Coastal Zone Management Plan for the Richmond River Estuary

Volume 2: Estuary Management Study

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August 2011

Synopsis

This Estuary Management Study (Volume 2) provides background information on the estuarine processes and their interaction in the Richmond River Estuary and defines values, management objectives, issues to be addressed and potential management options. The Coastal Zone Management Plan (Volume 1) provides a ten year strategic plan for the implementation of management strategies.

Acknowledgement

Council has prepared this document with financial assistance from the NSW Government through the Office of Environment and Heritage. This document does not necessarily represent the opinions of the NSW Government or the Office of Environment and Heritage.

Cover photo: Sediment laden freshwater plume discharging from the Richmond River Estuary to the Pacific Ocean at Ballina after a moderate rainfall event (Photo: C. Cooksey)

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PROJECT 10-008 – RICHMOND RIVER ESTUARY MANAGEMENT STUDY AND COASTAL ZONE MANAGEMENT PLAN

REV	DESCRIPTION	AUTHOR	REVIEW	APPROVAL	DATE
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EXECUTIVE SUMMARY

Background

The Richmond River estuary is highly valued by the community and is a focal point for local commerce, tourism and recreation. The estuary, with its associated wetlands and waterways, supports a rich biodiversity and a range of important environmental functions and local industry. Despite these recognised values, the system is under pressure from past and existing development, catchment disturbance and hydrological modification, land use management and large-scale vegetation changes. Looking forward, the estuary faces increased pressure from future development within the catchment, increasing population use of the estuary and the impacts of global climate change.

The natural characteristics of the Richmond River catchment and floodplain, such as the presence of potential acid sulfate soils, a large floodplain to catchment ratio and variable flushing characteristics are all elements that interact with and exacerbate the impact of human pressures. Together these factors contribute to the degradation of the waterway and occurrence of undesirable events such as poor water quality episodes and fish kills, particularly following some flood events.

The Richmond River Coastal Zone Management Program

The NSW Government's Estuary Management Program was established 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/Coastal Zone Management Plan that reflects the needs of the local community and the environment and which identifies issues, possible solutions and actions to implement these solutions.

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). This Draft Estuary Management Study (EMS, Volume 2 of the CZMP) is a culmination of the Data Compilation Study (WBM, 2004) and the Estuary Processes Study (EPS, WBM, 2006; ABER, 2007; ABER, 2008). The Draft EMS brings together the information to identify the estuary management issues and formulate options for management.

A substantial component of the Draft EMS and Draft CZMP were prepared prior to finalisation of the 2010 Guidelines. However, following public exhibition of the Draft CZMP, the documents were amended to ensure consistency with the minimum requirements of the Guidelines.

Councils are required to submit draft CZMPs to the Minister for certification under the Coastal Protection Act, 1979 (refer Figure 1).

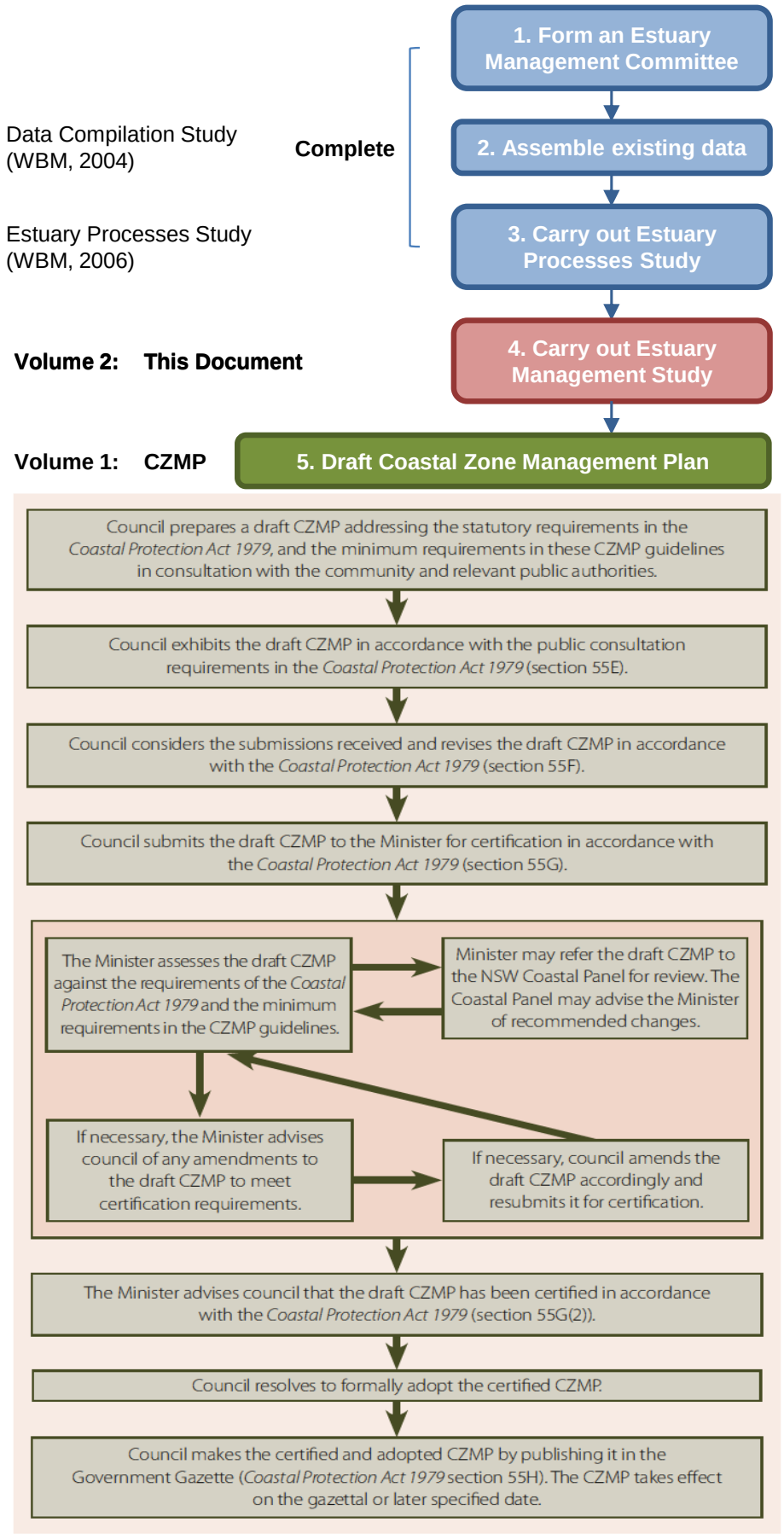


Figure 1 - CZMP preparation and certification process for the Richmond River Estuary

Source: Modified from DECCW, 2010c

Study Area

The Richmond River estuary is located on the far north coast of NSW. The estuary is situated within three local government areas (Ballina Shire, Lismore City and Richmond Valley council areas). It includes the tidal waters of the Richmond River to Casino, Wilsons River to Boatharbour, Bungawalbin and North Creek, and incorporates foreshore and adjacent lands. The study focuses on the immediate catchment of the estuary as this is considered to have the most impact on the health of the estuary and is an important component for future estuary management. The upper catchment is also considered where there is a clear influence on issues to be addressed by this CZMP.

Given the large size of the Richmond River floodplain (approximately 1,000km^2) and three local government jurisdictions, twelve Management Zones were developed dividing the floodplain into smaller units. In defining the zones, the objective was to provide a manageable breakdown of the floodplain area to facilitate implementation of the management actions. The zones align with sub-catchments or with a part of the floodplain that is segregated by geography or infrastructure boundaries such as roads. The zones also break the study area down to a more suitable scale on which to describe the major geographical features of the landscape and to introduce some of the key issues.

Aims of the Estuary Management Study

This Draft EMS brings together the latest scientific knowledge and goals of the community and government agencies to identify estuary values, issues, objectives and develop management options with the aim of improving the health of the estuary and providing for the various uses of the estuary.

Development of the Management Strategies

Management issues for the estuary have been identified from the available background data in the EPS (WBM, 2006; ABER, 2007; ABER 2008) and recent scientific research. The significance and values of the estuary have been derived from the scientific understanding of the estuary and the outcomes of the consultation with stakeholders. These identified values have been used to develop management objectives for the estuary. The management objectives are consistent with the goals and objectives of the NSW Coastal Protection Act, 1979, Coastal Policy, 1997 and Sea Level Rise Policy Statement, 2009.

For each major topic, the identified issues, related objectives and potential management options were identified and prioritised for implementation (refer Figure 2 below).

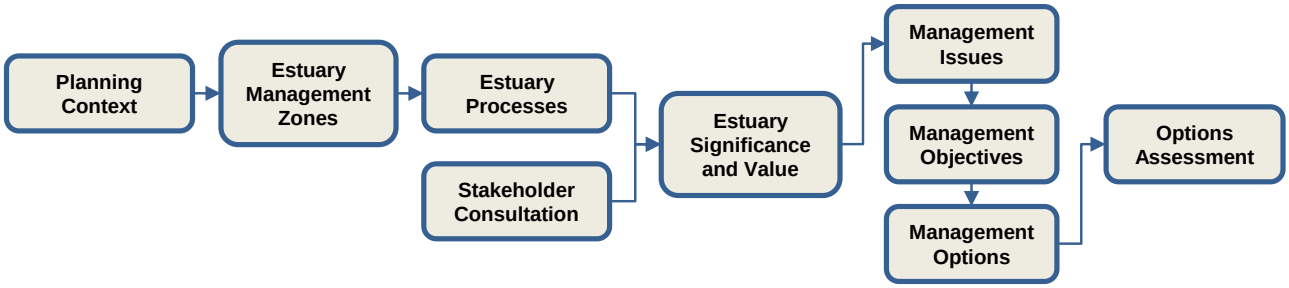


Figure 2 - Development of the Estuary Management Study (Volume 2 of the CZMP)

Management Issues Identified for the Richmond River Estuary

The key issues affecting the Richmond River estuary were identified in the EPS (WBM, 2006; ABER, 2007; ABER, 2008). The EPS documents the scientific understanding of the estuary's physical, chemical and biological processes, their interrelationships and how human activities have impacted upon them. The following discussion summarises the current status of identified issues.

Administration and Governance

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

Improved governance arrangements will rely on clearly defined responsibilities and adequate funding to implement these responsibilities.

Climate Change Adaptation

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

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

Monitoring and Evaluation

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

Poor Water Quality Episodes and Fish Kill Events

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

that their frequency and severity are greatly exacerbated by catchment and floodplain modification. Further information on specific issues is provided below.

Floodplain Vegetation Clearing and Modification

From early colonisation, European land clearing on the floodplain has replaced flood adapted native trees and shrubs with exotic grasses and crops which quickly die and decompose in summer when flooded. This was found to be a major factor in fish kill events in the Richmond River in the EPS (WBM, 2006) and recent studies have offered greater insight into the nature and extent of blackwater events. Prolonged inundation of the floodplain during and immediately following flooding can cause the decay of the underlying vegetation and rapid decomposition of accumulated organic matter (Eyre *et al*., 2006). The decomposition process strips oxygen from the overlying water, creating 'blackwater'. The mass drainage of this ponded blackwater via the drainage network and tributaries as floodwaters recede can cause hypoxic (very low dissolved oxygen) conditions along large stretches of the estuary (Wong *et al*., 2010). Low dissolved oxygen levels in water causes stress to fish and other aquatic organisms and in extreme cases can result in widespread fish kills such as those observed in the Richmond River in 2001 and 2008.

Floodplain Drainage Infrastructure

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

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

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

ASS is the common name given to naturally occurring sediments and soils containing iron sulfides. The exposure of these soils to oxygen by drainage or excavation leads to the generation of sulfuric acid often also releasing toxic quantities of iron, aluminum and heavy metals (DERM, 2009). Approximately 68,000 ha of the Richmond River floodplain is classified as having some level of ASS risk. Disturbance of these areas by historical and on-going drainage and agricultural practices has resulted in the oxidation of ASS resulting in chronic and acute discharges of acid and associated pollutants to adjacent waterways (ABER, 2007).

Five priority areas for the management of ASS in the study area were identified and mapped by Tulau in 1999, during a state-wide study of ASS. These are Tuckean Swamp, Rocky Mouth Creek, Sandy Creek – Bungawalbin Creek, Maguires Creek - Emigrant Creek, and Newrybar-North Creek.

Monosulfidic black ooze (MBO) is created by rotting organic matter in ASS environments and typically occurs on drain bottoms and sides. When disturbed and transported during flow events, MBOs have the capacity to rapidly deoxygenate water and severely disrupt the ecology of waterways (Bush et al., 2003). MBOs are known to occur in the Richmond River estuary and have been identified as a factor

in fish kills (ABER, 2007). The Tuckean has one of the highest recorded concentrations of MBOs in the world (Bush *et al*., 2004).

Diffuse Pollutant Loadings from Agricultural Land

Agriculture is an important contributor to the local economy and is a key component in the social fabric of the region. Agricultural land use and some management practices are also identified as one of the major causes of poor water quality in the catchment and contribute to a broad range of issues in the estuary including the contribution of significant sediment, chemical and nutrient loads to the estuary during runoff (rain) events (WBM, 2006). Agricultural fertilisers are reported as a major source of nutrients. Transportation of nutrients to waterways during rainfall events dominate the annual nutrient budget for the estuary (ABER, 2007). Grazing is a dominant land use in the Richmond River catchment and unrestricted stock access to waterways creates issues of bank instability and erosion through trampling, damage to riparian vegetation and direct input of nutrients and contaminants from direct contact. Contaminant inputs and increased turbidity have flow-on effects to estuarine ecosystems and productivity in the immediate vicinity and downstream in the estuary (WBM, 2006).

Addressing the impacts of agricultural land use on the estuary, while continuing to enhance the local economy and protecting rural lifestyles, is one of the biggest challenges facing long-term management of the estuary. Approximately 75% of the Richmond River estuary study area considered in the EPS (WBM, 2006) is zoned for various forms of agricultural use. Management of these lands has a large bearing on future outcomes for estuarine values.

Poor Condition of the Riparian Zone

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

The issues associated with the poor condition or lack of vegetation within the riparian zone are associated with the loss of the functions and values of this important zone. Riparian zone functions include fisheries habitat, terrestrial habitat, bank stability and maintenance of soil structural integrity, land use buffering, water quality filtering, lowering water temperature and reducing aquatic weeds as well as providing scenic amenity. The absence of many of these functions is apparent throughout the majority of the study area.

Vegetation Management

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

- Loss of vegetation and associated fauna species resulting in reduced biodiversity values of the Richmond River and its catchment;
- Fragmentation of habitats where fauna rely on vegetated “movement” corridors to move between remaining vegetation remnants. In many places these corridors do not exist;
- Increased sediment and nutrient loads to the estuary; and
- Changes in morphological (erosion, accretion) processes within the estuary (WBM, 2006).

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

Outbreaks of aquatic weeds are known to occur in several locations within the study area. These weeds can reduce the ecosystem values of open water for birds and fish. Aquatic weeds can cause diurnal fluctuations of dissolved oxygen and provide a source of organic matter for the production of MBOs, which when mobilised by flood flows can completely deoxygenate the water column.

Waterway Usage

The Richmond River estuary is highly valued for various forms of recreational use, and these pursuits constitute the dominant use of the estuary. Commercial boats also utilise the estuary for fishing, oystering and tourism activities which are also of high significance in the region. The key issues identified for management include:

- Current boating facilities are not adequate to meet current (at peak usage) and projected future demand;
- Concern about cooperative use of the waterway between various forms of recreational and commercial users; and
- The protection of the ecological values of the estuary from recreational activities such as propeller and anchor damage to seagrass beds in Mobbs Bay.

The community perceptions around the need for dredging in the lower estuary and concern about impacts on estuarine ecosystems are also issues that continue to be raised within the community.

Wastewater and Urban Inputs

The relative impact of sewerage systems (including STPs and overflow structures) and urban stormwater outlets on estuary water quality varies greatly and is dependent on the volume and quality of flows from these sources compared to loading from diffuse sources in the catchment. In general the EPS (WBM, 2006) reported that during significant rainfall events, the impact of nutrient loads and pollutants from urban runoff and sewerage systems was negligible in comparison to the impact of diffuse loads. Pollutant loads from urban inputs become relatively more important to water quality during the dry season when catchment inputs are low.

The EPS (WBM, 2006) identifies sewerage system inputs during these dry times as a potential risk to water quality although a comprehensive assessment of risk across the study area has not been conducted to date. Stormwater from urban areas has also been identified as a source of pollutants to receiving water bodies including litter, nutrients, sediment, oxygen-depleting substances and hydrocarbons.

STPs are licensed by the NSW Office of Environment and Heritage. Councils monitor water quality discharged to the environment to ensure compliance with licence conditions. Upgrades to STPs occur on an as needs basis to cater for increased population growth, meet environmental standards and replace aging infrastructure.

Rural areas that are not serviced by a reticulated sewage system rely on on-site sewage management systems (OSSMs) such as traditional septic tanks or other treatment systems. Past investigations have indicated that many systems are failing to meet appropriate standards and are potential contributors of contaminants to the estuary. Many OSSMs in the catchment are not registered and condition and impact of systems on water quality in the catchment is unknown. The Councils undertake on-site sewage and wastewater management programs including specification of design requirements and audit and inspection of on-site systems. Inspections are on-going.

All councils within the study area are actively involved in the management of urban stormwater through a variety of projects, programs and policies including Stormwater Management Plans and Development Control Plans.

Cultural Heritage

The Richmond River estuary has high spiritual and cultural significance for local communities. Both European and Aboriginal heritage sites and items exist in and around the estuary and their recognition and protection are important to the local community. All levels of Government maintain registers of important sites, which are then afforded varying levels of protection under current legislation. During the community consultation phase of this study, the issue was raised that there were a number of sites of Aboriginal cultural heritage significance in the Richmond area that were currently not registered with relevant authorities and therefore there was concern about the on-going protection of sites.

Fisheries and Aquaculture Management

There is concern that the findings and strategies documented in the General Fisheries Environmental Impact Statement (EIS, NSW Fisheries, 2003) are not well understood within the community and that commercial fishers are being unfairly blamed for fish decline in the estuary.

Despite this, there is increasing recognition in both the recreational and commercial fishing sectors that their respective activities are highly regulated and that factors such as the major fish kills in 2001 and 2008, as well as the cumulative effects of habitat degradation, fish migration barriers and declining water quality are all contributing to reduced fish stocks. The 2008 fish kill and ensuing temporary fishing closure polarised community views on who was to blame and what was to be done to avoid repeat occurrences.

There are a range of issues affecting the oyster aquaculture industry in the Richmond River estuary such as QX disease, water quality issues (e.g. periodically high levels of faecal coliforms in North Creek has resulted in harvest closures), vandalism of oyster racks and theft of oysters and the presence of pesticide residues is an ongoing concern for the industry.

Another important issue raised during community consultation phases was the importance of acknowledging and communicating traditional Aboriginal fishing rights and practices in accordance with Native Title.

Estuary Values

The main aim of the estuary management planning process is to increase resilience within the estuary and to protect and enhance the key values.

Economic Values

- The Richmond River catchment supports a wide range of land uses (particularly agriculture) which are important contributors to the local and regional economy.
- Commercial fishing and oyster aquaculture contribute to the local and regional economy.
- The estuary and particularly the lower estuary is considered to be a key attraction for tourists and recreational users to the area, with associated economic benefits.
- The freshwater sections of the estuary are a valuable source of water for agriculture and also provide potable town water supply from the tidal pool upstream of Lismore.

Social Values

- The Richmond River Estuary has high cultural and spiritual significance to local Aboriginal communities.
- A number of European cultural heritage sites and items exist in and around the estuary and their acknowledgement and protection is important to the community.
- The estuary and foreshore areas are highly valued by the community and visitors for recreational activities.
- Scenic amenity is valued highly by the local community and visitors.
- The estuary provides opportunities for both formal and informal education.

Ecological Values

- The Richmond River Estuary and wetlands provide a diversity of habitats for a range of terrestrial and aquatic species.
- The estuary supports a number of rare and threatened communities.
- Estuarine wetlands including mangroves, saltmarsh and seagrass areas provide an important role in healthy ecosystem function.
- The Richmond River estuary is recognised as one of the two most important locations for shorebird habitat in Northern NSW (DECCW, 2010b). The Clarence estuary is the other important site.
- The riparian zone provides a number of important ecological functions.
- Good water quality is highly valued and considered a general indicator of estuary health by the community.

Management Objectives

Based on the established values of the estuary and the issues summarised above, management objectives for the estuary were developed. The objectives set specific aims for future management of the estuary giving consideration to the values and key issues.

Table 1: Richmond River Estuary Management Objectives

No.	Objective
O1	To encourage economically viable and environmentally sustainable land use practices in the catchment
O2	To ensure strategic planning instruments and programs are consistent with and where applicable, directly address the aims of the CZMP
O3	To ensure efficient and effective management of the estuary through appropriate governance, funding and monitoring
O4	To increase knowledge of the impact of existing practices on estuary values and facilitate continuous improvement
O5	To reduce pollutant loads to the estuary
O6	To protect and enhance the riparian zone
O7	To minimise the frequency and severity of environmental events such as fish kills

No.	Objective
O8	To optimise flood mitigation works and flow control structures to improve estuarine water quality
O9	To minimise constraints to estuary adaptation to climate change
O10	To protect and enhance the biodiversity values of the estuary
O11	To provide for increased use of the estuary whilst minimising environmental impact and conflict between users
O12	To protect the cultural heritage values of the estuary
O13	To protect and enhance visual amenity/ aesthetic appeal of the estuary
O14	To enhance sustainable commercial return from industries relying on the estuary and the floodplain
O15	To minimise risk to the health and safety of users of the estuary

Potential Management Options

A suite of options available for the sustainable management of the estuary has been compiled and developed to a point where the options can be compared and prioritised. The options have been formulated to address the identified issues and achieve the management objectives and are made up of both short-term and long-term components.

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

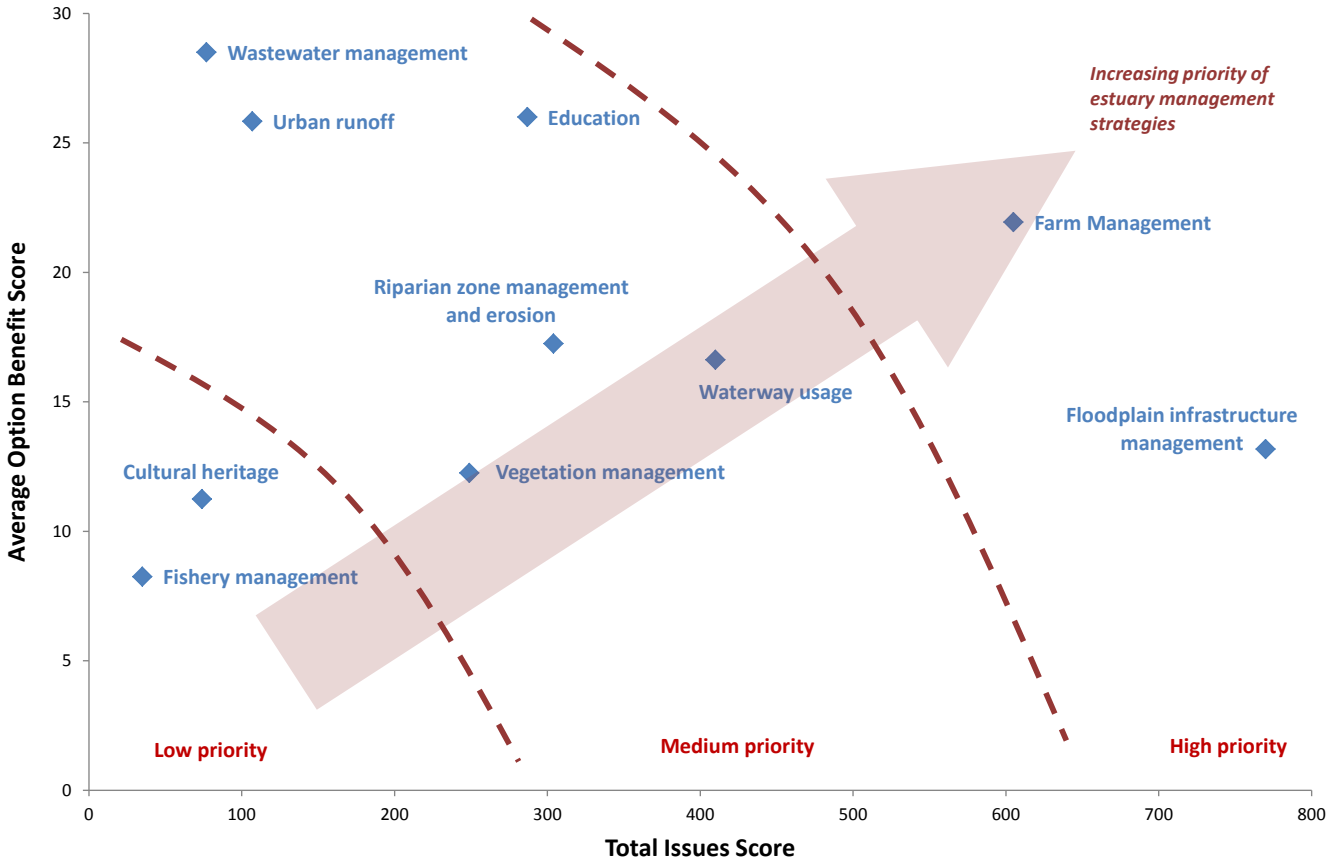
- All issues were ranked to focus management effort on those issues regarded as a priority in achieving the objectives of the plan;
- The individual options were assessed to determine the effectiveness in addressing the priority issues (“Issues Score”);
- The individual management options were assigned an “Option Benefit Score”; and
- The Average Option Benefit Scores (average of the Option Benefit Scores) for each category of option were visually compared with the associated issue priority.

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 similar outcomes 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 does not provide a full representation of the required management effort. To address this, issues and options were grouped into categories to enable development and comparison of management strategies.

Figure 3 compares the Average Option Benefit Scores and the Total Issues Scores for each category of issue (Strategies). The Strategies have been assigned a low, medium or high priority based on their capacity to address the identified issues and their overall benefit. Based on the priorities displayed here, the management strategies will be developed as part of the Draft CZMP.

Administration and Governance, Climate Change Adaptation and Monitoring and Evaluation are considered to be fundamental management strategies that influence all options of the management plan. For this reason they have not been prioritised in the same way as the other strategies and do not appear in this chart. The strategies (in priority order) and their component options are shown in Table 2

The classification of strategies as low priority for management is not a reflection of the level of importance of these factors, but rather an indication of the capacity of the actions contained in these strategies to achieve the defined objectives in terms of overall estuary health.



*Note that strategies considered to be fundamental management considerations were not prioritised i.e. Administration and Governance, Climate Change Adaptation and Monitoring and Evaluation.

Figure 3 - Relative Priority of Management Strategies

Table 2: Prioritised Management Strategies and Options

Fundamental Management Strategies	
Administration and Governance	
1	Review estuary governance and administration
Climate Change Adaptation	
39	Assessment and mapping of tidal inundation extent including potential sea level rise
41	Planning for sea level rise and climate change impacts incorporating Government policy and guidelines, current research and best-practice management
Monitoring and Evaluation	
2	EcoHealth monitoring program (comprehensive, catchment-wide monitoring program)
3	Develop catchment/water quality modelling tool to support decision making

HIGH PRIORITY	
Floodplain Management	
4	Identify and prioritise drainage for infilling of redundant drains and reshaping of other drainage
5	Identify and prioritise levees for redesign and/or remodelling
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 management including changes to inundation tolerant pasture species
10	Retirement/buy back backswamp areas and return to wetlands
11	Work with backswamp property owners to identify alternative management strategies
21	Review water sharing plans regarding groundwater extraction and acid sulfate soil (ASS) effects
Farm Management	
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

MEDIUM PRIORITY	
Education	
37	Estuary-wide community education and consultation program
Waterway Usage	
15	Review boat passage areas impacted by erosion
26	Zoning to prevent access to sensitive estuarine vegetation areas
27	Estuarine vegetation signage / education to protect sensitive areas
28	Implement Recreational Boating Study actions
32	Investigate usage conflicts and need for management
33	Develop strategic plan for estuary usage
34	Review of waterfront structures and licensing
38	Cost benefit analysis of dredging operations in lower estuary
Riparian Zone Management and Erosion	
22	Riparian buffer zone identification (planning)
23	Identify priority riparian areas and rehabilitate

Wastewater Management	
19	Support the continuing upgrade / augmentation of Sewage Treatment Plants (STPs) where required
20	Wastewater Reuse
40	Support the on-going on-site sewerage management inspections and improvements
Urban Runoff	
16	Further promote Council's stormwater education programs
17	Support and promote existing planning mechanisms for Water Sensitive Urban Design (WSUD) for new developments
18	Continue Council's program for retrofit of GPTs and other stormwater improvement devices
Vegetation Management	
24	Continue aquatic weed management and support improved technology for better environmental outcomes
25	Retain, rehabilitate and conserve existing native floodplain vegetation

LOW PRIORITY	
Cultural Heritage	
35	Identification and registration of cultural sites available to council planners
36	Develop Cultural Site Management Plans for sites in and around the estuary where appropriate
Fishery Management	
29	Ensure key research findings in the fishing and aquaculture sector are communicated to the public as well as within and across government agencies.
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

Development of the Coastal Zone Management Plan

Based on the options identified as part of this Draft EMS, a prioritised schedule for implementing the management strategies has been developed and presented in the Draft CZMP (Volume 1). The implementation of the plan will be supported by a process for reviewing the effectiveness of the plan and adapting it as required. This aspect of the project is essential for ensuring that the estuary management options identified become a reality and that the estuary is better managed into the future.

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1. INTRODUCTION

1.1 Purpose of this Estuary Management Study

The purpose of this Estuary Management Study (EMS) is to investigate the current uses and health status of the Richmond River Estuary and to define management objectives and options for future management of the estuary. The Draft EMS achieves this by drawing upon previously completed studies into the estuarine processes and the values associated with the estuary and identifies how the values are impacted by those processes. The Draft EMS defines management objectives for the long-term strategic management of the Richmond River Estuary and investigates management options to address the current and future threats to its social, environmental and economic values.

Volume 1, the Draft Coastal Zone Management Plan (CZMP) for the Richmond River Estuary (CZMP) documents the recommended actions that are required to achieve the objectives for management of the estuary.

1.2 The Study Area

The Richmond River estuary is located on the far north coast of NSW. The estuary is situated within three local government areas (Ballina Shire, Lismore City and Richmond Valley Council areas) as shown on Figure 4. An additional three councils (Clarence Valley, Kyogle and Byron Shire) have jurisdiction in the upper catchment.

The region experiences a mild subtropical coastal climate with moderate maximum and mild minimum temperatures and high intensity rainfall. The ocean controls the climate of the coastal towns, with more inland centres such as Lismore and Casino experiencing higher maximum and lower minimum temperatures. The majority of rain falls in the summer and autumn months (WBM, 2006).

The study area includes the tidal waterways, foreshore and adjacent lands of the Richmond River estuary, including the entrance and lower reaches of the major tributaries. The study focuses on the immediate catchment of the estuary as this is considered to have the most impact on the health of the estuary and will form the focus for future (estuary) management. The upper catchment is also considered where it affects the issues to be addressed by the study, such as urban, agricultural and forestry runoff, which contribute to increased surface flows and input of sediment and nutrients.

Given the large size of the study area (floodplain >1,000km^2) and the three local government jurisdictions, twelve management zones were developed. The management zones are discussed in Section 3.

Figure 4 - The Richmond River Catchment and Estuary Management Study Area

1.3 Structure of this Report

The sections of this Report describe the steps in the development of the potential management options for the Richmond River Estuary. The process followed is summarised in Figure 5.

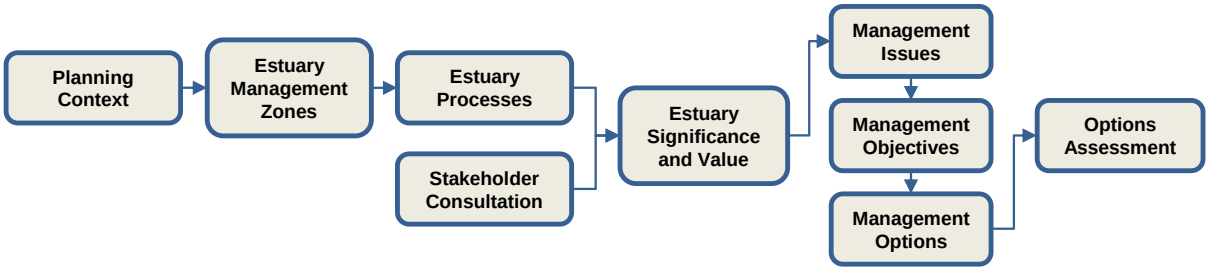


Figure 5 – Development of the Estuary Management Study

Section 1 - Introduction: Introduces the purpose of the document and the study area.

Section 2 - Planning Context: discusses the planning framework, administration and governance that applies to the management of the Richmond River estuary

Section 3 - Estuary Management Zones: Describes the major features and values of the estuary management zones and introduces the issues in each zone.

Section 4 - Estuary Processes: Provides an update of recent technical information related to the management of the Richmond River Estuary, since the completion of the Estuary Processes Study.

Section 5 - Stakeholder Consultation: Summarises the consultation activities undertaken as part of the Estuary Management Planning Process.

Section 6 - Estuary Significance and Values: Discusses the significance and values of the estuary derived from the scientific understanding and the outcomes of the stakeholder consultation.

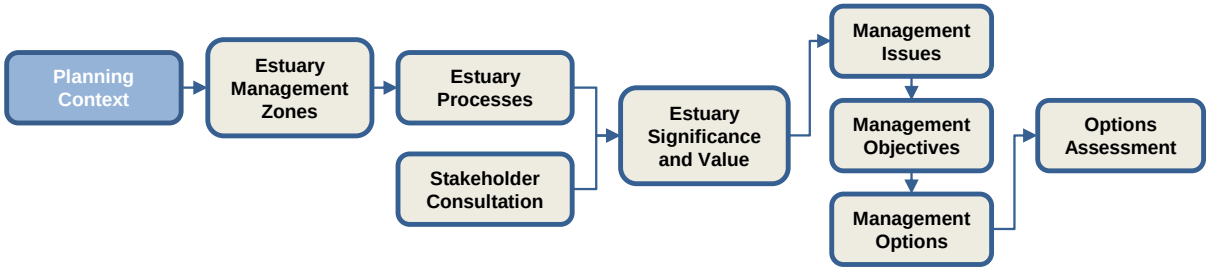
Section 7 - Estuary Management Issues, Objectives and Options: Outlines the current status of identified issues in the estuary. Based on the established values of the estuary and the issues, management objectives and options were also developed to protect the identified values.

Section 8 - Estuary Management Options Assessment: Options are compared on a triple bottom line basis.

Section 9 - Preparation of the Coastal Zone Management Plan: describes the next steps in the CZMP process.

The Appendices provide detailed information on certain aspects of the EMS.

2. PLANNING CONTEXT



This Section discusses the planning framework, administration and governance that apply to the management of the Richmond River estuary. The development of management options will be consistent with the existing policies and strategic plans.

Detailed information on the planning framework is provided in Appendix 1.

2.1 The Richmond River 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. 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 Estuary Management Manual (NSW Government, 1992).

This Draft Estuary Management Study (EMS, Volume 2 of the Draft CZMP) is a culmination of the Data Compilation Study (WBM, 2004) and the Estuary Processes Study (WBM, 2006, ABER, 2007; ABER, 2008). The Draft EMS brings together the information to identify the estuary management issues and formulate options for management. A substantial component of the Draft EMS and Draft CZMP were prepared prior to finalisation of the 2010 Guidelines. However, following public exhibition of the Draft CZMP, the documents were amended to ensure consistency with the minimum requirements of the Guidelines. Councils are required to submit draft CZMPs to the Minister for certification under the Coastal Protection Act, 1979 (refer Figure 6).

This document has been prepared with financial assistance from the NSW Government through the Office of Environment and Heritage.

2.1.1 Management Framework

The Draft 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).

NSW Coastal Policy, 1997

The NSW Coastal Policy, 1997 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. 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. The overriding vision of the 1997 Coastal Policy is the ecologically sustainability of the NSW Coast. Nine goals have been adopted which represent a commitment to:

- Protecting, rehabilitating and improving the natural environment of the coastal zone;
- Recognising and accommodating the natural processes of the coastal zone;
- Protecting and enhancing the aesthetic qualities of the coastal zone;
- Protecting and conserving the cultural heritage of the coastal zone;
- Providing for ecologically sustainable development and use of resources;
- Providing for ecologically sustainable human settlement in the coastal zone;
- Providing for appropriate public access and use;
- Providing information to enable effective management of the coastal zone; and
- Providing for integrated planning and management of the coastal zone.

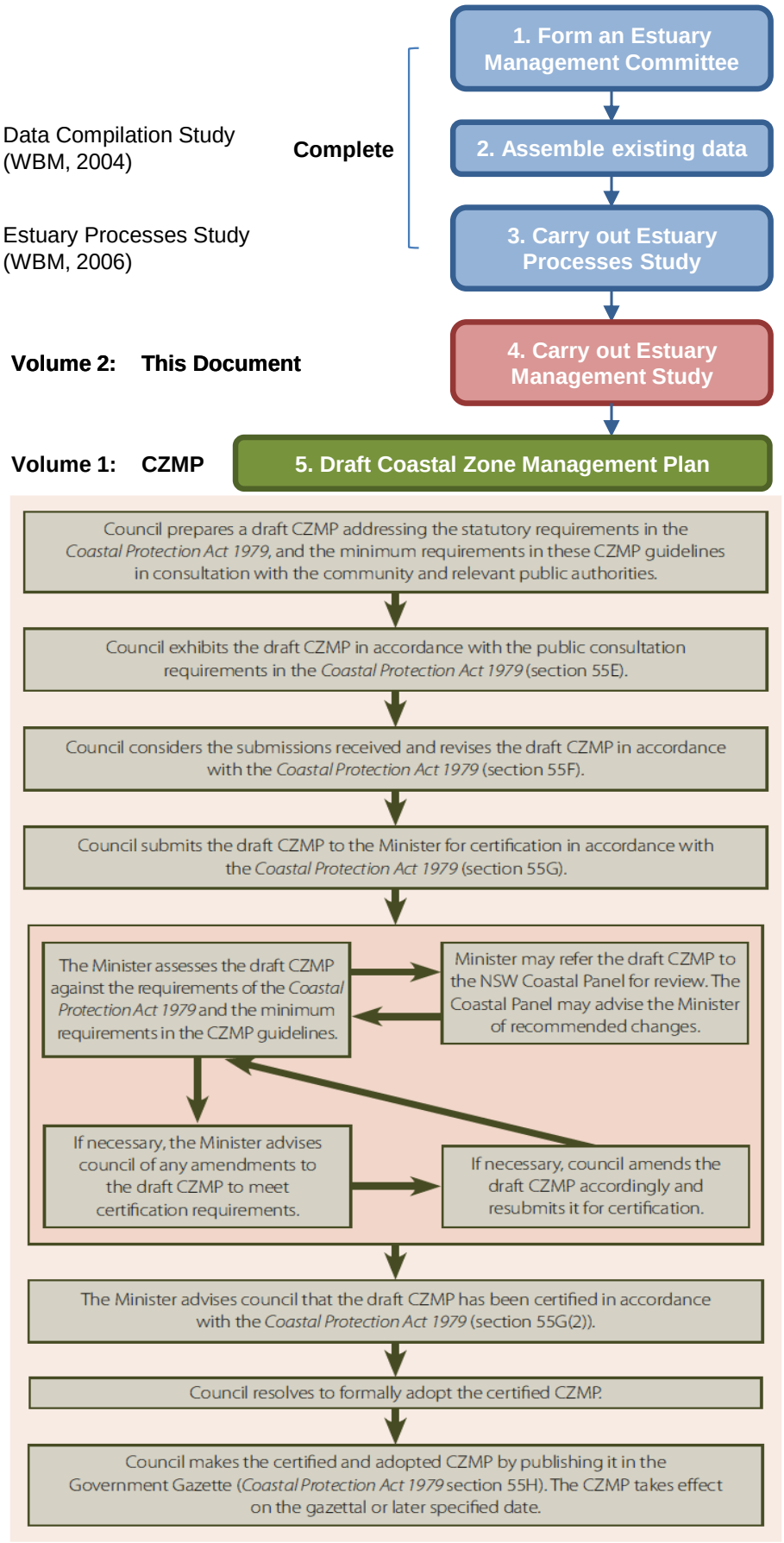


Figure 6 - CZMP preparation and certification process for the Richmond River Estuary

Source: Modified from DECCW, 2010c

Coastal Protection Act, 1979

The Coastal Protection Act, 1979 makes provisions relating to the use and occupation of the coastal region in order to preserve and protect these areas whilst encouraging sustainable use of the areas. The Act also facilitates the carrying out of certain coastal protection works. The objectives of the 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.

2.2 Administration and Governance

The management of the Richmond River Estuary is undertaken by various local and state government bodies.

2.2.1 Local Government

Councils have a central role in the management of estuaries. There are three local general purpose councils with jurisdiction in the study area: Lismore City Council (LCC), Richmond Valley Council (RVC) and Ballina Shire Council (BSC). There are also three council appointed and funded entities: Richmond River County Council (RRCC), Far North Coast Weeds (FNCW) and Rous Water, which have certain responsibilities legally delegated to them by the general purpose Councils.

General Purpose Councils

The local general purpose councils are responsible for land use allocation and development in the immediate area and surrounding the estuary. The councils also have significant planning and development powers as consent authorities under the Environmental Planning and Assessment Act,

1979. Together with other government agencies and catchment management authorities, councils act as an interface between the community and state authorities.

The Local Government and Shires Associations of NSW website provides a useful description of local government responsibilities with regard to natural resource management. This is provided below:

As the sphere of government closest to the community, local government is responsible for good governance and the care and protection of local communities within a framework of sustainable development.

As managers of public land and land use planners, local government is responsible for policy development and implementation of land use planning as well as regulating a wide range of activities that may impact upon natural resource management. Local government also has a key role to play in translating the policies of Commonwealth and state governments into on-ground projects.

Local Government has a range of functions, powers and responsibilities at its disposal to influence natural resource management - on both private and public land. These include:

- Strategic planning through land use zoning and statutory controls on all freehold land and locally managed public open space;
- Development control of activities and works on land as specified by Council's LEP;
- Enforcement powers for development consent conditions, waste management and unauthorised land uses (e.g. land clearing, drainage, and filling);
- Administrative responsibility for state agency coordination through integrated planning, licensing and development concurrence;
- Stormwater management and control; sewerage and drainage works, and flood control;
- Pest, plant and animal risk control measures;
- Influence over land clearance patterns through incentive programs (planning amendments, rate differentials, levies, rural fire management and developer contributions);
- Management of local open space to restore remnant vegetation and recreate habitat; and
- Primary advocate for and coordinator of local community groups and interests.

County Councils

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. RRCC's proclamation was amended most recently on 5 September 2008, when natural resource management was formally incorporated as an RRCC function where issues arise from RRCC's flood mitigation activities (refer to amendment published in NSW Government Gazette No. 110, 2008). RRCC receives Council contributions to fund delegated responsibilities and for maintenance of council assets. State government also provides contributions for maintenance of floodgates drains and levees.

RRCC is responsible for exercising all the powers and duties under the Local Government Act 1993 in relation to the prevention or mitigation of menace to the safety of life or property from floods and natural resource management issues arising therefrom. This involves water quality monitoring, research, environmental education, works to improve discharge from community flood mitigation infrastructure, drain modification, wetland and creek restoration. RRCC also has a coordinating role in floodplain management, working with constituent Councils, State agencies, and floodplain industries to develop long term effective natural resource management strategies for the Richmond River floodplain and estuary (RRCC, 2009). However, the RRCC delegated responsibilities are limited to impacts associated with flood mitigation activities which are primarily restricted to floodplain drainage

infrastructure and maintenance, and therefore do not cover all of the estuary management issues (such as waterway usage, riparian zone management, farm management, fisheries and aquaculture, wastewater management, urban runoff and heritage).

FNCW is the local control authority responsible for administering the Noxious Weeds Act, 1993 in the Northern Rivers region of NSW. Responsibilities include:

- Controlling noxious weeds on public land including roadside weed management and aquatic noxious weeds on rivers and public lagoons;
- Conducting inspections of private property for presence of noxious weeds;
- Enforcement of control of noxious weeds through requests and fines as necessary; and
- Provide advice on weed management issues.

Rous Water is the regional water supply authority providing potable water in bulk to the Council areas of Lismore (excluding Nimbin), Ballina (excluding Wardell), Byron (excluding Mullumbimby) and Richmond Valley (excluding land to the west of Coraki). Catchment management activities are carried out by Rous Water to protect its drinking water sources and to protect and restore ecological systems and improve waterway health and water quality.

2.2.2 State Agencies

There are a number of State agencies who have various regulatory and strategic roles related to the estuary. These include:

- Office of Environment and Heritage (OEH), within the Department of Premier and Cabinet, including:
    - the National Parks and Wildlife Service (NPWS); and
    - in regulatory matters for environment protection, OEH acts under the powers of the Environment Protection and Regulatory Group (EPRG).
- Department of Primary Industries (within the Department of Trade and Investment, Regional Infrastructure and Services) including:
    - The NSW Office of Water - responsible for the water management functions (including legal, policy and regulation);
    - Primary Industries - Agriculture;
    - Primary Industries - Fisheries;
    - Marine Parks Authority;
    - Catchment Management Authorities (refer Section 2.2.3); and
    - Crown Lands division – responsible for ownership and management of Crown Land which in most cases is the bed and banks of estuaries below mean high water level and other land parcels including foreshore reserves, road reserves.
- Department of Planning – the state authority on planning and environmental assessment matters; and
- NSW Maritime – responsible for marine safety, regulation of commercial and recreational boating and oversight of port operations.

2.2.3 Catchment Management Authority

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.

2.2.4 The Richmond River Estuary Management Committee

The role of an Estuary Management Committee is to provide ongoing feedback during the various steps of the CZMP preparation process. The Richmond River Estuary Management Committee comprises representatives from a wide range of stakeholders:

- BSC;
- LCC;
- RVC;
- OEH – EPRG;
- OEH - NPWS;
- DPI – Agriculture;
- DPI – Fisheries;
- RRCC;
- Richmond River Cane Growers Association;
- NSW Sugar Cooperative;
- NSW Farmers Association;
- Ballina Fisherman's Cooperative;
- Aboriginal Community;
- Oyster growers;
- Community Representative; and
- Environmental Representative.

