Appendix 1: Planning Context

This Appendix provides detailed information on the planning processes that apply to the management of the Richmond River estuary.

1. PLANNING CONTEXT

1.1 NSW Coastal Zone Management Planning Process

1.1.1 NSW State Rivers and Estuaries Policy, 1993

The policy requires that the sustainability of the river and estuarine resources and their biophysical functions will be given explicit consideration in resource management decision making. The objectives of the policy are to manage the rivers and estuaries of NSW in ways which:

- Slow, halt or reverse the overall rate of degradation in their systems;
- Ensure the long-term sustainability of their essential biophysical functions, and
- Maintain the beneficial use of these resources.

These objectives will be achieved through the application of the following management principles:

- Those uses of rivers and estuaries which are non-degrading should be encouraged;
- Non-sustainable resource uses which are not essential should be progressively phased out;
- Environmentally degrading processes and practices should be replaced with more efficient and less degrading alternatives;
- Environmental degraded areas should be rehabilitated and their biophysical functions restored;
- Remnant areas of significant environmental values should be accorded special protection; and
- An ethos for the sustainable management or river and estuarine resources should be encouraged in all agencies and individuals who own, manage or use these resources, and its practical application enabled.

1.1.2 Coastal Zone Management Program

The NSW Government's Estuary Management Program was established in 1992 with the aim of protecting and restoring the health and functionality of estuaries along the NSW coastline and to implement the State Government's Estuary Management Policy, 1992. The program encourages local stakeholders to responsibly manage their local estuaries through the formation of an Estuary Management Committee and the development of an Estuary Management Plan that reflects the needs of the local community and the environment, identifying issues, possible solutions and methods to implement them.

Coastal councils are now required to prepare a coastal zone management plan (CZMP) in accordance with the guidelines adopted in 2010 under section 55D of the Coastal Protection Act, 1979 (DECCW 2010c). The Guidelines replace the draft Estuary Management Manual (NSW Government, 1992).

The CZMP supports the goals and objectives of the NSW Coastal Policy 1997 and the NSW Sea Level Rise Policy Statement, 2009 and assists in implementing integrated coastal zone management. The draft CZMP was prepared in accordance with Part 4A of the Coastal Protection Act, 1979 and CZMP guidelines (DECCW, 2010c).

Councils are to submit draft CZMPs to the Minister administering the Coastal Protection Act 1979 for certification under the Act. When a draft CZMP is submitted, the Minister will make an assessment of whether to certify the CZMP by considering whether it meets the requirements of the Coastal Protection

Act 1979 and the minimum requirements in these guidelines. The Minister may refer the draft CZMP to the NSW Coastal Panel for review (Figure 1).

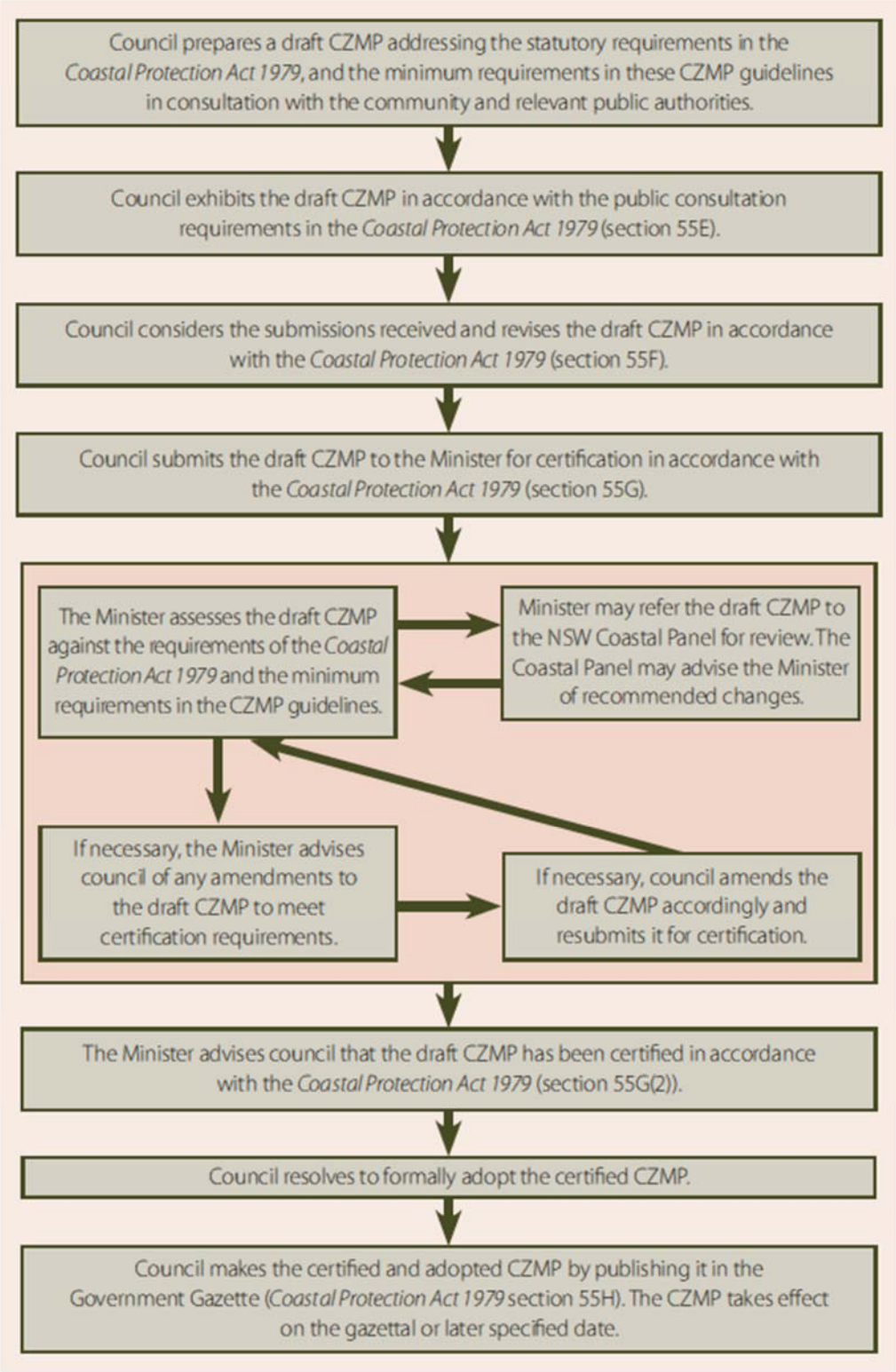

Figure 1: CZMP preparation and certification process (DECCW, 2010c)

1.1.3 NSW Coastal Policy, 1997

The NSW Coastal Policy was introduced with the aim of protecting and conserving coastal environments, including estuarine environments, for future generations. The Policy responds to the fundamental challenge to provide for population growth and economic development without placing the natural, cultural, spiritual and heritage values of the coastal environment at risk. To achieve this, the Policy has a strong integrating philosophy based on the principles of ecologically sustainable development (ESD).

The Coastal Policy represents an attempt by Government to better co-ordinate the management of the coast by identifying, in a single document, the State's various management policies, programs and standards as they apply to a defined coastal zone. These policies, programs and standards frequently obtain their legitimacy from other legislation or programs and are often implemented by local councils or the community, either in partnership with the State Government or independently.

The Policy addresses a number of key coastal themes including:

- Population growth in terms of physical locations and absolute limits;
- Coastal water quality issues, especially in estuaries;
- Disturbance of acid sulfate soils;
- Establishing an adequate, comprehensive and representative system of reserves;
- Better integration of the range of government agencies and community organisations involved in coastal planning and management;
- Indigenous and European cultural heritage; and
- Integration of the principles of ESD into coastal zone management and decision making.

The management of the coastal zone is the responsibility of a range of government agencies, local councils and the community. The Policy provides a framework for the balanced and coordinated management of the coast's unique physical, ecological, cultural and economic attributes.

1.2 Other Relevant Management Policies

1.2.1 NSW Wetland Policy, 2010

Consistent with the priority on natural resources management in the NSW State Plan to deliver better outcomes for native vegetation, biodiversity, land, rivers and coastal waterways, this policy aims to provide for the protection, ecologically sustainable use and management of NSW wetlands.

The policy covers all wetlands in the state, including those that are mapped and the many that are yet to be formally identified in recognition of their critical importance in the ecological and hydrological systems of the state's catchments.

The State Plan, which this policy is aligned with, includes a target for improving the condition of 'important wetlands' (defined as being those listed under the Ramsar Convention or in the Directory of Important Wetlands in Australia, Environment Australia, 2001). Within the Richmond River estuary, the Bundjalung National Park and the Broadwater wetlands are listed as nationally important wetlands.

Other significant wetlands in NSW include those mapped under State environmental planning policy no. 14 – Coastal wetlands (SEPP 14) and others listed as endangered ecological communities under the Threatened Species Conservation Act 1995. Numerous other wetlands also provide significant ecosystem services and are valued by local communities. In recognition of the State Plan wetland target, and to

maintain an extensive and diverse state-wide network of wetlands, this policy proposes to focus on sites of:

- International importance (RAMSAR sites);
- National importance, that is, sites listed in the Directory of important wetlands of Australia;
- Regional significance, for example, sites identified by regional organisations dealing with natural resource management in consultation with their communities.

Opportunities to support local wetlands in partnership with land holders should also be considered and identified in investment or management plans.

1.2.2 NSW State Groundwater Policy Framework Document, 1997

The purpose of the Groundwater Framework Policy document is to provide a clear NSW government policy direction on the ecologically sustainable management of the State's groundwater resources for the people of NSW. The focus of the Policy is on water below the ground surface in a geological structure or formation, and on the ecosystems from which these waters are recharged or into which they discharge. It provides for the better consideration of all issues which affect, or are likely to affect the condition and functioning of the resources of these areas including water chemistry, geology, aquifer recharge and discharge, and dependent ecosystems such as wetlands, lakes and streams, springs and seeps. It requires that careful consideration be given to all factors affecting the stability, vulnerability, and productivity of these systems.

1.2.3 NSW Government Sea Level Rise Policy Statement, 2009

To support sea level rise adaptation, the NSW Government has prepared a Sea Level Rise Policy Statement. This sets out the Government's approach to sea level rise, the risks to property owners from coastal processes and assistance that Government provides to Councils to reduce the risks of coastal hazards.

The Policy Statement includes sea level planning benchmarks which have been developed to support consistent consideration of sea level rise in land-use planning and coastal investment decision-making. The adopted benchmarks are for a rise relative to 1990 mean sea levels of 40 cm by 2050 and 90 cm by 2100. These benchmarks represent the Government's guidance on sea level rise projections for use in decision-making.

1.2.4 NSW Oyster Industry Sustainable Aquaculture Strategy, 2006

The NSW Oyster Industry Sustainable Aquaculture Strategy (OISAS):

- identifies those areas within NSW estuaries where oyster aquaculture is a suitable and priority outcome;
- secures resource access rights for present and future oyster farmers throughout NSW;
- documents and promotes environmental, social and economic best practice for NSW oyster farming and ensures that the principles of ecological sustainable development, community expectations and the needs of other user groups are integrated into the management and operation of the NSW oyster industry;
- formalises industry's commitment to environmental sustainable practices and a duty of care for the environment in which the industry is located;

- provides a framework for the operation and development of a viable and sustainable NSW oyster aquaculture industry with a clear approval regime and up-front certainty for existing industry participants, new industry entrants, the community and decision makers;
- identifies the key water quality parameters necessary for sustainable oyster aquaculture and establishes a mechanism to maintain and where possible improve the environmental conditions required for sustainable oyster production; and
- ensures that the water quality requirements for oyster growing are considered in the State's land and water management and strategic planning framework.

1.2.5 NSW Diffuse Source Water Pollution Strategy

The NSW Diffuse Source Water Pollution Strategy provides a framework for coordinating efforts in reducing diffuse source water pollution across NSW. The Strategy promotes partnerships, provides a guide for investment, and provides a means to share information on projects and their outcomes across the State. Developing and implementing this Strategy is a joint initiative by the State's natural resource managers (at State, regional and local government levels), building on and supporting a range of existing diffuse source water pollution management actions.

The main aim of the Strategy is to reduce diffuse source water pollution inputs into all NSW surface and ground water and contribute towards the community agreed NSW water quality objectives and State-wide Natural Resource Management targets listed in the State Plan - A new direction for NSW.

A Priority Action Plan has been developed as part of the NSW Diffuse Source Water Pollution Strategy. It identifies agreed projects that will be progressed across NSW to help improve management of priority diffuse source water pollution problems. The first NSW Diffuse Source Water Pollution Strategy Annual Report was published in November 2010. It reports on the implementation of the individual actions identified it the Priority Action Plan.

1.3 Regional Management Plans

1.3.1 Estuary General Fisheries Management Strategy

The Estuary General Fishery is one of nine major commercial fisheries in NSW. It is a large and diverse fishery harvesting a wide range of finfish and shellfish for sale from estuarine waters using a range of commercial fishing gear. The fishery also includes the taking of invertebrates (such as beachworms and pipis) by hand from ocean beaches. The strategy contains the goals and objectives for the fishery, a detailed description of the way the fishery operates, and describes the management framework for the future. It also outlines a program for monitoring the biological, social and economic performance of the fishery, establishes trigger points for the review of the strategy, and requires annual reporting on performance in order to ensure the objectives set out in the strategy are met. Information about the impacts of harvesting by other fishing sectors (such as recreational fishing) is also provided, however the rules applying to such sectors are dealt with under separate management arrangements and are not the subject of this strategy.

1.3.2 Status of Fisheries Resources Report

The Status of Fisheries Resources in NSW 2006/07 is a general overview of the state of fish populations that are harvested by commercial fisheries that are licensed by NSW DPI. In particular, the document contains a summary of the state of knowledge of all 92 key species taken by the Estuary General, Estuary Prawn Trawl, Ocean Hauling, Ocean Trawl and Ocean Trap and Line Fisheries.

1.3.3 Northern Rivers Regional Biodiversity Management Plan

The Northern Rivers Regional Biodiversity Management Plan constitutes the national regional recovery plan under the Environment Protection and Biodiversity Conservation Act 1999 for threatened species and ecological communities principally distributed in the Northern Rivers Region of NSW. The Plan is part of an Australian Government-funded pilot to trial the integration of regional recovery and threat abatement planning. It provides a regional approach to the delivery of recovery actions necessary to ensure the long-term viability of threatened species and ecological communities in the Region.

1.4 Local Management Plans

1.4.1 Catchment Action Plan

Catchment management has a direct impact on estuarine environments. The condition of an estuary reflects the land-use activities occurring in the catchment upstream and it is critical to consider the catchment management framework in relation to estuary management planning.

The Catchment Management Authorities Act 2003 requires each catchment management authority to prepare catchment action plans in partnership with regional community and government agencies. A catchment action plan sets out the long-term direction for community and government investment and action in natural resource management. It is the primary mechanism for regional delivery of the NSW State Plan's targets for biodiversity, water, land and community.

The 2006 Northern Rivers Catchment Action Plan (CAP) has been developed by the Northern Rivers Catchment Management Authority (NRCMA) under the Catchment Management Authorities Act 2003 (NRCMA, 2006). The Plan sets a 10-year investment strategy for targeted investment for the region which extends over most of the NSW North Coast, from the Camden Haven River in the south to the Queensland border in the north and extending west to the Northern Tablelands.

The CAP draws together targets outlined in three previous Catchment Blueprints that have been reviewed and evaluated through a facilitated process of stakeholder engagement. Targets aim to improve the natural assets such as water, coastal landscapes and estuaries, the marine environment, soil, cultural heritage and biodiversity. The CAP also promotes the value of communities in the catchment, and aims to capture the communities' priorities and aspirations for the protection and enhancement of natural resources in the region.

The CAP outlines many varied approaches to achieve targets, the majority of which rely on voluntary input from landholders and other stakeholders. The CAP also provides priorities to guide a range of other processes including local government and NSW Government regulatory processes.

The Natural Resources Commission (NRC) has a statutory role to audit whether the NSW CAPs are being implemented effectively. The audit of the Northern Rivers CAP was undertaken in November 2009.

1.4.2 Interim Water Quality and River Flow Objectives

The ANZECC Guidelines for Fresh and Marine Water Quality (2000) provide a framework for conserving ambient water quality in rivers, lakes, estuaries and marine waters. This framework is used to develop water quality and river flow objectives.

DECCW (then EPA) has developed water quality and river flow objectives for the Richmond River Catchment. Each objective aims to improve river health by recognising the importance of natural river flow patterns. Councils are required to consider these environmental values and long-term goals when assessing and managing the likely impact of its activities on waterways.

The objectives were developed in a whole of government process lead by DECCW. Objectives were developed through extensive community consultation and are intended to assist resource managers in assessing and setting targets for environmental values with associated water quality indicators defined by ANZECC.

There are eleven WQOs that provide reference levels to guide water quality planning and management. The objectives consist of three parts, environmental values, their indicators, and their numerical criteria. Environmental values outline values and beneficial uses of the environment that are important to a community. The primary contact recreation environmental value for example, includes swimming or any activity with a likelihood of water being swallowed. The indicators provide a measurement of specific environmental trends while the criteria provide the framework for measuring how close current water quality is to meeting the desired levels.

1.4.3 Water Sharing Plan

DECCW has prepared a draft Water Sharing Plan for the Richmond River Area unregulated, regulated and alluvial water sources (under the management and licensing provisions of the Water Management Act 2000). The draft Plan was placed on public exhibition between 9 November 2009 and 15 January 2010. The Plan focuses on water sharing rules for the environment, access rules and extraction allowances and dealing rules which control the trade of water.

1.4.4 National Parks and Reserves Plans of Management

The management of national parks, nature reserves and state conservation areas in NSW is in the context of the legislative and policy framework, primarily the National Parks and Wildlife Act 1974 (NPW Act), the NPW Regulation, Threatened Species Conservation Act 1995 (TSC Act) and the policies of the National Parks and Wildlife Service (NPWS).

Other legislation, international agreements and charters may also apply to management of the area. In particular, the Environmental Planning and Assessment Act 1979 (EPA Act) may require the assessment and mitigation of the environmental impacts of works proposed in this plan. The Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) also applies in relation to actions that may impact on matters of national environmental significance, such as migratory species and threatened species listed under that Act.

A plan of management is a statutory document under the NPW Act. Once the Minister has adopted a plan, no operations may be undertaken within the planning area except in accordance with this plan. This plan will also apply to any future additions to the planning area. Should management strategies or works be proposed for the planning area or any additions that are not consistent with this plan, an amendment to this plan or a new plan will be prepared and exhibited for public comment.

The following Plans of Management are relevant to the Richmond River estuary:

- Bungawalbin and Yarringully Parks and Reserves Draft Plan of Management;
- Richmond River Nature Reserve Plan of Management (2005); and
- Broadwater National Park, Bundjalung National Park and Iluka Nature Reserve Plan of Management (2005).
- Ballina Nature Reserve Plan of Management (2003)

1.4.5 Crown Reserves Plans of Management

Plans of Management for Crown Reserves have been prepared in accordance with the provisions of Section 112 of the Crown Lands Act 1989. The plans aim to enhance public access, tourism and recreation opportunities on the Crown Reserves. Issues addressed include:

- Improved facilities and infrastructure for open space and foreshore areas
- Improved public foreshore access and pedestrian linkages
- Management of native vegetation
- Management of foreshore erosion
- A range of strategies to support the long-term financial sustainability of the foreshore reserve system

Relevant plans include:

- Woodburn Master Plan, Plan of Management and Risk Management Plan (draft 2010);
- Coraki Master Plan, Plan of Management and Risk Management Plan (draft 2010); and
- Evans Head Coastal Reserves Plan of Management (2010).

1.4.6 Wilsons River Catchment Plan

The Wilsons River Catchment Management Plan (CMP) is a risk-based catchment and investment strategy to direct activities aimed at protecting drinking water quality at the Wilsons River Source and an environmental monitoring program to underpin the ongoing adaptive management of the water source catchment. The present CMP report has been developed as a point of reference to support catchment management activities. Management issues and options identified in the plan were derived from the CMP project risk assessment, literature review, community consultation and catchment modelling.

1.4.7 Health Rivers Commission Inquiries

The Healthy Rivers Commission conducted an inquiry into NSW Coastal Lakes to highlight the need for improved and coordinated management of coastal lakes. The Commission's principal recommendation is that the Government adopts a new comprehensive, and more effective set of over-arching arrangements for the management of coastal lakes and their catchments, through endorsement of the Coastal Lakes Strategy: An Assessment and Management Framework. The recommended Coastal Lakes Strategy builds on recent government decisions and proposals in its Action for the Environment: Environment Statement 2001 and the Coastal Protection Package. A central element of the strategy is the preparation of Sustainability Assessment and Management Plans for coastal lakes, which themselves would constitute key elements of the Comprehensive Coastal Assessment that the Government has initiated. The Coastal Lakes Strategy is an over-arching set of arrangements designed to improve the management (by all relevant parties) of coastal lakes and their catchments so that progress towards the long term goal of healthier coastal lakes is achieved in a timely and cost effective manner. The strategy incorporates:

- Principles for managing coastal lakes,
- A framework for managing major classes of coastal lake,
- A classification of coastal lakes,
- Requirements for preparing and implementing Sustainability Assessment and Management Plans for each coastal lake,

- Implementation arrangements, and
- A range of supporting initiatives.

1.4.8 Northern Rivers Farmland Protection Project

The Farmland Protection Project seeks to protect important farmland from urban and rural residential development by mapping farmland and developing planning principles. The project endeavoured to put forward policies which can be of genuine long-term benefit to agriculture in the region without imposing unnecessary restrictions on farmers.

The project aims to protect a broad range of lands to cater for a range of agricultural industries that may be important currently or in the future, thereby keeping land options open for new crops and farming methods. Urban and rural residential development will be limited on land identified by the project so that areas with the most potential for production are not lost to urban uses.

1.4.9 Far North Coast Regional Strategy 2006 - 2031 (2006)

The Far North Coast Regional Strategy (FNCRS) aims to guide local planning in the six north coast LGAs for the next 25 years and inform decisions on service and infrastructure delivery. The FNCRS identifies priority areas for development for economic and residential purposes over the next 25 years.

1.4.10 Far North Coast Regional Conservation Plan (Draft, 2009)

Within the FNCRS, the Government committed to the development of a Far North Coast Regional Conservation Plan (the RCP). The RCP is a partner document to the FNCRS. The RCP identifies priority conservation outcomes over the period 2006 - 2031. The RCP also provides an offset guide to maximise the conservation of biodiversity over the next 25 years by focusing future offsetting effort to ensure biodiversity values are improved or maintained.

1.4.11 Floodplain Management Plans

The Floodplain Development Manual published in 2005 was prepared in accordance with the NSW Government's Flood Prone Land Policy. It guides councils in the development and implementation of detailed local floodplain risk management plans to produce robust and effective floodplain risk management outcomes.

The floodplain risk management process consists of the following steps:

- Flood Study: Defines the nature and extent of the flood problem, in technical rather than map form.
- Floodplain Risk Management Study: Determines options in consideration of social, ecological and economic factors relating to flood risk.
- Floodplain Risk Management Plan: Preferred options publicly exhibited and subject to revision in light of responses. Formally approved by the council after public exhibition and any necessary revisions due to public comments.
- Plan Implementation: Implementation of flood, response and property modification measures (including mitigation works, planning controls, flood warnings, flood readiness and response plans, environmental rehabilitation, ongoing data collection and monitoring) by Council.

The status of Floodplain Risk Management Plans within the lower Richmond valley is shown in Table 1.

Table 1 – Floodplain Management Plans

Council	River	Urban Centres	Floodplain Risk Planning Status
Richmond Valley	Richmond	Casino	Casino FS – 1988 Casino FRMS & MP - 2002
Lismore City	Wilson	Lismore	Lismore FS & FRMS – 1993 Lismore FRMP – 2001 Lismore FRMP Update – underway-scheduled completion late 2011.
Richmond Valley	Mid Richmond	Tatham, Caraki, Woodburn, Broadwater	Mid-Richmond FS – 1999 Mid-Richmond FRMS – 2002 Mid-Richmond FRMP – 2004 Mid-Richmond Flood Mapping Study - 2010
Ballina Shire	Richmond	Cabbage Tree Island	Cabbage Tree Island FRMP - 2009
Ballina Shire	Richmond	Wardell	Wardell FRMP - 2009
Ballina Shire	Lower Richmond	Ballina	Ballina FS (update) – 2008 Ballina FRMS & FRMP –Underway – scheduled for completion in late 2011.

Note: FS – Flood Study, FRMS – Floodplain Risk Management Study, FRMP – Floodplain Risk Management Plan.

1.5 Planning Instruments

Planning and development in NSW is carried out under the Environmental Planning and Assessment Act 1979 and Environmental Planning and Assessment Regulation 2000. Environmental planning instruments (state environmental planning policies and local environmental plans) are legal documents that regulate land use and development.

Table 2 – State Environmental Planning Policies

Policy	Application to this Study
North Coast REP (1988)	This plan covers all of the North Coast LGAs. It identifies environmental features that are important to the region and provides a basis for new urban and rural development. The plan sets requirements for, and guides, the preparation and processing of local environmental plans and some forms of development.
SEPP Rural Lands, 2008	The aim of this policy is to facilitate the orderly and economic use and development of rural lands for rural and related purposes.
SEPP Remediation of Land, 1998	Councils must ensure contaminated land undergoes remediation before it is developed through the application of land remediation guidelines. The appropriate management and remediation of contaminated sites will minimise the risk of contamination of waterways.
SEPP Building Sustainability Index (BASIX), 2004	BASIX was mandatory for regional NSW from 2005/06. All new residential development, as well as residential alterations and additions, are required to meet targets for water and energy efficiency. This SEPP operates in conjunction with the EP&A Amendment (BASIX) Regulation 2004.

Policy	Application to this Study
SEPP Infrastructure, 2007	Provides a consistent planning regime for infrastructure and the provision of services across NSW, along with providing for consultation with relevant public authorities during the assessment process. The SEPP supports greater flexibility in the location of infrastructure and service facilities along with improved regulatory certainty and efficiency The policy consolidates and updates 20 previous State planning instruments which included infrastructure provisions. It also includes specific planning provisions and development controls for 25 types of infrastructure works or facilities.
SEPP Major Development, 2005	Defines certain developments that are major projects to be assessed under Part 3A of the Environmental Planning and Assessment Act 1979 and determined by the Minister for Planning. It also provides planning provisions for State significant sites. In addition, the SEPP identifies the council consent authority functions that may be carried out by joint regional planning panels (JRPPs) and classes of regional development to be determined by JRPPs. Note: This SEPP was formerly known as State Environmental Planning Policy (Major Projects) 2005.
SEPP 71 Coastal Protection	The policy has been made under the Environmental Planning and Assessment Act 1979 to ensure that development in the NSW coastal zone is appropriate and suitably located, to ensure that there is a consistent and strategic approach to coastal planning and management and to ensure there is a clear development assessment framework for the coastal zone
SEPP 62 Sustainable Aquaculture	Encourages the sustainable expansion of the industry in NSW. The policy implements the regional strategies already developed by creating a simple approach to identity and categorise aquaculture development on the basis of its potential environmental impact. The SEPP also identifies aquaculture development as a designated development only where there are potential environmental risks.
SEPP 44, Koala Habitat Protection	Encourages the conservation and management of natural vegetation areas that provide habitat for koalas to ensure permanent free-living populations will be maintained over their present range. The policy applies to 107 local government areas. Local councils cannot approve development in an area affected by the policy without an investigation of core koala habitat. The policy provides the state-wide approach needed to enable appropriate development to continue, while ensuring there is ongoing protection of koalas and their habitat
SEPP 26 Littoral Rainforests	Protects littoral rainforests, a distinct type of rainforest well suited to harsh salt-laden and drying coastal winds. The policy requires that the likely effects of proposed development be thoroughly considered in an environmental impact statement. The policy applies to 'core' areas of littoral rainforest as well as a 100 metre wide 'buffer' area surrounding these core areas, except for residential land and areas to which SEPP No. 14 - Coastal Wetlands applies.
SEPP 19 Bushland in Urban Areas	Protects and preserves bushland within certain urban areas, as part of the natural heritage or for recreational, educational and scientific purposes. The policy is designed to protect bushland in public open space zones and reservations, and to ensure that bush preservation is given a high priority when local environmental plans for urban development are prepared.

Policy	Application to this Study
SEPP 14 Coastal Wetlands	Ensures coastal wetlands are preserved and protected for environmental and economic reasons. The policy applies to local government areas outside the Sydney metropolitan area that front the Pacific Ocean. Land clearing, levee construction, drainage work or filling may only be carried out within these wetlands with the consent of the local council and the agreement of the Director General of the Department and Planning. Such development also requires an environmental impact statement to be lodged with a development application.

1.6 Local Government Planning Context

Local environmental plans guide planning decisions for local government areas. Through zoning and development controls, they allow councils to supervise the ways in which land is used. Ballina Shire, Lismore City and Richmond Valley Councils have prepared Draft LEPs in accordance with the new standard instrument.

Development control plans, prepared in accordance with the Environmental Planning and Assessment Act, are also used to help achieve the objectives of the local plan by providing specific, comprehensive requirements for certain types of development or locations, e.g. for urban design, and heritage precincts and properties.

1.6.1 Richmond and Brunswick Catchment Model

The Richmond and Brunswick Catchment Model, a three-dimensional Z scale creation representing a river catchment, is a regional education initiative involving Rous Water, Richmond River County Council, Lismore City, Byron Shire, Ballina Shire, Richmond Valley and Kyogle Shire Council.

The model has three running creeks and a river, an estuary and beach to show how the water cycle works, as well as street drains, canals and a sewerage treatment plant to show how reticulated water and waste water also affects the catchment.

The model is contained within a trailer so it can be transported and set up just about anywhere. The project partners will be taking it to schools, local events, markets and field days.

1.6.2 Council Strategic Plans

Strategic plans prepared by the local Councils are discussed in the following tables.

Table 3 – Ballina Shire Council Strategic Plans

Plan	Application to this Study
Community Strategic Plan and Delivery Program	As part of the Department of Local Government's Integrated Planning and Reporting Framework, Council prepared a Community Strategic Plan (CSP) from which a Delivery Program was developed. The Delivery Program provides a summary of the actions Council is undertaking to achieve the CSP Objectives and Outcomes. The Operational Plan outlines the principal activities (i.e. services) to be provided in each year, along with the key service delivery measures that are being recorded to achieve the actions identified in the CSP and the Delivery Program. Relevant Delivery Program actions include: • Provide a proactive approach to Coastline Management to ensure the community is informed and appropriate strategies are in place; • Provide a proactive approach to Flood Management to maximise community safety and knowledge • Provide contemporary stormwater management and infrastructure to minimise environmental impacts • Improve overall health of Richmond River • Continue bush land regeneration work • Progress resource sharing arrangements with other local government authorities to increase efficiencies • Progress Coastal Reserve Planning
Ballina Foreshore Master Plan	The Ballina Foreshore Master Plan builds on existing information on Crown land and Council sites on the Richmond River foreshore located between Burns Point ferry and the Missingham Bridge. The foreshore land includes several large Crown and Council sites and a number of smaller ones that together provide a foreshore asset for the Ballina community. In preparing g the Ballina Foreshore Master Plan each site was assessed in terms of physical and environmental characteristics, existing infrastructure and facilities and planning constraints and opportunities.

Plan	Application to this Study
Ballina Coastal Reserve Precinct Plan	The Ballina Coastal Reserve Plan of Management has been developed for the coastal Crown lands within Ballina Shire north of the Richmond River to the northern Shire boundary. The Ballina Coastal strip consists of 93% Crown land of the immediate coastal foreshore and approximately 85% of all land east of the Coast Road. The preparation of the Plan of Management allowed for the creation of a single Reserve for Public Recreation and Coastal Environmental Protection under section 87 - Crown Lands Act 1989 that is known as the Ballina Coastal Reserve. Ballina Council was subsequently appointed as the Trust manager of this very large Crown Reserve. The Ballina Coastal Reserve Plan of Management was prepared to assist Ballina Shire Council in achieving integrated, balanced, responsible and ecologically sustainable development and management of the Ballina Shire coast. The Precinct Plans are designed to develop the management objectives and recommended management strategies found in the Plan of Management. Precinct Plans are action plans developed at a local level to address social, recreational and environmental issues. The five Precincts delineated in the Plan of Management are: 1. Northern Shire boundary on Seven Mile Beach to Ross Street just south of Lake Ainsworth 2. Lake Ainsworth to Shag Rock (south of Lennox Point) 3. Shag Rock, Boulder Beach, Skennars Head and North Sharpes Beach 4. Flat Rock, Angels Beach and Black Head 5. Shelley Beach, Ballina Lighthouse Beach, Shaws Bay and surrounds.
Vegetation and Land Management in the Maquires Creek Catchment	This report has been prepared for Richmond Landcare Inc. and Ballina Shire Council, in conjunction with Landcare groups in the Maguires Creek catchment, to provide information relating to the current land use, existing native vegetation and environmental restoration projects being undertaken within the catchment.
Shaws Bay Estuary Management Plan	The Management Plan documents the management needs of Shaws Bay and the proposed activities which will address these needs.
Lake Ainsworth Management Plan	The Management Plan develops appropriate management objectives and actions relating to Lake Ainsworth.
Chickiba Lakes Acid Sulfate Soils and Wetland Management Plan, 2006	This Plan assesses and sets out the requirements for management of any site disturbance associated with infrastructure maintenance (mainly drain clearing), wetland rehabilitation works, and other minor works that may impact on Acid Sulfate Soils (ASS) in the Chickiba Lakes area at East Ballina. The aim of this Chickiba Lakes ASS and Wetland Management Plan is to undertake an assessment of the present ASS status of the defined sites, and provide future management recommendations for the Chickiba Lakes area.
Vegetation Management Plans	Ballina Council is in the process of producing Vegetation Management Plans for all the reserves in the Shire that contain native vegetation.
Acid Sulfate Soils Management Plan	Recent changes to Council's local environmental plan now require development consent to be obtained for certain works on lands where there is a potential to expose acid sulfate soils, either by excavation or by lowering the water table.

Plan	Application to this Study
Coastline Management Study	Part one of the Ballina Coastline Management Study (Values Assessment) identifies the ecological, cultural, heritage, recreational and economic values of the Ballina coastline. Part two of the study (Management Options Assessment) identifies where coastal values may be under threat from coastline erosion and outlines various management options.
Wardell and Cabbage Tree Island Floodplain Risk Management Study	This report documents the findings of investigations undertaken to assess a range of potential flood damage reduction measures that could be implemented at Wardell and Cabbage Tree Island. It also documents measures to address emergency response management issues that are likely to exist at Cabbage Tree Island during major flooding of the Richmond River
State of the Environment Report	SOE reporting is effectively a "Report Card" on the condition of the environment and natural resources. Council prepares these reports each year, as a measure of what initiatives have been undertaken in the local area in response to environmental issues, and to assess new emerging environmental trends.
Lower Richmond River Recreational Boating Study	The Study formulates an integrated short term and long term strategy, comprising strategic options that will address the current and future needs and requirements of recreational boating within the lower Richmond River Estuary, including a program of works and actions to establish Ballina as a premier recreational boating destination and service centre.

Table 4 – Lismore City Council Strategic Plans

Plan	Application to this Study
Community Strategic Plan and Delivery Plan	As part of the Department of Local Government's Integrated Planning and Reporting Framework, Council prepared a Community Strategic Plan (CSP) from which a Delivery Program was developed. The Delivery Program provides a summary of the actions Council is undertaking to achieve the CSP Objectives and Outcomes. The Operational Plan outlines the principal activities (i.e. services) to be provided in each year, along with the key service delivery measures that are being recorded to achieve the actions identified in the CSP and the Delivery Program. Relevant Delivery Program actions include: • Development and implementation of Lismore Biodiversity Management Strategy • Improve catchment management
Acid Sulfate Soil Management	Council has responded to the issue of ASS management through an amendment to its Local Environment Plan and introduction of a Development Control Plan (DCP). The aims of this Plan are to ensure effective management of ASS areas by providing guidance on the procedures involved in managing ASS areas, ensuring activities within an ASS area are identified and requiring soil assessments be undertaken to clarify the extent of risk.
Water Quality and Quantity Policy	This overarching policy applies to all sections within Council having an impact on water quality and stream flows, and contains 3 relevant objectives: • To protect, restore and actively manage the riparian zone • To improve stormwater quality • To improve practices in rural areas

Plan	Application to this Study
Biodiversity – Flora and Fauna Policy	This policy applies to all sections within Council having an impact on native flora and fauna, and contains 3 objectives: • To ensure Council has the information needed to protect and manage native flora and Fauna • To improve the habitat value of remnant and regrowth native vegetation • To foster and promote protection and restoration activities
Land Management Policy	This policy applies to all sections within Council influencing land use and management, and contains 3 objectives. These are: • To create a social and planning environment that reduces conflict and uncertainty in rural zones. • To encourage sustainable land-use practices and partnerships. • To limit landuse changes that diminish scenic amenity.
Heritage Policy	This policy applies to all sections within Council having an impact on cultural and natural heritage. This policy has 3 objectives: • To improve Council's awareness and management of local Aboriginal heritage • To conserve and protect local heritage • To promote and educate the community of the benefits of heritage management
Funding and support for environmental initiatives Policy	This overarching policy applies to all sections involved in implementing the environmental policies of Council, and contains 2 objectives: • To provide adequate funding to enable Council to meet its environmental obligations • To provide adequate information at an appropriate scale to support Council's environmental decision-making.
Restoration of Tucki Tucki Creek recreation Park	Since the purchase of land for the Tucki Tucki Creek Recreation Park in Goonellabah Lismore Council has had an on-going works program to provide recreation facilities, restore vegetation along the creek and improve stormwater devices. Much of this work has utilised Commonwealth job skills programs such as Work for Dole and Greencorps. More recently Council assisted in the formation of a landcare group, made up of local residents, called 'Upper Tucki Tucki Creek Landcare'. Council has received funding under the Estuary Management Program to assist in the ongoing restoration of vegetation along the creek and improve habitat. This funding will also be used to assist the Landcare group with tools and equipment
State of the Environment Report	SOE reporting is effectively a "Report Card" on the condition of the environment and natural resources. Council prepares these reports each year, as a measure of what initiatives have been undertaken in the local area in response to environmental issues, and to assess new emerging environmental trends.
Stormwater Management Plan	As recommended by the Stormwater Management Plan 2007, Lismore City Council will be implementing a number of practices, programs and policies aim at improving the quality of stormwater flowing from the urban areas. The Stormwater Management Services Charge will allow Council to undertake stormwater management actions that would otherwise remain unfunded.

Table 5 – Richmond Valley Council Strategic Plans

Plan	Application to this Study
Community Strategic Plan	RVC is currently finalising its Community Strategic Plan following community consultation and input into development of the draft Plan.
Evans River Estuary Management Plan	The Estuary Management Plan for the Evans River has been prepared on behalf of the Evans Coastline and Estuary Management Committee, Richmond Valley Council and the Department of Land and Water Conservation, to fulfil the requirements of the NSW Estuary Management Policy (1992) and the NSW Coastal Policy (1997). The Plan provides a program of strategic actions to assist government authorities and other stakeholder groups to sustain a healthy estuary through appropriate waterway, foreshore and catchment management. The Plan presents an integrated suite of management strategies, giving due consideration to the complex interactions between many estuarine processes and functions.
Lower Evans River Dredge Feasibility Assessment	As part of the Evans River Estuary Management Study, an assessment was carried out to determine the feasibility of dredging the lower reaches of the Evans River. The feasibility of dredging sediment from the lower reaches of the Evans River was assessed with the aim of returning the river to former conditions, as much as possible. The dredging proposal considered in this assessment incorporates the removal of sediment from the bed of the Evans River between Iron Gates and the Elm Street bridge.
Richmond River Flood Mapping Report	This study represents the first stage of the floodplain risk management process. The study is the first of three studies aimed at understanding and managing flooding within the Richmond Valley between Casino, Lismore and Broadwater.
Climate Change Adaptation	At the Council meeting of 15 June 2010, Council adopted Scenario 3 to apply to the 2010 base flood modelling. Levels for this scenario have been prepared for the 20, 50, 100, 500 year and PMF design floods. The new flood levels with climate change 3 form the basis for future development. Climate Change Scenario 3: 2010 Base Design Flood Model + 900mm sea level rise + 10% increase in rainfall intensity
State of the Environment Report	SOE reporting is effectively a "Report Card" on the condition of the environment and natural resources. Council prepares these reports each year, as a measure of what initiatives have been undertaken in the local area in response to environmental issues, and to assess new emerging environmental trends.

1.6.3 Richmond River County Council

Richmond River County Council (RRCC) was constituted by proclamation on 25 November 1959 and has been delegated with the responsibility for flood mitigation activities for Ballina, Lismore and Richmond Valley Councils. Council's proclamation was amended most recently on 5 September 2008, when natural resource management was formally incorporated as a Council function.

RRCC provides a coordinating role in floodplain management, working with constituent Councils, State and Commonwealth agencies, university researchers, and floodplain industries to develop long-term effective natural resource management strategies for the Richmond River Floodplain and estuary. Council is responsible for the routine maintenance of its various canals and floodgate structures including the construction and replacement of flood mitigation infrastructure. This includes:

- 76 drainage canals totalling 140km in length.
- 450 flood control structures such as floodgates and culverts.
- 33 levees totalling 77km in length.
- Pump stations used to reduce flooding in Lismore (located at Browns, Hollingsworth and Gasworks Creeks).
- A weir in the Tuckombil Canal 1km south of Woodburn on the Pacific Highway which, (1) prevents the flow of salt water from the Evans River into the freshwaters of the mid-Richmond; (2) prevents Blackwater flows following summer floods from the Richmond impacting on the Evans; and (3) provides flood escape from the mid-Richmond.
- Lismore levee totalling 2km in length - designed to protect Lismore in the event of a 1 in 10 year flood.
- South Lismore levee totalling 5.5km in length - designed to protect South Lismore in the event of a 1 in 10 year flood.

The Richmond Floodplain Committee (RFC) was established by Richmond River County Council with the support of local councils and state agencies in November 2000 to 'coordinate natural resource management activities and projects on the floodplain in partnership with councils, state government and the community'. The management of natural resources on the estuary and floodplain is presents great challenges and needs long-term community and government support.

Over a number of years the RFC has implemented on-ground works to enhance wetlands, reduce drainage density, monitor water quality and reduce chronic acidification of water ways in dry times through controlled tidal flushing. The RFC also set up the estuary management committee responsible for the implementation of the estuary management planning process for the Richmond River estuary.

Within the principal activities of flood management and mitigation, the Richmond River County Council is currently involved in a wide range of catchment based initiatives, as either the lead agency or in a support/partnership capacity.

