



## LAKE MACQUARIE COASTAL ZONE MANAGEMENT PLAN - PART B

for the **Estuary**

**FINAL**

October 2015





# LAKE MACQUARIE COASTAL ZONE MANAGEMENT PLAN

## PART B

## FOR THE ESTUARY

**October 2015**

Prepared by  
Umwelt (Australia) Pty Limited

on behalf of  
Lake Macquarie City Council

Lake Macquarie City Council has prepared this document with financial assistance from the NSW Government through its Estuary Management Program. This document does not necessarily represent the opinions of the NSW Government or the Office of Environment and Heritage.

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## Executive Summary

The Estuary part of the Lake Macquarie Coastal Zone Management Plan focuses on maintaining a healthy lake, which supports the lifestyle valued by the local community. This Coastal Zone Management Plan has been developed under the NSW Government's Estuary Management Program in accordance with the specifications of Part 4a of the Coastal Protection Act 1979.

The Estuary part of the CZMP focuses on the waters and foreshores of Lake Macquarie, but also considers actions in the catchment that have the potential to significantly affect the health and amenity of the Lake. This Plan does not cover any open coast or the Swansea Channel, which are covered by Part A and Part C of the CZMP, respectively.

Part B of the CZMP is supported by the *Lake Macquarie Waterway Flood Study* and the *Lake Macquarie Waterway Flood Risk Management Study and Plan* and should be read in conjunction with those supporting documents.

### The Plan aims to:

- Build a management bridge between lake and foreshore policies and local people, so that looking after the lake (a nationally significant natural and social asset) is central to everyone's lives.
- Provide a framework for all stakeholders to achieve the best outcomes for a healthy estuary in an established and growing urban and recreational context.
- Facilitate integrated management of the whole coastal zone within the City of Lake Macquarie.
- Identify collaborative partnerships (across levels of government, between local Councils and with private sector and community organisations) to streamline and align implementation of coastal management actions.
- Provide a clear pathway for the delivery of estuary management actions, monitoring and review of performance.
- Create the conditions that support resilient natural systems and a resilient coastal community

The Estuary part of the CZMP draws on the best available technical and scientific information, together with community knowledge, information about current community attitudes and values and best management practice information. The Plan presents a summary of the relevant environmental processes of the estuary, its foreshores and the wider catchment area. It explores the interaction of these processes with social and economic values of the local area and their influence on estuary management principles. Based on this information a wide range of potential management options have been formulated including options canvassed from community and stakeholder representatives. All options have been assessed against prioritisation criteria and subsequently classified. The matrix below provides a summary of the classification scheme applied.

<b>Importance</b>	<b>Higher</b>	<p style="text-align: center;"><b>Category A</b> <b>Important and Easy</b> Take action NOW.</p> <p>These actions treat high priority risks, and can be completed with available funds, (proportional investment to risk and benefits); they are consistent with current legislation/policy and governance arrangements</p>	<p style="text-align: center;"><b>Category B</b> <b>Important but Tricky</b></p> <p>Take action NOW to reduce barriers and enhance opportunities.</p> <p>These are 'preparation' actions, so that actions can move into the Important and Easy category when needed.</p>
	<b>Lower</b>	<p style="text-align: center;"><b>Category C</b> <b>Not so Important, but Easy</b></p> <p>Take action when opportunities present – these actions are 'bonuses' – schedule for implementation, but not urgently.</p>	<p style="text-align: center;"><b>Category D</b> <b>Too Hard for Now</b></p> <p>Take action to remove barriers and enhance opportunities when opportunities present</p>

Management options assessed as Category A, form part of a 4 year Action Plan which identifies funding sources, performance criteria and responsible agencies for these priority actions. Many of the actions in the plan will be the responsibility of Council; however a healthy estuary in a growing and active urban community is not achieved by the work of local government alone. The Plan highlights collaborative governance arrangements with state agencies, businesses and residents as key contributors to the ongoing success of estuary management.

This Part B of the CZMP has an indicative 10 year timeframe. Progress with implementation should be formally reviewed annually. A complete review and amendment of the CZMP, including Part A, should occur after a minimum 5 years, and should redress outstanding issues, new environmental management practices, new scientific data, and changed governance and administrative arrangements.



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## 1.0 A New Plan for the Lake Macquarie Estuary

The NSW coastal zone contains over 130 estuaries that vary in size from small coastal creeks and lagoons to large lakes and rivers. Lake Macquarie is the largest coastal estuary in eastern Australia, covering an area of approximately 110km<sup>2</sup>. It is situated between Sydney and Newcastle and is bordered by residential, industrial, rural and undeveloped land. The Lake is of significant ecological value, whilst also providing for a range of on and off water recreational activities.

The term 'resilience' is used in environmental and socio-economic contexts to describe the capacity of systems (ecological or human) to absorb or cope with change, such as external shocks and internal pressures, but still retain fundamental functions and relationships.

When we refer to a resilient Lake Macquarie, the intent is to achieve natural and human systems which can jointly accommodate change (whether planned or unplanned) so that estuary processes continue to function in a healthy way and provide the recreational and amenity services that are valued by a growing and changing community. A healthy lake and a socially, environmentally and economically engaged community are co-dependent.

The management of the Lake Macquarie estuary over the last 10 to 15 years is widely regarded as one of the most successful natural resource management stories in Australia. In the early 1980s, the estuary was struggling to accommodate a range of threats including

- uncontrolled stormwater discharges from expanding urban areas, many of which were also not connected to sewer;
- discharges from waste water treatment plants into poorly flushed estuarine tributaries;
- long term heavy metal contamination with both air emissions and discharges to Cockle Creek affecting local ecological and human health;
- discharges from historical coal mines;
- significant sediment loads from unsealed tracks along power easements throughout the catchment;
- ongoing hydrodynamic adjustments to the construction of entrance training walls, and a major dredging campaign to facilitate water transport of power station components;
- thermal discharges from power stations;
- widespread clearing and/or mowing of foreshore vegetation; and
- largely unrestricted recreational use of the lake, catchment and foreshore.

Sampling of water quality, seagrass health, accumulation of foreshore ooze and other lake health indicators demonstrated a disturbing decline.

The Lake Macquarie Estuary Management Plan was prepared in 1997 (WBM Oceanics, 1997) and subsequently reworked into prioritised implementation packages by the Premier's Task Force. The Task Force recommendations, including a dedicated, cross jurisdiction Office of the Lake Macquarie and Catchment Coordinator, were adopted by State Cabinet in 1999.



For 10 years, this integrated and resourced estuary management model delivered works on the lake foreshore, in the catchment and in Swansea Channel. Investment included community awareness and education programs; establishing benchmarking and monitoring programs; stormwater treatment devices; innovative wetland, foreshore and creek bank stabilisation and rehabilitation; and extensive revegetation of key sub-catchments. After 2009, management of these estuary health enhancement projects was continued by Council.

Over this period, several other major initiatives have contributed to recovery of the health of Lake Macquarie estuary system.

- Lake Macquarie became a recreational fishing haven, removing the pressures of commercial fishing on fish stocks;
- a significant extension to the provision of reticulated sewerage services, and a focus on reducing overflows from sewage pump stations;
- removal of lake discharges from sewage treatment plants, with the construction of an offshore discharge point and increased reuse of effluent (e.g. at Eraring Power Station);
- closure of the Pasmenco Smelter and remediation of the site;
- new requirements for design and construction of jetties, ramps and other foreshore structures to reduce impacts on seagrass; and
- improved planning controls for managing erosion and sedimentation from developing residential and commercial areas.

The net positive effect of this investment is demonstrated in the results of ecological condition monitoring and estuary health trends. It is also demonstrated in increased community appreciation of the value of a healthy estuarine system, underpinning the high amenity value of the city.

This document, the Estuary part of the Coastal Zone Management Plan (CZMP) builds upon and supersedes the previous Estuary Management Plan adopted in 1997. The new plan takes into account environmental and social change over the past 15 years, as well as the lessons from the significant works undertaken to restore and protect the lake over this period. Specifically:-

- The condition of the estuary in terms of water quality and seagrass health has improved. The improvement works over the past fifteen years have provided valuable insights into the most effective mechanisms for dealing with the drivers of impacts on a large lake system in a largely urbanised catchment.
- The population of Lake Macquarie has increased by about 1800 people a year in recent years. Lake Macquarie has been identified as a continuing growth centre in the lower Hunter region, with a projected increase of some 60,000 people by 2031. Lifestyle and recreational preferences are evolving with changing age structure, wealth and opportunities.
- Many major industries around the lake have closed and long term sources of contamination have been remediated, refocusing attention on the impacts of broader catchment runoff.

- The statutory framework which governs coast and estuary management in NSW has undergone significant reform and further reforms are proposed during 2015. The local planning framework, including the zoning of the lake in the Lake Macquarie LEP have been updated and standardised.
- There is better understanding of the vulnerability of the natural and built environment of Lake Macquarie to climate change impacts, both in terms of sea level rise and climate parameters such as water temperature and storminess.

## 1.1 Purpose of this Part B of the CZMP

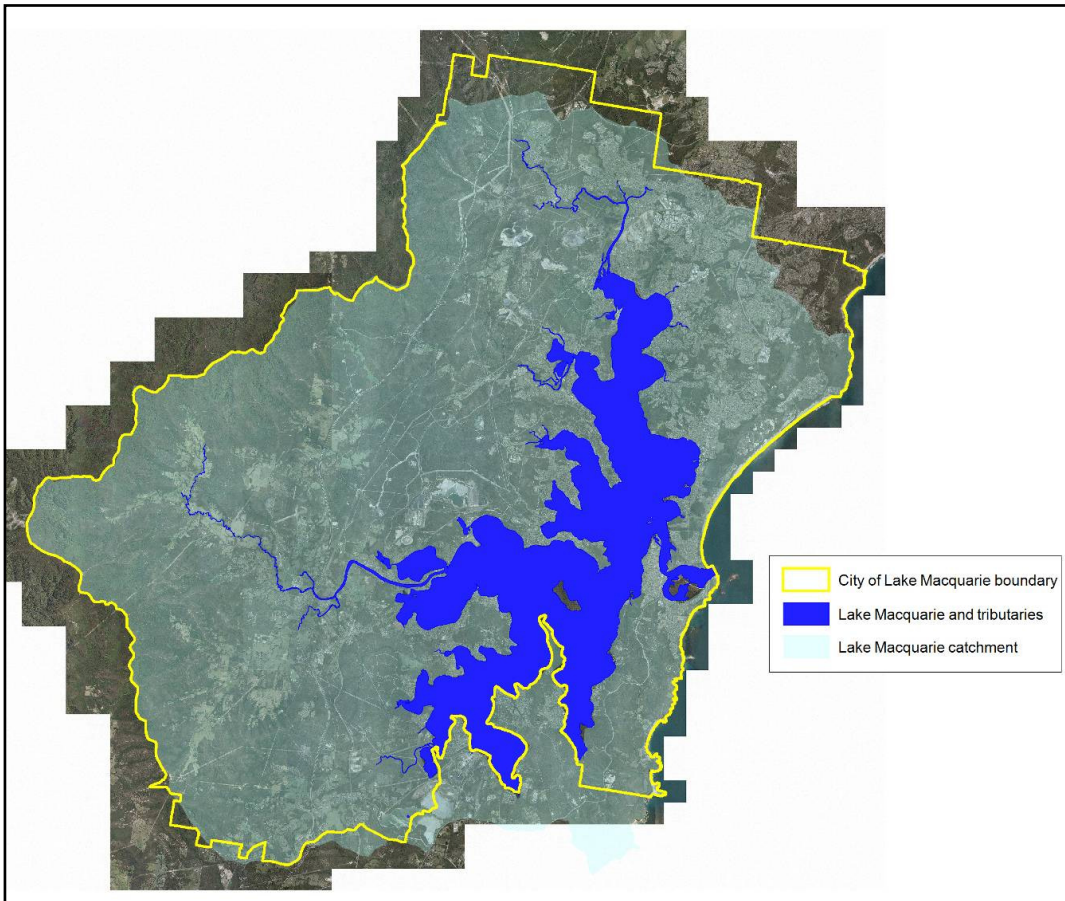
The Estuary part of the CZMP provides the framework within which Council, state agencies and the people of Lake Macquarie will work together to protect the health of natural lake systems and to maintain a safe and accessible waterway for recreation and community amenity.

The role of this Part B of the CZMP is to establish priority actions to continue to build ecological and social resilience in the estuary context, and continue to build capacity to manage the lake to deliver benefits for the environment and benefits for the community.

### The Estuary part of the CZMP will

- Build a management bridge between coastal (lake and foreshore) policies and local action.
- Provide a framework for all stakeholders to achieve the best outcomes for a healthy estuary in an established and growing urban and recreational context.
- Contribute to integrated management of the whole coastal zone within the City of Lake Macquarie.
- Identify collaborative partnerships (across levels of government, between local Councils and with private sector and community organisations) to streamline and align implementation of coastal management actions.
- Provide a clear pathway for the delivery of estuary management actions, monitoring and review of performance.
- Create the conditions that support resilient natural systems and a resilient coastal community.

The Estuary part of the CZMP focuses on the waters and foreshores of Lake Macquarie, but also considers actions in the catchment that have the potential to significantly affect the health and amenity of the lake. The lake and its catchment are shown in **Figure 1.1**, with the parameters of the plan summarised in **Table 1.1**. Swansea Channel is the subject of a separate part of the CZMP and therefore management of this area (**Figure 1.2**) is excluded.



**Figure 1.1**  
– Lake  
Macquarie  
and  
catchment



**Figure 1.2** – Area covered  
by the Swansea Channel  
part of the CZMP



**Table 1.1 – Parameters of the Estuary part of the CZMP**

<p style="text-align: center;"><b>Project Area</b></p> <p>The Estuary part of the CZMP covers the whole of the Lake Macquarie estuary and its estuarine tributaries, such as Cockle Creek, LT Creek, Stony Creek, Dora Creek, Wyee Creek and North Creek. Swansea Channel is the subject of a separate document.</p>	<p style="text-align: center;"><b>Timeframe</b></p> <p>The Plan is 10 years. It will be fully reviewed and updated at that time.</p>
<p style="text-align: center;"><b>Landscape Context</b></p> <p>The Lake Macquarie estuary is part of the NSW Coastal Zone. Estuary processes and estuary health are strongly influenced by catchment inputs, but also influenced by tidal exchange with the ocean, through Swansea Channel.</p>	<p style="text-align: center;"><b>Key Responsibilities</b></p> <p>The Plan sets out actions to maintain and improve the health of Lake Macquarie and community access and enjoyment to this large waterway in its urban coastal context. Many actions are for Council to implement, but will also require contributions from State agencies, businesses and the community. Part of the Lake Macquarie catchment is located in Wyong Shire, so a healthy lake also depends on actions by Wyong Shire Council.</p>

## 1.2 Statutory Context

### 1.2.1 NSW Coastal Protection Act 1979

The *Coastal Protection Act 1979* provides the framework for coastal zone management and CZMPs must show how the objects of the *Coastal Protection Act* have been incorporated into assessment, decision making and priorities.

Broadly, the issues to be addressed in a CZMP include:

- Managing risks to public safety and built assets/infrastructure;
- Pressures on coastal ecosystems; and
- Community use of the coastal zone (estuary).

Currently, a CZMP should also have regard for the objectives and priorities of the NSW Coastal Policy.

A CZMP should be designed to be aligned with a range of other plans and strategies which together provide for sustainable management of the natural systems and local communities of the coastal zone. The CZMP should not duplicate management actions that are contained in these other plans, but may make recommendations about changes to them.

**Table 1.2 – Objects of the Coastal Protection Act 1979**

<b>Protect enhance, maintain and restore biodiversity</b>	To protect, maintain and restore the environment of the coastal region and its associated ecosystems, ecological processes, biological diversity and water
<b>Secure and orderly use of resources</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.
<b>Account for social and economic benefits</b>	To recognise and foster the significant social and economic benefits to the State that result from a sustainable coastal environment, including: <ul style="list-style-type: none"> <li>• Benefits to the environment</li> <li>• Benefits to culture and heritage</li> <li>• Benefits to Aboriginal people in relation to their spiritual, social, customary and economic use of land and water</li> <li>• Benefits to urban communities, fisheries, industry and recreation</li> </ul>
<b>Public access, on foot</b>	To promote public pedestrian access to the coastal region and recognise the public's right to access
<b>Appropriate land tenure</b>	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.
<b>Involve community</b>	To recognise the role of the community as a partner with government, in resolving issues relating to the coastal environment
<b>Policy and program alignment across agencies</b>	To ensure co-ordination of the policies and activities of the government and public authorities relating to the coastal region and facilitate the proper integration of their management activities
<b>Prepare for climate change</b>	To encourage and promote plans and strategies for adaptation in response to coastal climate change impacts, including projected sea level rise
<b>Beach amenity</b>	To promote beach amenity

### 1.2.2 NSW Guidelines for Preparing Coastal Zone Management Plans 2013

The NSW Guidelines for Preparing Coastal Zone Management Plans (OEH, 2013) identify 10 principles which should be given effect in a CZMP.

**Table 1.3 – Coastal Principles for Consideration in CZMP (OEH 2013)**

<b>Principle</b>	<b>Details</b>	<b>Addressed by the CZMP</b>
<b>Principle 1</b>	Consider the objects of the <i>Coastal Protection Act 1979</i> and relevant NSW government policies.	Refer to Sections 1 of this document
<b>Principle 2</b>	Optimise links between plans relating to the management of the coastal zone.	This document is Part B of the overall Lake Macquarie Coastal Zone Management Plan, which provides consistency and integration in management of the open coast, the estuary and Swansea Channel.
<b>Principle 3</b>	Involve the community in decision making and make coastal information publicly available.	Council has elected to undertake community consultation concurrently for all parts of the integrated CZMP (coast, lake and channel).

Principle	Details	Addressed by the CZMP
		Notwithstanding, stakeholder organisations have been consulted individually, while community consultation undertaken as a part of previous studies has been considered.
<b>Principle 4</b>	Base decisions on the best available information and reasonable practice. Acknowledge relationships between catchment, estuary and open coast.	Management options recognise the overlap between flooding and oceanic processes through estuaries, streamlining management into one approach. A prioritisation system has been used to evaluate management options. This system is described in Section 5 of this report.
<b>Principle 5</b>	The priority for public expenditure is public benefit; it should achieve cost effective, practical, long term outcomes.	High level cost benefit analysis for management options has recognised the public benefit as priority for management options.
<b>Principle 6</b>	Adopt a risk management approach to managing risks to public safety and assets; use a risk management hierarchy and adopt interim risk reduction measures.	Council has recently adopted its Lake Macquarie Flood Risk Study and Management Plan (WMA Water 2012a-b). The Estuary CZMP refers out to this plan, which identifies high priority management responses to address lake flooding and inundation risks.
<b>Principle 7</b>	Adopt an adaptive risk management approach if risks are expected to increase over time, or to accommodate uncertainty.	The adaptability of management options to future circumstances was a consideration in selection of preferred options. A triggered based approach has been applied that recognises risks that are expected to increase over time.
<b>Principle 8</b>	Maintain the value of high value coastal ecosystems.	The Estuary part of the CZMP includes actions for rehabilitation of degraded estuarine ecosystems, and provision to improve resilience of existing high value ecosystems.
<b>Principle 9</b>	Maintain and improve safe public access to beaches and headlands, consistent with the NSW Coastal Policy.	Limited applicability to this Estuary part of the CZMP, however, public access along foreshore reserves is maintained and protected.
<b>Principle 10</b>	Support recreational activities consistent with the NSW Coastal Policy.	Gazettal of the CZMP will provide mechanism for inclusion of coastal hazards and the outcomes of this CZMP when planning for recreational activities within and around the waterway.

### 1.2.3 Environmental Planning Instruments

In addition to legislated Acts of Parliament, there are two main types of statutory environment planning instruments, Local Environmental Plans (LEPs) and State Environmental Planning Policies (SEPPs).



### 1.2.3.1 State Environmental Planning Policies

State environmental planning policies (SEPPs) deal with issues significant to the state and people of New South Wales. They are made by the Governor on the recommendation of the Minister for Planning. There are a number of environmental management SEPPs that apply to Lake Macquarie and its catchment (SEPP 14 Coastal Wetlands, SEPP 19 Bushland in Urban areas, SEPP 26 Littoral Rainforests, SEPP 44 Koala Habitat Protection, SEPP 71 Coastal Protection).

Of particular note, Division 25 of SEPP (Infrastructure) 2007 refers to waterway and foreshore environmental management activities, including riparian corridor management, bank stabilisation, weed management, revegetation activities, and the creation of foreshore access-ways. In this regard, the relevant local Council is deemed to be the public authority, and as such, does not require development consent to undertake waterway and foreshore environmental management activities.

### 1.2.3.2 Local Environmental Plans and Development Control Plans

Local Environmental Plans (LEPs) are planning instruments produced by local councils to direct the type of development in local government areas. LEPs aim to conserve the natural environment, whilst creating attractive living areas and ensuring development complies with ecologically sustainable principles. Through planning and development controls, they allow councils to regulate the ways in which land is used, by defining permissibility for different types of development across an entire local government area, as a requirement of the Environmental Planning and Assessment Act 1979. LEPs are statutory documents, meaning it is illegal to develop land contrary to that permitted by the LEP.

Development Control Plans (DCPs) are non-statutory instruments that support the LEPs, by providing specific, more comprehensive guidelines for types of development, or specific areas within a local government area. DCPs contain a specific range of conditions (including visual amenity, drainage, access, pollution control, vegetation etc.) aimed at optimising land use in an environmentally sustainable manner.

LEP2014 was published on the NSW Legislation website on Friday 12 September 2014 and became effective on 10 October 2014.

Within the LEP 2014, the lake and entrance channel are zoned 'W1 Natural Waterways'. Consistent with the understanding that Lake Macquarie is an important natural asset that also provides a significant recreational benefit for the community of the Hunter region, the W1 zone objectives are designed to balance the environmental, social, and economic values of the lake, so that the community can continue to enjoy the benefits of access to a healthy waterway.

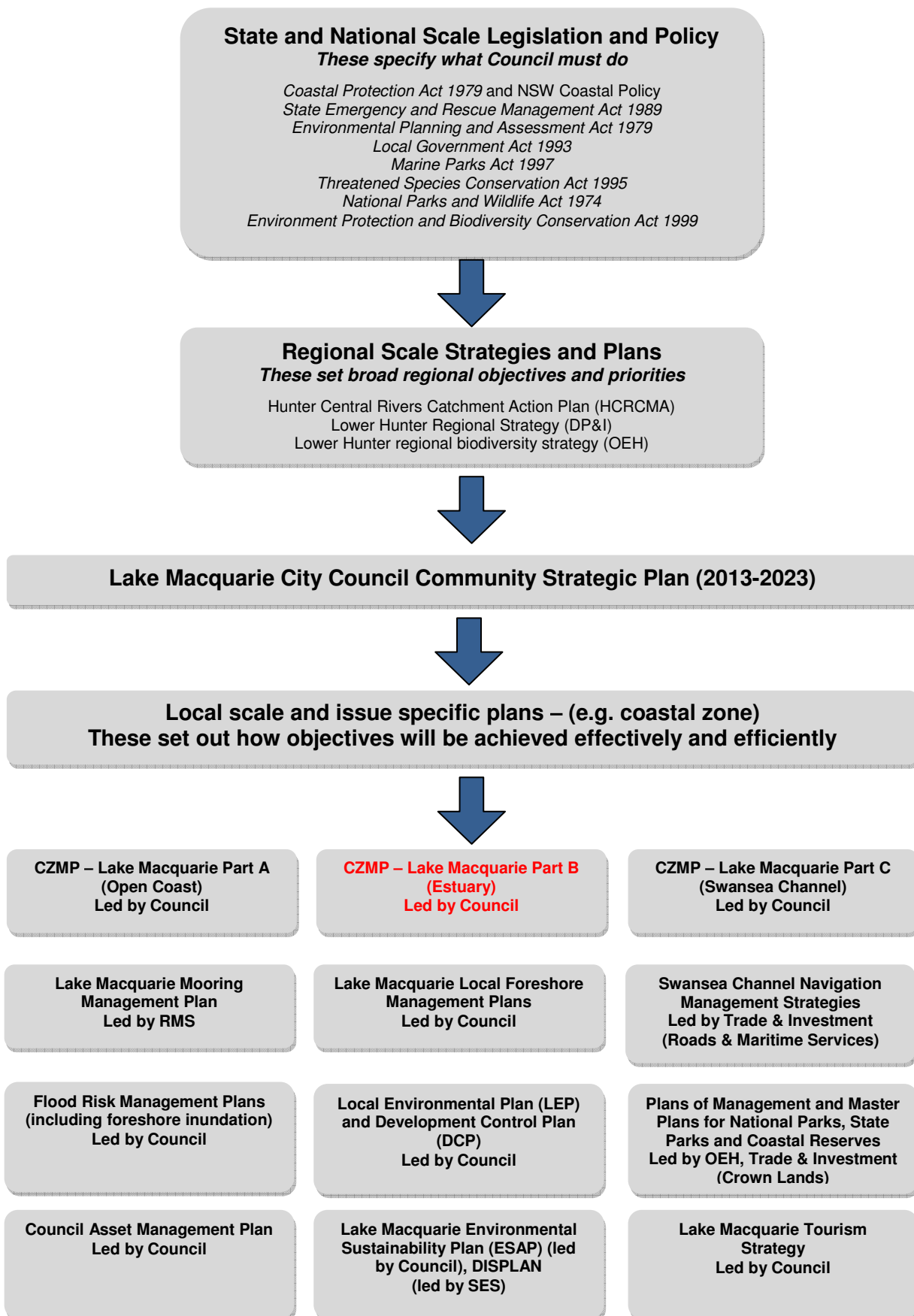
#### **Objectives of the W1 Natural Waterways Zone – LEP 2014**

- To protect the ecological and scenic values of natural waterways.
- To prevent development that would have an adverse effect on the natural values of waterways in this zone.
- To provide for sustainable fishing industries and recreational fishing.
- To provide for recreational use of Lake Macquarie and its waterways as an important environmental, social, and economic asset including maintenance or enhancement of public navigation channels to a depth suitable for yachting and other boating activities.

### **1.3 Linking Part B of the CZMP to Council's Strategic Objectives**

The Lake Macquarie Community Strategic Plan (CSP) sets the strategic direction for all of Council's activities over the next decade. This strategic framework highlights the importance that Council and its community place on achieving sustainable benefits for the natural systems of Lake Macquarie and for the community which lives around the lake or enjoys its waters and foreshores for recreation. The CZMP is one of the tools which Council uses to deliver these strategic objectives so the aim, process and priorities of this Part B of the CZMP should be consistent with the goals, vision and values of the Community Strategic Plan.