The Richmond River Estuary Technical Team consists of key personnel from the local government areas within the estuary and agency stakeholders including the councils, OEH and DPI (Fisheries, Crown Lands and CMA) representatives.

The Technical Team met on a regular basis to discuss on-going estuary management projects and provide feedback on the development of the Draft EMS and Draft CZMP.

2.3 Regional and Local Management Plans and Policies

Management plans and policies that apply to the Richmond River estuary include (refer Appendix 1):

- Estuary General Fisheries Management Strategy, 2003;
- NSW Sea Level Rise Policy Statement, 2009;
- Floodplain management plans for the management area;
- NSW Coastal Policy;
- Northern Rivers Regional Biodiversity Management Plan, National Recovery Plan for the Northern Rivers Region (DECCW 2010);
- NSW Wetland Policy, 2010;
- NSW Diffuse Source Water Pollution Strategy, 2009;
- Northern Rivers Catchment Action Plan, 2006 (refer Section 2.2.3);
- Interim Water Quality and River Flow Objectives;
- Draft Water Sharing Plan for the Richmond River Area unregulated, regulated and alluvial water sources;
- National Parks and Reserves Plans of Management;
- Health Rivers Commission Inquiry into NSW Coastal Lakes, 2002;
- Northern Rivers Farmland Protection Project, 2005;
- Far North Coast Regional Strategy 2006 – 2031;
- Far North Coast Regional Conservation Plan (Draft), 2009;
- Evans River Estuary Management Plan, 2002;
- Evans Head Coastline Hazard and Estuarine Water Level Definition Study;
- Wilsons River Catchment Management Plan 2009;
- Crown Reserves Plans of Management (Woodburn, Coraki and Evans Head); and
- Northern Rivers Biodiversity Management Plan, 2010.

2.4 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, SEPPs and local environmental plans, LEPs) are legal documents that regulate land use and development. Relevant SEPPs include (refer Appendix 1):

- North Coast REP (1988) – deemed a SEPP;
- Rural Lands, 2008;
- Remediation of Land, 1998;
- Building Sustainability Index (BASIX), 2004;
- Infrastructure, 2007;
- Major Development, 2005;

- SEPP 71 Coastal Protection;
- SEPP 62 Sustainable Aquaculture;
- SEPP 44 Koala Habitat Protection;
- SEPP 26 Littoral Rainforests;
- SEPP 19 Bushland in Urban Areas; and
- SEPP 14 Coastal Wetlands.

Strategic plans prepared by the local Councils guide local management strategies. These are discussed further in Appendix 1.

LEPs 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 which sets out 35 standard zones for councils to use when preparing new LEPs for their LGAs. The new LEPs are currently being finalised.

Types of zones relevant to the estuary include rural, residential, business, industrial, special purpose (tourist), recreation, environment protection and waterway zones. For each zone, the Standard Instrument sets out 'core' objectives for development, and certain mandated permitted or prohibited land uses.

Relevant Environment Protection zones include:

- E1 National Parks and Nature Reserves - All uses currently authorised under the National Parks and Wildlife Act 1974 are permitted without consent in this zone;
- E2 Environment Conservation - intended to protect land that has high conservation values outside the national parks and nature reserve system;
- E3 Environmental Management - intended to be applied to land that has special ecological, scientific, cultural or aesthetic attributes, or land highly constrained by geotechnical or other hazards; and
- E4 Environmental Living - intended for land with special environmental or scenic values, and accommodates low impact residential development.

Relevant Waterway zones include:

- W1 Natural Waterways - intended for natural waterways that are to be protected for their ecological and scenic values; and
- W2 Recreational Waterways - includes water-based recreation, boating and water transport, and development associated with fishing industries, such as natural water-based aquaculture and recreational fishing.

Development Control Plans, prepared in accordance with the Environmental Planning and Assessment Act, are also used to help achieve the objectives of local plans (including LEP and CZMPs) by providing specific, comprehensive requirements for certain types of development or locations. DCPs include provisions for vegetation management, development on the floodplain, tourist developments, coastal hazard protection, stormwater management, acid sulfate soils, water sensitive design and buffer areas.

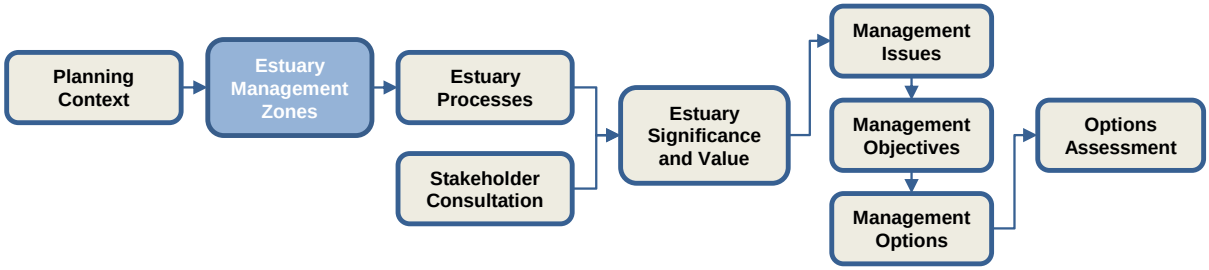
2.5 Relevant Legislation

Legislation relevant to the estuary management planning process is listed below (refer Appendix 1):

- (Commonwealth) Environment Protection & Biodiversity Conservation Act, 1999;
- Environmental Planning & Assessment (EP&A) Act, 1979;
- Coastal Protection Act, 1979;
- Local Government Act, 1993;
- Protection of the Environment Operations Act, 1997;
- Fisheries Management Act, 1994;
- Crown Lands Act, 1989;
- Marine Parks Act, 1977 and Marine Park Regulation, 2009 and Marine Parks (Zoning Plans) Regulation, 1999;
- Water Management, Act 2000;
- Catchment Management Authorities Act, 2003;
- Native Vegetation Act, 2003;
- Threatened Species Conservation Act, 1995;
- National Parks and Wildlife Act, 1989 (1974);
- Heritage Act, 1977;
- Noxious Weeds Act, 1993;
- Native Title (New South Wales) Act, 1994; and
- Soil Conservation Act, 1938.

Legislative requirements will be considered in the development of estuary management options (refer Section 7).

3. ESTUARY MANAGEMENT ZONES



This Section discusses the major features and values of the estuary management zones and introduces the issues in each zone.

The Richmond River estuary management zones are:

Zone 1 - North Creek;

Zone 2 - Emigrant / Maguires Creek;

Zone 3 – Back Channel;

Zone 4 – South Ballina/Empire Vale;

Zone 5 – Riley's Hill;

Zone 6 – Evans River;

Zone 7 – Rocky Mouth Creek;

Zone 8 – Swan Bay;

Zone 9 – Kilgin/Buckendoon;

Zone 10 – Tuckean;

Zone 11 – Lower Bungawalbin; and

Zone 12 – Upper Richmond/Wilsons River.

3.1 Management Zones

Given the large size of the study area (floodplain approximately 1,000 km^2) and the three local government jurisdictions, twelve Management Zones were developed by the Richmond River Floodplain Committee in 2007. The zones align with sub-catchments or with a part of the floodplain that is segregated by geography or infrastructure boundaries such as roads. The zones were selected as reasonable areas in which to base and enable natural resource management activities. The objective was to provide a manageable breakdown of the estuary area to facilitate implementation of the management actions. The 12 estuary management zones are shown in Figure 7.

The major features of each zone are discussed in the following sections including an introduction to the key management issues, a figure showing the major features of the zone and a figure showing the management issues within the zone. This information has been collated from background data including the Estuary Processes Study (EPS - WBM, 2006), consultation activities, knowledge of the estuary and input from the Technical Team (refer Section 2.2.4). This is provided as an indication of estuary management issues rather than comprehensive mapping of the extent and location of the issues. Further discussion on the estuary processes is provided in Section 4. Section 7 provides further discussion of relevant issues and options for management.

Land use mapping sourced from DECCW (2009) has been used to characterise the study area and while every effort has been made to produce accurate mapping, the data is not guaranteed to be free from error, and as land use is continually changing, this data should be viewed as a guide only.

3.2 Zone 1 - North Creek

North Creek is a shallow water ecosystem stretching from the marine dominated shoals adjacent to Ballina, through the upper estuarine swamps of the Ballina Nature Reserve, to the extensive freshwater floodplain of Newrybar Swamp. This waterway forms the north-east arm of the Richmond River estuary (Figure 8). This zone is within the BSC local government area.

The North Creek/Newrybar Management Zone comprises mostly agricultural land use (cane, grazing and increasing areas of macadamia) which is located in the upper parts of the catchment (behind Lennox Head and below Newrybar). The hydrology of this area has been modified by extensive drainage works and levee construction. The Union Drain enters the upper reaches of North Creek and the Newrybar Levee lies north of Ballina Nature Reserve (refer Figure 9).

The urban areas of Ballina including several industrial estates are situated in the lower reaches. Stormwater runoff has been identified as a potential source of contaminants in North Creek. The West Ballina Sewage Treatment Plant (STP) discharges treated wastewater to North Creek Canal in the south west of the Zone. Lennox Head STP is situated within this zone, north of Ballina and discharges treated wastewater via a pipeline to the Pacific Ocean.

The Ballina Nature Reserve occupies a large area in the mid-section of North Creek and provides habitat for a range of flora and fauna, including threatened species. The reserve comprises a wetland that contains mangroves, swamp sclerophyll forest and saltmarsh communities (NPWS, 2003). The mid and lower reaches of the zone are valued recreational areas used by local residents and tourists for fishing, boating and swimming. Sandy shoals in lower North Creek and the Richmond River adjacent to Ballina provide sheltered and unique environments for recreation. The lower estuary is a designated recreational fishing haven with the exception of the Mullet dig at Missingham Bridge which is fished by commercial fishers at certain times of the year. Commercial oyster culture occurs in North Creek and Mobbs Bay in South Ballina. Boat launch facilities are located at several points in this zone and WBM (2006) noted access issues due to high use of existing facilities at busy times of the year.

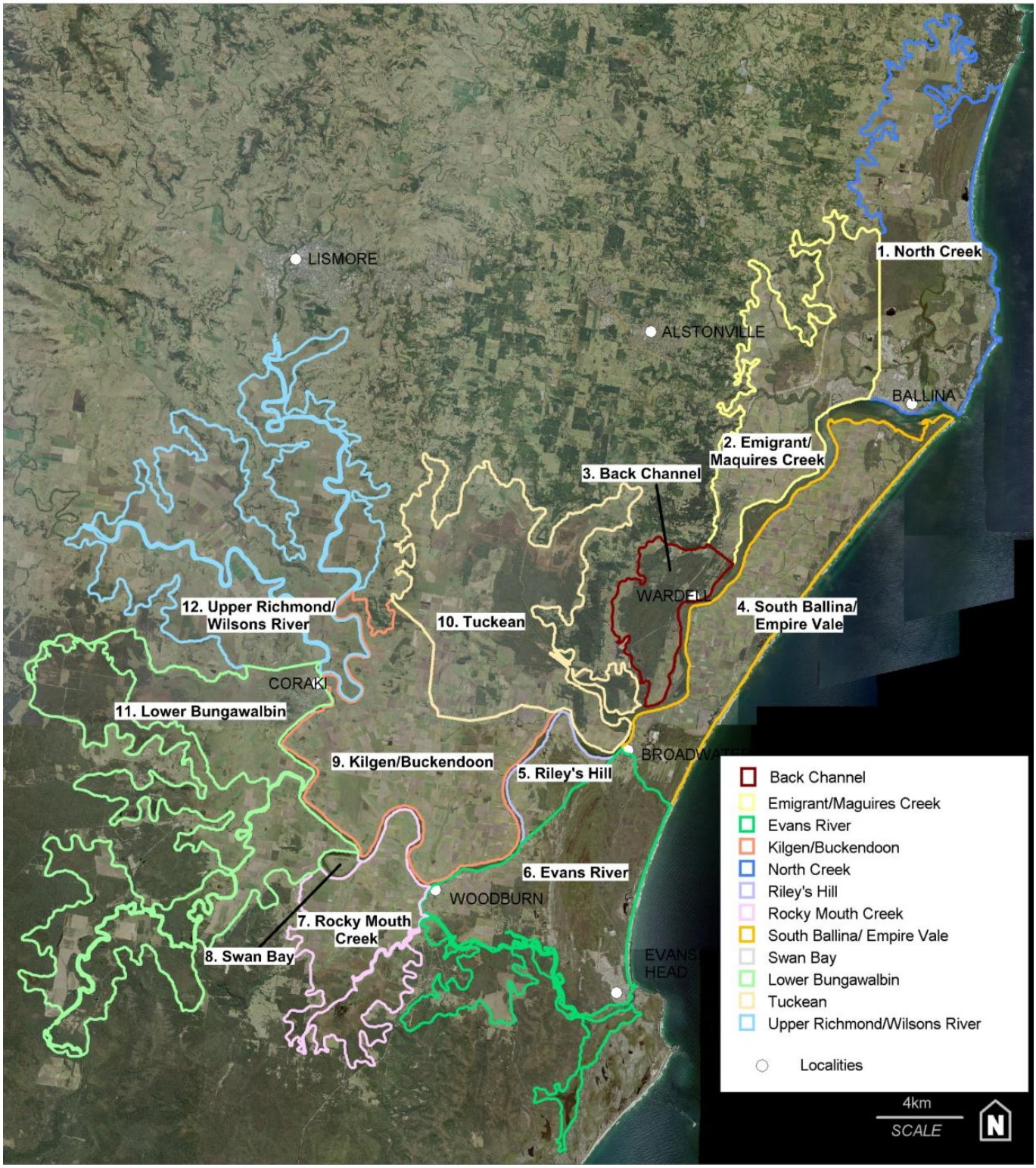


Figure 7 - Richmond Estuary Management Zones

Plate 1: Recreational users at the sand spit in the Richmond River near the Ballina Sailing Club

In the lower reaches of North Creek and the Richmond River, the majority of the shoreline is highly modified by urban development. Rock walls line much of the lower estuary shoreline to protect against bank erosion. Fragments of relatively extensive intertidal mangrove forest/saltmarsh remain. The lower reaches of North Creek also contain large inter-tidal sand shoals which are important feeding and roosting sites for resident and migratory shorebirds. Intertidal mangrove forests in North Creek constitute important nursery and feeding habitat for a diverse range of juvenile fish species. Good riparian vegetation cover exists along the middle reaches of North Creek and the vegetated zone is mostly greater than 50m wide with a high native cover in the canopy (>30% - 60%) (Australian Wetlands, 2010).

Plate 2: Lower North Creek

In the higher reaches above Ross Lane, the Creek has been channelised by drainage works. With the exception of pasture grasses and a few patches of regrowth upstream, riparian vegetation is almost non-existent on the channel. One exception of note is a 750m stretch of drain where a successful riparian planting trial has provided vegetated riparian zone for this section.

Large areas of the upper and mid reaches of this zone are identified as high risk ASS (ASS, Tulau, 1999). There is evidence of ASS runoff affecting the upper reaches of the North Creek estuary for periods following smaller runoff events during the wet season when groundwater levels are relatively high (ABER, 2008). Acidification is generally buffered by seawater flushing in the lower sections and is not a significant issue. Issues with low dissolved oxygen (DO) concentrations were also noted to increase upstream along North Creek. ABER (2008) indicated that DO concentrations were likely to be driven by high organic loads from groundwater inputs, leaf litter fall and deposition of algal blooms during summer. High nutrient concentrations combined with high temperatures noted in water quality results, were expected to be the main driver of the occurrence of algal blooms in summer. In addition, high faecal coliform levels in the lower reaches of North Creek have caused the extended closure of oyster harvest areas, and are threatening the viability of this industry (WBM, 2006). The source of pathogens is not currently known.

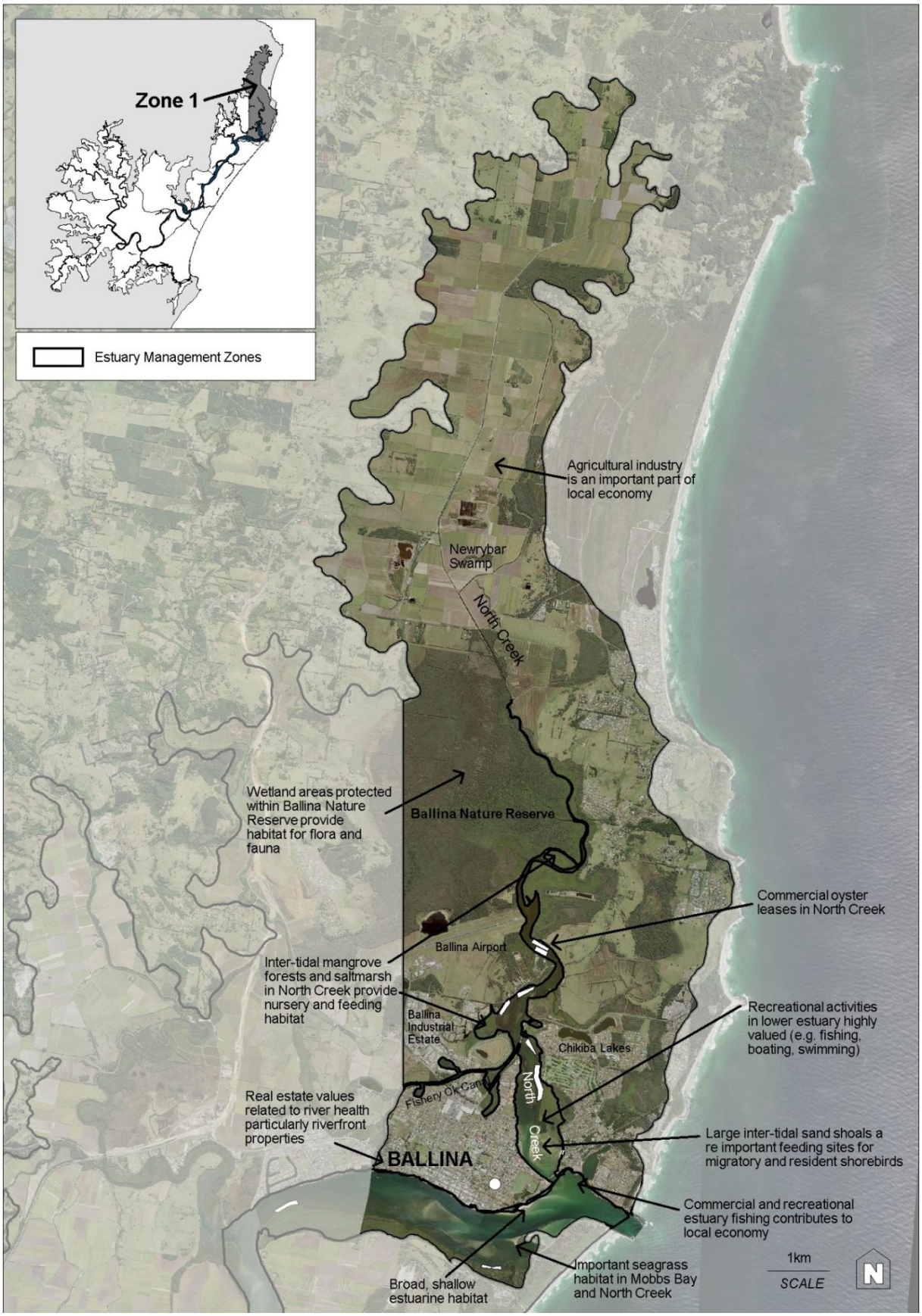


Figure 8 – Zone 1 North Creek/Newrybar: Major Features

Source: aerial photography provided by RRCC

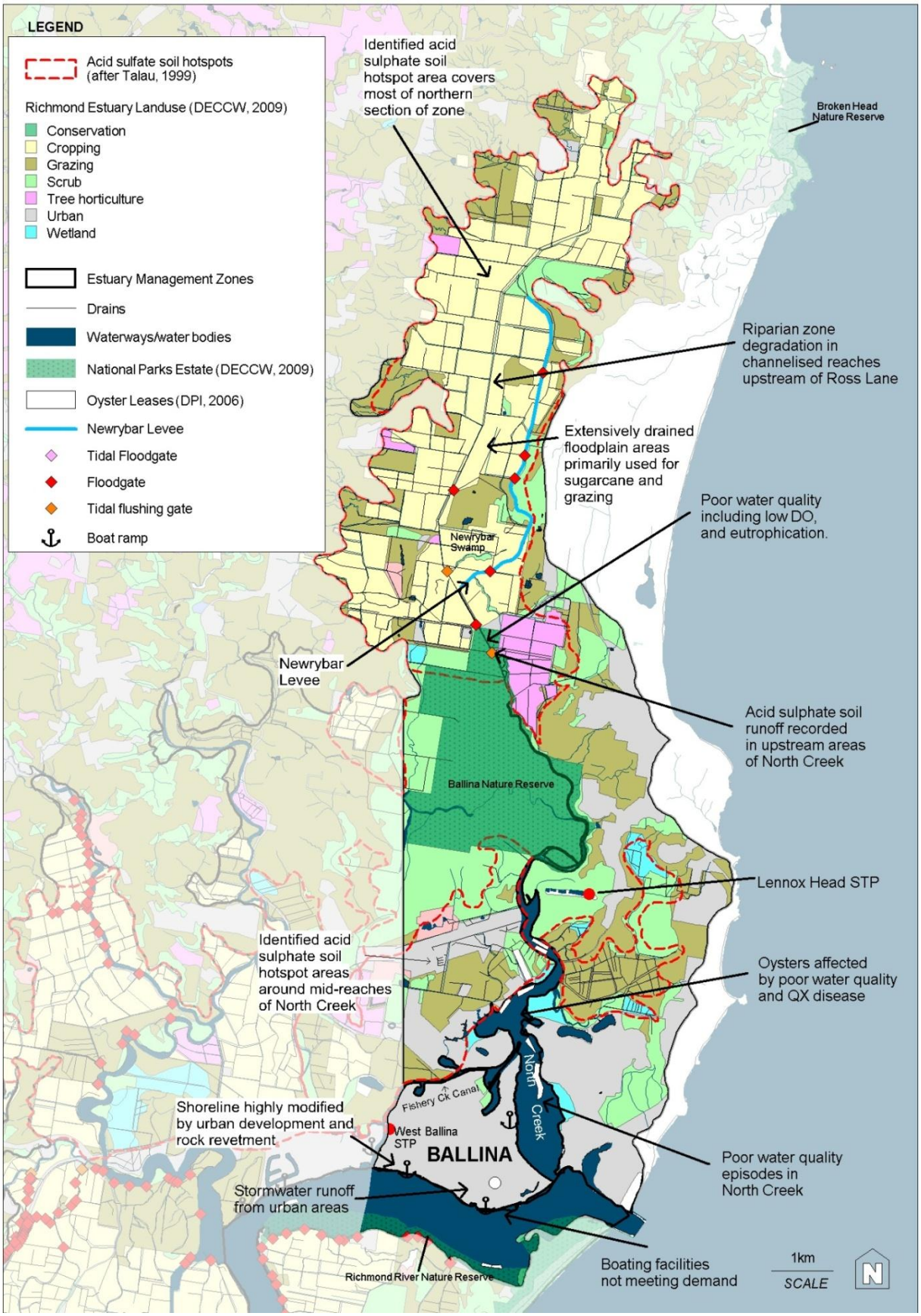


Figure 9 - Zone 1 North Creek/Newrybar: Management Issues

3.3 Zone 2 - Emigrant / Maguires Creek

This zone is within the BSC local government area. It includes the sub catchments of Emigrant Creek and Maguires Creek. Emigrant Creek is a shallow water ecosystem stretching from the marine dominated shoals at its confluence with the main Richmond River estuary, through the floodplain backswamps immediately north of the Pacific Highway, to the upper estuarine reaches traversing alluvial floodplains. In its upper reaches, Emigrant Creek Dam forms part of the town water supply catchment for Ballina and Lennox Head.

Maguires Creek drains from the Teven Valley and part of the Alstonville Plateau and intersects with Emigrant Creek approximately 7.5kms upstream of the confluence with the Richmond River. The lower estuarine reach also receives inputs from the Uralba floodplain to the south via Duck Creek (Figure 10).

Land use in the area is predominantly agricultural with sugar cane and some grazing on the floodplain and lower lying areas, and macadamia farming and some mixed horticulture on the higher areas. The floodplain has been extensively drained and many floodgates have been installed which greatly affects water flows and quality. The Ballina Bypass and proposed Tintenbar to Ewingsdale upgrade of the Pacific Highway also has potential implications for water quality in this zone during the construction phase.

Urban areas are located in the lower reaches and comprise West Ballina and the Ballina Quays canal estate. Commercial oyster leases exist in the Richmond River adjacent to this zone. The freshwater reach of Maguires Creek receives treated wastewater from the Alstonville STP. Boat launch facilities, a slipway and limited mooring sites exist in the lower sections of Emigrant Creek. Current boating facilities are not meeting demand (GHD, 2005).

Plate 3: Active erosion of topsoil from young Macadamia plantation

Source: P. Dwyer

The lower estuarine areas of Emigrant Creek are fringed with mangrove areas in good condition (Australian Wetlands, 2010). The riparian width varies from 50m wide to less than 10m where landuse

or roads come close to the creek edge. There are some areas of bank erosion in this reach identified as being impacted by boat wash. The riparian zone along much of the main Richmond River Channel is generally devoid of vegetation, with rock walls providing the only protection against bank erosion for much of the length.

The lower Emigrant Creek estuary downstream of the Pacific Highway Bridge contains significant shallow water shoals with a significant area of seagrass at the confluence with the main Richmond River Estuary. The shoals provide feeding and nursery habitat to various fish and other vertebrate and invertebrate species. The Creek is more dominated by freshwater than North Creek reflecting the greater in-filling of the lower floodplain, and higher freshwater inflows. The lower reaches of the system are also impacted by flood tide inputs of catchment runoff water from the main Richmond River estuary during high and post-high flow periods.

The mid and upper sections of this zone are identified as an ASS Hotspot (Tulau, 1999). Acid water runoff has been noted as affecting water quality in the mid and upper reaches, however tidal flushing in the lower reaches largely mitigates this issue.

The Ballina Quays Canal Estate located in West Ballina has been observed to be a confounding factor in blackwater fish kills. The design of the canals is such that it captures blackwater flow from the Richmond River cutting off fish escape and resulting in fish kills in the canals. Plate 4 shows a distinct blackwater plume entering the estate.

Plate 4: Blackwater plume entering Ballina Quays Estate after a moderate summer flood in January 2006

Source: C. Cooksey, 2006

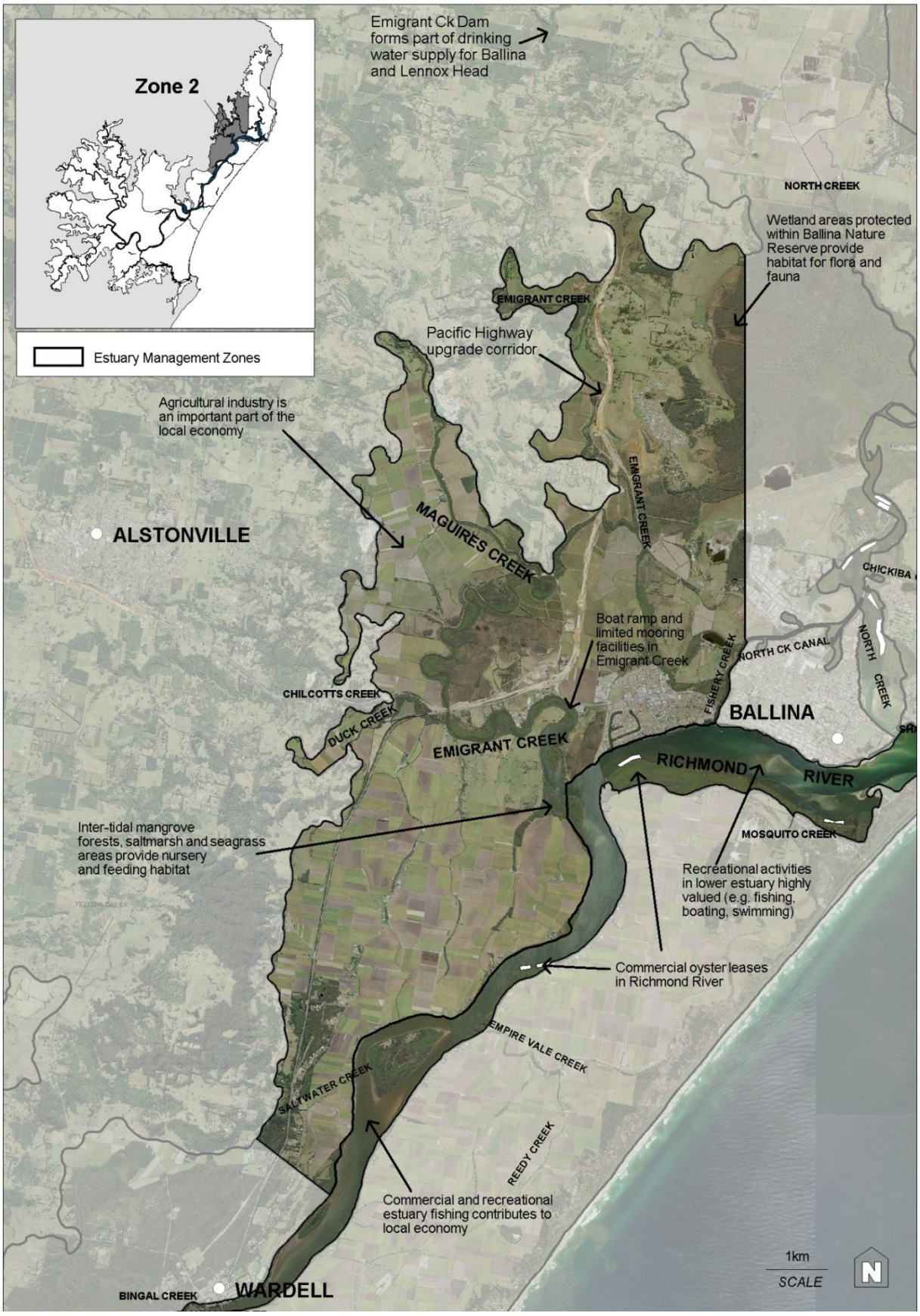


Figure 10 – Zone 2 Emigrant/Maguires Creek: Major Features

Source: aerial photography provided by RRCC

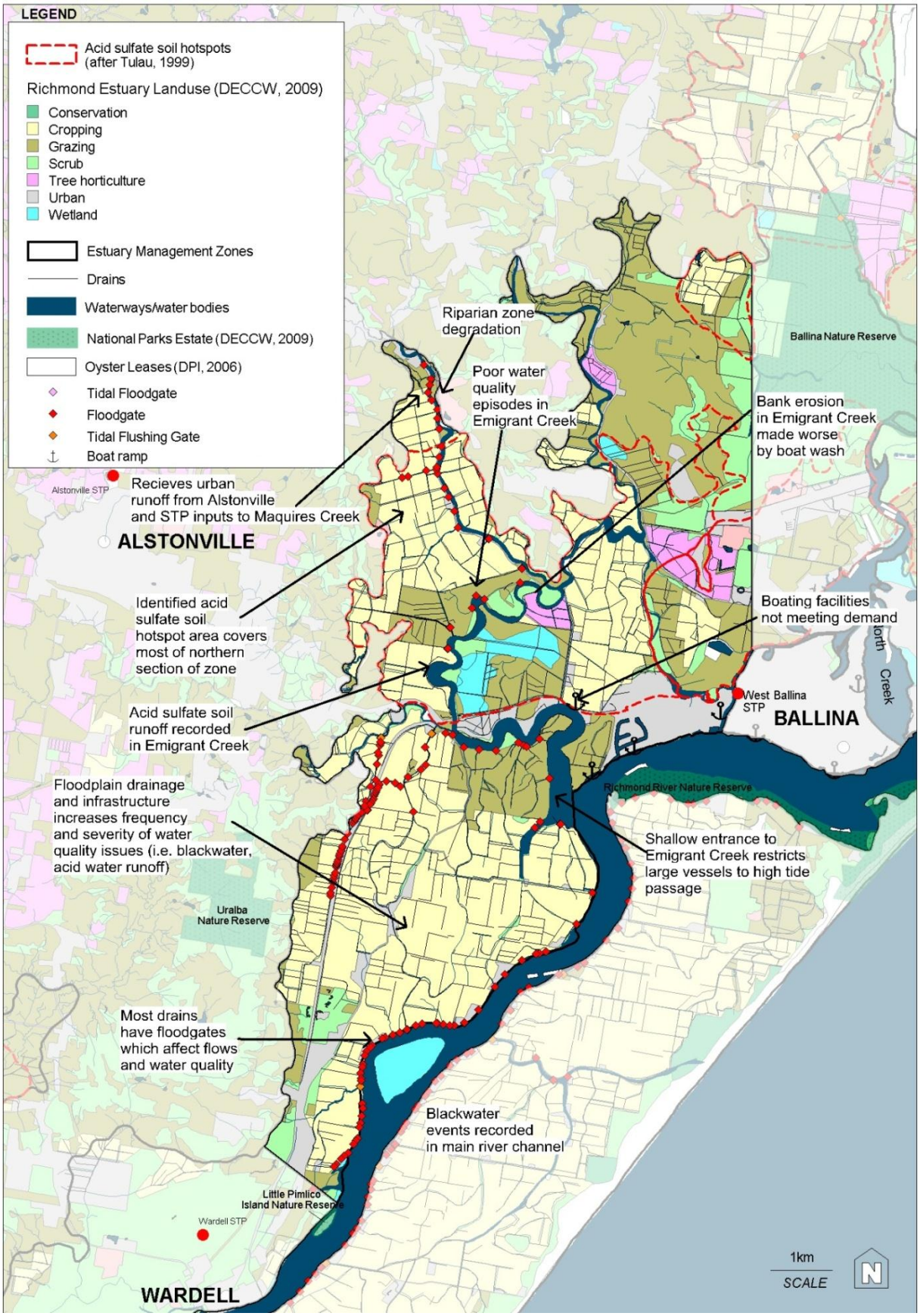


Figure 11 - Zone 2 Emigrant/Maguires Creek: Management Issues

3.4 Zone 3 – Back Channel

The Back Channel management zone is located on the western bank of the main Richmond River Estuary adjacent to Wardell, within the Ballina local government area. It has a discrete catchment bounded from the south, west and northwest by the Blackwall Range (refer Figure 12).

This zone consists of floodplain cleared for agriculture in the upper section with a large Crown Reserve in the middle parts, and estuary in the lower reaches. The Crown Reserve comprising remnant heath/swamp vegetation is drained by small channels feeding Bingal Creek, which enters the Richmond River Estuary just upstream of the Wardell Pacific Highway Bridge. A large area of cane farming exists south of Wardell, extending to the bank of the Richmond River. Urban areas of Wardell and small grazing leases make up the remaining areas. Wardell STP discharges treated wastewater to the Richmond River downstream of the main town. The proposed route for the Pacific Highway upgrade traverses the alluvial floodplain, although work has not begun on this section to date. Several quarries also exist in the southern end of this zone.

The Back Channel management zone includes the bank of the Richmond River near Wardell. The northern bank of the river has a healthy mature (>10 year old) corridor of mangroves and riparian vegetation with 30-60% native cover in the canopy and understorey (Australian Wetlands, 2010). On the southern side, the riparian vegetation is very narrow to non-existent in places. 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 land use.

Bingal Creek is a shallow waterway that flows into the main Richmond River channel above Wardell. Along its banks, intertidal mangrove wetlands (up to 60m wide) extend approximately 2.5km upstream of Wardell.

There are relatively few issues identified for this zone due primarily to the large areas of intact vegetation located within the Crown Reserve, occupying much of its area. Bingal Creek represents a rare example of what many of the flood-gated creeks to the Richmond would have looked like in a more natural state. Due to the relatively sparse representation in the main channel, Bingal Creek represents valuable wetland habitat for fish and invertebrates and it will be important to conserve this existing area into the future. One exception is some of the intertidal habitat in this reach of the main estuary which has been reduced by clearing and in-filling for sugarcane production (WBM, 2006).

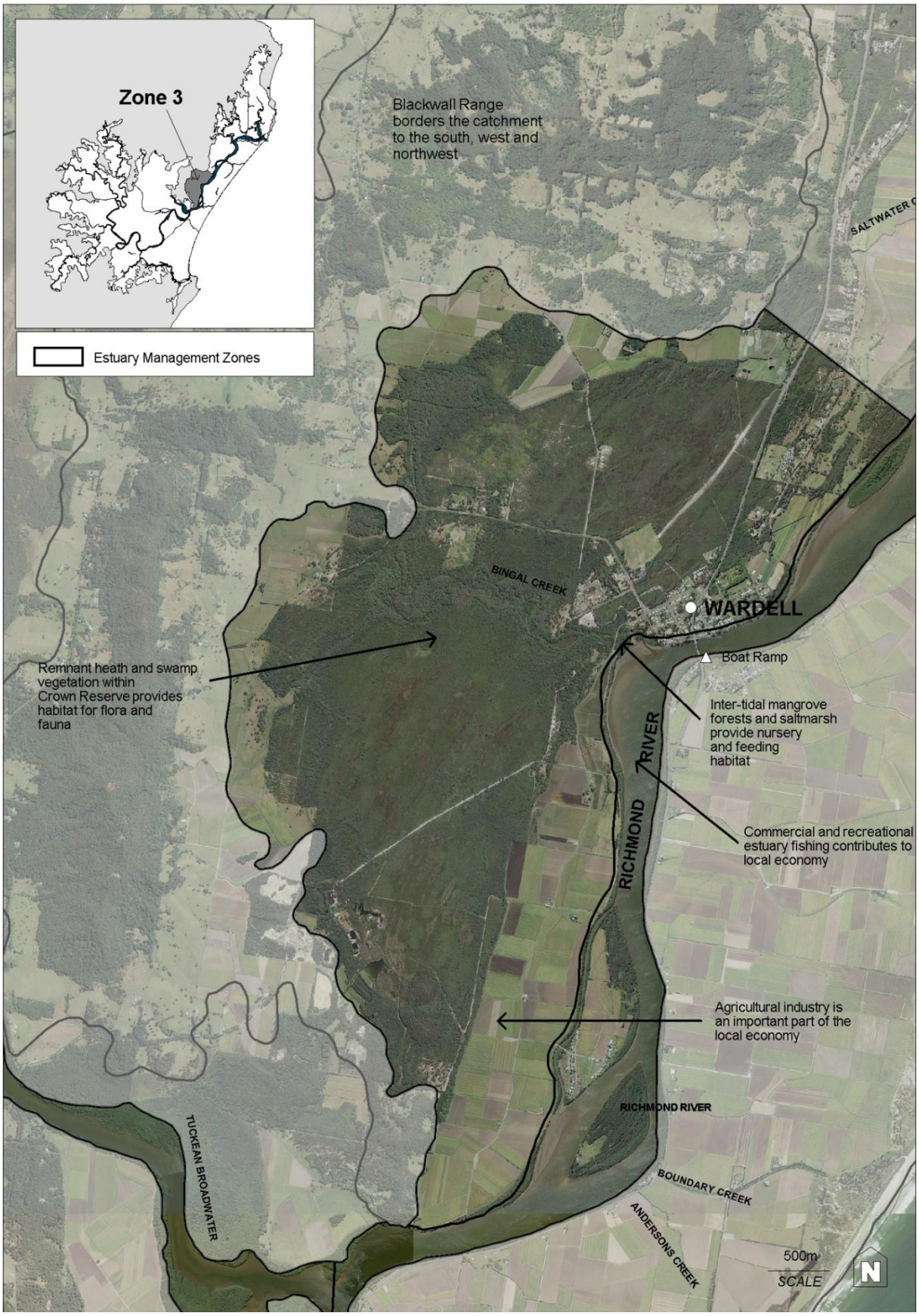


Figure 12 – Zone 3 Back Channel: Major Features

Source: aerial photography provided by RRCC

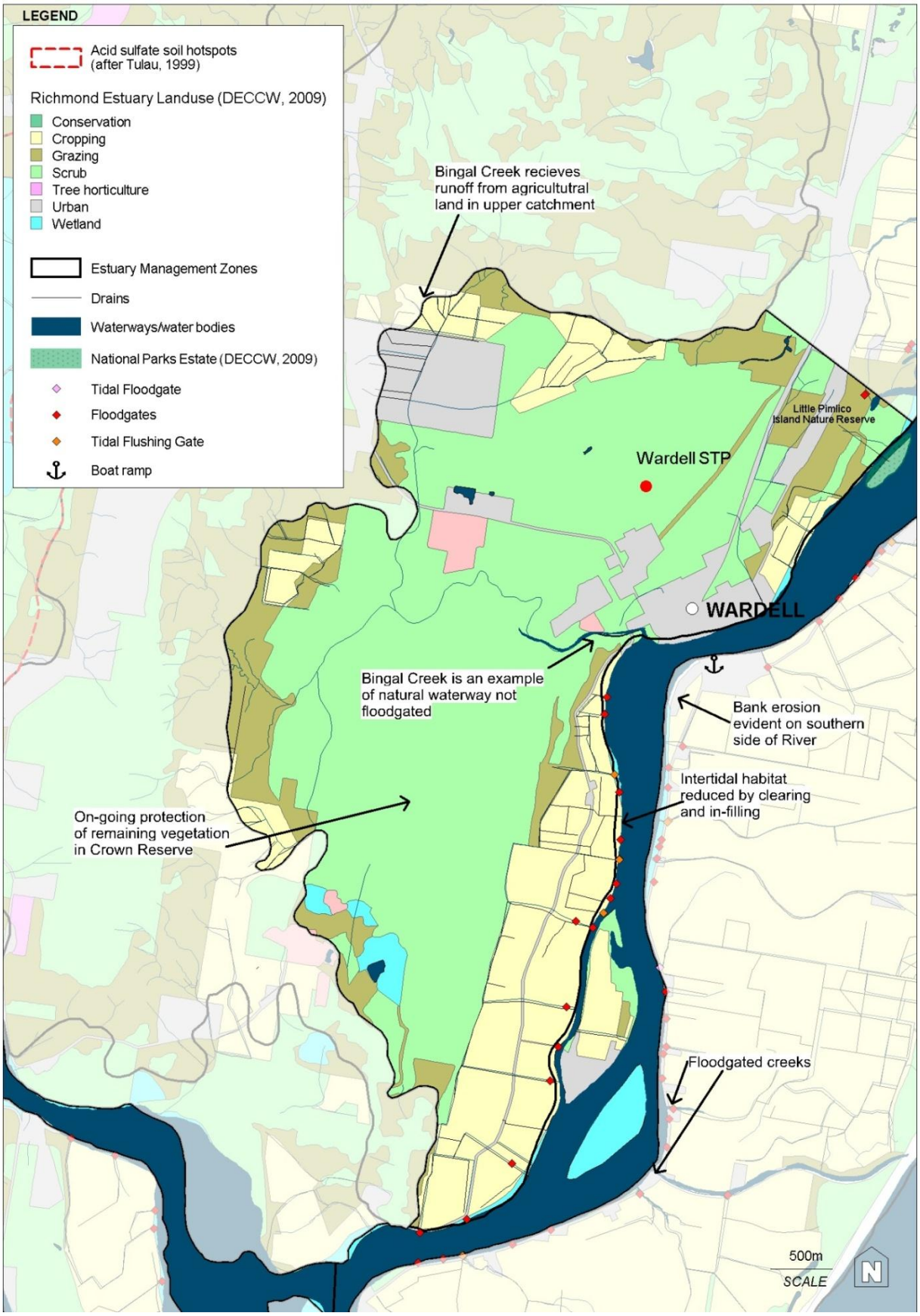


Figure 13 – Zone 3 Back Channel: Management Issues

3.5 Zone 4 – South Ballina/Empire Vale

The South Ballina / Empire Vale management zone encompasses extensive floodplain on the eastern side of the estuary stretching from South Ballina to Broadwater. The floodplain includes barrier dune ridges along its eastern fringe and predominantly alluvial sediments across the bulk of the floodplain. This northern part of this zone is within the BSC local government area and the southern section south of Boundary Creek is within the Richmond Valley council area.

Sugar cane farming accounts for the majority of the land area within this zone. Grazing, rural residential areas and fragmented conservation areas make up the remainder of land uses. Drainage of the floodplain is enhanced by a network of highly modified natural drainage depressions which discharge to the main Richmond River channel at various locations. Tidal exchange into these channels is controlled by tide gates at the confluence with the main river channel. Mangroves are extensive within the Richmond River Nature Reserve along the Richmond River adjacent to South Ballina Beach Road. Several large floodgates feed into the river along the zone. Mobbs Bay is a high use area for recreational boaters, jet skiers, water skiers and fishers and contains a significant roosting and breeding area for various resident and migratory shorebirds and important areas of seagrass and some commercial oyster leases. Scattered stands of casuarinas, littoral rainforest and seasonal wetlands form important habitat along the eastern (coastal) fringe of this zone.

Plate 5: Mangrove community within Richmond River Nature Reserve

Empire Vale Creek enters the Richmond River Estuary at Pimlico Island and tidal exchange is controlled by tide gates at the confluence. The lower reach of Empire Vale Creek has intermittent bands of riparian forest up to 50m wide. Infield drains are largely devoid of riparian vegetation throughout the floodplain. The area to the north of Empire Vale Creek drains north via a series of constructed drains discharging in the Mobbs Bay reach of the lower estuary. A significant stand of intertidal mangroves (up to 140m wide) exists adjacent to the mouth of Empire Vale Creek. The remainder of the riparian zone along much of the main Richmond River Channel is generally devoid of vegetation. The river foreshore upstream of the Burns Point Ferry is rock armoured for most of its length.

The lower reaches of this zone are highly visible from the town of Ballina and contribute significantly to the aesthetic appeal of the estuary.