1.7 Relevant Legislation

Legislation relevant to the estuary management planning process is discussed in the following table.

Table 6 – Relevant Commonwealth and State Legislation

Legislation	Application to this Study
Commonwealth	
Environment Protection & Biodiversity Conservation Act, 1999	The EPBC Act requires assessment and approval of actions that will potentially have a significant impact on matters of National Environmental Significance. Matters of National Environmental Significance include: • world heritage areas; • wetlands protected by international treaties; • nationally listed threatened species and ecological communities; • nationally listed migratory species; • nuclear actions; and • Commonwealth marine areas.
State	
Environmental Planning & Assessment (EP&A) Act, 1979	The Act requires that environmental assessment is undertaken for all activities. Environmental impact assessments may also be required to satisfy Commonwealth legislation processes. The Act gives the basis for the preparation of environmental planning instruments that may be directly or indirectly related to the water utility businesses. These include State Environmental Planning Policies (SEPP), Regional Environmental Plans (REP), Local Environmental Plans (LEP), Development Control Plans (DCP), Regional and Sub-Regional Strategies.
Local Government Act, 1993	The purposes of this Act are as follows: (a) to provide the legal framework for an effective, efficient, environmentally responsible and open system of local government in New South Wales, (b) to regulate the relationships between the people and bodies comprising the system of local government in New South Wales, (c) to encourage and assist the effective participation of local communities in the affairs of local government, (d) to give councils: • the ability to provide goods, services and facilities, and to carry out activities, appropriate to the current and future needs of local communities and of the wider public • the responsibility for administering some regulatory systems under this Act • a role in the management, improvement and development of the resources of their areas, (e) to require councils, councillors and council employees to have regard to the principles of ecologically sustainable development in carrying out their responsibilities.

Legislation	Application to this Study
Coastal Protection Act, 1979	The objects of this Act are to provide for the protection of the coastal environment of the State for the benefit of both present and future generations and, in particular: (a) to protect, enhance, maintain and restore the environment of the coastal region, its associated ecosystems, ecological processes and biological diversity, and its water quality, and (b) to encourage, promote and secure the orderly and balanced utilisation and conservation of the coastal region and its natural and man-made resources, having regard to the principles of ecologically sustainable development, and (c) to recognise and foster the significant social and economic benefits to the State that result from a sustainable coastal environment, including: (i) benefits to the environment, and (ii) benefits to urban communities, fisheries, industry and recreation, and (iii) benefits to culture and heritage, and (iv) benefits to the Aboriginal people in relation to their spiritual, social, customary and economic use of land and water, and (d) to promote public pedestrian access to the coastal region and recognise the public's right to access, and (e) to provide for the acquisition of land in the coastal region to promote the protection, enhancement, maintenance and restoration of the environment of the coastal region, and (f) to recognise the role of the community, as a partner with government, in resolving issues relating to the protection of the coastal environment, (g) to ensure co-ordination of the policies and activities of the Government and public authorities relating to the coastal region and to facilitate the proper integration of their management activities, (h) to encourage and promote plans and strategies for adaptation in response to coastal climate change impacts, including projected sea level rise, and (i) to promote beach amenity.

Legislation	Application to this Study
Protection of the Environment Operations Act, 1997	The objects of this Act are as follows: (a) to protect, restore and enhance the quality of the environment in New South Wales, having regard to the need to maintain ecologically sustainable development, (b) to provide increased opportunities for public involvement and participation in environment protection, (c) to ensure that the community has access to relevant and meaningful information about pollution, (d) to reduce risks to human health and prevent the degradation of the environment by the use of mechanisms that promote the following: (i) pollution prevention and cleaner production, (ii) the reduction to harmless levels of the discharge of substances likely to cause harm to the environment, (iia) the elimination of harmful wastes, (iii) the reduction in the use of materials and the re-use, recovery or recycling of materials, (iv) the making of progressive environmental improvements, including the reduction of pollution at source, (v) the monitoring and reporting of environmental quality on a regular basis, (e) to rationalise, simplify and strengthen the regulatory framework for environment protection, (f) to improve the efficiency of administration of the environment protection legislation, (g) to assist in the achievement of the objectives of the Waste Avoidance and Resource Recovery Act 2001.
Fisheries Management Act, 1994	The objects of this Act are to conserve, develop and share the fishery resources of the State for the benefit of present and future generations. In particular, the objects of this Act include: (a) to conserve fish stocks and key fish habitats, and (b) to conserve threatened species, populations and ecological communities of fish and marine vegetation, and (c) to promote ecologically sustainable development, including the conservation of biological diversity, and, consistently with those objects: (d) to promote viable commercial fishing and aquaculture industries, and (e) to promote quality recreational fishing opportunities, and (f) to appropriately share fisheries resources between the users of those resources, and (g) to provide social and economic benefits for the wider community of New South Wales, and (h) to recognise the spiritual, social and customary significance to Aboriginal persons of fisheries resources and to protect, and promote the continuation of, Aboriginal cultural fishing.

Legislation	Application to this Study
Crown Lands Act, 1989	The objects of this Act are to ensure that Crown land is managed for the benefit of the people of New South Wales and in particular to provide for: (a) a proper assessment of Crown land, (b) the management of Crown land having regard to the principles of Crown land management contained in this Act, (c) the proper development and conservation of Crown land having regard to those principles, (d) the regulation of the conditions under which Crown land is permitted to be occupied, used, sold, leased, licensed or otherwise dealt with, (e) the reservation or dedication of Crown land for public purposes and the management and use of the reserved or dedicated land, and (f) the collection, recording and dissemination of information in relation to Crown land.
Marine Parks Act, 1977 and Marine Park Regulation, 2009 and Marine Parks (Zoning Plans) Regulation, 1999	The objects of this Act are as follows: (a) to conserve marine biological diversity and marine habitats by declaring and providing for the management of a comprehensive system of marine parks, (b) to maintain ecological processes in marine parks, (c) where consistent with the preceding objects: (i) to provide for ecologically sustainable use of fish (including commercial and recreational fishing) and marine vegetation in marine parks, and (ii) to provide opportunities for public appreciation, understanding and enjoyment of marine parks
Water Management , Act 2000	The objects of this Act are to provide for the sustainable and integrated management of the water sources of the State for the benefit of both present and future generations and, in particular: (a) to apply the principles of ecologically sustainable development, and (b) to protect, enhance and restore water sources, their associated ecosystems, ecological processes and biological diversity and their water quality, and (c) to recognise and foster the significant social and economic benefits to the State that result from the sustainable and efficient use of water, including: (i) benefits to the environment, and (ii) benefits to urban communities, agriculture, fisheries, industry and recreation, and (iii) benefits to culture and heritage, and (iv) benefits to the Aboriginal people in relation to their spiritual, social, customary and economic use of land and water, (d) to recognise the role of the community, as a partner with government, in resolving issues relating to the management of water sources, (e) to provide for the orderly, efficient and equitable sharing of water from water sources, (f) to integrate the management of water sources with the management of other aspects of the environment, including the land, its soil, its native vegetation and its native fauna, (g) to encourage the sharing of responsibility for the sustainable and efficient use of water between the Government and water users, (h) to encourage best practice in the management and use of water.

Legislation	Application to this Study
Catchment Management Authorities Act, 2003	Northern Rivers Catchment Management Authority is the statutory body created in this Act relevant to the region. CMA activities assist Councils to protect water sources and reduce discharges from urban areas to the catchment. The Act gives the basis for the preparation of a catchment action plan which sets the direction over the next 10 years for investment in natural resource management in the Northern Rivers catchments.
Native Vegetation Act, 2003	The objects of this Act are: (a) to provide for, encourage and promote the management of native vegetation on a regional basis in the social, economic and environmental interests of the State, and (b) to prevent broadscale clearing unless it improves or maintains environmental outcomes, and (c) to protect native vegetation of high conservation value having regard to its contribution to such matters as water quality, biodiversity, or the prevention of salinity or land degradation, and (d) to improve the condition of existing native vegetation, particularly where it has high conservation value, and (e) to encourage the revegetation of land, and the rehabilitation of land, with appropriate native vegetation, in accordance with the principles of ecologically sustainable development
Threatened Species Conservation Act, 1995	The objects of this Act are as follows: (a) to conserve biological diversity and promote ecologically sustainable development, and (b) to prevent the extinction and promote the recovery of threatened species, populations and ecological communities, and (c) to protect the critical habitat of those threatened species, populations and ecological communities that are endangered, and (d) to eliminate or manage certain processes that threaten the survival or evolutionary development of threatened species, populations and ecological communities, and (e) to ensure that the impact of any action affecting threatened species, populations and ecological communities is properly assessed, and (f) to encourage the conservation of threatened species, populations and ecological communities by the adoption of measures involving co-operative management.

Legislation	Application to this Study
National Parks and Wildlife Act, 1989	The objects of this Act are as follows: (a) the conservation of nature, including, but not limited to, the conservation of: (i) habitat, ecosystems and ecosystem processes, and (ii) biological diversity at the community, species and genetic levels, and (iii) landforms of significance, including geological features and processes, and (iv) landscapes and natural features of significance including wilderness and wild rivers, (b) the conservation of objects, places or features (including biological diversity) of cultural value within the landscape, including, but not limited to: (i) places, objects and features of significance to Aboriginal people, and (ii) places of social value to the people of New South Wales, and (iii) places of historic, architectural or scientific significance, (c) fostering public appreciation, understanding and enjoyment of nature and cultural heritage and their conservation, (d) providing for the management of land reserved under this Act in accordance with the management principles applicable for each type of reservation.
Heritage Act, 1977	The objects of this Act are as follows: (a) to promote an understanding of the State's heritage, (b) to encourage the conservation of the State's heritage, (c) to provide for the identification and registration of items of State heritage significance, (d) to provide for the interim protection of items of State heritage significance, (e) to encourage the adaptive reuse of items of State heritage significance, (f) to constitute the Heritage Council of New South Wales and confer on it functions relating to the State's heritage, (g) to assist owners with the conservation of items of State heritage significance.
Noxious Weeds Act, 1993	The objects of this Act are as follows: (a) to reduce the negative impact of weeds on the economy, community and environment of this State by establishing control mechanisms to: (i) prevent the establishment in this State of significant new weeds, and (ii) restrict the spread in this State of existing significant weeds, and (iii) reduce the area in this State of existing significant weeds, (b) to provide for the monitoring of and reporting on the effectiveness of the management of weeds in this State.
Native Title (New South Wales) Act, 1994	The main objects of this Act are: (a) in accordance with the Commonwealth Native Title Act, to validate any past acts, and intermediate period acts, invalidated because of the existence of native title and to confirm certain rights, and (b) to ensure that New South Wales law is consistent with standards set by the Commonwealth Native Title Act for future dealings affecting native title
Soil Conservation Act, 1938	The Act addresses preservation of watercourse environments and the prevention of the destruction of trees and soil erosion on protected land.

Appendix 2: Addendum to the Coastal Zone Management Study for the Richmond River Estuary (Australian Wetlands, 2010)

DRAFT ADDENDUM to the Coastal Zone Management Study for the Richmond River Estuary

For Richmond River County Council

AUSTRALIAN WETLANDS PTY LTD

March 2010

Ref: BB074-2

RICHMOND RIVER COUNTY COUNCIL
Floodplain Management

Project control

Project name: Addendum to the Coastal Zone Management Study for the Richmond River Estuary

Project number: BB074-2

Client: Richmond River County Council
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1 Introduction

As part of the Coastal Zone Management Study for the Richmond River Estuary (CZMS), some further research was undertaken with regard to water quality impacts and monitoring, geomorphological conditions, riparian vegetation conditions and fauna. These data are presented as an Addendum to the CZMS and provide information towards consideration of the management of issues within the identified Management Zones of the Richmond River Estuary.

2 Riparian Vegetation Assessment

2.1 Summary

The riparian vegetation of the Richmond River Estuary is degraded for much of the area. The width of the bank vegetation is often <5 m and few native trees remain. Serious weed invasion is occurring on the banks as there is no natural vegetation to inhibit the growth of weeds. The major weeds are Camphor Laurel and Cockspur Coral Tree.

In some places, particularly North Creek and the lower Estuary, there is some remnant vegetation with good native canopy and mid-storey trees. The understorey is largely dominated by pasture grasses leaving little opportunity for seedling regeneration and nutrient cycling, suggesting that the current vegetation is not providing viable riparian function.

Potential demonstration sites exist in all the management zones. In the Swan Bay, Bungawalbyn, and Kilgin/Buckendoon/Dungarubba management zones potential demonstration sites are at Dungarubba Creek, Oakland Road and Woodburn on the opposite bank to the main town. Good opportunities for revegetation exist around the mouth of Rocky Mouth Creek in Woodburn and with landholders along the creek.

Current Landcare groups are actively involved in riparian vegetation management and enhancement in many of the management zones and Richmond Landcare Inc oversees many of the funded projects. These groups along with private landholder have made notable contributions to riparian vegetation improvements in the study area.

2.2 Background

Riparian vegetation is classified as *vegetation that is found on the banks of a river or stream, and any vegetation on land that adjoins, directly influences or is influenced by a body of water*. Riparian vegetation plays a crucial role in maintaining bank stability and control of bed erosion in streams, which can be directly linked to water quality issues. It can reduce the

amount of sediment and associated pollutants entering the stream. Research suggests that stream and river banks that are sparsely vegetated, erode at a much higher rate than those banks that are densely vegetated (Water Quality Monitoring 2004). A well vegetated streambank is resistant to streambank erosion due to the extra stability provided by the roots and other plant material, and because it can reduce flow velocity at the edges of the stream. Riparian vegetation also plays a role in increasing biodiversity and serves to provide habitat for native fauna. Loss of riparian vegetation, through clearing, livestock grazing or recreational uses, means that these benefits are lost and the overall condition of the stream can decline.

Assessment of vegetation health and the prioritisation of sites was adapted for this study from Owers (2002) and the Rapid Assessment Method (RAM) described in the *Riparian and In-stream Rehabilitation Plan for the Lower Freshwater Reaches of Currumbin Creek* (Australian Wetlands 2006). The assessment has been used successfully on other projects by the project team. This method was a similar but more rigorous assessment method than the one described within the *Tallebudgera Creek Riparian Vegetation Study* (GCCC, 2002).

A broad scale desktop study of aerial photography was used to assess the riparian widths and longitudinal connectivity for the estuary to the tidal limit (Appendix 1). This assessment also provided information on obvious changes in vegetation for on-ground assessment.

The on-ground survey of sites incorporated existing on-ground work sites and areas with potential for high profile demonstration sites for riparian rehabilitation. The desktop assessment was used to assist in identifying suitable sites for on-ground assessment.

Digital photographs were taken at the upstream midpoint of the site facing downstream and downstream facing upstream. Each photo point was noted using GPS coordinates, to identify the extent of the reach.

The field assessment recorded responses to variables in the Riparian Assessment Matrix described below with a brief description of the key features of each site. A list of dominant weed and native species was compiled for each site.

The results of the assessment including GPS locations are contained in a Riparian Assessment Matrix, described in the following section.

2.3 Riparian Rapid Assessment Method (RAM)

Details of the riparian RAM implemented are provided below. Two parameter types were recorded in this assessment, those based on riparian vegetation extent and quality, and those based on rehabilitation potential of the reach and threatening processes on site.

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The assessment of condition and extent of riparian vegetation incorporated the following parameters:

1. Longitudinal connectivity (Aerial Photograph Interpretation (API))
2. Width of riparian vegetation (API)
3. Native vegetation cover
4. Site weed control issues
5. Habitat quality assessment

1. **Longitudinal connectivity** measured the length of vegetation >5m wide along the stream for both banks. Four criteria were mapped: 1. Longitudinal connectivity >100m, width 50->100m, 2. Longitudinal connectivity > 100m, width 10-50m, 3. Longitudinal connectivity <100m, width 0-10m, 4. Longitudinal connectivity >100m, width 0-10m.

2. The **width of riparian vegetation** was also assessed from aerial photography and measured. Width was ground-truthed using the flowing criteria: Small Channel < 10 m wide, riparian vegetation width: 0 = <5 m vegetation, 5 = > 5 - <50m vegetated, 10= >100m. Large Channel ≥ 10 m wide: 0 =riparian width (rw)<1/2 channel width (CW), 2 = rw ½ to 1 x CW, 4 = rw 1- 2 x CW, 6= rw 3-4 x CW, 8 = rw 4 x CW., 10=rw10xCW

3. **Native vegetation cover** was measured by a percentage score of overall cover in the canopy and understorey and percentage of native cover in the canopy and understorey. This also gives a corresponding score for % weed cover in the canopy and understorey. Percentage cover and percentage native was classed using the following categories. 0=0, 1=1%, 2=2-10%, 3=11-30%, 4=31-60%, 5=61-100%.

4. **Site weed control issues measured the severity of weeds to indicate the recovery potential of the site.**
   The severity of weeds score (%): High 0 = > 31-100%, Med 5 = 10-30%, Low 10 = <10% or no threat. Dominant weeds in each of the canopy, mid and understorey layers were recorded. Any weeds from the priority weeds list of the Far North Coast County Council (FNCCC), were recorded and the number present on site was used as a rating: score 10 = no priority weeds, 5 = 1 priority weed, 0 = > 2 priority weeds. The priority weeds included the following: Cockspur Coral, Duranta, Groundsel, Water Lettuce, Honey Locust, Hymenachne, Chinese Tallow, Glush Weed, Cats Claw Creeper, Alligator Weed, Chinese Celtis, Water Hyacinth, Camphor Laurel, Salvinia, Broad-leaved Pepper and Alumen Grass.

5. **The habitat quality assessment** measures parameters that identify the values of established riparian habitat for mammals, reptiles and other fauna. The parameters and rating used was:
   - Vegetation community age class 0 = no riparian vegetation or isolated stag trees, 1= seedlings/ planting <5 yo with/without stag trees, 2 = regrowth 10yo, 3 = regrowth >10yo 4 = regrowth with stag trees, 5 =4 old growth >30 yo (Note: stag trees are isolated remnant individuals)

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- Tree hollows present, 0 = none, 5 present.
- Leaf litter class, 0 = none, 3 =1-60%, 5 =>60%
- Fallen logs/habitat structure, diversity, 0 =none, 3 = small debris, 5 = abundant
- Seed/fruiting trees: 0 = none, 3 = 1-4 trees, 5 = > 5 trees
- In-stream habitat (in freshwater large woody debris (LWD) or overhang branches etc) Mangrove pneumatophores >1m wide, 0 = none, 3 = <50 % site with habitat features, 5 = > 50 % of site with habitat features.

2.4 Results and Assessment

The on-ground field assessments and general field and mapping observations were used to provide a vegetation assessment overview based on management zones. The assessment results for each site and the site details are described below and the field results are shown in **Error! Reference source not found.** and Table 2.2. The sums of each assessed condition provide a relative indication of the importance of the condition at each site. From these on-ground field assessments and from general field and mapping observations, a vegetation assessment overview based on management zones has been provided.

A list of weed species observed at each Field Site is also provided in Table 2.3. A photographic Archive is provided for each management zone in Appendix 2.

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Table 2.1. Longitudinal connectivity, vegetation width and cover assessment of on-ground riparian site assessment. Refer to Section 2.2 for details on scoring.

SITE	Site Location	GPS	Management Zone No.	Management Zone name	1. LONGITUDINAL CONNECTIVITY	Bank 1	Bank 2	TOTAL SCORE	2.. WIDTH OF RIPARIAN VEGETATION	*Channel width (CW) m*	Vegetation width (m)	Vegetation width (m)	TOTAL SCORE	3. VEGETATION COVER	*Canopy*	% cover class	% native	*Understorey*	% cover class	% native	TOTAL SCORE
NC1	Nth Cr Road	28 50' 21.21"S, 153 34' 43.26"E	1	North Creek		5	5	**10**		*20m*	**0**	**6**	**6**			4	5		3	2	**14**
NC2	Upstream Ross Lane	28 47'12.76"S, 153 33' 50.14"E	1	North Creek		0	0	**0**		*<10m*	0	0	**0**			0	0		5	0	**5**
EC3	Emigrant Cr	28 50' 01.53"S, 153 30' 48.50"E	2	Emigrant/ Maguires		5	0	**5**		*>50m*	4	0	**4**			3	4		4	2	**13**
SB4	Sth Ballina Beach Road	28 52' 52.62"S, 153 33' 34.82"E	4	Sth Ballina		5	5	**10**		*5m*	5	5	**10**			5	5		5	0	**15**
SB5	Empire Vale	28 54' 46.58"S, 153 30' 30.60"E	4	Sth Ballina		0	0	**0**		*<10m*	0	5	**5**			3	5		5	0	**13**
SB6	Carney Lane River Dr	28 57' 6.07"S, 153 28' 29.80"E	4	Sth Ballina		5	0	**5**			0	0	**0**			3	4		5	0	**12**
SB7	Near Pimblico Is	28 54' 49.43"S, 153 29' 19.35"E	2	Emigrant/ Maguires		0	5	**5**		*>20m*	0	1	**1**			3	4		3	3	**13**
BC8	Wardell Bridge	28 57' 16.25"S, 153 27' 56.07"E	3	Back Channel		0	0	**0**			0	0	**0**			3	4		4	4	**15**
T	Broadwater	28 59' 50.68"S,	10	Tuckean		0	0	**0**		*>50m*	0	0	**0**			4	4		5	3	**16**

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SITE	Site Location	GPS	Management Zone No.	Management Zone name	1. LONGITUDINAL CONNECTIVITY	Bank 1	Bank 2	TOTAL SCORE	2.. WIDTH OF RIPARIAN VEGETATION	*Channel width (CW) m*	Vegetation width (m)	Vegetation width (m)	TOTAL SCORE	3. VEGETATION COVER	*Canopy*	% cover class	% native	*Understorey*	% cover class	% native	TOTAL SCORE
10/11	Road	153 24' 11.22"E																			
T12	BAG BARRAGE	28 58' 51.75"S, 153 24' 15.98"E	10	Tuckean		5	5	**10**		*>20m*	4	4	**8**			5	5		5	4	**19**
KB 13/14	Kilgin Drain to RR	29 01'31.58"S 153 22 '30.24" E	9	Kilgin /Buckendoon		0	5	**5**		*>50m*	0	0	**0**			0	0		2	0	**2**
KB15	Woodburn opp town	29 4' 6.42"S, 153 20' 34.57"E	9	Kilgin /Buckendoon		0	0	**0**		*>50m*	0	0	**0**			1	5		5	0	**11**
KB18	OAKLAND RD NEAR SCHOOL RD	29 4' 38.55"S, 153 20' 4.10"E	9	Kilgin /Buckendoon		0	0	**0**		*>50m*	0	0	**0**			2	2		4	1	**9**
RC17	Rocky Mouth Creek	29 02' 40.25"S, 153 20' 09.24"E	7	Rocky Mouth Creek		0	0	**0**		*<10m*	0	0	**0**			3	1		5	0	**9**
E19	TUCKOMBIL CANAL	29 05' 05.52"S, 153 20'16.79"E	6	Evans River		0	0	**0**		*>20m*	0	0	**0**			2	4		5	3	**14**
SB20	Swan Bay	29 3' 40.89"S, 153 17' 16.87"E	8	Swan Bay		5	5	**10**		*>20m*	2	0	**2**			4	4		5	4	**17**
UPRW R21/22	Coraki downstream	28 59' 6.10"S, 153 17' 14.37"E	12	Upper Richmond/		0	0	**0**		*>20m*	0	0	**0**			2	4		5	0	**11**

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SITE	Site Location	GPS	Management Zone No.	Management Zone name	1. LONGITUDINAL CONNECTIVITY	Bank 1	Bank 2	TOTAL SCORE	2.. WIDTH OF RIPARIAN VEGETATION	*Channel width (CW) m*	Vegetation width (m)	Vegetation width (m)	TOTAL SCORE	3. VEGETATION COVER	*Canopy*	% cover class	% native	*Understorey*	% cover class	% native	TOTAL SCORE
	boat ramp			Wilson River																	
UPRWR23	WYRALLA RD BRIDGE TO CORAKI	28 53' 29.78"S, 153 17' 49.75"E	12	Upper Richmond/ Wilson River		5	0	**5**		*>20m*	0	0	**0**			4	1		5	0	**10**
UPRWR24	WYRALLA RD UPPER	28 52' 06.87"S, 153 16' 14.12"E	12	Upper Richmond/ Wilson River		5	5	**10**		*>20m*	2	2	**4**			4	3		3	0	**10**
UPRWR25	LECESTER CR	28 47' 45.44"S, 153 14' 24.09"E	12	Upper Richmond/ Wilson River		0	5	**5**		*15m*	0	1	**1**			4	3		5	0	**12**
BU26	Bora Bungawalbyn Creek	29 2' 42.08"S, 153 15' 3.72"E	11	Lower Bungawalbyn		5	0	**5**		*10m*	5	0	**5**			5	5		4	4	**18**
BU27/28	Sandy Creek	29 1' 32.61"S, 153 15' 5.76"E	11	Lower Bungawalbyn		5	5	**10**		*<10m*	5	5	**10**			4	3		5	0	**12**
UPRWR 29/30	Tomki Tatham Bridge	28 55' 30.09'S, 153 09' 39.64"E	12	Upper Richmond/ Wilson River		0	0	**0**		*>15 m*	0	0	**0**			3	5		5	0	**13**

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SITE	Site Location	GPS	Management Zone No.	Management Zone name	1. LONGITUDINAL CONNECTIVITY	Bank 1	Bank 2	TOTAL SCORE	2.. WIDTH OF RIPARIAN VEGETATION	*Channel width (CW) m*	Vegetation width (m)	Vegetation width (m)	TOTAL SCORE	3. VEGETATION COVER	*Canopy*	% cover class	% native	*Understorey*	% cover class	% native	TOTAL SCORE
UPRW R31	Casino Weir	28 52' 4.56"S, 153 2' 33.21"E	12	Upper Richmond/ Wilson River		5	0	**5**		*20m*	2	0	**2**			4	5		5	0	**14**
UPRW R32	Wilson R Trinity	28 48' 0.09"S, 153 17' 9.39"E	12	Upper Richmond/ Wilson River		0	5	**5**		*<5m*	0	0	**0**			4	2		5	0	**11**

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Table 2.2 Weed control issues and habitat quality assessment of on-ground riparian site assessment.
Refer to section 11.2 for information on scoring.

SITE		GPS	Management Zone	Management Zone name	SITE WEED CONTROL	canopy weeds	mid storey	understorey	FNCC Priority weeds on site	TOTAL SCORE	HABITAT QUALITY ASSESSMENT	Veg community age class	Tree hollows present	Leaf litter class	Fallen logs	Seed/ fruiting trees	In-stream habitat (LWD overhang branches etc)	Habitat connectivity in-stream/ pools/ riffles, water flow	TOTAL SCORE
NC1	Nth Cr Road	28 50' 21.21"S, 153 34' 43.26"E	1	North Creek		10	10	0	5	**25**		2	0	3	0	3	5	10	**23**
NC2	Upstream Ross Lane	28 47'12.76"S, 153 33' 50.14"E	1	North Creek		10	10	0	10	**30**		0	0	0	0	0	0	0	**0**
EC3	Emigrant Cr	28 50' 01.53"S, 153 30' 48.50"E	2	Emigrant/ Maguires		10	10	0	10	**30**		2	5	3	3	3	3	10	**29**
SB4	Sth Ballina Beach Road	28 52' 52.62"S, 153 33' 34.82"E	4	Sth Ballina		10	10	10	10	**40**		4	5	5	5	5	5	0	**29**
SB5	Empire Vale	28 54' 46.58"S, 153 30' 30.60"E	4	Sth Ballina		5	5	0	10	**20**		3	5	0	0	3	3	5	**19**
SB6	Carney Lane River Dr	28 57' 6.07"S, 153 28' 29.80"E	4	Sth Ballina		0	0	0	0	**0**		1	5	0	3	3	5	5	**22**
SB7	Near Pimblico Is	28 54' 49.43"S, 153 29' 19.35"E	2	Emigrant/ Maguires		5	5	5	10	**25**		2	5	3	3	5	5	10	**33**
BC8	Wardell	28 57' 16.25"S,	3	Back Channel		10	3	10	10	**33**		3	5	3	3	3	3	10	**30**

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SITE		GPS	Management Zone	Management Zone name	SITE WEED CONTROL	canopy weeds	mid storey	understorey	FNCC Priority weeds on site	TOTAL SCORE	HABITAT QUALITY ASSESSMENT	Veg community age class	Tree hollows present	Leaf litter class	Fallen logs	Seed/ fruiting trees	In-stream habitat (LWD overhang branches etc)	Habitat connectivity in-stream/ pools/ riffles, water flow	TOTAL SCORE
	Bridge	153 27' 56.07"E																	
T 10/11	Broadwater Road	28 59' 50.68"S, 153 24' 11.22"E	10	Tuckean		10	0	0	5	**15**		4	5	3	3	5	5	10	**35**
T12	BAG BARRAGE	28 58' 51.75"S, 153 24' 15.98"E	10	Tuckean		10	5	0	10	**25**		4	5	3	3	5	5	5	**30**
KB 13/14	Kilgin Drain to RR	29 01'31.58"S 153 22 '30.24" E	9	Kilgin/ Buckendoon		0	0	0	5	**5**		0	0	0	0	0	3	5	**8**
KB15	Woodburn opp town	29 4' 6.42"S, 153 20' 34.57"E	9	Kilgin/ Buckendoon		0	0	0	0	**0**		0	0	0	0	3	3	10	**16**
KB18	OAKLAND RD NEAR SCHOOL RD	29 4' 38.55"S, 153 20' 4.10"E	9	Kilgin/ Buckendoon		0	0	0	0	**0**		0	0	3	3	3	3	10	**22**
RC17	Rocky Mouth Creek	29 02' 40.25"S, 153 20' 09.24"E	7	Rocky Mouth Creek		0	0	0	0	**0**		0	0	0	0	0	3	5	**8**
E19	TUCKOMBIL CANAL	29 05' 05.52"S, 153 20'16.79"E	6	Evans River		0	0	10	5	**15**		2	5	3	3	3	3	5	**24**
SB20	Swan Bay	29 3' 40.89"S, 153 17' 16.87"E	8	Swan Bay		0	0	0	0	**0**		2	5	3	3	3	5	10	**31**

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SITE		GPS	Management Zone	Management Zone name	SITE WEED CONTROL	canopy weeds	mid storey	understorey	FNCC Priority weeds on site	TOTAL SCORE	HABITAT QUALITY ASSESSMENT	Veg community age class	Tree hollows present	Leaf litter class	Fallen logs	Seed/ fruiting trees	In-stream habitat (LWD overhang branches etc)	Habitat connectivity in-stream/ pools/ riffles, water flow	TOTAL SCORE
UPRW R21/22	Coraki downstream boat ramp	28 59' 6.10"S, 153 17' 14.37"E	12	Upper Richmond/ Wilson River		10	5	0	0	**15**		1	0	0	0	3	3	10	**17**
UPRW R23	WYRALLA RD BRIDGE TO CORAKI	28 53' 29.78"S, 153 17' 49.75"E	12	Upper Richmond/ Wilson River		5	0	0	0	**5**		0	0	0	0	5	3	10	**18**
UPRW R24	WYRALLA RD UPPER	28 52' 06.87"S, 153 16' 14.12"E	12	Upper Richmond/ Wilson River		0	0	0	0	**0**		2	5	3	3	3	3	10	**29**
UPRW R25	LECESTER CR	28 47' 45.44"S, 153 14' 24.09"E	12	Upper Richmond/ Wilson River		10	0	0	5	**15**		3	5	0	3	5	5	10	**31**
BU26	Bora Bungawalbyn Creek	29 2' 42.08"S, 153 15' 3.72"E	11	Lower Bungawalbyn		0	0	5	0	**5**									
BU27/ 28	Sandy Creek	29 1' 32.61"S, 153 15' 5.76"E	11	Lower Bungawalbyn		5	0	0	0	**5**									

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SITE		GPS	Management Zone	Management Zone name	SITE WEED CONTROL	canopy weeds	mid storey	understorey	FNCC Priority weeds on site	TOTAL SCORE	HABITAT QUALITY ASSESSMENT	Veg community age class	Tree hollows present	Leaf litter class	Fallen logs	Seed/ fruiting trees	In-stream habitat (LWD overhang branches etc)	Habitat connectivity in-stream/ pools/ riffles, water flow	TOTAL SCORE
UPRWR 29/30	Tomki Tatham Bridge	28 55' 30.09'S, 153 09' 39.64"E	12	Upper Richmond/ Wilson River		10	5	0	0	**15**		2	5	0	0	3	3	10	**23**
UPRWR31	Casino Weir	28 52' 4.56"S, 153 2' 33.21"E	12	Upper Richmond/ Wilson River		10	5	0	5	**20**		2	5	0	3	5	3	10	**28**
UPRWR32	Wilson R Trinity	28 48' 0.09"S, 153 17' 9.39"E	12	Upper Richmond/ Wilson River		0	0	0	0	**0**		0	0	0	0	3	3	10	**16**

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Table 2.3 Weed species noted in the on-ground site assessment.

		NC1	NC2	EC3	SB4	SB5	SB6	SB7	BC8	T11	T12	KB14	KB15	KB18	RC17	E19	SB20	BU28	UPRWR21	UPRWR23	UPRWR24	UPRWR25	UPRWR26	UPRWR30	UPRWR31	UPRWR32	Sites present
Ageratina adenophora	Crofton Weed																										0
Ageratina riparia	Mist Flower																										0
Ageratum houstonianum	Blue Billy Goat Weed																					X		X	X	X	4
Ambrosia artemisiifolia	Annual Ragweed	X																				X					2
Anredera cordifolia	Madeira Vine							X							X							X			X	X	5
Asclepias curassavica	Redhead Cotton Bush	X																									1
Asparagus aethiopicus	Asparagus Fern	X					X	X																			3
Asparagus plumosus	Climbing Asparagus																X	X		X	X	X	X	X		X	8
Axonopus compressus	Carpet Grass	X	X				X															X					4
Baccharis halimifolia	Groundsel								X																		1
Bidens pilosa	Farmers Friend	X	X	X	X	X						X		X	X						X	X		X	X	X	13
Urochloa mutica	Para Grass		X					X		X	X	X		X	X				X	X							9
Bryophyllum delagoense	Mother of Millions																										0
Cabomba caroliniana	Cabomba																										0
Canna x generalis	Canna Lily							X																			1
Cardiospermum grandiflorum	Balloon Vine									X							X		X	X		X		X	X	X	8
Celtis sinensis	Japanese Hackberry																									X	1
Chloris gayana	Rhodes Grass		X			X	X													X		X					5

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		NC1	NC2	EC3	SB4	SB5	SB6	SB7	BC8	T11	T12	KB14	KB15	KB18	RC17	E19	SB20	BU28	UPRWR21	UPRWR23	UPRWR24	UPRWR25	UPRWR26	UPRWR30	UPRWR31	UPRWR32	Sites present
Chrysanthemoides monilifera	Bitou Bush						X																				1
Cinnamomum camphora -	Camphor Laurel	X	X				X		X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	19
Cocos plumosus	Cocos	X																									1
Colocasia esculanta	Elephant ears																										0
Commelina benghalensis	Hairy Commelina		X	X			X								X							X				X	6
Conyza albida	Fleabane	X	X																								2
Cuphea carthagenensis	Cuphea																										0
Cynodon dactylon	Common Couch			X	X	X	X			X					X		X	X	X			X				X	11
Desmodium uncinatum	Silverleaf Desmodium																										0
Eichhornia crassipes	Water Hyacinth																X										1
Elodea canadensis	Elodea																										0
Erechtites valerianifolia	Soft Top																										0
Erythrina crista-galli	Coral Tree						X	X		X		X	X	X	X	X	X	X	X	X	X	X	X			X	16
Erythrina sykesii	Coral Tree													X													1
Eugenia uniflora	Brazilian Cherry																										0
Gleditsia tricanthos	Honey Locust																							X			1
Gomphocarpus fruiticosus	Narrow Leaf Cotton Bush																										0
Ipomoea alba	White Ipomea																X			X	X						3
Ipomoea cairica	Coastal Morning Glory	X	X	X	X	X	X	X		X	X	X	X	X	X		X	X		X	X	X	X	X		X	21
Ipomoea indica	Morning Glory							X		X										X						X	4

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		NC1	NC2	EC3	SB4	SB5	SB6	SB7	BC8	T11	T12	KB14	KB15	KB18	RC17	E19	SB20	BU28	UPRWR21	UPRWR23	UPRWR24	UPRWR25	UPRWR26	UPRWR30	UPRWR31	UPRWR32	Sites present
Koelreuteria paniculata	Golden Rain Tree																									X	1
Lantana camara	Lantana	X			X	X				X				X	X							X	X	X			9
Ligustrum lucidum	Large Leaved Privet																									X	1
Ligustrum sinense	Small Leaved Privet																			X	X	X			X	X	5
Macroptilium atropurpureum	Siratro									X																	1
Megathyrsus maximus	Guinea Grass																										0
Melinis minutiflora	Molasses Grass																										0
Morus alba	Mulberry																			X		X			X	X	4
Myriophyllum aquaticum	Parrots Feather																										0
Nymphaea capensis	Cape Waterlily																										0
Nymphaea zanzibarensis	Water Lilly																										0
Ochna serrulata	Ochna																										0
Oxalis sp.	Oxalis																										0
Paspalum dilatatum	Paspalum																										0
Paspalum sp.	Paspalum Grass																										0
Paspalum urvillei	Vasey Grass	X	X	X		X	X						X	X	X	X				X		X					11
Paspalum wettsteinii	Broad-leaved Paspalum									X												X					2
Passiflora subpeltata	White Passionfruit	X																									1
Pennisetum alopecuroides	Swamp Foxtail																X										1
Pennisetum clandestinum	Kikuyu Grass		X			X	X						X		X		X			X	X	X					9

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		NC1	NC2	EC3	SB4	SB5	SB6	SB7	BC8	T11	T12	KB14	KB15	KB18	RC17	E19	SB20	BU28	UPRWR21	UPRWR23	UPRWR24	UPRWR25	UPRWR26	UPRWR30	UPRWR31	UPRWR32	Sites present
Pennisetum sp.	Bana Grass																										0
Persica sp.	Peach																										0
Phyllostachys aurea	Golden Bamboo																										0
Psidium guajava	Yellow Guava																				X						1
Ricinus communis	Castor Oil												X							X				X	X		4
Rivina humilis	Coral Berry														X				X	X						X	4
Salvinia molesta	Salvinia																										0
Schefflera actinophylla	Umbrella Tree																										0
Schinus terebinthifolius	Broad-leaf Pepper Tree																								X		1
Senecio madagascariensis	Fireweed																										0
Senna pendula var. glabrata	Easter cassia	X		X	X	X	X	X		X				X	X											X	10
Setaria sphacelata	Setaria												X	X	X	X				X	X	X					7
Sida rhombifolia	Paddy's Lucerne													X	X	X						X	X				5
Solanum mauritianum	Wild Tobacco																					X					1
Solanum seaforthianum	Blue Potato Vine									X										X							2
Sorghum halepense	Johnson Grass																		X	X		X		X			4
Sphagneticola trilobata	Singapore Daisy							X																			1
Tagetes minuta	Stinking Roger																										0
Tecoma stans	Yellow Tecoma																					X					1
Tradescantia albiflora	Wandering Jew									X								X		X		X				X	5

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		NC1	NC2	EC3	SB4	SB5	SB6	SB7	BC8	T11	T12	KB14	KB15	KB18	RC17	E19	SB20	BU28	UPRWR21	UPRWR23	UPRWR24	UPRWR25	UPRWR26	UPRWR30	UPRWR31	UPRWR32	Sites present
Trifolium repens	White Clover	X																									1
Vachellia farnesiana	Mimosa Bush																	X									1

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Zone 1 - North Creek/Newrybar

On-ground sites NC1, NC2

The riparian vegetation along North Creek was mostly greater than 50m wide with a high native cover in the canopy (>30% - 60%). The dominant species in the lower estuarine zones were Swamp Oak (*Casuarina glauca)* and Tuckeroo (*Cupaniopsis anacardioides*) on the banks, with mangroves including Grey Mangrove (*Avicennia marina*) and River Mangrove (*Aegiceras corniculatum*) at the water's edge.

The Ballina Nature Reserve covers a large section of North Creek. Extensive saltmarsh areas were found in the lower reaches of the creek. Although the canopy weed cover was low, the understorey weed cover was >90% in some areas. Threatening weeds include Ground Asparagus (*Asparagus aethiopicus)* with vines such as Coastal Morning Glory (*Ipomoea cairica*) and White Passionfruit (*Passiflora subpeltata*). These weeds were preventing regeneration in the understorey and reducing habitat for reptiles. These reaches have a high recovery potential if weeds and pasture grasses were controlled as there was an abundant seed source available for regeneration.

In the higher reaches above Ross Lane, the Creek has been channelized by historical drainage union works. With the exception of pasture grasses and a few patches of regrowth upstream, riparian vegetation is almost non-existent on the channel. The current landuse, predominantly cane farming, limits expansion of the riparian vegetation along this part of the creek.

Zone 2 - Emigrant/Maguires Creek

On-ground sites EC3

The lower estuarine areas of Emigrant Creek have good mangrove areas. The riparian width varies from wide 50m to <10m where landuse or roads come close to the creek edge. The dominant species were similar to North Creek with Swamp Oak (*Casuarina glauca)* and Tuckeroo (*Cupaniopsis anacardioides*) on the banks, and mangroves such as Grey Mangrove (*Avicennia marina*) and River Mangrove (*Aegiceras corniculatum*) dominating the water's edge. The major issues for riparian management in this area were urban and infrastructure encroachment and recreational landuse (e.g. vehicles causing damage to saltmarsh and creek banks).

Zone 3 - Back Channel

On-ground sites BC8

The Back Channel management zone includes the riverbank near Wardell. The northern bank of the river has a healthy mature (>10yo) corridor of mangroves and riparian vegetation with 30-60% native cover in the canopy and understorey. On the southern side, the riparian vegetation was very narrow to non-existent in places. Priority weeds were not evident. The

riparian vegetation on the southern side includes remnant mangroves and saltmarsh. The major issues affecting the recolonisation of mangroves are boat wash and encroaching landuse.

Zone 4 - South Ballina/Empire Vale

On-ground sites SB4, SB5, SB6, SB7

The South Ballina management area includes the Ballina Nature Reserve along South Ballina Beach Road. Mangroves were extensive in this reach. Several large floodgates feed into the river along the zone. The flood-gated area at Empire Vale has been identified as a potential riparian rehabilitation site as it is a refuge area for fish in flood times. The dominant canopy vegetation was Forest Red Gum (*Eucalyptus tereticornis*) and Hoop Pine (*Araucaria cunninghamii*), with mangroves along the main channel. The riparian vegetation was less than 30% cover but predominantly native with few weeds. Major weeds were Coastal Morning Glory (*Ipomoea cairica),* Lantana *(Lantana camara)* and Senna *(Senna pendula var. glabrata),* with pasture grasses and herbs such as Farmers Friend *(Bidens pilosa).* The riparian zone along the river was approximately 50m wide in this area, but became narrower to non-existent towards the locality around Keith Hall Road.

