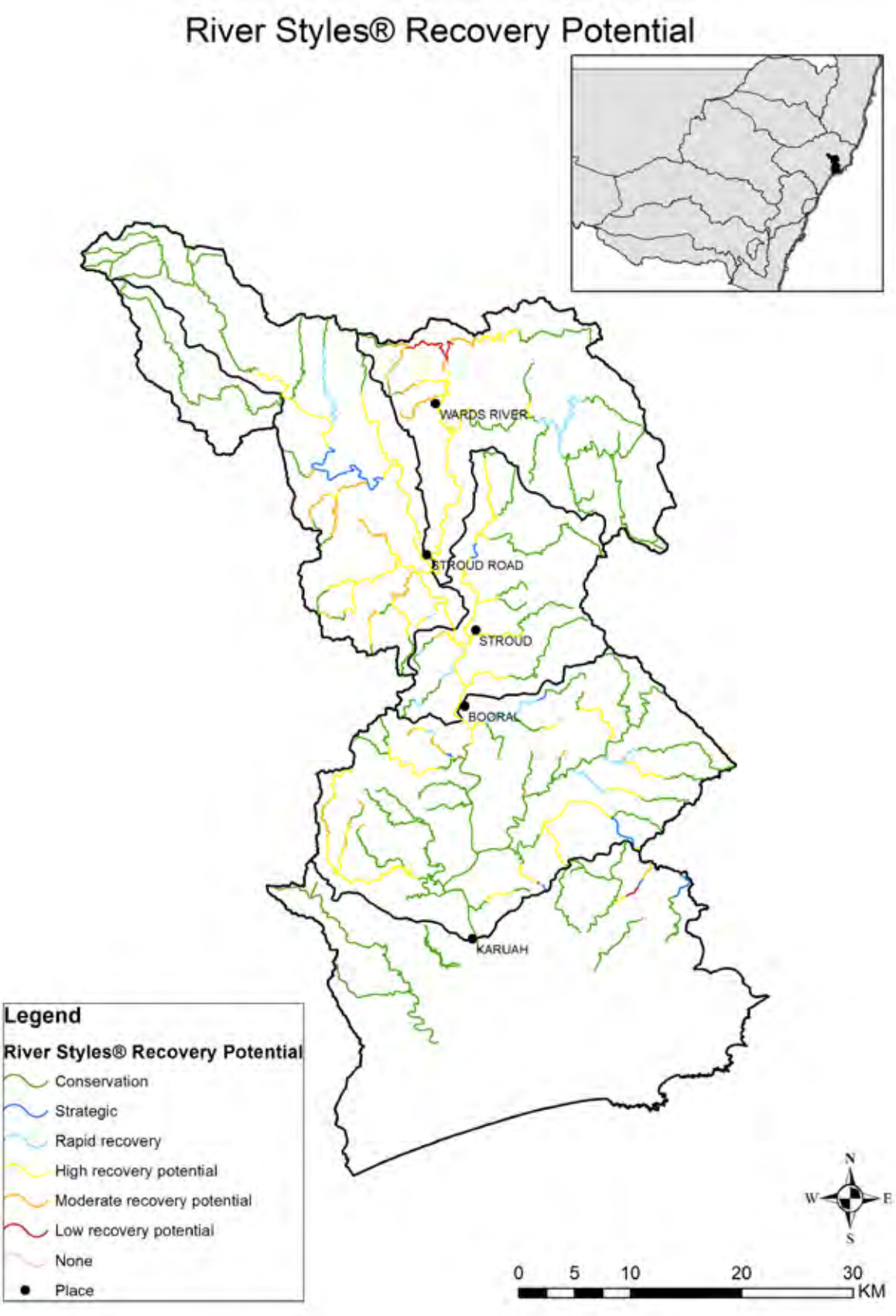


Figure 22. Karuah River, River Styles Recovery Potential

APPENDIX 5

Related Plans, Documents and Strategies

Agency	Title	Adopted
GLC	Great Lakes Local Environment Plan (LEP)	2014
	Great Lakes Development and Construction Plan (DCP)	2014
	Great Lakes Council Delivery Plan	2013-17
	Tops to Lakes Initiative	
	Great Lakes 2030 - Community Strategic Plan	2012
	Great Lakes Water Quality Improvement Plan	2009
	Great Lakes Rural Living Strategy	2009
	Great Lakes Heritage Study	2007
	Great Lakes Rural Living Strategy	2004
	Erosion and Sediment Control Policy	2002
MNCWCC	MNCWCC Regional Weed Management Strategy	2010-2015
MCW	Sustainable Water Cycle Management Strategy	2008
NPWS	Barrington Tops National Park, Mount Royal National Park, and Barrington Tops State Conservation Area Plan of Management	2010
	Monkerai Nature Reserve Plan of Management	2008
	Myall Lakes National Park, Little Broughton Island and Stormpetrel Nature Reserve Plan of Management	2002
	Karuah, Medowie and Wallaroo Group of Reserves (Incorporating Karuah National Park, Wallaroo National Park, Karuah State Conservation Area, Medowie State Conservation Area, Karuah Nature Reserve and Medowie Nature Reserve) Draft Plan of Management	2012
	Statement of Management Intent, Black Bulga State Conservation Area	
	Statement of Management Intent, The Glen Nature Reserve	
	Statement of Management Intent, Ghin-doo-ee National Park	
Hunter LLS	Hunter Central Rivers Catchment Action Plan	2013-2023
Crown Lands	Regional Reserves Strategy	2006
DPI (Fisheries)	Fisheries NSW Strategic Plan	2012-2015
	NSW Oyster Industry Sustainable Aquaculture Strategy, Second Edition	2014
Forest Corporation	Weed Management Plan - Central Region	2006
	Ecologically Sustainable Forest Management Plan - Northern Region	2005
PSC	Port Stephens Local Environment Plan (LEP)	2013
	Port Stephens Development Control Plan	2013
	Karuah Growth Strategy	2001
NoW	Water Sharing Plan for the Karuah River Water Source	2003
	River Condition Index in New South Wales: method development and application	2012

Agency	Title	Adopted
OEH	An Ecological Health Assessment of the Karuah River	2012
	NSW Biosecurity Strategy	2013-2021
	Mid North Coast Regional Conservation Plan (Draft)	2011
	New South Wales Natural Resources Monitoring, Evaluation and Reporting Strategy	2010-15
	NSW Biodiversity Strategy (Draft)	2010-2015
DP&E	Mid North Coast Regional Planning Strategy	2009
Port Stephens and Myall Lakes Estuary Management Committee	Port Stephens / Myall Lakes Estuary Management Plan	2000
HCED	A Strategy for the Management of Roadside Environments in the Hunter, Central and Lower North Coast Region of NSW	2007
	Hunter & Central Coast Regional Environmental Management Strategy	2010
MPA Now known as DPI (Marine Parks)	Port Stephens - Great Lakes Marine Park Operational Plan	2010

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