Figure 1.3 – Strategic Context of the Coastal Zone Management Plan



## 1.4 Who is this plan for?

The Estuary part of the CZMP has been prepared on behalf of Council to set strategic priorities for estuary management. Council is the authority with primary responsibility for the day to day management of the Lake Macquarie estuary. Council's authority derives from:

- The *Environmental Planning and Assessment Act 1979* (EP&A Act), through the function of the Lake Macquarie LEP 2014, with respect to managing development in and around the lake (via the provisions of land use zones in the LEP), including the lake catchment area. Part of the catchment of Lake Macquarie is in Wyong Shire Council (WSC) and WSC manages land use, land management and lake access in the southern catchment and around the southern shoreline.
- The *Local Government Act 1993*
- *Coastal Protection Act 1979*. The Coastal Protection Act requires that Councils prepare coastal zone management plans which address coastal risks and also consider sustainable community use of the coastal landscape.

Council will be responsible for many of the actions identified in the Estuary part of the CZMP to manage the health of the estuary and community use and enjoyment of the lake and its foreshores, but some management actions will be delivered by other organisations such as Wyong Shire Council (WSC) and State agencies such as Office of Environment and Heritage (OEH), NSW Department of Primary Industries (Fisheries), Roads and Maritime Service (RMS) or NSW Crown Lands.

The Plan is also for the people and businesses that live or work around and enjoy using Lake Macquarie. To achieve the objectives of the Plan and to provide the best framework for a healthy lake that people can continue to enjoy, the Plan includes actions that will be delivered in a partnership between Council and its community, including individuals and organisations such as Landcare, Local Aboriginal Land Councils, schools and businesses.

### **Organisational Partners in Delivery of the Estuary part of the CZMP**

- Wyong Shire Council and, other coastal councils on a less frequent basis;
- Hunter Councils Inc for a regional perspective on climate change, biodiversity and adaptation;
- OEH – Coastal Unit and National Parks Service (District offices);
- Environment Protection Authority in relation to licensed discharges to Lake Macquarie;
- Industry and Investment DPI Crown Lands, NSW Roads & Maritime and DPI Fisheries (as necessary);
- Local Land Services in relation to regional objectives and targets and the application of resilience concepts in the coastal landscape;
- Hunter Water Corporation;
- RMS

Council has a number of consultative processes that support a collaborative and inclusive approach to estuary management across State and local government and community stakeholders. The Plan will provide a strategic framework for these stakeholder groups which include

- Lake Macquarie City Council Aquatic Services Committee;
- Lake Macquarie City Council Estuary and Coastal Management Committee;
- Sustainable Neighbourhood initiatives; and
- Local area adaptation planning initiatives.

## 1.5 Knowledge Sources Informing the Plan

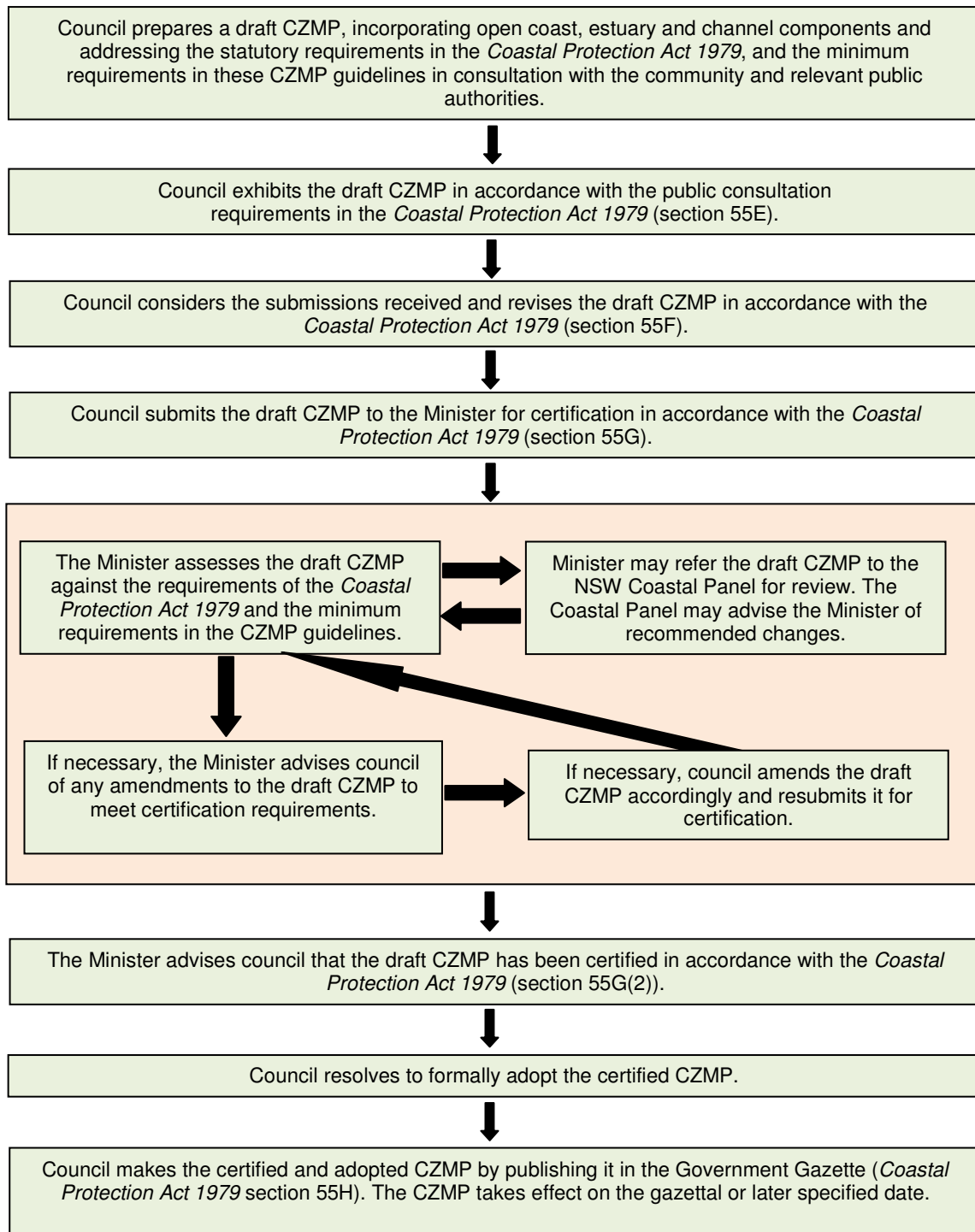
The Estuary part of the CZMP draws on the best available technical and scientific information, together with community knowledge, information about current community attitudes and values and best management practice information. In preparing this part of the CZMP, Council has drawn on a wide range of knowledge sources, including:

- recent scientific and community studies completed by Council, Office of Environment and Heritage (OEH), Department of Primary Industries (DPI) and universities;
- results of community surveys and interviews with stakeholders.
- discussion and recommendations from Council committees;
- statutory and policy requirements of NSW and Australian governments;
- studies and monitoring data collected and reported by State government, Council and industries around the Lake, such as Centennial Mines, Delta Energy, Eraring Energy and Hunter Water;
- reviews of the outcomes of previous management programs, such as the Lake Improvement Project managed by the Office of the Lake Macquarie and Catchment Coordinator; and
- risk assessment and analysis of issues and options.

## 1.6 Certification

The *Coastal Protection Act 1979* provides for certification of CZMPs that have been prepared by local council. A certified CZMP provides protection for Council in relation to certain decisions and also facilitates access to funding for coastal protection works or other community infrastructure. A schematic of the process for the CZMP preparation and certification, based on OEH 2013, is shown in **Figure 1.4**.

**Figure 1.4 – CZMP Preparation and Certification Process**





## 1.7 Funding for Estuary Management Actions

There are several strategies open to Council to provide human and financial resources for implementation of the Plan. Council is already addressing many issues through existing staff responsibilities. Additional options may include the following:

- Fostering of Council partnerships with land holders and community based organisations along the coast and with key NSW agencies such as OEH, Local Land Services (including the former Hunter Central Rivers Catchment Management Authority), Trade & Investment, Catchments & Lands (formerly Crown Lands), Hunter Water Corporation, Eraring/Origin Energy, Centennial Coal and Delta Electricity. **Table 1.5** identifies relevant asset owners in the estuary context.
- Partnerships or sponsorships with private sector businesses;
- Applications for funding through special coastal grant schemes (such as Caring for our Country Coastal Program, Crown Lands programs, RMS programs (Better Boating), OEH programs and Commonwealth emergency response programs). These grant funding programs generally require a dollar for dollar contribution from Council, so Council must have budget allocated to a project to be eligible for a grant.

**Table 1.5 - Assets and Responsible Parties in the Estuary Context**

Asset	Ownership
Lake bed and tidal tributaries up to the deed high water mark	Crown Lands Division
Public boat ramps	Lake Macquarie City Council Private entities
Public jetties	Lake Macquarie City Council
Marinas	Private entities
Licensed moorings	NSW Maritime
Reclaimed land below the deed high water mark	Crown Lands Division
Foreshore parks	Lake Macquarie City Council Crown Lands Division
State Conservation Areas adjoining the lake	NSW Parks & Wildlife
Absolute waterfront residential development	Private
Private residential boat ramps, slipways, jetties, mooring poles	Private
Cycleways / footpaths	Lake Macquarie City Council
Roads	NSW Roads and Maritime Lake Macquarie City Council

### 1.6.1.1 Stormwater levies

Both the NSW government and local councils recognise the impact that poor quality stormwater runoff from urban areas can have on the quality of receiving waters and a stormwater improvement program has been operating in NSW for approximately two decades. Both Wyong Council and Lake Macquarie Council are participants in this program. Effective management of stormwater also contributes to efficient water supply for non-potable uses.

The *Local Government Act 1993* and *Local Government (General) Regulation 2005* allow Councils to levy a stormwater service levy in their communities. The Department of Local

Government (2006) provided guidelines about how the levy could be charged and the purposes to which levy funds could be put.

Councils may levy a stormwater levy at up to \$25 for urban residential land and \$25/350m<sup>2</sup> for urban business land (Department of Local Government, 2006). The purpose of the charge is to allow councils the option to raise additional revenue to cover some or all of the costs of providing new/additional stormwater management services within a catchment, suburb, town or local government area. Councils must not use stormwater levy funds for dealing with stormwater runoff from public land. The levy relates to and must be spent on residential or business land. It does not apply to rural land.

## 2.0 The Natural Systems of Lake Macquarie

### 2.1 The Lake Macquarie catchment

Lake Macquarie has a surface area of approximately 110 square kilometres, with a catchment of approximately 650 square kilometres. The pattern of sub-catchment drainage to Lake Macquarie has several distinctive characteristics which influence the hydrology and water quality of the lake. Important features include:

- The major tributaries of the lake flow to bays along the western shore. These are Dora Creek, Cockle Creek (and its tributaries such as a Cocked Hat Creek), Wyee Creek and Stoney Creek. These catchments typically have very steep headwaters, dropping quickly to extensive reaches close to sea level. These catchments generally exhibit permanent freshwater flows or pools.
- Catchments to the north and east of the lake are smaller than those to the west. They include North and South Creek at Warners Bay, Jewells (primarily in coastal sands) and several short, steep catchments that flow from the high ridge enclosing the south eastern part of the lake. These catchments generally have intermittent flows.
- A low lying area of barrier sand with groundwater fed pools and wetlands enclosing the lake between Blacksmiths and Redhead.

### 2.2 Estuary Foreshore Geomorphology

Lake Macquarie has approximately 170 km of foreshore. The shape of Lake Macquarie, including foreshore features such as rock platforms and gravel or sandy shorelines, is the result of relatively stable sea level and climatic conditions over the past 6,500 years. Over this period, sea level fluctuations on the east coast have been restricted to one to two metres. This is the same order of magnitude as sea level changes that are currently projected for the next century.

The foreshores of the lake comprise:

- Rock (sandstone or conglomerate) based slopes, often with a narrow gravel beach or with rock outcropping in the near shore or as a small shore platform. These are common along the western side of the lake and at Green Point and Eleebana.
- Rock based slopes of lower gradient, underlain by mudstones or claystones. These shorelines may also have a narrow gravel beach. These tend to occur over short stretches within a local embayment. For both types of rock based shoreline, a bio-mantle of wrack, shell and sediment may accumulate over the rock. This mantle accumulates with periods of calm, north east waves and erodes when southerly waves approach the shore.
- Sandy shorelines that are back barrier deposits. These are most common between Belmont and Swansea Channel and at Swansea Flats. Sandy shores are erodible and low lying, low gradient foreshores that may also be subject to extensive shallow inundation.

- Creek delta deposits. These areas, such as the deltas of Cockle Creek, North and South Creeks, Dora Creek, LT Creek and Stony Creek have accumulated over thousands of years. They have low local relief and comprise a mix of sandy and fine particle sizes. Small accumulating deltas also occur within the lake adjacent to storm water outlets with larger subaqueous depositional forms lakeward of creek mouths.
- Creek floodplain deposits form the banks of estuarine tributary creeks. These tend to be fine grained materials, often with significant organic content. Stratification is associated with long term changes to channel position and channel form, over thousands of years. These materials are highly erodible and their relatively high organic content is a direct input to the organic load in the lake.
- Modified shorelines, with sea walls of varying designs (including design life), heights and lengths have been constructed on sections of both public foreshore and on parts of the 40% of the lake shore that is privately owned. These structures, of concrete, rock rubble, timber and other materials are typically backfilled with rubble and soil to form a flat surface for garden or recreational use. The rubble and soil fill behind sea walls is subject to erosion when walls are overtopped.

## 2.2.1 Foreshore Erosion

Foreshore erosion in Lake Macquarie is primarily driven by wind waves allowing wave energy to impact on the shoreline. It is not uncommon for wave heights of over 1 metre to occur in Lake Macquarie, particularly in areas with southern facing shorelines and a large fetch. Additional natural processes affecting foreshore erosion are long shore drift and incoming stream flows.

Foreshore erosion around Lake Macquarie presents a relatively minor risk to assets. Natural erosion processes account for minimal foreshore erosion in Lake Macquarie with a relatively limited number of erosion sites. Instead, it is primarily a result on anthropogenic modifications such as clearing of riparian vegetation, filling of foreshore land, and/or inappropriate stabilisation techniques (e.g. vertical concrete seawalls), which increase the vulnerability of the foreshore to lake processes.

### 2.2.1.1 Foreshore Rehabilitation Works

Council and the former Office of the Lake Macquarie and Catchment Coordinator, have collectively rehabilitated approximately 100 locations scattered around the foreshore of Lake Macquarie (see **Figure 2.1** for examples). The selection of priority foreshores for rehabilitation is based on the following criteria:

- Evidence of active foreshore erosion.
- Presence of a foreshore mini-escarpment limiting movement of seagrass wrack onto the terrestrial environment.
- Presence of seagrass wrack accumulation in the near shore environment. Such accumulation may vary in width and depth, sites of a higher priority will be those with a wider and thicker deposition area.
- Wind fetch and foreshore orientation – those sites exposed to a large wind fetch and having exposure to the prevailing winds (SE / NE) will be of higher priority as they have greater potential for wrack accumulation and wind waves contributing to foreshore erosion.

- Littoral vegetation – foreshore areas void of any native littoral vegetation will be of higher priority than sites with remnant vegetation cover. Lack of littoral vegetation increases the foreshore erosion potential and further development of mini-escarpment.
- Sites of high public usage – such areas may suffer from vegetation loss, soil disturbance, and constant use all contributing to instability of the foreshore environment. These areas may be considered a high priority if, when combined with the above mentioned factors, foreshore erosion is occurring. If such a site is considered a high priority, access areas should be incorporated into the design to facilitate public use of the area.
- Saltmarsh protection – remnant saltmarsh may be found behind eroding foreshores in areas of suitable habitat (low lying, inundated foreshore areas). Such areas should be considered a priority to protect the remnant saltmarsh from disturbance and loss due to foreshore retreat.

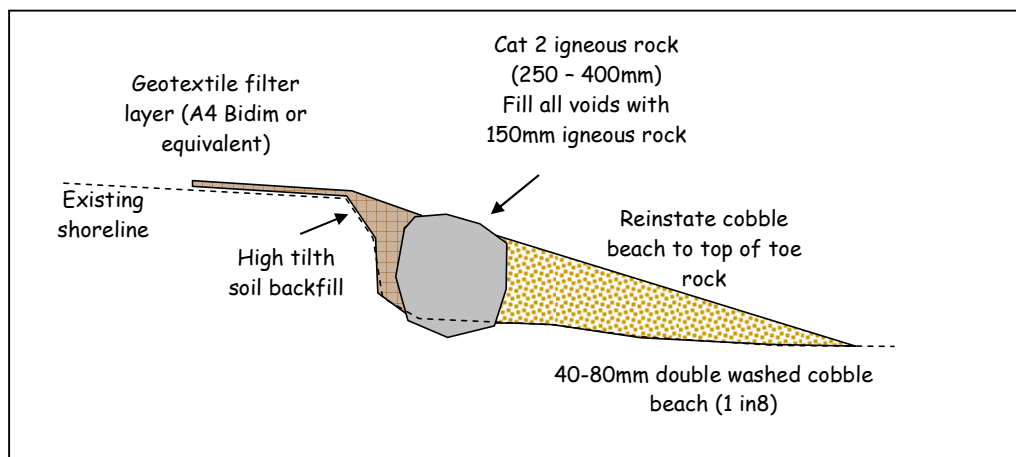
In more recent times, however, site selection for foreshore rehabilitation has been extended to include foreshore areas within sub catchments identified as high risk in terms of water quality.



Figure 2.1 – Location of Foreshore Stabilisation Works 2000-2014

The “cobble beach” rehabilitation technique has been used successfully in many locations throughout Lake Macquarie. In more recent times the standard technique (**Figure 2.2**) has been modified to alleviate the movement of the cobbles from their original placement area. In high energy environments, the movement of cobbles away from the desired area has been the point of failure for these sites. As a result, the placed cobble beach is depleted resulting in recommencement of the erosion process.

To address this displacement, larger cobble material (increase from 40-80mm to 100-150mm) was used to limit displacement by wind waves and members of the public. Although this size did remain where placed, it resulted in the growth of marine organisms on the cobble surface, such as oysters and algae on the cobble. Whilst this provided a stable foreshore environment, it presented a risk to foreshore users. Consequently, high use, high-energy foreshore environments continue to be rehabilitated using the 40-80mm cobbles. However, regular inspections are required to monitor the stability of the foreshore environment.



**Figure 2.2 – Typical foreshore rehabilitation cross section**

### 2.2.1.2 Local Planning Instruments

Council has prepared policy and guidelines for managing the shoreline, including designs that are suitable for different situations. These are formalised in the:

- Lake Macquarie Local Environmental Plan;
- Lake Macquarie Development Control Plan; and
- Lake Macquarie Foreshore Stabilisation and Rehabilitation Guidelines 2004;

Together, these requirements effectively prohibit traditional vertical seawalls on private land, other than in exceptional circumstances

Proposed management options for the next ten years will require a focus on assessing the stability of current treatments under adverse conditions, as well as developing treatment options adaptable to climate change impacts.



## 2.2.2 Bank Stability of Tributary Creeks

The stability of banks of tributary creeks of Lake Macquarie is an important factor that contributes to the maintenance of estuary health. Stability of creek banks is directly related to the degree of disturbance of the riparian zone; in particular, the clearing of riparian vegetation. Clearing results in the destruction of habitat both directly and indirectly, through removing the root systems that bind bank sediments and removal of shade and leaf litter, which are important for the survival of aquatic organisms. Loss of vegetation also removes the natural pollutant-filtering processes, resulting in, for example:

- increased sediment load;
- increased stormwater quantity;
- decreased water quality; and
- erosion and weed invasion.

### 2.2.2.1 Bank Stability Works

Council and the former Office of Lake Macquarie Coordinator have collectively restored around 70 stream-bank locations throughout the local government area since 1999. Council's approach to stream-bank restoration has evolved over the last few years from the application of a fairly standard rock revetment methodology to a more strategic approach involving the construction of bed control structures, mass plantings of locally sourced tube-stock where required and bush regeneration.

Bed control works help to prevent stream bed incision that ultimately results in bank failure and collapse. Concentrating on restoring the bed of a stream provides greater geomorphic stability than simply armouring the bank. This approach saves resources due to the fact that less rock is required and also results in a better environmental outcome in terms of improved water quality and the creation/restoration of aquatic habitat such as pools and riffles. Bed control works are usually augmented by a bush regeneration approach to weed removal and riparian plantings as required. Council has implemented this approach at a number of sites over the last twelve months with some excellent outcomes.

Prioritisation of stream restoration works is based on the following criteria:

- Evidence of active stream bank erosion or stream bed incision;
- Site is located on public land (either Council land or Crown land);
- The creek is identified as draining a high priority catchment (as identified in water quality studies);
- The proposed works must demonstrate not only increased stream-bank resilience but also an environmental/habitat benefit;
- The proposed works will add value to any existing works upstream or downstream; and
- Future maintenance considerations.



**Figure 2.3 - Bed control structure being keyed into bank at Slaty Creek, Holmesville**



**Figure 2.4 – Slaty Creek, post construction**

There is limited published quantitative assessment of the extent of issues related to bank stability in the estuarine tributaries, other than for sub catchments such as LT Creek and Muddy Lake where existing or potential sedimentation and erosion issues have been partly associated with catchment flow from licensed mining activities. The ongoing challenge for creek bank erosion is to better quantify impacts on estuary processes and to evaluate the improvements that have been achieved with protection and stabilisation works installed to date (i.e. the effectiveness of investment).

## 2.3 Estuary Hydrodynamic Processes

The coastal zone environment is dynamic. Estuary processes operate at different time scales, varying from hourly/daily to decades or more. Some processes such as tides vary in predictable ways; while for others, the extent and rate of change is much more uncertain. Long term changes to water levels associated with tides, sea level and storm activity are well documented. There is very clear evidence of past changes to sea level and storminess, over thousands of years. There is also now clear evidence of increasing global and regional sea level over the last century, although the rate of rise is not constant.

Modelling is used to project how changing these water level variables will affect hazards such as future inundation of low lying foreshore lands. There is significant uncertainty associated with exactly how and when changes to estuary processes will increase the risks associated with hazards such as inundation. This is because the actual water level results from the interaction and addition of several different water level drivers, which may not consistently coincide.

Estuary hydrodynamic processes in Lake Macquarie include:

- Tides and tidal circulation, in particular near Swansea Chanel, the lake's only connection to the ocean. The tidal range of the main body of Lake Macquarie is small, with a maximum tidal range of around 30cm;
- Wind waves and wind-driven circulation. This is the major component of physical water movement in Lake Macquarie;
- Catchment flows from rainfall events, entering the lake from small (short, often steep) sub-catchments and stormwater systems, as well as major creek systems including Dora Creek, Cockle Creek, Wyee Creek and Stony Creek. These creeks deliver approximately two thirds of the annual flows into the lake. After major rainfall events, fresh water discharges can be seen moving across the lake from sub-catchments such as Cockle Creek and Stony Creek/LT Creek, towards the entrance channel; and
- Other drivers of water level variability, such as low pressure systems and storm surge.

In Lake Macquarie, estuary hydrodynamic processes are also influenced by the intake and discharge of cooling water for power stations. For instance, the Eraring Power Station cooling water system drives water circulation in the central section of the lake, at a daily inflow rate equivalent to a 1 in 40 year ARI rainfall event. Cooling water discharges from Eraring Power Station also increase the temperature of lake waters in the lake embayments surrounding the power station by 2 °C above ambient lake temperature. In addition, some coal mines in the catchment of Lake Macquarie are licensed to discharge mine water (after meeting specified water quality objectives) at the surface, which then flows to the lake.

Interactions between these hydrodynamic processes affect:

- Water level and water quality in the lake;
- The extent of inundation hazard and foreshore erosion hazard around the lake, depending on shorelines of different gradients and materials. For example, some very low lying areas of the lake, such as parts of Swansea, are affected by tidal incursions into the stormwater system now; and
- Rates of sedimentation and the re-suspension of unconsolidated sediments from the beds of tributary creeks and the bed of the lake.

Detailed studies of lake tidal processes, water circulation, water quality and catchment flows have been completed for various management plans and development assessment projects around the lake, over a period of 30 years.

Council has completed a comprehensive flood study for Lake Macquarie and its tributaries (WMA Water, 2012a), which considers the interactions of all processes affecting water level in the lake and the potential for inundation of foreshores during major storm and runoff events. The flood study also models and evaluates the ways in which inundation of foreshore areas, including public open space and private residential land, would be affected by the long term rise in sea level that is projected by Australian and international scientists.

## 2.4 Estuary Inundation

Council has conducted detailed flood hazard and flood risk studies and prepared a flood risk management plan (WMA Water, 2012b) for areas affected by estuary inundation. The flood Risk Management Plan identifies properties and landscapes affected now and with potential to be affected in the future by lake based flooding. Council has adopted the management responses outlined in the Plan.

A brief summary of the background and management responses from the Flood Risk Management Plan is provided here. The CZMP does not include additional actions in relation to inundation.

### 2.4.1 Water Levels

The highest recorded lake water level is 1.25 mAHD in 1949 (at Marks Point), followed by 1.05 mAHD reached in the June 2007 long weekend storm/flood event and 1.00 mAHD in February 1990. The June 2007 long weekend storm/flood event, and the February 1990 flood event were of the order of a 30 year Average Recurrence Interval (ARI) design event. (WMA Water, 2012b).

The 30 year recurrence interval of these events means that the Lake Macquarie community has not experienced a real 'extreme' flood event (equivalent to a 100 year recurrence interval, for instance) in the last century or more. A flood event of this magnitude is modelled as producing a water level of 1.5 m AHD (excluding wave runup) (WMA Water, 2012).

## 2.4.2 Areas Currently Affected by Tidal Inundation or High Water Levels Driven by Storms and Heavy Rainfall

The Lake Macquarie Waterway Flood Risk Management Plan (WMA Water, 2012) was based on studies and modelling of flood hazard and flood risk around the entire Lake Macquarie foreshore and along tributary estuarine waterways. The study area included land up to 4m elevation AHD.