Native tree planting at Carney Lane was becoming established but further planting and weed control will be required. On the western bank, near Pimlico Island, a very narrow native riparian zone is threatened by weeds, particularly vines like Coastal Morning Glory (*Ipomoea cairica).*

Major issues for riparian management centre on boat wash and loss of native vegetation to weeds, as well as encroaching urban, agricultural and infrastructure landuses.

Zone 5 – Rileys Hill

This is a relatively small management zone with boat launch facilities, urban dwelling and agriculture (predominantly sugar cane). The riparian vegetation varied from some coverage (riparian width >10m) with some remnant native vegetation near to very limited. The dominant species along banks were Swamp Oak (*Casuarina glauca)* and Tuckeroo (*Cupaniopsis anacardioides*) on the banks, with mangroves including Grey Mangrove (*Avicennia marina*) and River Mangrove (*Aegiceras corniculatum*). Common Reed (*Phragmites australis*) and Cumbungi (*Typha orientalis*) provide habitat along the bank toe in places. The understorey vegetation was degraded with few native species. Landuse activities and road infrastructure were encroaching on the riparian zone.

Other issues for riparian management were boatwash and clearing of the existing vegetation. The opportunities for improvement of riparian vegetation in this management zone are varied and depend on site access and landuse limitations. Brolgas were observed in grazing paddocks in this zone.

Zone 6 - Evans River

On-ground sites E19

Vegetation along the Evans River is extensive in some areas but around the Tuckombil Canal, downstream of the Pacific Highway, there is no riparian canopy. Upstream of the Pacific Highway, the dominant canopy tree was Forest Red Gum (*Eucalyptus tereticornis*) along with Swamp Oak (*Casuarina glauca*) and Hoop Pine (*Araucaria cunninghamii*). There were no mid-storey species. Water couch (*Paspalum distichum*) colonised the edges of the banks.

The major weed species was Cockspur Coral Tree (*Erythrina crista-galli*). There is opportunity to manage bank erosion around the Tuckombil Canal using low riparian vegetation that can tolerate inundation. Revegetaion would require landholder support or need engagement with the RTA during the construction of the new route of the Pacific Highway.

RRCC has recently had a report completed on the management of the Tuckombil Canal and they have resolved to place the Tuckombil Canal Management Report on public exhibition and proceed to public consultation on the basis of a fixed weir.

Zone 7 - Rocky Mouth Creek

On-ground sites RC17

The vegetation along the riparian zone of Rocky Mouth Creek was dominated by a weedy canopy of Cockspur Coral Tree (*Erythrina crista-galli*). Camphor Laurel (*Cinnamomum camphora*) was also a major canopy weed along Rocky Mouth Creek. The canopy cover was less than 30% with almost no native species. The existing remnant native canopy vegetation included some Forest Red Gum (*Eucalyptus tereticornis*), with Black Tea-tree (*Melaleuca bracteata)* in the mid-storey. The toe of the bank was colonised by native species such as *Bolboschoenus* sp. and Common Reed (*Phragmites australis*). Pasture grasses dominated the understorey. Other major weeds included Senna *(Senna pendula var. glabrata)* and Madeira Vine (*Anredera cordifolia*).

Good opportunities for revegetation exist around the mouth of Rocky Mouth Creek in Woodburn and with landholders along the creek.

Zone 8 - Swan Bay

On-ground sites SB20

Riparian vegetation on the northern bank of Swan Bay extending to the start of Swan Bay Road, was dominated by native riparian species. The canopy cover was over 30% and up to 60% with a high percentage (60%) of native species. The dominant native canopy was Swamp Oak (*Casuarina glauca)* and Tuckeroo (*Cupaniopsis anacardioides*). The major mid-storey species included the threatened species Sweet Myrtle (*Gossia fragrantissima),* and more common Green Native Cascarilla *(Croton verreauxii)* and Foambark *(Jagera pseudomes).* The understorey

vegetation was heavily grazed by cattle and was dominated by pasture grasses and native species such as Basket Grass (*Oplismenus undulatus*) and Swamp Foxtail (*Pennisetum alopecuroides*). Smartweed (*Persicaria stigosa*), Cumbungi (*Typha orientalis*) and *Bolboschoenus* sp. colonised the edges of the oxbow.

Serious weeds were evident in the Swan Bay area. Water Hyacinth (*Eichhornia crassipes*) covered less than 10% over the water surface. This lower coverage was possibly due to control measures or flooding and flushing of the Oxbow. Cockspur Coral Tree (*Erythrina crista-galli*) was the main canopy and mid-storey weed. Several vines were encroaching on the remnant vegetation. These were Coastal Morning Glory, (*Ipomoea cairica*), White Morning Glory (*Ipomoea alba*), Climbing Asparagus (*Asparagus plumosus*) with large areas of Balloon Vine (*Cardiospermum grandiflorum*).

The Swan Bay region has major potential for rehabilitation. Existing remnant vegetation provides a useful reference community for edge plantings. Control of aquatic weeds will allow the oxbow to function as a valuable wetland for resident and migratory birds. Grazing may be used as a weed control method but at a lighter regime than the present one.

Zone 9 - Kilgin Buckendoon

On-ground sites KB14, KB15, KB18

The riparian vegetation of the Kilgin Buckendoon management zone varied from some coverage (riparian width >10m) with remnant native vegetation near Dungarubba Creek, to highly degraded near Kilgin Drain and along the channel to Woodburn. The native canopy cover was < 10% for most of this area of the channel.

The dominant species along banks were Swamp Oak (*Casuarina glauca)* and Tuckeroo (*Cupaniopsis anacardioides*) on the banks, with mangroves including Grey Mangrove (*Avicennia marina*) and River Mangrove (*Aegiceras corniculatum*). Hoop Pines (*Araucaria cunninghamii*) were also noted in the riparian zone and close to the water's edge in some places. Common Reed (*Phragmites australis*) and Cumbungi (*Typha orientalis*) provide habitat along the bank toe in places. The understorey vegetation was degraded with few native species. The dominant landuse throughout this area was cane farming with some Macadamia plantations and cattle grazing. Landuse was impacting on riparian vegetation in some places.

Cockspur Coral Tree (*Erythrina crista-galli*) appears to be increasing and was the dominant canopy weed along this riparian management zone. Other dominant weeds were Castor Oil Plant (*Ricinus communis*), and Para grass (*Urochloa mutica*), along the bank edges.

Other issues for riparian management were boatwash and current clearing of the existing vegetation. The opportunities for improvement of riparian vegetation in this management zone were high as there was existing remnant vegetation to provide structural cover and seed sources. The bank has high visibility and good access for works although in places the extent of

rehabilitation works will be limited by road infrastructure. Potential demonstration sites exist at Dungarubba Creek, Oakland Road and Woodburn on the opposite bank to the main town.

Zone 10 - Tuckean

On-ground sites T11, T12

Sites surveyed in the Tuckean covered the Baggotville Barrage to the mouth of the riverbank and along the Broadwater Road. The riparian vegetation in the Tuckean was often greater than 50m wide with a high native cover in the canopy (>-60% - 100%). Upstream of the Barrage, the Tuckean Nature Reserve covers a large area and mangroves were noted to be recolonising the upstream area. The vegetation downstream of the barrage was diverse with fresh and saltwater species co-existing. The dominant species along banks were Broad-leaved Paperbark (*Melaleuca quinquenervia*), Swamp Oak (*Casuarina glauca)* and Tuckeroo (*Cupaniopsis anacardioides*) on the banks, with mangroves including Grey Mangrove (*Avicennia marina*) and River Mangrove (*Aegiceras corniculatum*). The understorey vegetation along the banks included Water Ribbons (*Triglochin procera*), Cumbungi (*Typha orientalis*), River Lily (*Crinum pendunculatum*) and Sea Rush (*Juncus kraussii*). An extensive cover of Cape Waterlily (*Nymphaea capensis*) was evident both up and downstream of the Barrage. The vegetation downstream of the barrage provides significant estuarine habitat and should be highly valued.

The riparian vegetation along the main channel near Broadwater Road was highly diverse but narrow and threatened by climbing weeds in places. The main canopy tree was Forest Red Gum (*Eucalyptus tereticornis*) with Tuckeroo (*Cupaniopsis anacardioides*) on the banks. Mangroves, including Grey Mangrove (*Avicennia marina*) and River Mangrove (*Aegiceras corniculatum*) and Common Reed (*Phragmites australis*) were colonising the toe of the bank in many places. The riparian vegetation included remnant rainforest species such as Hard Quandong (*Elaeocarpus obovatus*), Green Native Cascarilla (*Croton verreauxii)*, Clerodendron (*Clerodendron floribundum),* Rapanea *(Myrsine variabilis)* and *Exocarpus latifolius.*

Several water weeds, transported to the site by flood waters, were evident near the bank. These were Parrots Feather *(Myriophyllum aquaticum*), Water Hyacinth *(Eichhornia crassipes),* Salvinia *(Salvinia molesta),* Water Lettuce *(Pistia stratiotes*), Duckweed (*Lemna* sp). and *Azolla* sp*.* The rotting biomass of these weeds in the brackish conditions of the estuary may present potential blackwater and low dissolved oxygen issues.

Zone 11 - Lower Bungawalbyn

On-ground sites BU26/27/28

The results of committed riparian management were evident in the riparian vegetation of the Bungawalbyn catchment. Weed control around the mouth of Bora Creek and along Bungawalbyn Creek has been successful. The width of the riparian zone was less than 10 m for much of the area but the riparian canopy cover was over 60-100%. The percentage of native species in the canopy was over 90%. The riparian vegetation was fenced with an electric fence

for cattle at the study site. The weed species that were present in low abundance were seedlings and mature plants of Climbing Asparagus (*Asparagus plumosus)*, Cockspur Coral Tree (*Erythrina crista-galli*) and Coastal Morning Glory Vine (*Ipomoea cairica*) was evident in places.

Weed control and planting along Sandy Creek has also been successful with a canopy cover of up to 60% native and a high diversity evident. The major canopy species was Forest Red Gum (*Eucalyptus tereticornis*), with Whalebone Tree (*Streblus brunonianus*), Rough-leaved Elm (*Aphananthe philippinensis*), and Sally Wattle (*Acacia melanoxylon*). The River Lilly (*Crinum pendunculatum*), Marsh Club-rush (*Bolboschoenus fluviatilis*) and Creek Mat Rush (*Lomandra hystrix*) were colonising along the toe of the bank. The high diversity on the Bungawalbyn provides important reference sites for future riparian rehabilitation. There is scope for further riparian rehabilitation activities in this area.

The dominant weed species in this zone was Mimosa Bush (*Vachellia farnesiana*).

The Bora Creek Management Plan has recently been completed and will assist with weed management and riparian revegetation strategies.

Zone 12 - Upper Richmond/Wilsons River

On-ground sites UPRWR21/22, UPRWR23, UPRWR24, UPRWR25, UPRWR26, UPRWR30, UPRWR32, UPRWR32

The Upper Richmond and Wilsons River estuary management zone includes Leycester Creek, the Wilsons River from Lismore to Coraki and the Richmond River from Casino to Coraki.

Leycester Creek is mainly cleared of riparian vegetation with some remnant areas near site UPRWR25. The remaining vegetation in this section is dominated by River Oak (*Casuarina cunninghamiana*) and Weeping Bottlebrush (*Callistemon viminalis*) with rainforest elements in the mid-storey. The dominant mid-storey species include Whalebone Tree (*Streblus brunonianus*), Red Kamala (*Mallotus philippensis*) and Cudgerie (*Flindersia schottiiana*). The understorey was dominated by pasture grasses and herbaceous weeds with some native grasses, including Basket Grass (*Oplismenus* spp.). The threatened species Thorny Pea (*Desmodium acanthocladum*) was also found. The toe of the bank was largely unvegetated but *Baumea articulata* and other sedges were colonising in a few places. This site has high regeneration potential with a percentage cover class of up to 60% in the canopy with 30% native species. The major weed species in the canopy were Mulberry (*Morus alba*), Camphor Laurel (*Cinnamomum camphora*) and Coral Tree (*Erythrina crista-galli*), which all pose a serious threat to the remaining native species if left uncontrolled. Other serious weeds on the site were Balloon Vine (*Cardiospermum grandiflorum*), Climbing Asparagus (*Asparagus plumosus*) and Coastal Morning Glory (*Ipomoea cairica*). Bank exposure in places was severely impacting erosion of the bank and causing slumping in places. Vegetation has been compromised.

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Wilsons River upstream of Lismore

The riparian vegetation along the Wilsons River above Lismore at the Trinity Sports Field, was dominated by a canopy of Camphor Laurel (*Cinnamomum camphora*) and Coral Tree (*Erythrina sykesii*). The native canopy cover was less than 10%, consisting of Silky Oak (*Grevillea robusta*) and Red Kamala (*Mallotus philippensis*). Several native species were present in the mid and understorey, including Whalebone (*Streblus brunonianus*), Small-leaved Tuckeroo (*Cupaniopsis parvifolia*), Rough-leaved Elm (*Aphananthe philippinensis*), Twin-leaved Coogera (*Arytera distylis*) with the threatened species, Thorny Pea (*Desmodium acanthocladum*). The major weeds were Madeira Vine (*Anredera cordifolia*), Coral Berry (*Rivina humilis*) and Senna (*Senna pendula*).

Wilsons River downstream of Lismore

Downstream from Lismore, the Wilsons River riparian corridor was sparse with a canopy cover of less than 10% in many places. The dominant native species were Forest Red Gum (*Eucalyptus tereticornis),* Weeping Bottlebrush *(Callistemon viminalis)* with some River Oak (*Casuarina cunninghamiana).* The percentage of native species in the canopy varied between 1% and 30%. The major weed species in the canopy were Mulberry (*Morus alba*), Camphor Laurel (*Cinnamomum camphora*) and Coral Tree (*Erythrina crista-galli*) which all pose a serious threat to the remaining native species if left uncontrolled. Other serious weeds on the site were Balloon Vine (*Cardiospermum grandiflorum*), Climbing Asparagus (*Asparagus plumosus*) and Coastal Morning Glory (*Ipomoea cairica*). Other serious understorey weeds included Para Grass (*Urochloa mutica*) and Johnson Grass (*Sorghum halepense*).

Upper Richmond River

The riparian corridor along the Richmond River to Casino was similar to the Wilson River. The dominant native species were Forest Red Gum (*Eucalyptus tereticornis),* Weeping Bottlebrush *(Callistemon viminalis)* with some River Oak (*Casuarina cunninghamiana).* Other native trees included Creek Lilly Pilly (*Acmena smithii*) and Twin-leaved Coogera (*Arytera distylis*) .The percentage of native species in the canopy varied between 1% and 30%. The understorey was dominated by pasture grasses and herbaceous weeds with some native grasses including Basket Grass (*Oplismenus* spp.). The major weed species in the canopy were Mulberry (*Morus alba*) Camphor Laurel (*Cinnamomum camphora*) and Coral Tree (*Erythrina crista-galli*), which all pose a serious threat to the remaining native species if left uncontrolled. Other serious weeds on the site were Balloon Vine (*Cardiospermum grandiflorum*), Climbing Asparagus (*Asparagus plumosus*) and Coastal Morning Glory (*Ipomoea cairica*).

Other serious understorey weeds included Para Grass (*Urochloa mutica*) and Johnsons Grass (*Sorghum halepense*). This area is reported to have Honey Locust (*Gleditsia tricanthos*) and *Hymenachne* sp. which are both potentially serious invasive weeds of the lower estuary in the future.

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The Richmond River at Casino has similar vegetation although some very useful regeneration work has been completed. This site has high potential as a focus site for revegetation works to demonstrate the appropriate species for slowing bank erosion.

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3 Geomorphological Assessment

3.1 Summary

The issues occurring within each of the 12 management zones are primarily the direct consequence of anthropogenic activity which began with permanent European settlement of the Richmond River Basin from around 1842. Extensive land clearance, initially for the timber industry, but also to facilitate the establishment of broad scale farm based agricultural enterprises has set the scene for an altered landscape which is more susceptible to fluvial erosion processes in a high rainfall region.

The cumulative effects of a largely cleared landscape are most evident along the steeper slopes of upper catchments and the upper to mid floodplain where erosion scarps and bank slumping are common in areas no longer bordered by natural riparian vegetation. Mass movement of eroded sediment is most evident in the lower floodplain where siltation and infilling of channels has progressively restricted navigation for boating and exacerbated the spread of floodwaters following high rainfall events.

Drainage modification for farming (particularly sugar cane), roads and flood mitigation measures have had a marked effect on the natural flow regime. In these areas, there is no longer the capacity for streams to establish natural meanders in response to landscape gradients and natural rates of flow. Consequently, drainage patterns are established to suit farming practices and in addition to hydrologic changes, can promote erosion of fallowed soil during high rainfall events, direct to the main river system.

The major management issues for the Richmond River Floodplain are highlighted in the summary table (Table 3.5) which shows sheet and rill erosion, drainage modification for agriculture, water course obstructions, and a lack of suitable riparian vegetation (within at least one portion of each zone) as the common elements across all Management Zones. The establishment of suitable vegetation for riparian corridors and natural vegetation for stabilisation of denuded banks would result in a significant reduction in bank erosion and sediment displacement.

3.2 Context of the Richmond River Estuary and Catchment

The geology of the Richmond River catchment is comprised primarily of Tertiary-Quaternary Sediments (river gravels, alluvium, sand and clay as well as beach and dune sands) and Tertiary Volcanics (Lismore Basalt) which overlay Palaeozoic Neranleigh-Fernvale Metasediments. In addition, there are several scattered outcrops of Mesozoic sediments, including the Walloon Coal Measures, Kangaroo Creek Sandstone and the Tabulam Group (Redcliff Coal Measures).

These Mesozoic sediments include rock types such as sandstone, siltstone, claystone, shale, conglomerate and coal (Brunker *et al*. 1972; Hanlon *et al*. 1970).

The five main soil types in the catchment are; red basaltic (kraznozem), chocolate, alluvial, podzolic and coastal heath soils. The red and chocolate soils have developed from Tertiary Basalts in elevated areas of high rainfall, the podzolic soils have developed from Mesozoic Sediments and the coastal heath soils have formed from Quaternary Sediments. Alluvial soils contain sediments from all geologic groups (Donnelly, 1997).

The Richmond River catchment covers an area of approximately 6900 km^2 which includes three main tributaries, the Wilsons River, the Richmond River and Bungawalbyn Creek (Hossain *et al*. 2002) and the floodplain (Donnelly 1997). Approximately 20% of the catchment has slopes exceeding 15°; 40% has slopes between 3° and 15°; with the remaining area comprised of flat land with extensive floodplains (WBM 2006; Hossain *et al*. 2001). Only 22% of the Wilsons River subcatchment is forested, compared with 42% of the Richmond River and 75% of the Bungawalbyn Creek sub-catchments (Hossain *et al.* 2002).

With the exception of the Bungawalbyn Creek subcatchment and the Border Ranges, the majority of the Richmond catchment has been extensively cleared of native vegetation with a significant number of natural water courses (tributaries) having been highly modified for agricultural drainage and/or flood mitigation purposes. Changes in the landuse patterns such as deforestation and agricultural activities in the upper catchments, development on the lower floodplains, and urbanisation in the lower coastal catchments, has significantly increased the supply of sediment to the river system (Hossain *et al*. 2004). Landuse, population density, geology and soils vary considerably across the catchment (McKee *et al*. 2001), and landuse changes in the subcatchments indicate a potential increase of suspended sediment load of about 6-fold since European settlement (Hossain *et al*. 2002).

Loose rock protection is present along most of the Richmond riverbank as far upstream as Wardell. Upstream from Wardell, bank erosion contributes substantially to downstream sediment loading. On the lower Richmond River floodplain, bank erosion does not significantly contribute to the sediment supply, nor do tributary streams other than for fine clays and silts during high rainfall run off events. The main contributors to bank instability are boat wake and locally generated wind waves (WBM 2006).

The straightening of existing river or tributary meander in areas of where drainage regimes have been altered, results in heightened erosion of banks, as it steepens the gradient of the channel and thus increases water velocity (Ladson 2008). The natural meander of water courses has been largely disregarded by agricultural land management practices, leading to significant increases in sediment transport downstream.

The catchment is characterised by net seaward-directed sediment transport, associated with the predominantly high river discharge and relative absence of available accommodation space

for sediment deposition (WBM 2006). Consequently, fine suspended sediment, and coarse sediment (as bed-load), is moved downstream along the bottom of the deltaic channels, due to unimpeded river flow. Where flow is impeded by built structures such as weirs and dams, sediment becomes trapped under normal flow regimes and there is often significant infilling from sediment build up.

The Richmond River Estuary can be described as a bar built, micro-tidal, mature wave dominated delta (Roy *et al*. 2001; Hossain *et al*. 2004; Hashimoto et al. 2006). The tidal influence extends to Boatharbour in the Wilsons River, to Casino in the Richmond River and 15km upstream in Bungawalbyn Creek (Hossain *et al*. 2001). Fine and coarse sediment enters the estuary from the catchment, subject to climatic conditions and the volume of river input. Seasonal and climate factors dominate the function of deltas, with episodic high-flow events causing intense flushing, sedimentation, and erosion in the main channels and floodplain (Eyre *et al*. 1998).

Suspended sediment transport through the estuary is controlled by many factors including river flow, tidal flows, tidal range, salinity, density, circulation and wind (Hossain *et al*. 2004). Freshwater discharge appears to be a major influence on sediment transport, deposition and export to the continental shelf (Hossain *et al*. 2001). Increasing amounts of sediment being received by estuarine ecosystems is increasing the economic burden on local communities as high standards of water quality are expected and there are escalating costs to remove sediment and maintain channels for navigation and flood mitigation purposes (Eyre *et al*. 1998).

3.3 Methodology for Field Site Assessment

3.3.1 Geomorphic Stability Assessment

Methodology developed by Rosgen (1996) and adapted after Dilworth (2008), was used to assess geomorphic stability at the same sites the vegetation assessment was carried out. Scores were given that related to stability characteristics, shown in Table 3.1, at the same sites where the vegetation assessment was complete.

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Table 3.1. Scoring system used to assess geomorphic stability.

Stability	*Characteristics*	*Score*
Stable	Geomorphic structures of the channel unaltered or largely unchanged from pre-European disturbance state, and geomorphic form processes (sediment transport) are in equilibrium with existing channel geometry. High sediment transport competence. Usually bedrock controlled and not subject to or likely to be subject to bed level adjustment.	10-8
Moderately Unstable	Stable convex stream banks with intact bank toes stable. Isolated incidences of bed and bank erosion may be present but can easily be addressed by restoring riparian vegetation, and bank protection.	8-5
Unstable	Both bed level and/or lateral adjustments are active in-stream. Vertical stream banks indicate major bank erosion, which is associated with active bed level adjustments (minor head cuts) are common.	5-3.5
Highly Unstable	The channel is entrenched and highly unstable with ongoing vertical and/or lateral bed and bank erosion. Stream banks are vertical to concave and numerous bed level adjustments are evident.	3.5-0

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3.3.2 Geomorphic Condition

Methodology developed by Lambert *et al*. (1999) and adapted after Dilworth (2008), was used to define the geomorphic conditions of each site assessed. The scoring was based on the conditions described in Table 3.2.

Table 3.2 Condition assessment used to classify the geomorphology.

Geomorphic Condition	*Characteristic*	*Score*
Near Intact	The geomorphic structure is largely unchanged from pre-disturbance state. Riparian vegetation is usually unchanged. Geomorphic form characteristics and processes are in equilibrium. The aquatic waterway is providing critical aquatic habitat refuge.	10-8
Good	Geomorphic structure is largely unchanged from pre-disturbance state, however, vegetation cover and composition may be significantly altered. Characteristics and processes are in equilibrium. The aquatic waterway is providing critical aquatic habitat refuge.	8-6.5
Moderately impacted	Geomorphic form characteristics and processes have been disturbed in the past and remain out of equilibrium. The waterway has not adjusted to prevailing conditions and is experiencing on-going changes. Aquatic habitat refuge is still provided however the condition is degraded.	6.5-4.5
Degraded	The channel has become entrenched laterally and vertically expanded to its most degraded condition. The channel is disconnected from the floodplain. Geomorphic form and characteristics are processes are degraded. Limited aquatic refuge habitat is provided.	4.5-0

3.3.3 Geomorphic recovery potential

Methodology developed by Lambert et al. (1999) and after Dilworth (2008), was used to determine a score for recovery potential. Table 3.3 outlines the characteristic used in the scoring.

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Table 3.3 Scoring system used to assess recovery potential at sites.

Recovery Potential	*Characteristics*	*Score*
Conservation	River structure and vegetation associations are relatively intact. Management strategies should aim to maintain, or improve the current River Style.	10-8
Strategic	Sites or reaches which are sensitive to disturbance triggering upstream geomorphic degradation, lateral or vertical expansion of the channel. These areas may deliver an oversupply of sediment to downstream reaches. Proactive management strategies are the most effective means of conservation. Attention should be placed on bed level adjustments.	8
High Recovery	These reaches have high inherent natural recovery potential and will respond well to improved land management and assisted regeneration.	8-6
Moderate Recovery	These moderately degraded sites/reaches have reasonable potential to recover and can be rehabilitated at reasonable cost. River structure and vegetation associations require improvement. Bed and bank rehabilitation strategies may be required to stabilise the waterway.	6-4
Degraded reaches	These highly degraded sites/reaches have little natural recovery potential (i.e. the water way shows signs of continued geomorphic degradation). Extensive bed and bank stabilisation works are required at considerable cost over a long period of time.	4-0

3.4 Results and Assessment

The observations made during a catchment tour together with a literature review and the results of the on-ground site assessment, were used to provide a geomorphic status assessment for each management zone. The results of the on-ground site assessment are provided in Table 3.4.

Additionally, photograph Archives for each management zone and at specific on-ground sites are presented in Appendix 2.

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Table 3.4 Geomorphic Assessment Scoring.

SITE		GPS	Management Zone Number	Management Zone name	BANK AND BED STABILITY	Geomorphic stability	Creek and Bank Condition	Recovery Potential	TOTAL SCORE
NC1	Nth Cr Road	28 50' 21.21"S, 153 34' 43.26"E	1	North Creek		5.5	5.5	7.5	**18.5**
NC2	Upstream Ross Lane	28 47'12.76"S, 153 33' 50.14"E	1	North Creek		5.5	5.5	7.5	**18.5**
EC3	Emigrant Cr	28 50' 01.53"S, 153 30' 48.50"E	2	Emigrant/ Maguires		5.5	5.5	7.5	**18.5**
SB4	Sth Ballina Beach Road	28 52' 52.62"S, 153 33' 34.82"E	4	Sth Ballina		5.5	5.5	7.5	**18.5**
SB5	Empire Vale	28 54' 46.58"S, 153 30' 30.60"E	4	Sth Ballina		5.5	5.0	6.0	**16.5**
SB6	Carney Lane River Dr	28 57' 6.07"S, 153 28' 29.80"E	4	Sth Ballina		6.0	5.5	5.5	**17.0**
SB7	Near Pimblico Is	28 54' 49.43"S, 153 29' 19.35"E	2	Emigrant/ Maguires		4.5	5	4.5	**14.0**
BC8	Wardell Bridge	28 57' 16.25"S, 153 27' 56.07"E	3	Back Channel		4.5	5	4.5	**14.0**
T 10/11	Broadwater Road	28 59' 50.68"S, 153 24' 11.22"E	10	Tuckean		3	5.5	5.5	**14.0**
T12	BAG BARRAGE	28 58' 51.75"S, 153 24' 15.98"E	10	Tuckean		7.5	6.5	8.5	**22.5**
KB 13/14	Kilgin Drain to RR	29 01'31.58"S 153 22 '30.24" E	9	Kilgin/ Buckendoon		3.5	4.5	3	**11.0**
KB15	Woodburn opp town	29 4' 6.42"S, 153 20' 34.57"E	9	Kilgin/ Buckendoon		4.5	2	8	**14.5**
KB18	OAKLAND RD NEAR SCHOOL RD	29 4' 38.55"S, 153 20' 4.10"E	9	Kilgin/ Buckendoon		4.5	3	7.5	**15.0**
RC17	Rocky Mouth Creek	29 02' 40.25"S, 153 20' 09.24"E	7	Rocky Mouth Creek		6.5	6	7	**19.5**
E19	TUCKOMBIL CANAL	29 05' 05.52"S, 153 20'16.79"E	6	Evans River		4	4	6.5	**14.5**
SB20	Swan Bay	29 3' 40.89"S, 153 17' 16.87"E	8	Swan Bay		7	7	7	**21.0**

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SITE		GPS	Management Zone Number	Management Zone name	BANK AND BED STABILITY	Geomorphic stability	Creek and Bank Condition	Recovery Potential	TOTAL SCORE
UPRWR21/ 22	Coraki downstream boat ramp	28 59' 6.10"S, 153 17' 14.37"E	12	Upper Richmond/ Wilsons River		5.5	5	7.5	**18.0**
UPRWR23	WYRALLA RD BRIDGE TO CORAKI	28 53' 29.78"S, 153 17' 49.75"E	12	Upper Richmond/ Wilsons River		6	5	6	**17.0**
UPRWR24	WYRALLA RD UPPER	28 52' 06.87"S, 153 16' 14.12"E	12	Upper Richmond/ Wilsons River		4	6	7	**17.0**
UPRWR25	LECESTER CR	28 47' 45.44"S, 153 14' 24.09"E	12	Upper Richmond/ Wilsons River		5.5	5	6.5	**17.0**
BU26	Bora Bungawalby n Creek	29 2' 42.08"S, 153 15' 3.72"E	11	Lower Bungawalbyn		7.5	7	8	**22.5**
BU27/28	Sandy Creek	29 1' 32.61"S, 153 15' 5.76"E	11	Lower Bungawalbyn		8.0	7	8	**23.0**
UPRWR 29/30	Tomki Tatham Bridge	28 55' 30.09'S, 153 09' 39.64"E	12	Upper Richmond/ Wilsons River		4.5	5	5.5	**15.0**
UPRWR31	Casino Weir	28 52' 4.56"S, 153 2' 33.21"E	12	Upper Richmond/ Wilsons River		5.5	5.5	4	**15.0**
UPRWR32	Wilson R Trinity	28 48' 0.09"S, 153 17' 9.39"E	12	Upper Richmond/ Wilsons River		4.5	5.0	5	**14.5**

Table 3.5 provides a summary of the issues in each zone. Some relevant photographs are provided in **Error! Reference source not found.** and Figure 3.2.

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Table 3.5 Management Zone Issues.

MANAGEMENT ISSUES	*MANAGEMENT ZONE*												
	1-North Ck Newrybar	2 – Emigrant/	3 –Back Channel	4 –South Ballina/	5 –Rileys Hill	6 -Evans	7 –Rocky Mouth Ck	8 –Swan Bay	9 –Kilgin/ Buckendoo	10 - Tuckean	11 –Lower Bungawalb	12 –Upper Richmond/
Lack of suitable riparian vegetation (upper reaches)	X	X				X	X			X		X
Lack of suitable riparian vegetation (middle)			X				X	X	X	X		X
Lack of suitable riparian vegetation (lower reaches)			X	X	X		X				X	
Drainage modification for agriculture	X		X	X	X	X	X	X	X	X	X	X
Drainage modification with steep sided banks				X	X	X	X	X	X	X		
Drainage and bank modification for flood mitigation				X	X	X	X	X	X	X	X	
Agricultural practices removing drainage sediment	X		X	X	X	X	X	X	X	X	X	
High flow erosion susceptibility increasing bank erosion						X				X		X
Water course obstructions (constructed flow restrictions)	X	X	X	X	X		X	X	X	X	X	
Erosion from flow redirection during flood conditions						X	X					
Interruptions to natural flow regime (e.g. dam construction)		X				X				X		
Sheet and rill erosion on cleared land	X	X	X	X	X	X	X	X	X	X	X	X
Mobilisation of chemicals from horticultural activity		X										
Geological substrate with high potential for erosion			X								X	
Downstream bulk sediment movement resulting in shoaling	X	X				X						
Increasing channel width and decreasing channel depth	X					X						
Stock access to watercourses	X	X					X	X	X	X	X	X
Recreational boating and fishing access (wave erosion)	X	X	X	X	X	X	X	X	X			X
Natural meander readjustment after altered flow regime						X						
In-filling due to isolation from the river system								X				

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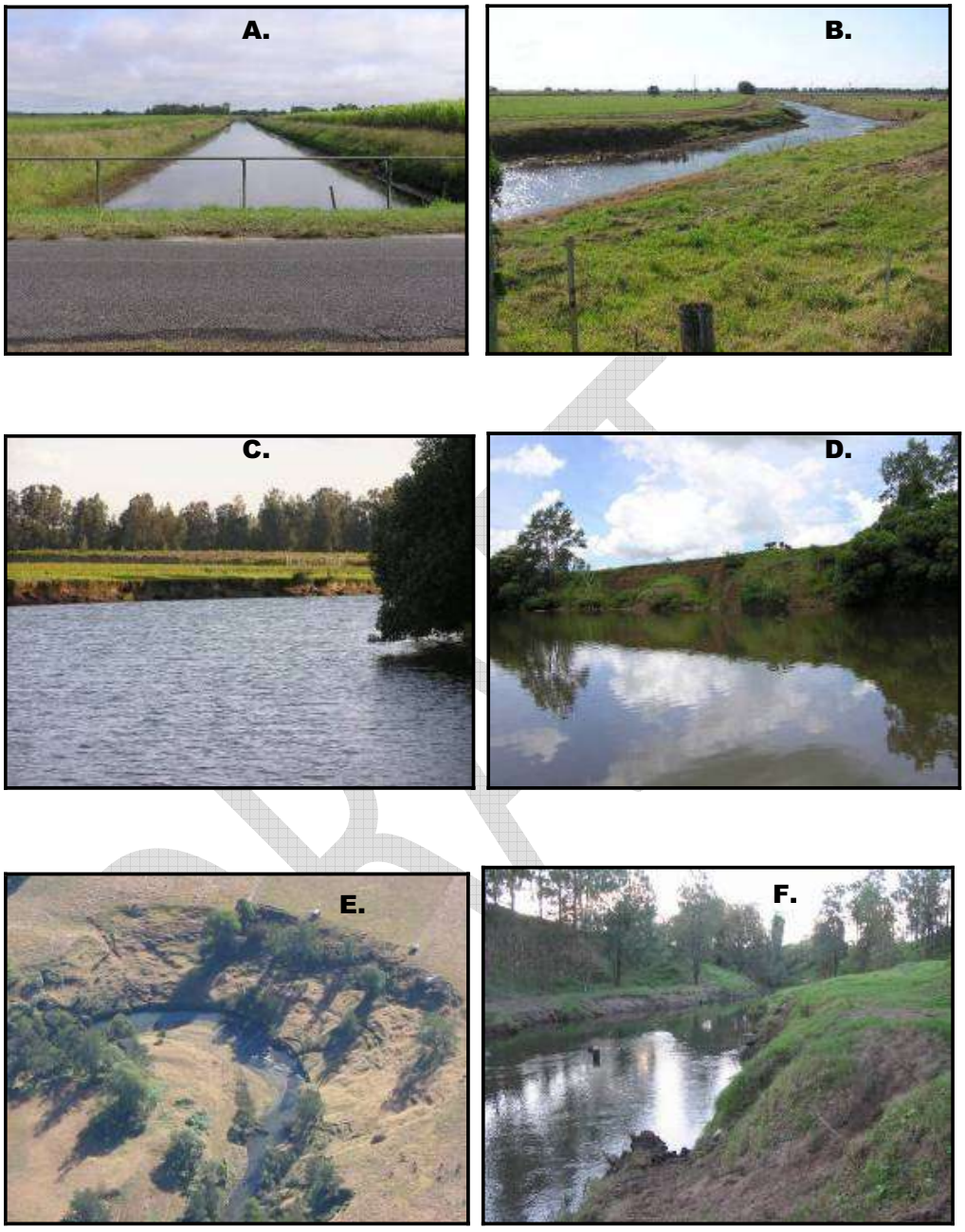

Figure 3.1. Examples of major geomorphologic issues in the Richmond River Floodplain.
A. Drainage modification for agriculture (Management Zone 9).
B. Drainage modification with steep sided banks (Management Zone 11).
C, D, E and F. Examples of bank slumping and erosion caused from removal of riparian vegetation (Management Zone 12).

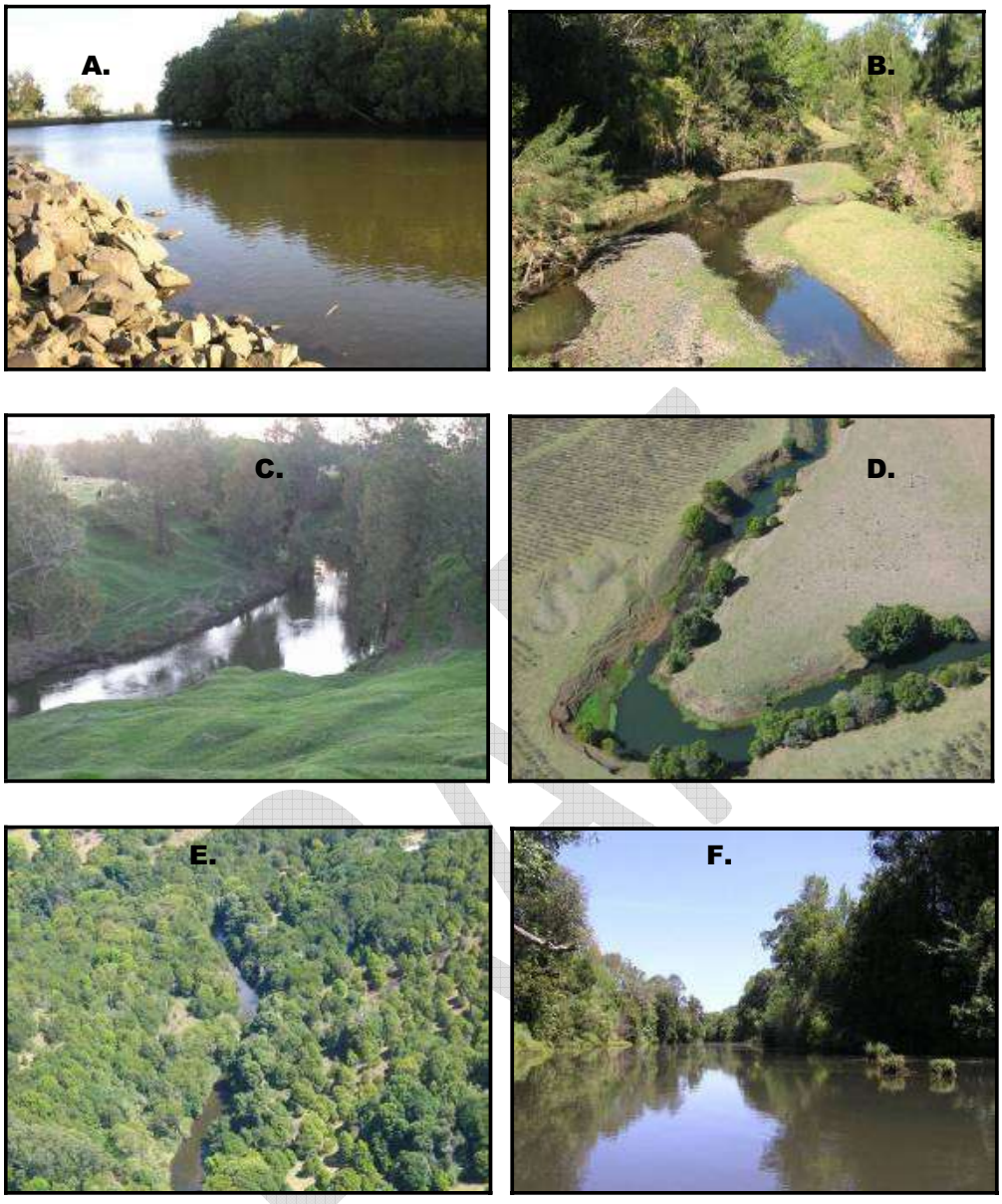

Figure 3.2 Examples of major geomorphologic issues in the Richmond River Floodplain.
A. Loose rock bank protection (Management Zone 1).
B. In channel sediment build up.
C. Cattle access to watercourse.
D. Denuded section of bank and encroaching agriculture.
E. Stream section with healthy riparian vegetation.
F. River section with healthy riparian vegetation.

Note: Photographs B to F are from Management Zone 12 and taken by NSW Fisheries, but are representative of the issues for the majority of Management Zones.

Zone 1 - North Creek/Newrybar

On-ground sites NC1, NC2

Geology

The upper catchment flows east from the coastal ridge at Newrybar which is a region underlain with Tertiary Volcanics (Lismore Basalts), down onto the coastal plain which is comprised of Quaternary Sediments (river gravels, alluvium, sand and clay, as well as beach and dune sands). In the northern most portion of this catchment (Midgen Creek), the upper catchment flows from a region consisting of Neranleigh-Fernvale Metasediments. The majority of the North Creek catchment including tributaries of Birrung Creek, Newrybar drain, Deadmans Creek, Roberts Creek, and Chickiba Creek, drain through lower lying swampy areas comprised mainly of Quaternary Sediments (Brunker *et al*. 1972).

Natural Land Cover

Most of the coastal sub-catchment has been modified from its natural state for agricultural use as well as urban coastal development on some upland ridgelines. The management zone has been extensively drained and cleared with a network of connecting artificial drainage systems adjacent to the coastal heath which has been selectively retained along the beach dune systems.

Current Land Use

The North Creek/Newrybar management zone has been cleared for grazing (cattle) and horticultural purposes in the upper reaches, and drained for agricultural purposes (predominantly sugar cane), on the lower lying areas. Dredging and expanding urban development is occurring in this area.

Soils

The North Creek/Newrybar management zone is made up of alluvial, red basaltic (kraznozem), podzol soil types, and coastal heath sands (Donnelly 1997).

Stream Pattern

The stream pattern can be described as dendritic in the upper region and both centripetal (unaltered) and distributary (altered with drainage) in the middle and lower reaches (Grotzinger *et al*. 2007).