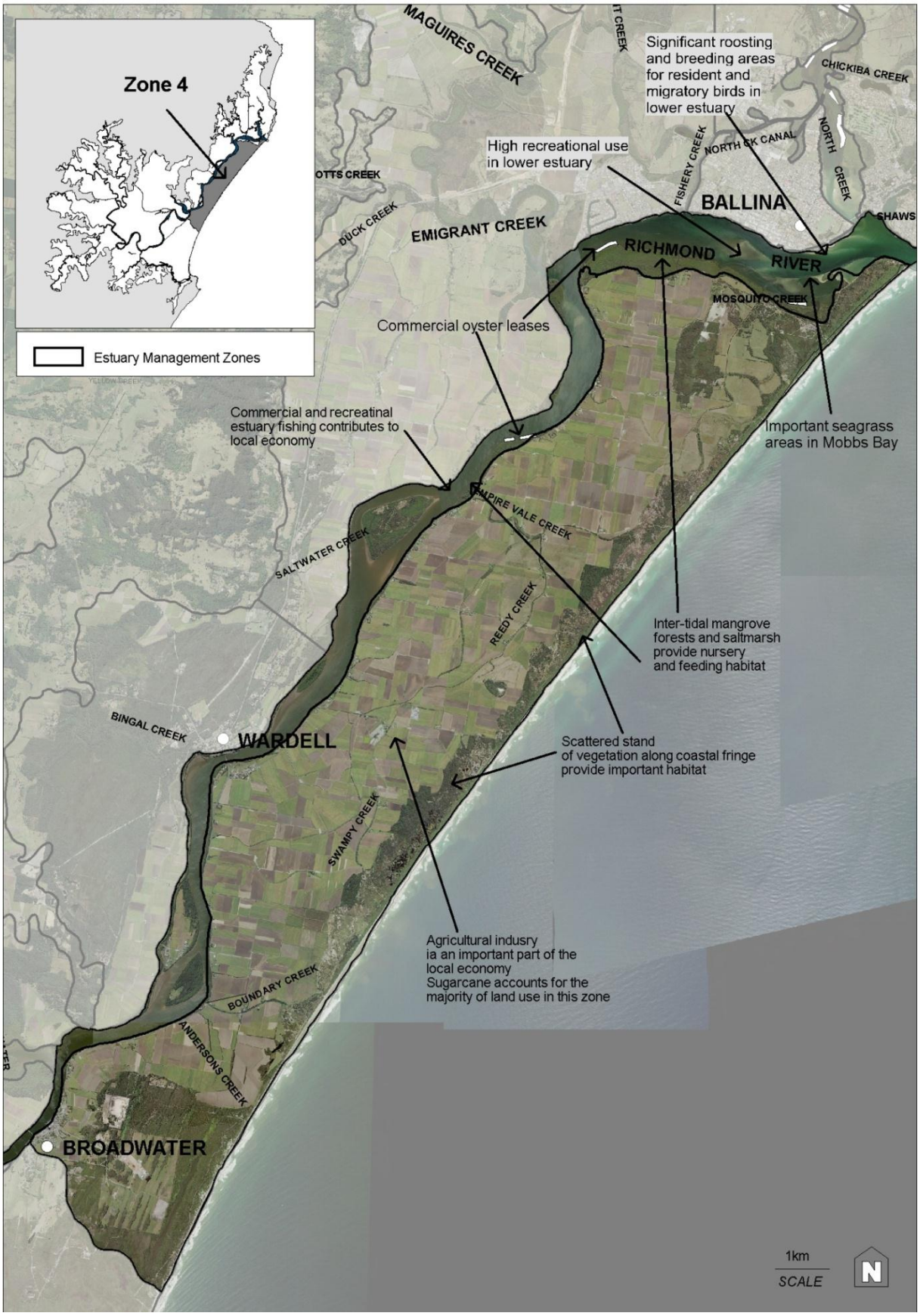


Figure 14 – Zone 4 South Ballina/Empire Vale: Major Features

Source: aerial photography provided by RRCC

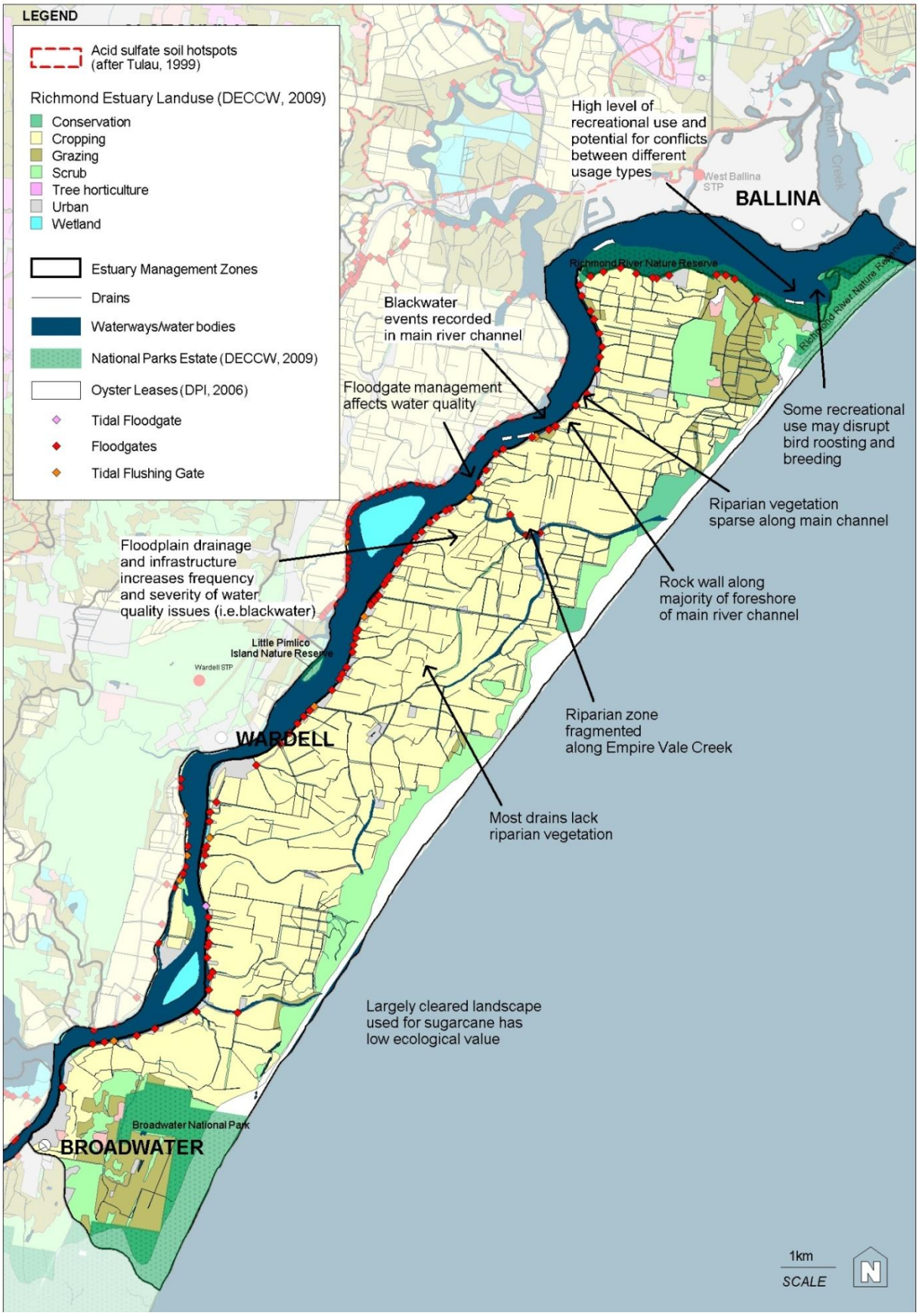


Figure 15 - Zone 4 South Ballina/Empire Vale: Management Issues

3.6 Zone 5 – Riley's Hill

The Rileys Hill Management Zone is relatively small in relation to other zones and is located upstream of Broadwater bordering the right bank of the Richmond River.

This zone is within the Richmond Valley council area and consists of cleared floodplain now used for sugar cane production, grazing and small areas of urban development. The north-west section of Broadwater National Park constitutes the central portion of this zone. Remnant vegetation protected within the National Park provides important habitat for flora and fauna including critical habitat for the endangered Oxleyan Pygmy Perch (Figure 16). The main Richmond River bank retains a fringe of mangroves for most of the management zone. Boat launch facilities exist in this zone and WBM (2006) noted access issues due to high use of existing facilities. The Riley's Hill STP discharges to the Richmond River upstream of Broadwater.

The riparian vegetation in this zone varies along the length of river bank from some coverage (riparian width >10m) with some remnant native vegetation to very limited cover. The understorey vegetation was degraded with few native species. Land use activities and road infrastructure are encroaching on the riparian zone. Drainage in this zone occurs via modified distribution channels within agricultural areas and most channels connect directly to the Richmond River (Grotzinger *et al*. 2007).

Plate 6: Riley's Hill Boat Ramp

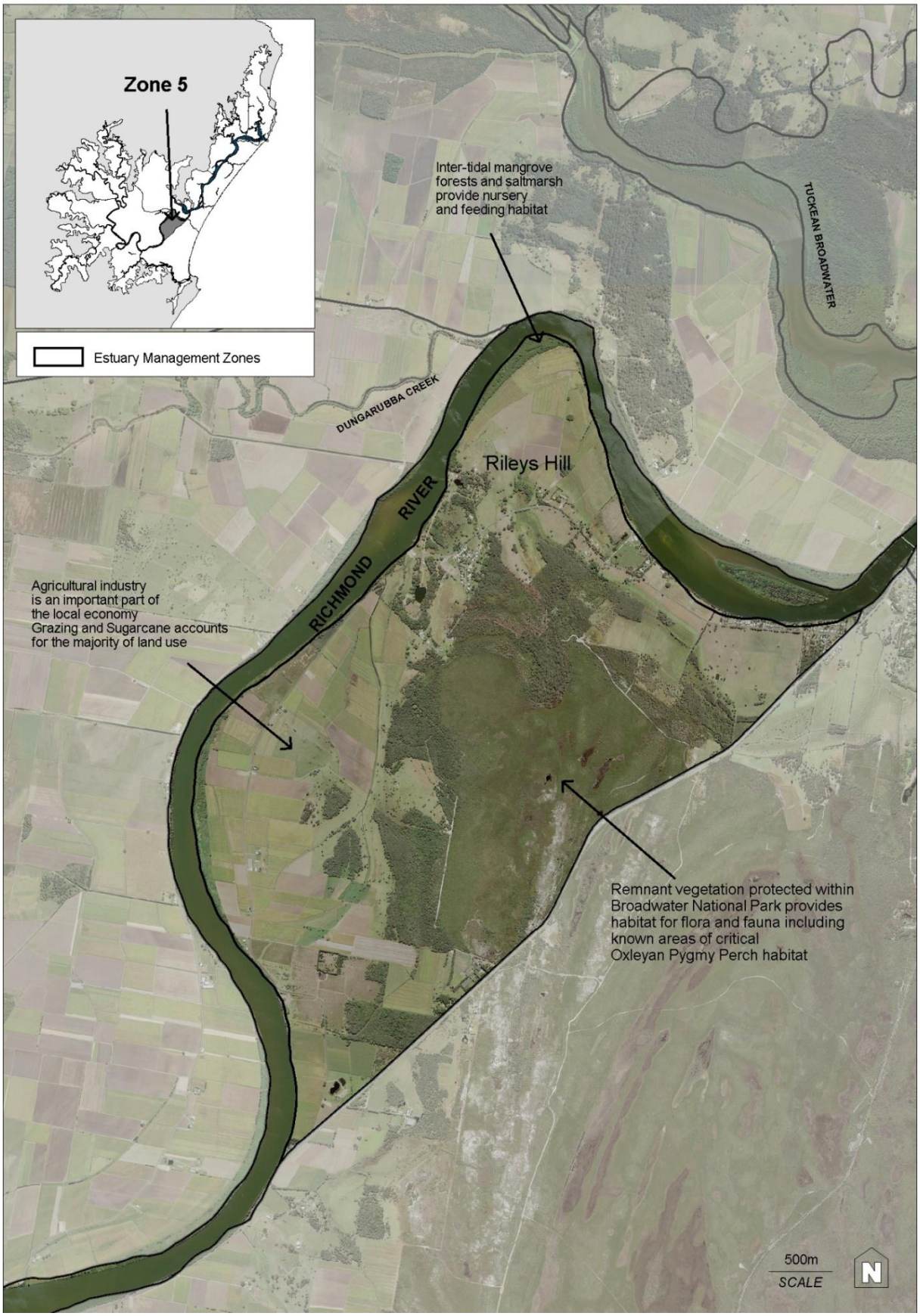


Figure 16 – Zone 5 Riley's Hill: Major Features

Source: aerial photography provided by RRCC

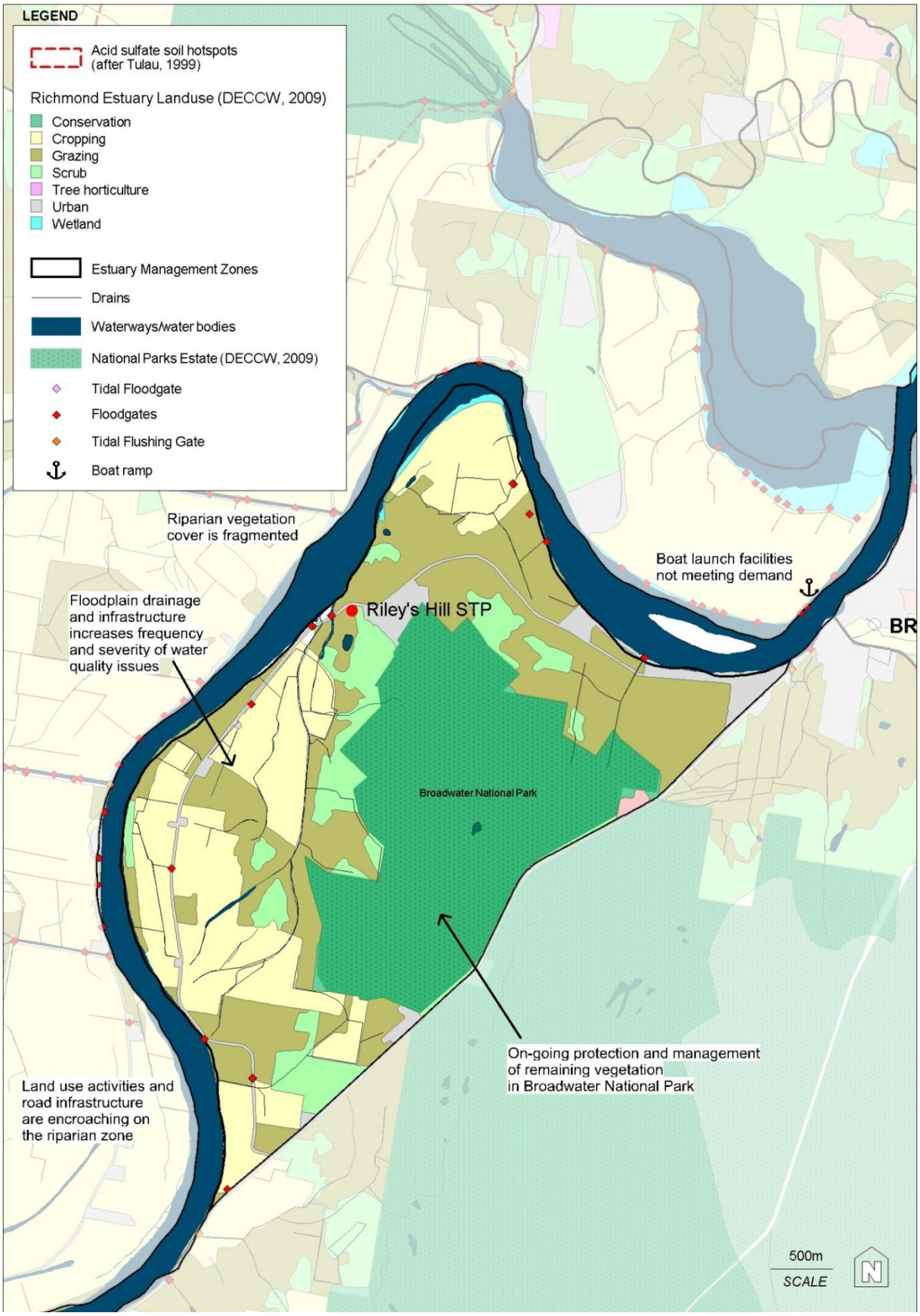


Figure 17 - Zone 5 Riley's Hill: Management Issues

3.7 Zone 6 – Evans River

The Evans River Management Zone extends from the ocean, west to the Richmond River bounded in the north by Boundary Creek and in the south by the Evans River floodplain. A major feature of this zone is the Tuckombil Canal which is an artificial channel connecting the Richmond River via Rocky Mouth Creek to the Evans River (Figure 18). Tuckombil Canal Weir effectively separates the Evans River and the Richmond River during normal flow reducing sediment transport and mixing. However during flooding it provides flood escape to the Evans River which lowers flood levels in the lower Richmond River. The Evans River Estuary Management Study and Plan was completed and adopted by Richmond Valley Council in 2002 and contains a suite of management actions for this estuary. This zone is within the RVC local government area.

Broadwater and Bundjalung National Parks make up a significant portion of the land area in this zone, with some cleared floodplain to the west and urban areas in Evans Head township which is located adjacent to the ocean entrance of the river. The western cleared floodplain originally covered in healthland and swamp vegetation is now used for agriculture including cattle grazing.

At the upstream end of the Evans River, former swamps were cleared and subsequently drained to form agricultural land. Lowering of the natural water table in these areas has increased acid runoff which can significantly lower the pH of the receiving waters, and along with low oxygen conditions, can lead to a stressed ecological environment (WBM, 2002). 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.

Plate 7: Bare riparian zone and active bank erosion along Tuckombil Canal

Sawpit Creek, Brandy Arm Creek and Oyster Creek drain the elevated ridgelines of the Evans River. A management plan for the Tuckombil Canal was completed by RRCC in 2009. It recommends the maintenance of the concrete weir installed in the canal in 2001 as a permanent structure.

RVC has completed an Estuary Processes Study (1999) and Estuary Management Study and Plan (2002) for the Evans River and is currently preparing the Evans Head Coastline Hazard and Estuarine Water Level Definition Study.

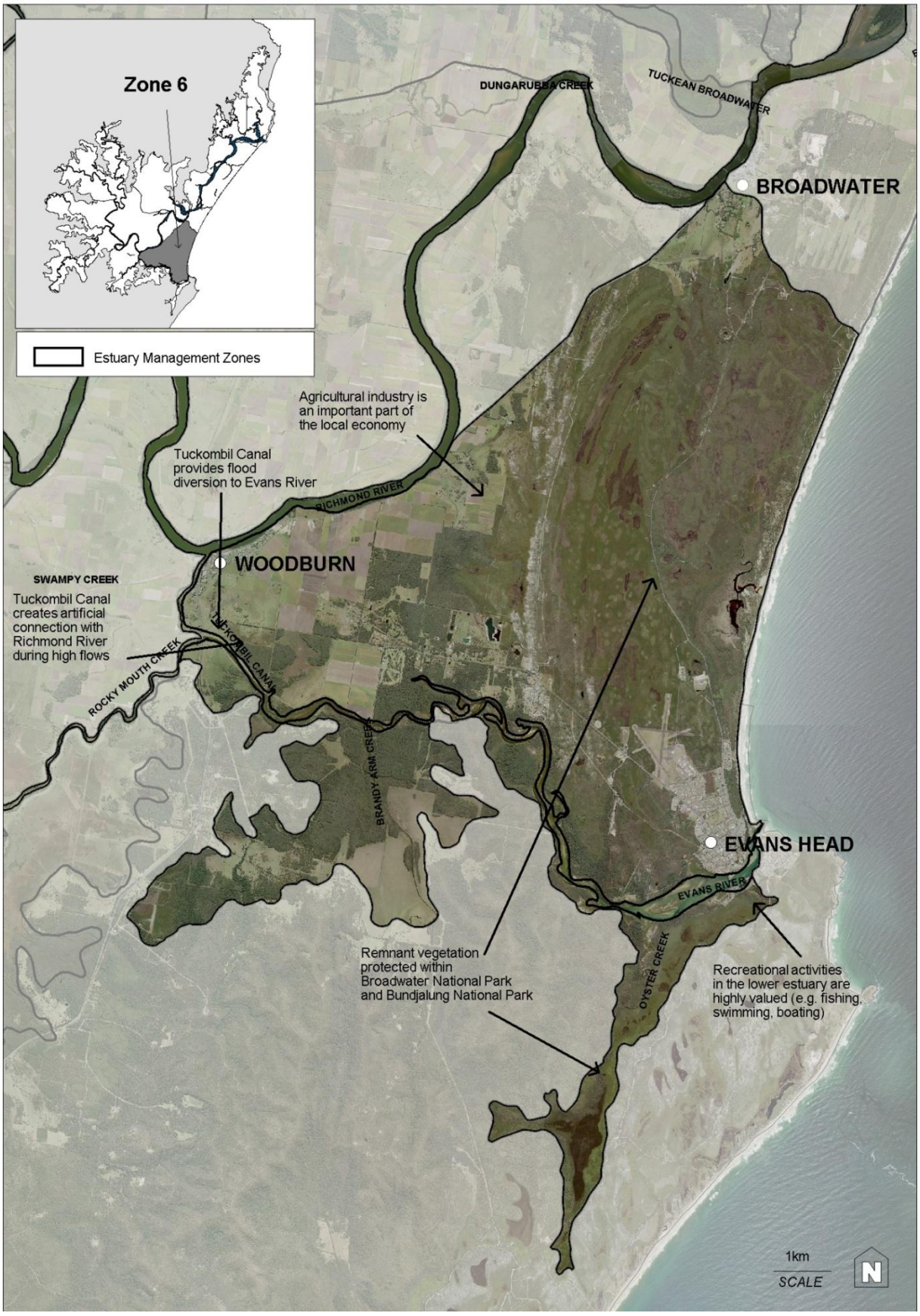


Figure 18 – Zone 6 Evans River: Major Features

Source: aerial photography provided by RRCC

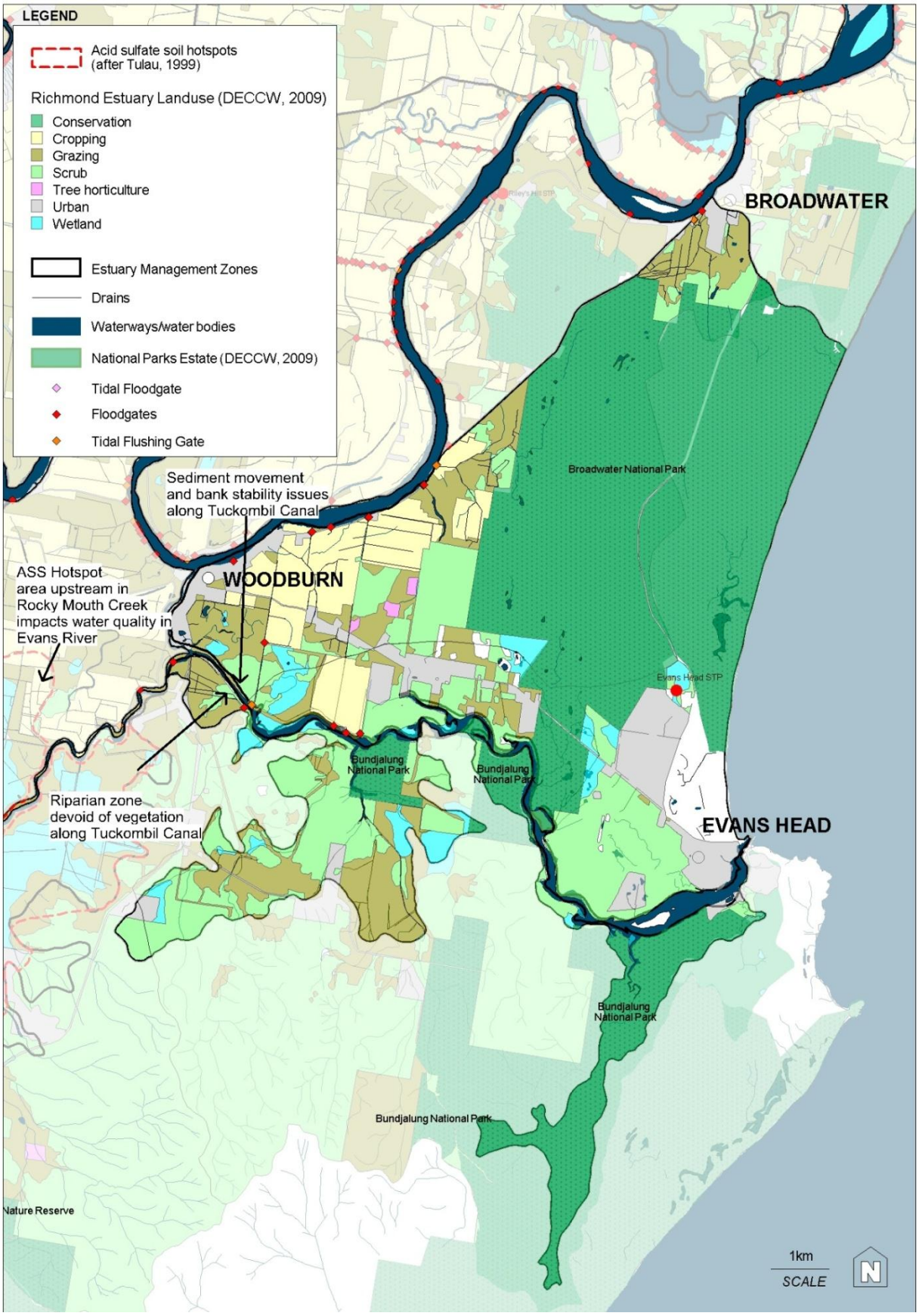


Figure 19 – Zone 6 Evans: Management Issues

3.8 Zone 7 – Rocky Mouth Creek

This zone comprises a low relief backswamp catchment draining via Rocky Mouth Creek to the confluence with the Richmond River Estuary at Woodburn. The backswamp floodplain is an in-filled estuarine embayment, and recent survey as part of the Richmond Flood Study has revealed the large backswamp basin has elevations of <1mAHD with some areas below sea level and subject to regular tidal movement. This zone is within the boundaries of Richmond Valley council area (Figure 20)

Significant drainage modification and riparian clearing has occurred in this zone. Current land use is dominated by cane farming and grazing. Eutrophication is common in the creek and high nutrient levels are likely to be caused by diffuse agricultural sources (ABER, 2008). There are extensive ASS deposits surrounding the south western reach of the creek. Drainage across the backswamp has been augmented by constructed drains which have led to widespread oxidation of ASS. Much of Rocky Mouth Creek Zone has been identified as an ASS hotspot area (refer Section 7.5.1). The backswamp areas of Rocky Mouth Creek have also been identified as one of the three major sources of blackwater to the estuary (Wong *et al*., 2010). At the time of high flow flood events there is considerable bank instability and erosion in this zone. Floodgates in Rocky Mouth Creek operate to limit inundation of the upper Rocky Mouth Creek catchment from Richmond River floods. In non-flood times the floodgates are opened to allow tidal flows for water quality improvements and fish passage.

The vegetation along the riparian zone of Rocky Mouth Creek is dominated by a weedy canopy of Cockspur Coral Tree (*Erythrina crista-galli*). Camphor Laurel (*Cinnamomum camphora*) is also a major canopy weed along Rocky Mouth Creek. The canopy cover is less than 30% with almost no native species. Pasture grasses dominated the understorey. Bank erosion is significant in areas devoid of vegetation.

Plate 8: Weed encroachment along Rocky Mouth Creek

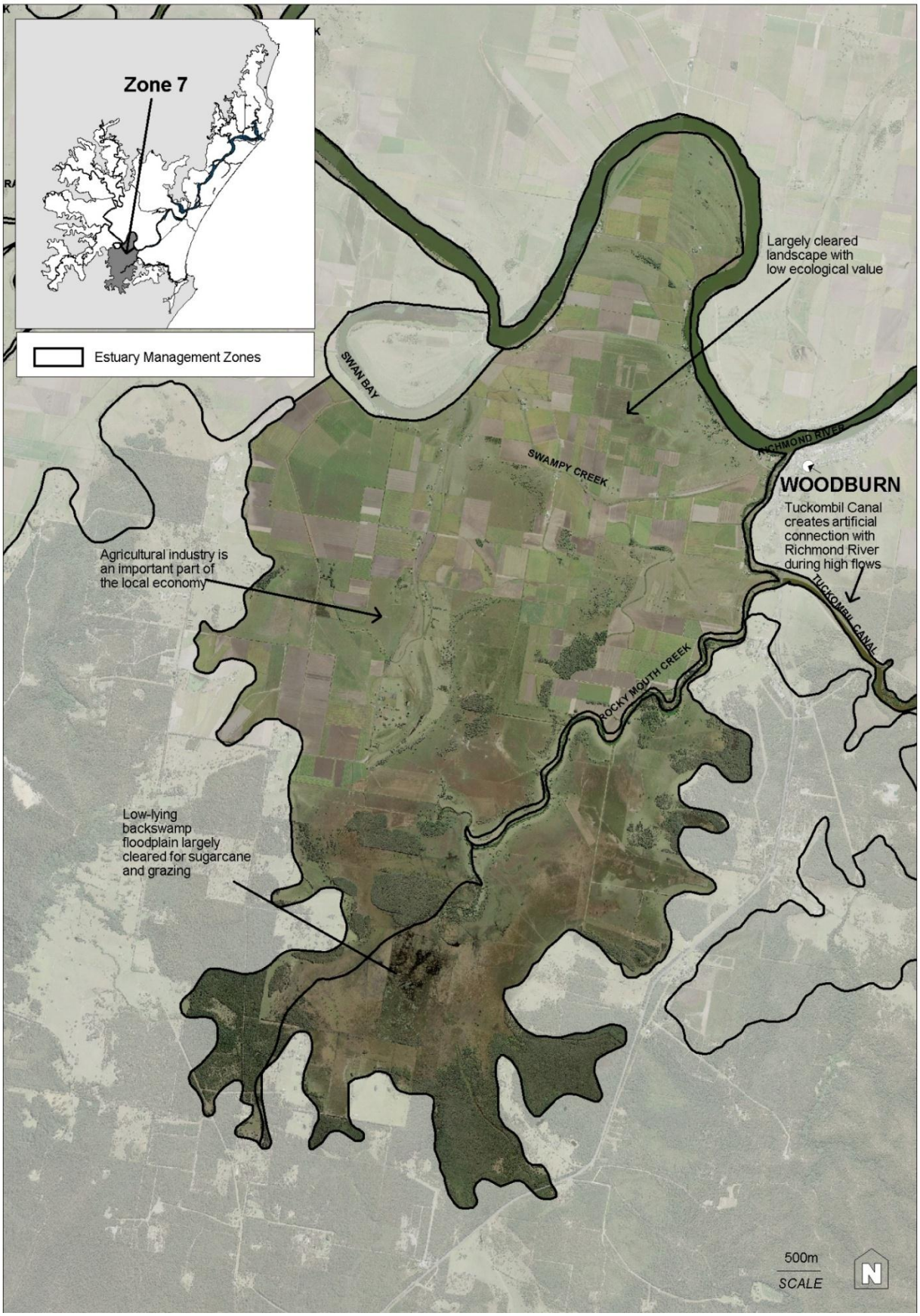


Figure 20 - Zone 7 Rocky Mouth Creek: Major Features

Source: aerial photography provided by RRCC

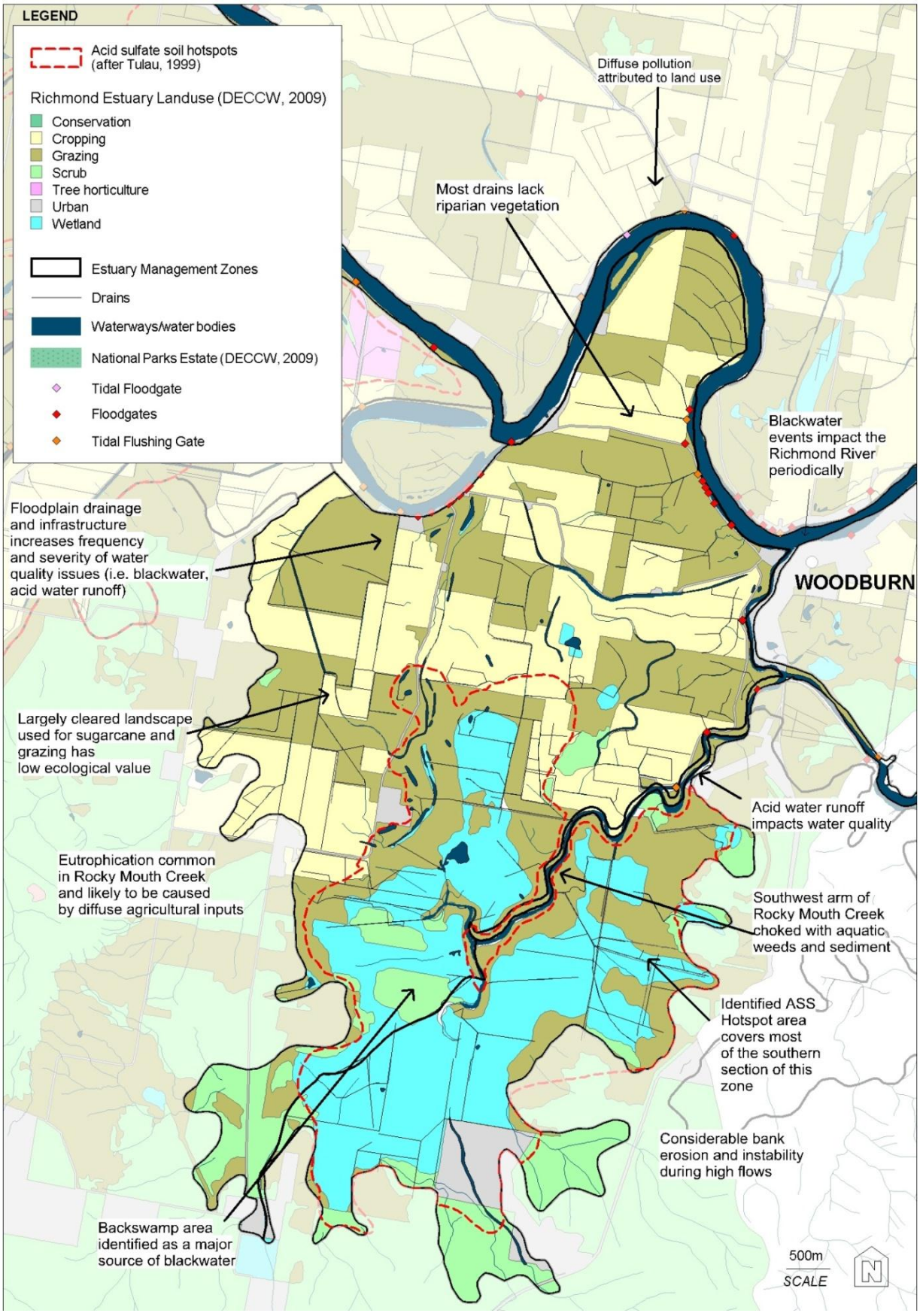


Figure 21 - Zone 7 Rocky Mouth Creek: Management Issues

3.9 Zone 8 – Swan Bay

Swan Bay is an oxbow partially cut-off lagoon, adjacent to the Richmond River, 8.3 km upstream of Woodburn, within the Richmond Valley council area (Figure 22). Its catchment constitutes a small part of the floodplain between the Rocky Mouth Creek backswamp and the lower Bungawalbin floodplain. Freshwater inputs to the bay are via four constructed drains. The downstream end of the bay is connected to the main estuary by a narrow channel. This waterway is recognised as an important fish nursery and water bird habitat.

Plate 9: Aquatic and Riparian weeds Swan Bay

Source: M. Wood

Swan Bay is surrounded by cattle grazing, tea tree and cane farming land where the native vegetation has been predominately cleared. The area is prone to weed and algae blooms indicative of nutrient enrichment and eutrophication. Periodic moderate acidification has been detected by water quality monitoring (ABER, 2008).

There is a narrow, fragmented riparian zone along the inland bank of Swan Bay, and no riparian zone along any of the drains (Australian Wetlands, 2010). Bank erosion is evident in areas devoid of riparian vegetation. Riparian vegetation on the northern bank of Swan Bay extending to the start of Swan Bay Road is dominated by native riparian species. The canopy cover is over 30% and up to 60% with a high percentage of native species.

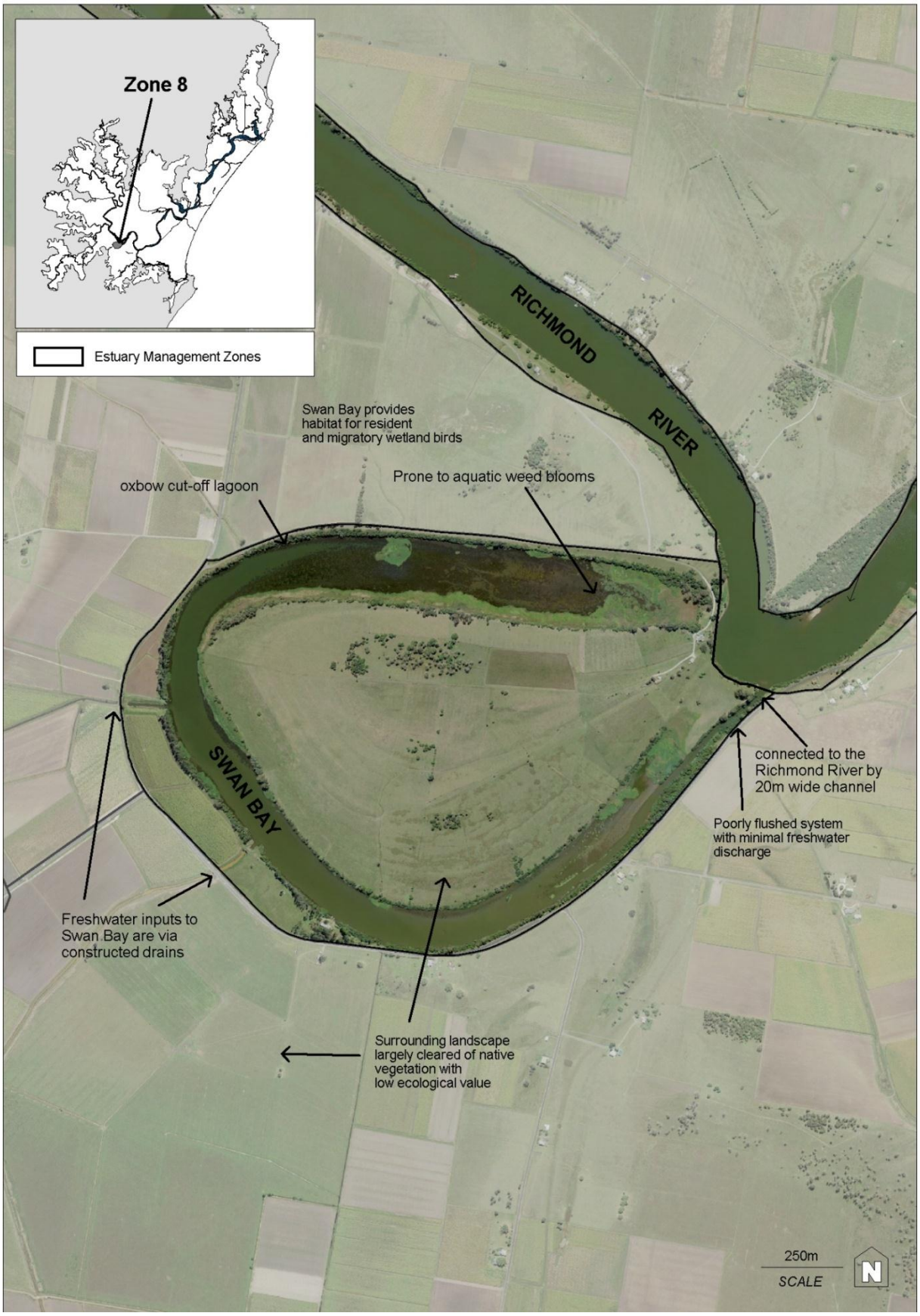


Figure 22 – Zone 8 Swan Bay Major Features

Source: aerial photography provided by RRCC

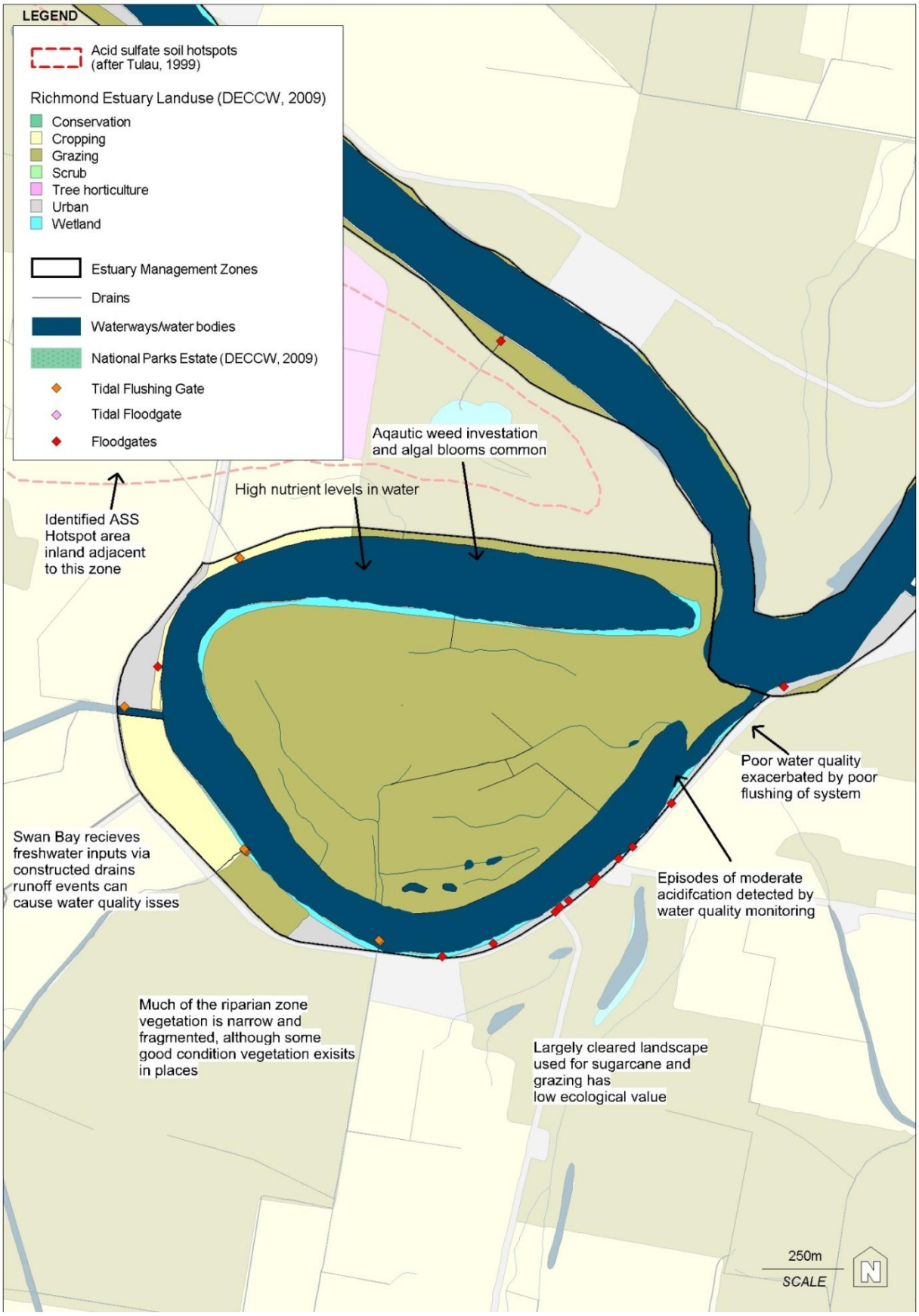


Figure 23 - Zone 8 Swan Bay: Management Issues

3.10 Zone 9 – Kilgin/Buckendoon

The Kilgin / Buckendoon management zone includes the Dungarubba area and comprises the extensive floodplain extending to Coraki to the west, and Woodburn in the south. This zone lies within the Lismore council area.

The floodplain has been extensively cleared of native vegetation. It contains large areas of relatively rich alluvial sediments which are currently under sugarcane, and large areas of estuarine backswamp sediments cleared for grazing. There are areas of ASS within these backswamps, although no hotspot areas have been identified in this zone. Acid water runoff from this and adjacent zones also affects water quality in the main river channel. The floodplain is drained by a network of constructed drainage channels and one natural creek line, Dungarubba Creek, entering the Richmond River Estuary via headworks spanning from Oakland Road to about 4.5kms upstream of Broadwater. This zone was identified by ABER (2008) as having a high risk of poor water quality, primarily associated with low dissolved oxygen.

There is little or no riparian vegetation along any of the drains, and the main river channel is also devoid of riparian vegetation for much of the length of this zone. Dungarubba Creek is the one example of a natural creek line with a largely intact riparian zone (Figure 24).