Areas affected by lake flooding occur around the entire foreshore. Consistent with the NSW Floodplain Development Manual, the Plan describes risk management measures relating to flood modification, property modification and response modification. There are multiple possible options within each of these strategic measures. Council has commenced the implementation of the Plan and in particular has commenced consultation with the most vulnerable communities about local-community specific packages of measures which they would implement over time to adapt to changing flood risk. Other actions include strategies to manage inundation impacts on stormwater and sewerage systems (note, sewerage is the responsibility of Hunter Water Corporation) roads, public access infrastructure, cycleways, footpaths, and foreshore protection structures. Council has prepared a Stormwater Asset Risk Management Plan.

Given that issues of inundation and flood risk are managed by Council through a separate funding and administrative program, the Estuary part of the CZMP does not address this issue in any further detail, nor make any recommendations in respect of flood risk management. Notwithstanding, integration between the two programs (i.e. flood management and estuary management) is achieved through acknowledgement of the need to align management actions and objectives in both programs to identify and manage potential conflicts.

Full details of the flood study and plan, including maps showing the 2m and 4m contours and floor levels of development within the study area, are available on the Council web site. Refer to **Appendix A** for a lake scale map of the following:

- Current 1:100 year flood envelope (1.5 metres AHD)
- 1:100 year flood envelope + 0.4 metre sea level rise (1.86 metres AHD)
- 1:100 year flood envelope +0.9 metre sea level rise (2.32 metres AHD)
- 1.0 m AHD (permanent inundation with 0.9 metre sea level rise)

## 2.5 Water Quality

Water quality in Lake Macquarie has improved significantly since the 1980s following significant investment in ecological health by local and state government. Expansion of reticulated sewerage, stormwater management, foreshore stabilisation and sediment control measures have systematically improved the ecological function of the lake environment, primarily by controlling the delivery of excess nutrient loads. In addition, bush regeneration and the stabilisation of potentially erodible surfaces have assisted in improving water clarity within Lake Macquarie.

Council's State of the Environment Report 2013/2014 reports that Secchi depth, which is an indicator of water clarity, improved by 110% between 2000/2001 and 2013/2014. Mean



Secchi depth improved from 1.64m to 3.66m. Water clarity improvements were achieved even with relatively high rainfall.

Despite significant achievements, water quality in Lake Macquarie is a source of continuing concern for the local community. The lake body generally has low nutrient and algal concentrations, good water clarity and excellent dissolved oxygen levels, indicating generally good condition. However, there are several poor water quality hot spots in the lake and its tributaries. These localities are affected by high (or increasing) sediment loads, well above natural nutrient loads. The same areas may also be affected by biological pollutants or other contaminants. Around 80% of pollutants entering Lake Macquarie arrive in runoff from non-point sources, such as urban stormwater.

### 2.5.1 Lake Water Quality

The impact of catchment runoff on the ecological health of the lake depends on both the load of sediments and nutrients and the capacity of the receiving embayment to assimilate that load. In particular:

- The large upper catchments contribute the majority of total nutrient load into the lake because of their relative size, even though many are well vegetated.

Some catchments continue to be significant sources of suspended fine sediments which reduce water clarity. Studies undertaken by OEH (used to calibrate the OEH water quality model) identified high Total Suspended Solids (TSS) in discharges from Cocked Hat Creek, Cockle Creek, Secret Bay and Dora Creek (**Figure 2.5**).

- Dissolved inorganic nitrogen (DIN), which is linked with excessive algal growth and poor water quality has been found to be elevated in the stormwater from relatively urbanised areas in the north of the lake catchment such as the catchments of North Creek, Winding Creek, Cocked Hat Creek and Cockle Creek (**Figure 2.6**).
- Some sub-catchments discharge nutrient loads disproportionate to their area, highlighted as the areas in the red to yellow range in **Figure 2.7**.
- Areas with slow tidal exchange or flushing are more sensitive to catchment inputs than open and well flushed parts of the lake. The sensitive receiving waters tend to be poorly flushed nearshore areas (e.g. around stormwater outlets where sediment shoaling can reduce wave action) and protected bays with restricted water circulation, particularly in the southern and western parts of the lake (**Figures 2.8 & 2.9**).
- The combination of elevated load and poor circulation is conducive to formation of algal blooms and the production of black ooze.
- A large proportion of the Lake Macquarie shoreline is highly developed for residential use, with approximately 40% (70 km) comprising absolute waterfront residential development. Foreshore modification associated with urban development includes construction of sea walls, mowing, removal of trees, construction of jetties and ramps, creation of sandy or pebbly beaches (over seagrass beds) and construction of stormwater outlets. In combination, these measures change the capacity of nearshore habits to process nutrients and organic matter and also constrain the ability of the nearshore and foreshore habitats to respond to predicted longer term changes such as sea level rise.

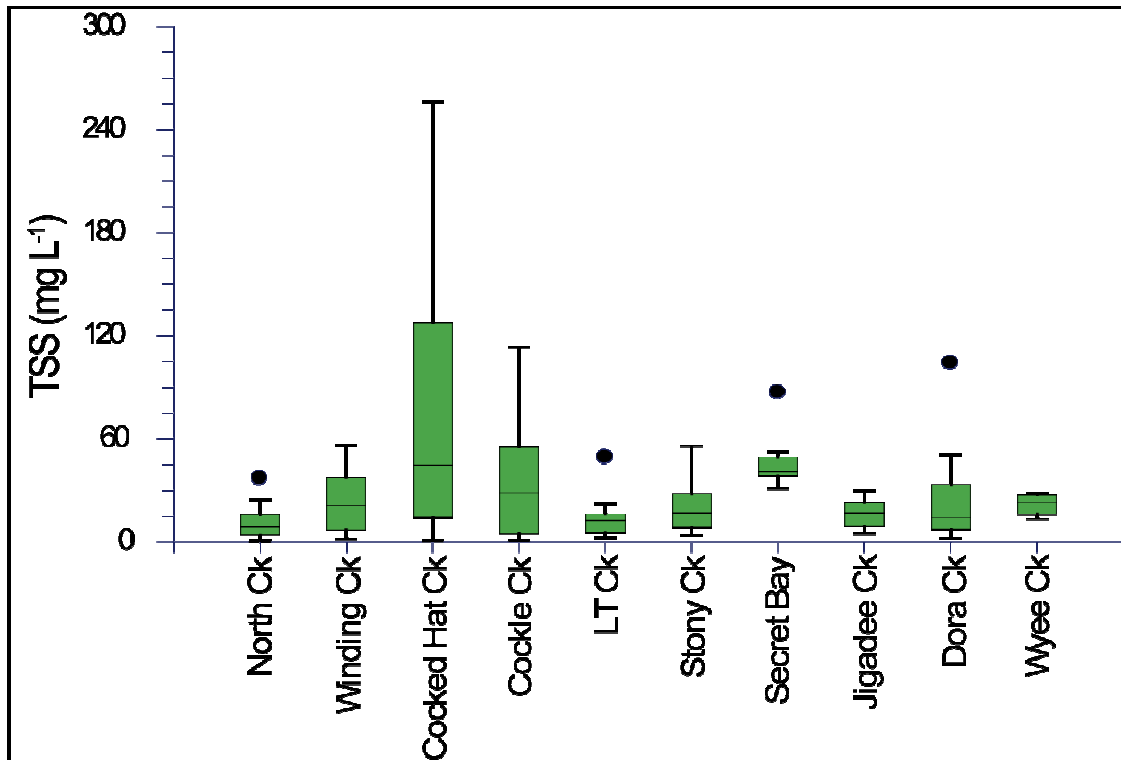


Figure 2.5– Total Suspended Solids (TSS) in major creeks discharging into Lake Macquarie

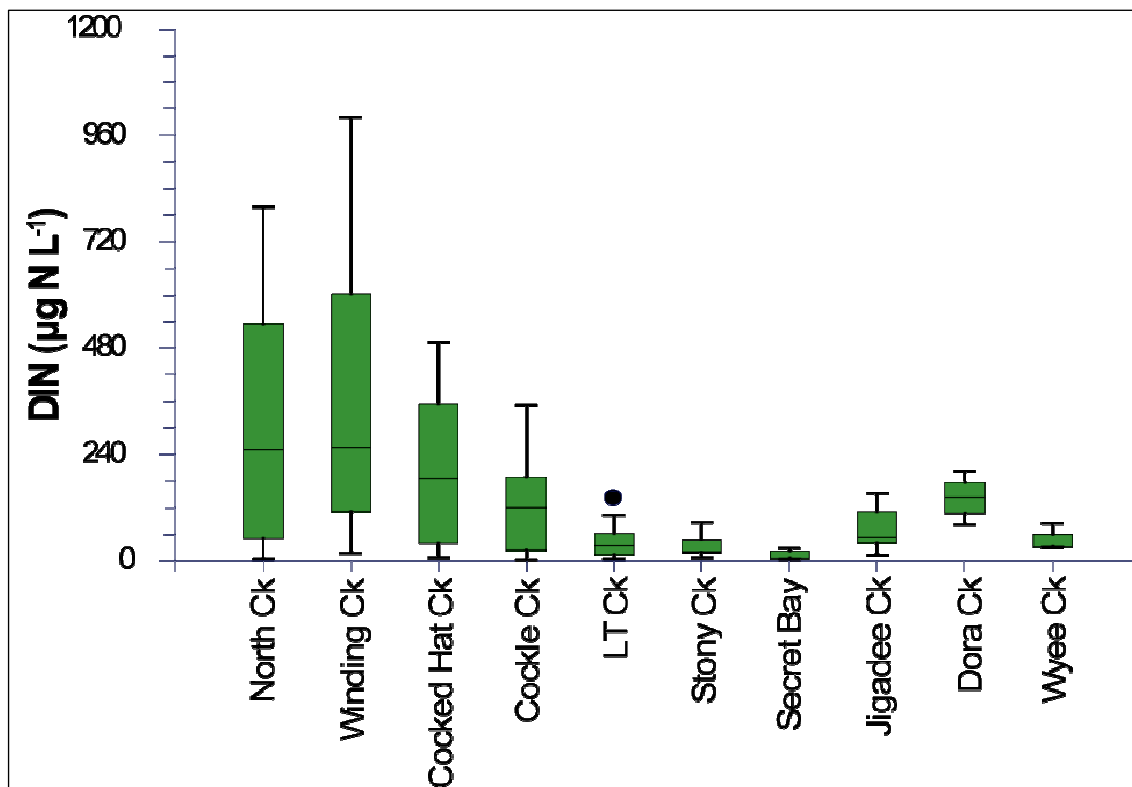


Figure 2.6 – Dissolved Inorganic Nitrogen (DIN) in major creeks discharging into Lake Macquarie

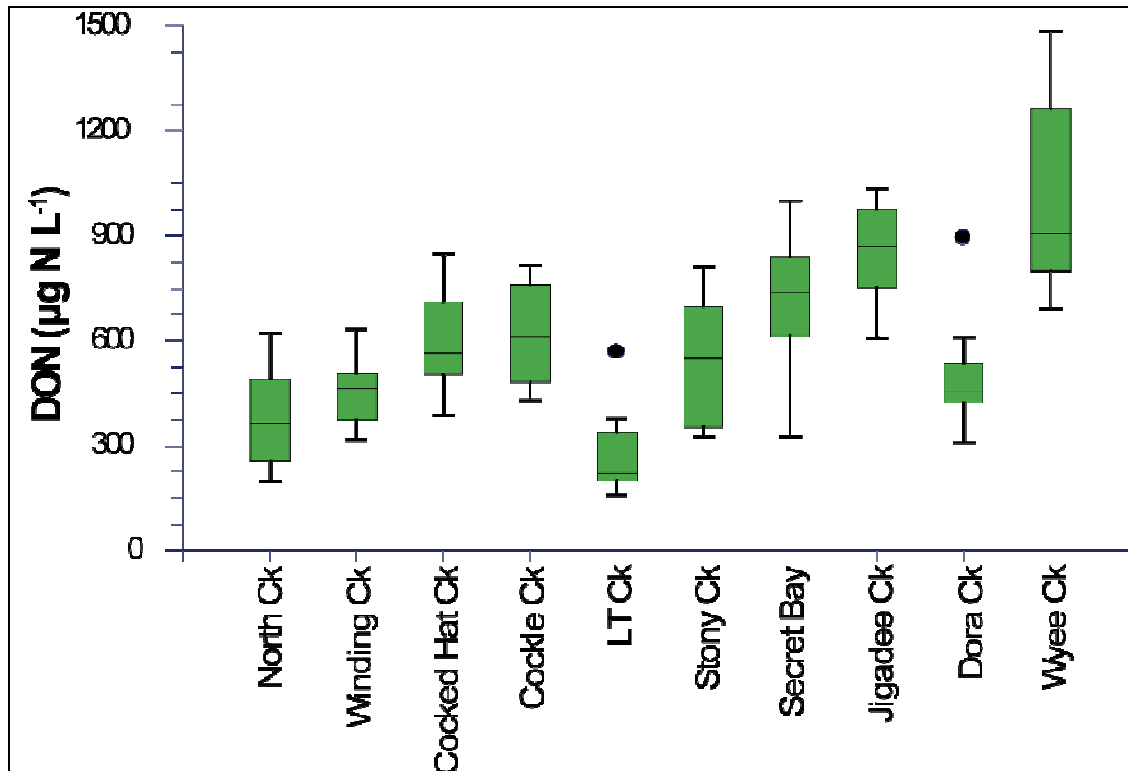


Figure 2.7 – Nutrient loads as Dissolved Organic Nitrogen (DON) in major creeks discharging into Lake Macquarie

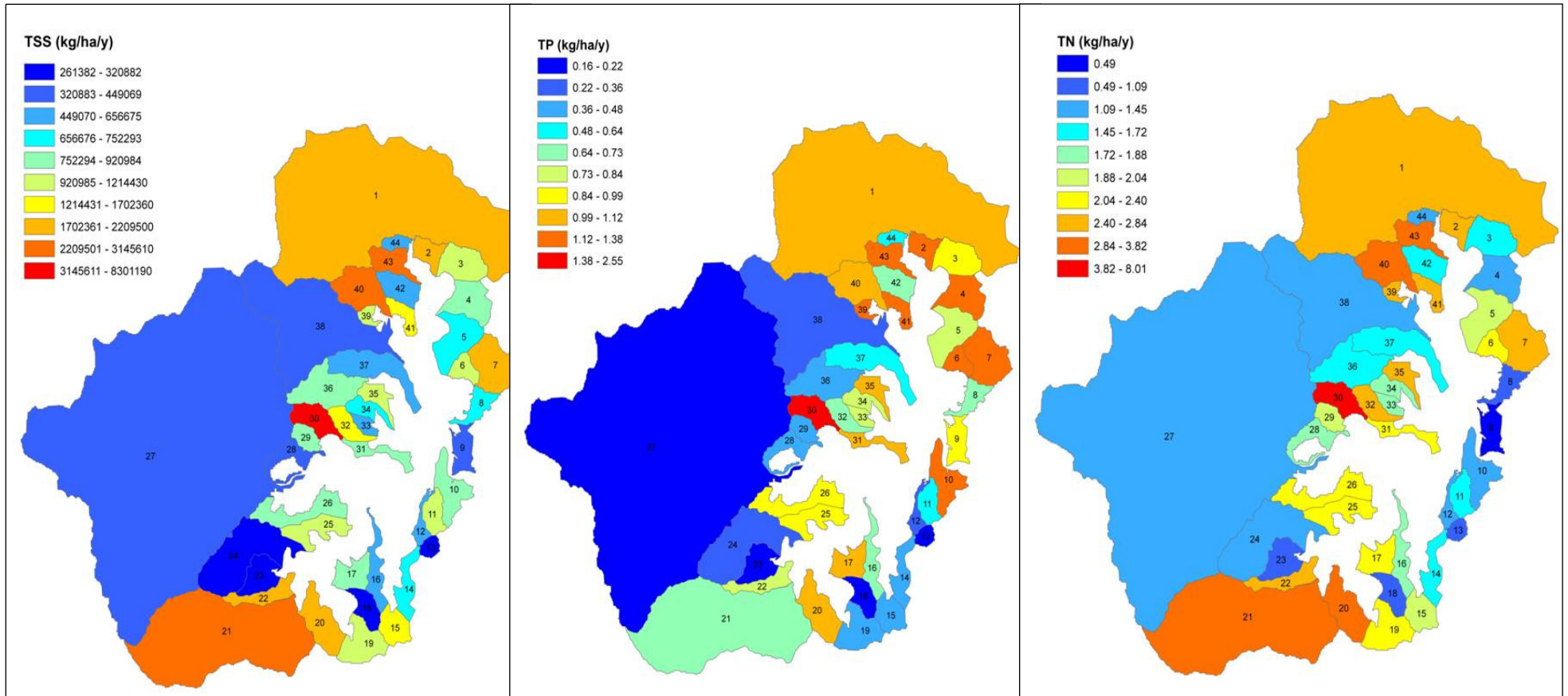
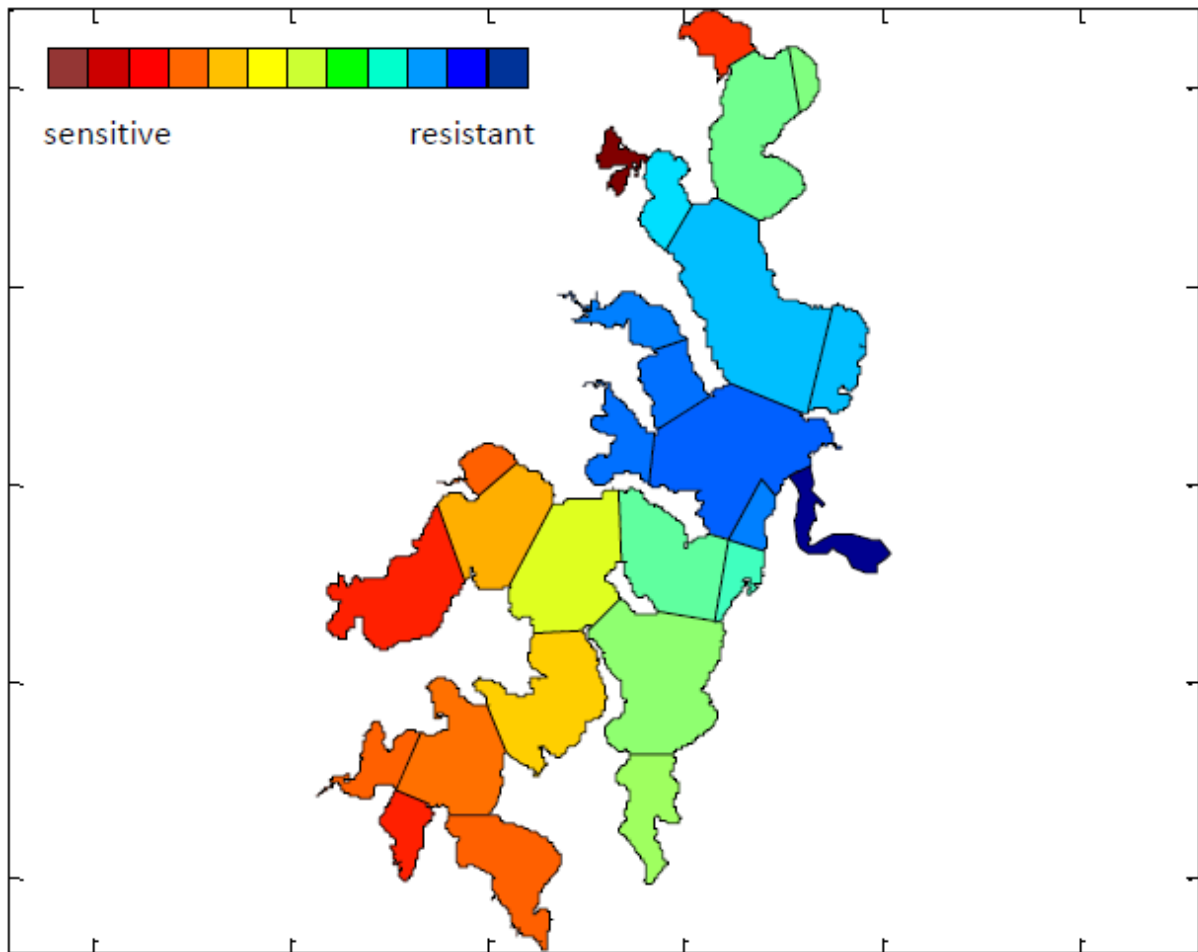


Figure 2.8 – Outputs from modelling runoff scenarios with respect to Total Suspended Solids (TSS), Total Phosphorous (TP) and Total Nitrogen (TN). The sub-catchments coloured yellow through to red deliver relatively high nutrient loads to the lake



**Figure 2.9 – Long term sensitivity of different zones around the lake to the combined impacts of TSS, bio-available nitrogen and organic enrichment from catchment sources.**

## 2.5.2 Water Quality in Lake Tributaries

Council conducts a water quality monitoring program in seven creeks in the lake catchment. Results are summarised in **Table 2.1**. The results are poor and there is no trend towards improving tributary health. The results highlight the importance of continuing focus on catchment water quality to protect the health of Lake Macquarie, although water quality in the lake is better than in any of these disturbed catchment tributaries.

**Table 2.1 – Water quality in tributary creeks**

Creek	Most recent result	Trend
Cocked Hat Creek (Edgeworth), part of Cockle Creek catchment	Poor – low taxa richness, poor stream quality rating, water quality assessed as unacceptable; riparian zone fair.	‘Unacceptable’ overall rating in 2011 and 2012, improving to ‘poor’ in 2013



Creek	Most recent result	Trend
Jigadee Creek (Cooranbong), part of Dora Creek catchment	Fair – taxa richness high, stream quality rating good; water quality poor; riparian assessment fair.	Overall assessment in 2011 was 'good', declining to 'fair' in 2012 and 2013.
North Creek (Warners Bay)	Unacceptable - Taxa richness low; stream quality poor; water quality unacceptable; riparian assessment fair	Overall assessment has declined from 'fair' in 2011, to 'poor' in 2012 and 'unacceptable' in 2013.
Slatey Creek (Barnsley), part of Cockle Creek catchment	Poor – taxa richness high; stream quality rating poor; water quality very good; riparian assessment fair	Overall assessment 'poor' in 2011, 'fair' in 2012 and 'poor' in 2013.
Winding Creek (Cardiff South), part of Cockle Creek Catchment	Poor – taxa richness high; stream quality rating poor; water quality fair; riparian assessment fair	Overall assessment 'fair' in 2011, declining to 'poor' in 2012 and 2013.

Factors contributing to the vulnerability of creek water quality include:

- They are the direct receiving waters from urban runoff and often have poor flushing (very slow tidal circulation and long residence times of runoff from minor events). Where high sediment loads are delivered to estuarine creeks, sediment (both coarse and fine) accumulates in the bed and around stormwater outlets. In creeks that are used for navigation, there may be pressure to dredge bed sediments. Council does not generally support dredging around stormwater outlets unless the function of infrastructure assets is impaired.
- Some receive runoff from intensive agricultural land uses and/or small commercial/industrial premises.
- Some receive some overflows from the sewage reticulation system (or septic tanks) and have poor flushing.
- In developed areas (e.g. LT Creek, North Creek, South Creek, parts of Dora Creek, Stony Creek) pollutants from suburban gardens flow directly to the waterway, and accumulate until the next major rainfall event.
- Several of the creeks have partially urbanised and partly bushland catchments, with multiple tracks and trails which contribute sediment load directly to the waterway.
- They may be affected by bank erosion, which adds sediment, organic load and nutrients to the waterway. In urban areas, riparian vegetation is depauperate.

- Parts of the bed and estuarine floodplain deposits of Lake Macquarie tributaries are affected by acid sulfate sediment and soil materials. When these materials are exposed to the air and oxidise, acid runoff is generated. The water quality of tributary estuarine creeks is more likely to be affected by acid discharges than the main body of the lake, which has better mixing and dilution characteristics. Previous examples of acid discharges in estuarine tributaries of Lake Macquarie include flows from disturbed soil on the floodplain of Dora Creek. Acid runoff to estuarine creeks, producing low pH waters, affects the health and diversity of ecological communities.

### 2.5.2.1 Stormwater Quality Improvement Devices

Stormwater Quality Improvement Devices (SQIDs) assist to manage stormwater quality and quantity from development. SQIDs function by detaining, retaining, harvesting, screening, filtering, infiltrating and/or biologically treating stormwater runoff to reduce the concentrations and loads of pollutants discharged to the receiving environments. Council currently maintains approximately 700 SQIDs through the local government area with a number of other SQIDs also maintained by owner's corporations, community associations or individual property owners. Whilst performance and maintenance of un-vegetated SQIDs is relatively simple to quantify, this is not the case for vegetated devices.

Preliminary results of SQID performance, prepared by the NSW Office of Environment and Heritage, indicate that water quality in devices is highly variable, depending on rainfall and catchment characteristics. However, comparisons of performance between a vegetated basin (Macquarie Hills), an unvegetated basin (Cameron Park) and a basin that is overgrown with excess vegetation (Croudace Bay) suggest that the quality/quantity of vegetation within a device significantly impacts performance, especially with regard to oxides of Nitrogen (NOx), through the process of denitrification (note: Nitrogen concentrations are considered to be the main factor limiting algal growth in estuarine environments such as Lake Macquarie).

The Flow Weighted Mean Concentration (FWMC) removal efficiencies of these devices for NOx measured to date are detailed in **Table 2.2**.

**Table 2.2 - Comparison of Flow Weighted Mean Concentration efficiencies of SQIDS based on vegetation condition**

Device	Condition	Removal Efficiency (FWMC for NOx)
WET 1 – Cameron Park	Unvegetated Basin	8%
WET 2 – Macquarie Hills	Vegetated with appropriate species in good condition	71.3%
WET5 – Croudace Bay	Overgrown with excess vegetation (Typha)	0.2%

While additional data is required, these preliminary results from three sites show that for oxides of Nitrogen, SQIDs with vegetation in good condition perform far better than either unvegetated SQIDs or SQIDs that have been poorly maintained and are overgrown with excessive vegetation (such as Croudace Bay). Further research is required to determine maintenance regimes that protect the pollutant removal efficiencies of vegetated devices, particularly in light of the significant financial investment required to establish these structures.

### 2.5.2.2 Local Planning Controls – Water Quality

Council has in place a range of planning controls and guidelines for new development, to ensure water quality objectives are achieved.

- Development Control Plan No. 1
- Handbook of Drainage Design Criteria (2014, updating an earlier 2008 version)
- Water Cycle Management Guidelines (2014)
- Stormwater Quality Improvement Device Guidelines (2014)
- Erosion and sediment control factsheets

### 2.5.3 Flows from Mining Sites

Historically, parts of Lake Macquarie and its tributary creeks have been affected by discharges from mine sites, including surface runoff from pit top areas, haul roads and old open cut workings; and groundwater pumped from underground workings.