Bank Stability

The upper reaches are lacking in riparian vegetation due to clearing for grazing which has lead to bank erosion and transportation of sediment downstream. The coastal sand plain is characterised by extensive drainage channels in which siltation (transported from upstream) is actively removed and often dumped as spoil along the banks as part of management practices to keep drains open. Riparian vegetation is non-existent along drainage channels due to the need for efficient drainage and access, as well as the practice of maximising land

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area for crop production. The middle section of North Creek passes through Ballina Nature Reserve and as such has extensive riparian vegetation resulting in good bank stability and erosion control. The lower estuary area has some loose rock protection, adjacent to urban settlement, where meander channels are undercutting the shoreline (WBM 2006).

Sediment Transport/Movement

The opportunity for sediment transport and movement is evident in the upper boundaries of the management zone due to past land clearing practices and a lack of riparian vegetation. The sediment is transported downstream in "slugs" during times of high rainfall making its way into the lower estuary (Hossain *et al*. 2001). Here, the sediment is trapped and is accreting in expanding mangrove forests. From the ocean side, marine sands are developing shoals around the Missingham Bridge area.

Zone Specific Issues

Major issues for the North Creek/Newrybar management zone include a lack of suitable riparian vegetation in the upper reaches which provides increased opportunity for bank instability and sediment mobilisation. Current agricultural practices for sugar cane farming provide a source of unconsolidated sediment as drain clearance spoil is readily transported downstream in high rainfall events.

- Lack of suitable riparian vegetation in upper reaches leading to bank instability.
- Drainage modification for agriculture.
- Agricultural practices remove drainage vegetation and sediment which is often deposited along the bank.
- Stock access to upper catchment watercourses.
- Unsuitable drainage and watercourse obstructions (bridges, crossings, pipes) which cause flow restrictions on farmed agricultural land.
- Recreational boating and fishing access in lower catchment.
- Sheet and rill erosion on cleared land.
- Catchment and marine sediment movement resulting in estuary shoaling.
- Increasing channel width and decreasing channel depth in the lower catchment.

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Zone 2 - Emigrant/Maguires Creek

On-ground sites EC3

Geology

Maguires Creek drains the eastern portion of the Alstonville plateau which is a region of Tertiary volcanic rock named Lismore Basalt. Off the edge of the plateau, the creek passes through exposed sections of ancient Palaeozoic strata identified as Neranleigh-Fernvale Metasediments, then flows down onto the coastal plain which is comprised of Quaternary Sediments (river gravels, alluvium, sand and clay). Tributaries of Maguires Creek include Willowbank Creek, Branch Creek and Houghlahans Creek. Maguires Creek joins Emigrant Creek 2km north west of West Ballina. Emigrant creek begins just east of Newrybar and cuts through Lismore Basalts, some minor outcrops of Neranleigh-Fernvale Metasediment at Tintenbar, before flowing onto the coastal plain at Cumbulum. Tributaries of Emigrant Creek include Sandy Flat Creek, (Brunker *et al*. 1972).

Natural Land Cover

Basalt areas were originally covered in rainforest which was known as the Big Scrub. Most of the management zone has been modified from its natural state for agricultural use as well as urban development on upland areas (eg. Alstonville). The management zone has been extensively cleared, originally for dairying, but in more recent times much of the upland area has been converted to horticulture which is mainly Macadamia Nut production. Natural vegetation cover has been removed with only the occasional isolated pocket of remnant vegetation remaining as an example of the once broad and rich species mix.

Current Land Use

The management zone has been extensively cleared for grazing (cattle) and horticultural purposes (WBM, 2006). Some areas are no longer used for agricultural production and are regenerating original forest vegetation cover, but with an increased mix of exotic weed species.

Soils

The management zone is made up of alluvial, red basaltic (kraznozem) and podzol soil types (Donnelly, 1997).

Stream Pattern

The stream pattern of Maguires Creek can be described as radial from the Alstonville plateau and parallel in the areas of pronounced localised relief. The stream pattern of Emigrant Creek can be described as parallel in the upland areas and both catchments are centripetal in the middle and lower reaches (Grotzinger *et al*. 2007). Emigrant Creek Dam is located in the middle to upper reaches of Emigrant Creek, at Knockrow, and was commissioned in late 1953. It should be noted that since construction there have been significant effects

downstream in relation to altered flow regimes and sediment movement. In more recent times, significant effort has been put into catchment revegetation around the Emigrant Creek Dam. Marine dominated shoaling occurs at the confluence with Richmond River.

Bank Stability

The upper reaches of the management zone are lacking in riparian vegetation due to clearing for grazing which has in turn lead to extensive erosion of banks and transportation of sediment downstream (WBM 2006). With a more recent change from grazing to horticulture some landholders have replanted riparian corridors resulting in bank stabilisation and improved stream management. Areas that are not currently used for agricultural production tend to have naturally regenerating riparian zones, however, the species mix is often predominantly exotic (i.e. Camphor Laurel). The coastal sand plain is characterised by extensive existing riparian corridors dominated by Mangrove species.

Sediment Transport/Movement

The past land clearance for grazing would have contributed significantly to the sediment load. With the change in land use to predominantly horticultural activity exposed soils and landforms will depend on crop style and farm management practices. Sediment contributions to the system also occur during the establishment of the chosen crop. The opportunity for sediment transport and movement is most evident in the steeper upper boundaries of the management zone with a lack of riparian vegetation. The sediment is transported from higher elevations downstream in "slugs" during times of high rainfall and accumulates in the lower energy drainage network of the coastal floodplain. This is evidenced by expanding mangrove forests and extensive shoaling in estuarine and tidal channels (WBM 2006).

Zone Specific Issues

A major issue for the Emigrant/Maguires Creek management zone is a lack of riparian vegetation in the steeper upper areas of the drainage network where higher stream velocities readily erode banks leading to increased sediment transport and deposition lower down in the catchment.

- Lack of suitable riparian vegetation in upper reaches leading to bank instability.
- Interruption of natural flow regime with construction of Emigrant Creek Dam.
- Sheet and rill erosion on cleared land.
- Potential mobilisation of chemicals due to horticultural management practices.
- Stock access to upper catchment watercourses.
- Unsuitable drainage and watercourse obstructions (bridges, crossings, pipes) which cause flow restrictions on farmed agricultural land.
- Recreational boating and fishing access in lower catchment.
- Bulk sediment movement resulting in downstream estuary shoaling.

Zone 3 -Back Channel

On ground sites BC8

Geology

The Back Channel management zone drains the eastern portion of the Blackwall Range which is a complex geological feature comprised of predominantly Mesozoic sediment (sandstone, siltstone, claystone and conglomerate) which is named the Tabulum Group. There are some minor Lismore Basalt caps above these sedimentary layers at higher elevations and significant outcrops of Neranleigh-Fernvale Metasediments below, adjacent to the coastal plain. The coastal plain is comprised of Quaternary Sediments including river gravels, alluvium, sand and clay (Brunker *et al*. 1972). The area is drained by a number of minor water courses such as Bingal Creek and areas under agriculture are networked with a constructed drainage system.

Natural Land Cover

Basalt areas were originally covered in rainforest which have now been cleared for agriculture. Steeper slopes in the management zone remain forested with a strip of farmed land at the base of the Blackwell Range down onto the coastal plain. The centre portion of the coastal plain remains as Crown Reserve, and is predominantly low-lying swampland and scrub. The proposed route for the Pacific Highway upgrade runs through the farmed land between the Blackwell Range and Crown Reserve.

Current Land Use

The management zone has been partially cleared on lower slopes and sections of the coastal plain for cropping (sugar cane), especially those areas adjoining the Richmond River. Higher slopes are utilised for cattle grazing and minor horticultural activities. To the north west of Wardell a significant area (~1km^2) is being mined for mineral sands.

Soils

The management zone is made up of red basaltic (kraznozem), podzol and alluvial soil types (Donnelly 1997).

Stream Pattern

The natural stream pattern can be described as centripetal which connects with a series of modified distributary channels within agricultural cropping areas. Many of the modified watercourse channels connect directly to the Richmond River (Grotzinger *et al*. 2007).

Bank Stability

The eastern range escarpment is incised with a series of steep flowing and eroded water courses which connect to Bingal Creek. The upper reaches have retained riparian vegetation which diminishes significantly in the lower reaches and in areas under agricultural production on the coastal plain. Drainage networks with the extensive Crown Reserve retain natural vegetation cover. Bank stability along this section of the Richmond River is artificially

maintained with a series of loose rock walls, especially around the town of Wardell (WBM 2006).

Sediment Transport/Movement

As the Blackwall Range is primarily sedimentary strata it is more susceptible to erosion, and as such, higher sediment loads should be anticipated from this area as a natural process. Consequently, it is particularly important to retain riparian vegetation on the upper steep slopes which will help minimise and manage the erosion of unconsolidated sediment.

Zone Specific Issues

A major issue for the Back Channel management zone is in the upper reaches where steep gullies leading to the Blackwall Range pass through geological substrate that has a high potential for erosion. It is especially important to maintain vegetation cover in this area.

- Lack of riparian vegetation in agricultural areas of both the lower and middle reaches leading to bank instability.
- Drainage modification to facilitate improved agricultural production.
- Agricultural practices remove drainage vegetation and sediment which is deposited along the bank.
- Sedimentary substrate of the upper reaches is particularly vulnerable to erosion on cleared land.
- Recreational boating and fishing access on the Richmond River.
- Sheet and rill erosion on cleared land.
- Stock access to upper and mid catchment watercourses.
- Unsuitable drainage and watercourse obstructions (bridges, crossings, pipes) which cause flow restrictions on farmed agricultural land.
- Uncertainty associated with erosion implications of the Pacific Highway upgrade and flooding.

Zone 4 -South Ballina/Empire Vale

On ground sites SB4, SB5, SB6, SB7

Geology

The South Ballina/Empire Vale management zone is drained by minor tributaries, Mosquito Creek, Empire Vale Creek, Reedy Creek, Boundary Creek and Everson's Creek, all of which have been extensively modified for use as drainage channels for agriculture. Most of the management zone is comprised of Quaternary Sediments of which the eastern portion is predominantly beach and dune sands and the western portion is comprised of river alluvium.

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East of Broadwater is Cook's Hill which is the only elevated portion in the zone and is comprised of ancient Palaeozoic metamorphic rock types, group named as Neranleigh-Fernvale Metasediment (Brunker *et al.* 1972).

Natural Land Cover

The management zone was originally covered with low lying swampland, coastal heath, and portions of littoral rainforest in the lee of the beach hind dunes. Richmond River Nature Reserve is in the lower estuarine area of this zone.

Current Land Use

The area has been extensively sand mined along the coastal dune systems and cleared between back dunes and the river for agriculture (sugar cane). A small southern section east of Broadwater is not under agriculture and is predominantly heath land.

Soils

The management zone is made up of mainly alluvial and coastal heath soil types (Donnelly 1997) with a small section of podzolic soil east of Broadwater.

Stream Pattern

The natural stream pattern is now essentially only modified distributary channels within agricultural areas and most channels connect directly to the Richmond River (Grotzinger *et al*. 2007).

Bank Stability

Most of the drainage network for the management zone is maintained by farm management practices which require free flowing movement of groundwater away from areas of crop production. Banks are inherently unstable due to the use of machinery for their modification and construction and this results in unnatural steep sides as a means to maximise cropping area and agricultural production. Feasibility studies are currently being conducted through NSW NPWS in order to manage erosion issues at Mobbs Bay. The erosion at Mobbs Bay has been exasperated by a slumping in the sub-tidal barrier over the last 15 years.

Sediment Transport/Movement

High rainfall events will result in significant sediment mobilisation due to most drainage channels being devoid of natural riparian vegetation (WBM 2006). This can lead to the easy movement of unconsolidated sandy sediment and loam soil types during periods of high flow rates.

Zone Specific Issues

As the zone is relatively flat and wholly contained within the Lower Richmond River Floodplain management issues are primarily concerned with drainage and flood mitigation.

- Lack of natural riparian vegetation in agricultural areas resulting in bank instability.

- Drainage modification with steep sided unnatural banks.
- Recreational boating and fishing access on the Richmond River.
- Drainage modification for flood mitigation (including levee construction and flood gates).
- Sheet and rill erosion on cleared (agricultural) land.
- Unsuitable drainage and watercourse obstructions (bridges, crossings, pipes) which cause flow restrictions on farmed agricultural land.
- Drainage modification to facilitate improved agricultural production.
- Mobbs Bay shore erosion issues.

Zone 5 -Rileys Hill

Geology

Rileys Hill management zone is drained by unnamed minor tributaries, some of which drain the northern portion of Broadwater National Park. Most of the management zone is comprised of Quaternary Sediments (alluvium, sands and clay) but Rileys Hill, which is the only elevated portion of the management zone, is an outcrop of Mesozoic sediment (Tabulam Group, including sandstone, shale and conglomerate) (Hanlon *et al*. 1970).

Natural Land Cover

The management zone was originally covered with low lying swampland, adjacent to the river, heath on the sand plain, and a portion of woodland on the elevated ridge of Rileys Hill.

Current Land Use

The area has been extensively cleared along the river floodplain for agriculture (sugar cane) and residential development on Rileys Hill. A significant portion of the management zone is part of Broadwater National Park.

Soils

The zone is made up of mainly alluvial and coastal heath soil types (Donnelly 1997) with a small section of podzolic soil at Rileys Hill.

Stream Pattern

The natural stream pattern is now essentially only modified distributary channels within agricultural areas and most channels connect directly to the Richmond River (Grotzinger *et al*. 2007).

Bank Stability

Other than drainage originating in Broadwater National Park most of the drainage network for the management zone is maintained by farm management practices which require free flowing movement of groundwater away from areas of crop production. Banks are inherently

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unstable due to a lack of vegetation and the use of machinery for their construction and modification. This results in unnatural steep sides as a means to maximise cropping area and agricultural production. The main Richmond River bank retains a fringe of mangroves for most of the management zone.

Sediment Transport/Movement

High rainfall events will result in sediment mobilisation due to most drainage channels being devoid of natural riparian vegetation and constructed in loamy soils with unconsolidated sediment. Significant sections of the floodplain zone are impacted by major flood events in the Richmond River (WBM 2006).

Zone Specific Issues

Issues associated with a reliance on a modified and constructed drainage network, in association with measures for flood mitigation, are the primary concerns within the management zone.

- Lack of natural riparian vegetation in agricultural areas resulting in bank instability.
- Drainage modification with steep sided unnatural banks.
- Drainage modification to facilitate improved agricultural production.
- Agricultural practices remove drainage vegetation and sediment which is often deposited along the bank.
- Recreational boating and fishing access on the Richmond River.
- Drainage modification for flood mitigation (including levee construction and flood gates).
- Sheet and rill erosion on cleared (agricultural) land.
- Unsuitable drainage and watercourse obstructions (bridges, crossings, pipes) which cause flow restrictions on farmed agricultural land.

Zone 6 - Evans

On ground sites E19

Geology

The Evans management zone is not contained by catchment boundaries and geologically is situated primarily on Quaternary Sediments (i.e. alluvium, sands and clay), although the Evans River passes through outcrops of Mesozoic Sediments, including the Tabulam Group and the Redcliff Coal Measures, at a river constriction known as Iron Gates. The Evans headland is a complex geological area that includes Palaeozoic Metasediments. Quaternary beach sands and dune complexes extend north from the river mouth (Hanlon *et al*. 1970).

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Natural Land Cover

The majority of the management zone is part of either Broadwater National Park (north) or Bunjalung National Park (south) and typifies the original heath land and swamp vegetation of the area. Coastal woodland can be found on low ridgelines of Mesozoic sediment that traverse sections of the Parks.

Current Land Use

The western portion of the management zone (adjacent to Woodburn) has been cleared along the river floodplain for agriculture, mainly sugar cane and some cattle grazing. The township of Evans Head extends across the floodplain and headland at the mouth of the Evans River.

Soils

The management zone is made up of predominantly alluvial soil types closer to the Rivers and sandy coastal heath in the rest of the area (Donnelly 1997).

Stream Pattern

Sawpit Creek, Brady arm Creek, Oyster Creek and Rocky Mouth Creek drain the elevated ridgelines of Mesozoic Sediments south of the Evans River with a centripetal stream pattern. The Tuckombil Canal was constructed around 1900 and connects Rocky Mouth Creek, a tributary of the Richmond River, with the upper reaches of the Evans River. This has major implications for bank stability and movement of sediment, especially during times of flood and/or high flow regimes. The purpose of the Tuckombil Canal construction was to alleviate flooding in the mid Richmond area. The section of Rocky Mouth Creek (from Tuckombil Canal to the Richmond River) can be subject to flow reversal dependant upon flow regimes and river levels. Control of water through the canal is by means of a temporary concrete fixed weir, replacing the fabridam about seven years ago (B. Eggins, pers.comm. 2009).

Bank Stability

The drainage network in the cleared areas of the management zone is maintained by farm management practices. The main Richmond River bank has virtually no (or extremely ineffective) riparian vegetation for most of the management zone. The increased flow regime during times of flood has had a detrimental effect on much of the bank stability for the Evans River. Some banks appear to have receeded many tens of metres since 1953 (WBM 2002). Property owners are encouraged to fence off river banks from stock access, with grant funding being provided through local government.

Sediment Transport/Movement

Floodwaters originating from the upper Richmond catchment are redirected through the Tuckombil Canal resulting in significant detrimental impacts on the Evans River System. Therefore, upstream high rainfall events will result in additional sediment mobilisation from beyond the natural catchment and with a lack of natural riparian vegetation along the canal and upper reaches compound the usual erosion and deposition issues. Sections of the Evans

River floodplain will be impacted by "overflow" flood events from the Richmond River (WBM 2002).

Zone Specific Issues

The major issue for the Evans management zone is alteration of natural flow regimes following construction of the Tuckombil Canal and the impact of higher flows increasing bank erosion along the length of the main river channel.

- Lack of natural riparian vegetation in agricultural areas resulting in bank instability.
- Drainage modification with steep sided unnatural banks.
- Agricultural practices remove drainage vegetation and sediment which is often deposited along the bank.
- Recreational boating and fishing access on the Evans River and Richmond River.
- Bank erosion is mainly the result of the higher energy associated with flooding from the Richmond River through Tuckombil Canal.
- Some banks have also been weakened by the removal of riparian vegetation, mainly for flood mitigation purposes.
- The increase in flows is causing bank erosion and the downstream bulk transport and deposition of channel sands in the Evans River, upstream of Iron Gates.
- The sediment derived from bank erosion is gradually transported downstream mainly by flood flows and is causing significant shoaling between Iron Gates and Elm Street bridge. A sedimentation study in 1986 shows the material in the Evans is marine derived and it is natural shoaling. The Tuckombil canal and Evans were eroding at the same pace as other streams and rivers.
- Natural meander readjustment of the Evans River channel is working to increase depth as a result of altered flow regimes.
- Erosion from flow reversal and redirection of floodwater in lower Rocky Mouth Creek during peak flood conditions. There is some scouring just downstream of the tidal structure (GHD 2006).
- Sheet and rill erosion on cleared land along lower Rocky Mouth Creek and around Woodburn.
- Control and alteration of flow regimes by means of a Fabridam at the head of Tuckombil Canal.

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Zone 7 -Rocky Mouth Creek

On ground sites RC17

Geology

Rocky Mouth Creek management zone is situated primarily on Quaternary Sediments (i.e. alluvium, sands and clay), with the upper catchment around the Mooninba Range comprised of Mesozoic Sediments including the Tabulam Group and the Walloon Coal Measures (Hanlon *et al*. 1970).

Natural Land Cover

Most of the management zone has been cleared of its original vegetation which was originally low lying swamp and wetland forests with open woodland on elevated ridges.

Current Land Use

The river floodplain is used for agriculture, mainly sugar cane and some cattle grazing, and is recognised as a hot spot for acid sulphate soils (Ferguson and Eyre 1995).

Soils

The management zone is made up of predominantly alluvial soil types with podzolic soils on elevated slopes and ridges (Donnelly 1997).

Stream Pattern

The stream pattern of the tributaries of Rocky Mouth Creek can be described as largely modified distributary drainage channels. Former dendritic water courses such as Swampy Creek are no longer connected to the natural drainage network and have been modified through agricultural land use. The lower reaches of Rocky Mouth Creek between the Richmond River at Woodburn and the Tuckombil Canal can be bi-directional, controlled by a "Fabridam" (inflatable rubber barricade) that prevents the intermixing of Evans River and Rocky Mouth Creek waters, except during flood events (Grotzinger *et al*. 2007).

Bank Stability

The drainage network in the cleared areas of the management zone is maintained by farm management practices. The main Richmond River bank has virtually no (or extremely ineffective) riparian vegetation for most of the zone. Rocky Mouth Creek has sections of riparian vegetation but the majority of the creek banks are unstable, having been cleared to allow for cattle access and maximisation of land for cropping.

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Sediment Transport/Movement

The flow characteristics of Rocky Mouth Creek are influenced by the flow in the Tuckombil Canal. In times of flood, water will back up in Rocky Mouth Creek and as the majority of sediment transport occurs during flood events it can be expected that some sediment movement will be diverted into the Evans River system via Tuckombil Canal as drained flood overflow (WBM 2002).

Zone Specific Issues

Extensive drainage for agriculture across the zone and alteration of flow regimes through the connection of lower Rocky Mouth Creek with the Tuckombil Canal are the major management issues.

- Lack of natural riparian vegetation across upper, middle and lower reaches in agricultural areas resulting in bank instability.
- Drainage modification with steep sided unnatural banks.
- Agricultural practices remove drainage vegetation and sediment which is often deposited along the bank.
- Bank erosion resulting from higher energy associated with flood redirection from the Richmond River through Tuckombil Canal.
- Some banks have been weakened by the removal of riparian vegetation, mainly for flood mitigation purposes along the Richmond River.
- Stock access to watercourses on grazing properties.
- Sheet and rill erosion on cleared land.
- Unsuitable drainage and watercourse obstructions (bridges, crossings, pipes) which cause flow restrictions on agricultural land.
- Drainage modification to improve opportunities for agriculture.

Zone 8 -Swan Bay

On ground sites SB20

Geology

Swan Bay management zone includes a major anabranch of the Richmond River and is connected via a small channel to the main river. The zone is comprised entirely of Quaternary Sediments (i.e. river alluvium) (Hanlon *et al*. 1970).

Natural Land Cover

The management zone was originally covered with mid floodplain mixed vegetation, dominated by low lying wetland species.

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Current Land Use

The area has been almost entirely cleared for agriculture, principally sugar cane and cattle grazing.

Soils

The management zone is solely river sourced alluvial soil types (Donnelly 1997).

Stream Pattern

All water courses flowing into the anabranch are modified distributary drainage channels. The anabranch is slowly infilling with sediment as it becomes further disconnected from the river system with only low energy water movement. Flood sourced sediment is transported across and into the management zone during major flood events (Grotzinger *et al*. 2007).

Bank Stability

The drainage network for the management zone is maintained by farm management practices. The main Richmond River bank retains a very thin (and mostly ineffective) fringe of riparian vegetation for much of the zone. Consequently, the river bank is unstable and erodes during flood events (WBM 2006).

Sediment Transport/Movement

High rainfall results in significant sediment mobilisation due to most drainage channels being devoid of natural riparian vegetation and this can lead to easy movement of the unconsolidated alluvial soil. Most sections of the floodplain within the zone will be impacted by overflow floodwaters from the Richmond River.

Zone Specific Issues

Major issues include drainage modification for agriculture and flood mitigation and sediment infill of the Swan Bay anabranch.

- Lack of natural riparian vegetation in agricultural areas resulting in bank instability.
- Drainage modification with steep sided unnatural banks.
- Infilling due to isolation from river system.
- Sheet and rill erosion on cleared land.
- Unsuitable drainage and watercourse obstructions (bridges, crossings, pipes) which cause flow restrictions on agricultural land.
- Drainage modification to improve opportunities for agriculture.
- Stock access to watercourses.

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Zone 9 -Kilgin/Buckendoon/Dungarubba

On ground sites KB14, KB15, KB18

Geology

The management zone is almost exclusively Quaternary Sediments (i.e. river alluvium), with the exception of Newbys Hill and McPherson Trig Station at Bungawalbyn. These are two small elevated outcrops of Mesozoic Sediments which are further identified as Walloon Coal Measures and Kangaroo Creek Sandstone rock substrate (Hanlon *et al*., 1970; Brunker *et al*. 1972).

Natural Land Cover

Virtually all the management zone has been drained and cleared of its original vegetation which was originally low lying wetland forests and floodplain woodlands. Only small fragments of original vegetation remain as slightly elevated isolated remnants.

Current Land Use

The river floodplain is exclusively used for agriculture, mainly sugar cane and some cattle grazing on elevated areas.

Soils

The management zone is made up of mainly alluvial soil types (Donnelly 1997), except for the two elevated knolls at Bungawalbyn which have a podzolic soil profile.

Stream Pattern

The stream pattern within the zone can be described as mainly modified distributary drainage channels. Former dendritic water courses, such as Dungarubba Creek, have been altered and now exist as part of the agricultural drainage network (Grotzinger *et al*. 2007).

Bank Stability

The drainage network throughout cleared areas of the management zone is maintained by farm management practices. The main Richmond River bank has minimal riparian vegetation in some areas and is subject to erosion (WBM 2006). The majority of the drainage banks have been cleared to allow maximum utilisation of land for cropping and grazing, and consequently can be regarded as unstable at times of high flow.

Sediment Transport/Movement

Sediment transport and movement is greatly influenced by the extent of fallow agricultural land at the time of higher rainfall events. The extensive drainage network facilitates the ready transport of sediment away from ploughed paddocks and often directly into the river system. During flooding sediment is easily moved and distributed across the floodplain area in accordance with currents and the extent of inundation (WBM 2006).

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Zone Specific Issues

The major issue for the Kilgin/Buckendoon management zone is a lack of natural riparian vegetation and farm management practices which maintain most watercourses as open drains.

- Lack of natural riparian vegetation in agricultural areas resulting in bank instability.
- Drainage modification with steep sided unnatural banks.
- Agricultural practices remove vegetation and sediment from drains which is often deposited along the bank.
- Recreational boating and fishing access on the Richmond River.
- Some banks have also been weakened by the removal of riparian vegetation, mainly for flood mitigation purposes along the Richmond River.
- Stock access to watercourses on grazing properties.
- Sheet and rill erosion on cleared land.
- Unsuitable drainage and watercourse obstructions (bridges, crossings, pipes) which cause flow restrictions on agricultural land.
- Drainage modification to improve opportunities for agriculture.

Zone 10 -Tuckean

On ground sites T11, T12

Geology

Tuckean management zone is almost exclusively Quaternary Sediments (i.e. alluvium, river gravels, sand and clay), but is fringed with lower elevated outcrops of Mesozoic Sediments including the Tabulum Group, Walloon Coal Measures and Kangaroo Creek Sandstone. These layered sediments are found in low ridges to the east, north and west of the drainage floodplain and higher elevations in these areas are capped with Tertiary Basalts (Hanlon *et al*. 1970; Brunker *et al*. 1972).

Natural Land Cover

Most of the management zone has been extensively drained and cleared of its original floodplain and swampland vegetation to provide for agricultural production. However, the lower lying centre of the zone has retained some natural and regenerating vegetation within the Tuckean Nature Reserve. Much of the Reserve is a mix of floodplain and swampland vegetation bisected by major drainage channels.

Current Land Use

The Tuckean has a mix of cropping (sugar cane), mainly around the southern and western margins, with cattle grazing being predominant to the north and alongside the Nature Reserve in the west and east.

Soils

The management zone is made up of mainly alluvial soil types (Donnelly 1997), with podzolic soils on elevated portions to the west at Tuckurimba, north at Cedar Island, and east along the Blackwall Range.

Stream Pattern

The stream pattern of watercourses can be described as modified distributary drainage channels throughout the bulk of the floodplain area that connects through to Bagotville at the head of the Tuckean Broadwater. A barrage at Bagotville restricts tidal movement and ingress of saltwater beyond the Broadwater. A centripetal network of streams originally drained the Tuckean Basin, however, natural drainage patterns are now only evident in the upper reaches of Stibbards Creek, Tucki Tucki Creek, Marom Creek, Youngman Creek, Gum Creek, and Yellow Creek, all of which are now connected to major drainage channels (Grotzinger *et al*. 2007). The Tuckean is regarded as a hotspot for Acid Sulphate Soils as a consequence of lowering water tables via extensive drainage modification (Ferguson and Eyre 1995).

Bank Stability

The drainage network in the cleared areas of the management zone is maintained by farm management practices. Major drainage channels within Tuckean Nature Reserve retain clearance spoil on the banks and consequently are not naturally vegetated. Drainage channels are generally steep sided, poorly stabilised and subject to erosion during periods of high flow. The majority of the drainage banks have been cleared to allow maximum utilisation of land for cropping, stock access, and ease of maintenance. Bank stability along the Tuckean Broadwater is poor due to flow constrictions at the Bagotville Barrage which channel water and provide higher energy for increased erosion downstream. Much of the land area is subject to flooding.

Sediment Transport/Movement

In high rainfall events the drainage network facilitates the ready transport of sediment away from ploughed paddocks and grazing areas to be deposited along the major channels of the Tuckean Basin. This requires regular clearance and maintenance, especially as waters slow toward the Barrage in all but the greater flood events. During flooding beyond the drainage channels sediment is easily moved and distributed across the basin area in accordance with currents and the extent of inundation (WBM 2006).

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Zone Specific Issues

Management of the Tuckean is an ongoing problem centred on the positive and negative consequences of the Bagotville Barrage. Primarily, siltation is an issue within the agricultural drainage network and erosion is a concern downstream of the barrage.

- Lack of natural riparian vegetation in agricultural areas of the middle and upper reaches, resulting in bank instability.
- Drainage modification with steep sided unnatural banks.
- Agricultural practices remove drainage vegetation and sediment which is often deposited along the bank.
- Some banks have also been weakened by the removal of riparian vegetation, mainly for flood mitigation purposes, upstream of the Bagotville Barrage.
- Drainage modification to improve opportunities for agriculture.
- Increased bank erosion as a result of high flow channelling through the Bagotville Barrage.
- Unsuitable drainage and watercourse obstructions (bridges, crossings, pipes) which cause flow restrictions on agricultural land.
- Interruption to the natural flow regime with the construction of the Baggotville Barrage.
- Sheet and rill erosion on cleared land.
- Stock access to watercourses on grazing properties.
- Agricultural encroachment on wetland vegetation.
- ASS hot spot.

Zone 11 -Lower Bungawalbyn

On ground sites BU28

Geology

The Swan Bay/Lower Bungawalbyn management zone is a mix of Quaternary Sediments (i.e. river alluvium, gravels, sand and clay) on the lower floodplain, and Mesozoic Sediments (Kangaroo Creek and Grafton Formation Sandstones) on higher elevations and upper tributary catchments. Some small Tertiary Basalt caps are present in the Ellangowan district and the management zone is separated from the Coastal sub-catchment in the south east by the Richmond Range, an extensive and elevated area of Grafton Formation Sandstone (Hanlon *et al*. 1970; Brunker *et al*. 1972).

Natural Land Cover

Much of the management zone has retained its original vegetation in an extensive network of State Forests. Although the forests have been managed and supplemented with selected

plantation eucalypt species they can still be regarded as a retention of a more representative natural vegetation cover (for the particular soil types and geological substrate) than any other management zone of the Richmond Floodplain. However, lower reaches of the zone, around Bungawalbyn and Bora Ridge, have been cleared for agriculture. Original vegetation of these areas would have included a higher swampland and floodplain species mix.

Current Land Use

The river floodplain in lower reaches and along the major watercourses has some agricultural use with cropping and cattle grazing. However, the majority of the management zone is NSW State Forest, including Bungawalbyn, Ellangowan, Myrtle, Whiporie, Giberagee, and Doubleduke State Forests. Some large sections of these forests are maintained and managed as plantations.

Soils

The management zone is made up of primarily alluvial soil types (Donnelly 1997), and podzolic soils on the elevated Sedimentary substrates.

Stream Pattern

The drainage pattern of streams are centripetal and remain largely natural except for drainage modification to suit agricultural practice in the lower reaches, close to the Richmond River around Bungawalbyn and Bora Ridge. Major connecting streams of Bungawalbyn Creek include Sandy Creek to the north, Myrtle Creek to the south west, with Myall Creek and Scrubby Creek to the south (Grotzinger *et al*. 2007). Each of these tributaries drain large areas of State Forest. Much of the land area is subject to flooding.

Bank Stability

The drainage network within agricultural cropping areas of the Lower Bungawalbyn Creek is maintained by farm management practices. Due to a catchment of lower gradient landforms bank heights are more moderate than the other Richmond River sub-catchments and consequently banks are generally more stable, however, bank instability is still present. This is especially so with the areas of State Forest where extensive natural and riparian vegetation is maintained.

Sediment Transport/Movement

The Lower Bungawalbyn management zone is an area of the greater Bungawalbyn Creek sub-catchment of the Richmond River Basin where sediment transport and movement is substantially less due to flatter topography and extensive vegetation cover within State Forest estate (Hossain *et.al.* 2002). Podzolic soils and sandy alluvium are less susceptible to transport in high rainfall events when stream gradients are low and natural vegetation maintains bank stability.

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Zone Specific Issues

Recognition of a geological substrate with a high potential for erosion is a major issue for the Lower Bungawalbyn management zone. Despite gentler slopes and lower landforms in upper and mid reaches it is particularly important to maintain suitable riparian zones along watercourses which will minimise erosion potential. The low lying nature of the zone results in substantial flooding.

- Lack of natural riparian vegetation in agricultural areas (particularly the lower reaches) resulting in bank instability.
- Agricultural practices remove drainage vegetation and sediment which is often deposited along the bank.
- Some banks have also been weakened by the removal of riparian vegetation, mainly for flood mitigation purposes on lower reaches adjacent to the Richmond River.
- Some exposed and sandy unconsolidated soils with high potential for erosion in areas of cleared landscape, generally agricultural areas.
- Stock access to watercourses on grazing properties.
- Sheet, rill, and gully erosion on cleared land.
- Unsuitable drainage and watercourse obstructions (bridges, crossings, pipes) which cause flow restrictions on agricultural land.
- Drainage modification to improve opportunities for agriculture.
- ASS
- Blackwater source after flooding events.

Zone 12 - Upper Richmond/Wilson Management Zone

On ground sites UPRWR21/22, UPRWR23, UPRWR24, UPRWR25, UPRWR26, UPRWR30, UPRWR32, UPRWR32

Geology

The Upper Richmond/Wilson management zone is a mix of Quaternary Sediments (i.e. river alluvium, gravels, sand and clay) on the lower floodplain, and Tertiary Basalts on higher elevations and fringing ridgelines (Brunker *et al*. 1972).

Natural Land Cover

Most of the management zone has been cleared of its original vegetation which was primarily low lying wetland forests and woodlands on the floodplain, grading through to dense areas of rainforest on the basalt soils and southerly aspects of higher elevations. Only small fragments of original vegetation remain, usually as isolated and unconnected remnants in

elevated areas. Some significant areas such as Tucki Tucki Nature Reserve, are retained on northerly and western aspects of some floodplain bordering ridgelines.

Current Land Use

The river floodplain has a dual agricultural use with cropping (mainly sugar cane) on the lower reaches of the Wilson's River and Pelican Creek sub-catchment at North Codrington, and cattle grazing in upper reaches on both the floodplain and surrounding slopes. The floodplain of the Richmond River between Coraki and Tatham also has dual agricultural use with a mix of both cropping and cattle grazing.

Soils

The management zone is made up of primarily alluvial soil types (Donnelly 1997), and basalt derived kraznozem and chocolate soils on elevated and surrounding slopes.

Stream Pattern

Except for the lower reaches around North Codrington and South Gundurimba there is minimal drainage alteration to facilitate agricultural cropping. The stream pattern of the minor tributaries that flow into the Wilson's River below Lismore, plus Pelican Creek, can be described as centripetal. Some minor streams south of Lismore are maintained as drains within grazing properties and also as a drainage network in areas adjacent to urban and industrial development. A farm drainage network is also maintained along both banks of the Richmond to Tatham. Only one named tributary, Walsh's Creek (also centripetal in stream pattern), enters the main river channel at Codrington (Grotzinger *et al*. 2007).

Bank Stability

The drainage network within agricultural cropping areas of the Lower Richmond and Wilson's Rivers is maintained by farm management practices. The main Wilson's River bank has minimal riparian vegetation in most areas and the connecting minor streams are generally totally cleared and stabilised by grazing pasture only. Pelican Creek retains some form of riparian vegetation for approximately half its length but has exposed banks through areas of agricultural cropping. The Richmond River has typically high steep banks and minimal riparian vegetation. Significant sections of the bank are devoid of any vegetation as a result of clearing for cattle access and erosion during past flood events (WBM 2006).

Sediment Transport/Movement

The Upper Richmond/Wilson management zone is an area of mid-catchment for the Richmond River Basin where sediment transport and movement is influenced by the extent of fallow agricultural land at the time of higher rainfall events. During floods and as a consequence of elevated landforms in the upper regions of both the Wilson's River and Richmond River sub-catchments suspended sediment loads have been estimated at greater than 93% compared to the Bungawalbyn Creek sub-catchment which has flatter topography and extensive forest coverage (Hossain *et.al.* 2002). The drainage network facilitates the ready transport of sediment away from both ploughed and grazing paddocks and into the

river system. With the higher energy of flooding sediment is easily moved and distributed across the floodplain area in accordance with currents and the extent of inundation.

Zone Specific Issues

Cattle access to steep sided drainage channels and the main riverbank create a management concern as regularly used tracks remain unvegetated and are further eroded in times of flood. Most of the typically steep banks of the zone are cleared of riparian vegetation and are vulnerable to erosion during high flow flood events.

- Lack of natural riparian vegetation in agricultural areas of upper and middle reaches resulting in bank instability.
- Recreational boating and fishing access on the Richmond and Wilsons River.
- Sections of unstable and unvegetated banks as a result of stock access to watercourses.
- High steep banks susceptible to ongoing erosion during high flow conditions.
- Sheet, rill, and gully erosion on cleared land.
- Drainage modification to improve opportunities for agriculture.

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4 Water Quality Impacts

4.1 Summary

The E2 modelling results provide very useful information that helps inform the management needs for each management zone.

Additionally, Table 4.1 in the CZMS describes the in-stream and downstream contributions of loading from each of the management zones under three different flow conditions.

The assessment approach was an informed semi-quantitative method of enabling a snapshot understanding of management issues associated with water quality impacts. Current information as well as previous data analyses and interpretation (ABER 2008) are used to inform the following discussion of each management zone.

Also a photographic archive of management zones is presented in Appendix 2.

4.2 Background

The Richmond River is predisposed to water quality challenges due to its relatively small catchment area (6979km^2) and large floodplain (990km^2) with a very small water surface area (19km^2). It is a poorly flushed system with a tidal pinch near Pimilco which results in poor water exchange upstream from this area. The upper catchment areas have largely been cleared and the land use is now predominantly agriculture. This change in land use has contributed to high TSS and nutrient loadings from these areas. Additionally, there are eight sewage treatment plants in the study area and several more in the catchment area, which manage waste from the larger urban areas including Ballina, Lismore, Casino, Wardell, Alstonville, Nimbin, Dunoon, and Coraki. Stormwater runoff from these urban areas also enters the Richmond River. The large expanse of rural residential living within the area also results in a significant number of on-site sewage treatment facilities. The labyrinth of road networks and the lack of hard surfaces on some of these also contributes to TSS loading.

The hydrology of the large floodplain has largely been modified through drainage channels and changes in vegetation types. The exposure of Acid Sulfate Soils (ASS) has occurred as a result of floodplain drainage and other activities that altered the ground water hydrology. Flood waters can become acid when draining occurrs from large areas of ASS. Blackwater events are significant post flooding in the Richmond River Estuary and Eyre et al. (2006) have determined that at 25˚ the Richmond River floodplain has the potential to deoxygenate 12.5 x 10^3 mL of saturated freshwater. This scale of deoxygenation is sufficient to completely deoxygenate floodwater stored on the flood plain within 3 to 4 days. Historical information

suggests that flood water can persist on the floodplain for around 6 days and in some places for several weeks. Both black water events and acid water event have contributed to fish kills in the Richmond River. There are also potential health risks related to mosquito borne infections after flood events and while water is still stored on the floodplain. Healthy, ecologically balanced wetlands systems can minimise mosquito infestation.

It will be important for the Management Plan to provide actions that build resistance in the Richmond River so the extreme effects flood events do not result in a collapse of the environmental services the river provides. Future climate change scenarios in this region predict more frequent and intense storm activity which will potentially result in more storm surge, erosion and flood events. Richmond River must be able to recover between events to ensure its long term health. Currently, it is not known when a critical threshold will be reached in the Richmond River where recovery does not occur but evidence suggests that fish kills are becoming more severe and more frequent.

The development of a Water Quality Monitoring Strategy for the Richmond River Estuary as part of the Management Study and Plan, provides the basis for an integrated approach to this facet of the estuary (see Appendix 3).

4.3 Data review

A detailed review of existing water quality data from the Richmond River floodplain and estuary (ABER 2008) has been used to characterise water quality and key processes in each of the management zones. Summary statistics (boxplots) have been presented showing the temporal variation in water quality at each site.

4.4 Flow weighted assessments

The results of water quality data review have been synthesised for low (<10%ile flow), median and high flow (>90%ile flow) scenarios into a risk assessment matrix. This is to recognise the important distinction between processes affecting water quality under different flow scenarios.

4.5 Catchment modelling

An E2 catchment export model of the Richmond River catchment recently developed by the Department of Environment and Climate Change and Water (DECCW) was used to provide estimates of hydraulic and pollutant loadings from a total of 49 subcatchments. Runoff was estimated by scaling measured river flow from available stations in upper sub-catchments to total catchment area (source NSW DWE).

4.6 Estuarine response model

An estuarine response model (ERM) of the Richmond River Estuary has been developed to estimate the relative impact of management zone exports on the health of the Richmond River Estuary. It is also used to assess critical thresholds (guidelines) for primary water quality drivers (e.g. light climate and nutrient concentrations) necessary for maintaining key ecosystem processes.

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The model is based on a modified 1D box model approach, comprising 13 boxes from the mouth at Ballina to the upper limit of salt penetration at Coraki (Figure 4.1). The transport / mixing sub-model accounts for variation in the principle drivers of estuarine biogeochemical processes:

1. morphology and depth
2. freshwater inflows
3. tidal mixing
4. water residence times (eg Figure 4.2)
5. nutrient and TSS inputs
6. light climate

The biological response sub-model predicts the growth and biomass of phytoplankton and benthic microalgae, as well as rates of bacterial breakdown of organic matter. The net impacts on important water quality parameters such as dissolved oxygen are then estimated.