Plate 10: An isolated remnant of lowland rainforest on floodplain located on southern side of Tuckean Swamp at Dungarubba

Source: G. Owers, 2010

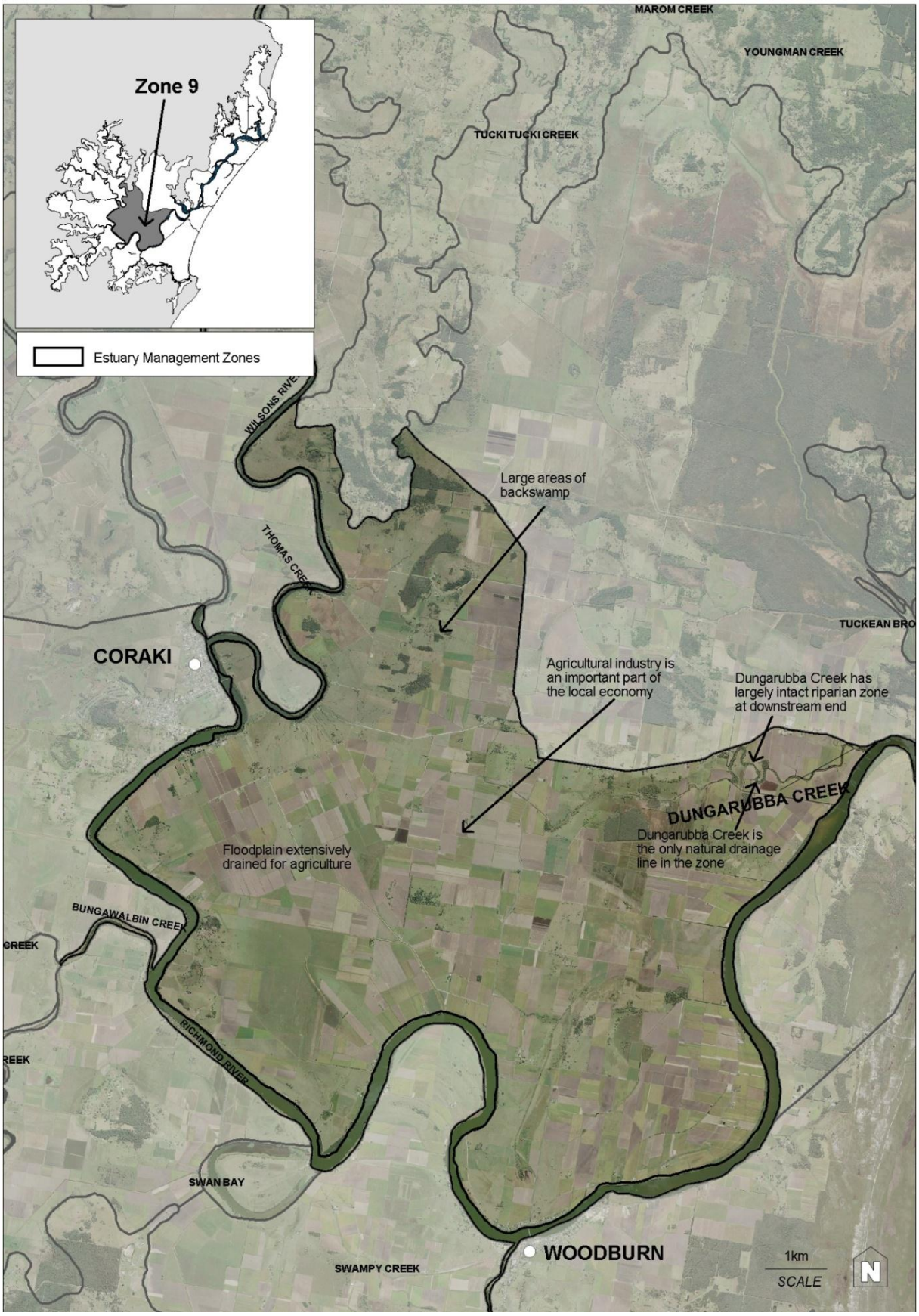


Figure 24 – Zone 9 Kilgin/Buckendoon: Major Features

Source: aerial photography provided by RRCC

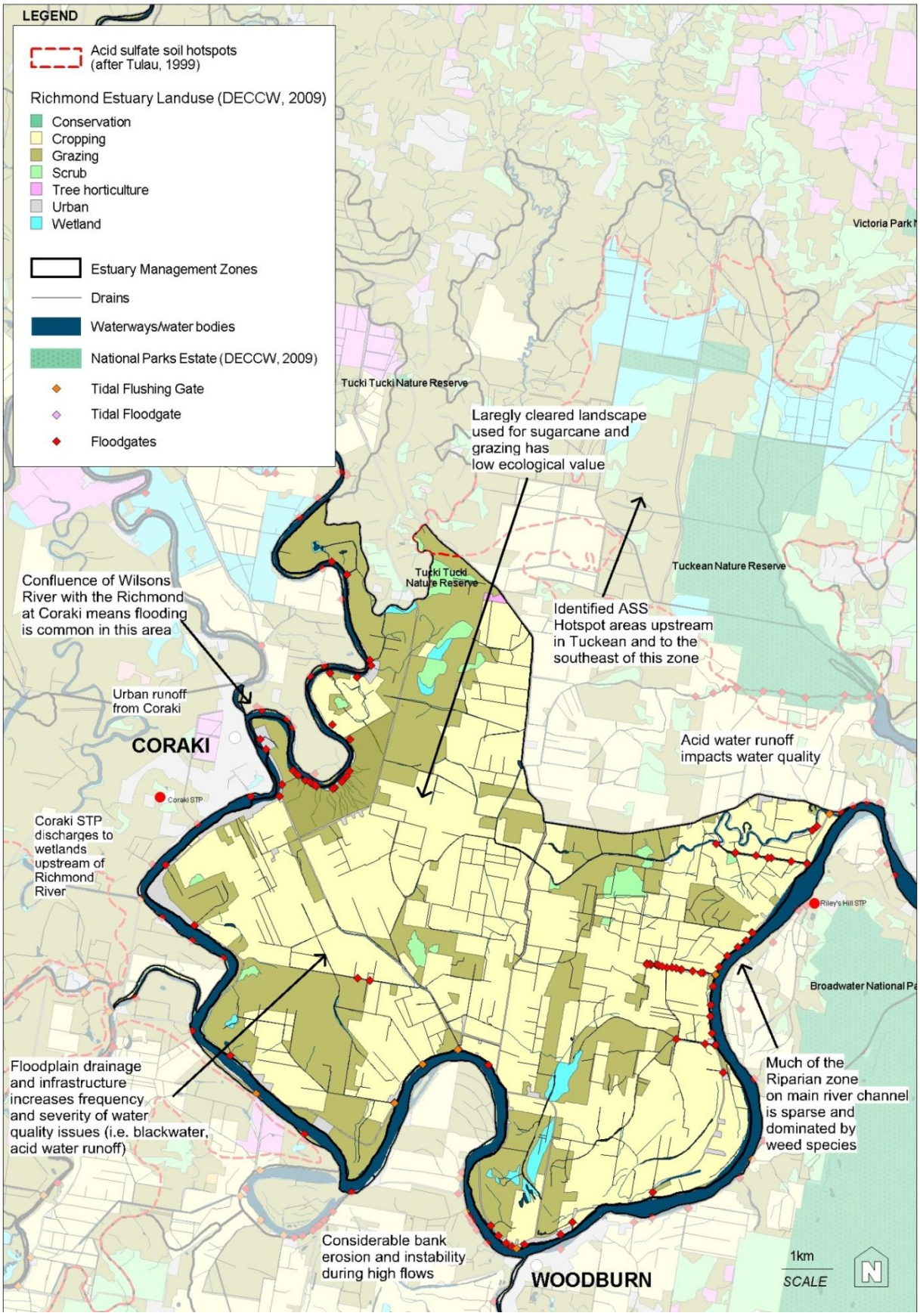


Figure 25 - Zone 9 Kilgin/Buckendoon: Management Issues

3.11 Zone 10 – Tuckean

Tuckean Swamp is an extensive, low-lying backswamp floodplain (5,000ha) receiving runoff via five creek systems from the upper catchment on the Alstonville Plateau (Marom Creek, Tucki Tucki Creek, Youngman's Creek, Gum Creek and Yellow Creek). The large backswamp areas are at elevations of mostly <1mAHD which is at or below sea level. Water exits the catchment via a tidal reach known as the Tuckean–Broadwater (Baldwin, 1997). A tidal barrage, known as the Bagotville Barrage, is located at the confluence of the drainage network to the south. The barrage is fitted with a series of floodgates providing a discharge point to the Richmond River (Figure 26). The majority of this zone is within the LCC local government area with the eastern portion lies within the BSC local government area.

The Tuckean Swamp is extensively drained and dominant land uses are sugar cane and cattle grazing. Upper catchment land uses are more varied including significant areas of macadamia orchards and mixed horticulture. Tuckean Nature Reserve occupies a large area (1,300 acres) of this zone.

There are significant management issues in the Tuckean that affect the health of the Richmond River estuary downstream. The eastern and north-eastern regions of the Tuckean backswamp contain large areas of actual ASS and potential ASS deposits. The area was identified by Tulau (1999) in ASS hotspot mapping and is one of the largest areas of ASS in NSW (WBM, 2006). Peat fire risk is also heightened within drained and/or ASS areas, where the peat dries out and vegetation dies off and becomes fuel. Peat fires are known to occur in the Tuckean and can last for several months, only to be extinguished by flooding. In addition, the Tuckean has one of the highest recorded concentrations of monosulfidic black ooze (MBO) reported in the world (Bush *et al*., 2004). The backswamp areas of the Tuckean have been identified as one of the three major sources of blackwater to the estuary (Wong *et al*., 2010).

Plate 11: Acid scald in the Tuckean

Source: M. Wood

Despite major issues with ASS and blackwater, the Tuckean also contains areas of high value vegetation. High Conservation Vegetation including Endangered Ecological Communities exist along the eastern side of this zone including Swamp Sclerophyll Forest on Coastal Floodplains, Sub-tropical Coastal Floodplain Forest, Swamp Oak Forest, and Freshwater Wetlands on Coastal Floodplains. Important but isolated small remnants of vegetation remain among sugarcane land in the south of the zone and their protection is important to conserve biodiversity values of this area.

The riparian survey undertaken by Australian Wetlands (2010) for the Tuckean zone covered the Tuckean Broadwater between Bagotville Barrage and the confluence with the main river channel. The riparian vegetation was often greater than 50m wide with a high native cover in the canopy (60% - 100%). The riparian vegetation along the main channel near Broadwater Road was highly diverse but narrow and threatened by climbing weeds in places. The riparian vegetation included remnant rainforest species. Several water weeds, transported to the site by flood waters, were evident near the bank.

The Tuckean Broadwater is steadily infilling and narrowing due to the constriction of the Bagotville Barrage. Mangroves have colonised mudflats and all sea grasses have gone. The Bagotville Barrage has also created a separation of vegetation with freshwater *Melaleuca quinquenervia* upstream and Mangroves downstream. Some colonising by mangroves has been recorded since the implementation of tidal flushing in 2002. Of note for management is the encroachment of *Melaleuca quinquenervia* in the backswamp, which is occurring in response to altered hydrology and fire and is impacting the natural biodiversity of the area.

Plate 12: Westerly view of Tuckean Swamp showing drains traversing wetlands in foreground

Source: J. Baldwin, 1997

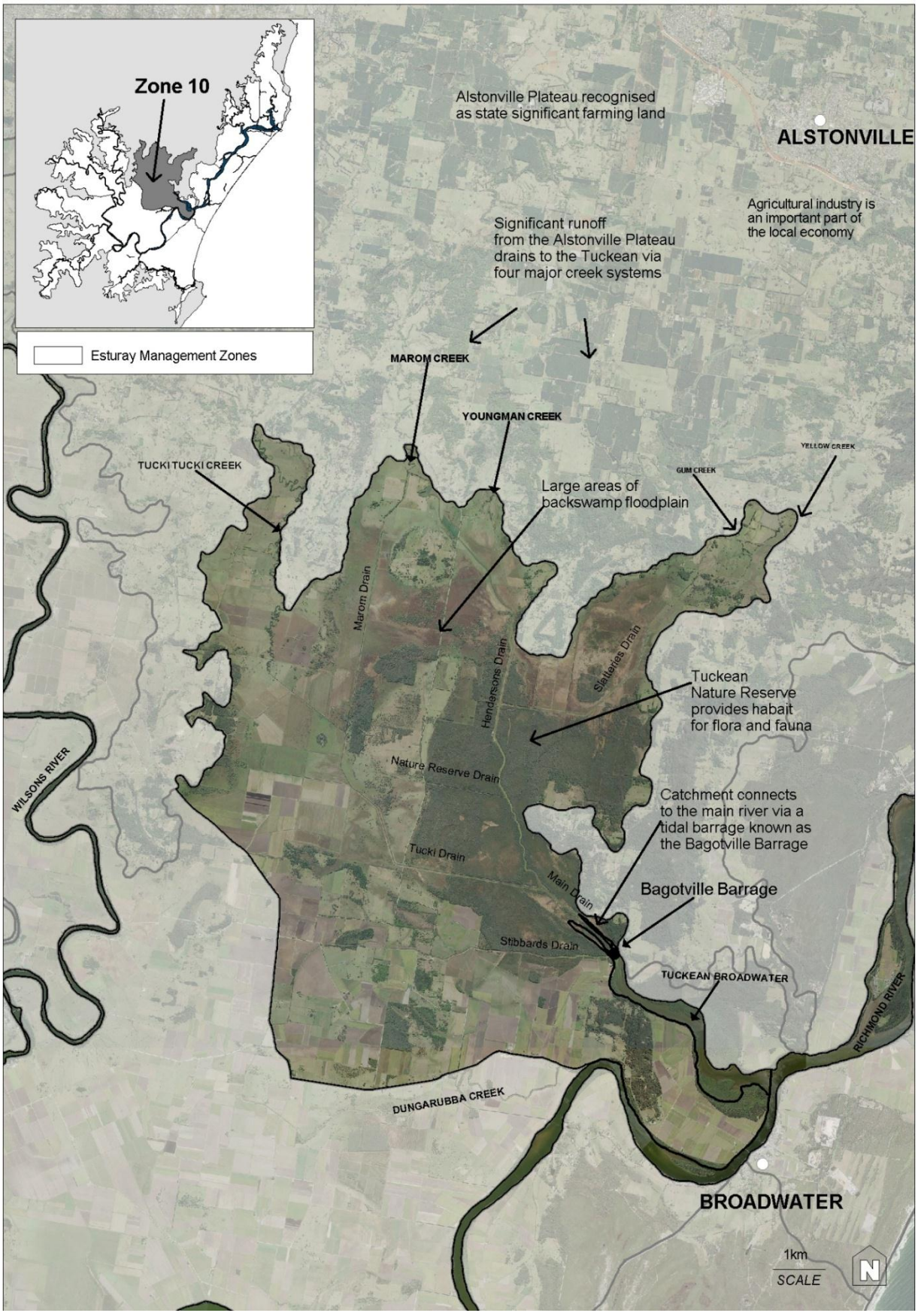


Figure 26 – Zone 10 Tuckean: Major Features

Source: aerial photography provided by RRCC

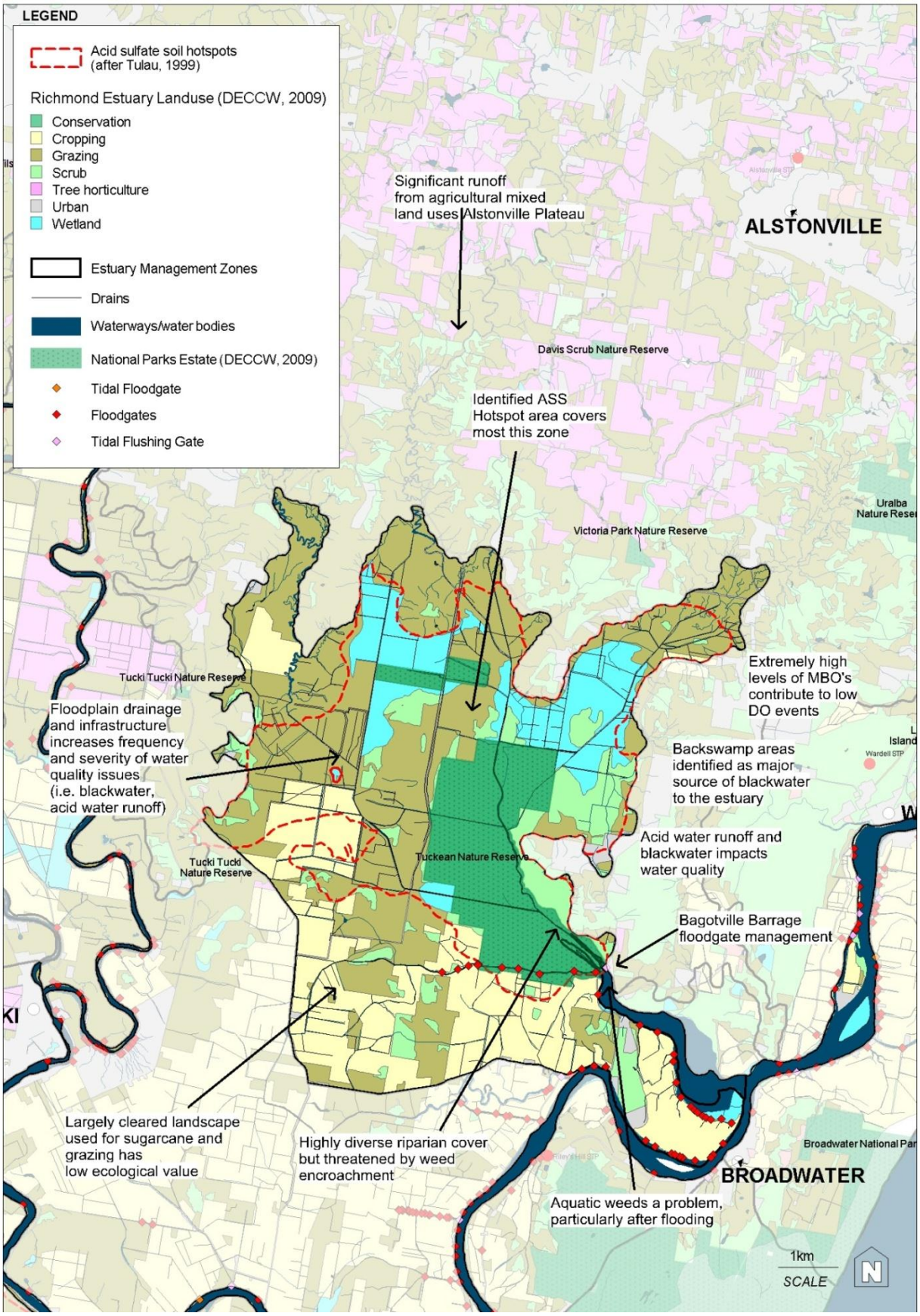


Figure 27 - Zone 10 Tuckean: Management Issues

3.12 Zone 11 – Lower Bungawalbin

The Lower Bungawalbin management zone encompasses both the lower alluvial floodplain reaches of Bungawalbin Creek and the backswamp areas of Sandy Creek. This zone lies within the RVC local government area.

In their natural state, the Kookami and Bora Codrington Swamps, along with the Richmond River paleochannel region to the east of Kookami, constituted an extensive open wetland swamp system with large areas of semi-permanent water bodies (Owers, 2005). Draining of the swamp system began in the late 1800s resulting in widespread shifts away from wetland vegetation and oxidation of ASS (WBM, 2006). Backswamp areas and Sandy Creek have active ASS areas creating considerable acid runoff and have been identified as ASS hotspots (refer Section 7.5.1). The backswamp areas of Bungawalbin and Sandy Creek have also been identified as one of the three major sources of blackwater to the estuary (Wong *et al*., 2010). The Bungawalbin sub catchment is one of the highest contributors of freshwater to the Richmond estuary and as such has a major influence on water quality in the main estuary.

The lower reaches of Bungawalbin Creek feature a meandering tidal channel through the alluvial floodplain with numerous oxbow cutoffs. The riparian zone, along the lower reaches of the creek, is generally narrow and fragmented, while the upper reaches feature extensive tracts of overhanging riparian vegetation.

The Sandy Creek channel becomes shallower as it traverses the Kookami Swamp, where it is augmented by constructed drainage. The Bora Codrington Swamp lies to the south of Kookami, and is drained by a network of constructed drainage at its confluence with Sandy Creek. Riparian vegetation is fragmented along much of Sandy Creek and is largely absent from drains in Kookami, Haughwoods and Bora Codrington Swamp.

All publicly owned floodgates are actively managed. Rehabilitation works have been implemented at Mynumai Lagoon, Bora Creek and Seelim Creek. Drain infilling and groundwater management have been implemented at Haughwoods Canal and Bora Codrington.

Plate 13: Pelicans on a flooded paddock Ellangowan Road, Bungawalbin

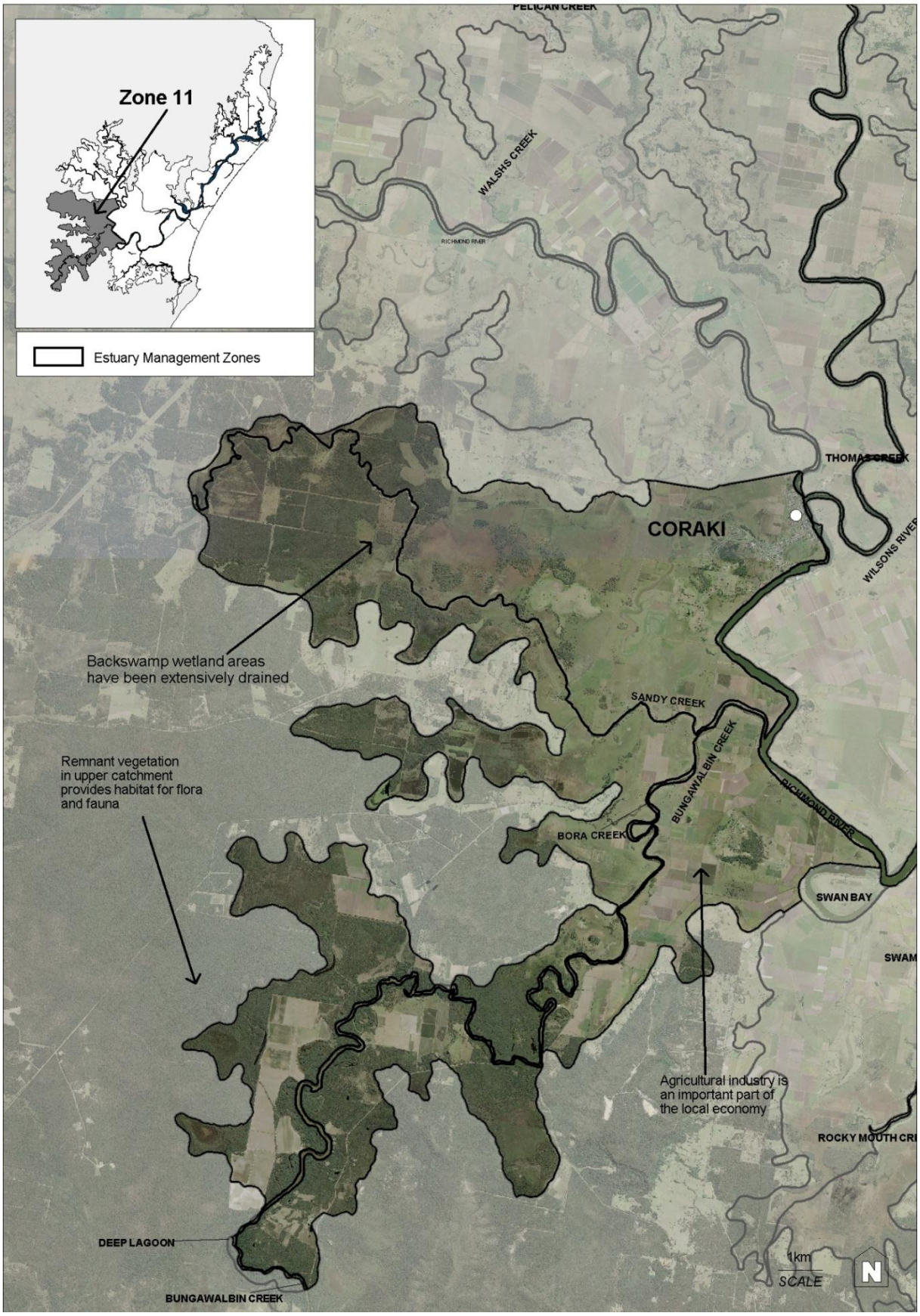


Figure 28 – Zone 11 Lower Bungawalbin: Major Features

Source: aerial photography provided by RRCC

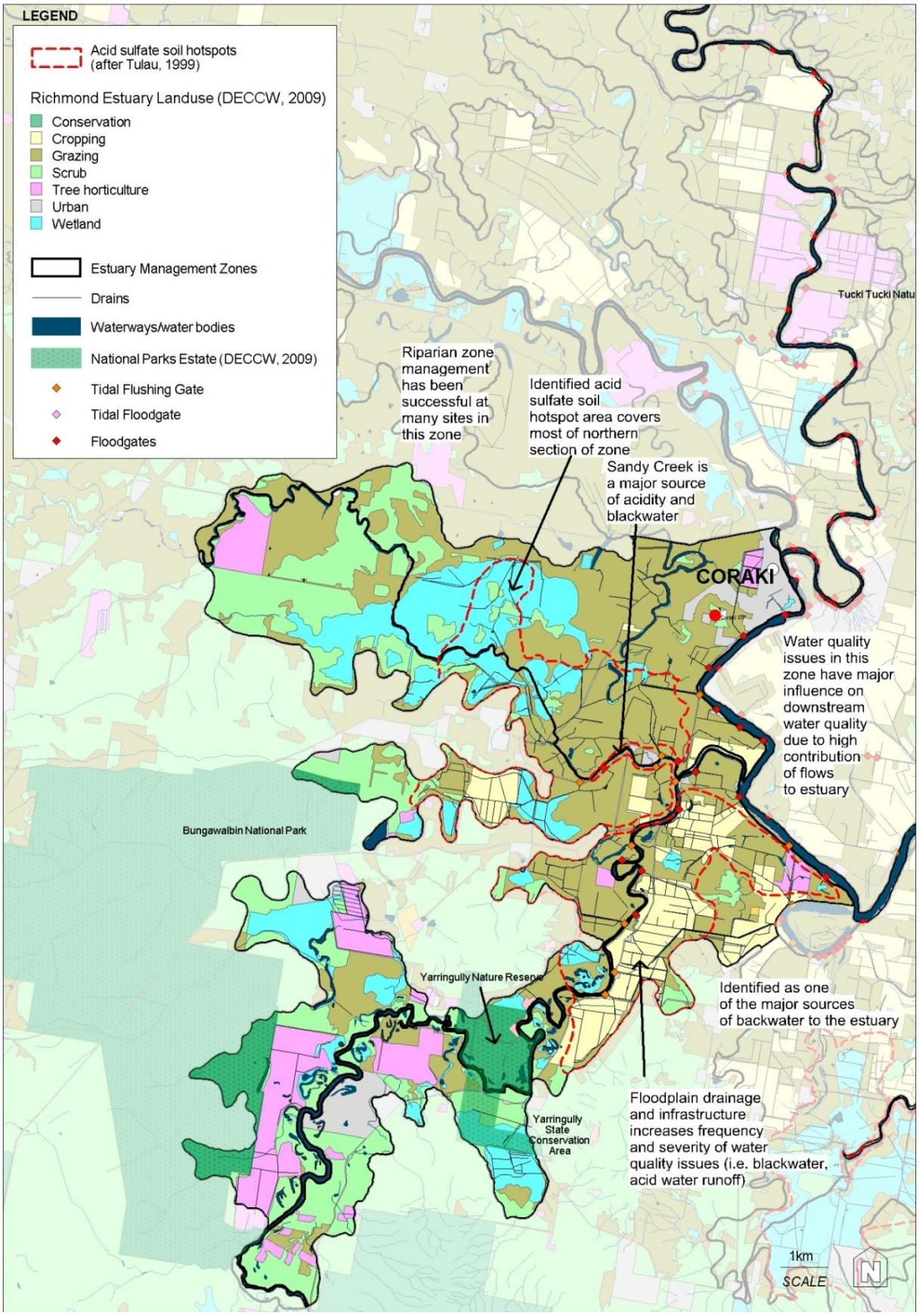


Figure 29 - Zone 11 Lower Bungawalbin: Management Issues

3.13 Zone 12 – Upper Richmond / Wilsons River

The Upper Richmond / Wilsons River management zone encompasses the alluvial floodplains of the Richmond and Wilsons River tidal arms above Coraki. This zone is within the boundaries of both LCC and RVC (Figure 30).

The zone has a large floodplain and catchment area, mainly cleared for agriculture (grazing and cropping). There are also substantial areas of agriculture in the upper catchment areas that contribute to the overall sediment and nutrient load of the estuary. The EPS (WBM, 2006) reported that the Wilsons River catchment was expected to generate the highest phosphorus loads in the Richmond catchment (WBM, 2006). Major urban areas of Lismore and Casino lie upstream of this zone, and the estuary is subject to wastewater discharges and urban runoff from these sources. Much of the area also contains septic tanks and rural residential subdivision is a growing pressure, increasing the septic load in the area. Rous Water has a licence to extract water for town water supply from the tidal pool upstream of Lismore (NSW Office of Water, 2009).

Small areas of remnant vegetation remain within Tucki Tucki Nature Reserve, Ruthven Recreation Reserve and Travelling Stock Reserve. The Pelican Creek Management Plan was completed in 2006 and contains a suite of management actions recommended to improve the ecological values of Pelican Creek. Restoration of Pelican Creek riparian sites was carried out in 2007-2009. Wilsons River is mainly cleared of riparian vegetation with some remnant areas. Bank erosion and slumping was recorded by Australian Wetlands (2010) and attributed mainly to lack of vegetation cover.

Inundation of the upper Wilsons floodplain during floods is considered to be a large contributor of blackwater to the Richmond River Estuary (Eyre *et al*., 2006).

Plate 14: A typical area of floodplain in the lower Pelican Creek Catchment

Source: LCC, 2006

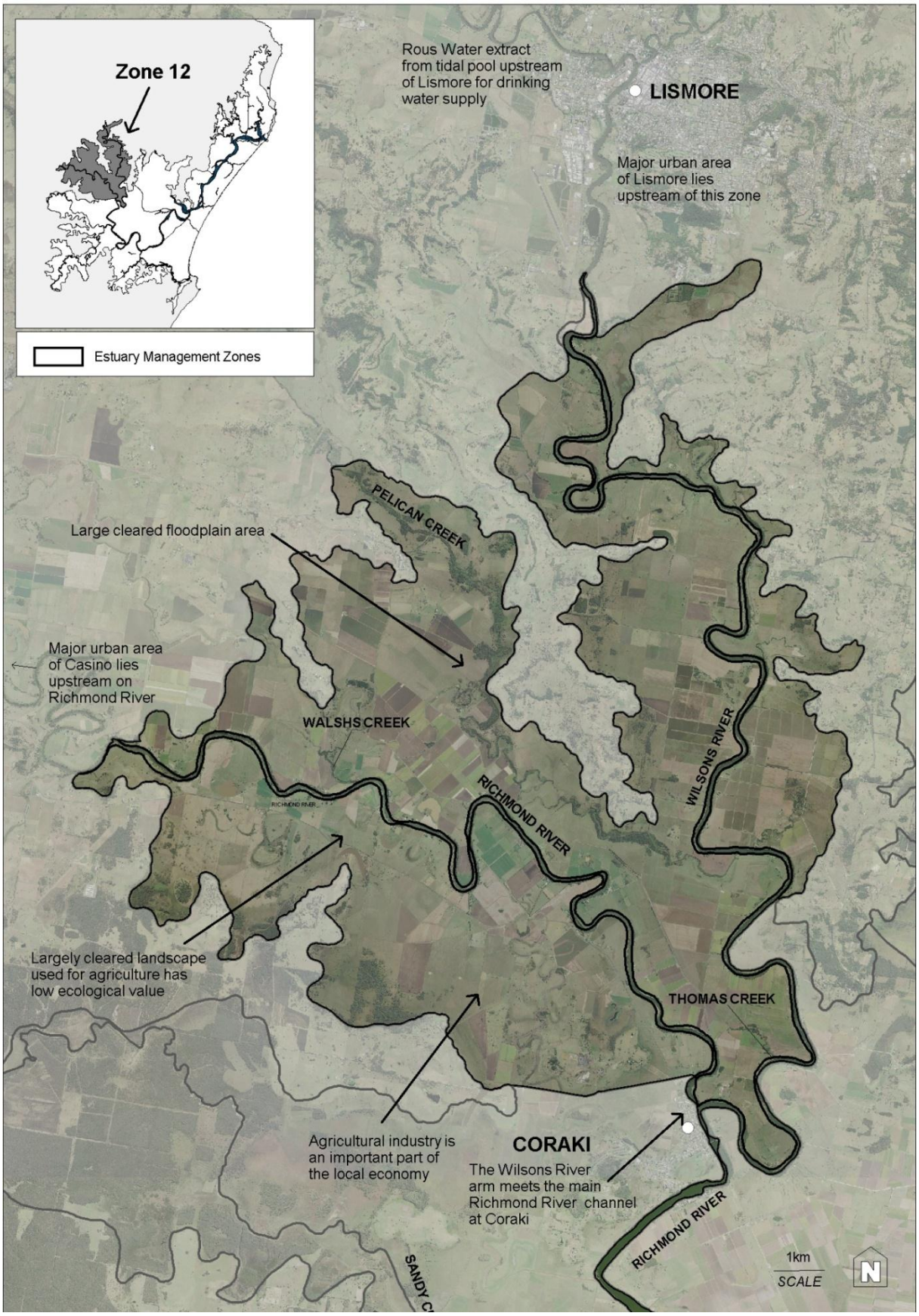


Figure 30 – Zone 12 Upper Richmond / Wilsons River: Major Features

Source: digital imagery provided by RRCC

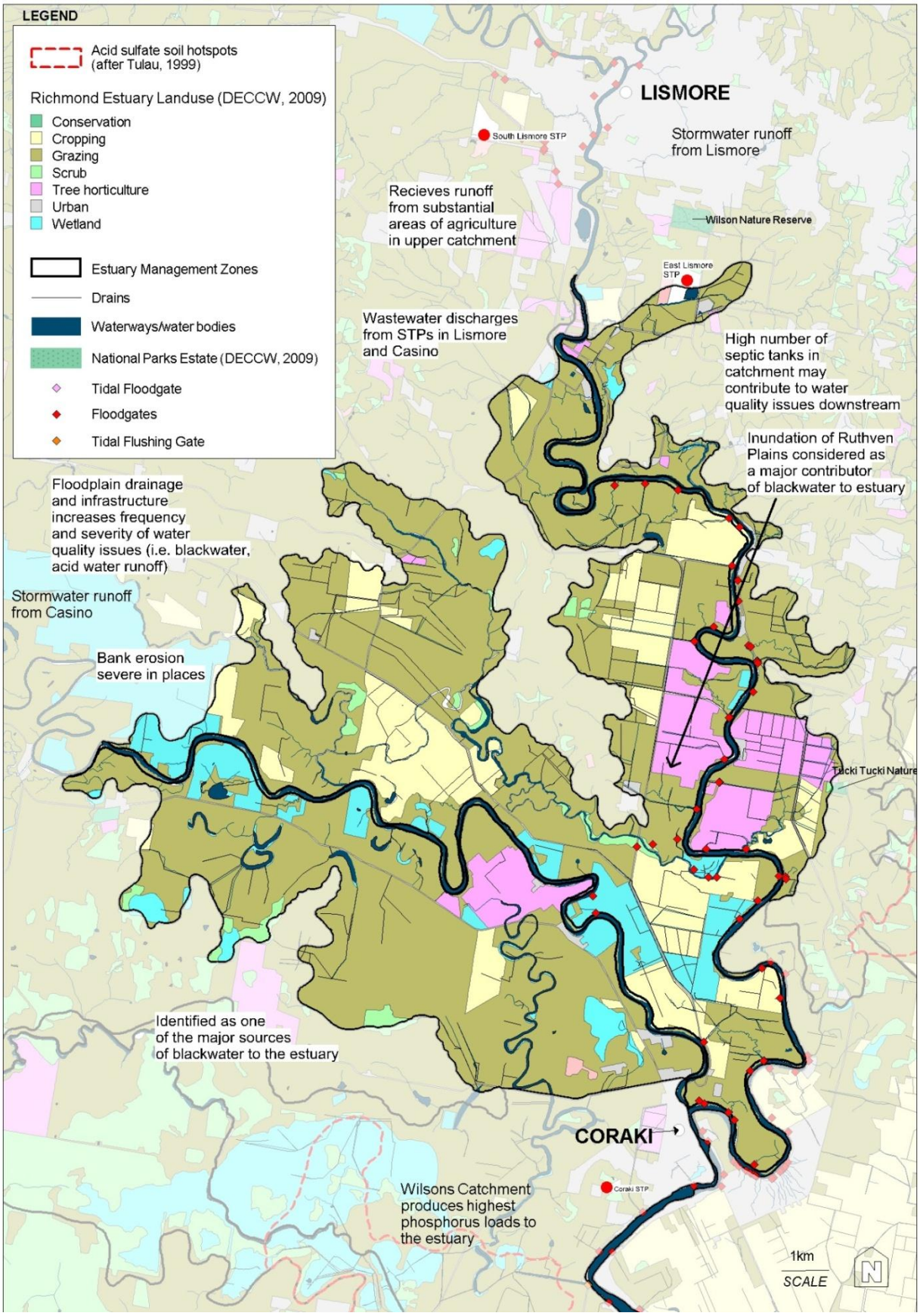
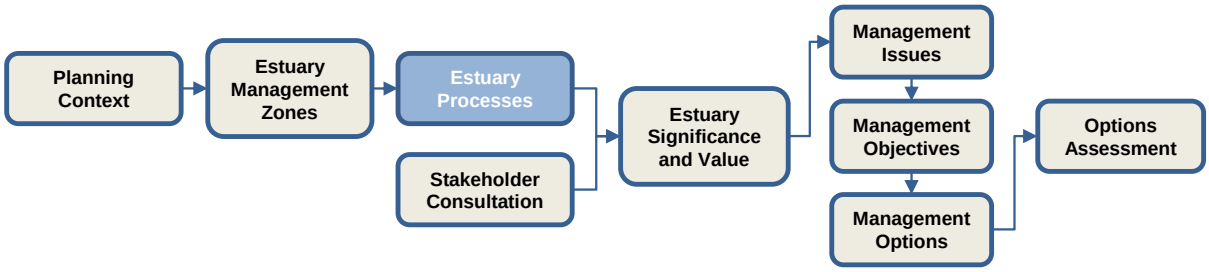


Figure 31 - Zone 12 Upper Richmond / Wilsons: Management Issues

4. ESTUARY PROCESSES



This Section provides an update of recent technical information related to the management of the Richmond River Estuary, since the completion of the Estuary Processes Study (WBM, 2006; ABER, 2007; ABER, 2008).

Further discussion of estuary issues is provided in Section 7.

4.1 Estuary Processes Study

The Richmond River Estuary Processes Study (EPS - WBM, 2006) and technical review (ABER, 2007) provide scientific understanding of the key processes controlling ecological patterns within the estuary and identify the issues and knowledge gaps to be considered in the development of the Draft EMS and Draft CZMP. These documents provide an overview of the key physical, chemical and biological processes operating within the estuary and how these processes interact and influence each other. They provide a description of the processes involved for each issue and the flow of impacts through the system. The combination of the two documents provides a good scientific basis on which to build management strategies for the Richmond River. The key findings of these documents are discussed in this Draft EMS.

4.2 Recent Research

Since the completion of the EPS (WBM, 2006), a number of subsequent studies have been undertaken in the estuary. The following section provides a review of relevant recent studies currently available that have specific relevance to the development of the Draft EMS and Draft CZMP, to update the current understanding and emerging issues. Please note there are also a number of studies currently underway or in planning stages that may offer further insights into management issues. When available, this work should be utilised to optimise any recommendations of the Draft EMS and Draft CZMP. Understanding the complexity and range of issues and pressures on the estuary will be important for developing options for sustainable management.

4.2.1 Water Quality and Fish Kills

Since completion of the EPS (WBM, 2006), further study has been undertaken in the Richmond catchment and waterways to provide more information on fish kill events occurring in the Richmond following floods and particularly to provide details on the sources of poor water quality, blackwater and potential remediation options.

Blackwater is a term used to describe floodwaters with very low oxygen content and high organic load, emanating from the floodplain's backswamp areas. The organic matter suspended in the water column turns the floodwaters 'black' and gives off an unpleasant odour. Blackwater has been identified as the primary contributor to fish mortality events on the lower Richmond (Moore, 2006; Eyre *et al*., 2006; Wong et. al, 2010). Wong *et al*. (2010) recently completed a large-scale study of post-flood water quality in the Richmond that identified the backswamp areas of the Tuckean, Rocky Mouth Creek and Bungawalbin Creek systems as the most significant sources of blackwater. This correlates with results of a water quality data review conducted by ABER (2008), which identified the Tuckean, Rocky Mouth Creek, Bungawalbin, and Kilgin/Buckendoon areas as high risk for water quality impacts, primarily associated with low dissolved oxygen. These areas are all located in the mid-estuary, which is in contrast to previous concerns that deoxygenated waters were coming from the upper estuary.

Eyre *et al* (2006) tested the deoxygenation potential of various types of floodplain vegetation. Slashed pasture was found to be the most oxygen demanding, followed by harvested tea tree and cane trash. However, ten hours after inundation the oxygen consumption rates of slashed pasture and tea tree cuttings had decreased to a rate less than the harvested cane trash. They estimated that the lower floodplain (an area of approximately 31,000ha based on the February 2001 flood event) has the capacity to deoxygenate all stored floodwaters within 3 to 4 days.

Plate 15: Left - The 2008 Richmond River fish kill. Right: Clean-up after fish kill

Source: M. Riches, P. Dwyer

Recent studies have also confirmed the role of the existing floodplain drainage systems in exacerbating the problem by acting as a conduit for deoxygenated waters to discharge to the main river channel (Wong *et al*., 2010; Eyre *et al*, 2006). As floodwaters begin to recede in the main river channel, drains convey deoxygenated water on the floodplain at high velocity to the main river resulting in large areas of the estuary being completely deoxygenated with the resulting increased magnitude and duration of poor water quality in the estuary.

It is well established that temperature is one of the major factors influencing deoxygenation, with higher temperatures leading to faster rates of decomposition and faster consumption of oxygen from the water. Higher temperature water also holds less dissolved oxygen than cooler water. Temperature was the main differentiating factor in comparing the January 2008 flood, and the May 2009 flood in the Richmond River (Wong *et al*., 2010). Wong *et al*.(2010) attributed the higher temperatures experienced in January 2008 as a major factor in the subsequent fish kill, reasoning that no fish kill occurred following the May 2009 flood when temperatures were approximately 10 degrees cooler.

Management recommendations coming out of recent studies generally correlate with those discussed in the EPS (WBM, 2006) and involve changes in landscape management and farming practices. The emphasis of the recent studies is on changes in pasture management to more inundation tolerant species, and changes in harvest and trash management, such as removing slashed pasture from flood-prone areas (Eyre *et al*., 2006; Moore, 2006). While harvest management changes were one of the recommendations coming out of Eyre et al. (2006), the removal of slashed pasture is impractical on a number of levels and undesirable for farmers who wish to return nutrients to the soil. It is not considered to be a feasible solution in blackwater management. Recommendations for changes to floodplain management were to retain deoxygenated floodwaters in low lying areas for longer, to allow oxygen consumption processes to be completed before releasing this water back to the estuary (Eyre *et al*., 2006). Walsh *et al*. (2010) recently conducted an assessment of identified blackwater mitigation options for the Richmond River Estuary and concluded that there were a range of options available

likely to have positive benefits for the estuary, but many factors required further investigation to effectively plan for implementation. Options for management of blackwater are discussed further in Section 7.5.3.

Results of a water quality review by ABER (2008) for each of the major floodplain sub-catchments were synthesised into a risk assessment to prioritise sub-catchments in terms of water quality impacts. The assessment is qualitative, providing a low, medium or high rating for acidity, dissolved oxygen, turbidity, nutrients and organic matter (OM) under different flow conditions. The risk assessment matrix (Table 3) highlights five priority sub-catchments for management of water quality issues: Tuckean, Bungawalbin/Sandy Creek, Kilgin/Buckendoon and Rocky Mouth Creek. Specific water quality issues are discussed further in Section 7.5.1.

Table 3: Risk assessment matrix for in-stream water quality and potential downstream impacts on the estuary (Red=High, Yellow=Medium, Green=Low).

		In stream						Downstream					
Subcatchment	**flow**	salinity	pH	DO	Turb	Nutrients	Organic matter	export	pH	DO	Turb	Nutrients	Organic matter
Tuckean	high	F	m	h	h	h*	h*	h*	m	h	h	h*	h*
	median	F	h	m	l	m*	m*	m*	h	m	l	m*	m*
	low	M	h	m	l	l*	l*	l*	l	l	l	l*	l*
Bungawalbyn / Sandy Creek	high	F	l	h	h	h*	h*	h*	m	h	h	h*	h*
	median	F	m	m	h	m*	h*	m*	l	m	m	l*	l*
	low	M	m	l	l	l*	l*	l*	l	l	l	l*	l*
Kigin / Buckendoon	high	F	l	h	h	m*	h*	m*	m	h	h	h*	h*
	median	F	h	m	m	m*	m*	l*	l	l	l	l*	l*
	low	M	m	h	h	h*	h*	l*	l	l	l	l*	l*
Rockymouth Creek	high	F	m	h	m	m*	h*	m*	m	h	h	m*	h*
	median	F	h	h	l	m*	m*	l*	l	m	l	l*	l*
	low	M	m	m	l	l*	l*	l*	l	l	l	l*	l*
Emigrant/Maguries	high	F	l	l	m*	m	m*	m*	l	m	m	m	m*
	median	F	l	m	m*	m	m*	m*	l	l	l	m*	m*
	low	M	l	h	l*	m	h*	l*	l	l	l	m*	l*
North Creek	high	F	l	m	m	h	m*	m*	l	m	m	m	m*
	median	F	m	l	l	m	m*	l*	l	l	l	l*	l*
	low	M	l	m	l	m	h*	l*	l	l	l	l*	l*
Empire Vale	high	F	l	l	m*	m	m*	l*	l	l	l	l*	l*
	median	F	l	m	m*	l	m*	l*	l	l	l	l*	m*
	low	M	l	h	l*	l	h*	l*	l	l	l	l*	l*

F=Freshwater , M=Mesohaline (between freshwater and seawater)

Source ABER, 2008

4.2.2 Richmond River Flood Study 2010

The Richmond River Flood Mapping Study was commission by RRCC and Richmond Valley Council (RVC) in 2008. The study (BMT WBM, 2010) provides an understanding of flood behaviour across the study area. The key outputs of the study were calibrated hydrologic and hydraulic models covering the entire Richmond River catchment, and detailed flood mapping of historical and design flood events, in particular flood levels and hazards. While playing a key role in asset protection and emergency planning, the models developed as part of this project can also be used and further developed for a range of future applications, in particular to aid floodplain management decisions.

The Digital Elevation Model (DEM) created as part of the flood study highlighted that some parts of the floodplain are at extremely low elevation. Areas such as Rocky Mouth Creek, parts of the Tuckean Swamp, Kilgen/Buckendoon, Emigrant/Maguires Creek, North Creek/Newrybar and South Ballina are at or below sea level (refer to Figure 35, Section 7.5.1) confirming the practical difficulties with maintaining drainage from these areas.

4.2.3 Riparian Zone and Geomorphological Assessment

The Estuary Management Committee commissioned a number of data collection and/or review exercises for the study area including an assessment of riparian vegetation, geomorphology, and water quality (Australian Wetlands, 2010). Details of the results of the study including raw data from on-ground assessments are provided in Appendix 2. The following Section is a brief description of this work and conclusions. The relevant results for each Management Zone are referred to in more detail in the Management Zone descriptions (Section 3) and Issues discussion (Section 7).