The amount of water accumulating in old and continuing mine workings is affected by depth of cover, geology and the type of workings. Licensed daily discharges from underground workings are in the range 7ML to 15ML per day per mine. These discharges will continue for the life of the mines and several decades beyond. Details about specific licence conditions are available on the EPA web site.

Most mines also have surface water management systems and are licensed to discharge specified volumes and water quality from the surface systems to receiving waters (Lake Macquarie or its tributaries).

Runoff and discharges of underground mine water convey low levels of contaminants such as heavy metals into Lake Macquarie and associated wetlands. For most underground mines, the largest inflow is from groundwater in the coal seams and much of this is transferred to licensed surface water discharges by the mine water management system. Licence and consent conditions require mines to monitor heavy metals in water discharged from mine sites (e.g. from Newstan, Mannering and Cooranbong/Mandalong Collieries). In many cases, mine water discharges have been occurring for decades, so that the existing ecological communities of the receiving waters/drainage systems reflect the flow volume and water quality (e.g. salinity) of the long term discharges. As production at underground mines is phased out or ceases over time, some discharges will also be significantly reduced, with potential impacts on the adapted ecology of receiving waters.

Because of the magnitude of discharge and the potential impacts on lake health, mining operators are required to conduct a range of studies and management procedures to mitigate known/legacy issues and potential future issues. These issues and studies include:

- the potential for underground mine water resources to be used within the broader lower Hunter water network, for specific applications that do not require potable quality water;
- studies of the levels of pollutants in catchment runoff, such as heavy metals, which may be derived from geological units in the catchment or from one of several land uses;
- groundwater quality studies;

- geomorphic studies of the scouring potential of discharges and of channel stability and sedimentology downstream of discharge points;
- impacts of subsidence on channel form and stability and also on lake bed levels (e.g. in relation to seagrass beds); and
- rehabilitation of previously disturbed catchments and drainage lines, to restore natural fluvial systems, sediment load and reduce contamination levels where relevant.

These studies and controls, which are developed by the EPA and licensed operations, will continue into the future. There is opportunity to enhance the integration of environmental data collected in mine monitoring programs into the broader data set for the Lake Macquarie estuary – both in terms of water quality and lake hydrology.

## 2.5.4 Contaminated Sediments

Sediments in the bed of Lake Macquarie have historically been contaminated by discharges from the Pasmenco smelter (now closed for ten years and site remediation is close to completion), power stations, coal mines and sewage treatment plants. There is also potentially a low level of metal concentration coming from the catchment, from exposed coal measures and potentially from transport infrastructure.

The greatest contamination of heavy metals in sediments has been found in the north of the Lake. Cockle Bay has recorded concentrations of metals with highest likelihood of causing adverse effects on sediment associated biota. Comparisons with historical sediment quality data indicate that there has been a marked reduction in surface metal concentrations throughout the lake over the past 20 years or more.

Research has shown that Selenium contamination has been occurring for a long period in Lake Macquarie (Peters *et al.*, 1999; Roach 2005). In anoxic sediments, Selenium is immobile but becomes mobile and available when the redox status of the sediment is altered through aeration by benthic macroinvertebrates, bacterial action or sediment movement. Once mobilised, Selenium accumulates within the tissues of animals and concentrated up the food chain through bioaccumulation. Whether Selenium mobilisation into the food chains causes any lasting effects to fish and avifauna still remains unclear.

Overall, metal and Selenium contamination in Lake Macquarie are issues that require an ongoing watching brief and tracking to confirm that the trend towards lower levels is continuing. If an increase in concentrations of heavy metal contamination in surface sediments is detected, detailed investigation of potential sources would be required. The primary source of contamination has been removed with the closure of Pasmenco and remediation of the Pasmenco site.

## 2.6 Ecological Health and Resilience

### 2.6.1 The Diversity and Condition of Ecological Communities of Lake Macquarie

The physical form and processes in Lake Macquarie provide the context for significant estuarine habitats and ecological communities which contribute to estuary functions and the health of the lake. Together, these ecological communities provide a range of 'ecosystem services' which support water quality suitable for human recreation and also a productive recreational fishery.

Annual report cards for Lake Macquarie have been developed using a number of indicators such as seagrass coverage, macroalgae biomass, chlorophyll-a, orthophosphate and turbidity. Results for these indicators in recent years suggest that most of the lake is in good condition and that ecological communities are behaving resiliently, given current levels of nutrient inputs. The Lake Macquarie report cards show that:

- Chlorophyll-a (an indicator of phytoplankton or microalgae in the water column) has shown a decrease over the last 15 years;
- seagrass coverage increased by 41 % between the years 2000-2006 based on annual monitoring; and
- macroalgae abundance has decreased by 77 %.

Consistent with the characteristics of a healthy estuary, seagrass and benthic microalgae (BMA) are the main primary producers within Lake Macquarie. In general, healthier estuary systems have seagrass and benthic microalgae, and display a lower abundance of macroalgae and phytoplankton.

Although the majority of the lake is too deep for BMA or seagrass growth due to limitation of light penetration; the BMA and seagrass populations in the shallow waters are a major sink for dissolved nutrients that are delivered to the lake from the catchment.

## 2.6.2 Seagrass

- There is approximately 15.3 km<sup>2</sup> coverage of seagrass in Lake Macquarie. This is the third largest area of seagrass in NSW.
- Lake Macquarie supports a variety of seagrass species. The most abundant and widely distributed seagrass in the lake is *Zostera capricorni*, though the lake also contains significant beds of the threatened seagrass species, *Posidonia australis*. Other species found in the lake include *Halophila ovalis* and *Ruppia megacarpa*.
- *Zostera capricorni* is highly variable in distribution and persistence within the lake. The nature of the variability is not clearly understood, though is likely to be linked to factors such as seasonality, mechanical disturbance and water clarity.
- Seagrass is the main source of primary production for the foodweb within the lake and is also the focus of recycling of organic matter and nutrients by invertebrate species.



- Seagrass beds stabilise the sediments in nearshore areas and can filter nutrients from the water thereby improving water quality.
- Shallow areas of the lake contain significant seagrass beds including threatened populations of *Posidonia australis*.
- Seagrass health is generally good in Lake Macquarie, however, its distribution is threatened in a number of locations, where water clarity is low and urbanisation inputs are relatively high compared to other areas. Generally, these areas are the poorly flushed inlets and bays of the Lake Macquarie system.

Threats to seagrass habitat within the nearshore environment of the lake includes pressures from recreational boating (traditional swing moorings, boat scour, shading by jetties and sediment resuspension from props), urbanisation (eutrophication, sediment loads) and industry (thermal pollution, eutrophication).

Swing moorings over *Posidonia australis* beds are a particular concern because:

- Populations of *Posidonia australis* in Lake Macquarie have suffered such a large reduction in abundance and spatial distribution, that they have been listed as 'endangered populations' under the threatened species schedules of the NSW Fisheries Management Act 1994 (DPI, 2012).
- The largest area of *Posidonia australis* in Lake Macquarie is in Belmont Bay, coinciding with one of the most popular mooring areas.
- *Posidonia australis* disturbed by swing moorings takes many years to recover from disturbance, if in fact at all.

Traditional block and tackle or swing moorings are detrimental to seagrass distribution and condition as the chain dragging on the sea floor physically rips out the seagrass and hinders regrowth in these areas. The cleared areas appear as very distinct bare circles in seagrass beds in aerial imagery (**Figure 2.10**).





**Figure 2.10 – Aerial image showing scouring of *Posidonia australis* beds in Belmont Bay as a result of traditional block and tackle or swing moorings. Source: Wright *et al.*, (2013)**

### 2.6.3 Wetlands

- There are more than 50 major natural wetland areas in the Lake Macquarie region, occupying some 2240 hectares (see **Figure 2.11**).
- Wetlands provide important ecosystem services including acting as a natural filter for water runoff. They actively trap sediment and decrease nutrients and pollutants from entering the main lake body.
- Wetlands are amongst the most threatened ecosystems in Lake Macquarie. Over 90% of wetland habitats have been cleared or filled. Around 35% of Lake Macquarie’s wetlands are reported to have been lost between 1983 and 2004, while 70% have been reduced in size and continue to diminish in size. Given the range of ecosystem services provided by healthy wetlands, these rates of decline mean that a response which stabilises habitat value and ecosystem service value is urgent.



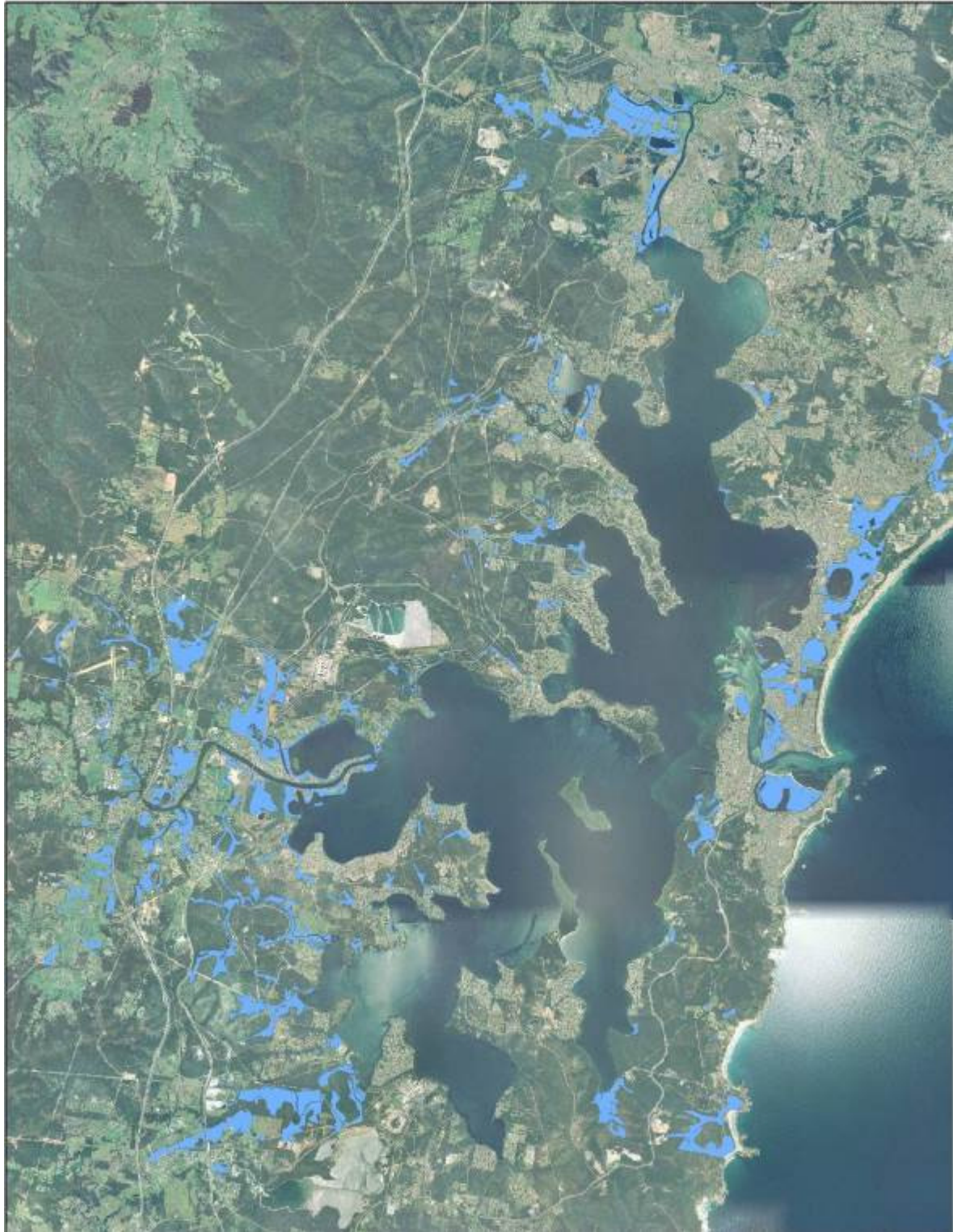
- Key threatening processes affecting wetlands include clearing of native vegetation, invasive plant species such as perennial grasses and alteration of natural flow regimes. However, they are also threatened by a wide range of practices such as fire regimes, polluted runoff, rubbish dumping, overgrazing and flood mitigation works.

- Wetlands are protected under multiple pieces of legislation and policy, including State Environmental Planning Policy 14, State Environmental Planning Policy 71 (both policies under the Environmental Planning and Assessment Act, which is currently undergoing a major review), *Threatened Species Conservation Act 1995* (endangered ecological communities), *Fisheries Management Act 1994* and the *Coastal Protection Act 1979*.

In 2010, Council engaged EcoLogical Australia to undertake a study to assess the potential impacts of climate change on wetlands in the LGA. The results of the sea level rise analysis indicated that approximately 680 ha or 28% of the current extent of low-lying wetlands will be inundated with 90 cm sea level rise. However, the impact of sea level rise differs greatly between wetland types. The most low-lying, saline wetlands (mangroves and saltmarshes) will be the most severely affected, while wetlands that occur predominantly at higher elevations, such as Lepironia Swamps and Paperbark dominated communities, will experience very little saltwater inundation. Spatially, the areas to experience the most significant inundation of wetlands are Dora Creek, Cockle Creek, the eastern coastal areas around Swansea and the lake's foreshore fringes.

The study recommended that management be focused on vulnerable wetlands, that provide habitat for threatened, migratory and juvenile species, and wetland complexes rather than small wetland patches containing only one type of vegetation. Larger areas of wetland that include a variety of wetland vegetation types in a connected patch or corridor are more likely to be resilient to climate change impacts. Examples of such areas include Cockle Creek and its floodplain and the coastal dune system at Belmont, including Jewells Swamp. Additionally, wetlands containing *Eucalyptus robusta* and *Melaleuca quinquenervia*, along with estuarine systems provide very important habitats for a number of threatened and migratory species.





**Figure 2.11 – Extent of all Wetland Types in Lake Macquarie LGA < 10m AHD**

### **2.6.3.1 Wetland Rehabilitation Works**

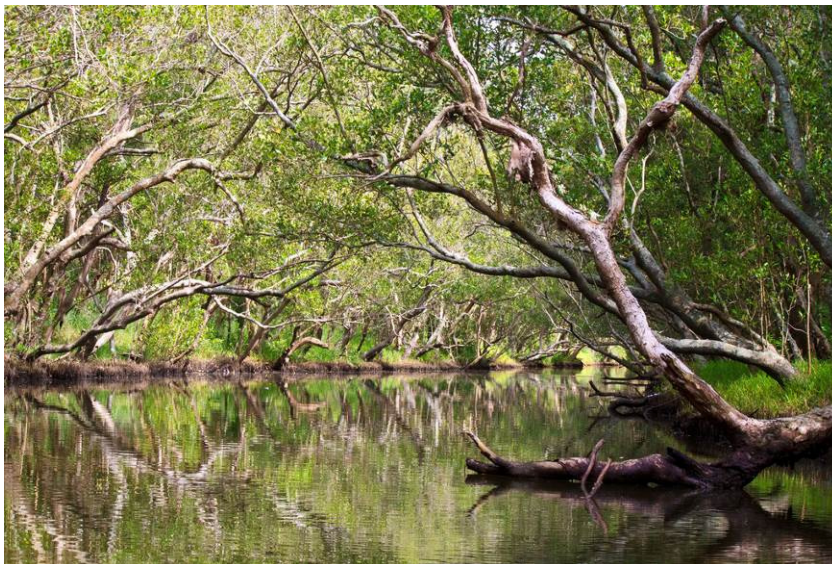
Previous wetland rehabilitation projects in the Lake Macquarie area (see **Table 2.3**) have consisted of weeding, planting and bush regeneration, along with rubbish removal, fencing and signage. Whilst these activities can improve the condition and protect important wetland areas, ongoing maintenance and monitoring is necessary to ensure these improvements are sustained.

**Table 2.3 – Wetland Rehabilitation Project Sites**

Year commenced	Site
2004	Pelican Flat
2004	Letchworth Parade Secret Bay
2004	LT Creek, Fennell Bay
2004	Edmunds Bay, Fennell Bay
2005	Belmont Lagoon
2005	Toronto Wetland
2005	Bonnells Bay Wetland
2007	Pelican Flat
2008	Whiteheads Lagoon
2010	Soldiers Road Pelican
2010	Marmong Wetland
2010	Secret Bay, Balmoral
2011	Lake Petite
2011	Belmont Lagoon
2011	Bonnells Bay
2011	Fennell Bay
2011	Dora Creek
2011	Blackalls Park
2011	Booragul

## 2.6.4 Mangroves and Saltmarsh

- Mangroves are present in various locations around Lake Macquarie with an estimated area of 1.14 km<sup>2</sup>.



- Saltmarsh has been lost around the lake due to development. Estimated coverage is 0.75 km<sup>2</sup>.
- Saltmarsh is an Endangered Ecological Community that is important to the ecology of the estuary in maintaining foodwebs, providing nursery areas for fish and prawns and important habitat for shorebirds.
- Saltmarsh communities were once common along the shores of Lake Macquarie, however, there has been an estimated 60–80% loss since commencement of land development in the 1800s (LMCC, 2009a).
- The distribution of saltmarsh is highly restricted around Lake Macquarie with the most extensive stands occurring at the lake ends of Cockle and Dora Creeks, on Coon Island, in Mannering Bay, Swansea Channel and Black Ned's Bay. Other smaller remnant areas can be found adjacent to urban developments. Losses have been significant since the 1960s and saltmarsh distribution is still threatened by development, encroachment by mangroves and lack of retreat area from sea level rise.

A number of areas around Lake Macquarie still support remnants of coastal saltmarsh communities; however, many of these areas are subject to mowing, slashing, damage from vehicles, weeds and other threats from urbanisation.

Rehabilitation efforts in NSW have often focused on re-instating saltmarsh through active restoration and reshaping of topography conducive to saltmarsh colonisation (for instance, see the work conducted around the Tuggerah Lakes). This can be highly effective particularly when using passive means (fencing, preventing mowing and trampling), changes to ground levels, removal of barriers and replanting with saltmarsh species.

### 2.6.5 Rocky Reefs

Four distinct zones of rocky reef have been identified within Lake Macquarie (Morton & Gladstone, 2010) based on distinct rocky reef fish assemblages. These zones are: around Moon Island, which is considered to have more coastal species; Swansea Channel, which provides a gateway for species to enter the lake; the central lake, including Pulbah Island, which signifies the furthest reach for many fish species associated with rocky habitat; and the lake margins, which tend to have lower abundances of several species found in other zones.

Rocky reef areas support diverse and abundant assemblages of fish that are important for recreational fishing and diversity within the lake environment. The presence of species typically restricted to rocky habitat (e.g. wrasses, mado, morwong, moray eels) indicates that this habitat provides resources that are different to seagrass habitat within the lake.

Rocky shorelines are generally in good ecological condition, but ecological habitats on shore platforms would be affected by sea level rise, becoming permanently inundated. Monitoring of changes to the diversity of species on shore platforms would be desirable.

## 2.7 Key risks to estuary health

Significant issues for management over the next ten years are as follows:

- Sediment, nutrient and organic matter loads in runoff from specific sub catchments;
- Storm water runoff from urban sub-catchments, particularly from new development in higher risk catchment areas, with erodible soil and creek banks;
- Cumulative interactions of recreational boating and lake ecology, particularly as the regional population which uses Lake Macquarie for recreation increases. Challenging issues include mooring impacts on *Posidonia australis*;
- Habitat degradation of wetlands and saltmarsh in the foreshore environment, particularly in urbanised bays; and
- Maintenance and monitoring of sites subject to past rehabilitation projects.

Issues which will be watched closely over the next ten years and for which the community should prepare to act, include:

- heavy metal contamination (historical contamination of sediments and better understanding ongoing catchment sources);
- thermal pollution associated with power station discharges, in the context of climate change impacts on baseline lake water temperature;



- foreshore and creek bank inundation and erosion, particularly in response to sea level rise and other aspects of climate change. This will affect low lying ecological communities and wetlands; and
- transformation of natural shorelines with structures. Council already has design guidelines for seawalls and revetments on lake shorelines and creek banks. However pressure for structural protection of shorelines is expected to increase with changes to storm intensity and with rising lake levels.



## 3.0 Lake People and Lifestyle

### 3.1 The Lake Macquarie Community

The City of Lake Macquarie is the largest in the Lower Hunter and the fourth most populated local government area in NSW, with a population of approximately 202,000 (ABS, 2011) distributed around the lake in over 90 communities. In addition, with a population of approximately 5,600, the city of Lake Macquarie has the second largest Aboriginal community in NSW (ABS, 2011).

Between 2001 and 2011 the population of Lake Macquarie increased 4.7 per cent (ABS 2011). The largest population growth areas were West Wallsend and Morisset, with both experiencing a population increase of 8.2 per cent (LMCC, 2009b). Wyong Shire, immediately to the south of Lake Macquarie and with responsibility for managing the southern catchments of Lake Macquarie, experienced a population increase of 13.1 per cent between 2001 and 2011, to nearly 150,000 people (ABS 2011).

The Lower Hunter Regional Strategy (LHRS), a plan designed to guide and strategically direct development in the Lower Hunter over a 25 year period, forecasts population growth for the Lower Hunter. The LHRS projects an additional 160,000 residents and 115,000 new dwellings for the Lower Hunter by 2031, of which 60,000 people and 36,000 additional dwellings are projected for the Lake Macquarie local government area (DoP, 2006). Within Lake Macquarie LGA, Charlestown, Glendale/Cardiff and Morisset are designated as regional centres projected to experience substantial increases in the numbers of dwelling and employment. The LHRS proposed urban release areas at Cooranbong, Morisset, Wyee, the Catherine Hill Bay area and in the north-west of Lake Macquarie LGA (DoP, 2006).

## 3.2 Heritage

### 3.2.1 Aboriginal Cultural Heritage

Lake Macquarie, the coast and the catchment extending to the Watagan Ranges are part of the traditional country of the Awabakal people. Awabakal people have lived around Lake Macquarie and utilised its aquatic resources since the early Holocene period, over 8,000 years ago. They also occupied this landscape before it arrived at its current form, when sea level was much lower than now.

Awabakal ancestors were custodians of the landscape and this tradition has passed on to Awabakal people today. Physical evidence of past Awabakal life around the estuary includes grinding groove sites, middens, campsites, scar trees and rock shelters. These sites are vulnerable to disturbance by all forms of development and recreation. The vegetation and fauna of the lake and its foreshores and catchment are also highly valued by Awabakal people as these are the resources of which they are custodians.

In 2013, Council and representatives of Local Aboriginal Land Councils revised and signed a Statement of Commitment, on behalf of the Aboriginal community that recognised the contribution of Aboriginal culture to the City's landscape and to its social and cultural diversity. The Aboriginal Heritage Management Strategy sets out how Council and the local Aboriginal community will work as partners to implement the Statement of Commitment. The Strategy introduces the concept of Sensitive Aboriginal Cultural Landscapes (SACL). These more sensitive landscapes are defined and mapped from known archaeological evidence; the predicted extent of archaeologically significant areas; places associated with records of traditional Awabakal stories and practices; places that conserve important traditional

resources; and places that are important in the shared history of the City since European settlement. SACL mapped include the lake shore; ocean shore; terraces, deltas and riparian footslopes along creek corridors and upper catchments and escarpments of Watagan and Sugarloaf Ranges.

Threats identified to these landscapes include:-

- Historical use of the lake foreshore and lower reaches of estuarine creeks and wetlands for rail, power generation, sewerage and other infrastructure has destroyed middens and open campsites.
- Filling and formalisation of lake shorelines with sea walls, construction of slip ways, boat sheds and residences. All these activities have transformed the lake shore landscape, as well as damaging middens close to the lake shore. Some archaeological material remains in less formal foreshore reserves and where old houses or boat sheds are on piers rather than slab foundations.
- Foreshore and nearshore reserve management, including filling of low lying areas, mowing, installation of playing fields and parkland equipment has destroyed middens and open campsites. Scarred trees have also been lost from foreshore locations. Lower reaches of major creeks and their catchments – such as Dora Creek and Cockle Creek
- Land clearing for agricultural, industrial and urban uses has removed scarred trees and disturbed the structure and context of open sites. Stone arrangements have also been damaged or destroyed by land clearing activities.
- Land management within urban subdivisions has changed flows in creeks, increased erosion or sedimentation and encouraged invasion of culturally valued vegetation communities by weeds. Transport, water, sewerage and power infrastructure to support urban development can cause significant disturbance of long corridors across the landscape.
- Poor control of access within lake shore and bushland reserves (Crown Land, Community land and private land) has contributed to erosion, rubbish dumping and damage to vegetation associated with illegal four wheel drive and trail bike activity.
- Industrial development along major tributary creeks (for instance in the lower freshwater and estuarine reaches of Cockle Creek) has removed or damaged surfaces which would once have been associated with diverse Aboriginal community resources and archaeological evidence of past occupation.
- Coal mining (both open cut and underground) has contributed to the loss of Aboriginal sites and changes to cultural landscapes, either directly through extraction or indirectly due to subsidence impacts. It should also be noted however, that the existence of the underground mining industry in the western part of the City has clearly helped to maintain some relatively natural landscapes in this area.

It is evident that many of the threats to SACLs are similar to those that impact that the ecological features of the estuary and therefore estuary management actions are likely to provide enhancement of both natural and cultural values.

### 3.2.2 Historical Heritage of Lake Macquarie – a Working and Recreational Landscape

Lake Macquarie and its estuarine tributary creeks also have a strong historical heritage, with European settlement dating to the early nineteenth century. The focus of white settlement was around the discovery of coal in the late eighteenth century, originating in Newcastle, then spreading to the shores of Lake Macquarie within a few years. Lake Macquarie's heritage includes coal mining, forestry, farming, boat building and fishing. The Lake served as an important transport corridor for these industries, prior to the development of road transport.

An example of the historical settlement patterns and social context of the Lake (in this case, the Wangi Wangi area) is provided in **Figure 3.1**.

**Figure 3.1 - Glimpse of Lake Macquarie Heritage – Wangi Wangi**  
(Lake Macquarie History Online)



#### **Early Settlers:**

Wangi became a haunt of cattle thieves because of the ease with which the cattle could be penned on the peninsula. D.R. Israel bought the land about the turn of the century. Until 1916 a Chinese market garden, on the site of the Workers' Club, and a vineyard were the only permanent residences. There was a tollgate near Lakeview, where a 6 pence entry fee was charged. During the Depression many people lived in tents and shacks at Wangi, eking out the dole with fish and rabbits.