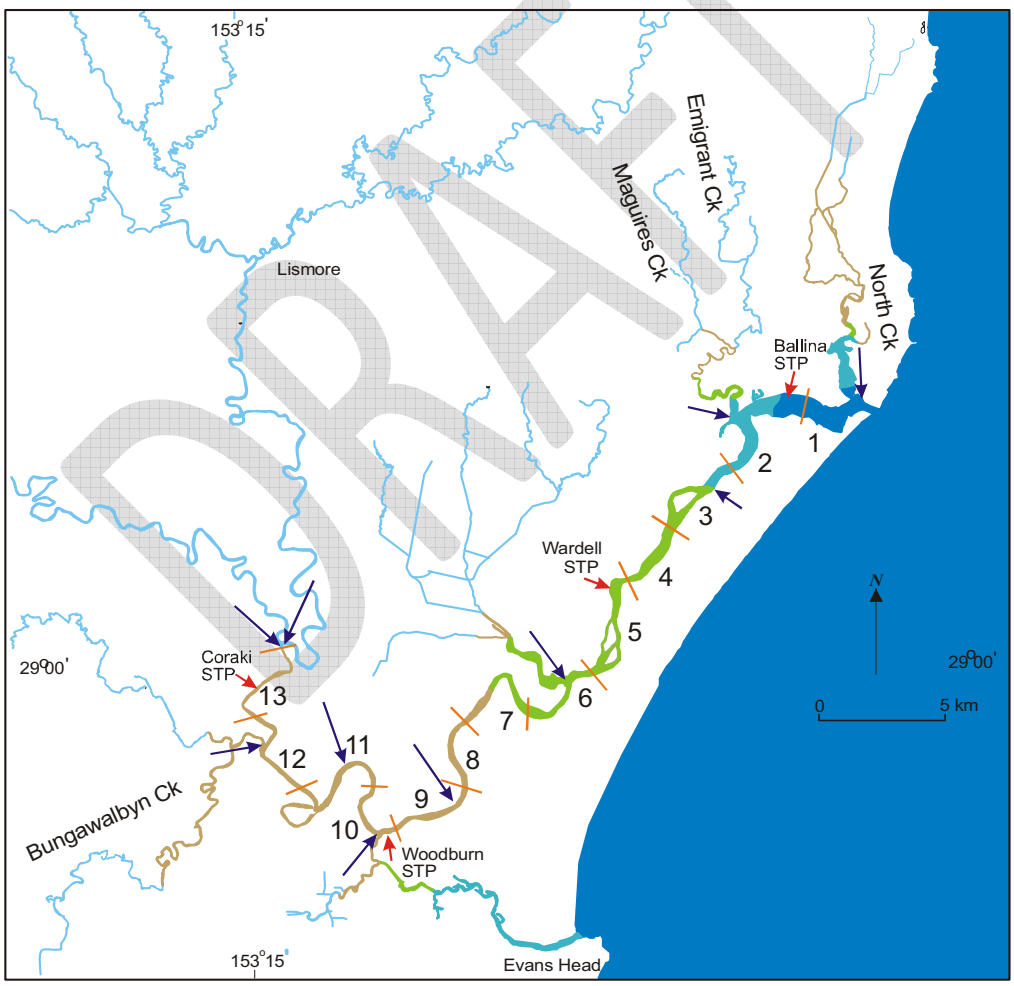

Figure 4.1; The location of box boundaries in the Richmond River Estuary Ecosystem Response Model (ERM), showing inputs of freshwater (blue arrows) and STP effluent inputs (red arrows).

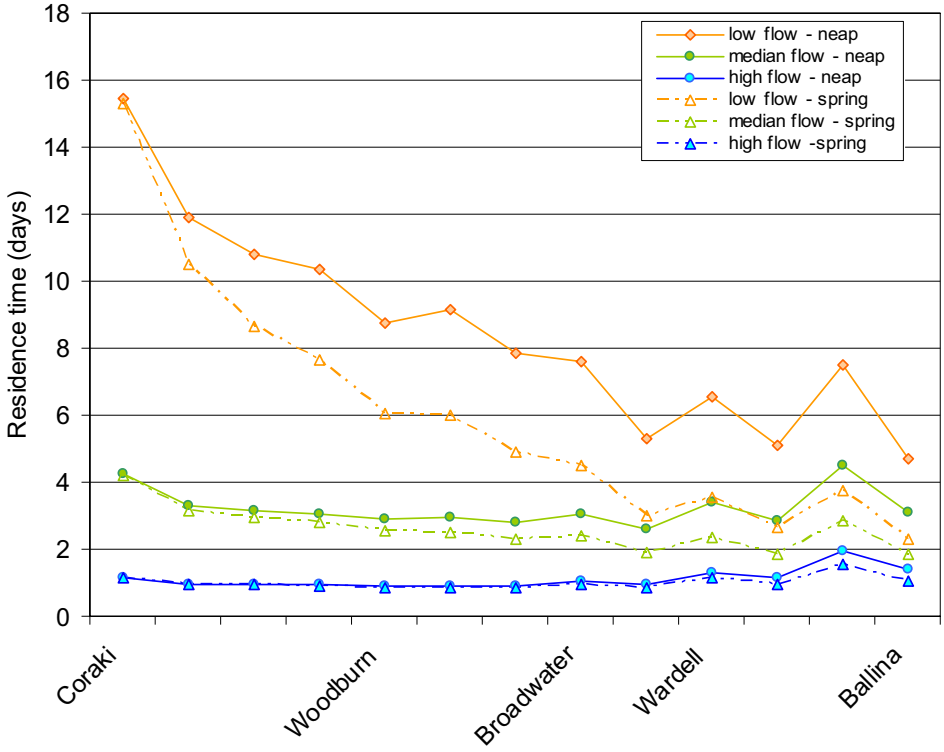

Figure 4.2 ERM estimations of water residence times in each of the 13 boxes along the Richmond River estuary for mean low flow, median and mean high flow conditions during neap and spring tides.
(*neap = a less than average tide occurring at the first and third quarters of the moon*)

4.7 In-stream and downstream impacts

All management zones include significant streams and aquatic habitat which form ecological extensions of the main Richmond River Estuary. These waterways are herein referred to as "in-stream", and associated water quality and threats for in-stream habitats are assessed as distinct from the "downstream" impacts / threats of management zone exports on the main Richmond River estuary. This recognises the ecological importance of smaller tributaries despite their relatively small impact on receiving water quality. In addition, the quality of exports from these in-stream waterways is commonly largely attenuated / modified by internal biogeochemical processes. As such, the maintenance of these processes that may be location-specific, is important to mediating downstream impacts.

4.8 Internal processes

The water quality assessment identifies key reaches / waterways within management zones where internal processes are an important consideration in the maintenance of good water quality and ecosystem health. The main concepts underpinning this analysis are outlined below.

4.8.1 Productivity and ecosystem function

The relative importance of pelagic (water column) and benthic (sediments) habitat is assessed in relation to each components contribution to internal primary productivity (i.e. photosynthesis) within each reach. Where possible this has been quantified using the ecosystem response model. The balance between pelagic and benthic productivity is an important feature of estuarine ecosystems, influencing the type of foodchains present and also the internal recycling of nutrients.

4.8.2 Internal nutrient recycling

Internal deposition and recycling of materials (i.e. water quality constituents) within the waterway can significantly alter water quality. For example, the development of phytoplankton blooms can completely remove all inorganic nutrients from the water column (even in highly enriched systems), and cause large fluctuations in dissolved oxygen. Bio-available nutrients can be released as organic matter (e.g. phytoplankton) is broken down by bacteria in the water column and sediments. A certain proportion of re-mineralised nutrients can be lost due to burial, or in the case of nitrogen, lost to the atmosphere via denitrification.

The relative importance of internal processes increases with water residence times (or "flushing times"), which in turn broadly increase as a function of 1) decreasing antecedent rainfall totals, and 2) distance upstream from the estuary mouth. Channel morphology and impediments to tidal exchange also impact on water residence times.

4.8.3 Light climate

The amount of light reaching the water surface (which is influenced by riparian vegetation cover), and the light attenuation properties of the water and its constituents (as measured by secchi depth) are fundamental controls over the productivity and nutrient recycling characteristics of the system. Both pelagic and benthic compartments can become light limited in turbid water. When sediments become light limited, production by benthic microalgae approaches zero and benthic processes become dominated by bacterial breakdown of organic matter. In extreme cases of eutrophication, this can exert a significant oxygen demand on the overlying water and cause hypoxia.

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4.8.4 Eutrophication

The term eutrophication refers to an increase in the rate of organic matter supply in aquatic ecosystems. This can be caused by nutrient enrichment stimulating algal blooms, or large loadings of organic matter or BOD. Eutrophication can significantly alter the quality of pelagic and benthic habitat due to the occurrence of hypoxia and high concentrations of toxic nutrients (e.g. nitrite), and in extreme cases cause permanent shifts in divers ecological communities towards simpler, microbial dominated assemblages.

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5 Fauna

The Richmond River Estuary forms part of the greater Moreton Bioregion which is recognised as having high biodiversity. This is because of the high variability in habitat with influences from both tropical climates to the north and temperate climates to the south.

Before the commencement of agricultural practices in the Richmond River catchment and other areas, much of the lower catchment consisted of extensive wetlands. To enable agricultural production, wetlands were drained and cleared of native vegetation. This reduced large amounts of habitat for native fauna, compressing their range significantly and excluding some species altogether. It is estimated that 106,000ha of terrestrial vegetation has been cleared since European settlement in the Richmond valley (SoE 2000 Richmond Valley Council 2003).

This period of change for the area also resulted in the mobilisation of acid sulfate soils that underlay much of the floodplain. Mobile chemicals resulted in reactions and processes that created conditions that were toxic to fish and other aquatic life (eg fish kills). Sometimes acidic water enters the estuary, while at other times black water enters from large stagnant waterbodies upstream. Both these conditions have major impacts on aquatic fauna and other connected species.

The Richmond River Estuary Processes Study (WBM 2006) identified likely impacts on aquatic fauna (including plankton, algae, invertebrates and fishes) from variations in water quality. Similar impacts are likely up the foodchain for marine birds and mammals. It is important to reiterate the connectivity of the estuary to other regions, especially in terms of organisms that travel larger distances, are migratory or have larger home ranges.

There is considerable community value placed on marine mammals such as whales, dolphins and dugongs, as well as many species of bird that inhabit both the estuary and the greater surrounding region. Improvements in the condition of the estuary will increase the available habitat for these species in the future and reduce the risks to their continued existence.

5.1 Summary

There are many species of wildlife present within the estuary, in both aquatic and terrestrial ecosystems. Species are resident, transitory and migratory for the area. The condition of the estuary reflects directly on its capacity to provide adequate habitat for wildlife. For example, in the past Dugongs were frequent in the waterways, however, with the reduction in sea grass and the increase in boat traffic and other impacts, Dugongs have not been recorded within the estuary for some years.

Recommendations towards reductions in threats to fauna have been addressed in Part 2, the Richmond River Estuary Management Plan, for each Management Zone as appropriate. Appropriate actions may be included in other activities such as riparian revegetation, weed control, boat speed control, improvements to water quality, etc.

5.2 Threats to fauna

Apart from the abovementioned water quality changes and threats there are also barriers to movement that threaten ordinary life functions of aquatic mammals and other fauna. The estuary areas provide extremely important feeding and breeding grounds for fish, birds and other fauna. Wetlands are biodiversity hotspots, with large numbers of insects and therefore insect-eating fauna (eg birds, bats, flying foxes, reptiles, etc.).

One of the most important threats is the loss of connectivity between biomes (ie ocean to floodplains to rainforests to mountains). The importance of corridors that allow genetic connectivity and passage for many different species, cannot be over-emphasised.

Environmental issues identified by the NSW NPWS (2008) that threaten flora and fauna, include:

- Climate change and water
- Pollution and contamination
- Pests and weeds
- Waste

The list of Key Threatening Processes in NSW identified by the NSW NPWS Scientific Committee that are relevant to this Study are:

- Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands - key threatening process listing
- Cane toad - key threatening process listing
- Clearing of native vegetation - key threatening process listing
- Death or injury to marine species following capture in shark control programs on ocean beaches - key threatening process listing
- Entanglement in or ingestion of anthropogenic debris in marine and estuarine environments - key threatening process listing
- Exotic vines and scramblers - key threatening process listing
- Human-caused climate change - key threatening process listing
- Invasion of native plant communities by bitou bush and boneseed - key threatening

process listing

- *Lantana camara* - key threatening process listing
- Loss of Hollow-bearing Trees - key threatening process determination
- Predation by feral cats - key threatening process listing
- Predation by the European red fox - key threatening process listing
- Predation by the plague minnow (*Gambusia holbrooki*) - key threatening process listing
- Removal of dead wood and dead trees - key threatening process listing

5.3 Endangered Species

The NSW *Threatened Species Act* (2003) identifies 41 threatened species as occurring or likely to occur in the Richmond River Estuary or nearby. Of these, 33 were listed as vulnerable and 8 as endangered. Priority actions for recovery of these species have been developed (NPWS Threatened Species Unit 2005). The listed endangered species are provided in Table 5.1 below (NSW NPWS 2008):

Table 5.1: NPWS Endangered Species listing for Northern Rivers CMA region and marine region.

Common Name	*Scientific Name*
Birds	
Beach Stone-curlew	*Esacus neglectus*
Gould's Petrel	*Pterodroma leucoptera leucoptera*
Little Tern	*Sterna albifrons*
Southern Giant-Petrel	*Macronectes giganteus*
Wandering Albatross	*Diomedea exulans*
Mammals	
Blue Whale	*Balaenoptera musculus*
Dugong	*Dugong dugon*
Reptiles	
Loggerhead Turtle	*Caretta caretta*

5.4 Vulnerable Species

Vulnerable species that are known to occur or are likely within the study area are provided in Table 5.2 (NSW NPWS 2008).

Table 5.2: Vulnerable species list (NSW NPWS database 2005)

Common Name	*Scientific Name*
Birds	
Antipodean Albatross	*Diomedea antipodensis*
Black-browed Albatross	*Thalassarche melanophris*
Black-tailed Godwit	*Limosa limosa*
Black-winged Petrel	*Pterodroma nigripennis*
Broad-billed Sandpiper	*Limicola falcinellus*
Flesh-footed Shearwater	*Puffinus carneipes*
Gibson's Albatross	*Diomedea gibsoni*
Great Knot	*Calidris tenuirostris*
Greater Sand-plover	*Charadrius leschenaultii*
Grey Ternlet	*Procelsterna cerulea*
Kermadec Petrel	*Pterodroma neglecta*
Lesser Sand-plover	*Charadrius mongolus*
Little Shearwater	*Puffinus assimilis*
Masked Booby	*Sula dactylatra*
Northern Giant-Petrel	*Macronectes halli*
Osprey	*Pandion haliaetus*
Pied Oystercatcher	*Haematopus longirostris*
Providence Petrel	*Pterodroma solandri*
Sanderling	*Calidris alba*
Shy Albatross	*Thalassarche cauta*
Sooty Albatross	*Phoebetria fusca*
Sooty Oystercatcher	*Haematopus fuliginosus*
Sooty Tern	*Sterna fuscata*
Terek Sandpiper	*Xenus cinereus*
White Tern	*Gygis alba*
White-bellied Storm-petrel	*Fregetta grallaria*
Mammals	
Australian Fur-seal	*Arctocephalus pusillus doriferus*
Humpback Whale	*Megaptera novaeangliae*
New Zealand Fur-seal	*Arctocephalus forsteri*
Southern Right Whale	*Eubalaena australis*
Sperm Whale	*Physeter macrocephalus*

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Common Name	*Scientific Name*
Reptiles	
Green Turtle	*Chelonia mydas*
Leathery Turtle	*Dermochelys coriacea*

5.5 Recovery Plans

Recovery Plans exist for the Gould's Petrel and the Little Tern, both listed as Endangered under NSW legislation. There are Threat Abatement Plans under development for many species and areas, including Bitou bush and Boneseed, and predation by plague minnow and red fox.

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7 Appendices

1 – Riparian vegetation assessment maps
2 – Photographic archive of assessment points for water quality, riparian vegetation and geomorphology
3 – Water Quality Monitoring Strategy

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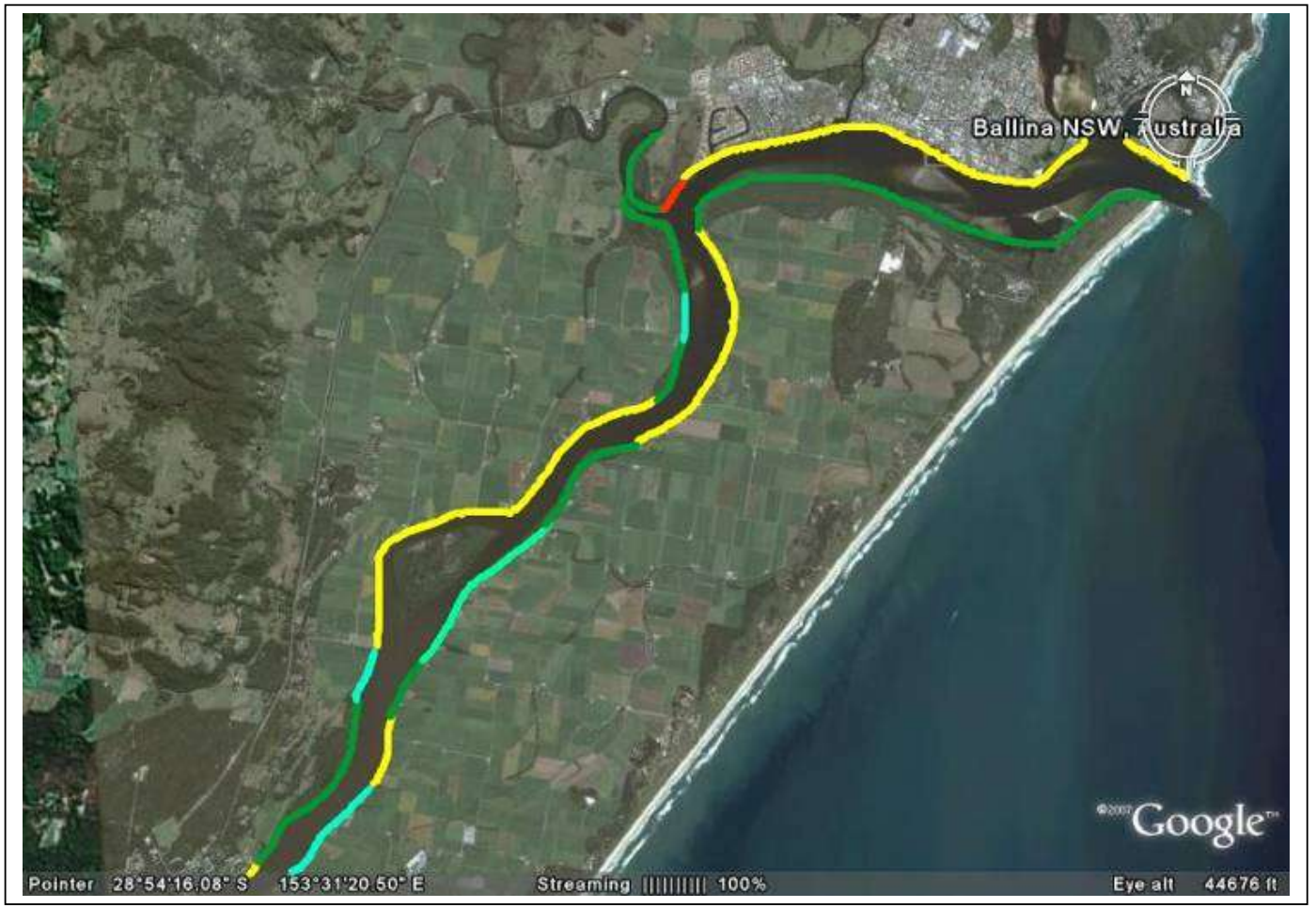
Appendix 1 – Riparian Vegetation Assessment Maps

Using aerial photography and on-ground assessment, the following maps have been compiled to depict riparian vegetation width, with green being the widest (50-100m)and blue next widest (10-50m). Yellow areas show width less than 10m over a distance greater than 100m and red areas are less than 10m wide and less than 100m long.

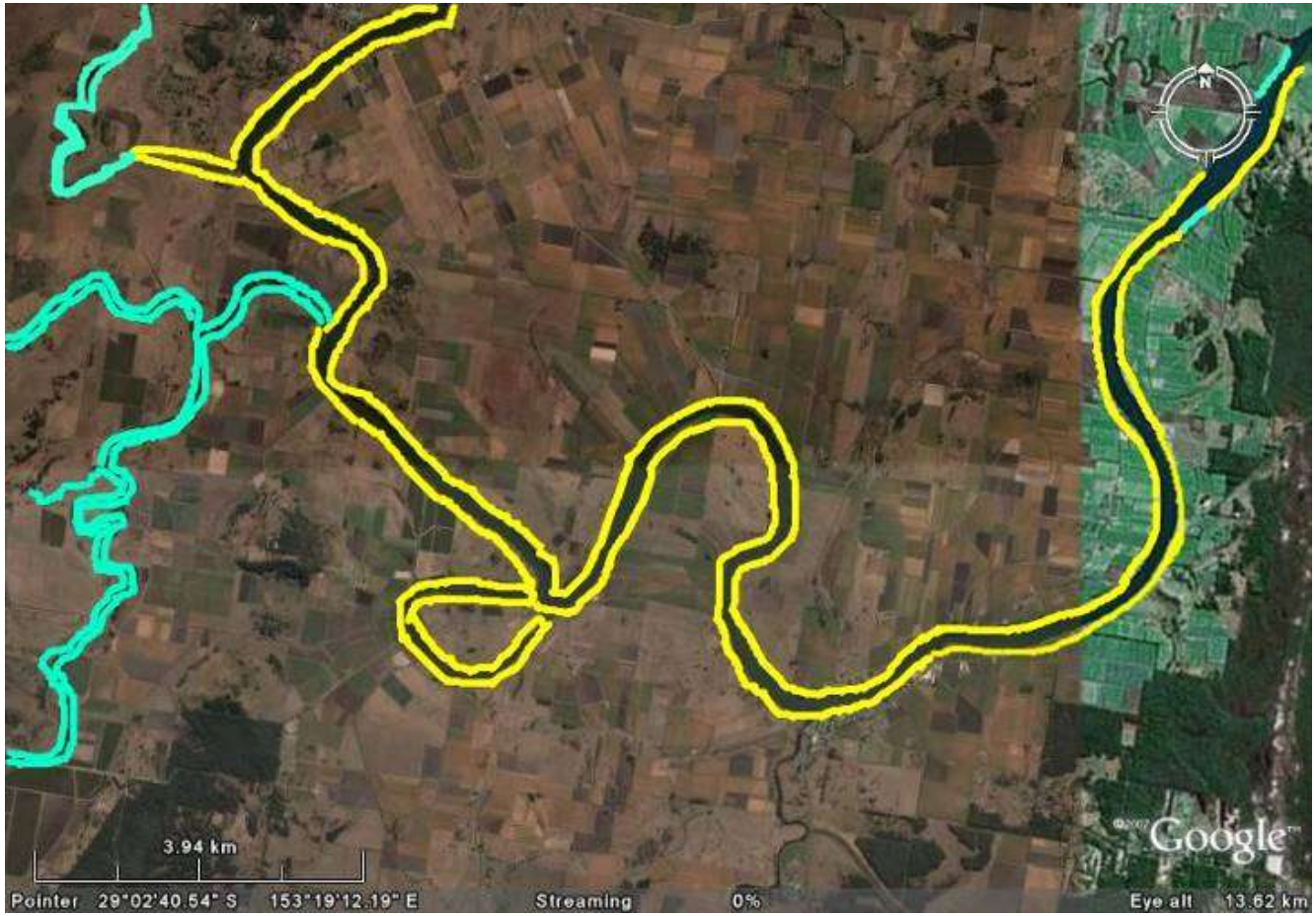
Desktop riparian assessment of the North Creek and Emigrant Creek area.

Legend for riparian vegetation
Width 50 ->100m, >100m long
Width 10-50m, >100m long
Width 0-10m, >100m long
Width 0-10m, <100m long

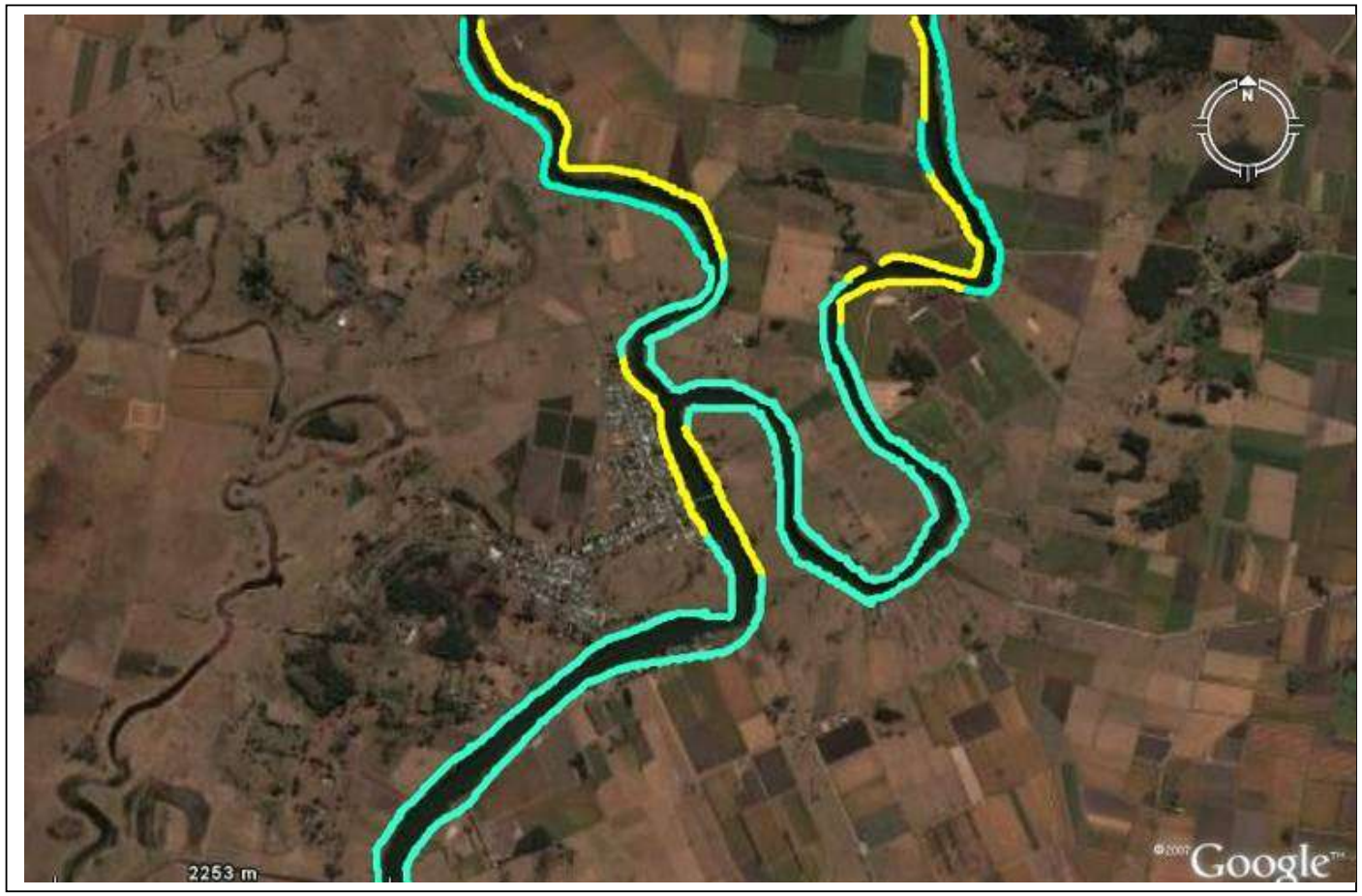
Tuckean – riparian vegetation width and longitudinal connectivity.



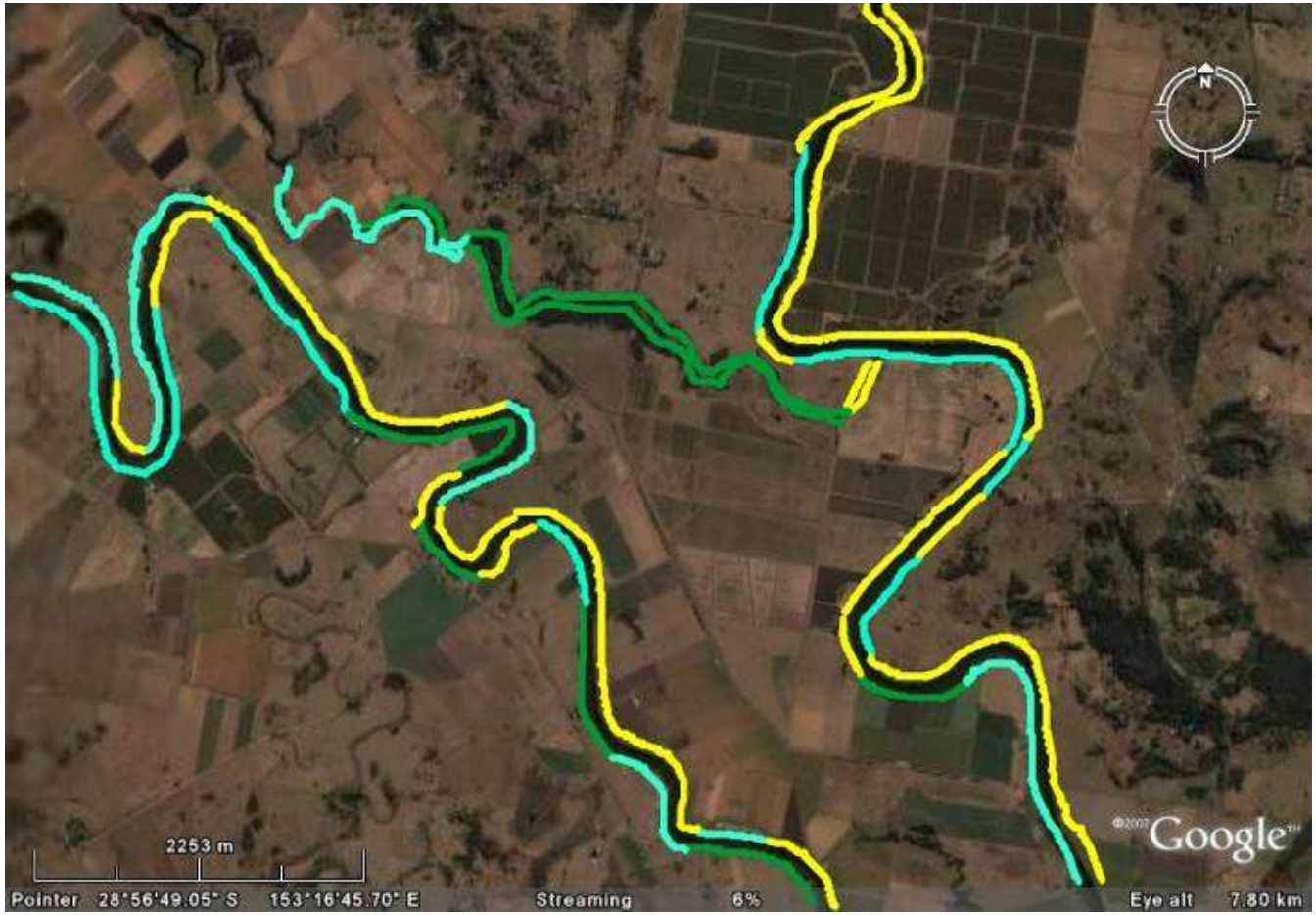
North Creek and Emigrant Creek – riparian vegetation width and longitudinal connectivity



Swan Bay and Bungawalbyn riparian desktop assessment.



Coraki area riparian desktop assessment.



Riparian desktop assessment upstream from Coraki.

Appendix 2 – Photographic Archive for water quality, riparian vegetation assessment and geomorphological assessment points

Zone 1 – North Creek

	
Mangrove regrowth near Ballina Fair	Sediment deposition and mangrove communities lower North Creek
	
Seagrass and mangroves lower North Creek	Public access to foreshore near Missingham Bridge. Note the shoaling from marine derived sediments in the background and rock retaining wall.

	
Recreational fishing in North Creek	Floodplain area and T-tree plantation in the background of picture adjacent to eroding shoreline in North Creek

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Wet pastures near NC2	Sugar cane at Ross Lane near NC2
	
An Estuary Management Plan was adopted by Ballina Council for Shaws Bay in 2000	Plumes from flood events can extend some distance out to sea.
	
Flood waters at the mouth of North Creek during February 2008.	Fish kill clean up in Ballina Keys February 2008 (Photo: NSW Fisheries)

Figure : Site NC1 and NC2

Zone 2 –Emigrant/Maguires Creek

	
Macadamia plantation on the floodplain near Teven in background. Note bank erosion Maguires Creek.	Development of macadamia plantation on land previously farmed for sugar cane. Teven/Tintenbar.
	
Confluence of Maguires Creek and Houghlahans Creek near Teven Golf Course. Note erosion scarp.	Tyres dumped near Pimlico Island. Perhaps crude attempts at bank stabilisation.
	
Bank slumping and weed infestation at Teven Bridge, Maguires Creek.	Dirt road and exposed bank at the causeway over Pearces Creek, Pearces Creek Hall Road.

	
Degraded wetland near the site of the Teven interchange of the Pacific Highway upgrade.	Water Hyacinth deposition and dead fish near Byrnes Point ferry after the fish kill in February 2008.

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Google image of the site	Mangrove recruitment
	
Pimlico Island	Drainage into Richmond River
	
Bank slumping and rock retainment.	View of the shoreline.

Zone 3 –Back Channel

	
Wardell Bridge (Pacific Highway)	Tea-tree plantation
	
Vegetation clearing	

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Google image of the site	River bank at Royal Hotel Wardell
	
Transport of water hyacinth during flood events occurs in the Richmond River.	Erosion control at Wardell

Site BC8 (Northern bank at Wardell).

Zone 4 –South Ballina/Empire Vale

	
Vegetation die back and erosion at Mobbs Bay (Photo: Michael Wood)	Prickly Pear infestation at Mobbs Bay (Photo: Michael Wood)
	
Construction of recreational facilities at Woodburn. The 2008 flood results in bank undercutting of the bank below the steps.	Broadwater Sugar Mill
	
Mangrove Removal on Plenkovich Road	Mangrove colonisation in areas around drains

	
Google Image of the site	Improvement in water quality will result in aquatic habitat values.
	
Over hanging vegetation provides good habitat for aquatic life.	A collaborative water quality project is currently underway at this site.
	
A good riparian zone exists here that is not confined by the road. Weed management is required.	Well structured riparian vegetation.

Images taken from Site SB5.

	
Google image of the site	Drain at Carney Lane
	
Mangroves mixed with grasses	Rover bank vegetation
	
Steep banks at the drain entrance to the river.	Opportunity exists for some vegetation enhancement.

Images taken from Site SB6

	
Mangroves at site SB4	Opportunities for riparian revegetation in the channel at site SB4.
	
Bank slumping resulting in mangrove destablilisation at Wardell. Site BC8 (Southern Bank opposite Wardell)	The extent of bank slumping at this site is significant. Site BC8 (Southern Bank opposite Wardell)

Images from sites SB4 and BC8 (Southern bank opposite Wardell).

Zone 5 –Rileys Hill

	
Improvement works could be conducted on the boat ramp at Rileys Hill (north side)	Steep bank at the boat ramp (south side)
	
Wetlands on private property with habitat value.	A pair of Brolgas was observed in the same wet pasture site on 9/4/08 and later on the 25/09/08.
	
Works being conducted to elevate land adjacent to the river	Tea-tree (mid ground) and sugar cane (far background) are both grown at Rileys Hill.

Zone 6 –Evans

	
Riparian vegetation north of Woodburn limited by the current highway	Opportunity exists for high profile riparian revegetation and weed management along the river bank at Woodburn.
	
Bank erosion on Tuckombil Canal (Site E19).	Tuckombil Canal joining the Richmond River to the Evans River (Site E19)
	
Coral Tree invasion on the lower river bank at Tuckombil Canal (Site E19)	Limited riparian vegetation at the Tuckombil Canal site (Site E19)

An overview of images from Management Zone 6 –Evans and on ground assessment site E19

Zone 7 –Rocky Mouth Creek

Google image showing the area of site RC17

Narrow riparian zone being used as a horse paddock at site RC17. Note the coral tree weed abundance. This landowner expressed interest in riparian revegetation

Weed infestation along Rocky Mouth Creek site RC17

An overview of images from Management Zone 7 –Rocky Mouth Creek and on ground assessment site RC17.

Zone 8-Swan Bay

Google image of the Swan Bay area

Riparian zone near Swan Bay showing extensive coral tree growth and exotic vines.

Richmond River in April 2008 after heavy rains near Swan Bay.

Sand extraction from the Richmond River near Swan Bay

Riparian vegetation at Swan Bay.

	
Terrestrial and aquatic vegetation at site	Shore line reeds
	
Wetland habitat with some weed aquatic weed issues	Mixed species of aquatic plants

Images from site SB20

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Zone 9-Kilgin Buckendoon

<table>
<tr><td>  </td><td>  </td></tr>
<tr><td>Kilgin Canal</td><td>Some large native eucalyptus on the riparian zone.</td></tr>
<tr><td colspan="2"> 
Some areas of riparian vegetation exist with notable native trees. Extent is limited by the road in places.</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>Vegetation clearing resulting in bank erosion</td><td>Large improvements to riparian zone can be made in high profile areas like Council managed parks. (Woodburn west bank)</td></tr>
</table>

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Riparian vegetation clearing (April 2008) destroyed native trees including Tuckeroos.	Good riparian vegetation cleared for unknown reasons (April 2008).
	
Dungarubba Creek restoration project	The boat ramp at Dungarubba Recreational Reserve needs improvement
	
Dungarubba Drain feeds into Dungarubba Creek restoration project	Riparian farming

	
Kilgin School Canal entrance to the Richmond River	Recent fill dumping and vegetation clearing at the Kilgin School Drain entrance (April 2008)
	
Richmond River at site KB13/14	Aquatic plants in the drain
	
Muddy sediments at the drain entrance	Vegetation on the toe of the bank

Images from site KB 13/14

	
Google image of this site	Extensive grazed riparian area note coral tree
	
Hugh potential exists for revegetation with limited weed removal required. Need land holder support for this site.	Weed invasion in grazing paddock
	
Cattle grazing in the riparian zone	Some good riparian vegetation upstream from this site.

Images from site KB15

	
Google image of this site	Bank slumping on opposite bank
	
Limited riparian vegetation at this site (opposite Bank)	Floating weeds and sparse riparian vegetation
	
Rocks used to retain bank and tree pruning is evident.	Riparian vegetation on Oakland Road bank

Images from site KB18

Zone 10 - Tuckean

Upstream from the Baggotville Barrage

The Tuckean is utilised by wetland birds.

Variable riparian vegetation along the channels

Mangrove fern at the Baggotville Barrage

The Baggotville Barrage

	
Google earth image of the site	Good riparian vegetation structure
	
Rock revetment and mangrove colonisation.	Interesting depositional area near the cutting edge of the bank. Note aquatic weeds.
	
Stormwater runoff and floodplain drainage at this site	Good native riparian trees

Images from site T11

	
Google image of the site	Rocky outcrop on the northern side of the barrage inhibits immediate erosion. Downstream erosion is notable (background)
	
Abundant water lilies on the estuary side of the barrage.	Southern side of the barrage on the estuary side
	
Northern side of the barrage	

Images from site T12

Zone 11-Bungawalbyn

Drainage channel through pasture

	
Riparian revegetation	
	
Drain management	Asparagus fern regrowth
	
Steep banks with some good native trre growth. The width of the riparian zone is limited.	

Images from site BU26

Active riparian revegetation

Landholder commitment to riparian vegetation enhancement.

Images from site BU27/28

Zone 12 –Upper Richmond/Wilsons River

	
Confluence of Leycester Creek and Wilsons Rivers at Lismore	Cattles access to streams enhances erosion, Wilsons River near Eltham.
	
Pelican Creek	Near the sale yards at Leycester Creek
	
Confluence of the Richmond and Wilsons River at Coraki	Exposed banks and bank slumping at Lismore.

	
Wyrallah boat ramp	Large area of exposed bank at the Wyrallah boat ramp
	
An interesting wetland site occurs near site 24.	Foreshore works in Lismore has been conducted as part of the levee construction.
	
Jabiru Geneebeinga wetlands are near Casino. Opportunities exists to protect further wetland refuge areas.	Turbidity is compromised during rainfall events in the Wilsons Creek at Bangalow, far upstream from the study area.

	
Camphor Laurel a large woody weed prominent in the management zone. Although a noxious weed they provide structural support for the riparian zone.	Cattle fencing and riparian revegetation on the Wilsons River.
	
Coral tree infestation along the Wilsons River near Lismore. Some structural support is provided b these weeds.	Riparian weed issues, Wilsons River.
	
Severe bank slumping, Wilsons River.	Slumping causing tree fell into the River, Wilsons River.

	
	Water extraction at the Lismore Source has the potential to compromise downstream water quality.

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A google image of the site	Cattle access to the river on opposite bank at Coraki
	
Public space on the river bank at Coraki	Fishing at the boat ramp in Coraki
	
View from the bridge downstream from Coraki	Fill dumping at the playground in the river side park, Coraki.

Images from site 21/22

	
A google image of this site	Some serious weed issues at this site
	
River extraction on the opposite bank at this site.	Post flood mud deposition at this site
	
Play ground and BBQ facilities are at this site. Some tree planting (background) and grass swales are used to divert rainwater to the river.	I view from the bridge at this site.

Images from site 23

	
A google image of this site.	
	
Grazing occurs at this site	Riparian grazing land with coral tree infestation on the river bank.
	
Some structural vegetation occurs at this site among intermittent exposed river bank areas.	Private riparian land

Images from site 24

	
A google image of the site.	Dairy cattle access to the river has been controlled at this site.
	
	Some weed management would benefit this site.
	
Willing landowner at this site provide possible further riparian management. Upstream of site	Downstream view at this site

Images from site 25

	
A google image of this site	Downstream from the bridge
	
Upstream of the bridge	The swing ropes indicate that primary contract recreation occurs at this site.
	
Weed issues at this site	Opportunities for riparian vegetation enhancement.

Images from site 29/30

	
A google image of this site	The Manyweathers Weir at Casino.
	
Riparian vegetation went some way to helping stabilise banks in recent flooding (2008).	Rocky substrate occurs at the foot bridge downstream from the weir. Some notable riparian plant has occurred along the path and Lomandra help stablilise the bank in the foreground.