Riparian Assessment

Australian Wetlands carried out an assessment of riparian vegetation for the study area combining a broad desktop study of aerial photography with an on-ground Rapid Assessment Method (RAM) to provide an overview of riparian vegetation based on management zones. The parameters recorded were:

- Longitudinal connectivity (Aerial Photograph Interpretation, API);
- Width of riparian vegetation (API);
- Native vegetation cover;
- Site weed control issues; and
- Habitat quality assessment.

These data may be useful in follow up surveys following any rehabilitation works. The main conclusion of the study was that the riparian zone bordering the Richmond River estuary and tributaries was generally devoid of vegetation for much of the area. Where riparian vegetation was present it was generally degraded, with only a few examples of intact riparian vegetation in good condition. The width of the bank vegetation was often less than five metres and few native trees remained. Serious weed invasion was occurring on the banks as there was limited natural vegetation to inhibit the growth of weeds. The major weeds were Camphor Laurel and Cockspur Coral Tree. In some places, particularly North Creek and the lower Estuary, there was some remnant vegetation with good native canopy and mid-storey trees. The understorey was largely dominated by pasture grasses leaving little opportunity for seedling regeneration and nutrient interception, suggesting that the current vegetation is not providing viable riparian function.

Geomorphological Assessment

The geomorphological assessment involved observations made during a catchment tour together with a literature review and the results of the on-ground site assessment. Data gathered were used to provide a geomorphic status assessment for each management zone. Scores were assigned to each site based on various assessment methods for the following categories:

- Stability;
- Condition; and
- Recovery potential.

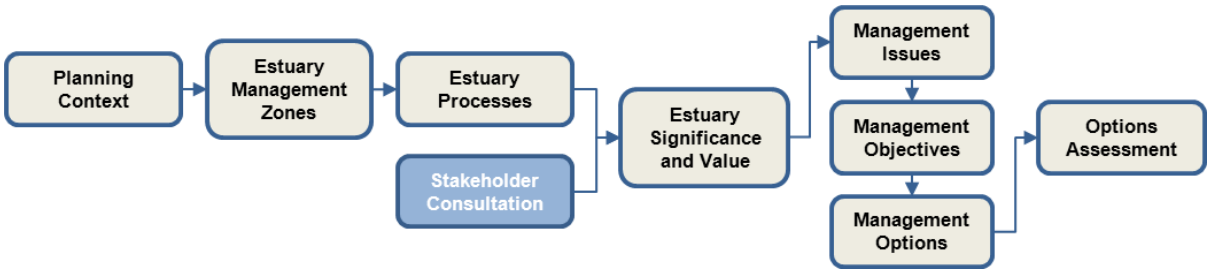
The issues occurring within each of the twelve management zones are primarily a direct consequence of anthropogenic activity which began with permanent European settlement of the Richmond River Basin from around 1842. Extensive land clearance, initially for the timber industry, but also to facilitate 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 this 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.

Drainage modification for farming (particularly sugar cane), roads and flood mitigation measures have impacted the natural flow regimes. 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, promote erosion of fallowed soil during high rainfall events, and facilitate direct transport to the main river system.

The major geomorphic-related management issues for the Richmond River Floodplain were sheet and rill erosion, drainage modification for agriculture, water course obstructions, and a lack of suitable riparian vegetation as the common elements across all Management Zones.

5. STAKEHOLDER CONSULTATION



This Section summarises the consultation activities undertaken as part of the Estuary Management Program.

Various forms of stakeholder consultation have been conducted throughout the Estuary/Coastal Zone Management Planning Process. The Richmond River Estuary Management Committee was formed in 2002 to oversee the process from data compilation study and estuary processes study to development of the Draft EMS and Draft CZMP (refer Section 2.2.4). The Floodplain Management Committee was formed in 2000 by RRCC. Its role is to contribute to floodplain management and environmental improvement. The Richmond River Estuary Technical Team was established to oversee the development of the studies and management plans.

The Richmond River EPS (WBM, 2006) included a community consultation phase via a community survey, although there were limited responses at that time. Australian Wetlands conducted a wide range of stakeholder engagement activities on behalf of the Estuary Management Committee in 2007/08.

The Draft EMS and Draft CZMP were placed on public exhibition between 14 March and 6 May 2011. A public meeting was held and submissions were invited.

Feedback from stakeholders has been considered in the preparation of the Draft CZMP for the Richmond River Estuary including definition of values (Section 6).

Appendix 3 provides further detail on the consultation activities.

5.1 Community Consultation

5.1.1 Estuary Processes Study, 2006

During the preparation of the EPS (WBM, 2006), community consultation activities were initiated through the Estuary Management Committee to obtain information on:

- The current types and locations of estuarine use;
- The values of the estuary; and
- Estuarine issues that require management.

Consultation techniques included site inspections with Committee Members and a Discussion Paper, which was distributed to members of the Estuary Management Committee in order to obtain comment on specific items. A copy of the Discussion Paper is included in Appendix 3.

5.1.2 Draft CZMP preparation 2007/08

Consultation activities were conducted by Australian Wetlands during 2007/08 with particular groups representing specific interests in the estuary, community focus groups made up of interested individuals as well as canvassing of the broader community through local radio, newspapers and information stalls. The groups involved in community consultation were:

- Estuary Management Committee;
- Floodplain Committee;
- Northern Rivers CMA;
- Local Government (BSC, RVC and LCC);
- Indigenous Groups (Bundjalung Elders, Ngulingah Local Aboriginal Land Council, other key Aboriginal stakeholders);
- Community Focus Groups (lower catchment and upper catchment groups);
- General Community communication (ABC radio, newspaper, information stalls at public events); and
- Far North Coast Weeds;

The local community was surveyed for their opinions on the estuary, its condition, issues and possible means to improve the condition. Their values were recorded and a list of estuary values developed. Healthy water quality was the highest priority over all. The feeling from the community is that if the water quality was good then ecologically, economically, socially and aesthetically the river would benefit. Other issues raised included a need to address governance issues and identifying who takes responsibility for implementing and funding the actions. There was also a view from the community that the local, state and federal departments relevant to natural resource management are fragmented and do not interact efficiently. Results of the consultation activities are included in Appendix 3.

5.1.3 Public Display of Draft EMS and Draft CZMP, 2011

The Draft EMS and Draft CZMP were placed on public exhibition between 14 March and 6 May 2011 to provide the community with the opportunity to assess what is proposed for the estuary, the actions and implications of the proposed strategies and to provide feedback on the management plan. An introduction to the project, the Draft documents and a Summary Document were available from the RRCC website with hard copies available for review at Council administration offices in Lismore, Ballina, Casino and Evans Head. Posters advertising the exhibition period were on display at Council

offices and advertisements were placed in local media. A public meeting was held on 28 March 2011 in Ballina to provide information on the draft documents. Submissions on the draft documents were reviewed and considered in the finalisation of the Draft EMS and Draft CZMP.

5.2 Indigenous Community Consultation

Consultation activities with Indigenous representatives identified a number of information gaps and recurring issues including:

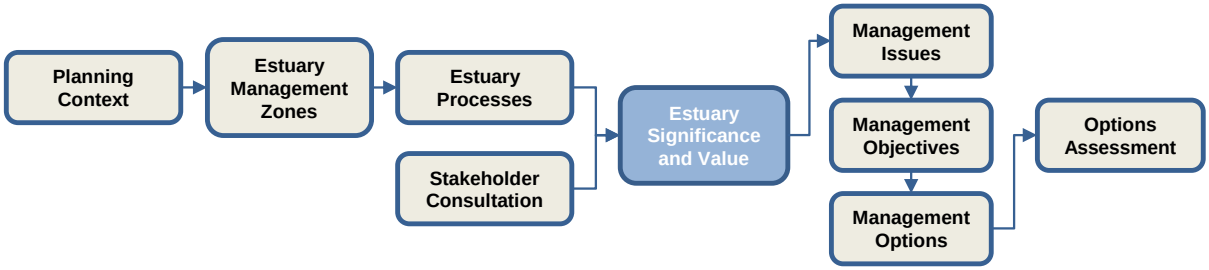
- Satisfactory resolution of Native Titles and Claims – there are four Native Title Claims covering approximately 90% of the study area currently being assessed (claims apply to land other than freehold land such as Crown Land and leasehold lands);
- Lack of community understanding regarding Indigenous Fishing Rights;
- Cultural Heritage Studies are incomplete. All levels of Government maintain registers of levels of protection under current legislation, ongoing studies aim to improve the Aboriginal Heritage listings within the Richmond River;
- Timely adoption of cultural heritage sites and artefacts in appropriate registers to ensure long term preservation; and
- Protection of cultural and heritage items and sites from future activities (e.g. land clearing or foreshore works occurring around the estuary).

The resolution of the above issues will help engage the Aboriginal community and aid further cooperation. Through indigenous engagement, a historical and cultural perspective on the use and health of the estuary can be obtained.

5.3 Council and Agency Stakeholder Consultation

The Richmond River Estuary Technical Team consists of key personnel from the local government areas within the estuary and agency stakeholders (refer Section 2.2.4). The Technical Team met on a regular basis to discuss on-going estuary management projects and provide feedback on the development of the Draft EMS and Draft CZMP (Volume 1).

6. ESTUARY SIGNIFICANCE AND VALUES



The significance and value of the estuary have been derived from the scientific understanding of the estuary (Section 4) and the outcomes of the stakeholder consultation (Section 5).

6.1 Estuary Significance

The Richmond River is one of the major coastal drainage systems in northern NSW with a catchment area of approximately 6,850 km^2. The Richmond River is unique, with a large flood plain (approximately 1,000 km^2) relative to catchment area and a small water surface area (19km^2) (WBM 2006).

Many significant townships exist in the study area, with most located on the banks of the Richmond River estuary system including Lismore on the Wilsons River, Casino on the upper Richmond River, Coraki (near the meeting of the Wilsons and Richmond Rivers), Woodburn, Wardell, and Ballina on the lower portions of the Richmond River. There is increasing population pressure with the major urban centres targeted as expanding regional centres and the close proximity to south-east Queensland and resulting tourism and development pressures.

Major changes since European settlement are (ABER, 2007):

- 70% of the land around the estuary has been cleared. There is currently little native forest remaining, with most large remnants restricted to steep slopes or heathlands. Very little remnant vegetation occurs on the floodplain areas adjacent to the estuary;
- Most of the cleared and drained lands are utilised for cattle grazing or sugar cane production;
- The hydrology of the floodplain has been significantly modified. The naturally swampy floodplain has been extensively drained via complex networks of drainage channels and floodgates;
- While urban areas account for only 2% of the land around the Richmond River estuary, the urban growth rate is rapidly increasing. The population of Lismore City, Ballina and Richmond Valley Shires now exceeds 100,000 and future urban expansion will be necessary to accommodate projected increases in population;
- Much of the lower estuary, including the entrance, has been rock lined to stabilise shifting channels and maintain navigation.

Approximately 34,000 ha of floodplain within the Richmond River catchment are potentially underlain by high risk ASS, with another 34,000 ha having low risk ASS (WBM, 2006). The natural characteristics of the Richmond River catchment and floodplain, such as presence of potential ASS, large floodplain to catchment ratio and poor flushing characteristics are all elements that interact with and exacerbate the impact of human pressures. Together these factors contribute to the degradation of the waterway and occurrence of undesirable events such as poor water quality episodes, fish kills and oyster declines, which impact on commercial, social, environmental and cultural values.

6.1.1 National Significance

The catchment of the study area occurs in the McPherson-Macleay Overlap area, which is an area of extremely high biodiversity, resulting from the wide range of soil types, climate and topography across the region. This overlap area has the third highest level of biodiversity in Australia (Richmond Regional Vegetation Committee, 2002).

Within the Richmond River estuary, the Bundjalung National Park and the Broadwater wetlands are listed in the Directory of Important Wetlands in Australia (Environment Australia, 2001). The estuarine wetlands of the Richmond River catchment provide habitat for a large number of migratory waders including federally listed threatened species.

The estuary is a significant contributor to the Australian east coast fishery through a range of mechanisms including direct contribution to catches, provision of nursery habitats, spawning stock and nutrients for offshore fisheries.

6.1.2 State Significance

The Richmond River catchment includes large areas of National Park (Broadwater, Bundjalung and Bungawalbin National Parks) and Nature Reserves (Richmond River, Yarringully, Ballina and Tuckean Nature Reserves).

The wetlands of the Richmond River catchment provide habitat for one of the widest range of wetland dependant threatened species in NSW. The high-energy nature of the NSW north coast means there are no intertidal wetlands between estuaries, so there is a natural fragmentation of these habitats on a regional scale, giving weight to the conservation significance of habitats in each estuary (ABER, 2007).

The Richmond River is the seventh largest (by surface area) estuary in NSW, with the fifth largest finfish catch in the region (ABER, 2007). In addition to the high fisheries/productivity value of the estuary, the estuary supports species, habitats and communities of conservation concern. These include:

- Rare and threatened communities, as defined under the Threated Species Conservation Act, 1995 (refer WBM, 2006), namely:
    - Coastal Saltmarsh;
    - Swamp Oak Floodplain Forest;
    - Swamp Sclerophyll Forest On Coastal Floodplains;
    - Freshwater Wetlands On Coastal Floodplains;
    - Littoral Rainforest;
    - Lowland Rainforest on Floodplains; and
    - Ripple-leaf Muttonwood (*Rapanea* species A Richmond River).
- Wetlands of conservation significance: SEPP 14 wetlands (4964 ha) and Zone 7(a) Environmental Protection (Wetlands) or E2 (Environmental Conservation) under the new LEP instrument;
- SEPP 26 Littoral rainforest (47.1 ha); and
- Oxleyan Pygmy Perch – Evans Head (Fisheries Management Act 1994).

6.1.3 Regional Significance

Agriculture is a major driver of the local economy, employing approximately 10% of the working population in the North Coast Region (includes Byron, Ballina, Richmond Valley, Lismore City and Kyogle Shires). Local forms of agriculture include cattle grazing, sugar cane cropping, and horticulture. The Alstonville Plateau area has been designated state significant farmland as part of the Northern Rivers Farmland Protection Project. Areas designated as regionally significant farmland include parts of North Creek, Empire Vale and Woodburn (DPI, 2005).

As well as the agriculture industry, the Richmond River estuary has regionally important commercial and recreational fisheries. Commercial fishers target a wide range of species although four species represent approximately 87% of the total catch (1997-2004): Mullet (51% of catch), school prawn (27.5% of catch), Long-finned eel (4.8% of total catch), and Luderick (3.7% of total catch). The Sydney

rock oyster is grown and harvested within the Richmond River. The farm gate oyster sales of the Richmond River estuary oyster industry are estimated to be around $200,000/year, which is about 0.5% of the State industry income (ABER, 2007).

Tourism and recreation are also major economic drivers for the North Coast Region. Outdoor recreation and sports (e.g. swimming, fishing, boating) are popular activities, particularly in the lower estuary near Ballina. The value of tourism to the North Coast Region is estimated at $646 million, and supports some 6,000 jobs. Tourism has been identified as a priority industry for the North Coast Region.

6.2 Estuary Values

The Richmond River estuary is highly valued by the community and is a focal point for local commerce, tourism and recreation. The estuary with its associated wetlands and waterways support a rich biodiversity and a range of important environmental functions including ecosystem services (habitat, breeding areas and food sources) as well as local industry. Despite these recognised values, the system is under pressure from past and existing development, catchment disturbance and hydrological modification, land use management and large-scale vegetation changes. Looking forward, the estuary faces continued pressure from future development within the catchment.

The main aim of the coastal zone management planning process is to increase resilience within the estuary and to protect and enhance the key values and it is therefore an essential step in the EMS to clearly document these values. Review of previous documentation was undertaken in order to identify and assess the established values for the estuary (WBM, 2006 and ABER, 2007). The reported outcomes of community consultation undertaken by Australian Wetlands in 2008 (refer Section 5) were specifically reviewed to ensure the values identified by the community are carried through and considered throughout the development of the EMS and Draft CZMP. The identified values are used to develop management objectives for the estuary (refer Section 7). Key statements describing the values identified by this process are provided below. Values have not been prioritised or ranked.

6.2.1 Economic Values

- The Richmond River catchment supports a wide range of land uses which are important contributors to the local and regional economy.
    - Agricultural practices occupy approximately 75% of the study area. Sugarcane is the dominant crop on the floodplain between Ballina and Coraki. Grazing land and cropping areas such as macadamia, tea tree and other mixed horticulture make up the rest of agricultural land use. Agriculture employs approximately 10% of the working population of the North Coast and makes up a significant portion of the local economy (WBM, 2006). The farm gate value of agricultural production in the North Coast Region was estimated in excess of $650 million (for the year 2000). In addition to this, the “add-on”value of agricultural-based industries contributed a further $1 billion to the regional economy (ABER, 2007). Although agriculture is identified as a key influence on the health of the estuary, management options need to consider and provide a balance between the economic and social values of the industry and environmental considerations.
    - Real-estate values and the associated rate base are recognised as a major driver of the local economy and are related to river health, the recreational opportunities a healthy river provides and scenic amenity.

- Fishing and oyster aquaculture contribute to the local and regional economy.
    - Commercial catch comprises mostly sea mullet and school prawns. Crab, eel and finfish (including sand whiting, bream, flathead and mulloway) are also significant commercial species in the estuary (WBM, 2006). Recent economic modelling of the direct and indirect benefits of the Ballina commercial fishing industry estimated total flow-on effects of $16.9 million derived from output, $2.9 million in generated income and the generation of 75 employment positions (Harrison, 2009).
    - There are 10 current oyster leases in the lower Richmond estuary. These are shown in the zone maps provided in Section 3.
    - Recreational fishing is a popular lifestyle choice for residents and visitors to the estuary with flow-on economic implications for local commerce including boat supplies, bait/tackle shops and tourism.
- The estuary and particularly the lower estuary is considered to be a key attraction for tourists and recreational users to the area, with associated economic benefits.
    - Tourism activities include recreational fishing, boating, swimming, holidaying, day trips, ecotourism, bird watching and nature appreciation. Tourism has been identified as a priority industry for the North Coast Region and was estimated to have a value of $646 million for the region (ABER, 2007).

Plate 16: Boating in the lower estuary

- The freshwater sections of the estuary are a valuable source of water for the agricultural industry and also provide potable town water supply from the tidal pool upstream of Lismore.
    - Rous Water has an entitlement to extract a maximum of 5,400ML/annum from the tidal pool upstream of Lismore on the Wilsons River for town water supply (NSW Office of Water, 2009).

- There are over 150 extraction licences for irrigation of agricultural lands located within the Richmond tidal pool making up 25% of the total entitlement for the unregulated system (NSW Office of Water, 2009).
- There are over 1,000 groundwater extraction licences with a total entitlement of 6,176ML/annum with 47% for stock and domestic purposes, 34% for irrigation and 18% for industrial purposes. Forty per cent of licences are located in the floodplain alluvium (NSW Office of Water, 2009).
- The Alstonville Plateau groundwater aquifers are also a major source of groundwater in the Richmond River catchment with water extracted for irrigation, stock watering and town drinking water supply (NSW Office of Water, 2009).

6.2.2 Social and Cultural Values

- The Richmond River Estuary has high cultural and spiritual significance to local Aboriginal communities.
  - Fishing along the estuary is an important part of Aboriginal culture. There are many sites of Aboriginal heritage significance around the estuary and their recognition and protection is of high importance to the community.
- A number of European cultural heritage sites and items exist in and around the estuary and their acknowledgement and protection is important to the community.
  - European heritage items are related to key industries such as forestry and agriculture and associated transportation networks and include wharves, shipwrecks and heritage buildings in and around the estuary.
- The estuary and foreshore areas are highly valued by the community and visitors for recreational activities.
  - Activities include fishing, boating, swimming, surfing, walking and bird watching in the estuary and adjacent foreshore areas. It is important to the local community to have permanent public access to the ocean and foreshore areas.
  - The natural appeal of the estuary (e.g. Plate 16) should be preserved.
- Scenic amenity is valued highly by the local community and visitors.
  - Specific characteristics identified by the community include clean beaches and foreshore areas, presence of native flora and fauna (including threatened species), good water quality and appreciation of landscape, geomorphic and estuarine features.
- The estuary provides opportunities for both formal and informal education.
  - The ecological and cultural characteristics, economic aspects and management issues of the estuary offer a diverse range of educational opportunities for students and the general public.

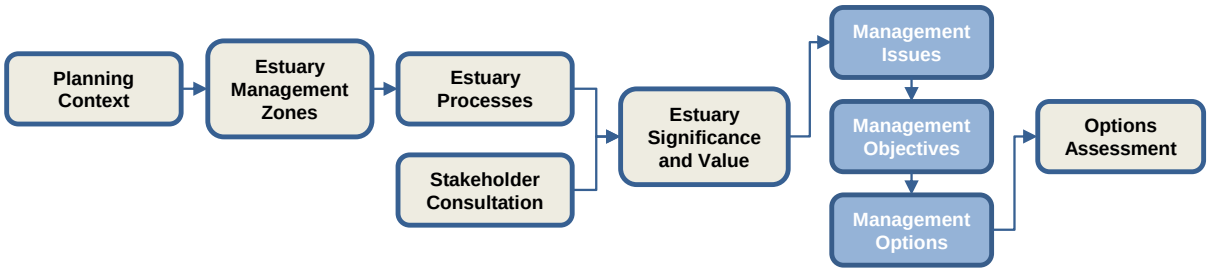
6.2.3 Ecological Values

- The Richmond River Estuary and wetlands provide a diversity of habitats for a range of terrestrial and aquatic species.
    - This includes those protected under state and Commonwealth legislation, species of fisheries value and migratory birds protected under international agreements.
- The estuary supports a number of rare and threatened communities.
    - Examples are SEPP 14 wetlands, Endangered Ecological Communities (EECs) including Coastal Saltmarsh, Swamp Oak Floodplain and Littoral Rainforest.
- Estuarine wetlands including mangroves, saltmarsh and seagrass areas provide an important role in healthy ecosystem function.
    - The role of wetlands includes bed/bank stabilisation, cycling of nutrients and habitat for fisheries nursery and breeding grounds.
- The Richmond River estuary is recognised as one of the two most important locations for shorebird habitat in Northern NSW (DECCW, 2010b).
- The riparian zone provides a number of important ecological functions.
    - It provides wildlife corridors that create connectivity in a largely cleared and fragmented landscape. It also provides an erosion buffer for waterways to reduce and filter overland runoff of nutrients and contaminants. Additionally, riparian vegetation cover provides shade which reduces water temperature, increases dissolved oxygen levels and aquatic habitat and reduces aquatic weed.
- Good water quality is highly valued and considered a general indicator of estuary health by the community.
    - Water quality was given the highest priority during community consultation. The perception is that if water quality is good, then ecological, economic and social values will be preserved or enhanced.

Plate 17: Kingfisher at Swan Bay

Source: M. Wood

7. ESTUARY MANAGEMENT ISSUES, OBJECTIVES AND OPTIONS



The key issues affecting the Richmond River estuary were identified in the Estuary Processes Study (WBM, 2006; ABER, 2007; ABER, 2008). The following section outlines the current status of identified issues of the estuary.

Based on the established values of the estuary (Section 6) and the issues discussed in the following sections, management objectives have been developed.

The potential management options raised during this discussion are carried through to the options assessment process detailed in Section 8.

7.1 Options Development Process

Management issues for the estuary have been identified from the available background data in the EPS (WBM, 2006; ABER, 2007; ABER 2008) as summarised in Sections 3 and 4. The significance and values of the estuary have been derived from the scientific understanding of the estuary and the outcomes of the stakeholder consultation (refer Section 5). The identified values have been used to develop management objectives for the estuary. The management objectives are consistent with the goals and objectives of the NSW Coastal Protection Act, 1979, Coastal Policy, 1997 and Sea Level Rise Policy Statement, 2009 as described in Section 2.

For each major topic, the identified issues, related objectives and potential management options have been identified (but not prioritised or ranked) in the following sections. Section 8 summarises the ranking of issues and the assessment and prioritisation of the management options. Appendix 4 provides the full lists of management issues, objectives and options.

The Draft CZMP (Volume 1) describes the proposed actions to be implemented by the Councils and other public authorities to address priority management issues in the estuary over the implementation period.

7.2 Administration and Governance

7.2.1 Issues

Governance

The stakeholder groups involved with management of the estuary include:

- Three local councils (Ballina Shire Council, Lismore City Council and Richmond Valley Council);
- Council appointed and funded entities, Richmond River County Council (RRCC), Far North Coast Weeds (FNCW) and Rous Water;
- The Northern Rivers Catchment Management Authority (NRCMA);
- A range of State agencies and state funded entities (e.g. OEH, DPI);
- Private landholders;
- Indigenous Groups; and
- Community groups (e.g., Landcare, Bushcare and Coastcare groups).

The responsibilities of the local and state government agencies are discussed in Section 2.2. The development and implementation of the Draft CZMP will require collaboration between a range of stakeholders including all the constituent and county councils, state government, industry, landholders and community.

The governance of the Richmond River estuary is complicated with no overriding body responsible for its management as a whole. Management activities are currently carried out through a range of different programs, by the various stakeholders and through various sources of funding. For example, RRCC responsibilities are limited by legislation to projects related to floodplain management, with funding by the local councils. Together, the local Councils and various state government agencies are responsible for other natural resource management aspects of the estuary (such as pollution control, climate change, stormwater management, sewerage, environmental water management, land management, Crown lands, agriculture, fisheries and maritime issues).

The responsibilities of the local councils are defined by the Local Government Act 1993, but management effort is limited by:

- Council administrative boundaries – council management and funding priorities are usually limited to programs in their own LGA, without a holistic estuary-wide focus; and
- Pressures on available council funding (as a result of other competing council functions) limits the effort applied to estuary management.

The existing estuary management governance model is disjointed due to the multi-agency responsibility, lack of a holistic approach, financial constraints and inefficiencies in the delivery of management programs. The lack of coordination between the various management entities has been identified as a significant barrier to successful estuary management. Community confusion about the role of the various local and state departments in estuary management was also identified as an issue during the community consultation phase of this study. Improved governance arrangements will rely on clearly defined responsibilities and adequate funding to implement these responsibilities. Current legislated responsibilities do not allow any one party to provide the appropriate governance and administration role.

Planning Instruments

Permitted land uses within the study area are detailed in the LEPs of Ballina Shire Council, Richmond Valley Council and Lismore City Council. The LEPs are supported by a number of Development Control Plans (DCPs) to provide more detail in relation to controls for specific types and forms of development throughout each LGA.

The major land zonings/land uses in close proximity to the estuary are primarily rural zoned lands, which are used for cropping, grasslands and for grazing cattle. The EPS (WBM, 2006) also identified examples of poor urban development which have resulted in the loss of significant habitat areas and due to their proximity to the estuary are likely to be contributing pollutants to the waterways. Other key land uses in the study area in close proximity to the estuary include urban residential living. The EPS found that agriculture in the study area is having a variety of water quality impacts on the estuary. Although agricultural/urban land uses in the study area are known to be impacting on water quality within the estuary, the land use planning of local Council's currently supports these land uses.

No.	Administration and Governance Issues
I1	Lack of protection to estuaries through existing planning instruments
I2	Lack of good governance model for integrated decision making and coordination
I4	Lack of clear delineation of administrative and legislative obligations between the parties responsible for estuary management

7.2.2 Management Objectives

Table 4 shows the relationship between estuary administration and governance issues, related values and management objectives. Because administration and governance affects all aspects of the estuary, it is relevant to all the estuary values.

Table 4: Relationship between Estuary Administration and Governance Values, Issues and Objectives

Values	Issues	Objectives
• The Richmond River catchment supports a wide range of land uses which are important contributors to the local and regional economy • Commercial fishing and oyster aquaculture contribute to the local and regional economy • The estuary and particularly the lower estuary is considered to be a key attraction for tourists and recreational users to the area, with associated economic benefits • The freshwater sections of the estuary are a valuable source of water for the agricultural industry and also provide potable town water supply from the tidal pool upstream of Lismore • The Richmond River Estuary has high cultural and spiritual significance to local Aboriginal communities • A number of European cultural heritage sites and items exist in and around the estuary and their acknowledgement and protection is important to the community • The estuary and foreshore areas are highly valued by the community and visitors for recreational activities • Scenic amenity is valued highly by the local community and visitors • The Richmond River Estuary and wetlands provide a diversity of habitats for a range of terrestrial and aquatic species • The estuary supports a number of rare and threatened communities • Estuarine wetlands including mangroves, saltmarsh and seagrass areas provide an important role in healthy ecosystem function • The riparian zone provides significant protection to estuary water quality • Good water quality is highly valued by the community.	I1 - Lack of protection to estuaries through existing planning instruments I2 - Lack of good governance model for integrated decision making and coordination I4 - Lack of clear delineation of administrative and legislative obligations between the parties responsible for estuary management	O2- To ensure strategic planning instruments and programs are consistent with and where applicable, directly address the aims of the CZMP O3 - To ensure efficient and effective management of the estuary through appropriate governance, funding and monitoring O4 - To increase knowledge of the impact of existing practices on estuary values and facilitate continuous improvement

7.2.3 Potential Management Options

Administration and Governance

To address the administration and governance issues, the model for delivery of the estuary management program in the Richmond River needs to be reviewed. There is a clear need to facilitate efficient and strategic decision making, ideally within the current legislative responsibilities. Potential solutions to achieve this are:

- Empowerment of a single entity;
- A new partnership or trust; or
- More efficient administrative procedures and responsibilities within the existing governance arrangement.

A new partnership was implemented for the Clarence River Estuary (The Clarence Floodplain Project, CFP), hosted by local government (Clarence Valley Council) and including organisations, groups and stakeholders (the partners). The inclusive approach used to engage and involve floodplain landholders, stakeholders and project partners has resulted in widespread support and acceptance of the project in the Clarence Valley community. The Clarence Valley Council was formed through an amalgamation of Grafton City, Maclean, Copmanhurst and Pristine Waters Councils and the Lower Clarence and Clarence River County Councils. The hosting and involvement of a single local government body resulting from the amalgamation, may contribute to the success of the partnership. In the case of the Richmond River estuary, the various local government bodies and current division of responsibilities may reduce the success of such a partnership.

The governance arrangements are complex with various statutory implications to be considered. It is clear that further work is required to assess the current governance model and recommend modification or alternative arrangements taking into account the full suite of administrative, funding logistical and legal considerations. Therefore the recommendation of this study is to conduct a comprehensive review of the current governance and administration arrangements to direct further action.

Planning Instruments

Any future developments in the study area, in particular new urban subdivisions (identified by Council's in their urban land release areas) should apply a holistic management approach to the improvement of stormwater and water quality and the appropriate management of existing vegetative communities (i.e. rehabilitation of riparian vegetation and dedication of waterway buffer zones). This is discussed further in Section 7.7.

The absence of riparian vegetation has been found to coincide with areas of active bank erosion. Future planning controls and agricultural practices need to support better management of the riparian zone. This may involve Councils and other State Government departments dedicating riparian buffer areas on streams and waterways of the estuary and encouraging farmers to abide by these buffers and employ best practice land management techniques. Better management of riparian vegetation on existing Crown land and the preservation of foreshore Crown land for conservation is also a key consideration. The provision of funding incentives and labour assistance through existing funding avenues should also be offered to land owners to facilitate these actions. This is discussed further in Section 7.7.

No.	Administration and Governance Management Options
1	Conduct a comprehensive review of current governance and administration arrangements

7.3 Climate Change Adaptation

7.3.1 Issues

Natural variations in temperature and rainfall in NSW are influenced by the naturally variable climate systems. Although there is natural variability in the climate, there is consensus among climate scientists that the rate and magnitude of climate change that NSW is currently experiencing are outside the expected range of this natural variability. Climate change is an important consideration for strategic planning, particularly in coastal areas where the combined effects of sea level rise and increased storminess are considered key threats.

Tidal inundation of the stormwater network in Ballina currently occurs with king tides but no serious threats to public safety or built assets have been identified. Similarly, tidal inundation risk in the Evans River is currently not considered significant. However, the coastal hazards of tidal inundation and erosion within estuaries caused by tidal waters are expected to increase in severity and extent under climate change impacts, particularly sea level rise. Estuary bank erosion risks to development and infrastructure adjacent to the estuary is expected to increase in extent and severity under sea level rise scenarios.

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

Sea level rise in the Richmond River estuary is anticipated to result in issues including:

- Inundation and landward recession of low lying ecosystems;
- Increased salt penetration through the estuary and adjoining wetland systems;
- Increased erosion exacerbated by increased tide heights;
- Increased inundation of low lying lands, infrastructure and development; and
- Implications for drainage and flooding in urban and agricultural areas.

The EPS (WBM, 2006) states that sea level rise will increase the average depth in the estuary and that tidal propagation up the estuary and potential changes in salinity regime may be expected. It is anticipated that sea level rise will naturally result in the landward recession of fringing estuarine wetland systems. The location of estuarine habitats such as mangrove forests and salt marsh are controlled principally by tidal range and salinity influence and will gradually respond to changes in increases in average water levels and salinity. There is a risk that natural upslope migration of these wetlands will be curtailed by anthropogenic constraints such as roads, levees, agriculture and urban development on the landward side. Under these conditions the landward side of these important habitats will be fixed but the lower margin will gradually be pared away, leading to a loss of habitat area. Increased estuary levels will affect riparian and other low-lying vegetation in the freshwater reaches of the estuary in a similar way. Water-logging will gradually kill off the lower vegetation, whereas the upper boundary may be restricted. It is not currently known to what extent barriers to upslope migration will affect the wetlands and vegetation communities of the Richmond River estuary.

Akumu *et al*. (2010) modelled the potential impact of sea level rise on coastal wetland communities in Northern NSW. The model indicated that the area of mangroves, saltmarsh, transitional marshes and estuarine open waters will all increase by the end of the century. The area of tidal flats, non-tidal swamps, inland freshwater marshes and inland open waters all showed decreases according to the model. The modelling did not consider salinity affects, human impacts or physical barriers to migration but provides general indications of vegetation change that could be expected in an unmodified catchment and within the limits of the model. The potential changes in salinity regime and implications for estuarine ecosystems and adjoining land uses has not been fully explored. There may be

increasing pressure to reduce saline intrusion into low-lying farm lands and long-term floodgate management policies (see Section 7.5) will need to consider the implications of sea level rise and potential salinity increases. Similarly, more frequent flooding of low-lying urban areas, such as much of Ballina, creates risks for the estuary in terms of managing urban drainage impacts, potential effects on sewerage infrastructure and overflows.

The issue of potential increased storminess is less well understood. It is generally anticipated that rainfall events will become more intense, even if average rainfall reduces, in response to climate change. This may result in effects such as more floods as well as greater erosion of unconsolidated sediments within the catchment. It is not known whether key issues for the estuary such as blackwater related fish kills (see Section 7.5.1) will be exacerbated by climate change factors, however increased temperatures are expected to have implications for water quality.

No.	Climate Change Adaptation Issues
I33	Predicted sea level rise may result in impacts associated with shoreline recession, implications for draining and flooding, damage to infrastructure, inundation of low lying ecosystems, habitat modification including landward migration of ecological communities and bank erosion
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

7.3.2 Management Objectives

Table 5 shows the relationship between Climate Change Adaptation issues, related values and management objectives.

Table 5: Relationship between Climate Change Adaptation Values, Issues and Objectives

Values	Issues	Objectives
• The Richmond River catchment supports a wide range of land uses which are important contributors to the local and regional economy • The estuary and particularly the lower estuary is considered to be a key attraction for tourists and recreational users to the area, with associated economic benefits • The Richmond River Estuary has high cultural and spiritual significance to local Aboriginal communities • A number of European cultural heritage sites and items exist in and around the estuary and their acknowledgement and protection is important to the community • The estuary and foreshore areas are highly valued by the community and visitors for recreational activities • The Richmond River Estuary and wetlands provide a diversity of habitats for a range of terrestrial and aquatic species • The estuary supports a number of rare and threatened communities • Estuarine wetlands including mangroves, saltmarsh and seagrass areas provide an important role in healthy ecosystem function • The riparian zone provides significant protection to estuary water quality	I33 - Predicted sea level rise may result in impacts associated with shoreline recession, implications for draining and flooding, damage to infrastructure, inundation of low lying ecosystems, habitat modification including landward migration of ecological communities and bank erosion 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	O9 - To minimise constraints to estuary adaptation to climate change

7.3.3 Potential Management Options

Climate change is inevitable and planning benchmarks already exist in terms of future sea level rise (NSW Government Sea Level Rise Policy, 2009). Locally, there will be impacts from climate change that are unavoidable such as sea level rise and changes to rainfall patterns and therefore long-term management planning needs to consider the likely changes to the Richmond River estuary and the factors constraining adaptation to such change. An overall goal for the management of the estuary is to ensure that the estuary is as healthy and resilient as possible, so that it can respond naturally to the impacts of climate change.

Data on coastal hazards needs to be obtained to inform land use planning, floodplain and estuarine management strategies into the future. This should include assessment and mapping of the tidal inundation extent for the estuary and estimation of estuary foreshore erosion due to physical processes and flood events, both incorporating the NSW sea level rise benchmarks. With respect to tidal inundation, the CZMP Guidelines (DECCW, 2010c) require the assessment and mapping of the 1, 50 and 100 year ARI events for the present day, 2050 and 2100 planning periods. BSC is currently preparing a Floodplain Risk Management Study and Management Plan for the Lower Richmond which is scheduled for completion in late 2011. The coastal hazard of tidal inundation will be addressed through this process. The coastal hazard of erosion within estuaries should be investigated under consideration of projected climate change impacts as an action under the CZMP for the Richmond River Estuary.

In relation to the Evans River, RVC has completed an Estuary Processes Study (1999) and Estuary Management Study and Plan (2002) and is currently finalising the Evans Head Coastline Hazard and

Estuarine Water Level Definition Study. RVC plans to prepare a CZMP for the Evans River estuary and Evans Head coastline which will consider coastal and flooding hazards and identify management requirements.

The risks identified through the tidal inundation and estuary erosion hazard assessments will need to be addressed via development of appropriate management actions aimed at reducing the hazard risk to persons, development and infrastructure.

Similarly, the projected climate change impacts on estuary health need to be assessed. This should include impacts from increased tidal inundation of the estuary and increased flooding due to increased tail water levels under 2050 and 2100 sea level rise scenarios. Studies should be undertaken to evaluate potential estuarine wetland habitat distribution in the face of sea level rise and changes in tidal range and salinity in the Richmond River estuary. This information should be incorporated into planning instruments (e.g. LEPs) to ensure that upslope migration of key habitats can be accommodated within the long-term land use adjoining the estuary. As part of this, planning instruments should include provision for buffer zones and offsets as appropriate to achieve no net loss of mangrove, saltmarsh habitats and priority riparian habitats within the study area (refer Section 7.7).

Opportunities for carbon sequestration should also be identified as part of future land use planning.

The management of the floodplain's drainage network, including the operation of flood gates, modification of levees and drains as well as planning for future floodplain uses should ensure that climate change effects are considered. In particular, the possibility of increased flooding from higher ocean water (tail water) levels, high tidal inundation, more saline intrusion and potential for intense storms and flooding events, and how responses to these issues may affect estuarine health should be evaluated. This is discussed further in Section 7.5.

Climate Change is considered to be an overarching issue that will affect most of the issues associated with the estuary. It will be necessary, therefore, to consider the impact of climate change as an integral part of each management option and strategy.

No.	Climate Change Adaptation Management Options
39	Assessment and mapping of tidal inundation extent including potential sea level rise
41	Planning for sea level rise and climate change impacts incorporating Government policy and guidelines, current research and best-practice management

7.4 Monitoring and Evaluation

This section focuses on monitoring of water quality in the estuary. Other aspects of estuary health and the monitoring requirements are discussed in the relevant management strategies in the Draft CZMP (Volume 1) as well as this Draft EMS, namely:

- Riparian vegetation and erosion (Section 7.7);
- Vegetation and habitat management (Section 7.8);
- Waterway usage (Section 7.10);
- Wastewater management (Section 0); and
- Fisheries (Section 0).

7.4.1 Issues

Currently, water quality monitoring in the Richmond River Estuary is carried out primarily by local councils at specific locations for a range of purposes including mandatory monitoring of licensed discharges (STPs), State of the Environment reporting and 'Beachwatch' programs monitoring recreational water quality conditions. Other monitoring is carried out for specific projects or investigations, and have generally been short term in response to certain issues or events.

There is generally a good understanding of the major water quality issues for the estuary. A number of recent studies have investigated major issues associated with ASS, flooding and associated blackwater events and fish kills in the mid and upper sections of the estuary. However, some uncertainty remains regarding the sources of some water quality problems and the relative impact of various sources. One example is the periodic high levels of nutrients and faecal coliforms measured in North Creek. While the poor water quality episodes are recorded in the lower reaches, and a number of potential sources have been identified such as agricultural and urban runoff or STP input, the specific source of contaminants in this case has not been established.

Current monitoring does not provide a consistent approach over the catchment and therefore the identification and separation of specific issues and sources of water quality problems over time. Additionally, there is no integrated environmental monitoring and reporting system in place at a scale that is meaningful to determine the effectiveness of management and investment in programs and projects that affect the estuary. An effective ecosystem health monitoring program is regarded as a key component of an estuary management program in order to measure the relative success of management efforts on the overall health of the estuary. Specific investigations may also be required in targeted areas to fill gaps in the current understanding of water quality issues and sources in order to direct appropriate management actions as required.

No.	Monitoring and Evaluation Issues
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

7.4.2 Potential Management Options

To address the need for a more coordinated approach to water quality monitoring, the Northern Rivers CMA has commenced the Northern Rivers Ecosystem Health Monitoring Program (Ecohealth), a comprehensive marine, estuarine and freshwater monitoring program that reports on the health of our waterways. The program is modelled on the South East Queensland Healthy Waterways Partnership and the NSW State Monitoring, Evaluation and Reporting program. The program aims to bring together the aquatic sampling programs of government and other natural resource management agencies and partners into a standardised, region-wide system. A pilot project has commenced in the Bellingen catchment and is proposed to be implemented for the Hastings, Camden Haven and Coffs Harbour estuaries in 2010/2011. It is envisaged that the Northern Rivers EcoHealth program is eventually implemented across all catchments in the region, including the Richmond. Although the EcoHealth program is only at the pilot stage, it is expected that this program would provide the monitoring data required to effectively implement estuary management priorities.

A targeted approach to estuary management also requires a tool to support decision making. In particular, there is a need to determine the benefits of upstream improvement works on downstream water quality. Some tools have already been developed including E2 (Source Catchments) - a software product for whole-of catchment modelling developed by eWater, and the Coastal Eutrophication Risk Assessment Tool (CERAT) developed by OEH to help identify and prioritise land use planning decisions to protect and preserve the health of estuaries.

In response to complaints from oyster growers in North Creek regarding water quality, Ballina Shire Council plans to apply for funding to undertake a study to identify sources of faecal coliforms and nutrients in the catchments. This is discussed further in Section 7.14.3.

No.	Monitoring and Evaluation Management Options
2	EcoHealth monitoring program
3	Develop catchment/water quality modelling tool to support decision making
31	Further research into sources of water quality issues in North Creek

7.5 Floodplain Infrastructure Management

7.5.1 Issues

The Richmond River floodplain has been extensively modified by a complex network of constructed drains, modified canals, artificial levee banks and floodgates. Installation of floodplain drainage channels began in 1888 (Hendersons Drain, Tuckean Swamp) and accelerated in the early 1900s for the purpose of draining wetlands for agriculture and for flood mitigation. Floodgates were installed to prevent back-flooding of drains, creeks and tributaries and subsequently the inundation of agricultural land on the floodplain during minor flood events or by salt water from high tides. Drainage infrastructure is a dominant feature on the floodplain as shown in Figure 32 (floodgates represented by red icons; private drains shown as grey lines; RRCC managed infrastructure shown as coloured lines).

There are many types of floodgates in the Richmond River Floodplain, but the majority utilise the simple passive design, where the pressure of the downstream water seals the gate and when the downstream water level drops, the floodgates open to permit drainage. Floodgates are artificially lifted for cleaning and repairs and also for improvement in water quality, weed management, to provide greater control over surface and groundwater management. They can also be operated to allow for pasture inundation in some cases. RRCC currently has 44 actively managed floodgate systems totaling 141.5 kms of drainage and creek channels being tidally flushed and 6 more systems in the planning stages (RRCC, 2011). Tidal flushing is a dry weather strategy to improve water quality in drainage systems and positive results have been recorded during trials on the floodplain (refer Section 7.5.3).

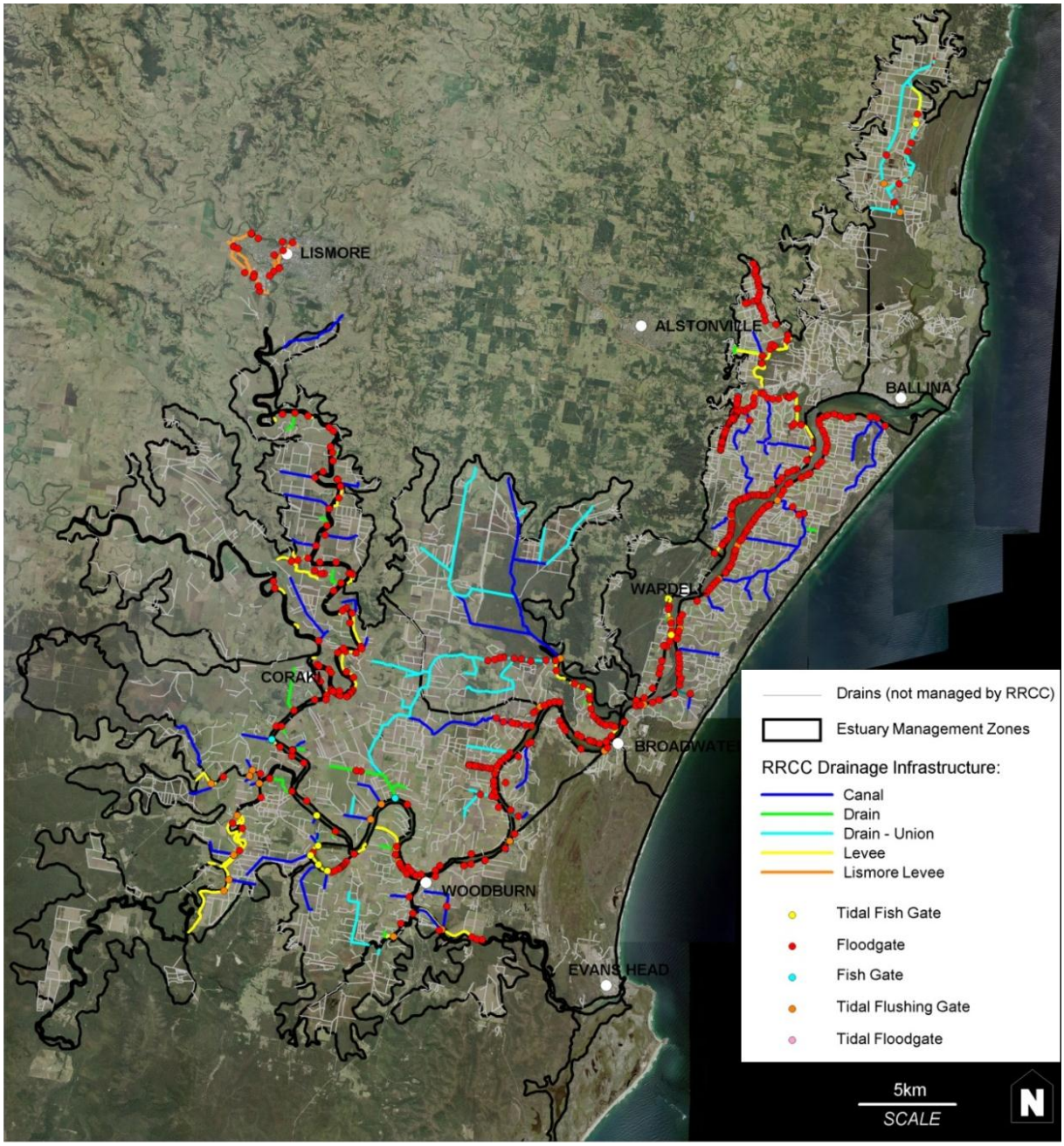


Figure 32 - Floodplain Management Infrastructure including assets managed by RRCC and other drainage

Source mapping data: RRCC

In recent research the issue of drainage infrastructure acting as a conduit for deoxygenated floodwaters brings with it considerations for floodgate management post-flood. The mass-drainage of waters was identified as having significant impacts on estuary health and cited as a key factor in the severity of fish kills observed in 2001 and 2008.