#### **Early Industries:**

Tourism was developed by D.R. Israel, using his three ferries. There were three wharves: at Lake View, Wangi Wangi and Wangi East, and baths were constructed nearby. There was a guesthouse at Lake View.



#### **Early Transport:**

The few roads were so bad that most people caught the train to Toronto and the ferry to Wangi. There were three ferries: the Wangi Wangi, Wangi Pioneer and Wangi Queen, bringing provisions and passengers.

When roads were provided in the early twentieth century, they favoured communication with Cessnock rather than Newcastle. So Wangi became a favourite holiday area for Coalfields families. Albert Hawkins drove the first car, an Australian Six, to Wangi and needed four men to push it through Stockyard Creek.

Lake Macquarie estuary also has an important history and continuing value as a yachting/dinghy sailing major training ground for national and international sailors. For the people of the Hunter valley, the lake has significant landscape heritage value, as a place to live and a place for recreation, attached to the shoreline and foreshore reserves. These heritage and cultural values are separate from but associated with the natural values and systems of the estuary. In general, the cultural heritage and landscape heritage values of Lake Macquarie have not been widely promoted.

### 3.3 Water-based Community Use

#### 3.3.1 Boat Ownership and Usage

Lake Macquarie is widely regarded as one of the best yachting waterways in Australia, for small to medium sized vessels. Boating activity across all types of recreational use has increased in popularity in Lake Macquarie in recent years.

Boating activities on Lake Macquarie include:

- Dinghy racing and recreational sailing
- Yacht racing and recreational sailing/cruising
- Fishing
- Water skiing and wake boarding, particularly in relatively sheltered bays
- General powered runabout use to reach picnic spots on bushland foreshores or islands
- Holiday raft-ups, where groups of boats may stay moored in one location for several days
- Kayak, surf ski paddling and stand up paddle boards, generally for recreational purposes rather than racing
- Rowing
- Dragon boats and outriggers

In NSW, boat registration has grown on average by approximately 2.8 per cent annually over the last decade. The Hunter Inland Region, which includes Lake Macquarie, accounts for 24 per cent of recreational vessels and 15 per cent of commercial vessels in NSW (NSW Maritime, 2010). **Table 3.1** shows the numbers of boats registered in Lake Macquarie and the projected increase in boating usage over the next decade. These statistics do not include ownership of unpowered vessels such as kayaks and surf skis, which are not required to be registered with RMS.

**Table 3.1 – Boat Ownership and Projected Growth**

Boat size/year	2007*	Projected 2015#	Projected 2020#	Projected 2026#
Draught less than 2 m (includes most motor vessels)	14,834	19,214	22,621	27,517
Draught greater than 2m (mostly keeled yachts)	1,239	1,605	1,889	2,299
Total registered vessels	16,073	20,818	24,511	29,816

\*From Patterson Britton 2007

#From RMS 2012

These statistics indicate that by 2026, the projected boating usage (in terms of ownership) of powered vessels and registered sailing boats/yachts in Lake Macquarie will have almost doubled. This is a major challenge for Council and RMS in terms of facilities and safety, and for waterway users looking for a quality recreational experience.

### 3.3.2 Boat Ramps

Boat ramps provide convenient access to the lake for trailer-launched boats. There are approximately 50 public boat ramps on the Lake Macquarie foreshore. In addition, many waterfront residents also maintain a small private boat ramp, associated with a private jetty and boatshed.

Public boat ramps providing access to Lake Macquarie are managed by Council (in the northern part of the lake) and WSC (around the southern foreshore).

Most ramps provide lake access for local communities; only a few ramps are highlighted as regional facilities, established to cope with high usage. Cockle Creek, Warners Bay/Eleebana and Swansea Channel are examples.

### 3.3.3 Jetties and Moorings

#### 3.3.3.1 Moorings

The Lake Macquarie Mooring Management Plan (LMMMP) was published by the NSW Waterways Authority in 2007. The LMMMP provides for the management of existing moorings, expansion of mooring areas to recognised limits, and the authorised removal of moorings in areas where there is 'demonstrated environmental, safety or navigation concerns' (Waterways Authority 2007).

Mooring statistics provided by RMS are consistent with increasing demand. In 2007, there were 1,401 registered moorings in Lake Macquarie (Waterways Authority 2007). However, since this time the number of registered moorings has risen to above 2,300 across 43 distinct mooring areas (RMS 2013). Approximately 20 per cent of Lake Macquarie moorings are located in the approved mooring areas at Belmont Bay and Croudace Bay.

There is pressure for additional mooring space in Lake Macquarie. However, limited water depth surrounding some existing mooring locations, as well as constraints to free movement of vessels around and/or through mooring areas, are issues for the expansion of mooring sites.

Populations of some of the State's most significant beds of the seagrass *Posidonia australis* are found within some mooring areas in Lake Macquarie (e.g. Belmont Bay and Marks Point). *Posidonia australis* is an endangered seagrass population found within coastal bays, estuaries and coastal lakes that are subject to frequent tidal flushing (DPI, 2012). Significant impacts to the *Posidonia australis* population in Lake Macquarie are already apparent; as a result of mooring chains on 'traditional' swing moorings dragging on the substrate around the mooring.

Siltation may constrain access to moorings in a small number of locations such as the mouth of Black Ned's Bay and along LT Creek, North Creek and South Creek. Occasional dredging is required to maintain access for keeled vessels. Dredging may not be compatible with other ecological values, or with the risk of disturbing contaminated sediment in these creeks and shallow bays.

Given the time that has elapsed since the LMMMP and advances in the understanding of the extent of impacts (in particular those related to swing moorings) and improvements in a range of mooring designs that can potentially minimise these impacts, it would appear to be timely and prudent to update the LMMMP to reflect this contemporary knowledge so that best practice mooring management can be incorporated into the overall management strategy for Lake Macquarie.

### 3.3.3.2 Private Jetties and associated ramps and rails

Between January 2005 and June 2013, 228 private foreshore developments (i.e. boatsheds, slipways, jetties, pontoons, etc.) were approved by Council. The majority of these are concentrated near designated mooring areas adjacent to residential areas where properties have absolute water frontage.

Wooden and mesh jetties in Lake Macquarie result in a significant reduction in seagrass cover in the immediate vicinity; approximately 74 per cent and 54 per cent respectively (Gladstone, 2007). Although the jetty construction process has minimal impact on seagrass, the presence of multiple jetties in an embayment results in increased shading of seagrass beds (Gladstone, 2007). Where jetties are associated with shallow water or private ramps and rails, seagrass can be damaged by cumulative boat and propeller drag.

### 3.3.4 Marinas

Marinas are permanent boat storage facilities, which can be located wholly on land or on a waterway, or partially on land and a waterway. Facilities commonly associated with marinas are related to repair and maintenance, refuelling, sewage pump-out, car parking, and mooring or berthing. There are four marinas within Lake Macquarie, located at:

- Marks Point (Marks Point Marina), which also provides shipwright services. Development approval was given in March 2013 for expansion of the Marks Point Marina, which will allow for 'up-to-date maintenance and vessel handling facilities with new floating berths'.
- Swansea (Pelican Marina) – a small marina on Swansea Channel.
- Marmong Point (Marmong Point Marina) - 245 berths, sheltered swing moorings, plus dry storage. This is the largest of the Lake Macquarie marinas and provides a facility used by boat owners from around the lake, Newcastle and the lower Hunter. Marmong Marina proposes a new foreshore function centre and new dry storage facility.
- Wyee Point (Wyee Point Marina) - 36 berths.



The small Wyee Point marina is currently the only one in southern Lake Macquarie. A master plan for a potential marina site at Trinity Point (Bardens Bay) was approved by Council in 2005. A subsequent concept plan for the proposed development of the site (2007) included up to 308 marina berths. This was revised to 188 marina berths and associated commercial and residential development in a Part 3A development application. After significant community and Council opposition to the proposal, it was approved by the Minister for Planning in 2009, after referral to the Planning Assessment Commission for independent advice. Construction has not commenced at this time.

The potential for the expansion of marina infrastructure is one strategy to accommodate projected increases in the demand for on-water boat storage and could be incorporated into an update of the LMMMP.

### 3.3.5 Dinghy Storage

Within NSW, boat registration has grown on average by approximately 2.8 per cent annually in the last decade, resulting in increased demand for mooring and boat storage facilities (NSW Maritime, 2010). Boat ownership in the Hunter region, including Lake Macquarie, has grown at above the NSW rate. As a result, problems associated with the storage of dinghies in public parks/reserves are reported to be an increasingly important issue, with more than 1,500 dinghies left on the Lake Macquarie Foreshore (LMCC, n.d.). Concerns have been expressed by Council and some community members that dinghies left in foreshore reserves clutter the foreshore and reduce accessibility for other users, smother or shade foreshore ecological communities, create problems for mowing maintenance and damage trees and shrubs.

Similar dinghy management issues occur in other urban waterways (e.g. around Sydney Harbour, Port Hacking and Brisbane Water) and several local government areas have adopted dinghy storage policies and requirements where the foreshore is intensively used for dinghy storage and access to moored vessels.

To enable management and control of the storage of dinghies on public land around the Lake Macquarie foreshore, Council introduced the Dinghy Management Policy in 2011. The objectives of this policy are as follows:

- To rationalise the number of dinghies stored on public land by the removal of derelict, abandoned or unauthorised vessels;
- To reduce Council's exposure to litigation;
- To improve the availability of open space parkland and public access to foreshore reserves;
- To improve maintenance of reserves by reducing the number of dinghies stored on public land; and
- To reduce the amount of damage to trees and native vegetation caused by the tethering of dinghies.

Opinions on the significance of dinghy storage vary across the community. For instance, while some people think dinghies are unsightly and untidy in foreshore reserves, others believe they add to the scenic value.

Full implementation of the Dinghy Management Policy (2011) would require significant changes to the way that dinghies are currently stored and how people access their moored vessels. Extensive consultation is required before these changes are enforced.

For Lake Macquarie, the primary decisions are about:

- the significance of dinghy storage as an issue in foreshore reserves;
- where dinghy storage in a foreshore reserve is acceptable (which reserves, and in which parts of reserves);
- whether dinghy storage racks or other structure are necessary. If so, which design(s) are appropriate for the locality? Do tall dinghy storage structures create more visual impact issues than dinghies on the ground?;
- ownership and identification of dinghies to facilitate management of inappropriate dinghy placement; and
- linking dinghy storage/management to the overall plan of management and masterplan for the reserve or a sequence of reserves along the foreshore.

### 3.3.6 Dredging for Navigation Access

Maintenance dredging for safe navigation is one of the objectives of the proposed W1 Natural Waterways zone of the draft Lake Macquarie LEP 2014:

- *To provide for recreational use of Lake Macquarie and its waterways as an important environmental, social, and economic asset including maintenance or enhancement of public navigation channels to a depth suitable for yachting and other boating activities.*

Therefore, dredging for navigation purposes is a potential component of the overall mooring strategy for the lake and specific works could be identified and prioritised in any update to the LMMMP.

### 3.3.7 Fishing

Lake Macquarie is a recreational fishing haven and no commercial fishing has occurred in the lake for more than 10 years.

Recreational fishing is managed by Industry and Investment (Department of Primary Industries) (Fisheries). LMCC and Wyong Shire Council have an ancillary role in terms of provision of launching ramps, wharves and jetties that support lake access for anglers. Council's efforts to protect the health of estuarine systems through its investment in stormwater controls and lake foreshore management structures also supports ongoing recreational fishing.

## 3.4 Foreshore-based Community Use

### 3.4.1 Foreshore Reserves and Facilities

Lake Macquarie has approximately 170 kilometres of foreshore, of which approximately 40 per cent is privately owned (i.e. residential properties with absolute water frontage); the remainder is reserve land. Reserves are a publicly-owned resource managed by Council or the NSW National Parks and Wildlife Service (NPWS). In addition, there are a number of Landcare sites within foreshore reserves around Lake Macquarie; with over 260 registered Landcare groups within Lake Macquarie (OLMCC, 2009).

As part of the Lake Macquarie Improvement Project community surveys were completed to obtain information on community attitudes towards the local environment, activities commonly undertaken and the issues that concern local residents. Results from the community survey completed in 2006 indicate that the local community base many recreational activities around the lake, with 44 per cent of respondents indicating they use the lake at least once a week (FordComm Consulting 2006). The most popular lake-related activities were picnicking and walking.

The recreational focus of foreshore reserves is 'passive' terrestrial based activity, except where a specific piece of boating infrastructure is located in the reserve (such as sailing clubs and launching ramps). The focus is therefore generally on management for people looking out over the lake, rather than using the shoreline for water access or approaching the lake shore from the lake.

Foreshore reserves provide community access to water views and at selected sites, to activities crossing the interface between lake and land. Foreshore treatments in Council reserves are also an opportunity to showcase management techniques that support ecological resilience and protect cultural values while also providing safe community access.

Lake Macquarie has an extensive network of off-road shared pathways providing recreational opportunities for cycling, jogging and walking. Social research undertaken to inform the LMCC *Cycling Strategy 2021* indicates that a many cyclists make use of off-road paths, such as those along the lake foreshore, with more than 70 per cent of respondents (both regular and infrequent cyclists) indicating off-road paths as their key destination for cycling trips (LMCC, 2012). This cyclist preference for off-road paths is in part due to risks associated with riding on the road, with 23 per cent of respondents having been involved in an accident and 75 per cent of accidents involving a motor vehicle (LMCC, 2012).

## 3.5 Linking Lake and Foreshore Use

Improved capacity to manage recreational use across the lake and foreshore interface is key to sustainable use. This is currently managed through a series of management plans as outlined below.

### 3.5.1 Plans of Management and Master Plans

Plans of Management and Masterplans are the key planning documents for foreshore reserves. They set out the purpose and objectives of the reserves and how they will be managed to achieve the stated objectives. Council has generic Plans of Management for all reserves under its care and control. For high usage foreshore reserves, Council has also prepared detailed Plans of Management and/or Masterplans, under the *Local Government Act 1993* and/or *Crown Lands Act 1989*.

#### 3.5.1.1 Integrated Foreshore Management Strategy

Council prepared an Integrated Foreshore Management Strategy for Lake Macquarie in 2002. The Strategy responded to policy and development issues at the time including

- the effectiveness and appropriateness of current Foreshore Building Lines;
- the need to prioritise foreshore acquisition areas for additions to foreshore reserves;
- limitations on public access to foreshore areas due to physical obstacles such as seawalls, jetties and other structures;

- concerns of waterfront property owners related to security and amenity; and
- unauthorised foreshore reclamation and other work.

There would be value in a review of implementation and updating of the strategy, as well as involving the community further in decisions relating to policy about foreshore access, amenity, tenure, design, planning requirements and other matters. A number of issues and potential actions noted in the foreshore management strategy are included in this CZMP, as they are of continuing significance to the health of the lake and to community use and enjoyment of the land and water interface. Potential future impacts of erosion, accretion and inundation on public access infrastructure is also an issue for further consideration.

### 3.5.1.2 Crown Reserve

Lake Macquarie is part of a regional Crown Reserve, which also includes Crown land in the lake catchment. In June 2012, the NSW Government embarked on a comprehensive review of Crown land management. The 2014 Review report proposes a range of reforms to improve the management of the Crown estate, including the development of a contemporary legislative framework.

### 3.5.2 Bushland Foreshores

Areas of bushland foreshore are one of the key landscape features of Lake Macquarie. During the consultation process for this CZMP, some stakeholders noted issues about recreational access in bushland reserves around the lake, both in terms of over-use and constraints to access. Examples included Point Wolstoncroft, Wangi Point and Pulbah Island. These reserves are managed by Crown Lands or by OEH (National Parks).

The bushland reserves managed within the State Conservation Area and on other sections of foreshore managed by Council, Crown Lands or private land, have special ecological and cultural heritage values.

Issues that have been noted by the community regarding access include:

- Increasing invasive weed species.
- Overused tracks with inadequate cross drainage – soil loss into the lake.
- Accumulated litter from use of bushland areas.
- Damage of understory and small trees by campers or picnickers scavenging firewood.
- Damage of Aboriginal cultural sites or places.
- Limited water based access.
- A desire by some to return to access arrangements of the past (e.g. increase access to Pulbah Island and develop tourism opportunities there, such as happens on Sydney Harbour islands).

Any change to current management arrangements in these reserves requires collaboration between management authorities (Crown Lands, Council, NPWS) and must also be consistent with the agreed strategic direction for managing recreational use of the lake.

### 3.5.3 Commercial Foreshores

During consultation about the CZMP, some community stakeholders noted poor access from the water to commercial/tourism centres around the lake. Although lake to land access is also a potential issue at other locations, such as Wangi, Gwandalan and Nords Wharf, the focus of these concerns is Warners Bay. The foreshore reserve at Warners Bay is a heavily used community asset, with usage linked to both the outlook across the lake and to the proximity of the Warners Bay commercial centre with shops, restaurants and cafes.

At other waterfront villages/centres around the lake, such as Toronto and Belmont, a public wharf, extending into deep water, provides a link from boats to the foreshore, enabling people arriving by boat to tie up for specified periods and unload passengers. Waterway users note that at Warners Bay, the existing jetty does not extend into deep enough water to be accessible from the water, except in small tenders or runabouts. It is not suitable for unloading passengers from yachts or larger cruisers. The nearest public jetty for this purpose is at Speers Point Park.

## 3.6 Safety Issues

### 3.6.1 Needle-stick Injury

During consultation with lake users for this Estuary part of the CZMP, comments were made about the presence of used needles in foreshore reserves such as Speers Point Park. This is also likely to be the case in other heavily used foreshore parks that are near urban centres.

The unsafe disposal of used syringes is not isolated to Lake Macquarie. In the Lake Macquarie context, the extent of risk is not currently known. In the absence of details about the number of discarded used syringes in foreshore areas, risks can be mitigated by raising awareness of the potential for injury, providing safe needle disposal bins and encouraging people to wear lake shoes when wading in the nearshore. Beach cleaning activities may be feasible at some locations, but more information about the risk is needed.

### 3.6.2 Razor Clams (*Pinna bicolor*)

Razor clams are a widespread component of the ecology of Lake Macquarie. The fan-shaped clams can grow up to 50 cm long and bury themselves in seagrass sediments and sand leaving a thin edge protruding. The sharp upward facing shell edges are a hazard for people walking and swimming in shallow water. In addition, empty razor clam shells can be homes for blue-ringed octopus.

Razor clams are filter feeders and play an important role in improving water clarity and providing nutrients within seagrass beds. They grow rapidly, reaching lengths of 200mm within one year and live for up to 18 years (Burns, 2010). This longevity makes them effective bio-indicators for the health of the lake, as they reflect the history of pollutant loads. Pollutants are incorporated into the growth rings of the shell of the animal which can then be analysed to show declines and improvements in the water quality over time.

Recruitment of razor clams is sporadic and much of the animals' energy is put into repair and maintenance of its shell rather than reproduction. Therefore, overfishing or removal may impact heavily on numbers. In recent years there is a perception that numbers of razor clams have increased in the lake which is a concern for local communities with regards to safety. The cause of this perceived increase is unknown (the increase has not been verified), though if true, may be linked to the removal of commercial fishing from the lake in 2002.

Licensed recreational fishers are allowed to take a limit of 20 per day for consumption and razor clams are manually removed from targeted high use recreational areas by qualified divers under regulations set by NSW Fisheries. It is considered essential to understand the consequence of the removal of razor clams from the lake on other species and the lake ecology before large scale removal of the species is undertaken.

### **3.6.3 Sharks**

Lake Macquarie is a large coastal lake that attracts marine species of fish including sharks such as hammerhead, whaler and bull sharks. Anecdotally, there has been an increase in shark sightings. However, in the absence of monitoring data, it is difficult to determine whether this is due to an increase in the number of lake users or a true increase in shark numbers. Regardless, the threat of sharks has raised concerns for public safety, especially at popular swimming locations.

Potential management responses, already occurring, include clear information about the potential presence of shark species in the lake; awareness raising about their role in the ecosystem; and the need for vigilance when undertaking recreational activities. Vigilance could include advice about higher hazard at certain locations and at certain times, how to report shark sightings, information about first aid and emergency contacts.

Some lake users have suggested that swimming areas in Lake Macquarie should be provided with shark nets. Council has adopted a policy that shark netting will not be installed in Lake Macquarie. This is because the current risk, despite increased sightings, is low. Shark netting is not reliable, and requires a high investment for installation and ongoing maintenance. It also interferes with other ecological processes in the lake such as seagrass wrack movement along and across the foreshore and can encourage blue ring octopus. In addition, many people who swim in Lake Macquarie do not use formal swimming areas but use attractive foreshore areas around the entire 170km lake frontage.

Council has requested that DPI Fisheries continue to provide updates on shark monitoring data for Lake Macquarie, so that the risk of shark bite can continue to be reviewed.

### **3.6.4 Blue-ringed Octopus**

The warm waters and ideal habitats (rocky shores and seagrass beds) of Lake Macquarie provide ideal locations for the venomous blue-ringed octopus. Indeed, relatively large numbers of the small octopus can be found around the margins of the lake. Although highly venomous the blue-ringed octopus is docile, non-aggressive and normally harmless unless harassed or handled. The venom in the saliva is administered by a bite from the beak which is on the underside of the animal so stepping on one may not necessarily lead to a bite. However, it is recommended that shoes that cover the whole foot be worn when wading through shallow areas of seagrass.

Generally, people are bitten when they pick up the small striking octopus for a closer look. Therefore, education into the presence of blue-ringed octopus and reasons for leaving them undisturbed is essential along with details of first aid if bitten.

### 3.6.5 *Caulerpa taxifolia* Infestation

The marine invasive species *Caulerpa taxifolia* has previously been detected in Lake Macquarie but is not currently considered to be an active issue. However, vigilance is still required to keep this pest out of the lake.

The principal response at this time is monitoring of aquatic vegetation communities at key sites around the lake. This would be supported by information for waterway users about the risks associated with the species and how to avoid bringing it into Lake Macquarie.

## 3.7 Summary of Management Issues

Issues that are the focus of Council and community action over the next ten years include:

- Planning for increasing demand for recreational opportunities on Lake Macquarie and its foreshores, as the regional population increases and participation in recreational activities on the lake increases.
- Improving the connectivity of lake and land (foreshore) based recreation, with appropriate placing and design of recreational infrastructure and facilities.
- Detailed place management plans for sensitive and/or heavily used areas, e.g. Point Wolstonecroft, Pulbah Island and major foreshore reserves.

Issues that should be watched closely over this period, building knowledge and with preparation for action, include:

- Safety of lake users, including sharks, razor clams.
- User interactions on land and water. Increasing demand for recreation opportunities on public open space opens the potential for conflicts between user groups in some locations.
- Potential impacts on community access to the lake and foreshore resulting from future erosion, accretion and inundation.



## 4.0 Consultation about Lake Management

Lake Macquarie is a highly valued coastal landscape, although not everyone uses and values the lake in the same way. Council offers several processes to make sure that many community voices and opinions are heard in the planning and management processes that relate to the lake. These include the following:

- Council facilitates and supports an Estuary and Coastal Management Committee, which meets every two months. The focus of this Committee is the healthy functioning of the estuary, but the committee recognises the critical social context of Lake Macquarie as a residential and recreational asset. Members include Councillors, State agencies, Council staff and representatives of community groups or interests. This Committee has existed since before the 1997 Estuary Management Plan was prepared and provides a wealth of lake management memory.
- Lake Macquarie is a recreational waterway of State significance. To facilitate management of boating access and uses, Council supports an Aquatic Services Committee. Members include agency representatives (RMS, DPI, and Marine Rescue), representatives of sailing clubs and boating associations, Council staff and Councillors. This group provides advice to Council about public boat ramp and jetty structures, mooring management, dinghy storage, dredging and other matters.
- Council conducts a regular community survey to track attitudes to the environment and Council's management approach.
- Council uses its website to provide information about upcoming information, policy changes or events, and to receive feedback electronically.
- Technical and planning studies (including the draft CZMP) are exhibited for community feedback before they are finalised.

### 4.1 What Do People Value About the Lake – Previous Surveys

As part of the Lake Macquarie Improvement Project, Living Lake Macquarie Community Surveys were undertaken each year (FordComm, 2006), with the aim of the surveys to obtain information on:

- issues that concern residents;
- community attitudes toward and perceptions of the local environment; and
- community activities and impacts on the environment.

Survey results consistently indicated that the most popular lake-related activities are walking and picnicking on the Lake Macquarie foreshore. In addition, respondents were presented with a list of environmental issues and required to give each a ranking out of ten (where 10 is most significant), in regard to their significance in maintaining the environmental quality of Lake Macquarie. The key issues given a ranking of 8 to 10 out of 10 are summarised in **Table 4.1**, with a comparison of results from 2000 and 2006. The results highlight a potential disconnect between awareness of the importance of healthy estuarine ecological communities (e.g. seagrass), and resident interest in factors influencing the health and resilience of these ecological communities (noting the significant reduction in the perceived importance of sea wall removal and vegetation around the lake foreshore).

**Table 4.1 – Comparison of Perceived Importance of Environmental Issues for Survey Results 2000 and 2006<sup>#</sup>**

Issue	2000 (%)	2006 (%)	% Change
Healthy Seagrass Beds	61.0	65.4	+ 4.4
Sensitive Urban Development	52.8	69.7	+ 16.9
Environmentally Sensitive Drainage System	84.0	81.3	- 2.7
Vegetation Around the Lake Foreshore	76.7	68.7	- 8.0
Removing Seawalls Around Lake Foreshore	53.2	21.4	- 31.8

Source: Fordcomm Consulting, 2000 & 2006. # Results are presented for issues ranked 8 to 10 out of 10

In early 2012, Micromex Research undertook community research aimed at examining the community's attitude and perception of current and future services provided by Council. The survey sampled the views of 1,000 residents of Lake Macquarie (Micromex Research, 2012). Results from this research indicate an increase in the perceived importance of a number of environmental services in Lake Macquarie, including:

- lake and foreshore maintenance;
- coastline management;
- bushland maintenance;
- planning for natural disasters; and
- overall appearance of the City.

Lake and foreshore maintenance was assigned an 'extremely high' importance rating by residents, reflecting the high recreational value of the foreshore reserves. Planning for natural disasters (including flood risk management) was assigned a 'very high' importance rating (Micromex Research, 2012). The research results indicate that respondents felt Council needs to continue current lake and foreshore maintenance practices.