Images from site 31

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A google image of the site locality	Downstream of the site
	
Undercutting of banks	Upstream of the site
	
Site vegetation and bank view.	Some threatening vines

Images from site 32

Appendix 3 – Water Quality Monitoring Strategy

Richmond Estuary Monitoring Strategy (REMS)

The Richmond River is predisposed to water quality challenges due to its relatively small catchment area (6979km^2) and large floodplain (990km^2) with a very small water surface area (19km^2). It is a poorly flushed system with a tidal pinch near Pimlico which results in poor water exchange upstream from this area. The upper catchment areas have largely been cleared and the land use is now predominantly agriculture. This change in land use has contributed to high TSS and nutrient loadings from these areas. Additionally, there are eight sewage treatment plants in the study area and several more in the catchment area, which manage waste from the larger urban areas including Ballina, Lismore, Casino, Wardell, Alstonville, Nimbin, Dunoon, and Coraki. Stormwater runoff from these urban areas also enters the Richmond River. The large expanse of rural residential living within the area also results in a significant number of on-site sewage treatment facilities. The labyrinth of road networks and the lack of hard surfaces on some of these also contributes to TSS loading.

The hydrology of the large floodplain has largely been modified through drainage channels and changes in vegetation types. The exposure of Acid Sulfate Soils (ASS) has occurred as a result of floodplain drainage and other activities that altered the ground water hydrology. Flood waters can become acid when draining occurs from large areas of ASS. Blackwater events are significant post flooding in the Richmond River Estuary and Eyre et al. (2006) have determined that at 25˚ the Richmond River floodplain has the potential to deoxygenate 12.5 x 10^3 mL of saturated freshwater. This scale of deoxygenation is sufficient to completely deoxygenate floodwater stored on the flood plain within 3 to 4 days.

Historical information suggests that flood water can persist on the floodplain for around 6 days and in some places for several weeks. Both black water events and acid water event have contributed to fish kills in the Richmond River. There are also potential health risks related to mosquito borne infections after flood events and while water is still stored on the floodplain. Healthy, ecologically balanced wetlands systems can minimise mosquito infestation.

Overview

The aim of this strategy is to provide an optimised, cost-efficient way to:

- Monitor ecosystem health along the estuary (including tidal pools) and tributary waterways on the floodplain,
- Monitor the main drivers of ecosystem health,
- Assess the performance of sub-catchment management initiatives in improving ecosystem health, and
- Interpret data within a functional catchment export-estuarine response model framework that can be used as a predictive risk assessment tool.

Integrated catchment-wide monitoring

The Richmond River estuary is the unifying element for environmental management across all local government areas (LGAs). Each LGA attempts to maintain good water quality throughout their particular part of the catchment and estuary, however, the ultimate goal is to improve the ecosystem health of the Richmond estuary. Monitoring strategies should, therefore, not only cover particular localised issues, but also place these into the wider system context (i.e. how does each LGA impact on the estuary as a whole).

At present, there is monthly water quality monitoring data collected from each of the constituent councils. This data will be used to assist with future monitoring, however, a coordinated approach will provide more robust results.

Centralised approach

Disparate LGA water quality monitoring programs across the Richmond River catchment would be best served by centralising and standardising the collection, storage and analysis of samples to a catchment-wide monitoring strategy. This allows for a standardised approach to sampling protocols, analysis, quality assurance and database management ensuring high quality data. It is important that the strategy is consistent with state-wide monitoring efforts (e.g. the Monitoring, Evaluation and Reporting program currently being undertaken by DECCW 2008).

Organisation

The strategy should be ideally overseen by a single authority (e.g. Richmond River County Council), and include regular consultation with contributing stakeholders. It is anticipated that the strategy could be run by one full-time Water Quality Officer. Time weighting for duties would include:

- Sample collection 0.3
- Sample analysis 0.3
- Data management 0.2
- Reporting and Liaison 0.2

The position would require field, laboratory and data analysis skills. Data quality can be improved keeping the chain of custody from sample collection, storage, analysis to data management with one person. Data would be made available using existing reporting framework for Councils.

Monitoring locations

The choice of monitoring locations will be determined by a trade-off between costs / logistics and information gained. A core set of main channel sample locations should be maintained

along the estuarine gradient and tidal pool in order to provide assessment of system-wide water quality, and a context for gauging impacts of sub-catchment inputs. Ideally, these should include representatives from each reach.

Sampling locations within each sub-catchment unit should include as a minimum a site at the catchment outlet, sites relevant to current management initiatives, and major secondary sub-catchments (e.g. a minimum requirement for the Bungawalbyn / Sandy Creek management unit would be sites in both creeks upstream of their confluence and one site downstream of their confluence). Ideally, a site representative of the primary water quality stressor (e.g. the Bora Codrington drain) should be included. It is anticipated that the strategy would utilise car and boat based sampling to cover the minimum of sites throughout the catchment and estuary.

Boat-based sampling is preferable for estuarine monitoring due to the ability to:

- choose ecologically-relevant sites rather than be constrained by accessibility considerations,
- collect mid-stream samples (away from bank disturbance effects),
- take depth profiles which provide valuable information about stratification,
- allow samples to be collected at a standard state of tide along the estuarine gradient, thereby improving the quality of the data and power of interpretation.

Car-based sampling is required to cover most of the catchment outlet sites. Problems associated with bank-based sampling can be overcome using various remote sampling aids (e.g. extension poles for probes and collection containers), or utilising bridges where appropriate.

Indicative sites have been identified (Figures 8.1 to 8.4) according to:

- strategic location at key catchment outlets,
- ability to monitor indicators pertinent to management zone issues, and
- ability to monitor indicators relevant to ecosystem health within a reach.

A total of 36 car-based and 15 boat-based sites have been identified, which is approximately 3 car-based and 1 boat-based sample per management zone (note that not all management zones contain equal numbers of sites – number of sites per zone was commensurate with the magnitude of the zones issues).

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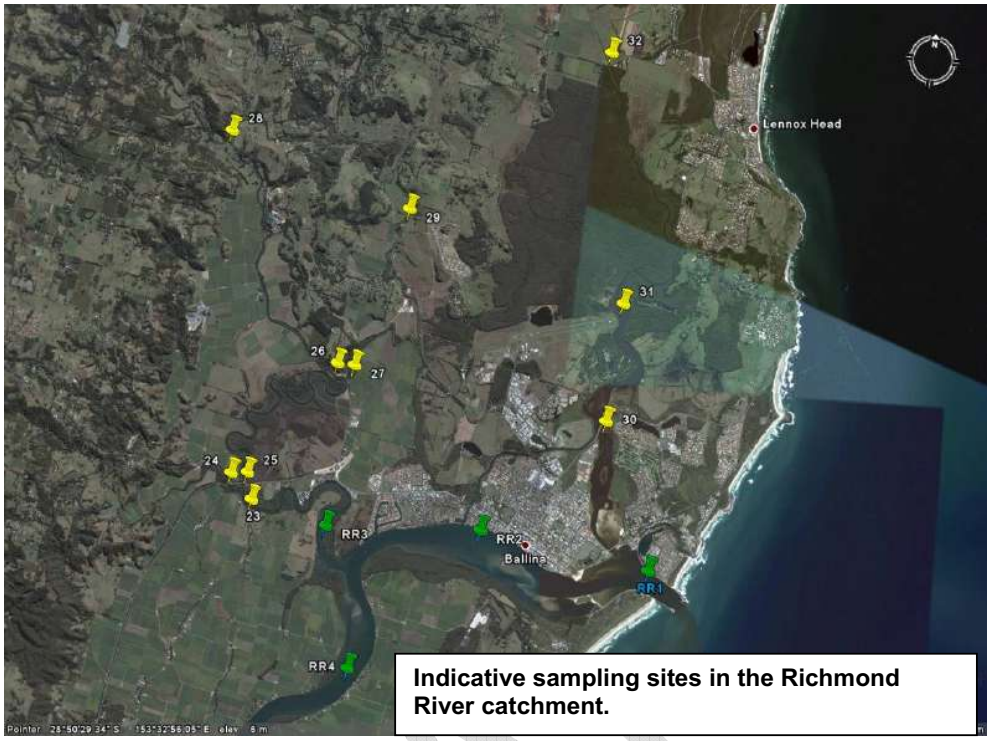
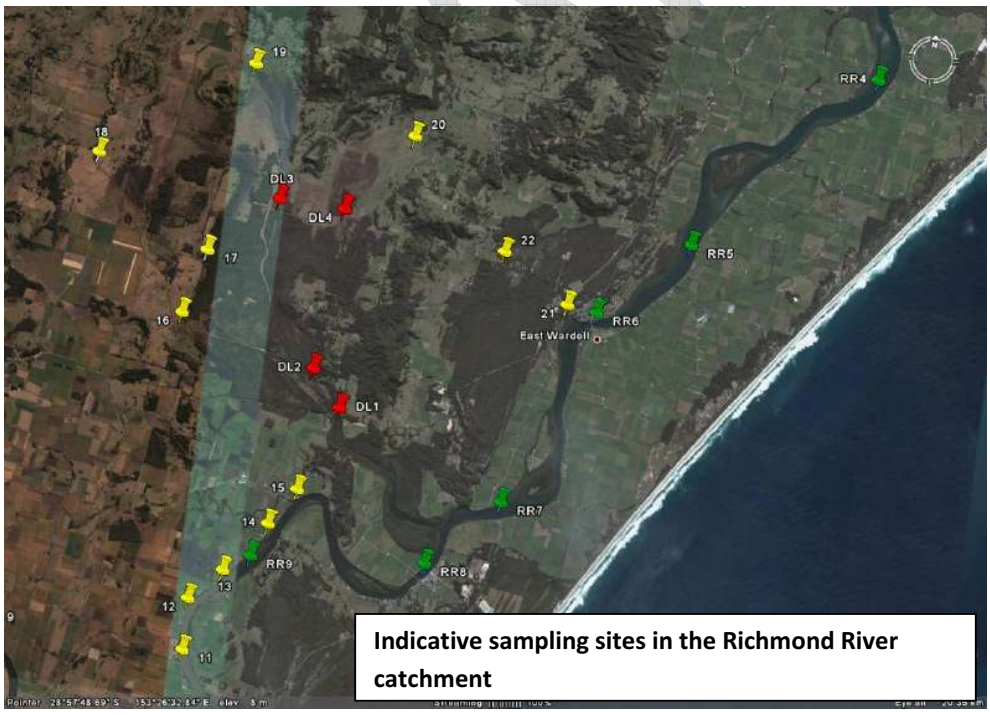


Indicative sampling sites in the Richmond River catchment.



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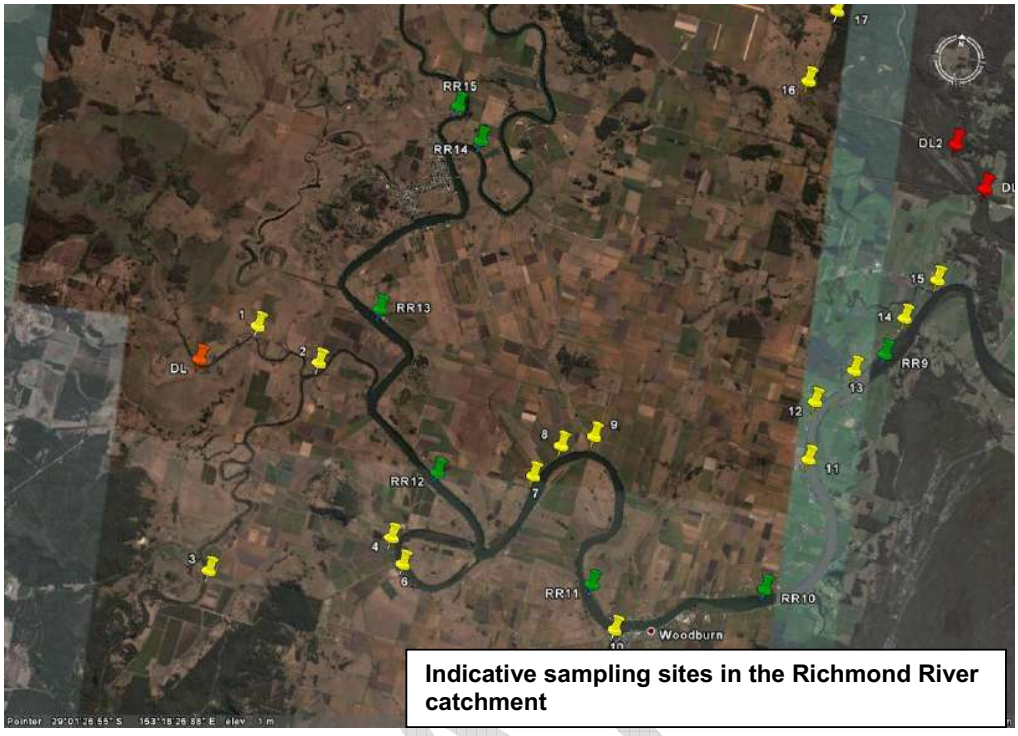
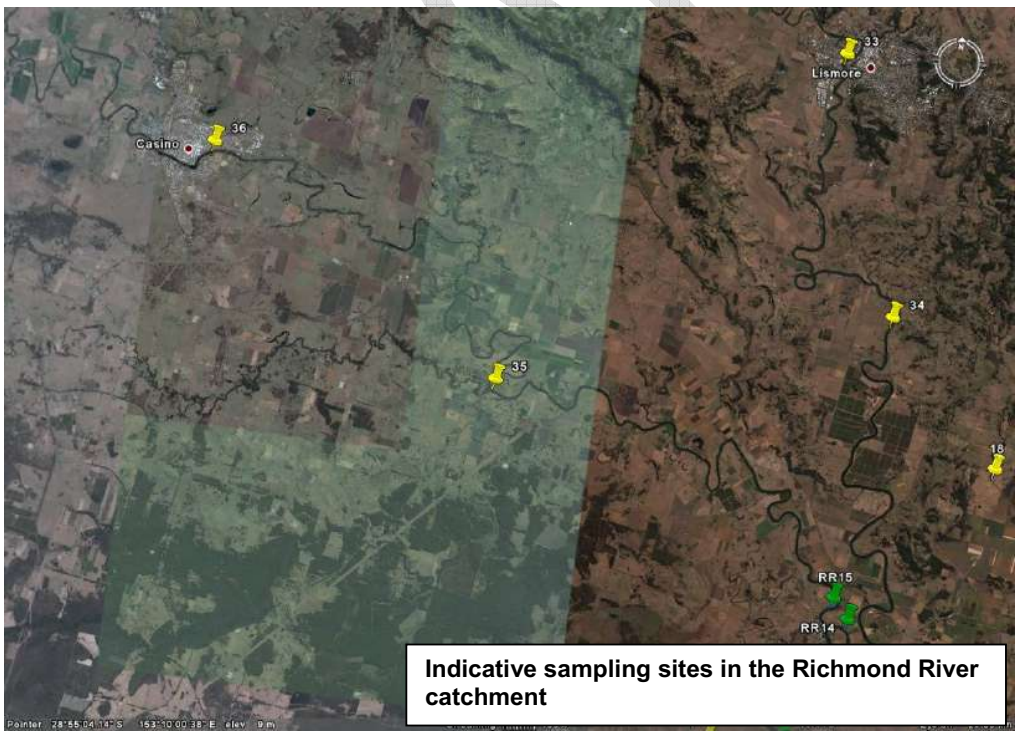


Indicative sampling sites in the Richmond River catchment



Indicative sampling sites in the Richmond River catchment

Monitoring frequency

A minimum routine frequency of monthly samples across all locations is required to properly ascertain seasonal trends due to temperature and broader wet/dry seasonal changes, however, it is insufficient to assess the magnitude / persistence of extreme water quality events (e.g. hypoxia) alone. The power of a monitoring strategy to accurately constrain environmental trends increases with the sampling frequency, which needs to consider the time frame of processes which impact on water quality.

Monthly samples will commonly miss the extremes of water quality variation in response to high flow events, and will only provide a coarse measurement of impacts arising from in-stream processes (e.g. algal blooms and subsequent hypoxia). Fortnightly samples are most likely to represent the minimum sampling frequency needed to describe temporal variation in internal processes and reduce the standard error of estimations. In addition, a flow weighted component to the strategy (e.g. revert to weekly samples after major rainfall events) would greatly improve understanding of catchment exports and ecosystem responses to these inputs to the estuary.

Water quality parameters

A full suite of physico-chemical parameters (temperature, conductivity, dissolved oxygen, pH, faecal coliforms and turbidity) should be measured at each site regardless of what other parameters are measured. These provide vital information pertinent to ecosystem health, e.g. salinity regime (and therefore relative freshwater influence), acidity and trophic status (e.g. hypoxia).

The choice of additional water quality parameters should be addressed on a site by site basis, depending on the primary water quality stressors (e.g. ASS runoff and blackwater) relevant to the site. Catchment outlet sites should include collection of samples for organic dissolved and particulate nutrients and inorganic dissolved nutrients, as well as total suspended solids and chlorophyll-*a*.

Quality assurance protocols

A full record sheet should be maintained for every sample collected (see example record sheet attached as Appendix 1).

Due to the uncertainty introduced to data through poor calibration, it is essential that calibration, according to instrument specifications and using certified high quality standards and reference waters, is carried out pre- and post-sampling. These results should be reported in the Richmond River Water Quality Database (RRWQDB) to allow subsequent quality assessments to be made on data. All data should be entered into the RRWQDB as soon as possible and checked for consistency. Any unexplained anomalies in the data should be addressed immediately to ascertain whether the anomaly reflects a methodological

artefact or bona fide environmental trend. These results will be available to all extension officers in real time.

Analytical protocols

To ensure the recovery of good quality data (and hence return for sampling costs), it is critical that all laboratory analysis is NATA certified, and is carried out using the current best-practice methods for marine, estuarine and freshwater water samples. In particular, it is recommended that a low level analysis protocol for inorganic and total nutrients be developed that accounts for interferences due to variable salinity of samples. All analyses should include standard reference materials, and regularly cross check laboratory performance by sending replicate samples to other approved laboratories for analysis.

Data management

Data from the Richmond River Estuary Water Quality Monitoring Strategy (RREWQMS) would be stored centrally in the RRWQDB originally developed by WBM Oceanics as part of the Richmond River Estuary Processes Study. The database currently stores data in Microsoft Access format and provides statistical interpretation via Microsoft Excel and a graphical interface using MapInfo. There is scope for upgrading the current system to make it more user friendly and tailoring outputs to integrate seamlessly with the catchment export and estuarine modelling tools (see below).

In situ data-loggers

These provide valuable information on water quality variation in response to tidal variations, floodgate management, and critical thresholds for the outflow of backswamp runoff. In particular, well-maintained loggers provide crucial feedback on the effectiveness of drain management initiatives (e.g. sills) as long as the data period spans the full range of climatic extremes.

The network of loggers currently maintained in the Tuckean Swamp / Broadwater provides a good system overview by spanning the gradient from the upper, middle, and lower backswamp through to the broadwater. There are major issues associated with *in situ* dataloggers, which must be addressed to maximise the recovery of good quality data:

- Probes should be referenced to AHD to allow proper assessment of tidal impacts and critical levels;
- Probe drift due to biogeochemical fouling should be minimised by regular servicing and calibration,
- If probes are set at a fixed height above the channel bed, an assessment of stratification in the waterway and the potential artefacts likely caused, should be undertaken.

Data analysis and interpretation

Well coordinated REMS could;

- Provide measurable performance indicators for sub-catchment management initiatives (see zone specific indicators in Part 2),
- Improve the diagnostic power of monitoring to detect environmental changes,
- Improve understanding of the Richmond River ecosystem and its likely response to climate change and catchment management scenarios, and
- Meet LGA requirements for environmental audits and reporting.

Catchment export and estuarine response models

The Department of Environment and Climate Change (DECC) has recently completed a comprehensive E2 catchment export model of the entire Richmond River catchment. The model includes up-to-date landuse assessments for each sub-catchment and allows the estimation of pollutant loads from each sub-catchment and testing of landuse change scenarios on loads. This catchment export model has been coupled to an estuarine response model (ERM) of the Richmond estuary which estimates the relative impact of management zone exports on the health of the Richmond estuary. It is also used to assess critical thresholds (guidelines) for primary water quality drivers (e.g. light climate and nutrient concentrations) necessary for maintaining key ecosystem processes.

The model is based on a modified 1D box model approach, comprising 13 boxes from the mouth at Ballina to the upper limit of salt penetration at Coraki. The transport / mixing sub-model accounts for variation in the principle drivers of estuarine biogeochemical processes:

- morphology and depth
- freshwater inflows
- tidal mixing
- water residence times
- nutrient and TSS inputs
- light climate

The biological response sub-model predicts the growth and biomass of phytoplankton and benthic microalgae, as well as rates of bacterial breakdown of organic matter. The net impacts on important water quality parameters such as dissolved oxygen are then estimated.

Interpretation of routine monitoring data

Data collected routinely as part of the proposed REMS can be easily interpreted in the catchment export-ERM framework to give an indication of ecosystem health status against a set of system-specific health guidelines. Catchment outlet data can be used to calibrate and update export coefficients in the E2 model to give more realistic estimations of loads.

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Wilsons River

Key monitoring sites and assessment parameters

The following series of Tables provide key monitoring sites and parameters for the assessment of inputs and ecosystem health in Management Zones 1 to 4 and 7 to 12, described in the Coastal Zone Management Study for the Richmond River Estuary and Plan (Australian Wetlands 2009).

ZONE 1 – North Creek	Phys-chem	Secchi	nutrients	BOD	Chlorophyll-*a*	TSS
Input sites						
Newrybar Swamp at Ross Lane	X		X	X		X
Ballina STP	X		X	X	X	X
Ballina urban runoff	X		X	X		X
In-stream health sites						
Upper North Creek estuary	X	X	X		X	X
Mid North Creek estuary	X	X	X		X	X
Lower North Creek estuary	X	X	X		X	X
Lower Richmond estuary	X	X	X		X	X

ZONE 2 – Emigrant / Maguires Creek	Phys-chem	secchi	nutrients	BOD	Chl-a	TSS
Input sites						
Emigrant Ck at Cumbalum	X		X	X	X	X
Maguires Ck at Teven	X		X	X	X	X
Uralba Ck at highway	X		X	X	X	X
Pimlico Ck at highway	X		X	X	X	X
In-stream health sites						
Emigrant Ck at confluence	X	X	X		X	X
Maguires Ck at confluence	X	X	X		X	X
Emigrant estuary at Pacific Highway	X	X	X		X	X
Lower Emigrant estuary	X	X	X		X	X
Lower Richmond estuary at Byrnes Pt	X	X	X		X	X
Lower Richmond estuary at Pimlico	X	X	X		X	X

Zone 3 – Back Channel	Phys-chem	secchi	nutrients	BOD	Chl-a	TSS
Input sites						
Bingal Ck at Wardell Rd	X		X	X	X	X
Pacific highway upgrade sites	X		X	X	X	X
Instream health sites						
Bingal Ck at confluence	X	X	X		X	X
Mid Richmond estuary at RR5	X	X	X		X	X
Mid Richmond estuary at RR6	X	X	X		X	X
Mid Richmond estuary at RR7	X	X	X		X	X

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Zone 4 – South Ballina / Empire Vale	Phys-chem	secchi	nutrients	BOD	Chl-a	TSS
Input sites						
Empire Vale Ck at Reedy Ck Rd	X		X	X	X	X
In-stream health sites						
Empire Vale Ck at outlet	X	X	X	X	X	X
Lower Richmond estuary at RR1	X	X	X		X	X
Lower Richmond estuary at RR2	X	X	X		X	X
Mid Richmond estuary at RR4	X	X	X		X	X
Mid Richmond estuary at RR5	X	X	X		X	X
Mid Richmond estuary at RR6	X	X	X		X	X
Mid Richmond estuary at RR7	X	X	X		X	X
Mid Richmond estuary at RR8	X	X	X		X	X

Zone 7 – Rocky Mouth Creek	Phys-chem	secchi	nutrients	BOD	Chl-a	TSS
Input sites						
Rocky Mouth Ck at tide gates	X	X	X	X	X	X
In-stream health sites						
Rocky Mouth Ck at fabridam	X	X	X	X	X	X
Rocky Mouth Ck at Woodburn	X	X	X	X	X	X
Upper Richmond estuary at RR10	X	X	X		X	X
Upper Richmond estuary at RR11	X	X	X		X	X

Zone 8 – Swan Bay	Phys-chem	secchi	nutrients	BOD	Chl-a	TSS
Input sites						
Northern drain	X	X	X	X	X	X
Southern drain	X	X	X	X	X	X
In-stream health sites						
Swan Bay	X	X	X	X	X	X
Upper Richmond estuary at RR11	X	X	X		X	X
Upper Richmond estuary at RR12	X	X	X		X	X

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Zone 9 – Kilgin / Buckendoon / Dungarubba	Phys-chem	secchi	nutrients	BOD	Chl-a	TSS
Input sites						
Oakland Rd drain1	X		X	X	X	X
Oakland Rd drain2	X		X	X	X	X
Oakland Rd drain3	X		X	X	X	X
Kilgin Rd drain1	X		X	X	X	X
Kilgin Rd drain2	X		X	X	X	X
Kilgin Rd drain3	X		X	X	X	X
Kilgin Rd drain4	X		X	X	X	X
Kilgin Rd drain5	X		X	X	X	X
Instream health sites						
Mid Richmond estuary at RR8	X	X	X		X	X
Upper Richmond estuary at RR9	X	X	X		X	X
Upper Richmond estuary at RR10	X	X	X		X	X
Upper Richmond estuary at RR11	X	X	X		X	X
Upper Richmond estuary at RR12	X	X	X		X	X

Zone 10 - Tuckean	Phys-chem	secchi	nutrients	BOD	Chl-a	TSS
Input sites						
Yellow Ck at Justilius Rd	X		X	X	X	X
Marom Ck at Tuckean Island Rd	X		X	X	X	X
Tucki Ck at Mathieson Ln	X		X	X	X	X
Instream health sites						
Tucki Drain at Tuckean Island Rd	X	X	X		X	X
Nature Res. Drain at Tuckean Island Rd	X	X	X		X	X
Main drain at Baggotville Barrage	X	X	X		X	X
Mid Richmond estuary at RR7	X	X	X		X	X
Mid Richmond estuary at RR8	X	X	X		X	X

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Zone 11 – Lower Bungawalbyn	Phys-chem	secchi	nutrients	BOD	Chl-a	TSS
Input sites						
Bungawalbyn Ck at Neileys Lagoon Rd	X		X	X	X	X
Instream health sites						
Bungawalbyn Ck at Boggy Ck Rd	X	X	X	X	X	X
Sandy Ck at Myall Ck Rd	X	X	X	X	X	X
Bungawalbyn Ck at Coraki-Woodburn Rd	X	X	X	X	X	X
Upper Richmond estuary at RR12	X	X	X	X	X	X
Upper Richmond estuary at RR13	X	X	X	X	X	X

Zone 12 – Upper Richmond / Wilsons	Phys-chem	secchi	nutrients	BOD	Chl-a	TSS
Input sites						
Wilsons River at South Lismore	X	X	X	X	X	X
Richmond River at Casino	X	X	X	X	X	X
Instream health sites						
Wilsons River at Whyrallah	X	X	X	X	X	X
Richmond River at Tatham	X	X	X	X	X	X
Wilsons River at Coraki	X	X	X	X	X	X
Richmond River at Coraki	X	X	X	X	X	X
Upper Richmond estuary at RR13	X	X	X	X	X	X

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Appendix 3: Consultation Activities

This Appendix provides detailed information on the consultation activities undertaken during the preparation of the EPS (WBM, 2006), the Draft EMS and Draft CZMP

Richmond River Estuary Processes Study Discussion Paper

Introduction

The Richmond River Estuary is a highly valued natural resource for local inhabitants and tourists alike. The estuary supports a diverse range of human usage, of both a commercial and recreational nature, as well as supporting a variety of significant ecological communities. Recent investigations into the health of the estuary indicate that ecological communities supported by the estuary may be under stress from the types of human usage currently occurring on and around it.

Furthermore, the demands for living close to water are increasing Australia wide, and it is expected that there will be increases in the local population as a result of this demand. This is likely to lead to a corresponding increase in estuary usage, which if unmanaged, will exacerbate existing conflicts, cause additional habitat degradation, further reduce water quality levels, etc. In 1987, the NSW State Government introduced the *Estuary Management Policy.* One of the primary outcomes of the policy has been to introduce a process of addressing these issues before they became problematic.

For the Richmond River, this process commenced in 2000 with the formation of the Richmond River Estuary Management Committee. This Committee is responsible for the preparation of a series of key documents as outlined under the *Estuary Management Policy.* At the present time, the Committee is overseeing the preparation of an **Estuary Processes Study** (EPS) for the Richmond River Estuary. The EPS is primarily a technical study that will support the later preparation of an **Estuary Management Study and Plan**. WBM has been commissioned by the Richmond River County Council (which coordinates between the Ballina Shire Council, Lismore City Council and Richmond Valley Council) to prepare the EPS.

Purpose of the Discussion Paper

The EPS aims to develop the necessary scientific understanding of the estuary to enable informed decision making when the Estuary Management Study and Plan are commenced. To enable an initial prioritisation of key issues for the estuary and to assist us in understanding how it is currently used and valued by locals and tourists, this discussion paper has been prepared to obtain feedback from Estuary Management Committee Members.

In completing the discussion paper, it is important for Committee members to bear in mind that they are members of a group which represents the broader community. The discussion paper should take approximately 30 minutes to complete. When complete, please return (by mail or fax) your completed discussion paper no later than Friday 4th March 2005 to: Damion Cavanagh, WBM, PO Box 203, SPRING HILL QLD 4004, or fax 07 3832 6744. If you wish to speak to Damion he may be contacted on 07 3831 6744.

Please also note that when marking up the map provided, ensure that any marks/comments are referenced back to the questions in the discussion paper.

Executive Summary from the Data Compilation Study

WBM completed the Data Compilation Study (DCS) for the Richmond River estuary in 2004. The DCS aimed to guide and facilitate the efficient preparation of an Estuary Processes Study for the estuary, as well as provide a framework for the effective and efficient analysis of estuary processes.

The Principal conclusions and recommendations from the DCS as detailed in its Executive Summary are reiterated below:

- **Flooding and Tidal Hydraulics** – Following the review of hydrodynamic and hydrological processes, it is evident that considerable information, at various scales, has been gathered since the 1950's on the issue of flooding and flood mitigation. The ongoing work involving the Floodplain Management Studies from the affected local councils provide details on the current understanding, causes and management strategies. Further information is available in GIS format in terms of drainage and environmentally sensitive risk areas. Assessments of the extensive impacts caused by flooding in the region have been undertaken on social, financial and ecological grounds.

  Adequate sources have been identified in terms of hydraulic data as well as extensive recent flood studies. The review has also identified a number of calibrated hydrodynamic and flood models of the Richmond River. No additional data is required for an Estuary Processes Study (EPS) and it is recommended that the relevant Floodplain Management Studies be continued with implementation of the corresponding Floodplain Management Plans.

- **Water Quality** – Extensive monitoring data has been collected in terms of water quality. The principal conclusions from the studies are that water quality is poor when related to accepted guidelines and key indicators. Certain sources have also presented data that indicate a continuing decline in water quality in the estuary.

  The runoff from acid sulfate soils is attributed as being a significant cause of low pH and deficient dissolved oxygen levels periodically observed in the estuary. Intensive research has been exhibited as part of this review into the behaviour and impacts of acid sulfate soils. Nutrient over-enrichment from point and diffuse sources has also been identified, as has turbidity and sediment load issues attributed to diffuse catchment loads.

  Sufficient data has been identified to define the magnitude of point sources, such as the council sewage treatment works. Monitoring data and predictive capacities for diffuse catchment loads have also been researched. Data defining the point and diffuse loads within the estuary should therefore be collated from the variety of sources cited in this study. It is concluded that this data will be sufficient for the purposes of an EPS.

  It has been noted that the water quality data has in many cases not taken into consideration flow regimes, natural variability and the internal cycling of nutrients. It is recommended that the EPS collate and analyse all available data, and coordinate to collect any further required data to satisfy key spatial and temporal deficiencies. It is also recommended that the EPS incorporate investigations into key internal cycling processes, such as sediment fluxes, denitrification, etc.

Water quality modelling is recommended to improve system understanding and a predictive capacity for the Richmond River estuary. As previously mentioned, the review has also identified calibrated hydrodynamic models of the Richmond River.

- **Protection of Aquatic Habitat** – The aquatic biodiversity of the Richmond area has been the subject of many studies as evidenced in this report. The conclusions all indicate the same situation that the overall river health and extent/condition of aquatic habitat is in a poor state and in decline, river heritage is degraded and fish stocks are threatened. The "State of the Environment", NSW Fisheries and other ongoing government agency studies form a good source of information, with pressures such as the intensity of fishing, boating, erosion, barriers and the introduction of alien species having been identified.

  The EPS should collate and analyse all available data, and coordinate to collect further data to satisfy key spatial and temporal deficiencies. Continuation of a coordinated approach to ecological monitoring is also recommended.

- **Fishing and Fishery Management** – Numerous studies have been identified indicating that the impacts of recreational and commercial fishing are inherently linked to the state of the aquatic habitat and biodiversity generally. It is reported that in addition to natural pressures and effects, fishing, dependent on the intensity and type, can have substantial detrimental effects on fish stock and aquatic biodiversity. The stresses applied by the growing recreational fishing population, as well as the commercial fishing community, have been assessed by several sources.

  It is concluded that sufficient data exists for the purposes of an EPS. It is recommended that the EPS should correlate the existing data with that of water quality and aquatic habitat.

- **Fish Kills** – The available literature widely attributes the significant depletion of dissolved oxygen and the resulting fish kills that have occurred during major flooding to the runoff of acid sulfate soils. Intensive research has been exhibited into the behaviour and impacts of acid sulfate soils. An emerging issue related to acid sulfate soils in both coastal and inland areas is the presence of monosulfidic black oozes. These highly reactive sediments are often found in the drains in acid sulfate soil landscapes and can cause rapid and complete deoxygenation of waters when mobilised. They are considered to be a significant contributing factor in the deoxygenation of North Coast Rivers.

  An additional possible cause for the occurrence of deoxygenation and fish kills has been identified as increased oxygen demand from floodplain vegetation following flood events. A database of fish kills and investigations into the recovery of fish stocks has been established by NSW Fisheries.

  Research, management and guidelines relating to the general acid sulfate soil problem have been implemented. It is concluded that sufficient data exists for the purposes of an EPS and as with the fishery data, it is recommended that the EPS should correlate the existing data with water quality and aquatic habitat data.

- **Erosion and Riparian Vegetation** – Many sources have cited riverbank erosion as a major issue for the Richmond catchment. The principal causes are identified as the change of land use and the loss of riparian and other stabilising vegetation. Studies exist that map the condition and extent of riparian vegetation. Further mapping of active erosion zones is recommended, as data is deficient in this area. An assessment of the key erosional mechanisms involved should be

undertaken utilising the results of the survey, possibly supported by the interpretation of other modelling studies.

- **Shoaling, Navigation and Dredging** – A deficient amount of data has been found to be available in terms of these issues. Dredging ceased when the requirement for access to cane barges was removed and the subject is the focus of widespread concern with inconclusive studies that have examined the long-term trends in the spatial variation of sedimentation.

  Further research is therefore recommended, as there are differing accounts on the extent of the problem and the trends prior to and following dredging activities. The collation of dredging event data is recommended to provide an accurate picture of past activities. Additional bathymetric surveys, including the examination of historical survey sites, are also recommended to allow further comparison with historical data.

- **Water Extraction and River Flow** – The drought in 2003 brought this issue to the forefront and the need for long term planning to supply agricultural and urban requirements has been voiced. The extraction of river flows for irrigation and other demands is a significant concern for many licence holders. An initial investigation into the impacts of further extraction from and upstream of the tidal pool was undertaken in 1999.

  In light of the recent development of water quality and river flow objectives and changes in land use, such as subdivision, the increasing demand for water resources from the system has been acknowledged by several key sources. The variability of flow required for estuarine health is also a significant concern.

  Data is available concerning the number of licence holders and the rate of extraction from all areas of the Richmond River. Guidelines for river flow have also been established. Further investigations and modelling into the impacts of increased extraction for irrigation and domestic water supply purposes is recommended.

- **Waterway Usage –** Recognised as a priority issue in the lower estuary, the major concern is focussed on the lack of facilities and planning in relation to the use of the estuary as a functional port and for pursuits such as boating. Following the demise of the Ballina Quays Marina, the consultations indicate that the estuary has been left with deficient amenities, services and non-existent available moorings. The aspirations of interested parties display that there is great potential for the estuary in terms of tourism and the area's future development if facilities were provided.

  It is recommended that a suitable infrastructure/usage investigation be incorporated into the Environmental Management Study, potentially as a separate component e.g. waterway users management plan, and supported with a review of available data from the processes study.

QUESTION 1. RESPONDENT DETAILS

Name: ……

Occupation/Organisation: ……..

Month/Year of Joining Committee: ……...

QUESTION 2. ESTUARINE USAGE

Please list/describe below the top five uses of the estuary that you are aware of. **Please also mark the locations of these uses on the maps provided**. Recreational uses may include such activities as fishing (boat or shore), oystering, sailing, water-skiing, jet-skiing, prawning, swimming, surfing, canoeing, picnicking/walking on the banks, bird-watching, four-wheel driving, camping, snorkelling, spear fishing, crabbing, etc. Commercial uses may include such activities as fishing, prawning, oystering, etc.

1. ……

2. ……

3. ……

4. ……

5. ……

QUESTION 3. ESTUARINE VALUES (FOR RESIDENTS)

Please list/describe below what you believe to be the five most valuable aspects of the Estuary. Aspects of value may include access to water, peace and tranquillity, water quality, recreational opportunities, commercial opportunities, natural surroundings, wildlife, natural beauty, views etc.

1. ……

2. ……

3. ……

4. ……

5. ……

QUESTION 4. ESTUARINE VALUES (FOR TOURISTS)

What do you believe to be the five most valuable aspects of the estuary to tourists, e.g. open waterways for waterskiing, availability of fish to catch, clean water for swimming?

1. ……

2. ……

3. ……

4. ……

5. ……

How valuable is tourism to the region (very, moderate, not important)?

QUESTION 5. VISUAL AMENITY

Please describe any features located on or near the estuary of high visual quality, i.e. scenic locations, etc, that you consider to be valued by both by locals and visitors. **Please also mark the locations of these high visual quality areas on the maps provided.**

……..…

……..…

……..…

……..…

QUESTION 6. USAGE CONFLICTS

Are there any present conflicts in the use of the estuary that you are aware of e.g., boating noise impacts on residential areas, waterway usage impacts on banks or seagrass areas, boat usage impacts on safety, etc? **Please also mark the locations of any conflict zones on the maps provided**.

……..…

……..…

……..…

……..…

……..…

……..

QUESTION 7. ISSUES/THREATS

List the top five short and long-term threats you consider are facing the health of the estuary. Short term may be considered as five years, while long term may be considered as 20 years? Please note that a **healthy river** has been defined by the Healthy Rivers Commission as, "*a river whose condition, as indicated by a broad range of environmental, social and economic characteristics, enables it to support the natural ecosystems, commercial activities and social amenity desired by the community*."

Short-term threats/issues

1. ……

2. ……

3. ……

4. ……

5. ……

Long-term threats/issues

1. ……

2. ……

3. ……

4. ……

5. ……

QUESTION 8. QUALITY OF LIFE CONTRIBUTION

What contribution do you consider the estuary makes to the quality of life (High/Medium/Low contribution) of most individuals (in the study area)? A brief explanation of your answer would also be helpful.

……

……

……

……

……

……

QUESTION 9. VISION FOR THE ESTUARY

What is your long-term vision for the estuary, i.e. estuary predominantly focused on catering to the needs of tourists, estuary remaining the same as it is now, estuary increasing its commercial usage, etc?

……..…

……..…

……..…

……..…

……..…

…….

QUESTION 10. BOATING/ESTUARY ACCESS

Please provide brief answers to the following questions specifically related to boating and access. Some of these questions may relate to those asked earlier, so please ignore this question if you have already addressed it.

Question 10.1

Please describe the principal boating types (e.g. boating for fishing, boating for skiing, commercial boating, etc) and the physical extent (please mark on maps provided) and estimated duration of boat usage undertaken in the estuary (i.e. 20 days per year). If you have addressed this in section 1.2, please ignore.

…….

…….

Question 10.2

What do you consider are the main social (e.g. relaxation), cultural (e.g. sporting) and economic benefits of boating to the region?

Social:

…….

Cultural:

…….

Economic:

…….

Question 10.3

Please describe the potential impacts of boating activities in relation to the social (i.e. noise issues, safety issues, etc) and environmental values (habitat preservation, bank stability, etc) of the estuary. If this question has been addressed in section 1.4 or 1.5 please ignore.

…….

…….

…….

…….

Question 10.4

Do you consider there to be potential for increased boating in the Richmond River estuary. If so, what form should this take and are there likely to be any impacts associated with the increased boating activity. If this question has been addressed in section 1.4 and 1.5, please ignore.

…….

…….

…….

…….

…….

…….

Question 10.5

Are there any impacts of shoaling on boating navigability? Do you think that this situation will change in the future?

…….

…….

…….

…….

…….

…….

Question 10.6

Are there any issues in relation to public foreshore access requirements? If so, where do you believe these issues exist (please mark on the map provided) and what may be done to resolve them.

…….

…….

…….

…….

…….

QUESTION 11. COMMUNITY AWARENESS

What do you believe to be the current overall level of community understanding of estuarine processes? What particular aspects of community understanding and awareness need to be improved to facilitate better estuarine management?

…….

…….

…….

…….

…….

RETURN DETAILS

Please return (by mail or fax) your completed discussion paper by **Friday 4th March 2005 to: Damion Cavanagh, WBM, PO Box 203, Spring Hill QLD 4004.** The discussion paper can be faxed to Damion on 07 3832 3627.

If you wish to know more about the study or wish to speak or meet with a study representative in person, please contact **Damion Cavanagh** on 07 3831 6744 or email him at dccavanagh@wbmpl.com.au.

Note: A series of maps of the catchment were provided at the rear of the Discussion Paper but have not been included here.