There is now recognition of the significant detrimental impact of floodplain drainage and regulation on floodplain wetlands, ASS management and water quality affecting the overall health of the estuary. Addressing the environmental impacts of floodplain infrastructure and management whilst maintaining adequate protection against flooding, is a key challenge for managing the on-going health of the estuary.

Plate 18: Closed floodgates on Empire Vale Creek, South Ballina

The Richmond River Estuary has a history of poor water quality episodes, particularly following flood events which are periodically associated with fish kills (Plate 19). While fish kills are a periodically occurring natural phenomenon, research has indicated that their frequency and severity are greatly exacerbated by floodplain modification (WBM, 2006).

Plate 19: Fish kill in the Richmond River (Ballina Quays Estate) in February 2008

Source: NSW Department of Industry and Investment – Primary Industries

The EPS (WBM, 2006) summarises the impacts of drainage structures as follows:

- Lowering of water-tables and preventing the natural ingress of river waters;
- Shifts from wetland vegetation species to vegetation intolerant of waterlogging;
- Increase in blackwater runoff events;

- Exposure of ASS and increase in chronic and acute impacts to aquatic biota; and
- Loss of agricultural land due to scalding by ASS, although the total areas affected were relatively small.

Table 6 shows a water quality risk assessment that was developed by the Richmond Floodplain Committee in 2007. The relative contribution of each sub-catchment to acid water and blackwater problems was estimated using local knowledge and experience. The impact on fisheries and overall biodiversity of the estuary ecosystem is also assessed including the scale of the impact. The three sub-catchments identified as presenting the highest risk to water quality in the estuary were the Tuckean (Zone 10), Rocky Mouth Creek (Zone 7) and Sandy Creek/Lower Bungawalbin (Zone 11) (also known as Swan Bay /Lower Bungawalbin). The right-hand side of the table provides an assessment of actions to date and how far specific strategies have been implemented.

The primary issues for estuary health associated with floodplain drainage are discussed in the following sections.

Table 6: Risk assessment of sub-catchments developed by Clay and Cabot (2007) on behalf of the Richmond Floodplain Committee.

Sub-catchments	Water quality problems			Impact on fisheries/biodiversity				Actions to date				
	Acid water	Blackwater from drain sludge (MBOs)	Blackwater from rotting vegetation	Impact upon fisheries	Impact upon Biodiversity	Localised impacts around floodgates	Impact upon entire estuary	Education effort by agencies & council	Site specific management strategies identified			Management strategies implemented
									Acid water	Blackwater from drain sludge	Blackwater from rotting veg	
Tuckean	h	h	h	h	h	h	h	h	yes	yes	no	partially
Rocky Mouth Creek	h	m	h	h	h	h	m	h	yes	yes	partially	partially
Sandy Creek / Bungawalbyn	m	m	h	h	h	h	h	h	yes	yes	partially	partially
Kilgin / Buckendoon / Dungarubba	h	l	m	h	h	h	m	m	partially	yes	partially	partially
Swan Bay	h	h	l	m	h	m	l	m	partially	partially	no	partially
North Creek/Newrybar	m	m	m	m	m	m	l	l	no	partially	no	partially
Emigrant / McGuire's Creek	m	l	m	l	m	m	l	l	no	no	no	nil
Lower Wilson/Richmond	l	l	h	l	l	l	m	l	no	no	no	nil
Sth Ballina / Empire Vale	l	l	m	m	m	m	l	m		no	no	partially
Back Channel	l	l	l	l	l	l	l	l	no	partially	no	partially
Evans	l	l	l	l	l	l	l	l	no	no	no	partially
Riley's Hill	l	l	l	l	l	l	l	l	no	no	no	nil

Acid Sulfate Soils (ASS)

ASS is the common name given to naturally occurring soils that contain iron sulfides, principally pyrite (Ahern *et al*., 1998). Un-oxidised pyritic soils are referred to as potential ASS (PASS). When the soils are exposed, oxidation of sulfides results in the generation of sulfuric acid and acid leachates. The soils are then referred to as actual ASS (AASS).

The formation of coastal ASS require the presence of iron-rich sediments, sulfate (usually from seawater), removal of reaction products such as bicarbonate, the presence of sulfate reducing bacteria and a plentiful supply of organic matter in a reduced (anoxic) low energy estuarine environment. The relatively specific conditions under which ASS are formed usually limits their occurrence to low lying parts of coastal floodplains, rivers and creeks (Ahern *et al*., 1998).

ASS materials in subsurface sediments do not pose a problem if left undisturbed. However, when exposed to air by either excavation or lowering of groundwater levels, the ASS materials oxidise and in the presence of water will form sulfuric acid and other acid products. This can occur through natural processes such as extended dry periods without rainfall resulting in a lowering of the water table and

formation of acid pools, which are later released during flooding events. Floodplain infrastructure including a combination of drains, floodgates and levee banks, artificially lowers groundwater levels, causing more frequent and extensive exposure and oxidation of ASS. Over extraction of groundwater can also lower water tables and expose ASS to oxidation. Figure 33 shows a conceptual model of ASS cause and effects developed for the Richmond River estuary including the impact of floodplain infrastructure. The model uses red arrows to show causative factors and green arrows to show factors that can potentially mitigate impacts.

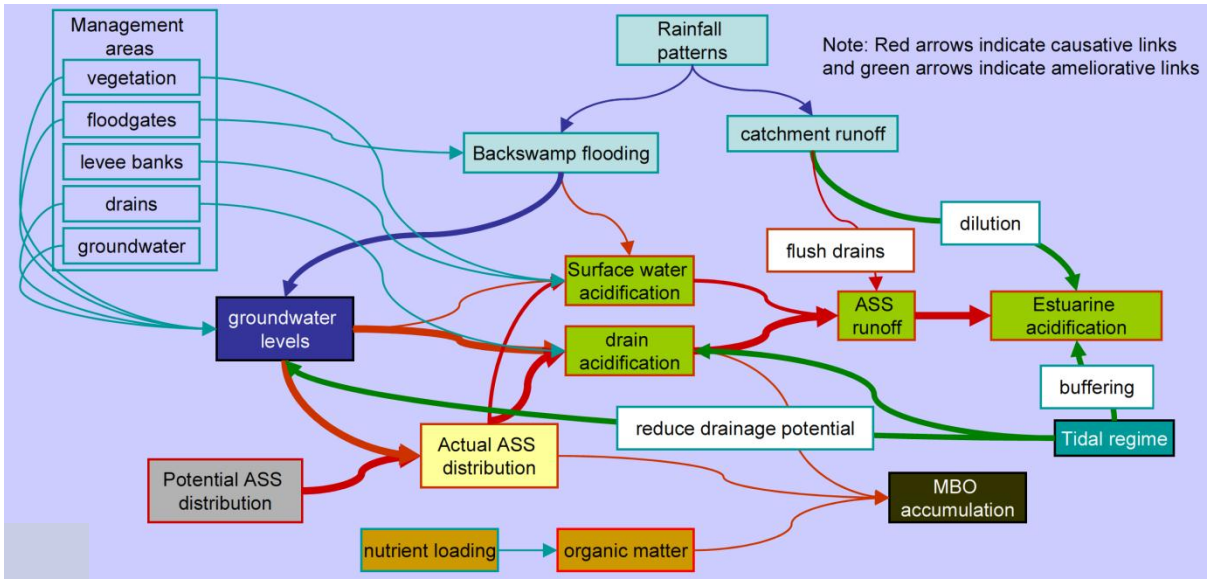


Figure 33 - Factors associated with ASS impacts

Source: ABER, 2007

ASS runoff impacts on the estuarine environment include low pH, high concentrations of toxic dissolved iron, aluminium and other metals (ABER, 2008). Exposure to ASS runoff can impair gill function and increase susceptibility to disease in fish, particularly Epizootic Ulcerative Syndrome (EUS), otherwise known as Red Spot Disease. Additionally, initial flushes of floodwaters in ASS environments can mobilise large amounts of MBOs from drain sediments which can cause local hypoxia events. Incidences of low pH in the lower estuary (i.e. near Ballina) are rare and are a result of the enhanced tidal flushing in these locations which act to neutralise, dilute and remove much of the acidic runoff from the estuary (WBM, 2006).

Approximately 68,000 ha of the Richmond River floodplain is classified as having ASS risk (WBM, 2006). The drainage and subsequent oxidation of ASS across the floodplain has resulted in chronic and acute discharges of acid and associated pollutants to adjacent waterways. Five priority areas for the management of ASS in the study area were identified and mapped by Tulau in 1999, during a state-wide study of ASS. Figure 34 shows the distribution of ASS hotspots across the study area. The Digital Elevation Model (DEM) created for the Richmond River Flood Study (BMT WBM, 2010) is provided as a base map for this figure to give an indication of the low elevation of the floodplain and specifically the ASS hotspot areas.

Priority ASS areas are:

- Tuckean Swamp;
- Rocky Mouth Creek;
- Sandy Creek – Bungawalbin Creek;

- Maguires Creek - Emigrant Creek; and
- Newrybar-North Creek.

Each of the above areas is discussed below in terms of the nature of the problem and current management activities occurring to address the problems.

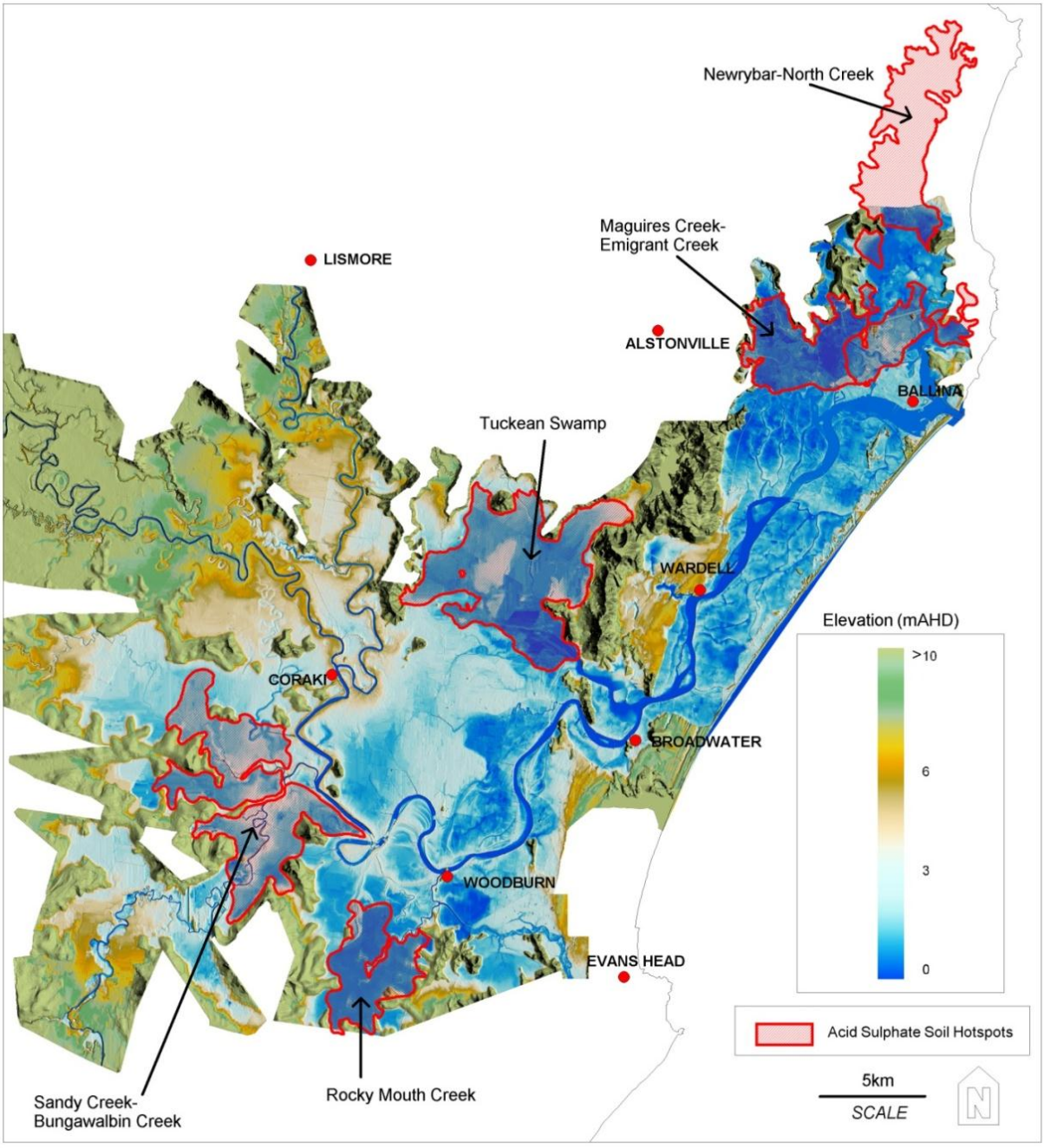


Figure 34 - ASS Hotspots shown over the floodplain Digital Elevation Model showing elevation
Source ASS Hotspots: Tulau (1999); Source of other mapping data, RRCC

Tuckean Swamp

Drainage of the Tuckean Swamp has dramatically altered the swamp's hydrology resulting in the widespread oxidation of ASS, and shifts in vegetation communities away from open wetlands to dry-land pastures and *Melaleuca* forests. The drainage system also provides a more efficient conduit for the transport of ASS runoff and blackwater to the estuary. Discharges from the Tuckean Swamp are commonly extremely acid (pH ~3.2) and contain high concentration of toxic metals such as dissolved aluminium (ABER, 2008).

The most northern reach of the Tuckean-Broadwater has been isolated by the construction of the Bagotville Barrage. Water quality has been significantly impacted by ASS runoff, which causes chronic acidification of the main and Meerschaum Vale drains and seasonal acidification of the upper reaches of the Tuckean Broadwater (Ferguson and Eyre, 1995). ASS runoff is characterised by high concentrations of dissolved metals (e.g. iron and aluminium), which rapidly precipitate as runoff mixes with estuarine receiving waters (Ferguson and Eyre 1999).

Rocky Mouth Creek

The Rocky Mouth Creek and Swan Bay consists of a backswamp draining to the Richmond River at Woodburn. Much of the backswamp area is below sea level and subject to rapid flooding after rainfall. The combination of low lying land and agricultural landuse have led to major water quality problems associated with ASS run off and blackwater, all of which are exacerbated by modified drainage. ASS runoff can be extreme and contains high concentrations of dissolved metals. The upper reach of Rocky Mouth Creek is prone to extreme acidification for extended periods of time following runoff events, with recovery greatly influenced by tidal mixing. Lin *et al* (2004) reported that acidic flows (ph<4.5) from May 1998 to July 2000, occurred intermittently for several months in the upper reaches. Dissolved oxygen data indicate that the creek is also prone to extensive periods of hypoxia due most likely to oxidation of ASS products or high biological oxygen demand (BOD) from floodwaters (ABER, 2008). Acid groundwater flows from Rocky Mouth Creek are also a significant contributor to acid flows.

Sandy Creek – Bungawalbin Creek

Draining of the swamps of Bungawalbin and Sandy Creek resulted in widespread shifts away from native wetland vegetation and towards oxidation of ASS (WBM, 2006). These areas now have active ASS which create considerable acid runoff via subsurface flows to the estuary. This sub catchment area contributes a large amount of flow to the main river channel and therefore has a major influence on acidification of the main estuary particularly during runoff events.

Maguire's Creek - Emigrant Creek and Newrybar-North Creek

Large areas of actual ASS are located in the north of the study area, in the upper reaches of North Creek and lower and mid reaches of Emigrant and Maquires Creek. Both areas have been extensively drained and are utilised for agriculture (mainly sugarcane and grazing land). Acidification has been noted as affecting water quality in the upper reaches of both North Creek and mid reaches of Emigrant Creek (ABER, 2008). In Emigrant Creek, acid water is known to become an issue following significant rainfall (Walsh *et al*., 2010). In the lower reaches, tidal flushing largely mitigates the impacts of acid runoff through the buffering effects of seawater. This was evidenced in ABER's (2008) low to medium risk rating for downstream acidification impacts from both zones.

Monosulfidic Black Ooze (MBO)

Monosulfidic black ooze (MBO) is created by rotting organic matter that is enriched with iron monosulfides. It is formed on drain bottoms and sides by bacterial catalysed chemical reaction when organic matter combines with iron and sulfur in a low energy reducing environment to form iron monosulfides (FeS). When disturbed and transported during flow events, MBOs have the capacity to rapidly deoxygenate water and severely disrupt the ecology of waterways (Bush *et al.,* 2003). MBOs form under conditions where there is low flow, an abundance of vegetation and high concentrations of iron and sulfur from ASS drainage. Flood-gated drainage canals through low lying backswamps over estuarine sediments provide excellent conditions for their formation (Johnston *et al* 2003). Fish kills associated with the disturbance and transport of MBOs have been reported for the Richmond River estuary (ABER, 2007). The Tuckean has one of the highest recorded concentrations on MBOs reported in the world (Bush *et al*., 2004).

Plate 20: Monosulfidic Black Ooze

Source: R. Bush

Blackwater Events

Blackwater is a collective term used to describe low oxygen floodwaters with high organic load emanating from backswamp areas following flood events (ABER, 2007). Blackwater may consist of inorganic blackwater from MBOs and/or organic blackwater from the decay of floodplain vegetation with the largest impact associated with organic blackwater. From early colonisation European land clearing on the floodplain has replaced flood adapted native trees and shrubs capable of withstanding floods with exotic grasses and crops which quickly die and decompose in summer when flooded. This was discussed as a major contributor to fish kill events in the Richmond River in the EPS (WBM, 2006) and recent studies have offered greater insight into the nature and extent of blackwater events (refer Section 4.2.1). Prolonged inundation of the floodplain during and immediately following flooding can cause the decay of the underlying vegetation and rapid decomposition of accumulated organic matter (Eyre *et al*., 2006). The decomposition process strips oxygen from the overlying water, creating 'blackwater'. The mass drainage of this ponded blackwater via the drainage network and tributaries as floodwaters recede can cause hypoxic (very low dissolved oxygen levels) conditions along large stretches of the estuary (Wong *et al.,* 2010). Aquatic life requires certain levels of dissolved oxygen in the water to live and when those levels drop, organisms will either escape to better quality water, or if this is not possible, they will inevitably die. When blackwater propagates through large areas of the estuary, as was seen during the 2001 and 2008 floods, major fish kills have occurred. Wong *et al*. (2010) identified the backswamp areas of the Tuckean, Rocky Mouth Creek and Bungawalbin Creek systems as the most significant sources of blackwater in the Richmond Estuary. Figure 35 shows the general location of the significant blackwater generation areas, using the DEM as a base mapping layer to give an indication of the low elevation at these sites.

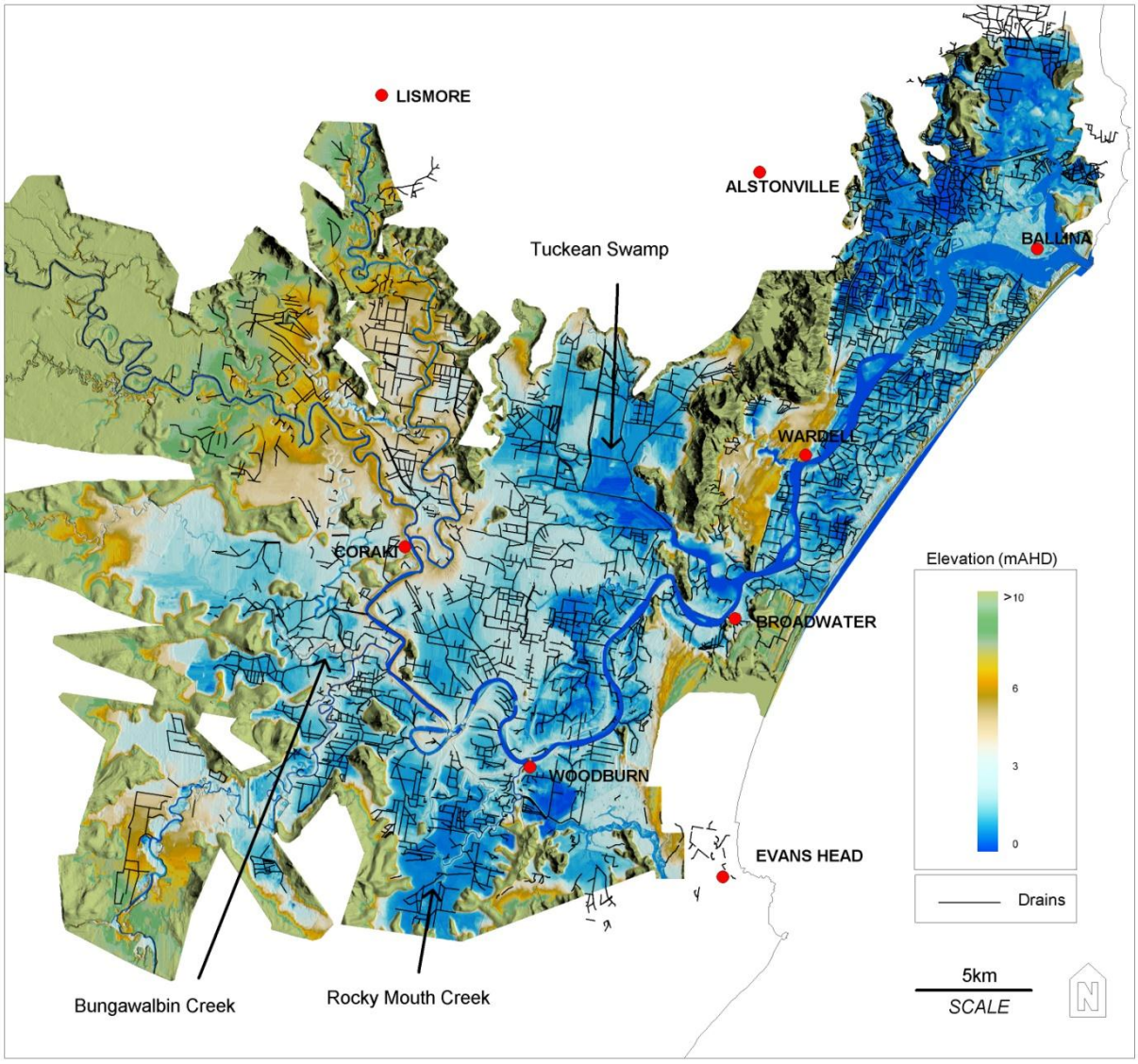


Figure 35 - Digital Elevation Model of the Floodplain showing low-lying areas (dark blue is at or below sea level), drains and identified blackwater source areas of Tuckean, Bungawalbin Creek and Rocky Mouth Creek

Source mapping data, RRCC

High water temperatures have also been found to be a significant factor in fish kills (Wong *et al.*, 2010) and this is likely due to higher temperatures leading to faster rates of decomposition and faster consumption of oxygen from the water and also because higher temperature water also holds less dissolved oxygen than cooler water.

A conceptual model of the Richmond Estuary February 2001 fish kill was developed by ABER (2007) illustrating the relationship between various factors contributing to blackwater events. The conceptual model is shown in Figure 36 over a time scale relative to the flood peak and recession. The frequency and extent of kills is determined by a complex interaction between these factors. As such, prediction of fish kills is difficult, however an understanding of primary drivers is important to inform mitigation strategies. Walsh *et al*. (2010) compared conditions during floods that result in fish kills against those that did not, and found that fish kill floods have significantly drier preceding conditions followed by short, sharp summer flood peaks. This finding highlights the fact that climatic influences and catchment conditions leading up to flooding as well as the flood magnitude and duration have a large influence over blackwater fish kills. The model also demonstrates the impact of drainage and flood mitigation works in creating much drier floodplains and hence a more frequent trigger for fish kills.

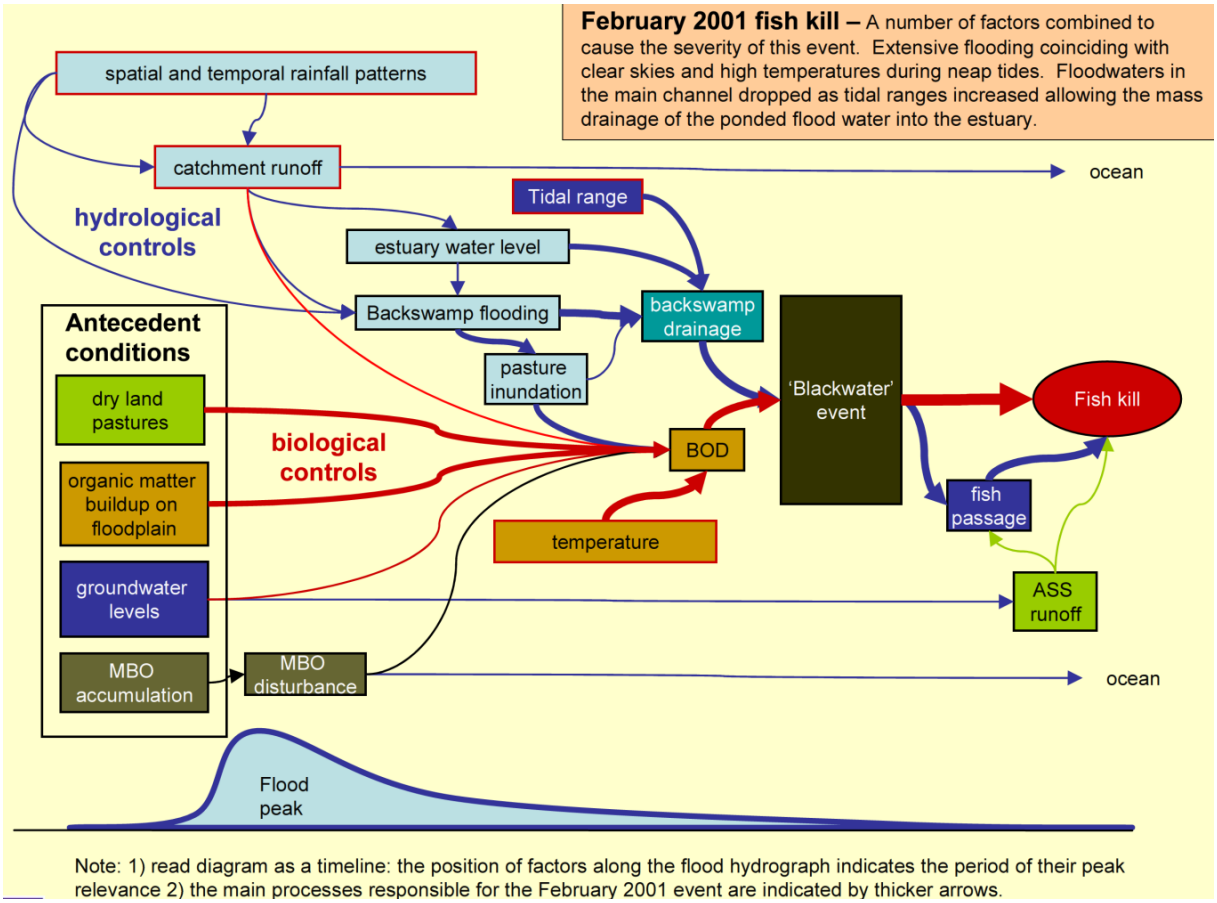


Figure 36 - A conceptual model of the Richmond Estuary February 2001 fish kill illustrating the relationship between various factors contributing to blackwater events

Source: ABER, 2007

While blackwater events have been recorded prior to floodplain drainage, the construction of drainage infrastructure on the Richmond floodplain has contributed significantly to blackwater production and impact by increasing the rate at which blackwater is produced and increasing the rate of delivery of blackwater to the main river channel (Walsh *et al*., 2010). The combination of floodplain drainage infrastructure (drains, levees and floodgates) creates much drier soil conditions during non-flood periods and facilitates the draining of freshwater from floodplain backswamps. Furthermore, original floodplain vegetation that was adapted to frequent inundation has been replaced by vegetation that is dominant under drier conditions (particularly pasture). The vegetation on drained floodplains is generally intolerant of waterlogging and consequently decomposes faster and demands more oxygen after inundation (Eyre *et al*., 2006). Another factor that exacerbates the impacts of blackwater events is the swift delivery of blackwater to the river via extensive drainage systems. These act as a conduit for blackwater to the main river channel as floodwaters in the main channel drop (Wong *et al*, 2010).

Plate 21 - Blackwater discharging from a drain into the acidified Richmond River at Swan Bay

(R. Bowie, 1996)

No.	Floodplain Management Issues
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)
I11	Blackwater events following flooding have been identified as the major cause of recent fish kills in the mid-lower estuary
I18	Floodgates affect tidal flushing, reduce aquatic habitat, interrupt fish passage, alter water chemistry and degrade floodplain soils
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.

7.5.2 Management Objectives

Table 7 shows the relationship between Floodplain Management issues, related values and management objectives.

Table 7: Relationship between Floodplain Management Values, Issues and Objectives

Values	Issues	Objectives
• Commercial fishing and oyster aquaculture contribute to the local and regional economy • The estuary and particularly the lower estuary is considered to be a key attraction for tourists and recreational users to the area, with associated economic benefits • The Richmond River Estuary has high cultural and spiritual significance to local Aboriginal communities • The estuary and foreshore areas are highly valued by the community and visitors for recreational activities • Scenic amenity is valued highly by the local community and visitors • The Richmond River Estuary and wetlands provide a diversity of habitats for a range of terrestrial and aquatic species	I10 - Acid water generation and runoff impacts estuarine ecology and contributes to fish kill events I11 - Blackwater events following flooding have been identified as the major cause of recent fish kills in the mid-lower estuary I18 - Floodgates affect tidal flushing, reduce aquatic habitat, interrupt fish passage, alter water chemistry and degrade floodplain soils 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.	O7 - To minimise the frequency and severity of environmental events such as fish kills O8 - To optimise flood mitigation works and flow control structures to improve estuarine water quality

7.5.3 Potential Management Options

In general, any management options that move towards the reinstatement of a more natural flows and restoring floodplain ecosystems would be a step towards improving water quality and general estuary health. There are a range of management options that have been developed through technical research and scientific trials both within the Richmond River catchment and at other locations. The effective application of various management options is dependent on a number of site specific factors and a case by case assessment of specific sites is required to recommend appropriate actions. Options identified for management of ASS, MBOs and blackwater issues are summarised below.

Acid Sulfate Soils

Several on-ground works are currently being implemented to manage ASS within the estuary management zones. Management actions include floodgate management and infilling and/or reshaping of drains for groundwater control. These methods seek to manage ASS by reducing the exposure of pyrite within the soil profile to air. By submerging the ASS, the risk of oxidising the pyrite within the ASS and subsequent acid leachate being released into the drains and downstream watercourses is reduced. These activities also reduce the interception of iron and aluminium rich groundwater and reduce the extent of accumulation of monosulfidic black oozes behind the floodgates.

Plate 22 - Floodgates on Tuckombil Canal, Evans River

Managing floodgates for tidal flushing has allowed for buffering of acid build-up (Moore, 2007). RRCC actively manage most of the major flood gated systems to allow tidal flushing where practical Floodgate management trials were conducted by RRCC on the Tuckean Barrage in 2002. Water quality monitoring showed that tidal flushing during dry times can decrease the build-up of acid waters upstream of the barrage and improve aquatic habitat. Even though water quality can quickly decline following rainfall, due to ASS runoff, the tidal flushing offers at least periodic improvements in water quality. Groundwater management, drain remodelling and drain infilling have also been conducted at various sites within the floodplain. In-filling and shallowing can also be used to partially restore former wetland floodplain hydrology, with subsequent water quality improvements.

These management actions have had major effects on reducing ASS exposure, oxidation and acid export. ABER (2008) reported on water quality improvements observed following drain management initiatives by RRCC. An example is provided in Figure 37, showing improvements in water quality (increase in pH levels) during dry periods related to partial infilling (installation of sills) of the Meerschaum Vale channel in 2005. The Floodgate Drain Management Guidelines (RRCC, 2006) provides guidance for RRCC staff, private contractors and landholders to undertake ‘Best Practice’ in flood mitigation drain and floodgate management. A review of the guidelines is recommended in association with review of floodgate management protocols to ensure the guidelines are updated with the latest information (scientific innovations, legislation, planning changes, best practice etc.), particularly with regard to sea level rise implications and the effects of blackwater releases via drains and floodgates to the Richmond River post-flood.

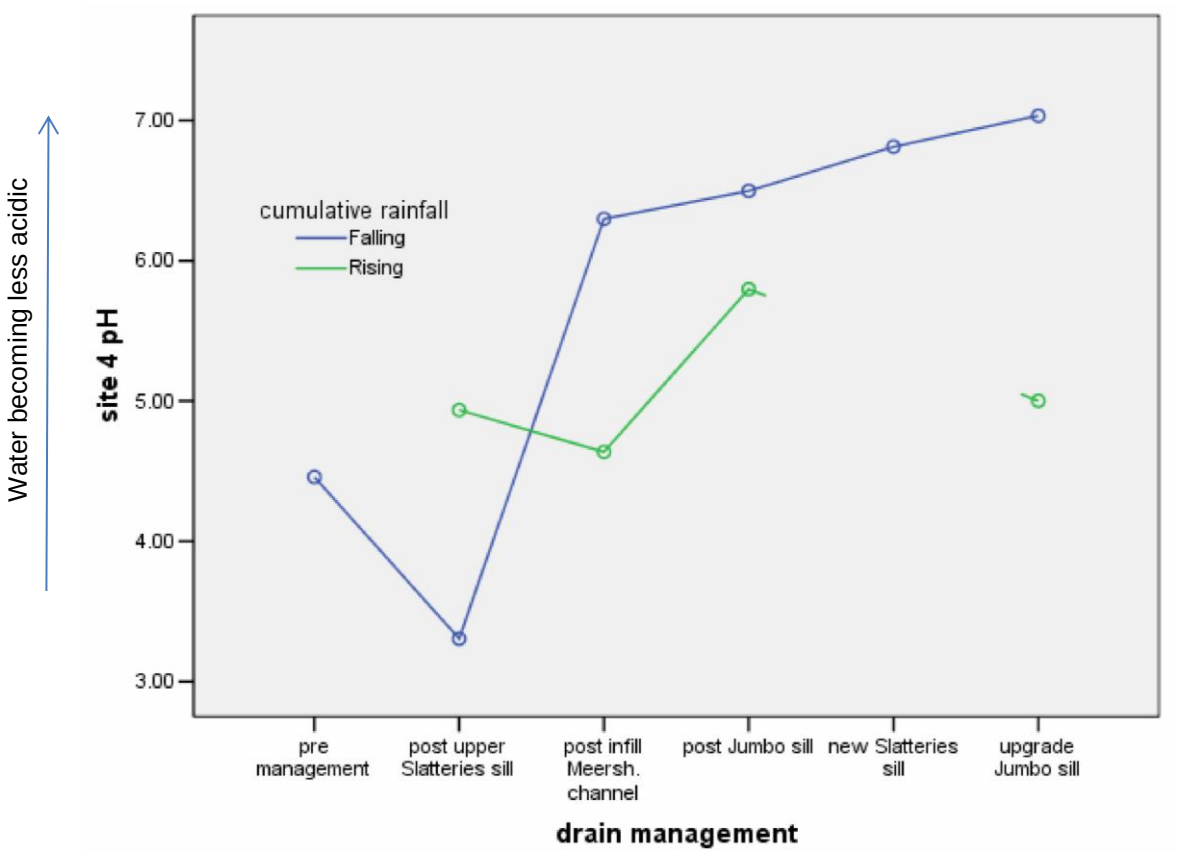


Figure 37 - Impacts of drain management initiatives on pH in the Tuckean

Source: ABER, 2008

During development of the Draft EMS, concerns were also raised about the effect of groundwater extraction on drawdown of the water table and resulting ASS effects. These concerns were specific to the area upstream of Ballina Nature Reserve in Zone 1 North Creek/Newrybar, which is an ASS hotpot area. There are several existing groundwater licences in the area and there is uncertainty about the effects of extraction on ASS effects. A review of Water Sharing Plans for the area in relation to groundwater extraction levels compared to freshwater recharge and considerations for sea level rise, will provide further understanding of ASS effects.

Blackwater

Walsh *et al*. (2010) recently conducted an assessment of blackwater mitigation options for the Richmond River Estuary. Options were compiled in consultation with the Estuary Floodplain Committee. Each option was assessed in terms of benefits (pros) and costs (cons). The options assessed were:

- Do nothing;
- Retain post-flood water inundation;
- Wet pasture management;
- Floodgate management;
- Laser levelling;
- Drain shallowing;
- Alternative land uses / crops;
- Remove vegetated biomass from floodplains; and

- Replace pastures with trees and shrubs.

Walsh *et al*. (2010) concluded that the identified options have a range of positive benefits for managing blackwater, and other issues such as ASS and MBOs. In terms of managing blackwater, the study identified a number of gaps in the current understanding related to specific details of on-ground application and also the extent to which specific management options will affect overall estuary health. Further studies were recommended to trial certain management activities (e.g. floodwater retention on backswamps) and fill these data gaps. An important part of scientific trials will be to review current and past work such as conducted at Clybacca and Little Broadwater and to build on existing knowledge.

Management actions as described above (apart from the do-nothing option) provide significant opportunity to improve water quality and minimise acid and blackwater events. On-ground application of these techniques and combinations of options varies significantly between the various sites. What may work in one particular area may not be successful in others due to site variation, and a range of potential environmental, economic and social constraints. There are also a number of other considerations that may constrain the implementation of effective management including landowner consent, suitable incentives for landowners, funding and resourcing arrangements, the age of existing drainage infrastructure at a particular site, legislative requirements and approvals. It will be necessary to carry out detailed on-ground assessment of each site to recommend an effective suite of management actions.

It is important that strategies are monitored to adequately gauge their success, assist with the planning of future rehabilitation techniques and to improve the understanding of how ecosystems respond to changes over time. The succession of landholders will also be of interest to monitor as changes in ownership of properties can also involve changes in land use and intensity with flow on consequences for on-ground projects to address floodplain drainage impacts. An audit of current active floodgate management practices is required to identify how well the current management activities are proceeding and whether changes to these arrangements are desirable.

No.	Floodplain Management Options
4	Identify and prioritise drainage for infilling of redundant drains and reshaping of other drainage
5	Identify and prioritise levees for redesign and/or remodelling
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 management including changes to inundation tolerant pasture species
10	Retirement/buy back backswamp areas and return to wetlands
11	Work with backswamp property owners to identify alternative management strategies
21	Review water sharing plans regarding groundwater extraction and ASS effects

7.6 Farm Management

7.6.1 Issues

Agriculture is an important contributor to the local economy and is a key component in the social fabric of the region. Agricultural land use and some management practices are also identified as one of the major causes of poor water quality in the catchment and contribute to a broad range of issues in the estuary. Addressing the impacts of agricultural land use on the estuary, while continuing to enhance the local economy and protecting rural lifestyles, is one of the biggest challenges facing long-term management of the estuary.

Approximately 75% of the Richmond River estuary study area considered in the EPS (WBM, 2006) is zoned for various forms of agricultural use. Management of these lands has a large bearing on future outcomes for estuarine values. Key issues relating to farm management are discussed below, as well as in Section 7.7 (Riparian Zone Management) and Section 7.5 (Floodplain Infrastructure Management) where farm related practices have a large influence.

Sediment, nutrient and chemical runoff

Sediment, nutrient and chemical runoff from agricultural land can be significant. The EPS (WBM, 2006) cites work undertaken in 1999 that estimates fluvial sediment loads to the estuary of 678,000 tonnes per year, with 85% generated by sheet and rill erosion of unconsolidated sediments. Hossain *et al*. (2001) investigated the timing of sediment inputs and showed that the majority (~97%) of catchment based sediment load to the estuary was generated during the wetter parts of the year. Although small flow events will transport and deposit this material within the estuary, large floods will flush these sediments completely from the system (Hossain *et al*., 2001).

The EPS (WBM, 2006) evaluated potential nutrient loads to the estuary and reported catchment total phosphorus input to the estuary of over 483 tonnes per year of which grazing (45.5%), cropping (21.6%) and horticulture (12.4%) were major contributors. McKee *et al*. (2000) found that 97% of the total nutrient load to the estuary was derived from diffuse sources. A large proportion of both nitrogenous and phosphatic fertiliser inputs are not utilised by the crops and animals within the catchment and may be lost by leaching or runoff to the downstream waterways. During the McKee *et al*. (2000) study, fertiliser inputs were found to account for 65.5% of the phosphorus and 26% of the nitrogen loads generated within the catchment.

As with sediments, it was concluded that the majority of flood-bourne nutrient loads delivered to the estuary are directly transported off shore when the estuary is flushed to the mouth (WBM, 2006). However, post-flood and during non-flood periods, particulates, organic matter and nutrients are deposited in sediments and the water column recycles the bioavailable nutrients (ABER, 2007). Several sites within the study area experience periodic eutrophication and this is controlled by complex nutrient cycling processes.

Threats to ecological processes in the water column related to farming practices were identified by ABER, 2007 as:

- Increased nutrient loadings due to diffuse and point sources may increase phytoplankton productivity and hence organic carbon loading (“eutrophication”). This has implications for dissolved oxygen concentrations, invertebrate, and fish ecology; and
- Increased phytoplankton biomass and turbidity associated with catchment-derived suspended solids cause an increase in light attenuation, and in extreme cases may result in dissolved oxygen stratification, with hypoxic conditions persisting in bottom waters.

Within the benthic zone, turbidity and phytoplankton blooms associated with point and diffuse sources will lower the relative importance of benthic production and cause a shift towards the detrital pathway (ABER, 2007).

The use of agricultural chemicals in the catchment and subsequent runoff is a potential issue, although ever-increasing regulation of the industry (e.g. the recent ban on the use of endosulfan with two year phase out period) has greatly reduced the risk of widespread contamination however community concern about the potential for contamination remains. There are some industries reliant on the estuary such as oyster aquaculture (see Section 7.14.1) that are particularly susceptible to contamination of this type.

Stock access to waterways

Allowing stock to access waterways is a common farming practice which alleviates the need to provide off-stream watering and allows stock access to fresh feed and shade within the riparian margin. Although usually confined to freshwater riverine reaches, the EPS (WBM, 2006) reports that cattle also access some mangrove areas within North Creek and Emigrant Creek.

Stock usually gain access to waterways through unfenced creek boundaries, often in areas where riparian vegetation has been cleared to the water's edge. Cattle herds will repetitively access the creek through the same areas, and the concentration of animal traffic in these locations leads to soil pulverisation, rut formation and areas of soil instability. Immature trees and shrubs are either grazed or trampled whilst larger trees become destabilised as soil is eroded from around their roots. Stock will wander along river banks to access other grazing or shade areas and can therefore impact large lengths of stream through relatively few access points.

Sediment loads into the estuary are likely to have increased in response to grazing pressures in the catchment. This is likely to have resulted in increased turbidity, with consequent flow-on effects to estuarine ecosystems and productivity (WBM, 2006).

Bank instability and high grazing pressure prevents re-establishment of native riparian vegetation in cattle impacted areas and results in increased weed infestation of riparian zones. This is further discussed in Section 7.7.

Plate 23: Cattle grazing the banks of the Richmond River near Casino. The green tinge to the water indicates an algal bloom.

Cattle urinate and defecate directly in the water, hence creating direct sources of nutrients and faecal contamination which is bourne downstream to the estuary every day of the year. Stock will also often become trapped in soft sediment and flood debris within the creek margins and may drown. Dead animals act as a source of contamination and an aesthetic and health issue and represent a loss of farm income.

Pasture Management

As discussed in Section 7.5.1, land clearing on the floodplain and the establishment of exotic grasses and crops has resulted in the dominance of flood-intolerant vegetation. The decomposition of organic matter following a flood has been found to be a major contributor to fish kill events through the creation of blackwater. This is exacerbated by the decomposition of flood-intolerant pastures and the resulting high oxygen demand. Similarly, the deoxygenation potential of slashed pastures, harvested tea tree and cane trash is high and retention of this vegetative matter on the land also contributes to the risk of blackwater during floods.

Lack of incentive for change

Farming practices are developed over generations and can be retained for generations. Although there is increasing awareness of farming impacts on waterways within the farming community, strategies to address issues are not always evident and farmers do not always have access to the information required to make informed decisions. Industry guidelines and standards may not address issues that have significant impacts on estuarine health as they are not usually written for that purpose.

The costs and benefits of alternative management approaches to high impacts activities needs to be undertaken at a farm scale and requires the individual landholders to be involved. Farmers do not always have access to the appropriate information, skills or guidance to allow a proper cost benefit analysis of alternative practices to be undertaken.