The Estuary part of the CZMP is one of the tools which provide more detail on how Council will meet these perceived community priorities, particularly in relation to environmental awareness and education and sustainable community behaviours that support a healthy lake and foreshore.

Stakeholder and community consultation conducted during the preparation of the Estuary part of the CZMP also highlighted the critical importance of the lake foreshore in terms of community value. The foreshore is valued by recreational users from the land base and also from the water base. The interface between land and water is where movement between the lake and foreshore facilities occurs and also where people using land or water gains a visual perspective of the 'other'. Facilities for moving between land and water were identified as key assets and were also the source of concern amongst some users who believe that the current access structures (such as jetties, ramps, sea walls and promenades and safe swimming areas), are not meeting the recreational potential of the foreshore.

## 4.2 Specific Community Consultation to Inform the Estuary part of the CZMP

During the preparation of the Estuary part of the CZMP, consultation meetings were conducted with a number of stakeholders. These discussions had the following objectives:

- To inform key stakeholders about the preparation of the updated Estuary part of the CZMP and how Council proposes to integrate the three parts of the CZMP for the Lake Macquarie estuary and the open coast.
- To confirm progress that has been made during the implementation of the previous estuary management plan and the Lake Macquarie Improvement Project and in particular to identify initiatives for lake health, implemented by stakeholders, which may not have been fully reported.
- To confirm and explore stakeholder perspectives on important issues to be addressed in the review of the Estuary part of the CZMP.
- To discuss new initiatives proposed by stakeholders as part of their operations, this could contribute to achieving the objectives of the Estuary part of the CZMP.
- To prepare the way for new partnerships which could contribute to ongoing protection of estuary functions, processes and values, including natural system and the significant social, recreational and economic values of Lake Macquarie as a community asset.

### 4.2.1 Preliminary Consultation

Prior to commencing the preparation of the Estuary part of the CZMP, Council consulted with its Estuary and Coastal Management Committee about issues, priorities and objectives. This resulted in a list of 19 objectives (**Table 4.2**).

**Table 4.2 – Objectives and Outcomes for the Estuary part of the Lake Macquarie CZMP, from Committee consultation**

Theme	Listed Objectives
<b>Ecological significance</b>	Recognise Lake Macquarie as an ecologically significant landscape at a Commonwealth and state level
	Protect and enhance estuary biodiversity, particularly EECs and Threatened Species (as listed under the TSC Act 1995) and other key habitats
	Increase native riparian and foreshore vegetation
	Facilitate the adaptation of estuarine communities to projected climate change and sea level rise
	Ensure new development maintains and enhances landscape values and ecological functions
<b>Catchment drivers of lake health</b>	Prevent catchment and point source pollutants from compromising social, environmental and economic values
	Reduce the catchment sediment load to the estuary
	Prevent further stream bank erosion throughout the catchment and remediate existing sites where appropriate

Theme	Listed Objectives
<p><b>Manage process hazards and risks</b></p>	<p>Make recommendations regarding the effective management of hazards, including flood and inundation hazards to property and infrastructure (public and private) as well as hazards to ecological processes</p>
	<p>Provide recommendations for the management of estuary foreshore recession hazards (including recession hazards associated with sea level rise).</p>
	<p>Adopt a risk management approach to managing risks to public safety and assets and pressures on estuary ecosystems; including avoiding risks where feasible and interim measures for high risks</p>
<p><b>Secure recreational amenity</b></p>	<p>Protect and preserve foreshore amenity, maintain and improve public access arrangements to estuary foreshores and creeks, support recreational uses and protect the cultural and heritage environment.</p>
<p><b>Efficient, aligned and cost effective management</b></p>	<p>Link Council's coastal zone management planning with other planning processes in the coastal zone</p>
	<p>Facilitate state and local government co-operation and integrated management initiatives</p>
	<p>Involve the community in the preparation of the CZMP, including making information about the plan publicly available.</p>
	<p>Base decisions for managing risks to public safety and built assets , pressures on ecosystems and community uses of lake Macquarie estuary on best available information</p>
	<p>Prioritise management actions based on public benefit; including cost effectively achieving the best practical long term outcomes</p>
	<p>Ensure existing estuary works can continue to be maintained over their asset life</p>

### 4.3 Consultation during the preparation of the Estuary part of the CZMP

During the preparation of the Estuary part of the CZMP, meetings were conducted with multiple stakeholder groups and organisations to provide an opportunity for people to contribute their ideas about important issues, priorities and options.

The stakeholder meetings included the following:

- **Briefing and workshop with the Lake Macquarie Estuary Management Committee.** Multiple stakeholder organisations from industry, government and community sectors are represented on the Committee, including individuals who have been involved in estuary management at Lake Macquarie for many years and have a strong sense of the extent of change. Current Lake Macquarie City Councillors are also part of the Estuary Management Committee. Committee members raised issues such as:
  - the progress that has been made in enhancing the health of Lake Macquarie over the last 20 years, with major programs such as the Office of the Lake Macquarie and Catchment Coordinator and significant Council investment in environmental infrastructure; and
  - the importance of managing Lake Macquarie as a high quality biodiversity asset within a growing urban setting, so that management must deal with dual objectives – maintaining healthy estuary systems and facilitating appropriate community use and enjoyment.

- **Briefing and discussion with Lake Macquarie Aquatic Services Committee.** Membership of this Committee includes RMS, Council and representatives of boating organisations such as the Boat Owners Association, marina operators and yacht clubs. The Committee noted the increasing number and size of boats using Lake Macquarie, and the potential for future conflicts between large power and sailing vessels. They discussed issues around jetty design and construction for private residences and the appropriate jetty length and clearance for environment protection, safe use, and avoidance of potential conflicts with other nearshore waterway users.
- **A separate meeting was held with representatives of boating organisations** (such as rowing clubs and sailing clubs), recognising that many of the current estuary management issues relate to access and services for the very large number of boating users in the Lake Macquarie community and the broader community. Boating representatives noted that there are currently few conflicts between waterway users. They noted concerns about the potential impact of W1 zoning for the lake on boating activities (moorings, jetties, dredging) and also some concerns about the suitability of environmentally friendly mooring designs in exposed locations. They commented on the potential to attract large numbers of visitors to the area with major lake based events. The group also noted the importance of maintaining jetties around the lake for public safety, particularly in adverse weather conditions. Other specific matters noted by the group included:
  - public access to the waterway at Warners Bay, particularly in relation to the length of the jetty;
  - storm water and creek discharges at Warners Bay, and impacts on near shore sedimentation. The potential for dredging in this area was noted;
  - the importance of planning for multiple use of the Lake Macquarie estuary, integrating its natural and community use values. There was discussion about the appropriate balance of policy and planning to meet these objectives;
  - need for increased trailer parking facilities close to popular ramps such as Valentine; and
  - potential need for dinghy storage facilities in some areas, as boating usage increases.
- **Workshop with Council officers from multiple divisions of Council** which have interests in the sustainable management of the Lake Macquarie estuary and its foreshore. Relevant parts of Council include strategic planning, development assessment planning, asset management, community development, community planning, environment management, sustainability, environmental risk and communications. These sections of Council are responsible for preparation of statutory planning instruments; policies, guidelines and protocols; preparation and distribution of community information; preparation of Plans of Management and Masterplans for Council owned or managed land on the foreshore; planning for recreation infrastructure and maintenance of recreation infrastructure.
- **Wyong Shire Council.** (WSC) manages the catchment of the southern part of Lake Macquarie and several of the lakeside villages in the south are in WSC. WSC also manages waterway access infrastructure in this area, such as at Boat Harbour Gwandalan, Sandy Beach Summerland Point, Chain Valley Bay, Mannering Park, Crangan Bay and Vales Point. These areas are highly valued for boating because they offer calm and protected waters. Discussions were held with WSC officers from planning, community development, environment and asset management sections of Council. The area of the Lake Macquarie catchment in Wyong Shire is significant but there is a relatively low level of development in this area. It does contain intensive rural uses such as chicken sheds and flower farms. The southern villages have a high proportion of older people and a relatively low socio-economic status.

- **Hunter Water Corporation.** HWC owns and manages water and sewerage infrastructure for the Lake Macquarie community. Sewerage infrastructure is often located on low lying land and lake foreshore areas. HWC has developed asset management standards which reference the LMCC sea level rise benchmarks and flood levels. HWC is managing its wastewater network to:
  - Reduce wet weather inflows (e.g. from illegal stormwater connections and from system leakages) – Winding Creek is a priority.
  - Minimise discharges to the estuary (primarily from pump station overflows).
  - Minimise dry weather infiltration. Sewerage infrastructure which is at or below lake water level is subject to dry weather infiltration and the potential for this to occur will increase as sea level rises. HWC has a program of capping manholes to reduce the potential for ingress of tidal water. The Swansea area is a priority in this regard.
  - Plan and implement upgrades to treatment capacity to accommodate planned population growth.
- **Centennial Coal.** Centennial operates underground coal mines in the Lake Macquarie catchment. As part of their operations and to meet licence requirements, Centennial monitors flows from its operations, surface and groundwater quality, the ecological condition of relevant estuarine tributaries, seagrass cover and health and other environmental parameters. It therefore maintains an extensive water quality data set, particularly for the western side of Lake Macquarie. Some Centennial mines have operated for many decades and the company is dealing with legacy issues such as sediment load in LT Creek.
- **Aboriginal community stakeholders** – Awabakal Traditional Owner families. The Traditional Owners described the very high cultural significance of parts of the lake shore and of Pulbah Island. They referred to the abundant evidence around the lake of traditional Aboriginal occupation, including grinding grooves on rock platforms, large midden sites, scarred trees, sites with hearths, very large numbers of flaked stone artefacts and places about which there are important cultural stories. They noted the potential conflicts between heavy recreational use and cultural values at a number of locations. The Traditional owners also referred to the importance of promoting the Awabakal heritage of Lake Macquarie and of telling the story of how Aboriginal people lived here as custodians of the estuarine landscape over thousands of years.
- **Eraring Energy (Origin Energy).** Eraring Energy operated the Eraring power station for several decades. The power station has now been sold to Origin Energy. As part of their operations and to meet licence requirements, Eraring Energy conducted extensive monitoring, particularly in relation to water quality and seagrass health. Data from monitoring programs is publicly reported in the Eraring annual licence returns. The method of seagrass monitoring was revised four years ago to be consistent with the recommendations of DPI Fisheries and OEH.

#### 4.3.1 Exhibition of the estuary part of the CZMP

The Draft Lake Macquarie Coastal Zone Management Plan (CZMP) was placed on public exhibition from 28 October 2014 through to 31 January 2015. The objective of the public exhibition period was to give all Lake Macquarie City residents a chance to understand and provide feedback on the actions proposed in the draft CZMP or to suggest new actions.

Community workshops, online engagement and 'pop-up' information booths were used to give the public information about the contents of the draft CZMP and to get community input

to the proposed actions and ensure that the challenges and opportunities from the perspective of the community were identified.

Two workshops were scheduled to cover the geographical spread of the estuary. Due to low registrations, one specific workshop for **Part B – The Estuary** was held at the Morisset Multi-purpose Centre, Morisset on 20 November - 6.30-9.30pm. Input was received from 21 participants attending this workshop.

Council's Have Your Say website also hosted a project page [www.haveyoursaylakemac.com.au/coastal-zone-management-plan](http://www.haveyoursaylakemac.com.au/coastal-zone-management-plan) where participants could rank the actions for the area of the Coastline.

A total of 38 responses were submitted on the actions for the Estuary.

### Overview

Of the 38 responses that were related to the Estuary, 14 responses were submitted directly through the website and 24 responses were submitted via the information pop-up booths. The themes of most interest to respondents (highlighted in **Table 4.3**) were:

1. Theme 2 - Actions for a healthy coastal zone, protecting the natural environment (including biodiversity and ecological resilience) *(16 responses)*
2. Theme 3 - Actions for sustainable community access, use and value *(12 responses)*
3. Theme 1 - Actions to manage coastal process hazards and risk (such as erosion and inundation) *(4 responses)*
4. Theme 6 - Actions for communication and collaboration *(4 responses)*

**Table 4.3 - Online consultation for Part B Estuary**

Theme	Online Consultation		
	Website	Pop-up	Total
1. Actions to manage coastal process hazards and risks (such as erosion and inundation)	2	2	4
2. Actions for a healthy coastal zone, protecting the natural environment (including biodiversity and ecological resilience)	5	11	16
3. Actions for sustainable community access, use and value	6	6	12
4. Improve Council's focus and capacity to manage coastal values	0	0	0
5. Strong governance and supportive partnerships	0	1	1
6. Actions for communication and collaboration	1	3	4
7. Knowledge and adaptation, managing uncertainty	0	1	1
<b>TOTAL RESPONSES</b>	<b>14</b>	<b>24</b>	<b>38</b>

**Table 4.4** shows what online respondents considered to be the top 10 management actions for the estuary.



**Table 4.4 - Ranked Management Options from online consultation**

Ranked management actions	Theme
1. Continue lake health and sea grass mapping and monitoring, and investigate partnership opportunities with other organisations required to monitor seagrass	2
2. Prioritise (saltmarsh), estuarine and floodplain wetland areas for protection and management	2
3. Continue compliance activities relating to erosion and sediment controls	2
4. Continue education programs for construction industry and residential property owners to promote best practice stormwater management	2
5. Prepare management guidelines for Posidonia in Lake Macquarie, consistent with the types of information that Council provides on other threatened species	2
6. Apply Water Sensitive Urban Design to all new developments to ensure treatment of stormwater in new subdivisions	2
7. Hold a forum to discuss options for boat moorings in Lake Macquarie to minimise impacts on sensitive sea grass beds and to provide practical designs	2
8. Develop a foreshore development guideline that includes low impact methods for recreational structures and foreshore stabilisation treatments	2
9. Review and apply Council's DCP controls and Water Cycle Management Guidelines for all new development	2
10. Continue to implement the current riparian corridor rehabilitation program	2

## Conclusion

Online and workshop consultation undertaken for Part B – The Estuary has assisted to prioritise the themes and management actions from the draft CZMP. **Table 4.5** below shows combined results of the top ranked theme and management actions for the Estuary.

**Table 4.5 – Top ranked theme and management actions - estuary**

<b>1. Theme 2 - Actions for a healthy coastal zone, protecting the natural environment (including biodiversity and ecological resilience)</b>
Continue lake health and sea grass mapping and monitoring, and investigate partnership opportunities with other organisations required to monitor seagrass.
Continue compliance activities relating to erosion and sediment controls.
Apply WSUD to all new developments to ensure treatment of stormwater in new subdivisions.
Prioritise estuarine and floodplain wetland areas for protection and management.
Continue education programs for construction industry and residential property owners to promote best practice stormwater management.
Hold a forum to discuss options for boat moorings in Lake Macquarie to minimise impacts on sensitive sea grass beds and to provide practical designs.
<b>2. Theme 3 - Actions for sustainable community access, use and value</b>
Establish an inter-council working group to provide consistent policy and strategy around access infrastructure for Lake Macquarie.
Introduce dinghy storage racks as a trial at selected high profile/high risk locations (e.g. Valentine, Marmong Point). Publicise and report on the trial
<b>3a. Theme 1 - Actions to manage coastal process hazards and risk (such as erosion and inundation)</b>
Continue Council's foreshore stabilisation program.
Identify actively eroding creek bank sites on public land.
Conduct coast information and action days with local communities on adaptive management of coastal risks.

<b>3b. Theme 6 - Actions for communication and collaboration</b>
Continue education programs for construction industry and residential property owners to promote best practice stormwater management
Continue adaptation conversations and planning with affected communities
Conduct community forums based on collaborative engagement processes when decisions about major coastal management issues are being made
Prepare and deliver a coastal communications strategy to increase appreciation of coastal values and attract more visitors to the coast

## 4.4 Important Challenges to our Living Lake and Lifestyle

A number of ‘stand out’ challenges for managing Lake Macquarie over the next decade were identified from consultation with diverse lake users and stakeholders with responsibilities for management of parts of the catchment and waterway. These are noted below (refer **Table 4.6**).

**Table 4.6 – Important Management Challenges for Lake Macquarie**

<b>Management Challenge</b>
<p><b>Communicating and Collaborating on Strategic Objectives</b></p> <ul style="list-style-type: none"> <li>• Policy settings for natural systems and community enjoyment – getting the best outcomes for a healthy estuary in a growing urban and recreational context.</li> <li>• Communicating with and engaging catchment and waterway users – making behaviours for a healthy lake ‘business as usual’, not an imposition.</li> <li>• Telling the story of Lake Macquarie – natural, cultural and social values, important places and their story.</li> <li>• Targeting information and ‘how to’ advice to the needs of specific user groups, whose activities can be a threat to lake health.</li> </ul>
<p><b>Best Management Practice for Existing and New Development in the Catchment</b></p> <ul style="list-style-type: none"> <li>• Planning and implementing appropriate controls for new development to minimise risks to lake health – turbidity limits on lake health in poor circulation bays.</li> <li>• Retrofitting controls (stormwater) to improve estuary health in sensitive/vulnerable existing development areas – turbidity, chlorophyll levels</li> </ul>
<p><b>Estuary Health and Hazard</b></p> <ul style="list-style-type: none"> <li>• The health status of the Lake Macquarie estuary.</li> <li>• The pressures affecting estuary health status and their relative magnitude.</li> <li>• Proposed actions in the implementation schedule to respond to estuary health pressures.</li> <li>• An estuarine monitoring program, consistent with the NSW Natural Resources Monitoring, Evaluation and Reporting (MER) Strategy.</li> <li>• Estuary processes and hazards within the plan’s area, to a level of detail sufficient to inform decision-making over a planning horizon to 2100.</li> <li>• Projected climate change impacts on estuary health, public safety and built assets.</li> <li>• Proposed actions in the implementation schedule to respond to estuary hazards (shoreline recession and inundation).</li> </ul>

<b>Management Challenge</b>
<p><b>The Foreshore as Contested Space</b></p> <ul style="list-style-type: none"> <li>• Improving the connectivity of water based and land based recreation – infrastructure design and location; foreshore reserve design.</li> <li>• Establishing an adaptive foreshore management mindset. Scenario testing and adaptive responses for various rates of change in natural and social systems. Emergency response planning and community decisions about triggers for initiating long term management responses.</li> <li>• Accommodating increased demand by recreational users – moorings, jetties, ramps, boat storage (dinghies on foreshore), foreshore facilities and links to commercial development (including marinas); information for waterway users.</li> <li>• The lake as an economic driver for the city – strategies to attract visitors (e.g. major events, foreshore access and interpretation) without detracting from current community values; streamlining event planning processes.</li> <li>• Need for detailed place management plans for sensitive and/or heavily used areas, e.g. Point Wolstoncroft, Pulbah Island; foreshore reserve and walk connectivity.</li> <li>• Planning for redesign/relocation of major infrastructure such as sewage system with higher lake levels.</li> <li>• Specific aspects of living on a natural waterway – behaviour changes: moorings over seagrass, razor clams, wrack management, foreshore designs, dredging.</li> </ul>
<p><b>Governance and Funding</b></p> <ul style="list-style-type: none"> <li>• Confirming and maintaining strong governance arrangements and partnerships across different levels of government. Determining who should lead what and when.</li> <li>• Consistent management approaches across Council/WSC interface at southern end of Lake Macquarie.</li> <li>• Sustainable funding model for a healthy coastal zone, including balancing Council investment in lake-focused and coast-focused management issues, access and recreation infrastructure.</li> <li>• Clear decision pathways for immediate and longer term actions.</li> </ul>
<p><b>Building and Applying Best Available Knowledge</b></p> <ul style="list-style-type: none"> <li>• Tracking change in estuary and coastal systems – what to measure, how to measure and report, to track lake condition and the influence of implemented management responses and external drivers (like sea level rise).</li> <li>• Accessing up to date science on coastal and estuary processes and understanding the uncertainty and complexity inherent in the interactions between the physical, biological, chemical and human systems in the estuarine landscape.</li> </ul>

## 5.0 Determining Priority Issues

Many issues associated with risks to the health of Lake Macquarie ecosystems, and threats to community use and enjoyment of the lake have been identified by Council, agencies, technical studies, community groups and individuals. Different stakeholders are likely to have different perceptions of the most important issues and management responses. This section outlines a process to help decide on a consistent suite of priority issues. Efficient and effective management requires that resources are targeted at the most important issues, rather than scattered across multiple less important risks to ecological and community resilience.

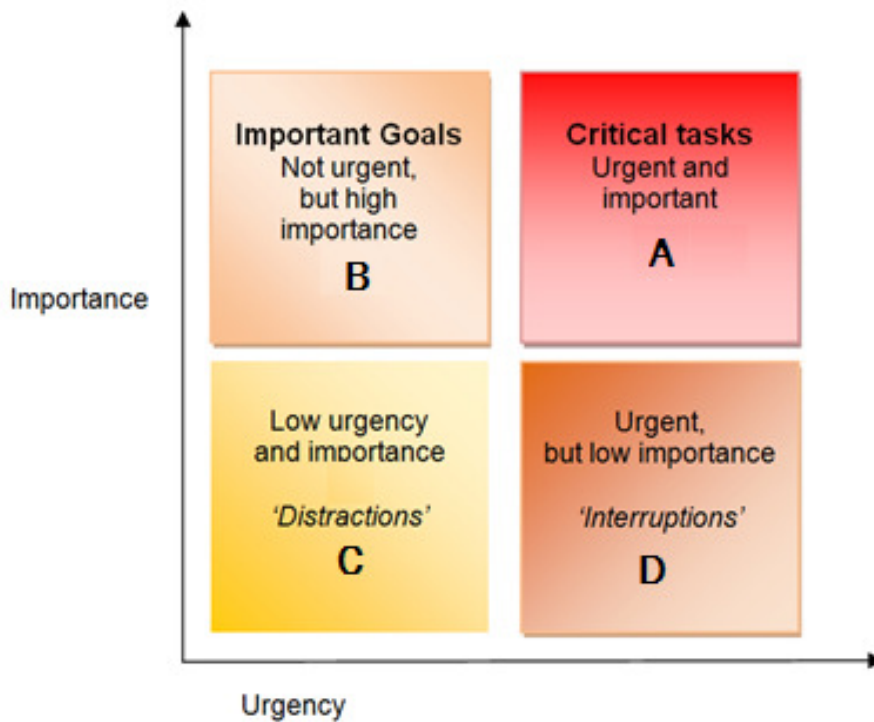
The process of determining important issues considers ‘important’ and ‘urgent’ characteristics in a four quadrant matrix. Issues that are assessed as ‘important’ will have one or more of the characteristics described in Table 5.1. Similarly, as noted in Table 5.1, issues or threats that are ‘urgent’ are generally those which will escalate rapidly if left unattended, or which are already associated with an intolerable risk to the lake and local communities.

**Table 5.1 – Criteria for Defining Priority Issues**

<b>Important</b>	<ul style="list-style-type: none"> <li>• This issue is associated with high risk</li> <li>• This issue affects many stakeholders and community users</li> <li>• The issue affects major community infrastructure and council or other stakeholder investment</li> <li>• The issue has a major impact on the ecology of the lake</li> <li>• The issue is relevant at all timescales</li> </ul>
<b>Urgent</b>	<ul style="list-style-type: none"> <li>• The issue or threat is already assessed as a high to extreme and intolerable risk (as defined in ISO 31000 risk processes)</li> <li>• If action is not taken immediately, the consequences will deteriorate rapidly</li> <li>• If not addressed, this issue will undermine progress on other issues</li> </ul>

**Figure 5.1** shows how importance and urgency are linked to distinguish issues or threats which are:

- ‘critical tasks’ – where effort should be focused;
- important long term goals, but not requiring significant effort immediately;
- distractions – risks that are neither urgent nor important, but which may generate attention which distracts managers from key threats; and
- interruptions – matters which arise from time to time and are urgent (e.g. media coverage, or a response to a localised crisis), but generally not related to important issues.



**Figure 5.1 – Urgency and Importance Matrix for Identifying Priority Issues**

**Table 5.2** applies the ‘Urgency and Importance Matrix’ to the issues identified in **Sections 2 to 4** of this plan. This enables each issue to be assigned a prioritisation category, which is one factor in determining those actions that will be prioritised for implementation.

**Table 5.2 – Categorisation of Estuary health, estuary hazard, community use and consultation issues**

Issue ID	Issue/Threat	Priority of the Issue, Based on Importance and Urgency
<b>A1</b>	Stormwater runoff from urban sub-catchments	<b>Category A</b>
<b>A2</b>	Sediment, nutrient and organic matter loads	
<b>A3</b>	Moorings	
<b>A4</b>	Damage to riparian vegetation (estuarine tributary creeks)	
<b>A5</b>	Inappropriate bank and foreshore stabilisation methods	
<b>A6</b>	Foreshore filling	
<b>A7</b>	Recession and inundation	
<b>B1</b>	Foreshore erosion	<b>Category B</b>
<b>B2</b>	Alteration of natural foreshores	
<b>B3</b>	Terrestrial invasive species	
<b>B4</b>	Aquatic invasive species	
<b>B5</b>	Sea level rise	
<b>B6</b>	Thermal pollution	
<b>B7</b>	Damage to foreshore aquatic vegetation communities	
<b>B8</b>	Private recreational infrastructure	
<b>B9</b>	Dinghy storage	

Issue ID	Issue/Threat	Priority of the Issue, Based on Importance and Urgency
<b>B10</b>	Health and safety of lake users	
<b>C1</b>	Heavy metal contamination	<b>Category C</b>
<b>C2</b>	Recreational fishing	
<b>C3</b>	Vehicle access	
<b>C4</b>	Community connection with environmental and historical values	
<b>C5</b>	Public access to the lake and foreshore	

## 5.1 Selecting the Most Appropriate Responses and Initiatives

For many estuary management issues, there are several options available that may meet Council, agency and community needs, now or at some time in the future.

Options that are available for decision makers include those listed in **Table 5.3**.