Appendix 1 – Community engagement, surveys, consultation and stakeholder workshops

Stakeholder engagement activities

DATE	TARGET	ACTIVITY
29th 30th September	TARGETED ABORIGINAL ENGAGEMENT	Information stall and 37th Indigenous football knockout
27th October	TARGETED COMMUNITY	Surfrider foundation talk, surveys and clean up
15th November	STAKEHOLDER MEETING	Richmond River Estuary Management Committee
18th November	TARGETED COMMUNITY CONSULTATION	Rivafest stand surveys, exposure Ballina
29th November	ANNOUNCEMENT	Echo Eof I announcement
10th Dec	STAKEHOLDER MEETING	Floodplain committee meeting and presentation
11th Dec	STAKEHOLDER MEETING	Richmond River Estuary Management Committee meeting and presentation
12th December	BSC, LCC, RVC	LEP planning workshop
14th December	Community Engagement	Extension of EoI submission ABC Radio interview 97.9 FM interview Northern Star advertised announcement
24th December	Close of expressions of interest	Sort applications
29th Jan 2008	Community engagement gap analyses	Seek people to invite to fill gaps in community representation
5th Feb	Meeting with Tracey King NGULINGAH LOCAL ABORIGINAL LAND COUNCIL	Way Forward Aboriginal engagement
3-10th March	Liaise with RRCC	Development of presentation material
12th March	Richmond River Rescue Meeting	Attendance and Disuccion
17th March	FOCUS GROUP Lower catchment e.g. Ballina	Presentation surveys questions stakeholder list
19th March	FOCUS GROUP Upstream e.g. Lismore/Casino	Presentation surveys questions stakeholder list
26th March	Meeting with Estuary Management Committee	Presentation and update
April	ABORIGINAL ENGAGMENT	Letters to key Aboriginal stakeholders requesting engagement
22nd April	FOCUS GROUP FEEDBACK	Provided Draft outcomes to attendees of focus groups and other interested community members. Feedback requested
5th May	FOCUS GROUP FEEDBACK	Incorporated all feedback (6 responses) into the focus group outcomes and replied to emails.
16th May	ABORIGINAL ENGAGMENT	MEETING WITH BUNDJALUNG ELDERS
20th May	STAKEHOLDER ENGAGEMENT North Coast Weeds – Des Boorman	Discussing priorities for vegetation assessment relative to noxious and environmental weeds
25th June	STAKEHOLDER ENGAGEMENT Meeting with CMA –Nicole Strehling	Discussion of Catchment Action Plan and incorporating targets into the EMP
1st July	ABORIGINAL ENGAGEMENT	WORHSHOP WITH BUNDJALUNG ELDERS COUNCIL ABORIGINAL ELDERS CORPORATION
9th July	ABORIGINAL ENGAGEMENT	Follow up letter to Chairperson of Bundjalung Edlers

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	Council Aboriginal Corporation and provision of additional information/ TBA
PUBLIC MEETING 2	Presentation of the Draft Study
PUBLIC MEETING 2	Presentation of Draft Plan

NOTES

- Richmond River Estuary Processes Study completed a community consultation phase (in total 3 survey forms were completed) although the lack of response was acknowledged no compensatory action was considered.

- The client is keen for all the community to know what an estuary is and the extent of the Richmond River Estuary

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RICHMOND RIVER ESTUARY COMMUNITY SURVEY

PART A: Community Survey for developing an education program

Richmond River County Council together with the local councils of Lismore, Richmond Valley and Ballina is developing a community education program throughout the Richmond Valley. The program aims to:

a. enhance community understanding of key cause and effect relationships with respect to behaviours that are placing pressure on the ecological, social and economic values of the Richmond River, and

b. Identify, promote and encourage changes in community and government behaviour that aim to improve the health and long term sustainability of the Richmond River.

The first stage of the project is to undertake a survey of users of the Richmond River Estuary as well as the general community within the Richmond Valley.

The survey seeks to gather current information on how and where people use the estuary, what they see as the most important and special attributes of the estuary, and importantly what current and long term issues and threats the community considers the estuary to face. The survey also seeks information on the types of actions and strategies people wish to see to improve and protect the estuary into the future.

The results from the survey will be used by the Richmond River County Council to develop a range of education strategies and programs which will raise the community's and our visitors understanding of the environmental, social and economic significance of the estuary system and the ways in which we can collectively work towards the long term sustainability of the Richmond River.

Your participation in the survey is important and very much appreciated.

Estuary Definition

"an estuary is a partially enclosed coastal body of water ... part sea ... part waterway ... part land. They are places of transition from salt water to fresh water, from tidal to non-tidal and from wet to dry".

Estuaries come in all shapes and sizes and go by many different names. They are often called bays, lakes, lagoons, harbours, rivers or inlets. Estuaries provide a wide range of unique environments where conditions are constantly changing. They are completely transformed twice a day by the flood and ebb of the tide.

Sustainability Definition

Sustainability or ecologically sustainable development is a global approach to future development. It is a process of economic and social development that maintains a healthy functioning environment upon which all life depends

Ecologically sustainable development is based on a set of principles to achieve:

- long term economic viability;
- social harmony; and
- a healthy and attractive natural environment. (Northern Rivers Regional Strategy)

For the purpose of this consultation process estuary sustainability is considered to refer to the use, care and management of the estuary system so as to maintain the environmental, social and economic welfare of the system for future generations.

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1. Survey Location
Location: Date:
2. Demographics
Town of Residence:
Age Group: 15-19 20-29 30-39 40+ Do you consider yourself part of a specific interest group (circle any that are relevant)? conservation indigenous tourism recreational fisher commercial fisher farmer local government other (please specify)_____
3. Estuary Definition
Please comment on what you understand to be the estuary; i.e how would you define the estuary?
4. Usage
a. Which location/s do you access and use the estuary and how do you use the estuary e.g. Wardell Boat Ramp/ launching boat; Pimlico Island/ fishing
b. Approximately how many times per year do you use the Richmond River Estuary?
c. What are the most frequent times of the year that you use the estuary?
Summer Autumn Winter Spring All Year

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5. Special Attributes
Could you please identify the main features of the Richmond River Estuary that you consider to be the most important or special?
6. Current Estuary Issues
Could you please advise what you consider to be the main issues or threats currently facing the Richmond River Estuary?
7. Long Term Estuary Issues
Could you please advise what you consider to be the main issues or threats facing the long term sustainability of the Richmond River Estuary?
8. Issue Management
Could you please comment on what actions or strategies you would like to see undertaken to best address these issues?

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9. Access to Information
Where do you most access information in relation to the current state of and issues relating to the Richmond River Estuary?
TV Newspaper Radio Internet . Brochures Other (please specify): _____
10. Further Information
Would you like further information and updates on the Richmond River Estuary and if so in what format?
Yes No TV Newspaper Radio Internet Brochures Delivered newsletter Other (please specify)_____
11. Current State of the Estuary
How would you rate the current state of the Richmond River Estuary?
Good (of a high standard with little or no improvement in quality required) Fair (acceptable quality but may/would benefit from improvement in quality) Poor (state affects but does not prohibit the range of current recreational uses and environmental attributes) Critical (State is not acceptable for current recreational and/or environmental quality)
12. Other Comments

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Part B: Community Survey to determine environmental values

QUESTION 1

What level of protection and management intent do you think is suitable for the Richmond River Estuary? Note: Details as specified by the National Water Quality Management Strategy (NWQMS)

ENVIRONMENTAL VALUE	SUPPORTING DETAILS	TICK THE LEVEL YOU THINK IS APPRORIATE FOR RICHMOND RIVER
High conservation/ ecological value system (HCV)	These are systems that are largely unmodified or have undergone little change. They are often found in national park, conservation reserves or inaccessible locations. Targets for these systems aim to maintain no discernable change from this natural condition	
Slightly to moderately disturbed system (SMD)	These systems have undergone some changes but are not considered so degraded as to be highly disturbed. Aquatic biological diversity may have been affected to some degree but the natural communities are still largely intact and functioning. An increased level of change in physical, chemical and biological elements of these systems is to be expected.	
Highly disturbed systems (HD)	These are degraded systems likely to have lower levels of naturalness. These systems may still retain some ecological or conservation values that require protecting. Targets for these systems are likely to be less stringent and may be aimed at retaining a functional but highly modified ecosystem that supports other environmental values as assigned to it (e.g. primary industry)	

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QUESTION 2

Please rate the following environmental values according to their relevance and level of importance to the Richmond River Estuary.

Environmental Value	Supporting detail	High	Medium	Low	Not Applicable
Aquatic ecosystems	**Habitat and wildlife in waterways and riparian areas**				
Primary Industries	**Irrigating** crops such as sugar cane, lucerne etc				
	Water for **farm use** such as fruit packing or milk sheds				
	Stock watering				
	Water for **aquaculture** such as oyster farming				
	Human consumption of wild or stocked fish or crustaceans				
Recreational & Aesthetic	**Primary recreation** with direct contact with water such as swimming or snorkelling				
	Secondary recreation with indirect contact with water such as boating, canoeing or sailing.				
	Visual appreciation with no contact with water such as picnicking, bushwalking, sightseeing				
Drinking water	**Raw drinking water** supplies				
Industrial uses	Water for **industrial use** such as power generation, manufacturing plants.				
Cultural & Spiritual	Cultural and spiritual values				

As specified in the National Water Quality Management Strategy (NWQMS)

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Town of Residence

Town	Number	Percent (%)
Ballina	15	51.7
Lismore	1	3.4
Lennox Head	10	34.5
Byron Bay	2	6.9
Wollongbah	1	3.4

Age Group

Age	Number	Percent (%)
15-19	2	7.1
20-29	2	7.1
30-39	7	25
40+	17	60.7

Interest Group

Group type	Number	Percent (%)
Conservation	14	38.9
Indigenous	1	2.8
Tourism	2	8.3
Recreational Fisher	11	30.5
Commercial Fisher	-	-
Farmer	2	5.5
Local Government	-	-
Boating	1	2.8
Surfer	2	5.5
Ecotourism	1	2.8
Scouts	1	2.8

Estuary Definition

Understand extent of Estuary?	Number	Percent (%)
Yes	10	37
No	17	63

Location of Use

Location of Use	Number	Percent (%)
Boat ramps	8	19.5
Boat docks	1	2.4
Break walls	1	2.4
Parks & walkways	6	14.6
Beaches / banks	3	7.3
Public Access points	4	9.8
Open water	3	7.3
Quays	1	2.4
Mobbs Bay	1	2.4
Shaws Bay	1	2.4

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North Creek	1	2.4
Broadwater	2	4.9
Wardell	1	2.4
Lismore	1	2.4
Ballina	3	7.3
All	4	9.8

Frequency of Use

Frequency	Number	Percent (%)
Daily	12	42.9
Weekly	7	25
Fortnightly	3	10.7
Monthly	1	3.6
Yearly	5	17.9

Timing of Use

Timing	Number	Percent (%)
Summer	8	23.5
Autumn	2	5.9
Winter	-	-
Spring	4	11.8
All year	20	58.8

Estuary Issues (given in total respondent numbers)

Issues	Current	Long - Term	Management
Agricultural Practices	9	7	7
Urban Developments	7	9	4
Loss & poor condition of riparian veg	-	-	2
Declining fish stocks	8	6	3
Obstructions to fish migration	-	-	-
Ballina STP discharge	2	-	2
Poor water quality (black and acid water)	14	9	1
Boating facilities not suitable	9	1	3
Climate change	-	2	-
Silting / infilling	6	5	3
Stormwater	2	1	1
Education / awareness	-	-	8
Rubbish	3	1	5
Non-compliance with rec fishing laws	1	1	-
Lack of fishing regulation enforcement	-	-	3
Community involvement	-	-	2
Wetland restoration	-	-	2
Aquatic weeds	1	-	
Erosion	3	-	1
Loss of wildlife	1	1	-
Boating pressure	2	1	1
No appreciation by authorities	1	1	-
Money	1		1

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Nutrients	1	1	

Access to Information

Access Type	Number	Percent (%)
TV	7	12.9
Newspaper	21	38.9
Radio	7	12.9
Internet	8	14.8
Brochures	8	14.8
Rous Water	1	1.9
Direct Inquiry	1	1.9
Visual inspection	1	1.9

Further Information

Want further Info	Number	Percent (%)
Yes	22	88
No	3	12

Further Information Type

Access Type	Number	Percent (%)
TV	6	14.6
Newspaper	12	29.3
Radio	6	14.6
Internet	5	12.2
Brochures	5	12.2
Delivered newsletter	6	14.6
Schools	1	2.4

Perceived state of the Estuary

Perceived State	Number	Percent (%)
Good	3	10.3
Fair	16	55.2
Poor	10	34.5
Critical	-	-

- Tweed River Floodplain Management could be useful for Richmond River
- Community should be informed of pollutant levels and management undertaken
- River health is OK in fine weather. The problem is when it rains
- We need exciting, interactive education involving Aboriginal people and culture
- Oysters for eating are a good benchmark for water quality targets
- Need a full time fisheries enforcement officer
- Excellent resource that deserves serious management for future users
- Carefully planned rock walls provide excellent hatcheries for fish stocks
- Need a dedicated “River Council” which controls how the estuary is used. Coordinate with Fisheries

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- Need shock tactics for the public so they understand the issues
- Survey people who live directly on the estuary. See what they see
- Harvest the estuary to create energy
- Eat stocked fish, not wild resources

Table : Results of public survey

QUESTION ONE: WHAT LEVEL OF PROTECTION & MANAGEMENT DO YOU THINK IS SUITABLE FOR THE RICHMOND RIVER?		
	Number of Respondents	Percent %
HIGH CONSERVATION	11	44
SLIGHT TO MODERATELY DISTURBED	13	52
HIGHLY DISTURBED	1	4
Total	25	100

Public Rating of Environmental Values (Given total respondent numbers)

PUBLIC COMMENTS	High	Medium	Low	N/A
AQUATIC ECOSYSTEM VALUES				
Habitat & wildlife in waterways and riparian areas	26	1	-	-
PRIMARY INDUSTRIES				
Irrigating crops such as sugar cane, lucerine etc.	6	10	10	2
Water for farm use such as fruit packing or milk sheds	5	12	10	2
Stock watering	6	12	7	1
Water for aquaculture such as oyster farming	14	11	2	-
Human consumption of wild or stocked fish or crustaceans	16	8	2	-
RECREATIONAL & AESTHETIC				
Primary recreation with direct contact with water such as swimming or snorkelling	18	7	4	-
Secondary recreation with indirect contact with water such as boating, canoeing or sailing	15	8	5	-
Visual appreciation with no contact with water such as picnicking, bushwalking, sightseeing	19	7	3	-
DRINKING WATER				
Raw drinking water supplies	13	7	6	2
INDUSTRIAL USES				
Water for industrial use such as power generation, manufacturing plants	5	10	12	-
CULTURAL & SPIRITUAL				
Cultural and spiritual values	17	9	2	-

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Public Rating of Environmental Values (Given as % by column)

PUBLIC COMMENTS	High	Medium	Low	N/A
AQUATIC ECOSYSTEM VALUES				
Habitat & wildlife in waterways and riparian areas	16.3	0.9	-	-
PRIMARY INDUSTRIES				
Irrigating crops such as sugar cane, lucerine etc.	3.8	9.8	16.4	28.6
Water for farm use such as fruit packing or milk sheds	3.1	11.7	16.4	28.6
Stock watering	3.8	11.7	11.5	14.3
Water for aquaculture such as oyster farming	8.9	10.8	3.3	-
Human consumption of wild or stocked fish or crustaceans	10	7.8	3.3	-
RECREATIONAL & AESTHETIC				
Primary recreation with direct contact with water such as swimming or snorkelling	11.3	6.9	6.6	-
Secondary recreation with indirect contact with water such as boating, canoeing or sailing	9.4	7.8	8.2	-
Visual appreciation with no contact with water such as picnicking, bushwalking, sightseeing	11.9	6.9	3.3	-
DRINKING WATER				
Raw drinking water supplies	8.1	6.9	9.8	28.6
INDUSTRIAL USES				
Water for industrial use such as power generation, manufacturing plants	3.1	9.8	19.7	-
CULTURAL & SPIRITUAL				
Cultural and spiritual values	10.6	8.8	3.3	-

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Public Rating of Environmental Values (Given as % by row)

PUBLIC COMMENTS	High	Medium	Low	N/A
AQUATIC ECOSYSTEM VALUES				
Habitat & wildlife in waterways and riparian areas	96.3	3.7	-	-
PRIMARY INDUSTRIES				
Irrigating crops such as sugar cane, lucerine etc.	21.4	35.7	35.7	7.1
Water for farm use such as fruit packing or milk sheds	17.2	41.4	34.5	6.9
Stock watering	23.1	46.2	26.9	3.8
Water for aquaculture such as oyster farming	51.9	40.7	7.4	-
Human consumption of wild or stocked fish or crustaceans	61.5	30.8	7.7	-
RECREATIONAL & AESTHETIC				
Primary recreation with direct contact with water such as swimming or snorkelling	62.1	24.1	13.8	-
Secondary recreation with indirect contact with water such as boating, canoeing or sailing	53.6	28.6	17.9	-
Visual appreciation with no contact with water such as picnicking, bushwalking, sightseeing	65.5	24.1	10.3	-
DRINKING WATER				
Raw drinking water supplies	46.4	25.0	21.4	7.1
INDUSTRIAL USES				
Water for industrial use such as power generation, manufacturing plants	18.5	37.0	44.4	-
CULTURAL & SPIRITUAL				
Cultural and spiritual values	60.7	32.1	7.1	-

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RICHMOND RIVER ESTUARY FOCUS GROUP MEETING FOR THE RICHMOND RIVER ESTUARY MANAGEMENT STUDY AND PLAN

17th March 2008 **Ballina Beach Resort**

ATTENDEES: Garry Owers, Ken and Sue Thurlow, Nadia Elliot-Burgess, Ken Clarke, Sergio Jacomy, Ian McCabe, Serge Killingbeck, Ellen White, Lee Andresen.

Amanda Reichelt-Brushett (Australian Wetlands) Ken McLeod (Ethos Foundation) Facilitator

RANKED IMPORTANCE OF ESTUARY VALUES TO THE COMMUNITY ESTUARY FOCUS GROUP

Attendees were asked to consider a list of estuary values, add to that list any estuary values that were deemed missing, and then through a multi-vote system rank the values in order of importance. The information below is a summary of the outcomes from the ranking assessment.

SOCIAL VALUES

*Intergenerational equity
*Education potential
*Recreational fishing
*Ocean access
*Foreshore access
*Swimming/snorkelling
*Boating
*Recreational Use of Foreshore
*Spiritual values

AESTHETIC VALUES

*Aquatic flora and fauna
*Ambience/experience of the environment
*Clean beaches and foreshores
*Scenic amenity/view
*Terrestrial flora and fauna

Highest Importance
Highly Important
Very Important
Important

ECONOMIC VALUES

*Economic health in general
*Fishing industry
*Farming lands
*Nature based activities
*River related industry
*Restoration and rehabilitation values
*Marketing
*Tourism
*Education resource
*Real estate values linked to river health

ECOLOGICAL VALUES

***Healthy Water Quality**
*Riparian Zone Integrity –corridor connectivity and vegetation
*Biodiversity
*Aquatic flora and fauna
*Floodplain revegetation
*Integrity of wetland species
*Threatened species/communities
*Wildlife corridors
*SEPP 14 wetlands
*Intertidal Shoals
*Nursery ground for fish

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COMMUNITY ESTUARY FOCUS GROUP FEEDBACK ON ESTUARY ISSUES

The focus group discussed the issues presented in the Estuary Processes Study, made recommendations to add issues and then broke off into 4 small working groups. Each working group were given 2-4 of the established issues to discuss and consider on new issues identified in earlier discussion. Some groups chose to

ISSUES IDENTIFIED IN THE RICHMOND RIVER ESTUARY PROCESSES STUDY		COMMUNITY COMMENTS AND FEEDBACK
DEVELOPMENT	land use mapping 10 years old	
	lack of estuary protection through Local Environmental Plans	
	urban development and infrastructure impacts	The impact of river heath will also affect real estate values
	dredging impacts and needs	
	flooding	
WATER QUALITY	sewer overflows and effluent e.g. North Creek	
	sediment and nutrient loads in catchment runoff	PRIORITY A within water quality-Sampling of sediment and biota including heavy metals, and other chemicals, fertilizers, pesticides. Toxicology sampling (independently verified) - ongoing
	quality -dredging in upper estuary impacting on turbidity levels	Marginal impact of existing facility
	management of floodplain areas (ASS and black water)	
	high flow pulses	
	faecal coliforms	
	monitoring approach and understanding	PRIORITY B within water quality. All data should be made available to the public. Need a catchment wide monitoring approach. Need benchmarks to assess condition -helps public understand improvement or decline. Need to define how to fund improvement works.
	stormwater	
	Impact from river bank erosion from stock access	
ECOSYSTEM AND BIODIVERSITY	poor water quality impinging on aquatic ecosystem health and function	
	loss of and damage to riparian vegetation	
	limited protection of sensitive ecological communities in the estuary e.g. seagrass and saltmarsh	
	poor condition of riparian vegetation	
	loss and degradation of key wetlands	

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	on floodplain and important terrestrial habitats	
	fish stocks	
	fish migration	
	protection of high conservation value remnants of private land	
		Documented database required. Should include: Chemical usage within catchment, historical / present from urban / agricultural / industrial Extractive industries impact (dredging etc)

ISSUES IDENTIFIED IN THE RICHMOND RIVER ESTUARY PROCESSES STUDY		COMMUNITY COMMENTS AND FEEDBACK
CULTURAL VALUES	Incomplete cultural heritage studies	
	Timely adoption of cultural heritage sites and artefacts int the appropriate registers to ensure long term preservation.	
	Protection of cultural and heritage items and sites from future activities (e.g. land clearing or foreshore works)	
	Limited knowledge transfer of Richmond River Estuary pre and post European history	
EDUCATION	poor understanding of fishing impacts on fisheries health and controls	
	estuary ecology	
	Programs and actions for estuary health and improvement	Use organisations such as Australian Seabird Rescue
		Educating public on needs and impacts of aquaculture
		How to bring about change - community actions - publicity - education
PUBLIC ACCESS AND RECREATIONAL AMMENITY	waterfront structures and licensing	Important: Marina – Ballina, Wharves / Jetty, Swing moorings
	lack of suitability of boating facilities	lack of solution to lack of boating facilities
	need for recreational boating plan	Implementation of plans that are there
	navigation improvement and information transfer	Upgrade of and holistic planning for markers Dredging of bar and river

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	lack of knowledge in terms of conflict between users	Relates to infrastructure, Lack of facilities (LGA knowledge)
	concentration of boating activities in the lower estuary, lack of facilities for small vessels e.g. kayaks.	
		Poor public access to foreshore, Need to go thru private land to get to public / crown land
		Local regulation "man on the ground"
RESEARCH	Factors affecting health	
	Information sharing and accessibility is limited	
		PRIORITY B within research Factors affecting health of river (prioritising)
		How to effectively implement remediation and rehabilitation measures
		PRIOITY A within water qulaity Using body of available knowledge

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ISSUES IDENTIFIED IN THE RICHMOND RIVER ESTUARY PROCESSES STUDY		COMMUNITY COMMENTS AND FEEDBACK
CLIMATE CHANGE	understand threats	
	implementing adaptive actions	
		Major mapping with coordination of Authorities and public – public needs access to metadata
		Effects on coastal transport (nearby roads), infrastructure, sewage etc.
		Need to relocate food supplies – more adaptable to change, less dependant on fixed structures
		Water level effects on contaminated sites: landfill / sewage etc.
		Health – eg. Vector / water borne diseases
		Development impacts of engineered solutions on other areas – impacts downstream - economic and social impacts particularly on urban development in low lying areas
ECONOMIC	Promotion and support of economically and environmentally sustainable agriculture industries (and practices) within the region and study area.	
	Promotion and support of economically and environmentally sustainable tourism within the region and study area.	
		Richmond River is important to ALL business and industry
AQUACULTURE	presence of QX disease and lack of understanding	
	loss of North Creek harvest area.	
	water quality concerns	-public -industry

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ADDITIONAL ISSUES IDENTIFIED IN THE COMMUNITY FOLCUS GROUP		
GOVERNANCE	GROUP 1	• It is impossible, in an environment starved for somewhere to moor a boat, to retain or secure mooring points. Administrative restraints are restrictive, out of date and the lack of focus on the objective, rather than process. Waterways in transition – not being able to respond – 'no man on the ground' • The ability to respond immediately is paramount • Higher degrees of discretion and flexibility are required. Management from Macquarie St doesn't work • Respond to Lower RR Recreational Boating Study. What happened to the action items. Where are the outcomes? ACTION – ACCOUNTABILITY • Plying limits – need revisiting and should not be administrative decision – again 'man on the ground' • Keeping regulations up to speed. This relates only to HIRE and drive
	GROUP 2	• Regulation in terms of predicted climate change impacts • Peak oil – economic effect • Integrated mapping / research initiatives between all levels of government and with public participation and access to outcomes • Future amalgamations – catchment integration, rather than fragmentation – ecological values to be an integral component of amalgamation decisions. Even without amalgamation, shires to cooperate within catchment boundaries. • **At local, state and federal government level fragmentation of mapping layers to be addressed and made freely available to public (priority)** • Governance by private rural landowners: buy backs? education? regulation? attractive covenants and stewardships?
	GROUP 3	• non compliance • lack of enforcement • lack of clarity (confusion) of roles and responsibilities of Government and Non Government agencies (**B**) • Competition between agencies (**B**) • Meaningful and useful performance targets for responsible agencies • Identification of sole authority to manage and regulate all agencies (eg. Northern Rivers Catchment Authority) (**A**) • OR separate body for management and regulation of all aspects
	GROUP 4	• no promotion or support across industry • no budget • no capacity to action • LGA has no teeth • No differential rating structure like other LGA's • Less effective Economic Development Unit due to funding and resource • Less effective Chamber of Commerce • NSW Maritime Control mooring systems. No mooring which results in anchors straight into seagrass beds eg. Mobbs Bay (due to litigation fears)

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RICHMOND RIVER CATCHMENT FOCUS GROUP MEETING FOR THE RICHMOND RIVER ESTUARY MANAGEMENT STUDY AND PLAN

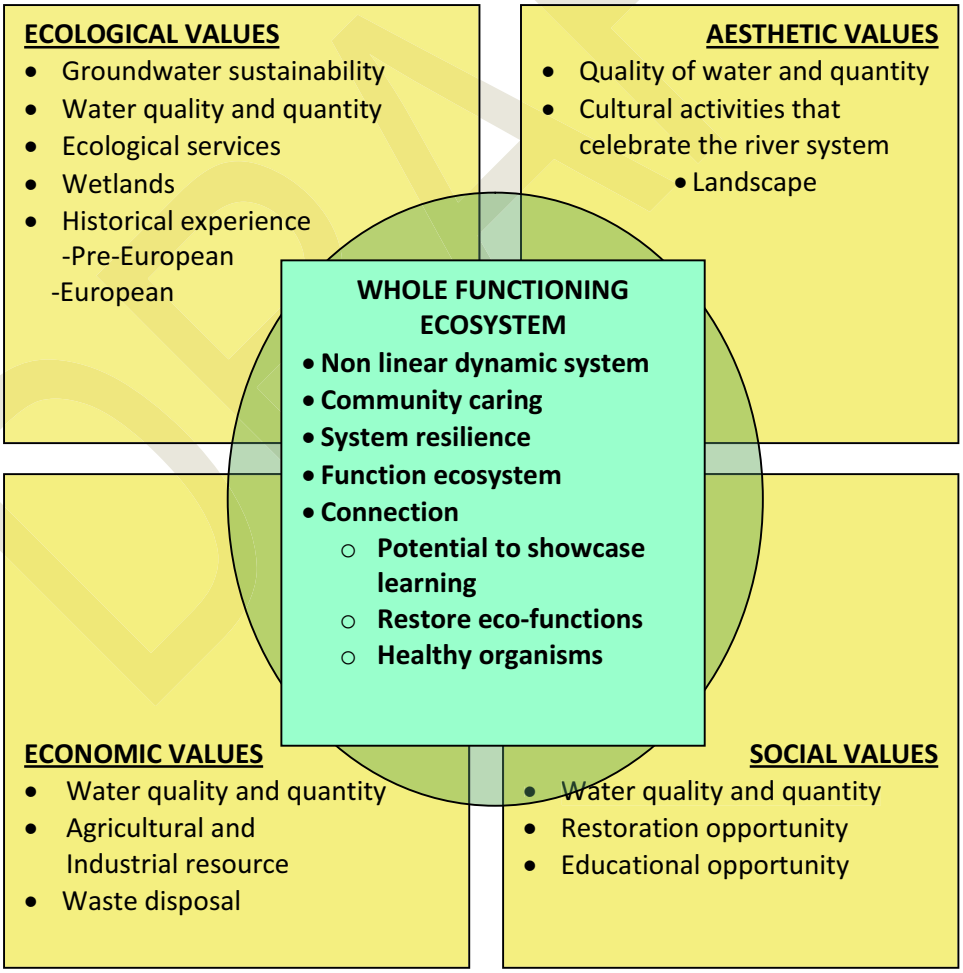
19th March 2008 **Lismore Workers Club**

ATTENDEES: Paul Weir, George Henderson, Eshana Bragg, David Pont, Daniel Clegg, Lynne Deweaver, Richard Gates, Simon Clough, Kristen Den Exter, Malcolm Johnson, Trevor Roberts, Maree Thompson, Emma Sweeny, Renee Silvester, Emma Murray, Bearnie Childs, Tom Amey.

Amanda Reichelt-Brushett (Australian Wetlands) Ken McLeod (Ethos Foundation) Facilitator

RANKED IMPORTANCE OF ESTUARY VALUES TO THE COMMUNITY CATCHMENT FOCUS GROUP

Attendees were asked to consider a list of estuary values, add to that list any estuary values that were deemed missing, and then through a multi-vote system rank the values in order of importance. The group as a whole preferred to focus on the integration of the values and open discussion led to producing the following holist valuing of the estuary.



COMMUNITY CATCHMENT FOCUS GROUP FEEDBACK ON ESTUARY ISSUES

The focus group discussed the issues presented in the Estuary Processes Study, made recommendations to add issues and then broke off into 4 small working groups. Each working group were given 2-4 of the established issues to discuss and consider new issues identified in earlier discussion. Some groups chose to prioritise sub issues presented in each issue.

ISSUES IDENTIFIED IN THE RICHMOND RIVER ESTUARY PROCESSES STUDY		COMMUNITY COMMENTS AND FEEDBACK
DEVELOPMENT	land use mapping 10 years old	
	lack of estuary protection through Local Environmental Plans	
	urban d'ment & infrastructure impacts	Consider waterless sewage systems
	dredging impacts and needs	
	floodplain	Return areas to wetland
		Population increase
		Humans need to take responsibility for all of their waste products
		Protection of important habitats
		Protection of high quality agricultural land
WATER QUALITY	sewer overflows and effluent e.g. North Creek	Eliminate overflows
	sediment and nutrient loads in catchment runoff	Reduce sediment runoff from farms and revegetate riparian zones
	quality -dredging in upper estuary impacting on turbidity levels	No dredging
	management of floodplain areas (ASS and black water)	More resources and more controls –investigate potential for carbon sink
	high flow pulses	Use floodplain to manage floods
	faecal coliforms	
	monitoring approach and understanding	More resources to increase community awareness of river science
	stormwater	Each LGA should develop stormwater DCPs
	Impact from river bank erosion from stock access	Off stream watering point should be a requirement
ECOSYSTEM AND BIODIVERSITY	poor water quality impinging on aquatic ecosystem health & function	
	loss of and damage to riparian vegetation	
	limited protection of sensitive ecological communities in the estuary e.g. seagrass and saltmarsh	
	poor condition of riparian vegetation	
	loss & degradation of key wetlands on floodplain & imp. terrestrial habitat	
	fish stocks	What are the impacts of trawling practices
	fish migration	
	protection of high conservation value remnants of private land	
		Integrated monitoring systems
		Access to planning and resources to best practice riparian restoration (advice training, education, skills in on-ground work)

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ISSUES IDENTIFIED IN THE RICHMOND RIVER ESTUARY PROCESSES STUDY		COMMUNITY COMMENTS AND FEEDBACK
CULTURAL VALUES	Incomplete cultural heritage studies	Use Bundjalung mapping program as a model
	Timely adoption of cultural heritage sites and artefacts int the appropriate registers to ensure long term preservation.	
	Protection of cultural and heritage items and sites from future activities (e.g. land clearing or foreshore works)	Sites should include 'landscapes'
	Limited knowledge transfer of Richmond River Estuary pre and post European history	
		Link with education on all levels primary, secondary and tertiary. Importance of school curricula and links to community (e.g. clean up days, litter surveys)
		Need to link cultural values to economic values
EDUCATION	poor understanding of fishing impacts on fisheries health and controls	
	estuary ecology	Education is required to understand how easily it can be impacted by poor landuse practices
	Programs and actions for estuary health and improvement	Estuary limit is Boatharbour, not Lismore or Lagoon Grass.
		Get all the public passionate about river quality
		Schools should use the river focus to engage in programs through environment groups, agriculture groups, sporting activities.
PUBLIC ACCESS AND RECREATIONAL AMMENITY	waterfront structures and licensing	
	lack of suitability of boating facilities	
	need for recreational boating plan	The boating plans need to address river bank erosion from power boats.
	navigation improvement and information transfer	
	lack of knowledge in terms of conflict between users	Kayaks and power boats usage needs clash
	concentration of boating activities in the lower estuary, lack of facilities for small vessels e.g. kayaks.	
RESEARCH	Factors affecting health	
	Information sharing and accessibility is limited	Information on monitoring needs to be reported back to the commmunity
		Need good monitoring to obtain ongoing database

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ISSUES IDENTIFIED IN THE RICHMOND RIVER ESTUARY PROCESSES STUDY		COMMUNITY COMMENTS AND FEEDBACK
CLIMATE CHANGE	understand threats	
	implementing adaptive actions	
		Explore carbon credits for revegetation of riparian zone and cattle paddocks
		Urgently need to understand the consequences of change including: Rainfall frequency and intensity Tolerance of species Determine species with tollerance
		Future planning must include climate change
		How does climate change influence the changing runoff from the Pacific Highway upgrade
		Individuals can be proactive
ECONOMIC	Promotion and support of economically and environmentally sustainable agriculture industries (and practices) within the region and study area.	Develop new opportunities for more sustainable industries. Sustainability need to be considered in terms of the role of the River as **source, sink and amenity**.
	Promotion and support of economically and environmentally sustainable tourism within the region and study area.	
		Consider carbon credit market
		Need to speak the economic language to influence decision making
		Ecosystem goods and services need to be factored in as real costs and benefits
		Footprint and lifecycle analyses of industries
AQUACULTURE	presence of QX disease and lack of understanding	
	loss of North Creek harvest area.	
	water quality concerns	

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ADDITIONAL ISSUES IDENTIFIED IN THE COMMUNITY FOCUS GROUP					
GOVERNANCE	GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5
Local government decisions are unpredictable/poor, lack of resources, high expectations,	∃	∃	∃		
LEPs could provide more leadership for issues affecting river health		∃			
Estuary over three local government areas (Catchment 5 LGAs)	∃				
Three levels of government have different rules that often conflict/ Duplication and fragmentation of plans and policies (in and between tiers of government) etc	∃		∃		
The whole of catchment approach should be taken into account for accessing information and research. Issues should not be looked at in isolation.	∃	∃			
Funding is lacking rate base is low compared to Gold Coast	∃				
Individuals and groups are driving the initiative for actions, governance should support this.	∃				
Government departments are out of touch with the locality and issues		∃			
Local government should develop partnerships with agriculture industry and community working groups. Would promote stewardship of river system on public and private land.		∃	∃		
Governments should treat the River health as essential infrastructure		∃			
Funding from existing and new sources needs to be channelled to management authority with long term model for change		∃	∃		
A bi-partisan/across shire "accord" for river management is required (or amalgamate)			∃		
Knowledge, values and issues need to be addressed in an integrated planning framework for effective funding and implementation of restoration,				∃	
Administrative restraints are restrictive, out of data and lack focus on current day objectives.					∃
Management should be interactive and resources need to be available for immediate responses to management needs					∃
Lower Richmond River Boating Policy is not active, who is accountable? Man on the ground required					∃
LAND USE					
Best practice agriculture (including aquaculture). Consideration to affects of land practices on health of catchment and estuary.	∃				
Community awareness of landuse is required	∃				
Sewage systems are inadequate	∃				
Monitoring systems need objective measures of thea level of impact of an activity on water quality (e.g. development)	∃				
Lack of awareness upstream of the effects downstream, lower river, estuary and ocean. (E.g. soil loss from macadamia farms)	∃				

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Appendix 4: Options Assessment

This Appendix provides detailed information on the assessment of management options including methodology and results

1. OPTIONS ASSESSMENT

The evaluation of potential management options is critical to the development of the management strategies. This has been undertaken as follows:

- The individual management options have been assigned an “Option Benefit Score”; and
- The total option scores for each category of option have been visually compared with the associated issue priority.

1.1 Ranking of Issues

A list of key issues was compiled from concerns raised by the scientific assessment (WBM, 2006; ABER, 2007; ABER, 2008), the general community and stakeholder groups. Key issues were grouped in terms of their overall impact and discussed in terms of major contributing factors.

All issues were ranked to focus management effort on those issues regarded as a priority in achieving the objectives of the plan. Issues were ranked with reference to:

- The importance of the issue in relation to the underlying ecological functioning of the river;
- The community perception of the issue;
- The degree to which the issue contributes to other issues in the estuary;
- The geographic extent and frequency of the issue; and
- The potential for the issue to have significant economic implications for the community - economic Implication scores were determined by a further break down and scoring according to the main economic sectors of the local area.

The issue ranking process and results are shown in Tables A1 and A2.

1.2 Option Benefit Score

Within the detailed descriptions of each management option, the social, environmental and financial considerations have been identified. The focus is on achievement of the key objectives, multiple issues and identification of high-value solutions.

The options assessment considered:

- Achievement of management objectives – achievement of the objectives is the primary goal;
- Social, environmental and economic consequences (of implementing as well as not implementing the option);
- Expected community and agency support; and
- 10 year implementation costs.

The options assessment process considered:

- The degree to which the option addresses the objectives – either directly contributes, indirectly contributes or conflicts with the objectives (Management Objective Score);
- The “Benefit” score – based on the likelihood of successful implementation and agency acceptability and likelihood of positive changes for the estuary (i.e. a combination of the consequences and the level of support); and

- The “Cost” score – classified as very high, high, medium or low based on capital and 10 year recurrent costs.

The overall Benefit/Cost score was derived by:

$$Option\ Benefit\ Score = \frac{Management\ Objective\ Score\ x\ Benefit\ Score}{Cost\ Score}$$

The Management Objective Score, Benefit and Cost Scores and overall Option Benefit Scores are provided in Tables A3, A4 and A5.

1.3 Comparison with Issue Priority

As each management option addresses a given issue or series of issues, it is possible to visualise the overall attractiveness of each option against the priority of the issue(s) addressed. Visualisation in this way provides additional information and management guidance that is not obvious when considering score matrices. This demonstrates the importance of considering issue priority as well as the ability of the options to address issues (i.e. another dimension to the decision making process).

The attached Table A6 shows the relationship between the issues and the options that address them. The Issues Score for each option is determined from the issues that the option addresses (weighted by the rank of the issues).

As part of the shortlisting process, a sensitivity analysis was also undertaken including potential climate change scenarios, conflicting priorities, data gaps and confidence in the scientific basis and/or expected outcomes of the options.

The attached Figure A1 compares the Option Benefit Score with the Issues Score for each individual option.

1.4 Strategy Evaluation

The options considered in this study have been identified for a range of purposes e.g. studies that are required to further refine or prioritise management actions, options that are complementary i.e. they achieve a similar outcome but are applicable to different geographical areas and/or issues, and options that are mutually exclusive in that only one of the options is appropriate. Because of this, the assessment of individual options shown in Figure A1 does not provide a full representation of the required management effort. To address this, the options have been assessed as bundles applicable to each issue category.

Figure A2 compares the Average Option Benefit Scores and the Total Issues Scores for each category of issues (Strategy). Based on the priorities displayed here, the management strategies will be developed as part of the Coastal Zone Management Plan.