A key lack of incentive to alter farming practices is the economic viability of such changes, particularly in the short-term where payback from up-front investment in more sustainable practices may leave significant farm revenue gaps. Economic initiatives that may be available to assist landholders are often dependent on short-term funding that is not consistently available. Additionally, knowledge of such incentives or the time to apply to gain access to such incentives may be not be available. It may be helpful to identify and target the catalysts for change such as change in landuse, change in ownership or when key infrastructure needs to be upgraded (e.g. publicly funded flood mitigation structures).

No.	Farm Management Issues
I1	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
I6	Unrestricted stock access causes vegetation damage and bank erosion.
I7	Lack of incentive for landholders to address bank erosion
I11	Blackwater events following flooding have been identified as the major cause of recent fish kills in the mid-lower estuary
I16	Poor water quality episodes (particularly nutrients and faecal coliforms) occur in the lower estuary but sources of pollutants are currently unclear
I22	Low ecological value of floodplain habitats results from widespread clearing, fragmentation and weed encroachment
I34	Possible increase in frequency and intensity of storm events due to climate change and altered flooding patterns, exacerbating erosion, bank stability, and water quality issues

7.6.2 Management Objectives

Table 8 shows the relationship between farm management issues, related values and management objectives.

Table 8: Relationship between Farm Management Values, Issues and Objectives

Values	Issues	Objectives
• The Richmond River catchment supports a wide range of land uses which are important contributors to the local and regional economy • The riparian zone provides significant protection to estuary water quality • Good water quality is highly valued by the community • Scenic amenity is valued highly by the local community and visitors • The estuary supports a number of rare and threatened communities • Estuarine wetlands including mangroves, saltmarsh and seagrass areas provide an important role in healthy ecosystem function	I1 - 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 I6 - Unrestricted stock access causes vegetation damage and bank erosion. I7 - Lack of incentive for landholders to address bank erosion I16 - Poor water quality episodes (particularly nutrients and faecal coliforms) occur in the lower estuary but sources of pollutants are currently unclear I22 - Low ecological value of floodplain habitats results from widespread clearing, fragmentation and weed encroachment I34 – Possible increase in frequency and intensity of storm events due to climate change and altered flooding patterns, exacerbating erosion, bank stability, and water quality issues	O1 - To encourage economically viable and environmentally sustainable land use practices in the catchment O2 - To ensure strategic planning instruments and programs are consistent with and where applicable, directly address the aims of the CZMP O6 - To protect and enhance the riparian zone O14 - To enhance sustainable commercial return from industries relying on the estuary and the floodplain O9 - To minimise constraints to estuary adaptation to climate change O5 - To reduce pollutant loads to the estuary O13 - To protect and enhance visual amenity/ aesthetic appeal of the estuary

7.6.3 Potential Management Options

Issues associated with agricultural land management are some of the most widespread and culturally challenging aspects of catchment management. In terms of the Richmond River estuary, the high level of agricultural land use means that any widespread changes in farm management will have a large bearing on the conditions of the estuary.

Riparian fencing is often recommended to protect riparian areas from stock damage. This strategy is rarely effective when undertaken in isolation from a comprehensive stock management strategy implemented on a stream reach basis. Construction of reliable off-stream stock watering facilities, provision of adequate pasture shade trees and ensuring on-going riparian fence maintenance is undertaken are key actions required to avoid stock access to waterways. With these measures in place, bank stabilisation, riparian vegetation regeneration and weed control often needs to be undertaken for several years before long-term improvements can be realised.

Careful strategic planning is required on a property by property basis to ensure that the implementation of such measures will be successful and that the farm can continue to operate as a sustainable commercial venture. Although continued provision of information to the farming community

is essential, it is unreasonable to expect that change will occur without planning assistance and continued incentives to change current unsustainable practices.

Options to address farm management impacts on the estuary are as follows:

- A high level evaluation of agricultural land is required to identify and prioritise those farming properties where tailored farm management plans are likely to result in the most benefits for the Richmond River estuary. This prioritisation study should consider up to date land-use mapping, agricultural industry sector, presence of other property risks (e.g. ASS, back swamp pastures – see Section 7.5), hydrological proximity to the estuary as well as other information that may indicate property owner willingness to participate. A social network study conducted by CSIRO and James Cook University in 2008 is an example where this sort of information was gathered efficiently through initial phone surveys;
- Preparation of farm management plans for priority properties. The plans should document implementation strategies to address specific environmental issues including stock impacts, riparian zone degradation, soil loss and erosion, fertiliser and pesticide use and storage, drainage, pasture/crop harvesting and management as well as a long-term farm economic plan and long-term strategy for adjustment to more estuary-friendly land uses;
- Provision of extension services and incentives to farmers to change farm or property management practices. Incentives could include supply of material, labour, buy back and/or long term stewardship payments or other compensation programs. Properties bought back would require ongoing management by a Government department, agency, community group or Non-Government Organisation (NGO). Another option is voluntary purchase and resale with a conservation covenant attached, such as the NSW Nature Conservation Trust covenant program.
- Identify and liaise with agriculture industry bodies to discuss agriculture related issues in the Richmond River estuary and seek to provide information for inclusion in industry documentation such as best practice guidelines, codes of practice and waterway health certification; and
- Continued provision of educational material that is accessible to landholders within the catchment on ways to improve their farm management practices. This option should include or provides links to a comprehensive internet resource as well as public displays at agricultural events (e.g. Primex) and industry forums where appropriate.

No.	Farm Management Options
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

7.7 Riparian Zone Management and Erosion

7.7.1 Issues

Riparian habitats are a significant component of estuarine and floodplain environments. Riparian zone functions include fisheries habitat, terrestrial habitat, bank stability and maintenance of soil structural integrity, land use buffering, water quality filtering, lowering water temperature and reducing aquatic weeds as well as providing scenic amenity.

Riparian Zone Condition

The EPS (WBM, 2006) compiled available mapping of broad vegetation types within 100m of waterways conducted by NPWS (2005) and DPI (2005). Detailed mapping data for riparian vegetation and the extent of weed invasion throughout the study area is not currently available.

More recently, work carried out by Australian Wetlands (2010, attached in Appendix 2) assessed the riparian vegetation of the Richmond River, however the assessment was limited to written descriptions of the study areas based on on-ground rapid assessment and broad mapping of riparian widths across the catchment. The main findings were that the riparian vegetation bordering the Richmond River Estuary and tributaries was degraded for much of the area. The width of the bank vegetation was often <5 m and few native trees remained. Serious weed invasion was occurring on the banks as there was no natural vegetation to inhibit the growth of weeds. There are some areas of remnant vegetation with good native canopy and mid-storey trees, particularly mid to upper Bungawalbin Creek and tributaries, mid North Creek and parts of the lower Estuary, but these are relatively rare within the estuary as a whole. The lack of riparian vegetation also allows the growth of aquatic weeds in some areas such as Sandy Creek through a combination of both nutrient and light availability (Owers, 2005). The EPS identifies the limited coverage and poor condition of the riparian zone as a key issue affecting overall estuary health (WBM, 2006).

Major disturbance factors for riparian vegetation in the Richmond River catchment are:

- Clearing of the bank/riparian vegetation;
- Ongoing disturbances associated with unrestricted stock access to banks;
- Lack of suitable buffer zones between land use and waterways, which is particularly; significant in areas of high soil disturbance such as cropping areas on steep slopes;
- Disturbance associated with infrastructure including waterfront structures and roads in close proximity to the river;
- Weed invasion; and
- Disturbance associated with periodic flooding.

Bank Erosion

Bank erosion can lead to a range of environmental, social and economic problems such as the loss of riverfront property and infrastructure, water quality degradation, destruction of natural and artificial levees, loss or destabilisation of native trees and the destruction of habitat and aquatic plants and animals.

Water quality issues associated with erosion include high turbidity and the mobilisation and transportation of nutrients and contaminants associated with sediment from land to waterways. Sedimentation in the main river channel is not considered to be a significant issue as most of this sediment is thought to be transported to the ocean during major events, with very little evidence of sedimentation or infilling of the river channel detected in recent river surveys (ABER, 2007). Sediment

can however be a major issue in the lower energy creeks where channels have become infilled with sand, such as Six Mile Swamp Creek in the Bungawalbin Catchment. Sediment transported from drains can also build mud flats and smother sea grass in the lower estuary. Shoaling in the lower estuary is determined by a balance between freshwater inflows and tidal range and shoals within the entrance are mostly stable other than reworking during major floods and some tidal movement (ABER, 2007).

Plate 24: Severe bank erosion and degraded riparian zone on the Richmond River near Casino

Bank erosion is prevalent in many areas within the estuary management zones. Bank erosion occurs mainly because of loss of vegetation in key riverbank areas where water velocities are high and banks scour, resulting in undercutting and bank slumping. Additionally, riparian areas can become susceptible to erosion as a result of trampling by stock (refer Section 7.7), vehicle access, boat wash and unlicensed access to the river (refer Section 7.10). The significance of these impacts varies according to the location along the river system. Large stretches of the Richmond River and its tributaries have been reported as being devoid of good quality riparian vegetation which in many instances coincides with areas of active bank erosion (WBM, 2006). Riparian vegetation is critical for maintaining bank stability and channel integrity as well as decreasing sediment run-off.

Predicted sea level rise due to climate change may increase erosion due to increased estuary water levels and the interaction of tidal waters with catchment floodwater. Climate change impacts are discussed in Section 7.3.

No.	Riparian Zone and Erosion Management Issues
I5	Absence or poor condition of riparian vegetation increases bank instability and erosion.
I6	Unrestricted stock access causes vegetation damage and bank erosion
I17	Lack or poor condition of riparian vegetation reduces the "filtering" of overland runoff and pollutants before reaching the estuary
I21	Lack or poor condition of riparian vegetation compromises habitat connectivity and value

No.	Riparian Zone and Erosion Management Issues
I9	Boat wash from power boats has led to riverbank destabilisation and substantial bank erosion, resulting in increased sediment loads to the estuary (refer Section 7.10)
I29	Illegal waterfront access to estuary causes damage to vegetation and bank destabilisation and limit community access (refer Section 7.10)
I33	Predicted sea level rise may result in impacts associated with shoreline recession, implications for draining and flooding, damage to infrastructure, inundation of low lying ecosystems, habitat modification including landward migration of ecological communities and bank erosion
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

7.7.2 Management Objectives

Table 9 shows the relationship between issues, related values and management objectives.

Table 9: Relationship between Riparian Zone Management Values, Issues and Objectives

Values	Issues	Objectives
• The Richmond River Estuary has high cultural and spiritual significance to local Aboriginal communities • The estuary and foreshore areas are highly valued by the community and visitors for recreational activities • Scenic amenity is valued highly by the local community and visitors • The estuary supports a number of rare and threatened communities • The riparian zone provides significant protection to estuary water quality • Good water quality is highly valued by the community	I5 - Lack or poor condition of riparian vegetation increases bank instability and erosion. I6 - Unrestricted stock access causes vegetation damage and bank erosion I17 - Lack or poor condition of riparian vegetation reduces the "filtering" of overland runoff and pollutants before reaching the estuary. I21 - Lack or poor condition of riparian vegetation compromises habitat connectivity and value I33 - Predicted sea level rise may result in impacts associated with shoreline recession, implications for draining and flooding, damage to infrastructure, inundation of low lying ecosystems, habitat modification including landward migration of ecological communities and bank erosion 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	O6 - To protect and enhance the riparian zone O15 - To minimise risk to the health and safety of users of the estuary

7.7.3 Potential Management Options

Given the current degraded status of much of the riparian zone in the study area, the task of addressing this issue is a major challenge for the Richmond River. The establishment of suitable vegetation for riparian biodiversity corridors and natural vegetation for stabilisation of denuded banks would result in a significant reduction in bank erosion and sediment displacement while enhancing ecosystem values and improving water quality for the estuary as a whole.

Future planning controls and agricultural practices need to support better management of the riparian zone. Identification of existing Crown land parcels and Council reserves along foreshore areas and

better protection of these areas is a priority. Dedicating riparian buffer areas on streams and waterways of the estuary and encouraging farmers to enhance these buffers and employing best practice land management techniques are also potential options. Education of farmers, landowners and the community is required to demonstrate the value of riparian zones. The supply of long term fully funded extension services would be advantageous where possible to enable working relationships to be built over long time frames. The provision of funding incentives and labour assistance through existing funding avenues should continue to be offered to land owners to facilitate these actions (refer to Section 7.6 for further discussion on farm management).

To identify the extent of erosion risk within the estuary, predicted tidal inundation levels need to be determined as discussed in Section 7.3.3 as well as the interaction of tidal waters with catchment flows and the influence of sea level rise. Areas susceptible to erosion risk and the requirement for buffer zones, riparian vegetation management or other erosion mitigation measures can then be determined.

There is currently no coordinated process for riparian management across the study area. Currently, a number of riparian zone management projects are underway in the study area by a number of different stakeholders including Landcare groups and private landholders in association with government agencies. 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. Most of the work is carried out on a case by case basis where landholders or groups are willing and funding is available. These projects have been successful in many areas and their value should not be understated in improving the current state, however an overall plan for riparian rehabilitation presents many advantages over the current approach. Benefits include optimisation of works to achieve best outcomes, promotion of works at visible sites, continued support for funding based on an overriding plan. By identifying and prioritising riparian areas for rehabilitation, managers can assess the areas that will provide the greatest benefits for the effort expended or ‘best bang for buck’. Prioritisation can consider a number of factors including:

- Identification of high impact land use, where vegetated buffers will provide benefits in soil retention/interception and improvement of overland runoff, thus improving water quality;
- Identification and prioritisation of bank erosion areas that would benefit from riparian planting;
- The location of key habitats and enhancement of these areas through greater connectivity created by riparian restoration;
- Land ownership - Crown land or council owned land may be more successful options than privately owned land as demonstration sites; and
- The location of sites in terms of public visibility to promote activities and act as demonstration sites and to enhance aesthetic qualities of the estuary.

Preliminary work by Australian Wetlands (2010, refer Appendix 2) has described the riparian vegetation for the study area, however, this information is not currently in a form suitable to direct management action. Several further tasks are required including:

- Mapping of the existing presence and condition of vegetation across the study area;
- Mapping Crown Land and Council foreshore and riparian land;
- Identification and prioritisation of rehabilitation areas based on factors discussed above; and
- Identification of funding sources and responsible parties for management of areas.

Examples of sites suitable for rehabilitation of the riparian zone exist in all the management zones. In the Swan Bay, Bungawalbin 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.

No.	Riparian Zone and Erosion Management Options
22	Riparian buffer zone establishment (planning)
23	Identify priority riparian areas and rehabilitate
41	Assessment and mapping of tidal inundation extent including potential sea level rise

7.8 Vegetation Management

7.8.1 Issues

Conservation of existing vegetation

With the exception of the Bungawalbin Creek subcatchment and the Border Ranges, the majority of the Richmond catchment has been extensively cleared of native vegetation. Based on a range of broad vegetation mapping datasets provided by NSW NPWS (2005), WBM (2006) estimated that approximately 26% of the study area supports remnant or regrowth native vegetation and estuarine and freshwater wetland habitats, approximately 9% of the study area supports disturbed vegetation communities and habitats and 65% of the study area is cleared or developed land.

The effects of vegetation clearing were summarised by the EPS (WBM, 2006) as:

- Loss of vegetation and associated fauna species. Clearing of vegetation has reduced the biodiversity values of the Richmond River and its catchment;
- Fragmentation of habitats. Remnants within the study area have vegetation corridors forming linkages to other remnants outside the study area. The current long-term viability of these remnants to species that rely on vegetated “movement” corridors may be severely compromised by any further broad-scale disturbance. Past vegetation clearing has resulted in many remnants becoming isolated due to the lack of connecting corridors;
- Increase sediment and nutrient loads to the estuary; and
- Changes in morphological (erosion, accretion) processes within the estuary.

The EPS compiled available mapping of broad vegetation types within the catchment from a number of sources. The habitats and communities of conservation concern were identified by WBM (2006) as:

- Rare and threatened communities, as defined under the TSC Act, namely:
    - Coastal Saltmarsh;
    - Swamp Oak Floodplain Forest;
    - Swamp *Sclerophyll* Forest On Coastal Floodplains;
    - Freshwater Wetlands On Coastal Floodplains;
    - Littoral Rainforest;
    - Lowland Rainforest on Floodplains; and
    - Ripple-leaf Muttonwood (*Rapanea species* A Richmond River).

- Wetlands of conservation significance. SEPP 14 wetlands (4,964 ha) and Zone 7(a) Environmental Protection (Wetlands) or E2 (Environmental Conservation) under the new LEP instrument; and
- SEPP 26 Littoral rainforest (47.1 ha).

The above areas support habitats for a wide range of threatened flora and fauna species, as listed under Commonwealth and state legislation.

Some areas are protected under council reserves while some areas of private land are protected under conservation covenants such as the OEH Voluntary Conservation Agreement or the NSW Nature Conservation Trust (NCT) land covenants. The NRCMA also has five or ten year Landholder Management Agreements (LMA) and ten year Property Vegetation Plans (PVP). Large tracts of remaining vegetation are protected within National Parks or Nature Reserves in the study area. Other areas on private land remain unprotected within Council's planning schemes and the States reserve system. These areas were mapped by WBM (2006). Activities in the catchment are known or are likely to impact on floodplain and terrestrial vegetation and their fauna species. Inappropriate fire regimes, changed hydrology, poor water quality, weed invasion, stock damage and current-day clearing can all impact on ecological values.

Aquatic Weeds

Outbreaks of aquatic weeds are known to occur in several locations within the study area. These weeds can reduce the ecosystem values of open water for birds and fish. Aquatic weeds can cause diurnal fluctuations of dissolved oxygen and provide a source of organic matter for the production of MBOs (refer Section 7.5.1), which when mobilised by flood flows can completely deoxygenate the water column. Examples of Lily outbreaks in the Tuckean have been reported as linked to MBO formation.

No.	Vegetation Management Issues
I22	Low ecological value of floodplain habitats results from widespread clearing, fragmentation and weed encroachment
Other related issues	
I5	Clearance or poor condition of riparian vegetation increases bank instability and erosion (refer Section 7.7)
I9	Boat wash from power boats has led to riverbank destabilisation and substantial bank erosion, resulting in increased sediment loads to the estuary (refer Section 7.10)

7.8.2 Management Objectives

Table 10 shows the relationship between vegetation management issues, related values and management objectives.

Table 10: Relationship between Vegetation Management Values, Issues and Objectives

Values	Issues	Objectives
• The Richmond River catchment supports a wide range of land uses which are important contributors to the local and regional economy • Scenic amenity is valued highly by the local community and visitors • The Richmond River Estuary and wetlands provide a diversity of habitats for a range of terrestrial and aquatic species • The estuary supports a number of rare and threatened communities • Estuarine wetlands including mangroves, saltmarsh and seagrass areas provide an important role in healthy ecosystem function	I22 - Low ecological value of floodplain habitats results from widespread clearing, fragmentation and weed encroachment	O10 - To protect and enhance the biodiversity values of the estuary O13 - To protect and enhance visual amenity/ aesthetic appeal of the estuary O1 - To encourage economically viable and environmentally sustainable land use practices in the catchment

7.8.3 Potential Management Options

Conservation of existing vegetation

Protection of existing native vegetative communities, particularly threatened communities and floodplain habitats is an on-going issue for management of overall ecosystem health. Rehabilitation of degraded habitats, particularly riparian and floodplain communities is required, focussing on improving ecological condition (e.g. weed control) and connectivity (e.g. protection and replanting) throughout the catchment. In order to identify areas for targeted improvement programs, further investigations is required involving:

- Review of mapping of high conservation value habitat and existing corridors (NPWS, 2005):
- Prioritise threatened species habitats and EECs on the study area floodplain for conservation, using currently available information; and
- Development of a prioritised list of land use planning changes to adequately protect important habitats considering a number of factors including mapping as above and landowner willingness, mitigation of water quality issues etc.

Aquatic Weed Management

Management of aquatic weeds is currently carried out by RRCC in the study area by mechanical harvesting and chemical controls. Much of this work is carried out as part of asset maintenance works, however environmental benefits, such as improved water quality and reducing factors in MBO formation are also acknowledged. In addition to routine aquatic weed management, a more holistic approach to management should be considered by addressing ecological issues that contribute to aquatic weeds such as improving tidal flushing, restoring a more natural hydrology, and increasing riparian planting for shade and as a nutrient buffer.

Plate 25: Aquatic weed removal at Mynumai Lagoon before (left) and after (right)

No.	Vegetation Management Options
24	Aquatic weed management
25	Retain, rehabilitate and conserve existing native floodplain vegetation

7.9 Education

7.9.1 Issues

Community education/involvement and capacity building is essential to the success of other management initiatives. In this way, education is relevant to all estuary management issues and the achievement of objectives.

It will be important to raise public awareness of the values and sustainable use of the Richmond River estuary through targeted community education programs. The issues are:

- Opinions and perceptions are sometimes based on old or inaccurate information;
- Information is not always available to the people best placed to make a difference (e.g. farmers);
- Social acceptability of management options will increase as community understanding of the issue increases;
- Conflict between users can be alleviated with the provision of objective information; and
- Community satisfaction with estuary management is sometimes based on perception rather than fact (e.g. perception of need for dredging).

7.9.2 Potential Management Options

Education programs are a major opportunity to improve estuary management by giving the community an understanding of the true impacts of activities.

A number of existing education programs should be supported through the estuary management planning process. These include:

- DPI (Agriculture) landholder education programs e.g. best practice land management;
- Rous Water catchment management initiatives;
- Northern Rivers CMA programs including community capacity building;
- Council initiatives e.g. waste management education centres, water education programs, stormwater management programs and state of the environment reporting, biodiversity programs; and
- OEH education resources.

RRCC in partnership with Ballina, Lismore and Richmond Valley Councils, OEH and the Northern Rivers CMA has been developing a program to promote the sustainable use of the Richmond River Estuary ("The Richmond River Estuary - Our Community's Natural Asset"). The program is jointly funded by the local and state governments and seeks to find out what the community knows of estuaries and actions that can help reduce potential and actual damage. Signs have been erected along the estuary to highlight some issues identified in a recent survey that the community have indicated that they are concerned about. Results of the survey will be used to develop a range of education strategies and programs which will raise the community's and visitors' understanding of the environmental, social and economic significance of the estuary system and ways to work towards the long term sustainability of the Richmond. This incorporates the Richmond and Brunswick catchment model (see Appendix 1).

Stephen Fletcher & Associates (2006), in its review of the "Richmond River Estuary – Our Community's Natural Asset" community education project, recommended that future education programs include:

- A regular column in local newspapers and regular radio segments discussing key issues, current initiatives and tips for residents to minimise impacts;
- High school education packages focussing on local ecology and biodiversity, cause and effect relationships and estuary health, sustainable participation and field work.
- Signage highlighting the estuary, its significance and tips to minimise impacts; and
- Brochures on estuary management issues.

It will be important to support education projects or programs that develop or widen the community's knowledge of, skills and commitment to protecting the Richmond River Estuary. This should include all aspects of estuary management to ensure public use of the estuary is undertaken sustainably.

No.	Education Management Options
37	Estuary-wide community education and consultation program

7.10 Waterway Usage

7.10.1 Issues

The Richmond River estuary is highly valued for various forms of recreational use, and these pursuits constitute the dominant use of the estuary. Commercial boats also utilise the estuary for fishing, oystering and tourism activities which are also important in the region. Providing appropriate boating facilities to meet growing demand (see GHD, 2005) ensuring cooperative use of the waterway between various forms of recreational and commercial users while protecting the ecological values of the estuary are key challenges for successful holistic management of the estuary.

Recreational use of the Richmond River estuary is varied and includes activities such as boating, swimming, fishing, surfing, water-skiing and wake-boarding, jet skiing and passive recreation. Consultation work carried out as part of the EPS (WBM, 2006) indicated that the community considers the value of boating in the estuary to be high with fishing from boats being the top recreational usage of the estuary (WBM, 2006). The EPS includes mapping of broad usage zones for the estuary. Generally the high use primary and secondary contact activities occur in the lower estuary with less intensive waterway usage upstream.

Dredging

Extensive navigational dredging of the lower Richmond River, particularly the entrance area, has occurred since 1883. Before 1911, dredging operations in the lower Richmond River were largely associated with the entrance training works and a navigation channel through the entrance and past the town shoal. Much of the dredged material was used for landfill at Ballina and hence lost to the active beach system. Between 1911 and 1974 periodic dredging was undertaken across the entrance bar and in other locations further up the lower estuary where increased depths were required for navigation purposes. Much of this material was side cast onto the shore or used for land reclamation at Ballina or on Pimlico or Cabbage Tree Islands. Since 1974 (cessation of coastal entrance dredging in NSW) dredging has occurred in North Creek for oyster leases and the extraction of 200,000m^3 in the early 1990s for bridge abutments and associated road works (WBM, 2006).

Dredging is periodically raised by the community as a measure to primarily address navigational issues in the lower estuary. The river entrance bar in particular, poses a hazard for vessels under adverse swell and tide conditions, and several small recreational boats have been overturned when attempting crossings under such conditions. The depth of the bar also poses problems for deep draft vessels even under ideal conditions, with depths of around 3.5 metres at low tide. A shoal within entrance upstream of the Coast Guard tower presents a secondary restriction at a depth of approximately 2.5m. These bars have maintained their current depth for a number of years without dredging (GHD, 2005). Such depths are regarded as adequate for recreational boating and current commercial activities (BSC, 2007) but limiting for larger vessels and some yachts that may wish to use the estuary. There is community support for increased marina facilities at Ballina (GHD, 2005) and further study in this regard should consider navigation constraints within the estuary.

Dredging of the bar or entrance shoals would only offer temporary depth increases as sand from the longshore transport system would quickly infill these areas (GHD, 2005) and may contribute to increased variability in bar location and increase risks for boat owners relying on deeper entrance conditions to overcome adverse crossing conditions. Other options such as modification to the entrance training walls have also been considered but are likely to result in similar bar conditions as experienced with the current arrangement (BSC, 2007). GHD (2005) reports that there is strong community support to ‘fix the Bar’ however NSW Waterways have indicated that once-off dredging or training wall extension would not provide a permanent solution.

The mouth of Emigrant Creek at the confluence with the Richmond River has also been raised as an area requiring dredging to maintain navigability at this location. There is a small marine industrial precinct located within the estuarine reaches of Emigrant Creek containing a slipway with hardstand facilities, industrial sheds and private slips as well as numerous channel mooring points. Access for deep drafted vessels is limited to high tides only with shoaling evident at the Creek mouth and some locations upstream.

Dredging has significant impacts on benthic communities through direct disturbance as well as through issues associated with sedimentation and turbidity plumes. NSW Fisheries (now Industry & Investment) have indicated that the presence of seagrasses, an important fisheries habitat at numerous locations, including the entrance to Emigrant Creek and in North Creek means that dredging is unlikely to be approved to increase navigability in these locations.

Sand Extraction

Dredging of sand from the lower estuary has also been raised as a potential commercial venture to capitalise on this frequently renewed resource. No assessment of the viability of this concept has been undertaken to date, although the potential environmental impacts, including effects on longshore transport of sand, and coastal beach erosion risks to the north of the river could be significant and would need substantial investigation. Of note is the North Creek Flood Study, which identified that sand extraction in North Creek would be likely to increase tidal amplitude and therefore the risk of flooding from tidal surge in this area.

Currently, one sand extraction operator (Boral) is permitted to extract sand from more upstream reaches of the estuary. Sand is extracted from the freshwater reaches of the river under a licence with the Department of Lands to extract up to around 37,000m^3 of material of year. The extraction occurs over a large area of the estuary from near Woodburn to up past Coraki and extensive portions of the Wilsons River from Coraki to up past Lismore. This operation has resulted in several complaints, which have been followed up by the Department of Lands and has resulted in modifications to the operating licence (WBM, 2006). It appears that these actions have solved this issue.

Boating Facilities

Recreational boating forms a vital component of the tourism sector of the Richmond River communities and is a significant lifestyle activity enjoyed by a large proportion of its residents. Many of the communities, particularly those in coastal areas, are reliant on tourism to drive their local economies. Availability of suitable river access points and appropriate and complimentary marine infrastructure is critical to the enjoyment of recreation boating in the estuary. The quality of this infrastructure is important in attracting and retaining visitors to the communities along the Richmond River as a destination of choice.

The Lower Richmond Recreational Boating Study was completed in 2005 (GHD, 2005). The study reported that current boating facilities in the lower estuary were inadequate to provide the expected level of service for local and visiting boats. Issues discussed centred on the upgrade of existing facilities and provided recommendations for the provision of new facilities. Ballina Shire Council is progressing with the implementation of aspects of the plan to improve recreational boating in the lower estuary. One of the major issues was the lack of pump-out facilities for boats in Ballina Shire. Where boats do not access the ocean to empty holding tanks, options for disposal of raw sewage are very limited.

Usage Conflicts

During the community consultation phase of the Draft EMS, the concern among the community for the potential for conflicts between different waterway uses was raised. Currently, there is generally not a lot of conflict between users, however as population increases and waterway sports expand and

diversify further, the potential for future usage conflicts is also increasing. NSW Maritime has identified that in addition to the traditional pursuits of sailing and boating, other waterway uses on the Richmond are now becoming popular (including canoeing, jet skiing, water skiing and the use of tubes towed behind powerboats) in the lower estuary in the urban areas of Ballina Island (WBM, 2006). Noise and safety are a key consideration for these activities. Over the past several years there has also been an increase in wakeboarding activities on the river which generates waves behind a boat which can cause nuisance issues for other users and is also known to cause significant bank erosion due to the generation of 'wake' (refer discussion of bank erosion below). Kite surfing is also a fast-growing sport and has potential as an emerging issue for safety concerns in the estuary. Anecdotal evidence suggests human activities (including boat access and dogs) are harming sea grasses and shorebird habitat in Mobbs Bay.

Public foreshore access

Public access to estuarine foreshore areas is highly valued by the community. One of the aims of the NSW Coastal Policy is to ensure the provision of public access to foreshores where feasible and environmentally sustainable. Public safety is a primary consideration when planning access facilities.

The EPS (WBM, 2006) identified existing access facilities including waterfront licences (for jetties, wharves, boatsheds, boat ramps, pontoons and slipways), boat harbours, mooring areas, parks and reserves and the Ballina Marine Industrial Precinct. Informal access to the foreshore causes bank erosion and trampling of vegetation which are likely to be exacerbated by the potential climate change impacts of sea level rise and increased storminess.

Current land-based foreshore access issues were identified along the riverfront in Ballina Island and other areas including Lismore where the presence of existing foreshore developments restricts public access. BSC is endeavouring to provide public access pathways adjacent to the lower Richmond River Estuary.

Licensing of waterfront structures

Waterfront structures (e.g. jetties, boat ramps and slipways) over lands below the high water mark of foreshore properties are generally located on Crown land and occupation of such lands must be authorised. Structures of this nature are called Crown Licence Points. WBM (2006) reported that 188 Crown Licence Points were registered on the Richmond River estuary and most were structures including jetties, pontoons, ramps and slipways. During development of the EPS (WBM, 2006), it was reported that there were currently a number of unlicensed waterfront structures in the estuary and there was concern about public safety and environmental damage (erosion, damage to sensitive vegetation etc.) as a result of poorly constructed or located structures. DPI and Crown Lands are the process of completing a program of assessing waterfront structures and reviewing licences to address this issue.

Bank erosion

Boat wash striking the river banks can cause rapid and severe erosion leading to a range of environmental problems. Such problems may include the loss of riverfront property, water quality degradation, loss or destabilisation of native trees and the destruction of habitat and aquatic plants and animals.

There are areas of active bank erosion throughout the lower Richmond estuary, however many are protected by bank protection works consisting predominantly of loose rock protection as far upstream as Wardell (WBM, 2006). Locations which are being impacted by boat wash are sections of Emigrant Creek and some sections of the North Creek Canal (WBM, 2006). Speed limits have been set by NSW Maritime for these areas, however the effectiveness of this measure in controlling speed and subsequent boat wash and bank erosion is currently unknown. Active bank erosion is evident in the

upper estuary, however, the principal causes for this were likely to be riparian vegetation clearing and stock trampling of banks, rather than from boat wash.

Tidal inundation and flood events can also increase bank erosion and impact riparian vegetation as well as property and infrastructure.

Damage to seagrass beds, salt marsh and mangrove communities

Estuarine vegetation such as seagrass, saltmarsh and mangrove communities provide a number of important ecological functions for the estuary including nursery and feeding grounds for fish and habitat for a range of other native fauna and flora including a number of threatened species. While large mangrove areas exist in the estuary, there are limited numbers of seagrass beds and saltmarsh areas present in the Richmond River (WBM, 2006). These areas of sensitive estuarine vegetation may be affected by boating, recreational users and unlicensed access points to the estuary due to propeller and anchor damage, boat wash and disturbance from built structures and vehicle access. The EPS reported that all areas of known seagrass in the Richmond can potentially be impacted by boating activities and areas near the confluence of Emigrant Creek and the Richmond River, Mobbs Bay and in North Creek (between the Missingham Bridge and Prospect Bridge) are most likely to be susceptible to these impacts. Within the estuary, most of the existing saltmarsh areas are protected behind fringing mangrove communities. The loss of fringing mangroves exposes the saltmarsh communities to boat wash, human access etc. and may create conditions that affect their ability to habitat these areas. WBM (2006) reported that while there was some physical controls (buoys) located to protect seagrass areas, the effectiveness of these measures was unknown and there was generally a lack of physical controls to limit potential impacts to mangrove and saltmarsh areas.

No.	Waterway Usage Issues
I8	Illegal waterfront access to estuary causes damage to vegetation and bank destabilisation and limit community access
I9	Boat wash from power boats has led to riverbank destabilisation and substantial bank erosion, resulting in increased sediment loads to the estuary
I23	Damage to seagrass beds and other sensitive estuarine vegetation caused by boat damage, recreational users and unlicensed access points to estuary
I27	Community concern about potential conflicts between different estuary uses such as swimming, boating and water skiing
I28	Current boating infrastructure in the lower estuary is inadequate to provide the expected level of service for local and visiting boats
I29	Illegal waterfront structures allow access to estuary posing risks to public safety
I30	Siltation is affecting navigation and/or safety in the lower river
I31	Lack of provision of appropriate public access to foreshore

7.10.2 Management Objectives

Table 11 shows the relationship between waterway usage issues, related values and management objectives.

Table 11: Relationship between Estuary Usage Values, Issues and Objectives

Values	Issues	Objectives
• The Richmond River catchment supports a wide range of land uses which are important contributors to the local and regional economy • Commercial fishing and oyster aquaculture contribute to the local and regional economy • The estuary and particularly the lower estuary is considered to be a key attraction for tourists and recreational users to the area, with associated economic benefits • The estuary and foreshore areas are highly valued by the community and visitors for recreational activities • Scenic amenity is valued highly by the local community and visitors • The Richmond River Estuary and wetlands provide a diversity of habitats for a range of terrestrial and aquatic species • The estuary supports a number of rare and threatened communities • Estuarine wetlands including mangroves, saltmarsh and seagrass areas provide an important role in healthy ecosystem function • The riparian zone provides significant protection to estuary water quality • Good water quality is highly valued by the community	I8 - Illegal waterfront access to estuary causes damage to vegetation and bank destabilisation and limit community access I9 - Boat wash from power boats has led to riverbank destabilisation and substantial bank erosion, resulting in increased sediment loads to the estuary I23 - Damage to seagrass beds and other sensitive estuarine vegetation caused by boat damage, recreational users and unlicensed access points to estuary I27 - Community concern about potential conflicts between different estuary uses such as swimming, boating and water skiing I28 - Current boating infrastructure in the lower estuary is inadequate to provide the expected level of service for local and visiting boats I29 - Illegal waterfront structures allow access to estuary posing risks to public safety I30 - Siltation is affecting navigation and/or safety in the lower river I31 - Lack of provision of appropriate public access to foreshore	O1 - To encourage economically viable and environmentally sustainable land use practices in the catchment O6 - To protect and enhance the riparian zone O10 - To protect and enhance the biodiversity values of the estuary O11 - To provide for increased use of the estuary whilst minimising environmental impact and conflict between users O14 - To enhance sustainable commercial return from industries relying on the estuary and the floodplain O15 - To minimise risk to the health and safety of users of the estuary

7.10.3 Potential Management Options

Dredging

Dredging of the Richmond River bar and the upstream shoals as well as other areas in the lower estuary such as North Creek and Emigrant has been suggested as a potential solution to navigation risks in these areas and increasing the potential for larger vessels to utilise the estuary. Whilst no detailed assessment on the feasibility or impacts associated with dredging has been undertaken, preliminary comments from NSW Maritime has indicated that irregular dredging would not provide successful alleviation of navigation issues in the long term and therefore any commitment to dredging in the lower estuary would need to be as part of a continued program probably coupled with cost recovery through sales of the extracted sand. At present there does not appear to be sufficient requirement for such a program and the combined impacts on benthic communities, water quality and the potential northward beach erosion present significant hurdles. A preliminary study into the feasibility of dredging operations, including associated commercial opportunities should only be undertaken if further assessment of marine facilities expansion in Ballina is to be undertaken.

Boating Facilities

The Lower Richmond Recreational Boating Study (GHD, 2005) developed strategies to address the current and future needs and requirements of recreational boating within the lower Richmond River estuary, including a program of works and actions focussing in the provision of boating infrastructure. BSC is progressing with the implementation of aspects of the plan to improve recreational boating in the lower estuary. Recommendations of the Boating Study should be considered in the management of boating facilities in the Richmond.

Usage Conflicts

NSW Maritime currently controls waterway usage for the purposes of boating. The NSW Maritime boating maps provide details of navigational controls, speed restrictions and other warnings for the Richmond River estuary. NSW Maritime also has a policing role on the waterway and responds to various complaints about nuisance activities on the water and conflicts between different uses. While the control mechanisms in place by NSW Maritime are currently addressing issues as required, there are emerging issues for the Richmond estuary and particularly the lower estuary. These issues are associated with a fast-growing population and expanding recreational use of the estuary and the need for strategic planning for future management. While usage conflicts are considered to be very minor occurrences at present, there is concern among the community about potential for future problems. Usage zones are utilised in other estuaries to separate various uses and locate certain uses in appropriate areas for example away from sensitive vegetation. Appropriate planning controls may offer a mechanism to reduce social and environmental impacts in the future.

Public Foreshore Access

The economic, social, environmental and cultural values, such as scenic amenity, fishing and aquaculture, tourism and recreational activities rely on the ability to access the waterway and foreshore areas. The desire for continuing and undiminished public access needs to be balanced with the ecological values of the estuary such as the diverse habitats, ecological importance of the riparian zone and water quality. A strategic plan for use of the Richmond River Estuary is required to address the identified issues associated with foreshore access and plan for current and future requirements. Potential impacts on access arrangements (e.g. erosion, accretion, tidal inundation) should be identified through the coastal hazard assessment of estuary erosion and tidal inundation (refer Section 7.3.3).

Licensing of waterfront structures

A review of waterfront structures licensing has been recently undertaken by DPI - Fisheries and Crown Lands (Marcus Riches, Fisheries Regional Manager, pers. comm). The review has provided an assessment of the current licensing and policing of waterfront structures. One of the outcomes of the review was mapping of colour coded zones for the estuary to assign areas where certain types of structures are permitted or restricted under existing policy. This review is currently being reported and should be available in the coming months. Recommendations of the review should be considered in future estuary management.

Bank erosion

Bank erosion from boat wash is considered to be largely controlled in the lower estuary through existing protection works, which extend from the river mouth to Wardell. While bank erosion is considered to be a significant issue impacting on estuarine health, most of the bank erosion exists in the upper reaches and other factors such as high velocity flood flows, poor riparian cover and condition and stock access are considered to be the primary causes, with boat wash as a minor or negligible factor. The exception noted in the EPS (WBM, 2006) was areas of active bank erosion in Emigrant Creek and North Creek, where boat wash was implicated as the primary cause. While speed limits are currently set in these areas to minimise the impact of boat wash on erosion, it is not clear whether this measure is enough to solve bank erosion issues. Further assessment of boat passage areas impacted by erosion is necessary to assess the current status of bank erosion and the adequacy of current speed limits in managing this issue.

Further assessment of erosion caused by tidal waters and flood events is required to determine the impacts to property, infrastructure and riparian vegetation. This should also consider sea level rise scenarios (refer Section 7.3).

Damage to seagrass beds, salt marsh and mangrove communities

There may be a need for further physical controls (e.g. signage, warnings) that limit potential impacts to sensitive estuarine vegetation, specifically seagrass, mangrove and saltmarsh areas.

No.	Waterway Usage Management Options
15	Review boat passage areas impacted by erosion
26	Zoning to prevent access to sensitive estuarine vegetation areas
27	Estuarine vegetation signage / education to protect sensitive areas
28	Implement Recreational Boating Study actions
32	Investigate usage conflicts and need for management
33	Develop strategic plan for estuary usage
34	Review of waterfront structures and licensing
38	Cost benefit analysis of dredging operations in lower estuary

7.11 Wastewater Management

7.11.1 Issues

Eight STPs discharge to the Richmond River within the tidal limit (Casino, South Lismore, East Lismore, Alstonville, Ballina, Wardell, Rileys Hill and Coraki STPs). Sewerage systems (including STPs and overflow structures) are regulated by OEH-EPRG through Environment Protection Licences (under the Protection of the Environment Operations Act, 1997) held by the respective Councils. Where required by the EPRG, the licences include Pollution Reduction Programs to improve the performance of the STPs. The STPs are generally meeting licence conditions although an upgrade of the treatment process is planned for Ballina STP including a new membrane bioreactor, UV disinfecting for all discharges, chlorination, and potential reuse for vegetation regeneration and open space in urban areas.

The impact of the STPs on estuary water quality depends on discharge flows and loads of pollutants such as nutrients and faecal coliforms. Pollutant loads from urban inputs become relatively more important to water quality during the dry season when catchment inputs are low. The EPS (WBM, 2006) identified STP input during these dry times as a potential risk to water quality although a comprehensive assessment of risk across all STPs influencing the estuary has not been conducted to date. During rainfall events, nutrient concentrations within the estuary increase by several times as a result of diffuse loads from the catchment (WBM, 2006). The EPS found that the impact of nutrient loads from urban runoff and STPs on water quality was negligible in comparison to the impact of diffuse loads.

Most urban areas within the Richmond River catchment are served by a reticulated sewerage system. Rural and rural residential areas without reticulated sewerage have on-site systems including composting toilets, septic systems, aerated wastewater systems, pump-out systems and grey water treatment systems. The design, installation and operation of domestic on–site sewage management systems are regulated under the Local Government Act 1993. The Councils have implemented on-site sewage and wastewater management strategies in accordance with the Local Government (Approvals) Regulation 1999 including audit and inspection of on-site systems. However, it is the responsibility of the owner or occupier of the premises that has an on–site wastewater system to ensure that on–site systems are designed, installed and managed so that pollution of groundwater or surface waters does not occur, and there is no risk to public health, safety and the environment from the operation of an on–site sewage management system.

Councils undertake random inspections annually as part of the audit program to identify failing systems. Annual inspections of on-site sewage and wastewater systems by LCC in 2007 revealed that 33% of systems inspected failed to meet operational criteria (Hydrosphere Consulting, 2010). Council backlog sewer programs have identified areas to be connected to the Council sewerage system based on the risks to public health, aquatic ecosystems, groundwater supplies and contamination of shellfish areas and inappropriate soils, lot size and topographic conditions. On-site wastewater systems in North Woodburn are known to cause public and environmental health impacts. A survey conducted by LCC's Environmental Health section indicated that 50% of the systems are failing due to poor soil permeability, small lot sizes and high rainfall. The systems do not comply with the on-site sewerage management strategy due to the close proximity to the Richmond River, flood liability and inadequate size of disposal area. LCC is planning to provide a reticulated sewerage system to North Woodburn with connection to the RVC Evans Head/Woodburn sewerage system.

BSC has identified 150 priority lots for connection to Councils sewerage system including North Creek Road. Council has also commenced a program of registration of all on-site sewerage management systems in the shire. RVC plans to provide a reticulated sewerage system to Broadwater by 2013.

No.	Wastewater Management Issues
I14	STP discharges are increasing the load of nutrients and other contaminants to the estuary but the magnitude of impacts is unknown
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.
I16	Poor water quality episodes (particularly nutrients and faecal coliforms) occur in the lower estuary but sources of pollutants are currently unclear

7.11.2 Management Objectives

Table 12 shows the relationship between wastewater management issues, related values and management objectives.

Table 12: Relationship between Wastewater Management Values, Issues and Objectives

Values	Issues	Objectives
• Commercial fishing and oyster aquaculture contribute to the local and regional economy • The freshwater sections of the estuary are a valuable source of water for the agricultural industry and also provide potable town water supply from the tidal pool upstream of Lismore • The Richmond River Estuary has high cultural and spiritual significance to local Aboriginal communities • The estuary and foreshore areas are highly valued by the community and visitors for recreational activities • The Richmond River Estuary and wetlands provide a diversity of habitats for a range of terrestrial and aquatic species • Estuarine wetlands including mangroves, saltmarsh and seagrass areas provide an important role in healthy ecosystem function • Good water quality is highly valued by the community	I14 - STP discharges are increasing the load of nutrients and other contaminants to the estuary but the magnitude of impacts is unknown 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. I16 - Poor water quality episodes (particularly nutrients and faecal coliforms) occur in the lower estuary but sources of pollutants are currently unclear	O5 - To reduce pollutant loads to the estuary O4 - To increase knowledge of the impact of existing practices on estuary values and facilitate continuous improvement

7.11.3 Potential Management Options

Environment protection licences are the central means to control the localised, cumulative and acute impacts of pollution in NSW although they are only applicable to point sources. Responsibility for management of STP discharges remains with the local councils, regulated by the OEH-EPRG under the Protection of the Environment Operations Act, 1997. This includes options for reuse of treated wastewater.

Responsibility for performance of on-site sewage systems remains with the property owner, regulated by the local councils under the Local Government Act, 1993.

Reduction of point source pollution such as nutrients and faecal coliforms from sewerage systems is consistent with the aims of the estuary management program. As these activities are managed and regulated by existing administrative processes, it is proposed that these activities continue outside but complimentary to the CZMP process, while ensuring consistency with the CZMP.