**Table 5.3 – Types of Options for Managing Estuary Issues**

Type of Response	Explanation / Example Actions
<b>Business as usual</b>	<ul style="list-style-type: none"> <li>Keep doing what we are doing now – the response that people are familiar with, using existing policy and resource allocation (not the same as doing nothing). This is also the baseline against which to compare other options.</li> </ul>
<b>No regrets</b>	<ul style="list-style-type: none"> <li>Actions that should be taken regardless of the current or expected hazard. Some education and monitoring/reporting actions can be considered as no regrets approaches. Actions that increase efficiency or effectiveness are also no regrets approaches.</li> </ul>
<b>Emergency response</b>	<ul style="list-style-type: none"> <li>Help lines and response mechanisms for flood events, shoreline erosion etc.</li> </ul>
<b>Education and awareness/skill development</b>	<ul style="list-style-type: none"> <li>Public workshops</li> <li>Signage in reserves;</li> <li>Publicity campaigns; and</li> <li>Clean up days, planting days.</li> </ul>

Type of Response	Explanation / Example Actions
<b>Structural and technical works</b>	<p>Includes options such as:</p> <ul style="list-style-type: none"> <li>• Stormwater quality improvement devices;</li> <li>• Shoreline treatments, such as cobble beaches;</li> <li>• Floodgates or barriers e.g. to prevent tidal incursion into fresh water systems;</li> <li>• Changes to infrastructure location or design, or maintenance schedules; and</li> <li>• Decommissioning or redesign or relocation of access infrastructure such as boat ramps, jetties/wharves.</li> </ul>
<b>Environmental sustainability programs (e.g. installing rainwater tanks to reduce peak catchment storm water flows); riparian rehabilitation</b>	<ul style="list-style-type: none"> <li>• Principally aimed at private residences or business in the catchment.</li> </ul>
<b>Land use planning and development control</b>	<ul style="list-style-type: none"> <li>• Design requirements for new development;</li> <li>• Zoning of foreshore land;</li> <li>• Prohibiting certain types of development;</li> <li>• Development Control Plans and Guidelines</li> </ul>
<b>Community on-ground works, such as weeding and tree planting</b>	<ul style="list-style-type: none"> <li>• Landcare;</li> <li>• Crown Reserve Trusts;</li> <li>• Sustainable Neighbourhood Groups</li> </ul>
<b>Economic mechanisms such as insurance or cost recovery for emergency response</b>	<ul style="list-style-type: none"> <li>• Insurance to share risks;</li> <li>• Buy back schemes;</li> <li>• Relocation incentives/subsidies; and</li> <li>• User pays for emergency or other incident assistance.</li> </ul>
<b>Planned relocation of assets</b>	<ul style="list-style-type: none"> <li>• Asset management plans for sewer, water, power, roads, storm water and pathways etc.</li> </ul>
<b>Monitoring the situation or environmental condition</b>	<ul style="list-style-type: none"> <li>• Could include monitoring of hazards (e.g. storm frequency and intensity), costs of damages, riparian vegetation condition along estuarine creeks; algae type and frequency in the lake or estuarine creeks; runoff (storm water) quality; fish diversity etc.</li> </ul>
<b>Regulatory or policy reform</b>	<ul style="list-style-type: none"> <li>• Includes new design standards, sea level benchmark policies, planning policies, offsets etc.;</li> <li>• Changed operating licence conditions for industry.</li> </ul>



The merits of various potential management responses can be assessed qualitatively by considering a suite of criteria which help decision makers to understand the relative costs, benefits and feasibility of potential responses. Hunter Councils (2012) provides a list of relevant criteria, drawing on a range of research and option filtering projects (**Table 5.4**). Any action that is selected for implementation should meet the 'effective', 'proportional' and 'compliant' criteria as a minimum. The other criteria may be considered desirable, but options that meet all criteria should have high priority.

**Table 5.4 – Evaluating Potential Management Options**

Filtering criteria – Options that are Feasible and Appropriate (Hunter Councils, 2012)	
<b>Minimum Criteria for Selected Action</b>	
<b>Effective</b>	Is the proposed action likely to meet the primary objective? Will it result in perverse outcomes in the longer term?
<b>Proportional</b>	Are the costs of the action likely to be in proportion to the expected benefits?
<b>Compliant</b>	Does the proposed action comply with existing legislation, policy and guidelines?
<b>Desirable Criteria for Selected Option</b>	
<b>No regrets/low regrets</b>	Is the proposed action something that should be taken anyway?
<b>Acceptable</b>	Is the option culturally, socially, environmentally or politically acceptable? Will there be a major backlash?
<b>Flexible</b>	Can the option be adjusted? Does it allow for incremental implementation? Does it allow alternative options to be implemented in the future?

These criteria have been used in the evaluation of options for managing the Lake Macquarie estuary and they inform the suggested priorities for implementing actions in option tables in **Sections 6 to 12** and in the implementation tables in **Sections 13 and 14.0**.

### 5.1.1 Applying the Filtering Criteria

**Table 5.5** shows how the criteria have been applied to identify categories of potential actions. Category A actions are actions that respond to important issues, can provide direct benefits and can be done now. Category B actions relate to important issues, but could not be implemented now because preparation is needed to address one or more of the criteria.

Category C actions could be done now, but address less important (and less urgent) issues, so they can be implemented when opportunities arise. Category D actions relate to less important issues but are also difficult to implement because they would not be consistent with current legislation or are high cost for the likely return to the community or the environment. These categories of value are noted in each of the option tables in **Sections 6.0 to 12.0**.

**Table 5.5 – Value of Potential Actions**

		Constraints	
		Less Constraints	More Constraints
Importance	Higher	<p><b>Category A</b> <b>Important and Easy</b> Take action NOW. These actions treat high priority risks, and can be done with available funds, (proportional investment to risk and benefits); they are consistent with current legislation/policy and governance arrangements</p>	<p><b>Category B</b> <b>Important but Tricky</b> Take action NOW to reduce barriers and enhance opportunities. These are ‘preparation’ actions, so that actions can move into the Important and Easy category when needed.</p>
	Lower	<p><b>Category C</b> <b>Not so Important, but Easy</b> Take action when opportunities present – these actions are ‘bonuses’ – schedule for implementation, but not urgently.</p>	<p><b>Category D</b> <b>Too Hard for Now</b> Take action to remove barriers and enhance opportunities when opportunities present (focus initially on ‘important but tricky’)</p>

## 5.2 Implementation Risks

Implementation risks refer to things that can go wrong as Council and estuary stakeholders commence projects aligned with any of the broad strategic themes identified in the CZMP. These factors can affect the likelihood that a management approach can be implemented as intended, or that it can be effective.

At any time, options and their implementation may be constrained by a range of non-technical factors, summarised below:

- Availability of resources. Where implementation is dependent on grant funding or other funding allocations from constrained budgets, which are competitive and uncertain, there is a risk that funding may be discontinued before the full strategy has been implemented (e.g. special purpose levies may be discontinued). In addition, the cost of monitoring programs, essential for adaptive learning and for identifying trigger points for changing management responses, may be overlooked in initial budget planning.
- Existing legislation. As noted above, compliance with existing legislation is essential for high priority management responses. However, there are situations where the existing legislation requires reform to accommodate new situations or pressures, and this has not been achieved, compromising the integrity of the particular option to be implemented.
- Community acceptance. Community preferences may change dramatically once a project starts to be implemented and the full consequences become clearer. Community preferences for investment and willingness to contribute may also change (e.g. in relation to special purpose levies or charges for use of facilities).
- Political will. Political interest and capacity can change after local government elections or more broadly after state or national elections.
- Existing planning or tenure arrangements (such as ‘existing use rights’).

- Poor scientific or technical knowledge/high uncertainty. In these situations, the management response may be a pilot process only, to build a body of knowledge about the likely effectiveness of structural or rehabilitation solutions.

### 5.3 Generating the implementation schedules

In general actions that were allocated an 'A' score in the tables in **Sections 6 to 12** are in the programs of work to be implemented in the first period of the Plan (0-4 years). Actions to be included in the short term programs of work are considered 'Important' and 'Easy' to accomplish. They are also necessary for establishing the adaptive framework. These short term work programs include actions that address key risks or threats AND can be done within existing statutory and policy frameworks, require limited external collaboration (or partnerships that have already been established), can be funded internally (or with limited grants) and the work is within Council's technical and resourcing capacity. The themes and categories are included in the table to link actions in each program back to the issues identified during consultation and technical analysis.

Most of the actions that were placed in the 'B' category in **Sections 6 to 12** are also in these work programs for the second stage of implementation (medium term actions – 4 to 10 years). These actions may be included as a high priority when they describe work that is needed to address barriers to the implementation of other important actions. As above, the themes and categories are included in the tables to link actions in each program back to the issues identified during consultation and technical analysis.

Actions in Category C are included in, as 'no regrets' actions that Council could implement at any time, when adequate funds are available, or to support other priority actions. Options identified as Category D are generally not included in the implementation tables at this time.

## 6.0 Theme 1: Options to Manage Estuary Process Hazards and Risks

This section includes an evaluation of multiple options which could be considered for improved management of lake hydrodynamic and foreshore process issues. **Table 6.1** covers foreshores and creek banks.

**Table 6.1- Options relevant to the lake foreshore and creek banks**

What we want to achieve:							
<ul style="list-style-type: none"> <li>To actively manage streambank and foreshore erosion</li> <li>To plan and adapt for climate change impacts (recession and inundation) on the natural, built environment and community access arrangements.</li> </ul>							

ID No.	Option	Focus	Plan Reference	Issue Category	Proportional Investment to Risk Benefit	Immediate implementation possible	Value Category
1/1	Conduct a condition assessment of existing lake foreshore erosion treatment sites (on public land) to determine their current condition and performance.	Public foreshores subject to higher wave energy	Section 2.2.1 – Foreshore erosion	A2 A5 B1	Y	Y	A
1/2	Continue Council's foreshore stabilisation program	Priority sites displaying active erosion; Previously rehabilitated sites requiring maintenance	Section 2.2.1 – Foreshore erosion	A2 B1	Y	Y	A
1/3	Develop a Foreshore Guideline for residents that includes integration of environmentally friendly foreshore stabilisation techniques	DCP Guidelines	Section 2.2.1 – Foreshore erosion	A2 A5 A6	Y	Y	A
1/4	Identify actively eroding creek bank sites on public land	Whole of catchment	Section 2.2.2 – Bank stability of tributary creeks	A1 A2 A4	Y	Y	A

ID No.	Option	Focus	Plan Reference	Issue Category	Proportional Investment to Risk Benefit	Immediate implementation possible	Value Category
1/5	Continue Council's streambank stabilisation program	Tributaries in catchments with highly erodible soils; priority sites displaying active erosion	Section 2.2.2 – Bank stability of tributary creeks	A1 A2 A4	Y	Y	A
1/6	Review Council's Creek bank stabilisation guidelines and incorporate recommendations relating to predicted climate change impacts	DCP Guidelines	Section 2.2.2 – Bank stability of tributary creeks	A1 A2 A4 A5	Y	Y	A
1/7	Review a sample of creek bank stabilisation works undertaken by Council to identify any potential design improvements required for future works	Sites previously subject to rehabilitation works	Section 2.2.2 – Bank stability of tributary creeks	A1 A2 A4	Y	Y	A
1/8	Prepare flood risk management studies and plans to enhance understanding of risks and provide for consistent management of floodplains in the Lake Macquarie catchment	Major estuarine creeks	Section 2.2.1 – Foreshore erosion	A7	Y	Y	A
1/9	Establish consistent foreshore design requirements and management priorities with WSC	Development Control Plan; Foreshore stabilisation works undertaken by public authorities	Section 2.2.1 – Foreshore erosion	A5 B1 B2 B7	Y	N	B
1/10	Conduct a climate change risk review of high risk tributary catchments	High risk tributary catchments	Section 2.2.2 – Bank stability of tributary creeks	B6 B10	Y	N	B
1/11	Prepare policy statements to clarify requirements for filling of floodplain areas	Whole of catchment	Section 2.2.1 – Foreshore erosion	A7	Y	N	B

ID No.	Option	Focus	Plan Reference	Issue Category	Proportional Investment to Risk Benefit	Immediate implementation possible	Value Category
1/12	Conduct further consultation and training to support redesign and restructure of bank protection works on private land where they are contributing to poor sediment, nutrient or ecological outcomes.	Residents along tributary estuarine creeks	Section 2.2.2 – Bank stability of tributary creeks	A1 A2 A4 A5	N	Y	D
1/13	Unification, extension or removal of short seawalls to manage erosion edge effects	Priority foreshore areas subject to Climate Change Adaptation Planning	Section 2.2.1 – Foreshore erosion	A5 B1 B2	N	N	D
1/14	Control ad hoc access along the foreshore to limit vegetation trampling and bank destabilisation	Sites of high environmental significance	Section 2.2.1 – Foreshore erosion	B1 B2 B7 C3	N	N	D

## 6.1 Management Options – Inundation

Council has recently adopted its Lake Macquarie Flood Risk Study and Management Plan (WMA Water 2012a-b) and Council is currently implementing high priority actions from the Plan. The Estuary part of the CZMP does not propose additional management responses to address lake flooding and inundation risks. **Table 6.2** highlights high priority actions from the Flood Risk Management Plan.

**Table 6.2 – High and Medium Priority Actions from the Lake Macquarie Flood Risk Management Plan**

Action	Responsibility
<b>High Priority</b>	
Undertake a detailed assessment (Local Area Adaptation Plans) for each foreshore management area, in consultation with each affected community, of the implications and adaptation measures available to plan for and mitigate the effects of sea level rise (flooding and tidal inundation).	Council Commenced 2012
Undertake a detailed review of the provision and maintenance of services and infrastructure in the	Council and other service providers



Action	Responsibility
foreshore areas in the year 2050 and 2100.	
Establish criteria to define when land becomes “unsuitable” for current or proposed future use due to permanent inundation	Council
Review the wording on the Section 149 certificates, development restriction. Certificates and flood control lot certificates to incorporate revised flood planning levels and new permanent inundation planning level.	Council Implemented in 2012
Review strategic land use planning to accommodate adaptation to changed flooding and inundation due to sea level rise. The review should include suitable development densities and types, possible need for retreat areas, future protection and adaptation of foreshore ecosystems, foreshore access and recreation, foreshore community facilities, and land required for infrastructure and protection works.	Council and NSW Government
Develop or adopt financial models to prepare for future costs of possible protection works, infrastructure up-grades, relocations, and other adaptation options.	Council and other service providers
<b>Medium Priority</b>	
Undertake a review of the suitability of slab on ground construction in the foreshore areas and whether other forms of building construction can be undertaken that would reduce flood hazard and/or allow future adaptation such as house raising.	Council and NSW Government
Undertake a review of the flood warning system and if necessary update.	Council and Bureau of Meteorology
Review Council’s policy “Caravan Parks on Flood Prone Lands Surrounding Lake Macquarie Waterway (2005)” for caravan and cabin parks in the foreshore area.	Council and caravan park owners

## 7.0 Theme 2: Options for Healthy Lake Systems – Protecting Biodiversity and Ecological Resilience

This section highlights and evaluates potential options for improving the management of the biodiversity values of the estuary. **Table 7.1** evaluates options for a range of biodiversity management issues including estuary water quality, sea grass management (mooring management issues), foreshore access management and monitoring.

**Table 7.1 – Options for managing biodiversity issues**

What we want to achieve							
<ul style="list-style-type: none"> <li>• Clear lake water with low suspended sediment (TSS) and algae (Chlorophyll-a) concentrations.</li> <li>• Quality and flow of stormwater from existing urban areas that meets water quality objectives for the lake tributaries and the Lake itself.</li> <li>• Understanding of the distribution and severity of heavy metal contaminants in the estuary and tributaries</li> <li>• Protection and enhancement of estuary biodiversity, particularly EECs and Threatened Species (as listed under the TSC Act 1995) and other key habitats.</li> <li>• Measurable increases in the extent and health of native riparian, foreshore and aquatic vegetation.</li> <li>• New development and recreational use that occurs in a manner that maintains and enhances landscape values and ecological functions.</li> <li>• Resilient estuarine ecological communities (seagrass, saltmarsh, wetlands and mangrove and associated fauna) which can adapt to projected climate change and sea level rise.</li> <li>• Statutory protection and planning controls are consistent with the ecosystem service value of Lake Macquarie as a healthy functioning system.</li> </ul>							

ID No.	Option	Focus	Plan Reference	Issue Category	Proportional Investment to Risk Benefit	Immediate implementation possible	Value Category
2/1	Continue compliance activities relating to erosion and sediment controls	Greenfield development sites; development sites in close proximity to the lake and tributaries	Section 2.5.1 – Lake water quality Section 2.5.2 – Water quality in lake tributaries	A1 A2	Y	Y	A

ID No.	Option	Focus	Plan Reference	Issue Category	Proportional Investment to Risk Benefit	Immediate implementation possible	Value Category
2/2	Continue the lake health monitoring program (water quality and ecological indicators), consistent with NSW State-wide MER (Monitoring, Evaluation and Review) program	Ongoing data collection at existing monitoring sites	Section 2.5.1 – Lake water quality Section 2.5.2 – Water quality in lake tributaries	A1 A2	Y	Y	A
2/3	Apply WSUD to all new developments to ensure treatment of 50-80% of stormwater from each subcatchment in new subdivisions.	Generation hotspots within urban sub-catchments	Section 2.5.1 – Lake water quality Section 2.5.2 – Water quality in lake tributaries	A1 A2	Y	Y	A
2/4	Support further scenario testing of the Ecological response model with respect to stormwater treatment in specific subcatchments.	Sensitive sub-catchments	Section 2.5.1 – Lake water quality Section 2.5.2 – Water quality in lake tributaries	A1 A2	Y	Y	A
2/5	Review & apply Council's DCP controls and Water Cycle Management Guidelines for all new development	Whole of catchment	Section 2.5.1 – Lake water quality Section 2.5.2 – Water quality in lake tributaries	A1 A2	Y	Y	A
2/6	Monitor vegetated SQID performance in relation to maintenance practice	Whole of catchment	Section 2.5.1 – Lake water quality Section 2.5.2 – Water quality in lake tributaries	A1 A2	Y	Y	A
2/7	Continue to implement the current riparian corridor rehabilitation program.	Priority estuarine creek systems such as LT Creek, Mannering Creek, and Wyee Creek	Section 2.5.1 – Water quality in lake tributaries	A2 A4	Y	Y	A

ID No.	Option	Focus	Plan Reference	Issue Category	Proportional Investment to Risk Benefit	Immediate implementation possible	Value Category
2/8	Develop a riparian guideline that outlines develop requirements and restoration solutions	Whole of catchment	Section 2.5.2 – Water quality in lake tributaries	A2 A4 A5	Y	Y	A
2/9	Establish a mooring working group, to make recommendations on reducing mooring impacts on sensitive seagrass beds	Moorings over <i>Posidonia australis</i> beds	Section 2.6.2 - Seagrass	A3	Y	Y	A
2/10	Hold a forum to discuss options for boat moorings in Lake Macquarie to minimise impacts on sensitive seagrass beds and to provide practical designs.	Moorings over <i>Posidonia australis</i> beds; Mooring areas subject to high wave energy or currents	Section 2.6.2 - Seagrass	A3	Y	Y	A
2/11	Review DCP controls to incorporate best practice jetty designs suitable for installation in Lake Macquarie. Update as necessary to meet ecological and recreational objectives.	Development Control Plan	Section 2.6.2 - Seagrass	B7 B8	Y	Y	A
2/12	Prepare management guidelines for <i>Posidonia australis</i> in Lake Macquarie, consistent with the types of information that Council provides on other threatened species	Development Control Plan	Section 2.6.2 - Seagrass	A3 B7	Y	Y	A
2/13	Continue seagrass mapping and health monitoring, and investigate partnership opportunities with other organisations required to monitor seagrass	Partnerships; Consistent monitoring methodology	Section 2.6.2 - Seagrass	A1 B2	Y	Y	A
2/14	Prioritise and undertake rehabilitation works in estuarine and floodplain wetland areas for protection and management.	Areas sensitive to climate change impacts	Section 2.6.3 - Wetlands	A4 B7	Y	Y	A

ID No.	Option	Focus	Plan Reference	Issue Category	Proportional Investment to Risk Benefit	Immediate implementation possible	Value Category
2/15	Identify, prioritise and undertake rehabilitation works in wetlands (all types of estuary wetlands) where protected buffer areas can be established to facilitate retreat.	Planning controls and rehabilitation works	Section 2.6.3 - Wetlands	A7 B7	Y	Y	A
2/16	Develop a foreshore development guideline that includes low impact methods for recreational structures and foreshore stabilisation treatments	Development Control Plan; Absolute waterfront private property	Section 2.2.1 – Foreshore erosion Section 2.5.1 – Lake water quality Section 2.6.2 - Seagrass	A5 A6 B8	Y	Y	A
2/17	Continue education programs for construction industry and residential property owners to promote best practice stormwater management and how to reduce individual impacts.	Catchment-wide	Section 2.5.1 – Lake water quality Section 2.5.2 – Water quality in lake tributaries	A1 A2	Y	Y	A
2/38	Investigate the feasibility of a catchment based project to improve water quality and ecological condition in LT Creek and Fennel Bay	LT Creek	Section 2.5.1 – Lake water quality Section 2.5.2 – Water quality in lake tributaries	A1 A2	Y	Y	A
2/20	Retrofit existing stormwater quality improvement devices.	Generation hotspots within urban sub-catchments	Section 2.5.1 – Lake water quality Section 2.5.2 – Water quality in lake tributaries	A1 A2	Y	Y	A

ID No.	Option	Focus	Plan Reference	Issue Category	Proportional Investment to Risk Benefit	Immediate implementation possible	Value Category
2/21	Install and maintain WSUD devices to reduce sediment and nutrient load	Generation hotspots within urban sub-catchments	Section 2.5.1 – Lake water quality Section 2.5.2 – Water quality in lake tributaries	A1 A2	Y	Y	A
2/39	Advocate for a NSW Container Deposit System	Gross litter	Section 2.5.1 – Lake water quality Section 2.5.2 – Water quality in lake tributaries	A1 A2	Y	Y	A
2/18	Conduct an audit of privately owned/constructed foreshore structures and identify structures that are illegal or are having a significant impact on the health of the creek/foreshore area.	Privately owned foreshore properties	Section 2.5.1 – Lake water quality Section 2.5.2 – Water quality in lake tributaries	A5 A6 B2 B7	N	N	B
2/19	Regularly review water quality targets for runoff from new development	In conjunction with long-term monitoring results	Section 2.5.1 – Lake water quality Section 2.5.2 – Water quality in lake tributaries	A1 A2	Y	N	B
2/22	Investigate the use of stormwater levy funds to upgrade systems	Wyong City Council	Section 2.5.1 – Lake water quality Section 2.5.2 – Water quality in lake tributaries	A1 A2	Y	N	B
2/23	Initiate a targeted water quality improvement campaign with priority industry types	Industrial zones adjoining waterways	Section 2.5.1 – Lake water quality Section 2.5.2 – Water quality in lake tributaries	A1 A2	N	N	B



ID No.	Option	Focus	Plan Reference	Issue Category	Proportional Investment to Risk Benefit	Immediate implementation possible	Value Category
2/24	Conduct an audit of non-licensed premises that have potential to discharge polluted waters to Lake Macquarie	Industrial developments adjoining tributaries or the lake itself	Section 2.5.1 – Lake water quality Section 2.5.2 – Water quality in lake tributaries	A1 A2	Y	N	B
2/25	Explore options for integrating lake water quality and hydrology data sets from different sources – industry, Council and community, to provide access to a comprehensive suite of data for the lake.	Partnerships; Consistent monitoring methodology	Section 2.3 – Estuary hydrodynamic processes Section 2.5.1 – Lake water quality Section 2.5.2 – Water quality in lake tributaries	A1 A2	N	Y	B
2/26	Support research on the impacts of cooling water discharges on the estuarine ecology of Lake Macquarie	Discharge intake, outlets and surrounds	Section 2.3 – Estuary hydrodynamic processes	B6	Y	N	B
2/27	Clarify Council’s policy position on forced removal of illegal foreshore/creek bank structures.	Dora Creek, Shepherds Creek, residential areas most affected by sea level rise	Section 2.2.1 – Foreshore erosion Section 2.5.1 – Lake water quality Section 2.5.2 – Water quality in lake tributaries Section 2.6.2 - Seagrass	A4 A5 A7 B2	N	Y	B

ID No.	Option	Focus	Plan Reference	Issue Category	Proportional Investment to Risk Benefit	Immediate implementation possible	Value Category
2/28	Conduct community information days on foreshore and creek bank management – structures, planting and options for access.	Waterfront property owners	Section 2.2.1 – Foreshore erosion Section 2.5.1 – Lake water quality Section 2.5.2 – Water quality in lake tributaries Section 2.6.2 - Seagrass	A4 A5 B2 B7 B8	N	Y	B
2/29	Initiate a trial replacement of existing swing moorings with environmentally friendly moorings.	Lake Macquarie Yacht Club and/or Boat Owners Association.	Section 2.6.2 - Seagrass	A3	Y	N	B
2/30	Prepare and distribute written information for the community that identifies areas of seagrass (by species), stressing the ecological and community use value of healthy seagrass.	Waterfront property owners, mooring lease holders	Section 2.6.2 - Seagrass	B7	N	Y	B
2/31	Initiate research program into variations in seagrass dynamics and causes for observed seagrass losses.	Seagrass beds exhibiting high levels of spatial and temporal variation	Section 2.6.2 - Seagrass	B7	N	N	B
2/32	Investigate status and condition of remaining saltmarsh sites and opportunities for managing saltmarsh on private land.	Saltmarsh adjoining or within an urban / suburban context	Section 2.6.4 – Mangroves and Saltmarsh	A7 B7	N	N	B
2/33	Convert modified non-saline foreshore areas to saltmarsh.	Non-saline foreshore areas on public land	Section 2.6.4 – Mangroves and Saltmarsh	B2 B7	Y	N	B

ID No.	Option	Focus	Plan Reference	Issue Category	Proportional Investment to Risk Benefit	Immediate implementation possible	Value Category
2/34	Identify and promote nationally significant ecological values of Lake Macquarie, to enhance potential for access to Commonwealth funds for environmental management.	Catchment-wide	Section 2.0	All issues	N	N	B
2/35	In consultation with EPA, review the water quality management controls and processes at licensed premises.	EPA licensed premises	Section 2.5.1 – Lake water quality Section 2.5.2 – Water quality in lake tributaries	A1 A2	N	N	B
2/36	Support a partnership with power stations, OEH, EPA and DPI fisheries to determine and implement ongoing best practice management of discharge heat.	Partnerships; Best practice management	Section 2.3 – Estuary hydrodynamic processes	B6	Y	N	B
2/37	Support further investigation and analysis of catchment loads of metals and other substances (such as Selenium) and of the distribution of metalliferous contamination in bed sediments of the lake.	Northern reaches of the estuary	Section 2.5.4 – Contaminated sediments	C1	N	Y	C

## 8.0 Theme 3: Options for Sustainable Community Access, Use and Value

**Table 8.1** presents an evaluation of options which have the potential to manage a range of community use issues.

**Table 8.1: Options for community use issues**

### What we want to achieve:

- Cost effective, well designed foreshore and recreation infrastructure.
- An adaptive foreshore management mindset across the community.
- Acceptance amongst lake users that protecting the natural and cultural values of some locations constrains use.
- Foreshore access and usage is consistent with protection of natural bushland values along the foreshore.
- Sufficient safe and environmentally friendly boat moorings/berths to meet the needs of the recreational boating community.
- Public foreshore land is managed to provide access and amenity for diverse users.
- Recreational access does not interfere unreasonably with the amenity of local residents.
- A well developed and extensive foreshore pathway to provide along-shore access for residents and visitors and promote the natural and amenity values of the lake.
- Healthy fish stocks in Lake Macquarie, supporting recreational fishing.