Table A1: Ranking of Issues

Category	No.	Issue	Effect on Estuary Function	Community Perception	Cause of Other Issues	Geographic Extent	Issue Frequency	Economic Implications	Issue Score	Issue Rank
			[0-5]	[0-5]	[0-5]	[0-5]	[0-5]	[0-5]	[0-30]	
Administration and Governance	I1	Lack of protection to estuaries through existing planning instruments.	Pre- requisite						25	
Administration and Governance	I2	Lack of good governance model for integrated decision making and coordination	Pre- requisite						25	
Monitoring and Evaluation	I3	Current environmental monitoring (e.g. water quality) does not allow for assessment of overall ecosystem health, relative impacts of sources or changes associated with management efforts	Pre- requisite						25	
Administration and Governance	I4	Lack of clear delineation of administrative and legislative obligations between the parties responsible for estuary management	Pre- requisite						25	
Riparian Zone Management and Erosion	I5	Absence or poor condition of riparian vegetation increases bank instability and erosion.	3	4	3	5	5	2	22	2
Riparian Zone Management and Erosion	I6	Unrestricted stock access causes vegetation damage and bank erosion.	3	2	2	2	3	1	13	10
Riparian Zone Management and Erosion	I7	Lack of incentive for landholders to address bank erosion	3	2	3	3	3	1	15	8
Waterway Usage	I8	Illegal waterfront access to estuary causes damage to vegetation and bank destabilisation and limit community access	1	1	2	1	1	2	8	20
Waterway Usage	I9	Boat wash from power boats has led to riverbank destabilisation and substantial bank erosion, resulting in increased sediment loads to the estuary	1	2	1	2	2	1	9	17
Floodplain Infrastructure Management	I10	Acid water generation and runoff impacts estuarine ecology and contributes to fish kill events and chronic acid impacts (e.g. Red Spot Disease in fish)	5	5	3	3	3	1	20	4
Floodplain Infrastructure Management	I11	Blackwater events following flooding have been identified as the major cause of recent fish kills in the mid-lower estuary	5	5	3	4	2	1	20	4
Farm Management	I12	Agricultural activities including land clearing, use of fertilisers and pesticides, unrestricted stock access to banks, cultivation of steep slopes and high degree of soil disturbance have led to increased sediment, nutrient and contaminant loads to the estuary	5	5	4	4	5	2	25	1
Urban Runoff	I13	Stormwater runoff from some urban areas increases contaminants, litter, nutrients and sediment loads to the estuary	2	2	1	1	1	0	7	21
Wastewater	I14	STP discharges are increasing the load of nutrients and other contaminants to the estuary but the magnitude of impacts is unknown	2	4	1	1	2	0	10	15
Wastewater	I15	Many on-site sewage management systems in the catchment are not registered and condition and impact of on-site sewage management systems on water quality in the catchment is unknown.	1	2	1	1	1	1	7	21
Monitoring and Evaluation	I16	Poor water quality episodes (particularly nutrients and faecal coliforms) occur in the lower estuary but sources of pollutants are currently unclear	3	4	1	2	1	1	12	11
Riparian Zone Management and Erosion	I17	Lack or poor condition of riparian vegetation reduces the "filtering" of overland runoff and pollutants before reaching the estuary	3	3	3	5	5	1	20	4
Floodplain Infrastructure Management	I18	Floodgates can affect tidal flushing, reduce aquatic habitat, interrupt fish passage, alter water chemistry and degrade floodplain soils	4	4	4	4	4	1	21	3
Floodplain Infrastructure Management	I19	Floodplain drainage provides a conduit for pollutants, blackwater or acid runoff to the estuary especially in the post-peak flood period, and have been identified as a factor in severity of fish kills.	5	3	4	5	2	0	19	7
Administration and Governance	I20	Future land use changes pose further threats to estuary health (e.g. further land development, Pacific Highway upgrades)	2	3	2	3	0	0	10	15
Riparian Zone Management and Erosion	I21	Lack or poor condition of riparian vegetation compromises habitat connectivity and value	1	2	1	3	2	0	9	17
Vegetation Management	I22	Low ecological value of floodplain habitats results from widespread clearing, fragmentation and weed encroachment	1	2	3	3	2	1	12	11
Waterway Usage	I23	Damage to seagrass beds and other sensitive estuarine vegetation caused by boat damage, recreational users and unlicensed access points to estuary	2	2	1	2	2	0	9	17
Fishery Management	I24	Poor understanding of recreational and commercial fishing impacts and perceived decline of fish stocks	0	3	1	2	1	0	7	21
Fishery Management	I25	QX disease is present in the estuary and has been attributed to large-scale oyster mortality in commercial operations. There is a general lack of knowledge of the triggers of QX and how it may be controlled	1	2	0	1	2	1	7	21
Fishery Management	I26	Poor water quality (particularly faecal coliforms) in oyster culture areas results in extended oyster harvest closure periods and loss of productivity	1	2	1	1	2	0	7	21
Waterway Usage	I27	Community concern about potential conflicts between different estuary uses such as swimming, boating and water skiing	0	2	0	1	0	1	4	29
Waterway Usage	I28	Current boating infrastructure in the lower estuary is inadequate to provide the expected level of service for local and visiting boats	0	3	1	1	1	0	6	26
Waterway Usage	I29	Illegal waterfront structures allow access to estuary posing risks to public safety	0	1	1	1	1	0	4	29
Waterway Usage	I30	Siltation is affecting navigation and/or safety in the lower river	0	5	0	0	0	1	6	26
Waterway Usage	I31	Lack of provision of appropriate public access to foreshore	0	5	2	3	3	1	14	9
Cultural Heritage	I32	Protection of Aboriginal cultural heritage sites around the estuary from disturbance or destruction by river works and development	0	3	0	1	1	1	6	26
Climate Change Adaptation	I33	Predicted sea level rise may result in impacts associated with shoreline recession, implications for draining and flooding, damage to infrastructure, habitat modification including inundation of low lying ecosystems, landward migration of ecological communities and bank erosion	2	2	4	3	0	1	12	11
Climate Change Adaptation	I34	Possible increase in frequency and intensity of storm events due to climate change and altered flooding patterns, exacerbating erosion, bank stability, habitat modification and water quality issues	2	2	4	3	0	1	12	11

Table A2: Economic Implications of Issues

Category	No.	Issue	Economic implications for sector			Total	Average
			Tourism	Fishing	Agriculture	Score	Score
			[0-5]	[0-5]	[0-5]	[0-15]	(0-5)
Administration and Governance	I1	Lack of protection to estuaries through existing planning instruments.	0	0	0	0	**0**
Administration and Governance	I2	Lack of good governance model for integrated decision making and coordination	0	0	0	0	**0**
Monitoring and Evaluation	I3	Current environmental monitoring (e.g. water quality) does not allow for assessment of overall ecosystem health, relative impacts of sources or changes associated with management efforts	0	0	0	0	**0**
Administration and Governance	I4	Lack of clear delineation of administrative and legislative obligations between the parties responsible for estuary management	0	0	0	0	**0**
Riparian Zone Management and Erosion	I5	Absence or poor condition of riparian vegetation increases bank instability and erosion.	2	3	1	6	**2**
Riparian Zone Management and Erosion	I6	Unrestricted stock access causes vegetation damage and bank erosion.	1	2	1	4	**1**
Riparian Zone Management and Erosion	I7	Lack of incentive for landholders to address bank erosion	1	2	1	4	**1**
Waterway Usage	I8	Illegal waterfront access to estuary causes damage to vegetation and bank destabilisation and limit community access	2	3	0	5	**2**
Waterway Usage	I9	Boat wash from power boats has led to riverbank destabilisation and substantial bank erosion, resulting in increased sediment loads to the estuary	1	1	0	2	**1**
Floodplain Infrastructure Management	I10	Acid water generation and runoff impacts estuarine ecology and contributes to fish kill events and chronic acid impacts (e.g. Red Spot Disease in fish)	1	2	0	3	**1**
Floodplain Infrastructure Management	I11	Blackwater events following flooding have been identified as the major cause of recent fish kills in the mid-lower estuary	1	2	0	3	**1**
Farm Management	I12	Agricultural activities including land clearing, use of fertilisers and pesticides, unrestricted stock access to banks, cultivation of steep slopes and high degree of soil disturbance have led to increased sediment, nutrient and contaminant loads to the estuary	3	3	0	6	**2**
Urban Runoff	I13	Stormwater runoff from some urban areas increases contaminants, litter, nutrients and sediment loads to the estuary	1	0		1	**0**
Wastewater	I14	STP discharges are increasing the load of nutrients and other contaminants to the estuary but the magnitude of impacts is unknown	1	0	0	1	**0**
Wastewater	I15	Many on-site sewage management systems in the catchment are not registered and condition and impact of on-site sewage management systems on water quality in the catchment is unknown.	1	1	0	2	**1**
Monitoring and Evaluation	I16	Poor water quality episodes (particularly nutrients and faecal coliforms) occur in the lower estuary but sources of pollutants are currently unclear	1	1	0	2	**1**
Riparian Zone Management and Erosion	I17	Lack or poor condition of riparian vegetation reduces the "filtering" of overland runoff and pollutants before reaching the estuary	1	1	0	2	**1**
Floodplain Infrastructure Management	I18	Floodgates can affect tidal flushing, reduce aquatic habitat, interrupt fish passage, alter water chemistry and degrade floodplain soils	1	1	2	4	**1**
Floodplain Infrastructure Management	I19	Floodplain drainage provides a conduit for pollutants, blackwater or acid runoff to the estuary especially in the post-peak flood period, and have been identified as a factor in severity of fish kills.	1	0	0	1	**0**
Administration and Governance	I20	Future land use changes pose further threats to estuary health (e.g. further land development, Pacific Highway upgrades)	0	0	0	0	**0**
Riparian Zone Management and Erosion	I21	Lack or poor condition of riparian vegetation compromises habitat connectivity and value	0	0	0	0	**0**
Vegetation Management	I22	Low ecological value of floodplain habitats results from widespread clearing, fragmentation and weed encroachment	2	2	0	4	**1**
Waterway Usage	I23	Damage to seagrass beds and other sensitive estuarine vegetation caused by boat damage, recreational users and unlicensed access points to estuary	0	0	0	0	**0**
Fishery Management	I24	Poor understanding of recreational and commercial fishing impacts and perceived decline of fish stocks	0	0	0	0	**0**
Fishery Management	I25	QX disease is present in the estuary and has been attributed to large-scale oyster mortality in commercial operations. There is a general lack of knowledge of the triggers of QX and how it may be controlled	1	1	0	2	**1**
Fishery Management	I26	Poor water quality (particularly faecal coliforms) in oyster culture areas results in extended oyster harvest closure periods and loss of productivity	0	1	0	1	**0**
Waterway Usage	I27	Community concern about potential conflicts between different estuary uses such as swimming, boating and water skiing	1	1	0	2	**1**
Waterway Usage	I28	Current boating infrastructure in the lower estuary is inadequate to provide the expected level of service for local and visiting boats	0	0	0	0	**0**
Waterway Usage	I29	Illegal waterfront structures allow access to estuary posing risks to public safety	0	0	0	0	**0**
Waterway Usage	I30	Siltation is affecting navigation and/or safety in the lower river	2	1	0	3	**1**
Waterway Usage	I31	Lack of provision of appropriate public access to foreshore	2	2	0	4	**1**
Cultural Heritage	I32	Protection of Aboriginal cultural heritage sites around the estuary from disturbance or destruction by river works and development	1	1	0	2	**1**
Climate Change Adaptation	I33	Predicted sea level rise may result in impacts associated with shoreline recession, implications for draining and flooding, damage to infrastructure, habitat modification including inundation of low lying ecosystems, landward migration of ecological	1	1	1	3	**1**
Climate Change Adaptation	I34	Possible increase in frequency and intensity of storm events due to climate change and altered flooding patterns, exacerbating erosion, bank stability, habitat modification and water quality issues	1	1	1	3	**1**

Table A3: Management Objective Score

Rank	Option	Description	O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12	O13	O14	O15	Management Objective Score
			To encourage economically viable and environmentally sustainable land use practices in the catchment	To ensure strategic planning instruments and programs are consistent with and where applicable, directly address the aims of the CZMP	To ensure efficient and effective management of the estuary through appropriate governance, funding and monitoring	To increase knowledge of the impact of existing practices on estuary values and facilitate continuous improvement	To reduce pollutant loads to the estuary	To protect and enhance the riparian zone	To minimise the frequency and severity of environmental events such as fish kills	To optimise flood mitigation works and flow control structures to improve estuarine water quality	To minimise constraints to estuary adaptation to climate change	To protect and enhance the biodiversity values of the estuary	To provide for increased use of the estuary whilst minimising environmental impact and conflict between users	To protect the cultural heritage values of the estuary	To protect and enhance visual amenity/ aesthetic appeal of the estuary	To enhance sustainable commercial return from industries relying on the estuary and the floodplain	To minimise risk to the health and safety of users of the estuary	
2	1	Review estuary governance and administration	1.0	1.0	1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	**9**
24	2	EcoHealth monitoring program			1.0	1.0			0.5	0.5							0.5	**3.5**
20	3	Develop catchment/water quality modelling tool to support decision making	0.5				0.5		0.5	0.5	0.5				0.5	0.5	0.5	**4**
17	4	Identify and prioritise drainage for infilling of redundant drains and reshaping of other drainage					1.0		1.0	1.0	0.5	0.5	0.5			0.5		**5**
17	5	Identify and prioritise levees for redesign and/or remodelling					1.0	0.5	1.0	1.0	0.5	0.5	0.5					**5**
14	6	Review floodgate management protocols		1.0			1.0		1.0	1.0	0.5	0.5				0.5		**5.5**
31	7	Cost Benefit Analysis of backswamp farming activities	0.5				0.5		0.5	0.5		0.5				0.5		**3**
31	8	Scientific trials to investigate strategies for retention of water on backswamp areas	0.5				0.5		0.5	1.0						0.5		**3**
7	9	Changes in pasture and harvest management including changes to inundation tolerant pasture species	1.0				1.0	1.0	1.0		0.5	0.5	0.5		0.5	0.5		**6.5**
1	10	Retirement/buy back backswamp areas and return to wetlands	1.0	0.5	0.5		1.0	1.0	1.0	0.5	0.5	1.0	1.0	1.0	0.5	0.5		**10**
4	11	Work with backswamp property owners to identify alternative management strategies	1.0	0.5	0.5		1.0	1.0	1.0	0.5	0.5	1.0	1.0	1.0	0.5	-1.0		**8.5**
14	12	Farm management planning for priority properties	1.0	0.5	0.5		0.5	0.5	0.5		0.5	0.5			0.5	0.5		**5.5**
7	13	Liaise with agriculture industry bodies to improve education and ensure estuary friendly practices are incorporated into industry guidelines	1.0		0.5	0.5	0.5	1.0	0.5		0.5	0.5			0.5	1.0		**6.5**
11	14	Identify high impact farming activities and investigate alternatives	1.0				1.0	1.0		0.5	0.5	1.0	0.5	0.5				**6**
20	15	Review boat passage areas impacted by erosion					0.5	1.0				0.5	1.0	0.5	0.5			**4**
20	16	Stormwater education		0.5	0.5		0.5	0.5	0.5	0.5	0.5	0.5						**4**
36	17	WSUD for new developments	0.5	0.5			0.5					0.5			0.5			**2.5**
24	18	Retrofit GPTs and other stormwater improvement devices					1.0	0.5				0.5	0.5	0.5			0.5	**3.5**
7	19	Upgrade / augment STPs and other sewerage infrastructure where required					1.0		1.0			1.0	0.5	0.5	1.0	0.5	1.0	**6.5**
31	20	Wastewater Reuse	0.5				0.5					0.5	0.5		0.5		0.5	**3**
39	21	Review water sharing plans regarding groundwater extraction and ASS effects		0.5					0.5			0.5				0.5		**2**
6	22	Riparian buffer zone establishment (planning)	0.5	1.0			1.0	1.0	0.5		0.5	1.0		0.5	0.5	0.5		**7**
2	23	Identify priority riparian areas and rehabilitate	1.0				1.0	1.0	0.5	0.5	1.0	1.0	0.5	1.0	1.0	0.5		**9**
24	24	Aquatic weed management						0.5	0.5			1.0	0.5	0.5	0.5			**3.5**
5	25	Retain, rehabilitate and conserve existing native floodplain vegetation and wetlands	0.5				1.0	1.0	0.5	0.5	1.0	1.0		0.5	1.0	0.5		**7.5**
20	26	Zoning to prevent access to sensitive estuarine vegetation areas		1.0				0.5			0.5	1.0		0.5		0.5		**4**
31	27	Estuarine vegetation signage / education to protect sensitive areas	0.5	0.5				0.5				0.5		0.5	0.5			**3**
24	28	Implement Recreational Boating Study actions					0.5	0.5					1.0		0.5	0.5	0.5	**3.5**
24	29	Ensure key research findings in the fishing and aquaculture sector are communicated to the public			0.5	1.0						0.5	0.5			1.0		**3.5**
39	30	Identify and manage contamination sources in the estuary to minimise oyster harvest closures				1.0										1.0		**2**
14	31	Further research into sources of water quality issues in North Creek	0.5		0.5	1.0	0.5		0.5	0.5		0.5			0.5	0.5	0.5	**5.5**
31	32	Investigate usage conflicts and need for management		0.5									1.0		0.5	0.5	0.5	**3**
11	33	Develop strategic plan for estuary usage		1.0	1.0	0.5		0.5					1.0		1.0	0.5	0.5	**6**
19	34	Review of waterfront structures and licencing		0.5				1.0					1.0		0.5	0.5	1.0	**4.5**
36	35	Identification and recording of cultural sites available to council planners	0.5	0.5	0.5									1.0				**2.5**
36	36	Cultural site management plans	0.5	0.5	0.5									1.0				**2.5**
7	37	Estuary-wide community education and consultation program	1.0	0.5	0.5	0.5	0.5	0.5	0.5				0.5	0.5	0.5	0.5	0.5	**6.5**
39	38	Cost benefit analysis of dredging operations in lower estuary											1.0			0.5	0.5	**2**
11	39	Assessment and mapping of tidal inundation extent including potential sea level rise	1.0	1.0	0.5	1.0		1.0			1.0					0.5		**6**
24	40	Ongoing on-site sewerage management inspections and improvements	0.5	0.5			1.0					0.5		0.5			0.5	**3.5**
24	41	Planning for sea level rise and climate change impacts incorporating Government policy and guidelines, current research and best-practice management	0.5	0.5	0.5	1.0					1.0							**3.5**
Priority of Objective (out of 5)			*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	

Achievement of Objectives: Directly achieves objective (1), Indirectly or partly achieves objective (0.5), Indirectly or partly conflicts (-0.5), Conflicts with the objective (-1.0), does not achieve objective (0)

Table A4: Benefit and Cost Scores

Benefit Rank	Cost Rank	Option	Short Label	Description	Likelihood of Achieving Positive Outcomes			Expected Support		Benefit Score	Cost Score
					Economic	Social	Ecological	Community	Agencies		
1	11	1	1 Review governance	Review estuary governance and administration	2	2	2	2	2	**10**	**2**
16	2	2	2 EcoHealth	EcoHealth monitoring program	0	1	2	2	2	**7**	**4**
16	11	3	3 DSS	Develop catchment/water quality modelling tool to support decision making	1	1	2	1	2	**7**	**2**
16	2	4	4 Drains	Identify and prioritise drainage for infilling of redundant drains and reshaping of other drainage	0	1	2	2	2	**7**	**4**
27	5	5	5 Levees	Identify and prioritise levees for redesign and/or remodelling	0	1	2	1	2	**6**	**3**
6	11	6	6 Floodgates	Review floodgate management protocols	0	2	2	2	2	**8**	**2**
4	11	7	7 CBA Bswamp	Cost Benefit Analysis of backswamp farming activities	2	1	2	2	2	**9**	**2**
16	11	8	8 Trial Bswamp	Scientific trials to investigate strategies for retention of water on backswamp areas	1	1	2	1	2	**7**	**2**
16	5	9	9 Pasture	Changes in pasture and harvest management including changes to inundation tolerant pasture species	0	0	3	2	2	**7**	**3**
16	1	10	10 Buy Bswamp	Retirement/buy back backswamp areas and return to wetlands	1	0	3	1	2	**7**	**5**
6	5	11	11 Conv Bswamp	Work with backswamp property owners to identify alternative management strategies	1	0	3	2	2	**8**	**3**
1	5	12	12 FMP	Farm management planning for priority properties	2	2	2	2	2	**10**	**3**
1	11	13	13 Farm BPM	Liaise with agriculture industry bodies to improve education and ensure estuary friendly practices are incorporated into industry guidelines	2	2	2	2	2	**10**	**2**
34	11	14	14 ID Farm impacts	Identify high impact farming activities and investigate alternatives	0	1	3	0	1	**5**	**2**
16	11	15	15 Boat erosion	Review boat passage areas impacted by erosion	0	1	2	2	2	**7**	**2**
6	29	16	16 SW education	Stormwater education	0	2	2	2	2	**8**	**1**
16	29	17	17 WSUD	WSUD for new developments	0	1	2	2	2	**7**	**1**
6	29	18	18 GPT	Retrofit GPTs and other stormwater improvement devices	0	2	2	2	2	**8**	**1**
6	29	19	19 STP upgrade	Upgrade / augment STPs and other sewerage infrastructure where required	0	2	1	3	2	**8**	**1**
39	29	20	20 WW Reuse	Wastewater Reuse	0	0	1	1	1	**3**	**1**
41	29	21	21 WSP	Review water sharing plans regarding groundwater extraction and ASS effects	0	0	1	0	0	**1**	**1**
27	11	22	22 Riparian plan	Riparian buffer zone establishment (planning)	0	0	2	2	2	**6**	**2**
27	2	23	23 Riparian rehab	Identify priority riparian areas and rehabilitate	0	0	2	2	2	**6**	**4**
27	5	24	24 Aquatic weeds	Aquatic weed management	0	0	2	2	2	**6**	**3**
16	5	25	25 Floodplain cons	Retain, rehabilitate and conserve existing native floodplain vegetation and wetlands	0	1	2	2	2	**7**	**3**
36	29	26	26 Veg protection	Zoning to prevent access to sensitive estuarine vegetation areas	0	0	2	1	1	**4**	**1**
36	29	27	27 Veg sign	Estuarine vegetation signage / education to protect sensitive areas	0	1	1	1	1	**4**	**1**
6	29	28	28 Rec Boat Study	Implement Recreational Boating Study actions	2	1	1	2	2	**8**	**1**
39	29	29	29 Fish educ	Ensure key research findings in the fishing and aquaculture sector are communicated to the public	0	1	0	1	1	**3**	**1**
27	11	30	30 Oyster	Identify and manage contamination sources in the estuary to minimise oyster harvest closures	2	1	0	1	2	**6**	**2**
4	11	31	31 WQ studies	Further research into sources of water quality issues in North Creek	1	2	2	2	2	**9**	**2**
6	29	32	32 Usage conf	Investigate usage conflicts and need for management	1	2	1	2	2	**8**	**1**
6	11	33	33 Boat facility	Develop strategic plan for estuary usage	1	2	1	2	2	**8**	**2**
36	11	34	34 Wfront	Review of waterfront structures and licencing	0	1	1	1	1	**4**	**2**
34	29	35	35 Cultural reg	Identification and recording of cultural sites available to council planners	0	2	1	1	1	**5**	**1**
6	11	36	36 Cultural SMP	Cultural site management plans	0	3	1	2	2	**8**	**2**
6	11	37	37 Educ&Cons	Estuary-wide community education and consultation program	1	2	1	2	2	**8**	**2**
27	11	38	38 CBA dredge	Cost benefit analysis of dredging operations in lower estuary	0	1	1	2	2	**6**	**2**
16	11	39	39 Tidal Inundation	Assessment and mapping of tidal inundation extent including potential sea level rise	0	2	1	2	2	**7**	**2**
16	29	40	40 OSSM	Ongoing on-site sewerage management inspections and improvements	0	2	1	2	2	**7**	**1**
27	11	41	41 SLR Plan	Planning for sea level rise and climate change impacts incorporating Government policy and guidelines, current research and best-practice management	1	1	1	1	2	**6**	**2**
Weighting					*1*	*1*	*1*	*1*	*1*		

BENEFIT SCORING:

0 = not likely to achieve the outcome / not likely to be supported

↓

3 = is highly likely to achieve the outcome / is highly likely to be supported

COST SCORING:

1 = $0 to $10,000
2 = $10,000 to $100,000
3 = $100,000 to $1,000,000
4 = $1,000,000 to $10,000,000
5 = > $10,000,000

Table A5: Overall Options Score

Rank	Option	Description	Initial Score			
			Management Objective Score	Benefit Score	Cost Score	Option Benefit Score
2	1	Review estuary governance and administration	9.0	10	2	**45.00**
38	2	EcoHealth monitoring program	3.5	7	4	**6.13**
22	3	Develop catchment/water quality modelling tool to support decision making	4.0	7	2	**14.00**
36	4	Identify and prioritise drainage for infilling of redundant drains and reshaping of other drainage	5.0	7	4	**8.75**
32	5	Identify and prioritise levees for redesign and/or remodelling	5.0	6	3	**10.00**
13	6	Review floodgate management protocols	5.5	8	2	**22.00**
25	7	Cost Benefit Analysis of backswamp farming activities	3.0	9	2	**13.50**
29	8	Scientific trials to investigate strategies for retention of water on backswamp areas	3.0	7	2	**10.50**
20	9	Changes in pasture and harvest management including changes to inundation tolerant pasture species	6.5	7	3	**15.17**
22	10	Retirement/buy back backswamp areas and return to wetlands	10.0	7	5	**14.00**
12	11	Work with backswamp property owners to identify alternative management strategies	8.5	8	3	**22.67**
16	12	Farm management planning for priority properties	5.5	10	3	**18.33**
3	13	Liaise with agriculture industry bodies to improve education and ensure estuary friendly practices are incorporated into industry guidelines	6.5	10	2	**32.50**
21	14	Identify high impact farming activities and investigate alternatives	6.0	5	2	**15.00**
22	15	Review boat passage areas impacted by erosion	4.0	7	2	**14.00**
4	16	Stormwater education	4.0	8	1	**32.00**
17	17	WSUD for new developments	2.5	7	1	**17.50**
5	18	Retrofit GPTs and other stormwater improvement devices	3.5	8	1	**28.00**
1	19	Upgrade / augment STPs and other sewerage infrastructure where required	6.5	8	1	**52.00**
34	20	Wastewater Reuse	3.0	3	1	**9.00**
41	21	Review water sharing plans regarding groundwater extraction and ASS effects	2.0	1	1	**2.00**
14	22	Riparian buffer zone establishment (planning)	7.0	6	2	**21.00**
25	23	Identify priority riparian areas and rehabilitate	9.0	6	4	**13.50**
37	24	Aquatic weed management	3.5	6	3	**7.00**
17	25	Retain, rehabilitate and conserve existing native floodplain vegetation and wetlands	7.5	7	3	**17.50**
19	26	Zoning to prevent access to sensitive estuarine vegetation areas	4.0	4	1	**16.00**
28	27	Estuarine vegetation signage / education to protect sensitive areas	3.0	4	1	**12.00**
5	28	Implement Recreational Boating Study actions	3.5	8	1	**28.00**
29	29	Ensure key research findings in the fishing and aquaculture sector are communicated to the public	3.5	3	1	**10.50**
39	30	Identify and manage contamination sources in the estuary to minimise oyster harvest closures	2.0	6	2	**6.00**
8	31	Further research into sources of water quality issues in North Creek	5.5	9	2	**24.75**
10	32	Investigate usage conflicts and need for management	3.0	8	1	**24.00**
10	33	Develop strategic plan for estuary usage	6.0	8	2	**24.00**
34	34	Review of waterfront structures and licencing	4.5	4	2	**9.00**
27	35	Identification and recording of cultural sites available to council planners	2.5	5	1	**12.50**
32	36	Cultural site management plans	2.5	8	2	**10.00**
7	37	Estuary-wide community education and consultation program	6.5	8	2	**26.00**
39	38	Cost benefit analysis of dredging operations in lower estuary	2.0	6	2	**6.00**
14	39	Assessment and mapping of tidal inundation extent including potential sea level rise	6.0	7	2	**21.00**
9	40	Ongoing on-site sewerage management inspections and improvements	3.5	7	1	**24.50**
29	41	Planning for sea level rise and climate change impacts incorporating Government policy and guidelines, current research and best-practice management	3.5	6	2	**10.50**

Table A6: Issues Score

		Issues	Issue Score	1 Review estuary governance and administration	2 EcoHealth monitoring program	3 Develop catchment/water quality modelling tool to support decision making	4 Identify, prioritise and infill/reshape redundant drains	5 Identify, prioritise and redesign/remodel levees	6 Review floodgate management protocols	7 Cost Benefit Analysis of backswamp farming activities	8 Scientific trials to investigate strategies for retention of water on backswamp areas	9 Changes in pasture and harvest management including changes to inundation tolerant species	10 Retirement/buy back backswamp areas and return to wetlands	11 Work with backswamp property owners to identify alternative management strategies	12 Farm management planning for priority properties	13 Liaise with agriculture industry bodies to improve education and ensure estuary friendly practices are incorporated into industry guidelines	14 Identify high impact farming activities and investigate alternatives	15 Review boat passage areas impacted by erosion	16 Stormwater education	17 WSUD for new developments	18 GPTs and other stormwater improvement devices	19 Upgrade / augment STPs where required	20 Wastewater Reuse	21 Review water sharing plans regarding groundwater extraction and ASS effects	22 Riparian buffer zone establishment (planning)	23 Identify priority riparian areas and rehabilitate	24 Aquatic weed management	25 Retain, rehabilitate and conserve existing native floodplain vegetation	26 Zoning to prevent access to sensitive estuarine veg areas	27 Estuarine vegetation signage / education to protect sensitive areas	28 Implement Recreational Boating Study actions	29 Ensure key research findings in the fishing and aquaculture sector are communicated to the public	30 Identify and manage contamination sources in the estuary to minimise oyster harvest closures	31 Further research into sources of water quality issues in North Creek	32 Investigate usage conflicts and need for management	33 Develop strategic plan for estuary usage	34 Review of waterfront structures and licencing	35 Identify and registration of cultural sites available to council planners	36 Cultural Site management plans	37 Estuary-wide community education and consultation program	38 Cost benefit analysis of dredging operations in lower estuary	39 Assessment and mapping of tidal inundation extent including potential sea level rise	40 Ongoing on-site sewerage management inspections and improvements	41 Planning for sea level rise and climate change impacts incorporating current research and best-practice management
		Options		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**
1. Estuary Management and Governance	I1	Lack of protection to estuaries through existing planning instruments.	Pre-requiste	1												1								1				1	1								1	1	1			1		1		1
	I2	Lack of good governance model for integrated decision making and coordination	Pre-requiste	1	1	1																														1								
	I3	Current environmental monitoring (e.g. water quality) does not allow for assessment of overall ecosystem health, relative impacts of sources or changes associated with management efforts	Pre-requiste	1	1	1																																						
	I4	Lack of clear delineation of administrative and legislative obligations between the parties responsible for estuary management	Pre-requiste	1		1																												1									1
2. Bank Erosion and Sedimentation	I5	Absence or poor condition of riparian vegetation increases bank instability and erosion.	22												1	1	1	1							1	1													1					
	I6	Unrestricted stock access causes vegetation damage and bank erosion.	13												1	1	1								1	1													1					
	I7	Lack of incentive for landholders to address bank erosion	15	1											1	1	1								1	1													1					
	I8	Illegal waterfront access to estuary causes damage to vegetation and bank destabilisation and limit community access	8																						1	1				1						1	1			1				
	I9	Boat wash from power boats has led to riverbank destabilisation and substantial bank erosion, resulting in increased sediment loads to the estuary	9															1							1	1				1						1				1				
3. Water Quality and Fish Kills	I10	Acid water generation and runoff impacts estuarine ecology and contributes to fish kill events and chronic acid impacts (e.g. Red Spot Disease in fish)	20		1	1	1		1	1	1	1	1	1	1	1	1							1			1	1																
	I11	Blackwater events following flooding have been identified as the major cause of recent fish kills in the mid-lower estuary	20		1	1	1	1	1	1	1	1	1	1	1	1	1										1	1																
	I12	Agricultural activities including land clearing, use of fertilisers and pesticides, unrestricted stock access to banks, cultivation of steep slopes and high degree of soil disturbance have led to increased sediment, nutrient and contaminant loads to the estuary	25		1	1									1	1	1								1	1		1						1					1					
	I13	Stormwater runoff from some urban areas increases contaminants, litter, nutrients and sediment loads to the estuary	7		1	1													1	1	1				1	1								1					1					
	I14	STP discharges are increasing the load of nutrients and other contaminants to the estuary but the magnitude of impacts is unknown	10		1	1																1	1										1					1					
	I15	Many on-site sewage management systems in the catchment are not registered and condition and impact of on-site sewage management systems on water quality in the catchment is unknown.	7		1	1																												1					1		1	1	
	I16	Poor water quality episodes (particularly nutrients and faecal coliforms) occur in the lower estuary but sources of pollutants are currently unclear	12		1	1													1	1	1	1	1				1							1					1		1	1	
	I17	Lack or poor condition of riparian vegetation reduces the "filtering" of overland runoff and pollutants before reaching the estuary	20		1	1									1	1	1								1	1													1					
	I18	Floodgates can affect tidal flushing, reduce aquatic habitat, interrupt fish passage, alter water chemistry and degrade floodplain soils	21		1	1			1						1													1											1					
	I19	Floodplain drainage provides a conduit for pollutants, blackwater or acid runoff to the estuary especially in the post-peak flood period, and have been identified as a factor in severity of fish kills.	19		1	1	1	1	1	1	1	1	1	1	1													1																
	I20	Future land use changes pose further threats to estuary health (e.g. further land development, Pacific Highway upgrades)	10		1	1																					1	1										1					
4. Impacts on Native Flora and Fauna	I21	Lack or poor condition of riparian vegetation compromises habitat connectivity and value	9												1	1	1								1	1	1		1	1									1					
	I22	Low ecological value of floodplain habitats results from widespread clearing, fragmentation and weed encroachment	12							1	1	1	1	1	1	1	1										1	1	1										1					
	I23	Damage to seagrass beds and other sensitive estuarine vegetation caused by boat damage, recreational users and unlicensed access points to estuary	9		1																							1	1	1					1	1			1					
5. Fishing and Aquaculture	I24	Poor understanding of recreational and commercial fishing impacts and perceived decline of fish stocks	7		1																										1				1				1				
	I25	QX disease is present in the estuary and has been attributed to large-scale oyster mortality in commercial operations. There is a general lack of knowledge of the triggers of QX and how it may be controlled	7		1																										1	1										
	I26	Poor water quality (particularly faecal coliforms) in oyster culture areas results in extended oyster harvest closure periods and loss of productivity	7		1														1		1	1										1	1	1					1			1	
6. Estuary Users and Conflicts	I27	Community concern about potential conflicts between different estuary uses such as swimming, boating and water skiing	4																											1				1	1	1			1				
	I28	Current boating infrastructure in the lower estuary is inadequate to provide the expected level of service for local and visiting boats	6																											1				1	1	1			1				
	I29	Illegal waterfront structures allow access to estuary posing risks to public safety	4																											1				1	1	1			1				
	I30	Siltation is affecting navigation and/or safety in the lower river	6																											1					1	1			1	1			
	I31	Lack of provision of appropriate public access to foreshore	14																									1	1	1				1	1	1			1				
7. Social and Cultural	I32	Protection of Aboriginal cultural heritage sites around the estuary from disturbance or destruction by river works and development	6																																		1	1	1					
8. Climate Change	I33	Predicted sea level rise may result in impacts associated with shoreline recession, implications for draining and flooding, damage to infrastructure, habitat modification including inundation of low lying ecosystems, landward migration of ecological communities and bank erosion	12		1	1	1	1	1	1	1	1	1	1	1	1	1								1	1		1										1	1		1		1
	I34	Possible increase in frequency and intensity of storm events due to climate change and altered flooding patterns, exacerbating erosion, bank stability, habitat modification and water quality issues	12		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1				1	1		1											1		1		1
		Total Issues Scores		**115**	**275**	**270**	**83**	**63**	**104**	**95**	**95**	**95**	**95**	**95**	**220**	**205**	**180**	**43**	**38**	**31**	**38**	**29**	**22**	**45**	**152**	**152**	**73**	**176**	**79**	**41**	**51**	**21**	**14**	**93**	**28**	**92**	**70**	**31**	**43**	**287**	**6**	**68**	**26**	**74**

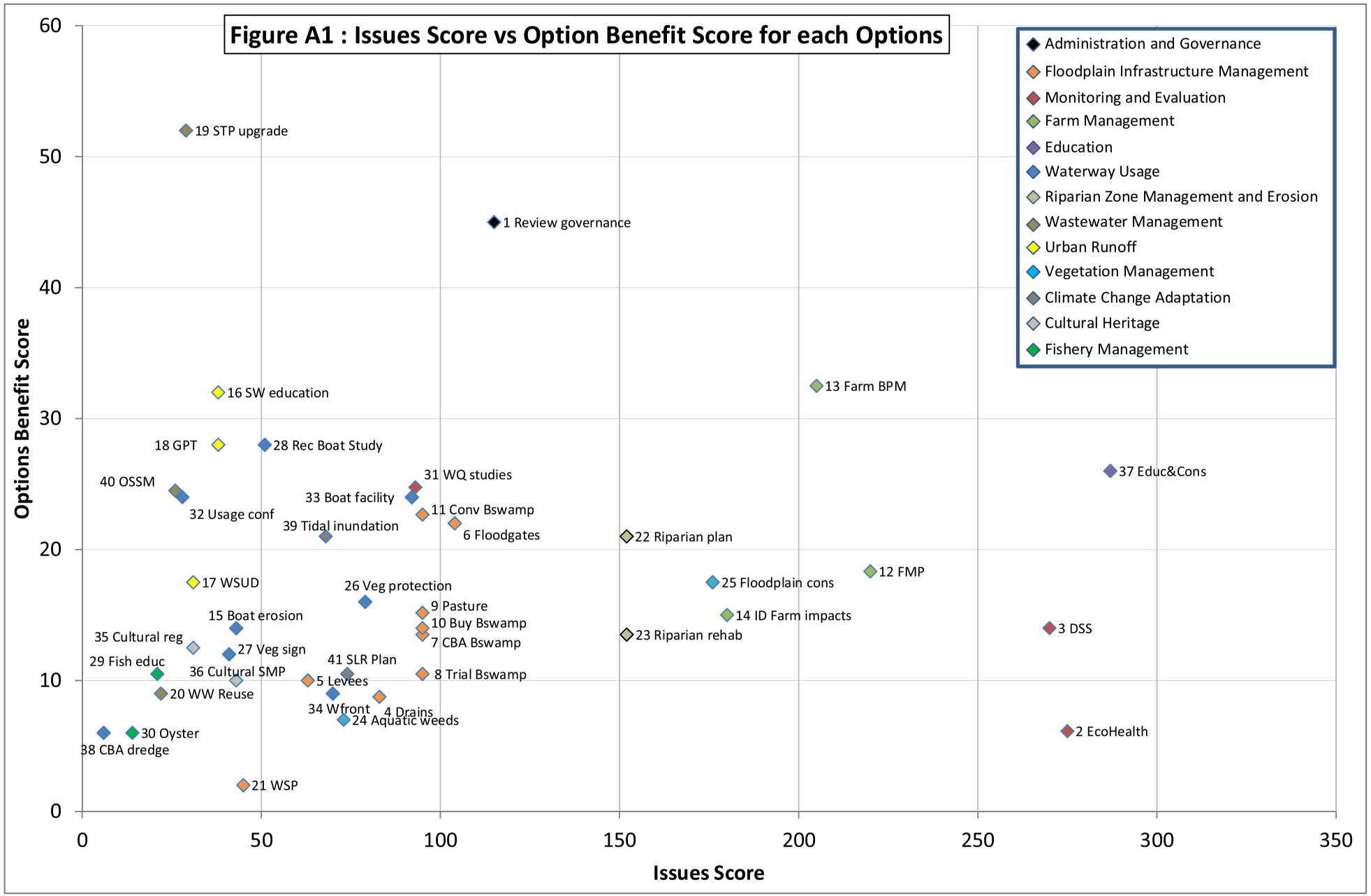
Figure A1 : Issues Score vs Option Benefit Score for each Options
Options Benefit Score
Issues Score
0
10
20
30
40
50
60
0
50
100
150
200
250
300
350
Administration and Governance
Floodplain Infrastructure Management
Monitoring and Evaluation
Farm Management
Education
Waterway Usage
Riparian Zone Management and Erosion
Wastewater Management
Urban Runoff
Vegetation Management
Climate Change Adaptation
Cultural Heritage
Fishery Management
19 STP upgrade
1 Review governance
16 SW education
13 Farm BPM
18 GPT
28 Rec Boat Study
37 Educ&Cons
31 WQ studies
40 OSSM
33 Boat facility
11 Conv Bswamp
32 Usage conf
39 Tidal inundation
6 Floodgates
22 Riparian plan
12 FMP
17 WSUD
26 Veg protection
25 Floodplain cons
9 Pasture
15 Boat erosion
14 ID Farm impacts
10 Buy Bswamp
3 DSS
35 Cultural reg
23 Riparian rehab
7 CBA Bswamp
27 Veg sign
41 SLR Plan
29 Fish educ
36 Cultural SMP
8 Trial Bswamp
5 Levees
20 WW Reuse
34 Wfront
4 Drains
24 Aquatic weeds
2 EcoHealth
30 Oyster
38 CBA dredge
21 WSP

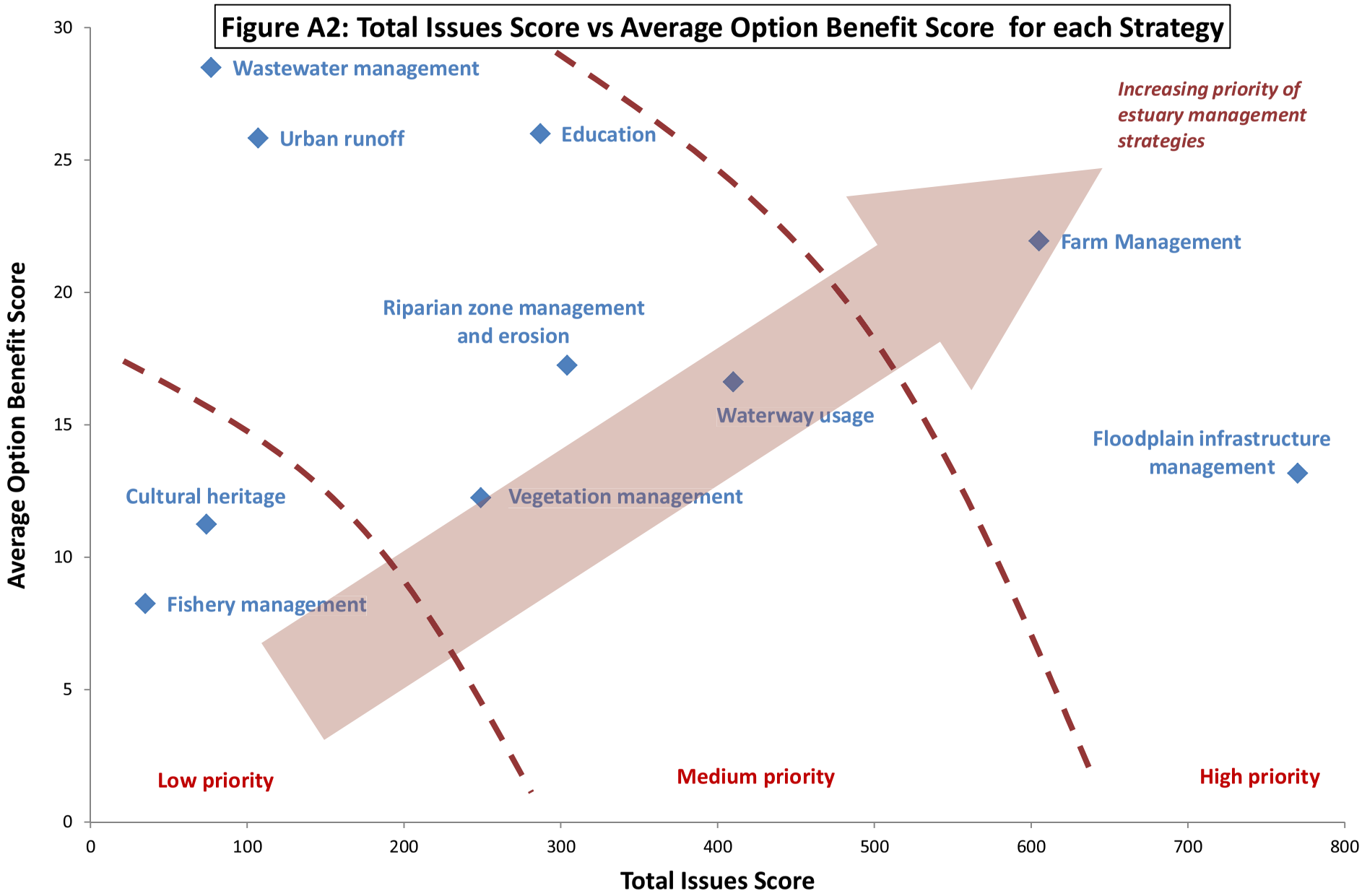
Figure A2: Total Issues Score vs Average Option Benefit Score for each Strategy
Average Option Benefit Score
Total Issues Score
0
5
10
15
20
25
30
0
100
200
300
400
500
600
700
800
Wastewater management
Urban runoff
Education
Riparian zone management and erosion
Waterway usage
Farm Management
Floodplain infrastructure management
Cultural heritage
Vegetation management
Fishery management
Increasing priority of estuary management strategies
Low priority
Medium priority
High priority