No.	Wastewater Management Options
19	Upgrade / augment STPs and other sewerage infrastructure where required
20	Wastewater Reuse
40	Ongoing on-site sewerage management inspections and improvements

7.12 Urban Runoff

7.12.1 Issues

Urbanisation has affected estuarine processes through:

- Changes to the hydrologic characteristics (catchment hardening) of lands making them drain more quickly, partly due to the increased imperviousness, i.e. road, roofs, etc;
- The use of hydraulically efficient stormwater pipe systems which remove stormwater to the waterway more quickly; and
- Changing the quality of stormwater runoff due to the influence of fertilisers, cars, lawnmowers, domestic animals, etc.

Stormwater from urban areas can often discharge significant loads of pollutants to receiving water bodies. These pollutants include litter, nutrients, sediment, oxygen-depleting substances and hydrocarbons, which are transported from the site by urban runoff or stormwater. Urban runoff has particularly been found to impact seagrasses and benthic communities within the Richmond River (WBM, 2006).

BSC and the community have identified urban stormwater as a significant issue with respect to the estuary. Many of the water quality complaints made to BSC relate to urban stormwater such as poor erosion control on building sites and vehicle wash-water discharged to drains. In a community consultation process undertaken for the Shaws Bay Estuary Management Plan, 45% of the 49 respondents identified runoff from the largely urban catchment discharging into the bay through the stormwater drains as a major issue for the health of the Bay (WBM, 2006).

A large proportion of people within the study area resides in, works or engages in recreation within urban centres. Some urban centres within the estuary are also located adjacent to water bodies used by residents, visitors and industries such as oyster leases dependent on good estuarine water quality. Any water quality impacts due to urban stormwater or practices within the urban environment that may contribute to poor urban stormwater quality would subsequently be more likely to be observed by people within these urban areas relative to those occurring in rural areas not frequented by the public (eg. acidic runoff discharge from drainage channels). The EPS (WBM, 2006) found that the impact of urban stormwater to overall estuarine water quality is a significant issue to the public and councils. The importance of managing urban stormwater will also become increasingly important as the extent of urban development increases to accommodate the increase in populations within the study area.

No.	Urban Runoff Issues
I13	Stormwater runoff from some urban areas increases contaminants, litter, nutrients and sediment loads to the estuary
I16	Poor water quality episodes (particularly nutrients and faecal coliforms) occur in the lower estuary but sources of pollutants are currently unclear

7.12.2 Management Objectives

Table 13 shows the relationship between urban runoff issues, related values and management objectives.

Table 13: Relationship between Urban Runoff Values, Issues and Objectives

Values	Issues	Objectives
• The Richmond River catchment supports a wide range of land uses which are important contributors to the local and regional economy • Commercial fishing and oyster aquaculture contribute to the local and regional economy • The freshwater sections of the estuary are a valuable source of water for the agricultural industry and also provide potable town water supply from the tidal pool upstream of Lismore • The Richmond River Estuary has high cultural and spiritual significance to local Aboriginal communities • The estuary and foreshore areas are highly valued by the community and visitors for recreational activities • The Richmond River Estuary and wetlands provide a diversity of habitats for a range of terrestrial and aquatic species • Estuarine wetlands including mangroves, saltmarsh and seagrass areas provide an important role in healthy ecosystem function • Good water quality is highly valued by the community	I13 - Stormwater runoff from some urban areas increases contaminants, litter, nutrients and sediment loads to the estuary I16 - Poor water quality episodes (particularly nutrients and faecal coliforms) occur in the lower estuary but sources of pollutants are currently unclear	O5 - To reduce pollutant loads to the estuary O15 - To minimise risk to the health and safety of users of the estuary O13 - To protect and enhance visual amenity/ aesthetic appeal of the estuary O4 - To increase knowledge of the impact of existing practices on estuary values and facilitate continuous improvement

7.12.3 Potential Management Options

The EPS (WBM, 2006) noted examples of poor urban development which are likely to have resulted in the loss of significant habitat areas and due to their proximity to the estuary are likely to be contributing pollutants to the waterways. There are many opportunities for retrofitting stormwater/water quality controls to existing urban developments to address impacts exist and these should be investigated and prioritised. Any future developments in the study area, in particular new urban subdivisions (identified by Councils in their urban land release areas) should apply a holistic management approach to the protection of stormwater and water quality and the appropriate management of existing vegetative communities. This should include:

- Management of stormwater to ensure no significant risk to public health, property and the environment;
- Reduction in stormwater volume and improved quality of stormwater entering the estuary; and
- Sustainable and affordable reuse of stormwater.

Water Sensitive Urban Design differs from conventional conveyance based management methods as it takes an integrated approach to the management of stormwater quality and quantity. It seeks to incorporate sound stormwater management principles into the design of the development during the planning stages to minimise the need for “end of pipe solutions”. Ideally, it also examines the total water cycle for the development and includes provision for water harvesting and water reuse.

The linkages between day-to-day activities and the health of the estuary, such as the impact of stormwater runoff on water quality in the estuary are not well understood. A key component of any

stormwater management program is education on the impacts of urban runoff and potential improvements.

All councils within the study area are actively involved in the management of urban stormwater through a variety of projects, programs and policies including Stormwater Management Plans and Development Control Plans. This includes water sensitive urban design requirements, gross pollutant traps, education programs, drain mapping and more stringent requirements such as 'no-net worsening' for new urban developments. For example, BSC has installed stormwater filters around the Shaws Bay subdivision and at the lookout in East Ballina to minimise the impact of stormwater pollution on Shaws Bay and surrounding waterways. Filters are placed inside stormwater drains to catch pollutants such as soil, garden waste and cigarette butts.

The state Government BASIX program incorprates requirements for rainwater detention and reuse as a requirement for all new developments.

The Local Government Act provide councils with the ability to raise additional funds for stormwater management services outside traditional funding sources. These additional funds (the stormwater charge) can be spent on urgent works to improve stormwater treatment and infrastructure, to improve the quality of stormwater that is returned to the waterways. The stormwater charge only relates to urban developed land within a town or village to which Council provides stormwater services.

The reduction of urban pollution such as nutrients and faecal coliforms is consistent with the aims of the estuary management program. As these activities are managed and regulated by existing Council services, it is proposed that these activities continue outside but complimentary to the CZMP process, while ensuring consistency with the CZMP.

No.	Urban Runoff Management Options
16	Stormwater education
17	Water Sensitive (Urban) Design for new developments
18	Retrofit GPTs and other stormwater improvement devices

7.13 Cultural Heritage

7.13.1 Issues

The Richmond River estuary has spiritual and cultural significance for local communities. Both European and Aboriginal heritage sites and items exist in and around the estuary and their recognition and protection are important to the local community.

The traditional owners and custodians of the study area are the Bundjalung and Widjabul people. There are currently a number of Native Title Claims covering approximately 90% of the study area, currently being assessed (claims apply to land other than freehold land such as Crown Land and leasehold lands). Given the long period of Aboriginal use of the land there are numerous sites around the Richmond River estuary that are of Aboriginal heritage significance (e.g. art sites, camp sites, middens, fishing and hunting areas, caves and rock shelters, burial sites, mythological sites and scarred trees).

The Richmond River estuary also contains a wide variety of European cultural heritage items due to the rapid changes in key industries such as forestry and agriculture and the associated transportation networks development to support the industries, i.e. shipping and then rail. There are many listed heritage items, which occur around the urban centres, e.g. heritage buildings.

All levels of Government maintain registers of important sites, which are then afforded varying levels of protection under current legislation. During the community consultation phase of this study, the issue was raised that there were a number of sites of Aboriginal cultural heritage significance in the Richmond area that were currently not registered with relevant authorities and therefore there was concern about the on-going protection of sites.

No.	Cultural Heritage Issues
I32	Protection of Aboriginal cultural heritage sites around the estuary from disturbance or destruction by river works and development

7.13.2 Management Objectives

Table 14 shows the relationship between Cultural Heritage issues, related values and management objectives.

Table 14: Relationship between Cultural Heritage Values, Issues and Objectives

Values	Issues	Objectives
• The Richmond River Estuary has high cultural and spiritual significance to local Aboriginal communities • The estuary and particularly the lower estuary is considered to be a key attraction for tourists and recreational users to the area, with associated economic benefits	I32 - Protection of Aboriginal cultural heritage sites around the estuary from disturbance or destruction by river works and development	O12 - To protect the cultural heritage values of the estuary

7.13.3 Potential Management Options

The protection of specific sites and locations of significance is already managed through various pieces of State Government legislation. The principle laws, which deal with Aboriginal heritage, are (refer Appendix 1):

- National Parks and Wildlife Act 1974 – This Act provides statutory protection for all Aboriginal objects and places in NSW. Areas are gazetted as Aboriginal places if the Minister is satisfied that there is enough evidence to show the area is, or was, of special significance to Aboriginal culture;
- Heritage Act 1977 – This Act protects the State's natural and cultural heritage. Aboriginal places or objects that are recognised as having high cultural value are listed on the State Heritage Register; and
- Environmental Planning and Assessment Act 1979 – This Act provides protection by considering impacts on Aboriginal heritage in land use and planning decisions. The three main areas are:
    - Planning instruments allow particular uses for land and specify constraints. Aboriginal heritage is a value which should be assessed when determining land use;
    - Section 79C of the Act lists matters which must be considered before development approval is granted. Aboriginal Heritage is one of the issues considered under the terms of Section 79C; and

- State government agencies act as the determining authority on the environmental impacts of proposed activities and must consider a variety of community and cultural factors, including Aboriginal heritage, in their decisions.

Existing State Government legislation is used to protect listed sites within the study area. There is recognition that further work is required to identify, assess and register remaining sites within the Richmond River catchment. There are ongoing studies underway which aim to improve the Aboriginal heritage listings within the Richmond River catchment and ensure their protection under legislation. The process requires extensive consultation and is likely to be on-going.

It may be appropriate in some instances to develop cultural site management plans for specific sites. The aim of these plans would be very site specific based on the requirements for management. At some sites it may be necessary to exclude access completely to protect cultural values, while at others, it may be acceptable to provide signage and create an educational experience for the broader public. Plans would need to be developed in close consultation with the local Aboriginal community and ensure all relevant groups are consulted. Any recommendations of this Draft EMS need to recognise the importance of both European and Aboriginal cultural heritage items and take their appropriate management into consideration when formulating management strategies for the estuary. Appropriate actions to protect and promote the cultural and heritage environment in the coastal zone, including responses to threats from projected sea level rise need to be incorporated in the CZMP in accordance with the APEC principles (Aboriginal People, the Environment and Conservation, DECC, 2008).

No.	Cultural Heritage Management Options
35	Identification and recording of cultural sites available to council planners
36	Cultural Site management plans

7.14 Fisheries and Aquaculture Management

7.14.1 Issues

Fisheries resources are an important value of the Richmond River estuary. Like water quality, there is general community perception that the state of the estuary's fish health and productivity is a key indicator of overall estuary health. Similarly, oyster productivity and saleability is regarded as being directly linked to estuary health. The estuary is well known as a recreational fishing hotspot and supports a range of commercial fishing activities.

Wild fisheries - a limited resource

It is generally accepted that that fish stocks have declined since the 'good old days' and it is recognised that wild fish stocks are a resource requiring active management to ensure sustainable harvests are achievable. Whether or not fish stocks are continuing to decline in the Richmond River estuary is difficult to determine. Some evidence indicates that fish stocks remain under pressure, for instance the Estuary General Fisheries Environmental Impact Statement (EIS, NSW Fisheries, 2003) notes that reported catch rates are not declining over time, however this is prefaced with the fact that fishing effectiveness is generally increasing and this factor is not readily incorporated into catch per unit effort statistics. WBM (2006) notes that both commercial fishing effort and associated catches are declining (Figure 38).

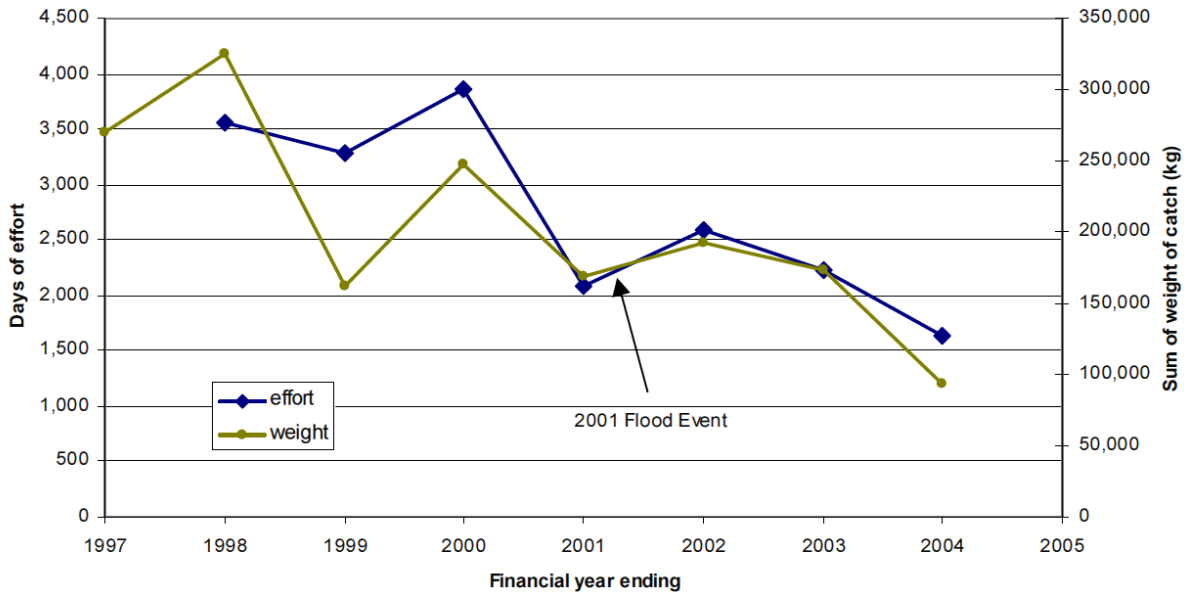


Figure 38: Declining commercial fishing effort and combined weight of catch

Source: WBM, 2006

There is also a view that the quality of catches in the recreational sector is improving, with such improvements being attributed to more stringent fisheries management and better technology. Regardless of the real trend in fish abundance, there is general community concern about fish stocks in the estuary and desire to ensure that recreational and commercial fisheries are preserved on a sustainable basis into the future.

Causes of decline in fish stocks

The factors implicated in the decline of fish stocks are reasonably well understood at a general level, however the key causes and the relative degree to which they influence fishing in the Richmond River estuary is not known. Given the migratory nature of many fish between estuaries, impacts in other estuaries as well as fishing effort along the coastline also have an impact on the Richmond River estuary fishery. Conversely the health of the Richmond estuary will impact on other estuaries. The importance placed on the value of the estuary fishery to the community dictates that on-going management action to address all the pressures on fish stocks is warranted.

Key considerations are:

- Habitat availability is a key factor in controlling fish populations in the estuary. The nursery value of estuaries for many species is well known and the degradation or complete removal of important habitats is as a major factor in fisheries management as loss of habitat can lead to fewer fish to share amongst all stakeholders;
- The presence of instream barriers such as weirs, floodgates and culverts in the catchment interrupt fish migration and dispersal within the catchment. These migrations are often essential for fish to complete their life cycle and the productivity of the catchment as a whole is reduced when effective fish passage is not available between downstream and upstream habitats;
- Poor water quality has a range of effects on fish populations. The most visible effect is evident in the large fish kills such as those experienced in the Richmond River estuary in 2001 and 2008. Fish kills are attributed to drainage from disturbed ASS catchments as well as the release of large volumes of black (deoxygenated) water from backswamp floodplain areas following summer floods (refer Section 7.5.1). Red Spot Disease (EUS) in fish is a chronic effect of acidified waters. More chronic effects of water quality degradation include effects on

fish stocks through restricting fish movement or habitat use in unfavourable areas, reduction on productivity and influences on the food chain and productivity; and

- The impact of overfishing can be dramatic as evidenced by the collapse of many fisheries throughout the world. To protect against overfishing, commercial and recreational fishing is regulated through the use of licence restrictions, bag or quota limits, restriction on the size range of fish taken and the establishment of no fishing zones.

Competition and conflict

Competition for a finite and potentially declining fish resource has the potential to generate significant conflict between commercial and recreational fishers accessing the same resource. Traditionally recreational anglers point to unsustainable catches by commercial operators as being the key cause of decline in fish stocks. It is worth noting however that recreational catches do exceed commercial takes for a number of target species (Table 15) and that recreational fishing effort will continue to increase with increasing population.

As a measure to reduce conflict, a Recreational Fishing Haven (Figure 39) was established in the lower estuary in 2002, where all netting and trapping is prohibited. There are also other restrictions placed on commercial fishers to reduce potential conflict between the sectors including the ban on weekend netting and netting operations in high visibility areas such as Ballina Quays and the artificial lakes at East Ballina.

Table 15: Commercial and recreational fish catches by species in NSW (1997-2004)

Harvest of key species by fishing sector	Recreational (kg)	Commercial (kg)*
Whiting	394,081	1,181,793
Flathead	886,824	496,335
Bream	728,752	365,383
Garfish	22,672	97,875
Tailor	252,736	190,675
Australian salmon	221,977	790,143
Snapper	116,967	273,159
Trevally	87,530	273,884
Leatherjackets	107,966	117,034
Wrasse/tuskfish/gropers	52,373	69,810
Luderick	280,130	503,600
Mackerels	128,627	443,567
Cod (various)	8,133	35,835
Catfish	94,222	28,965
Mulloway/jewfish	273,703	63,796
Morwong	139,929	429,606
Tuna/bonitos	844,480	1,000,500
Sharks/rays	60,186	441,090
Yellowtail kingfish	180,003	137,349
Prawns (saltwater)	104,833	2,346,976
Blue swimmer crab	154,831	165,461
Squid/cuttlefish	65,717	824,183
Mud crab	30,000	135,144
Lobsters	7,398	120,000
Abalone	10,570	304,000
Nippers	15,167	.
Other Saltwater Species	77,633	12,800,300

Source: DPI Fisheries Survey of Recreational Fishing in NSW
Data derived from a range of Commonwealth and State sources. Other species data based on a 5 year average of ocean fishery landings into NSW

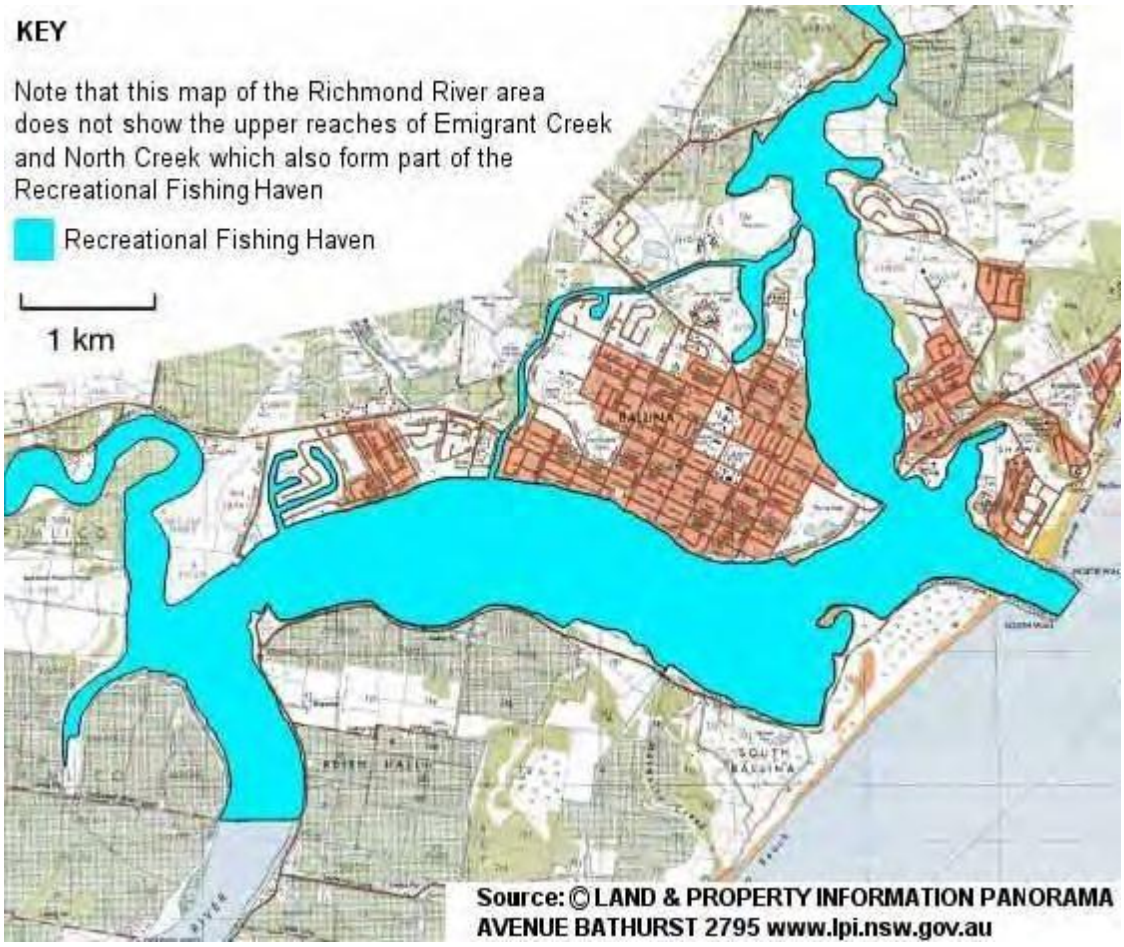


Figure 39: The Recreational Fishing Haven in the Richmond River estuary

The Estuary General Fisheries EIS and associated management strategy (NSW Fisheries, 2003) were produced in response to changes in the way commercial fisheries were managed in NSW. These changes were implemented to provide increased emphasis on environmental sustainability and continued viability of estuarine fisheries. There is concern that the findings and strategies documented in the General Fisheries EIS are not well understood within the community and that commercial fishers are being unfairly blamed for fish decline in the estuary.

Despite this, there is increasing recognition in both the recreational and commercial fishing sectors that their respective activities are highly regulated and that factors such as the major fish kills in 2001 and 2008, as well as the cumulative effects of habitat degradation, fish migration barriers and declining water quality are all contributing to reduced fish stocks. The 2008 fish kill and ensuing temporary fishing closure polarised community views on who was to blame and what was to be done to avoid repeat occurrences.

It is also important to acknowledge traditional Aboriginal fishing rights and practices in accordance with Native Title.

Oyster aquaculture

The EPS (WBM, 2006) notes that Ballina was named after the local Aboriginal name of ‘bullenah’ which means ‘place where oysters are plentiful’. Culture of the native Sydney Rock Oyster is the only aquaculture industry in the Richmond River estuary and is concentrated in the lower reaches of North Creek and Richmond River.

There are a range of issues affecting the oyster aquaculture industry in the Richmond River estuary:

- QX disease is a major threat to both production and saleability of oysters from the estuary and is caused by protozoan infestation of the oyster gut. After infection, the oyster's digestive gland is destroyed and the oyster cannot take up nutrients. At this stage, oysters rapidly loose condition and there is a high mortality rate. Although the triggers for QX disease are not fully understood, it is suspected that poor water quality is a major stressor which reduces an oyster's resistance to the disease. DPI is continuing research into management of the disease, including the development of QX resistant strains of the Sydney Rock Oyster. The Richmond River is classified as a high risk QX waterway which restricts the export of oysters to other, lower risk, estuaries. QX resistant strains are being grown in the Richmond estuary however oyster mortality is still occurring.

Plate 26: Oysters collected from the Richmond River with QX disease

Source: WBM, 2006

- Oysters are well known for their ability to accumulate contaminants from the surrounding water and therefore the industry relies on good ambient water quality to both maintain the health of the oysters and to ensure that the product is fit for human consumption. The saleability of oysters is not only governed by the NSW Food Authority which imposes monitoring requirements and imposes harvest restrictions when required but also the public perception of the environment they are grown in. The presence of periodically high levels of faecal coliforms in North Creek has resulted in harvest closures which was reported in the EPS (WBM, 2006) as typically extending for 9 months of the year. The presence of pesticide residues and potential effect on the oyster industry is an ongoing concern;
- Vandalism of oyster culture racks and theft of oysters is an emerging issue facing the industry. Apart from the commercial losses suffered by the growers, and risks to the viability of the industry there are significant human health risks. Oysters stolen and sold on the black market are not covered by the NSW Shellfish Program, may come from areas subject to closures are not depurated and are not subject to quality control testing.

No.	Fisheries Management and Aquaculture Issues
I24	Poor understanding of recreational and commercial fishing impacts and perceived decline of fish stocks
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
I26	Poor water quality (particularly faecal coliforms) in oyster culture areas results in extended oyster harvest closure periods

7.14.2 Management Objectives

Table 16 shows the relationship between Fisheries and Aquaculture issues, related values and management objectives.

Table 16: Relationship between Fisheries and Aquaculture Values, Issues and Objectives

Values	Issues	Objectives
• Commercial fishing and oyster aquaculture contribute to the local and regional economy • The estuary and particularly the lower estuary is considered to be a key attraction for tourists and recreational users to the area, with associated economic benefits • The Richmond River Estuary has high cultural and spiritual significance to local Aboriginal communities • The estuary and foreshore areas are highly valued by the community and visitors for recreational activities	I24 - Poor understanding of recreational and commercial fishing impacts and perceived decline of fish stocks 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 I26 - Poor water quality (particularly faecal coliforms) in oyster culture areas results in extended oyster harvest closure periods	O4 - To increase knowledge of the impact of existing practices on estuary values and facilitate continuous improvement O5 - To reduce pollutant loads to the estuary O7 - To minimise the frequency and severity of environmental events such as fish kills O8 - To optimise flood mitigation works and flow control structures to improve estuarine water quality O11 - To provide for increased use of the estuary whilst minimising environmental impact and conflict between users O14 - To enhance sustainable commercial return from industries relying on the estuary and the floodplain

7.14.3 Potential Management Options

None of the issues relating to fisheries and aquaculture management are unique to the Richmond River estuary and are currently being addressed to various degrees by industry regulation licensing and research programs. Work currently being undertaken on an industry or state-wide basis includes:

- Setting of bag and size limits for recreational anglers. This information is provided at a number of boat ramps within the Richmond River estuary, as well as at bait and tackle stores and with information provided when obtaining recreational fishing licences in NSW;
- Commercial fishing is licensed in NSW and catches are monitored through co-op returns. There is on-going review of catch and effort data for all estuaries in NSW including the Richmond;
- The impact of changes in fisheries regulation for NSW estuaries was assessed under the General Fisheries EIS produced in 2003. The associated strategy provides measures to address a range of goals including conservation of biological diversity, sustainable harvesting, conservation of threatened species and ecological communities, resourcing sharing and conflict minimisation, on-going commercial viability, management efficiency, knowledge improvement as well as monitoring and review. Many of these measures are consistent with the aims of the CZMP process and are supported; and
- Research into QX disease triggers and development of QX disease resistant strains of the Sydney Rock Oyster is being undertaken by Industry & Investment NSW.

On a local scale there are strong linkages to other management options identified to manage broad scale issues within the estuary as follows:

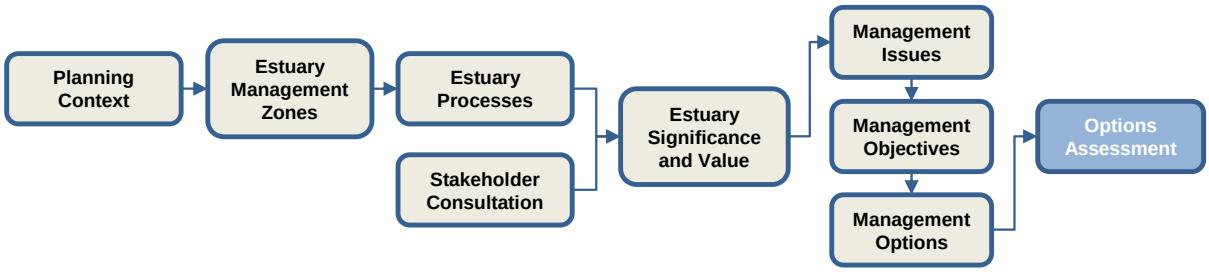
- Water quality in the estuary is a key determinant in achieving the objectives for fisheries and aquaculture management in the Richmond River estuary. Any measures that result in improvements in water quality in the estuary will be beneficial, so the options identified for floodplain management, farm management, riparian zone management, waterway usage, wastewater and urban runoff are particularly relevant; and
- Continued public education is important to increase awareness of commercial and recreational fishing impacts, to improve community understanding of indigenous fishing rights, to contribute to reducing pollutant load to the estuary (both rural and urban runoff) as well as reducing direct impacts such as boating damage to critical habitats and over-fishing.

Specific options identified to address local fisheries and aquaculture issues and to enhance the effectiveness of broader strategies are:

- Identify faecal contamination sources in North Creek and evaluate the most appropriate control measures; and
- Provide information links so that key research findings in the fisheries and aquaculture sector are communicated to the public (e.g. via council newsletters, web sites, etc).

No.	Fisheries and Aquaculture Management Options
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

8. ESTUARY MANAGEMENT OPTIONS ASSESSMENT



A suite of options available for the sustainable management of the estuary have been compiled in Section 7 and developed to a point where the options can be compared and prioritised. Further detail is provided in Appendix 4.

8.1 Assessment and Prioritisation of Options

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

- All issues were ranked to focus management effort on those issues regarded as a priority in achieving the objectives of the plan;
- The individual options were assessed to determine the effectiveness in addressing the priority issues ("Issues Score");
- The individual management options were assigned an "Option Benefit Score"; and
- The Average Option Benefit Scores (average of the Option Benefit Scores) for each category of option were visually compared with the associated issue priority.

Appendix 4 provides a detailed description of the options assessment process. The results of the options assessment (Option Benefit Score vs Issues Score) are shown in Figure 40.

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 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 41 compares the Average Option Benefit Score and the Total Issues Scores for each category of issues (Strategies) from Section 7. The Strategies have been assigned a low, medium or high priority based on their capacity to address the identified issues and their overall benefit. Administration and Governance, Climate Change and Monitoring and Evaluation are considered to be fundamental management strategies for the CZMP. These strategies have not been prioritised in the same way as the other strategies and are not included in this plot.

The classification of strategies as low priority for management is not a reflection of the level of importance of these factors, but rather an indication of the capacity of the actions contained in these strategies to achieve the defined objectives in terms of overall estuary health.

Based on the priorities displayed here, the management strategies will be developed as part of the Draft CZMP. The strategies (in priority order) and their component options are shown in Table 17.

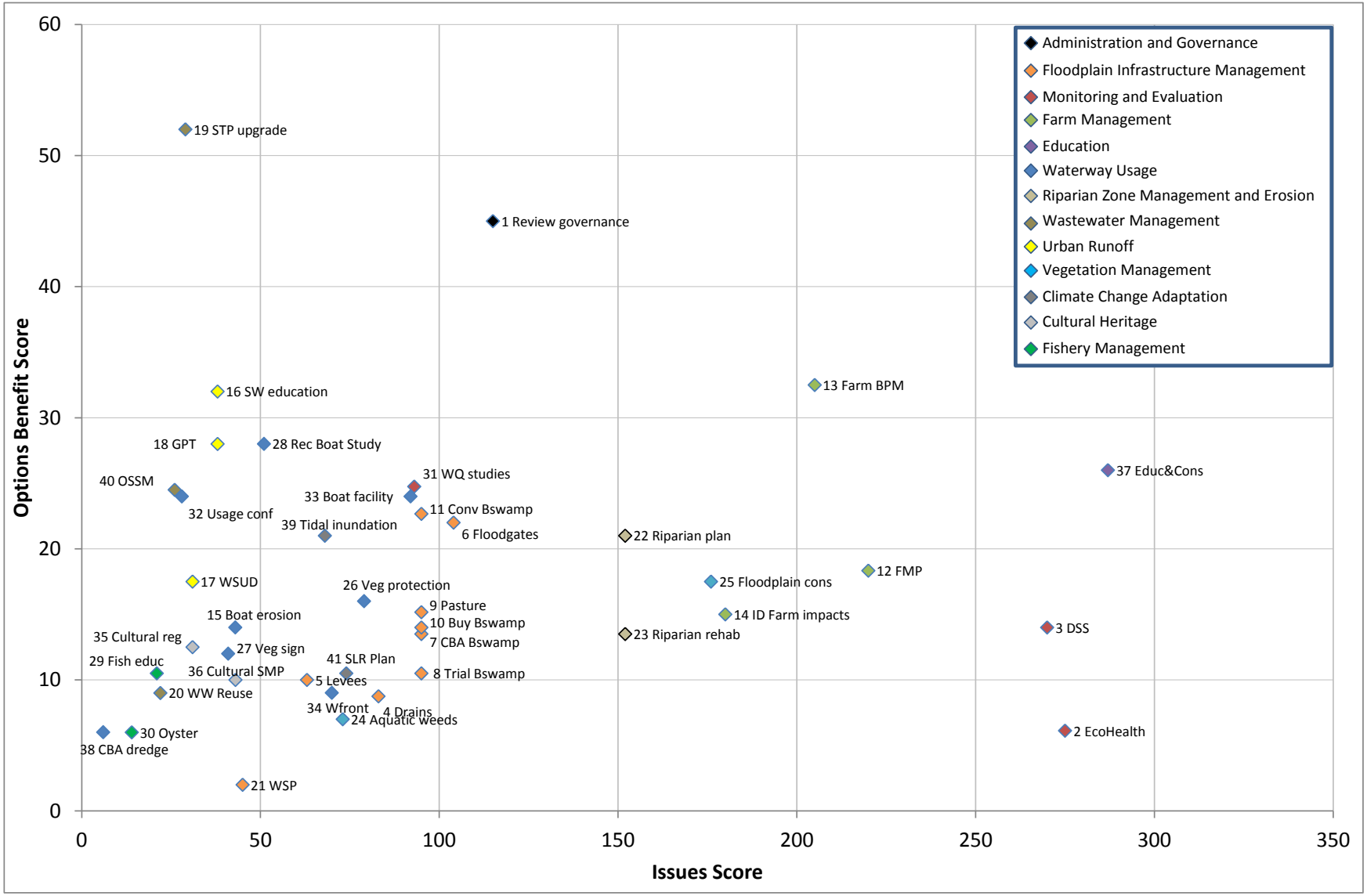
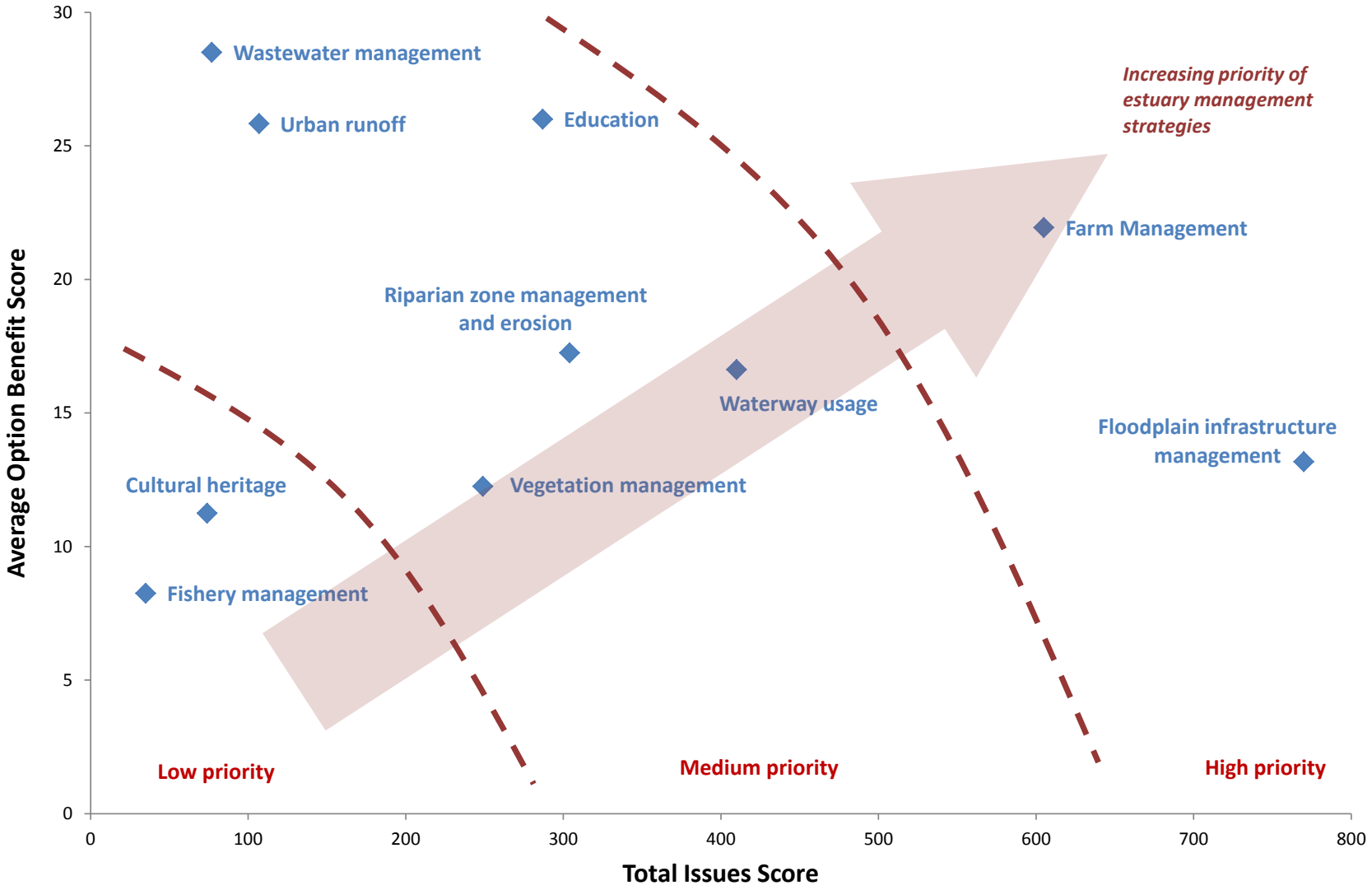


Figure 40 - Assessment of Management Options



*Note that strategies considered to be fundamental management considerations were not prioritised i.e. Administration and Governance and Climate Change Adaptation

Figure 41: Relative Priority of Management Strategies

Table 17: Prioritised Management Strategies and Options

FUNDAMENTAL MANAGEMENT STRATEGIES AND MANAGEMENT OPTIONS	
Administration and Governance	
1	Review estuary governance and administration
Climate Change Adaptation	
39	Assessment and mapping of tidal inundation extent including potential sea level rise
41	Planning for sea level rise and climate change impacts incorporating Government policy and guidelines, current research and best-practice management
Monitoring and Evaluation	
2	EcoHealth monitoring program
3	Develop catchment/water quality modelling tool to support decision making

HIGH PRIORITY MANAGEMENT STRATEGIES AND MANAGEMENT OPTIONS	
Floodplain Infrastructure Management	
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
21	Review water sharing plans regarding groundwater extraction and ASS effects
Farm Management	
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

MEDIUM PRIORITY MANAGEMENT STRATEGIES AND MANAGEMENT OPTIONS	
Riparian Zone Management and Erosion	
22	Riparian buffer zone establishment (planning)
23	Identify priority riparian areas and rehabilitate
Vegetation Management	
24	Aquatic weed management
25	Retain, rehabilitate and conserve existing native floodplain vegetation
Education	
37	Estuary-wide community education and consultation program
Waterway Usage	
15	Review boat passage areas impacted by erosion
26	Zoning to prevent access to sensitive estuarine vegetation areas
27	Estuarine vegetation signage / education to protect sensitive areas
28	Implement Recreational Boating Study actions
32	Investigate usage conflicts and need for management
33	Develop strategic plan for estuary usage
34	Review of waterfront structures and licensing
38	Cost benefit analysis of dredging operations in lower estuary
Wastewater Management	
19	Upgrade / augment STPs where required
20	Wastewater Reuse
40	Ongoing on-site sewerage management inspections and improvements
Urban Runoff	
16	Stormwater education
17	WSUD for new developments
18	Retrofit GPTs and other stormwater improvement devices

LOW PRIORITY MANAGEMENT STRATEGIES AND MANAGEMENT OPTIONS	
Cultural Heritage	
35	Identification and recording of cultural sites available to council planners
36	Cultural Site management plans
Fishery Management	
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

9. PREPARATION OF THE COASTAL ZONE MANAGEMENT PLAN

9.1 Development of the Coastal Zone Management Plan

Based on the options identified as part of this Draft EMS, a workable and prioritised schedule for implementing the management strategies will be developed and presented in the Draft CZMP for the Richmond River Estuary (Volume 1).

The preparation of the Draft CZMP will include development of:

- Management strategies based on the options identified in this Draft EMS;
- Broad actions (managerial, operational, planning, design and construction) required to implement each option;
- A 10 year schedule of actions required to implement the management strategy; and
- Key performance indicators (KPIs) and targets for the successful implementation of the actions.

Management actions will be assessed as immediate, ongoing, short term (1 - 3 years), medium term (4 - 6 years) and long term (7+ years). The implementation of some options may be reliant on pre-requisite actions that cannot be completed within the 10 year timeframe of this plan, but will be commenced within the implementation timeframe.

Management strategies will identify those responsible for the delivery of each action, the estimated costs to be faced and potential sources of funding. The strategies will consider and support the broader policies, strategies and targets identified at the state, regional and catchment level. Where issues are already being addressed by other management strategies, this will be recognised in the Draft CZMP.

A monitoring program will be developed for the Draft CZMP, utilising the KPIs, for the purposes of the on-going review and adaptation of the Draft CZMP to ensure it continues to deliver sustainable outcomes. For the identified KPIs, and the actions required to deliver them, requirements will be brought together to create a comprehensive, outcomes-focussed monitoring regime. Where relevant, links to the Councils' existing environmental monitoring and reporting (such as the State of the Environment reports) activities will be developed.

The implementation of the plan will be supported by a process for reviewing the effectiveness of the plan and adapting it as required. This aspect of the project is essential for ensuring that the estuary management options identified become a reality and that the estuary is better managed into the future.

GLOSSARY AND ABBREVIATIONS

Acid sulfate soils (ASS)	Holocene soils occurring in low lying floodplain areas with high concentrations of iron pyrite, formed as the by-product of sulfate reduction. ASS formed approximately 7,000-3,000 years before present when post-glacial sea levels reached their current level creating vast intertidal mangrove swamps.
Algal bloom	The rapid growth of phytoplankton resulting in a high biomass in the water column.
Anoxic	An oxygen-free environment.
Antecedent	Preceding the present.
Anthropogenic	Any phenomenon caused by human activities.
BASIX	Building Sustainability Index
Benthic microalgae (BMA)	Microscopic algae living in the surface sediments
Benthic	Belonging to the bottom, or sediments, of the estuary.
Bio-available	Nutrient forms (usually inorganic) available for plant growth.
Biological oxygen demand (BOD)	A measure of the amount of oxygen that will be consumed by biological processes over a given time period (usually 5 days).
Biomass	The living weight of plant or animal material (organic matter).
Blackwater	A collective term used to describe low oxygen floodwaters emanating from backswamp areas and floodplains.
BSC	Ballina Shire Council
CAP	Catchment Action Plan
Chemical oxygen demand (COD)	A measure of the amount of oxygen that will be consumed by chemical processes over a given time period (usually 5 days).
Chlorophyll-a	The green pigment in plants used to capture and use energy from sunlight to form organic matter (see photosynthesis). Concentrations of chlorophyll-a are used as an indicator for phytoplankton and benthic algae biomass.
CZMP	Coastal Zone Management Plan (equivalent to EMP).
DECCW	former NSW Department of Environment, Climate Change and Water
Diffuse Source Pollution	Non-point source pollution such as sediment or nutrients from catchment runoff or groundwater inputs.
DPI	Department of Primary Industries
Ecosystem	Refers to all the biological and physical parts of a biological unit (e.g. an estuary, forest, or planet) and their interconnections.
EMC	Estuary Management Committee
EMS	Estuary Management Study
EPA	Environment Protection Authority
Eutrophication	The process of nutrient enrichment of a water body resulting in the increase in plant biomass (algal blooms) and bacterial decay (heterotrophic activity). Often results in a reduction in species diversity, visual amenity, and the prevalence of toxic algal species.
Foodchain	The predator / prey interactions of an ecosystem component.
Foodweb	Foodchain interactions of the whole ecosystem.
Freshwater flushing time	The time (in days) that freshwater stays within an estuary before being transported to the sea by advection and tidal mixing.
Grazing	The eating of plants (e.g. phytoplankton) by animals (e.g. zooplankton).
Hypoxic	Critically low concentrations of dissolved oxygen (see anoxic).
LCC	Lismore City Council

LEP	Local Environmental Plan
Light attenuation	The absorbance of sunlight by dissolved and particulate matter in a water body.
LPMA	Land and Property Management Authority (formerly Department of Lands)
Monosulfidic Black Ooze (MBO)	An iron sulfide compound formed as a by-product of sulfate reduction. MBOs commonly form in acid environments with high organic matter supply and have a high chemical oxygen demand.
NOW	NSW Office of Water
NPWS	National Parks and Wildlife Service
NRCMA	Northern Rivers Catchment Management Authority
NRM	Natural Resource Management
Nutrient budget	A simple model quantifying nutrient loadings (by weight) to a waterway from different sources over a given time period (e.g. one year).
Nutrient limitation	The restriction of phytoplankton growth by the low concentration (availability) of a nutrient.
OEH	Office of Environment and Heritage
Physico-chemical	Basic water quality parameters e.g. temperature, pH, conductivity, turbidity.
Phytoplankton	Microscopic single-cell plants growing in the water column.
Point Source Pollution	A single point of pollutant discharge. For example, effluent from a sewage treatment plant.
Primary production	The formation of organic matter by autotrophs (e.g. phytoplankton).
Pristine	Undisturbed by human activities such as urban and agricultural development, pollution, erosion, weed infestations etc.
Reticulated Sewage System	Sewage piped to a centralised sewage treatment plant for treatment and disposal.
RRCC	Richmond River County Council
RVC	Richmond Valley Council
SEPP	State Environmental Planning Policy
Sulfate reduction	The bacterial breakdown of organic matter in anoxic sediments using sulfate instead of oxygen. Produces hydrogen sulfide, the ‘rotten egg gas’ smell common in muddy sediments.
STP	Sewage Treatment Plant. Raw sewage is collected from homes and businesses and transported via a network of pipes and pump stations to the sewage treatment plant, a centralised system for treatment and disposal.
Turbidity	A measure of the amount of light-attenuating particles in a water body.
Well-mixed	Where there is a little difference in salinity (or dissolved oxygen) between the surface and bottom water in the water column of an estuary.

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Appendix 1: Planning Context

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

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

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

Appendix 4: Options Assessment

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