ID No.	Option	Focus	Plan Reference	Issue Category	Proportional Investment to Risk Benefit	Immediate implementation possible	Value Category
3/1	Update the Mooring Management Plan for Lake Macquarie.	Mooring areas over seagrass beds	Section 2.6.2 – Seagrass Section 3.3.3 - Jetties and Moorings	A3 A7	Y	Y	A

ID No.	Option	Focus	Plan Reference	Issue Category	Proportional Investment to Risk Benefit	Immediate implementation possible	Value Category
3/2	Establish an inter-council working group to provide consistent policy and strategy around access infrastructure for Lake Macquarie.	Lake-wide	Section 3.3 – Water Based community Use Section 3.4 – Foreshore-based Community Use	B2 B7 B9 C2 C3	Y	Y	A
3/3	Continue to report on boat usage statistics for Lake Macquarie, including vessel size, numbers and locations of swing moorings, numbers of vessels berthed in marinas, and any incidents associated with mooring location, function or interaction with jetties.	Data collection	Section 3.3.1 – Boat Ownership & Usage	A3 B9 C3	Y	Y	A
3 /4	Introduce dinghy storage racks as a trial at selected high profile/high risk locations (e.g. Valentine, Marmong Point). Publicise and report on the trial.	Public foreshores adjoining mooring areas	Section 3.3.5 – Dinghy Storage	B9	Y	Y	A
3/5	Prepare a public wharf, jetty and boat ramp strategies for Lake Macquarie.	Long term recreational use	Section 3.3 – Water Based community Use	B2 B7 C5	Y	Y	A
3/36	Request Lake Macquarie participation in trials to reduce fishing impacts on turtles	Recreational crab net use	Section 3.3 – Water based community use	B2 B7	Y	Y	A
3/7	Investigate the feasibility of an integrated foreshore Icon Park network, including upgrades required at foreshore reserves (facilities, interpretation, pathways).	Community engagement regarding natural and historical values	Section 3.2 - Heritage	C3	Y	N	B

ID No.	Option	Focus	Plan Reference	Issue Category	Proportional Investment to Risk Benefit	Immediate implementation possible	Value Category
3/8	Prepare a boating management plan for Lake Macquarie.	Balance of recreation and environmental values	Section 3.3 – Water Based community Use	A3 B9 C3	Y	N	B
3/9	Investigate and assess the appropriate long term balance between swing moorings and marina berths for keeled and motor recreation vessels.	Data collection and analysis	Section 3.3.3 – Jetties and Moorings	A3	Y	N	B
3/10	Consult widely about issues associated with dinghy storage on the foreshore of reserves around Lake Macquarie.	Public foreshores adjoining mooring areas	Section 3.3.5 – Dinghy Storage	B2 B7 B9	N	N	B
3/11	Conduct an audit of dinghy storage on the foreshore of Lake Macquarie, considering locations, numbers of dinghies, ownership of dinghies (local or more remote), links to vessels moored in the bay; existing tethering processes; safety issues.	Public foreshores adjoining mooring areas	Section 3.3.5 – Dinghy Storage	B2 B7 B9	N	N	B
3/12	Implement the dinghy storage policy for Lake Macquarie.	Public foreshores adjoining mooring areas	Section 3.3.5 – Dinghy Storage	A3	Y	N	B
3/13	Update the integrated foreshore management strategy for Lake Macquarie, highlighting strategic direction for public land around the lake.	Strategy	Section 3.4 – Foreshore-based Community Use	All issues	N	N	B
3/14	Support NPWS in efforts to manage invasive species (lantana, bitou, asparagus fern, etc.).	NPWS reserves and adjoining public land	Section 3.4.1 – Foreshore Reserves	B3	Y	N	B

ID No.	Option	Focus	Plan Reference	Issue Category	Proportional Investment to Risk Benefit	Immediate implementation possible	Value Category
3/15	Investigate options and priorities for transfer other (not SCA) sections of bushland foreshore to conservation management	Bushland foreshore parcels without conservation status	Section 3.4.1 – Foreshore Reserves	Multiple issues	N	N	B
3/16	Investigate the likely cause of the apparent increase in the abundance of razor clams.	Waters adjoining public foreshores with high recreational use such as designated swimming areas	Section 3.6 – Safety Issues	B10	N	N	B
3/17	Provide sharps disposal bins located within foreshore reserve areas, accessible 24 hours daily.	High use public foreshores such as Speers Point Park	Section 3.6.1 – Needle-stick injury	B10	Y	N	B
3/18	Education on the presence of sharks in the lake and their role in the ecology of the lake.	Community engagement	Section 3.6.3 - Sharks	B10	N	N	B
3/19	Targeted removal of razor clams from popular recreational areas (e.g. Belmont Baths).	Designated swimming areas	Section 3.6.3 – Razor Clams	B10	N	Y	B
3/20	Beach and sandy foreshore cleaning to remove needles and syringes.	High recreational use public foreshores	Section 3.6.1 – Needle-stick injury	B10	N	N	B
3/21	Review Council's policy position on shark netting around public swimming areas	Policy review in light of updated incident data	Section 3.6.3 - Sharks	B10	N	N	B
3/6	Install signs warning the public of potentially hazardous marine life (razor clams, blue-ringed octopus), methods to avoid injury and the significance of these species to the ecology of the lake.	Public foreshores with high recreational use	Section 3.6 – Safety Issues	B10	Y	Y	C
3/22	Where a boat ramp currently does not have a jetty adjacent, construct a jetty/pontoon to streamline launching, boarding and retrieval.	Public boat ramps in waters with rapidly varying or high currents	Section 3.3.2 – Boat Ramps	B10 C5	N	N	C



ID No.	Option	Focus	Plan Reference	Issue Category	Proportional Investment to Risk Benefit	Immediate implementation possible	Value Category
3/23	Conduct a traffic study of cars and trailers using boat ramps around Lake Macquarie (in Lake Macquarie and Wyong Shire).	Data collection - balance of car versus trailer use of car-park facilities	Section 3.3.2 – Boat Ramps	C5	Y	Y	C
3/24	Consult with residents living in streets regularly used for parking for boat ramps and overflow from reserves in peak periods.	Informal and formal boat launch sites	Section 3.3.2 – Boat Ramps	C5	Y	Y	C
3/25	Install new artificial reefs to enhance fish stocks and diversity for recreational fishing.	Recreational fishing	Section 3.3.7 - Fishing	C2	Y	N	C
3/26	Prepare interpretative signage for lake foreshore paths to tell the story of the lake and its community lifestyle and heritage.	All public foreshore parks and bushland reserves	Section 3.4.1 – Foreshore Reserves	C4	Y	Y	C
3/28	Identify interpretative themes for different foreshore reserves around Lake Macquarie (i.e. one overarching design theme, different knowledge foci).	Community engagement	Section 3.4.1 – Foreshore Reserves	C4	Y	N	D
3/29	Review and update priorities for acquisition of land to maintain access, as previously identified in the draft foreshore strategy	Public access along the lake foreshore	Section 3.4.1 – Foreshore Reserves	C5	N	N	D
3/30	Dredge the nearshore at Warners Bay (and other locations where relevant) to provide navigable access to the existing jetty.	Public access	Section 3.5 – Linking Lake & Foreshore Use	C5	N	N	D

ID No.	Option	Focus	Plan Reference	Issue Category	Proportional Investment to Risk Benefit	Immediate implementation possible	Value Category
3/31	Design and construct a deep water access jetty at Warners Bay, similar to the one at Speers Point. The jetty would need to extend at least 40 metres from the shore and be designed to allow use in diverse weather conditions. Note exposure of the shoreline to southerly winds.	Warners Bay	Section 3.5 – Linking Lake & Foreshore Use	C5	N	N	D
3/32	Conduct routine studies of species present in Lake Macquarie and catch per unit effort of recreational fish.	Comparisons between artificial reefs, outlet canals and general lake body	Section 3.3.7 - Fishing	C2	N	N	D
3/33	Creation of clean sand bottom in nearshore shallow areas of popular swimming areas.	Improved recreational experience	Section 3.4 – Foreshore-based Community Use	C5	N	N	D
3/34	Construct and upgrade existing formal pathways for people to walk through bushland foreshore reserves (like the Green Point track).	Increase community connection with the natural environment	Section 3.4.1 – Foreshore Reserves	C4	Y	N	D
3/35	Extend the formal shared pathway around the foreshore.	Increase community connection with the natural environment	Section 3.4.1 – Foreshore Reserves	C4 C5	Y	N	D

## 9.0 Theme 4: Options to Enhance Council's Estuary Management Capacity and Focus

This theme is about Council's internal management capacity in relation to estuary health and use. **Table 9.1** evaluates potential management options.

**Table 9.1 – Potential options to enhance management capacity**

What we want to achieve for resources for lake management							
<ul style="list-style-type: none"> <li>Appropriate resourcing for estuary management programs, in the context of overall priorities in the coastal zone.</li> </ul>							

ID No.	Option	Focus	Plan Reference	Issue Category	Proportional Investment to Risk Benefit	Immediate implementation possible	Value Category
4/1	Develop an integrated coastal zone management implementation strategy and funding plan for the open coast and estuarine parts of the Lake Macquarie coastal zone.	Strategy	Section 1	Applies to all issues	Y	Y	A
4/2	Investigate and utilise all relevant and cost effective external funding avenues, to facilitate implementation. An example is potential packaging of coastal zone management activities to meet Commonwealth priorities.	Funding	Section 1.7 – Funding for estuary management actions	Applies to all issues	Y	Y	A

ID No.	Option	Focus	Plan Reference	Issue Category	Proportional Investment to Risk Benefit	Immediate implementation possible	Value Category
4/3	Review the membership of the Estuary and Coastline Management committee and reform as a Coastal Zone Panel, with representatives of key stakeholder groups for both the estuary and open coast. Also review membership of the Aquatic Services Committee.	Implementation	Section 4.0 – Consultation about Lake Management	Applies to all issues	Y	Y	A

## 10.0 Theme 5: Strong Governance and Supportive Partnerships

The options in **Table 10.1** address issues associated with Council's partnerships with adjoining local government areas, agencies and industry to achieve its objectives.

**Table 10.1 – Governance and partnerships**

<b>What we want to achieve for lake management responsibility and accountability:</b>							
<ul style="list-style-type: none"> <li>Clear definitions of objectives, responsibility and accountability so Council, agencies and community can work collaboratively. This includes all stages of adaptive management, from planning, through implementation, monitoring, evaluation and review.</li> </ul>							

ID No.	Option	Focus	Plan Reference	Issue Category	Proportional Investment to Risk Benefit	Immediate implementation possible	Value Category
5/1	Allocate resources to carefully monitor opportunities under all grant programs and to ensure grant applications are best positioned to deliver funding for CZMP projects.	Funding	Section 1.7 – Funding for estuary management actions	Applies to all issues	Y	Y	A
5/2	Maintain close liaison with State and Commonwealth agencies about Lake Macquarie issues and initiatives, to lay groundwork for investment in innovative management, planning, monitoring and reporting processes.	Partnerships	Section 4 – Consultation about Lake Management	Applies to all issues	Y	Y	A
5/3	Review the applicability of stormwater levies (Wyong Council) for estuary management works (catchment runoff controls) that focus on water quality and estuary health	Funding	Section 1.7 – Funding for estuary management actions	Applies to all issues	N	Y	B

## 11.0 Theme 6: Options for Communication and Collaboration – Behaviours to Make a Healthy Lake Business as Usual

The options in **Table 11.1** highlight how Council could work with its community to influence and change behaviours.

**Table 11.1 – Options to modify behaviour**

### What we want to achieve for useful information for sustainable behaviours:

- All decision makers have appropriate knowledge to balance ecological and community values
- Lake Macquarie residents, ratepayers and waterway users demonstrate behaviours consistent with stewardship of healthy estuary systems
- Residents, ratepayers and waterway users have access to knowledge that meets their needs, so they can make informed decisions about aspects of their lifestyle that have the potential to affect the health of the lake.
- Councillors own solutions that are good for the lake and good for the community.
- Residents, ratepayers and visitors have access to places and information which showcase the Awabakal and historic heritage values of the Lake Macquarie landscape.
- A transparent and accessible process for ratepayers and residents to contribute to objectives and decisions about the future of the lake.

ID No.	Option	Focus	Plan Reference	Issue Category	Proportional Investment to Risk Benefit	Immediate implementation possible	Value Category
6/1	Continue adaptation conversations and planning with affected communities.	Urban areas most affected by sea level rise	Section 2.4 – Estuary Inundation	B5	Y	Y	A
6/2	Regularly use electronic surveys and feedback opportunities on lake management issues, via Council's web site.	Community Consultation	Section 4.0 – Consultation about Lake Management	All issues	Y	Y	A

ID No.	Option	Focus	Plan Reference	Issue Category	Proportional Investment to Risk Benefit	Immediate implementation possible	Value Category
6/3	Collaborate with University of Newcastle and other tertiary institutions to bring new research results into the community.	Community engagement; research opportunities	Section 4.0 – Consultation about Lake Management	All issues	Y	Y	A
6/4	Use local media to promote estuary management activities or works	Community engagement	Section 2.0 – The natural systems of Lake Macquarie	All issues	Y	Y	A
6/5	Conduct community forums based on collaborative engagement processes when decisions about major lake management issues are being made.	Community engagement and consultation	Section 4.0 – Consultation about Lake Management	All issues	Y	Y	A
6/6	Encourage and support citizen science participation, as well as access work by professional scientists.	Data collection; community engagement	Section 2.0 – The natural systems of Lake Macquarie	All issues	Y	N	B
6/7	Applications for phones and other devices, which provide a guided trail around key ecological (or historical and cultural) places around the lake.	Community engagement	Section 2.0 – The natural systems of Lake Macquarie Section 3.3 - Heritage	All issues	Y	N	B
6/8	A formal lake shore walk, incorporating key messages from the CZMP	Community engagement	Section 2.0 – The natural systems of Lake Macquarie Section 3.3 - Heritage	Category A & B issues	Y	N	B
6/9	Continue Council's evening information sessions on topics about sustainable management of the coastal landscape.	Community engagement	Section 2.0 – The natural systems of Lake Macquarie	All issues	N	Y	B



ID No.	Option	Focus	Plan Reference	Issue Category	Proportional Investment to Risk Benefit	Immediate implementation possible	Value Category
6/10	Continue to offer summer programs about lake and beach ecology and processes.	Community engagement	Section 2.0 – The natural systems of Lake Macquarie	All issues	N	Y	B
6/11	Signage in popular reserves around the lake foreshore – stories about healthy lake processes, also linked to stories about historical and contemporary lake use.	Community engagement	Section 2.0 – The natural systems of Lake Macquarie Section 3.3 - Heritage	All issues	Y	N	B
6/12	Public art and designs for playgrounds and other equipment in reserves, to reflect the heritage and environmental values of the lake and its foreshore – with local focus – what’s special about this place? How do we tell the story of our lives in this landscape?	Community engagement	Section 2.0 – The natural systems of Lake Macquarie Section 3.3 - Heritage	All issues	N	N	B
6/13	Foreshore heritage trail development	Community engagement	Section 3.3 - Heritage	C4	N	N	D

## 12.0 Theme 7: Knowledge and Adaptation, Managing Uncertainty

The options in **Table 12.1** address ongoing knowledge improvement through monitoring, evaluation, reporting and research.

**Table 12.1 – Knowledge for adaptation**

**What we want to achieve for adaptive information:**

- Ongoing collaborative collection and publication of information about the condition and use of Lake Macquarie.

ID No.	Option	Focus	Plan Reference	Issue Category	Proportional Investment to Risk Benefit	Immediate implementation possible	Value Category
7/1	Implement a comprehensive estuary health and community use monitoring program, consistent with the NSW State-wide MER strategy but also tailored to provide appropriate management information for LMCC and its community. Report results annually	Monitoring; Community engagement; audit	Section 2.0 – The natural systems of Lake Macquarie	All issues	Y	Y	A
7/2	At intervals of no more than 10 years, review the implementation of the Estuary part of the CZMP, in conjunction with review and update of other components of the Lake Macquarie CZMP	Monitoring; Community engagement; audit	Section 12.1 – Reviewing the CZMP	All issues	Y	Y	A
7/3	Conduct an annual review audit of actions implemented from the Estuary part of the CZMP to inform progress and facilitate adjustments as necessary	Monitoring; Adaptive management	Section 12.1 – Reviewing the CZMP	All issues	Y	Y	A

## 12.1 Reviewing the Estuary part of the CZMP

The Estuary part of the CZMP, along with the other two parts, is intended to be implemented over a ten year period. Actions are proposed for urgent/short term implementation (Category A - less than 4 years, providing funds are available), for medium term implementation (Categories B & C - Year 4 to Year 8) and longer term implementation to be commenced after Year 8, but before 10 years (Category D). The CZMP also identifies some actions that are part of Council's long term adaptation strategy. These actions are unlikely to be implemented within the life of this CZMP (i.e. before a ten year review), but are included because they provide information about how Council will respond if certain trigger conditions are met.

A review of implementation progress will occur after four to five years (linked to Council's State of the Environment Reporting and strategic planning cycles). A full review of the effectiveness of the CZMP will occur after ten years. Strategic priorities and triggers for adaptive change to land use would be reviewed and updated at that time.

Coastal (estuary) hazard and risk studies will be reviewed when new projections are issued by the Intergovernmental Panel on Climate Change (IPCC) and/or the NSW Government Sea Level Rise Policy Statement is reviewed or at the direction of the NSW government.

The full review would consider:

- The extent to which proposed actions have been implemented, the cost of management and the reasons for variations from the proposed schedule (Resource Targets).
- The extent to which the actions in the Plan can be seen to have supported improvements to the condition of coastal ecosystems, or provided for ongoing safe community enjoyment of the coast (Recreational Access and Communication Targets).
- The extent to which Council has delivered the plan itself and/or in partnership with other organisations (Resource and Partnership Targets).
- The extent to which implementation of the CZMP has delivered on its objectives.

When reviewing the overall implementation of the CZMP, Council will involve the Estuary and Coastal Management Committee and provide opportunities for the broader community and stakeholder partners to contribute.

## 13.0 Implementation Schedule for Category A actions (Years 0- 4)

**Table 13.1** consolidates the Category actions which will be included in Council's operational planning for the next four years.

**Table 13.1 – High priority actions for implementation, Years 0-4**

ID No.	Option	Focus	Cost, resources and funding opportunities	Lead Responsibilities	Support responsibilities	Performance Measures
1/1	Conduct a condition assessment of existing lake foreshore erosion treatment sites (on public land) to determine their current condition and performance.	Public foreshores subject to higher wave energy	Current staff resources	LMCC	CLD NSW Fisheries	<ol style="list-style-type: none"> <li>1. Develop performance and condition criteria</li> <li>2. Identify sites requiring maintenance works</li> <li>3. Identify design modifications to improve longevity and effectiveness of works</li> </ol>
1/2	Continue Council's foreshore stabilisation program	Priority sites displaying active erosion; Previously rehabilitated sites requiring maintenance	\$200,000 per annum Seek external funding opportunities (NSW Estuary Management Grants Program) to match Councils contribution	LMCC	CLD NSW Fisheries OEH	<ol style="list-style-type: none"> <li>1. Construction of foreshore stabilisation projects</li> <li>2. Maintenance works undertaken as required</li> <li>3. Reduced foreshore erosion at work sites</li> </ol>
1/3	Develop a Foreshore Development Guideline that includes integration of environmentally friendly foreshore stabilisation techniques	DCP Guidelines	\$15,000  Seek external funding opportunities (NSW Estuary Management Grants Program) to match Councils contribution	LMCC	CLD NSW Fisheries OEH	<ol style="list-style-type: none"> <li>1. Guideline developed</li> <li>2. Recommendations incorporated into DCP</li> </ol>
1/4	Identify actively eroding creek bank sites on public land	Whole of catchment	Current staff resources	LMCC	CLD NSW Office of Water	<ol style="list-style-type: none"> <li>1. Apply existing prioritisation criteria to identify sites requiring stabilisation works</li> </ol>

ID No.	Option	Focus	Cost, resources and funding opportunities	Lead Responsibilities	Support responsibilities	Performance Measures
1/5	Continue Council's streambank stabilisation program	Tributaries in catchments with highly erodible soils; priority sites displaying active erosion	\$200,000 per annum Seek external funding opportunities (NSW Estuary Management Grants Program) to match Councils contribution	LMCC	CLD NSW Office of Water OEH	<ol style="list-style-type: none"> <li>1. Construction of streambank stabilisation projects</li> <li>2. Reduced bank erosion at work sites</li> </ol>
1/6	Review Council's Creek bank stabilisation guidelines and incorporate recommendations relating to predicted climate change impacts	DCP Guidelines	\$15,000 Seek external funding opportunities (NSW Estuary Management Grants Program) to match Council's contribution	LMCC	CLD NSW Office of Water OEH	<ol style="list-style-type: none"> <li>1. Guideline developed</li> <li>2. Recommendations incorporated into DCP</li> </ol>
1/7	Review a sample of creek bank stabilisation works undertaken by Council to identify any potential design improvements required for future works	Sites previously subject to rehabilitation works	Current staff resources	LMCC	CLD NSW Office of Water OEH	<ol style="list-style-type: none"> <li>1. Develop performance and condition criteria</li> <li>2. Identify sites requiring maintenance works</li> <li>3. Identify design modifications to improve longevity and effectiveness of works</li> </ol>
1/8	Prepare flood risk management studies and plans to enhance understanding of risks and provide for consistent management of floodplains in the Lake Macquarie catchment	Major estuarine creeks	\$250,000 per annum Seek external funding opportunities (NSW Floodplain Management Grants Program) to match Councils contribution	LMCC	OEH	<ol style="list-style-type: none"> <li>1. Development of Flood Risk Management Plans</li> <li>2. Incorporation of recommendations into local planning instruments</li> </ol>

ID No.	Option	Focus	Cost, resources and funding opportunities	Lead Responsibilities	Support responsibilities	Performance Measures
2/1	Continue compliance activities relating to erosion and sediment controls	Greenfield development sites; development sites in close proximity to the lake and tributaries	Existing staff resources	LMCC	EPA	<ol style="list-style-type: none"> <li>1. Water quality consistent with required targets downstream from new development sites</li> <li>2. Site monitoring undertaken at greenfield developments and sensitive locations</li> </ol>
2/2	Continue the lake health monitoring program (water quality and ecological indicators), consistent with NSW State-wide MER (Monitoring, Evaluation and Review) program	Ongoing data collection at existing monitoring sites	\$85,000 per annum	LMCC	EPA OEH NSW Fisheries	<ol style="list-style-type: none"> <li>1. Lake Health Annual report</li> </ol>
2/3	Apply WSUD to all new developments to ensure treatment of 50-80% of stormwater from each subcatchment in new subdivisions.	Generation hotspots within urban sub-catchments	Existing staff resources	LMCC	OEH	<ol style="list-style-type: none"> <li>2. Update LMCC Water Cycle Management Guidelines to incorporate objective</li> </ol>
2/4	Support further scenario testing of the Ecological response model with respect to stormwater treatment in specific subcatchments.	Sensitive sub-catchments	\$40,000 Seek external funding (NSW Estuary Management Program) opportunities to support implementation	LMCC	OEH	<ol style="list-style-type: none"> <li>1. Results of model incorporated into water quality objectives within the Water Cycle Management Guidelines</li> </ol>

ID No.	Option	Focus	Cost, resources and funding opportunities	Lead Responsibilities	Support responsibilities	Performance Measures
2/5	Review & apply Council's DCP controls and Water Cycle Management Guidelines for all new development	Whole of catchment	Existing staff resources	LMCC		<ol style="list-style-type: none"> <li>1. Water quality objectives within the LMCC Water Cycle Management Guidelines applied to all new development</li> <li>2. Water quality consistent with required targets downstream from new development sites</li> </ol>
2/6	Monitor vegetated SQID performance in relation to maintenance practice	Whole of catchment	As part of Action 2/2	LMCC	OEH	<ol style="list-style-type: none"> <li>1. Development of SQID Maintenance Guideline</li> </ol>
2/7	Continue to implement the current riparian corridor rehabilitation program.	Priority estuarine creek systems such as LT Creek, Mannering Creek, and Wyee Creek	As part of Action 1/5	LMCC	OEH NSW Office of Water	<ol style="list-style-type: none"> <li>1. Improvement in extent and condition of riparian vegetation</li> <li>2. Bush regeneration projects completed</li> </ol>
2/8	Develop a riparian guideline that outlines develop requirements and restoration solutions	Whole of catchment	\$15,000	LMCC	OEH NSW Office of Water	<ol style="list-style-type: none"> <li>1. Guideline developed</li> <li>2. Recommendations incorporated into DCP</li> </ol>
2/9	Establish a mooring working group, to make recommendations on reducing mooring impacts on sensitive seagrass beds	Moorings over <i>Posidonia australis</i> beds	<p>Staff resources</p> <p>Seek funding via RMS Boating Infrastructure Partnership Program</p>	NSW Maritime	LMCC NSW Fisheries CLD Transport NSW	<ol style="list-style-type: none"> <li>1. Working group established including Terms of Reference</li> </ol>



ID No.	Option	Focus	Cost, resources and funding opportunities	Lead Responsibilities	Support responsibilities	Performance Measures
2/10	Hold a forum to discuss options for boat moorings in Lake Macquarie to minimise impacts on sensitive seagrass beds and to provide practical designs.	Moorings over <i>Posidonia australis</i> beds; Mooring areas subject to high wave energy or currents	Staff resources  Seek funding via RMS Boating Infrastructure Partnership Program	NSW Maritime	LMCC NSW Fisheries CLD Transport NSW	1. Public forum competed
2/11	Review DCP controls to incorporate best practice jetty designs suitable for installation in Lake Macquarie. Update as necessary to meet ecological and recreational objectives.	Development Control Plan	As part of Action 1/3	LMCC	CLD NSW Fisheries OEH	1. Guideline developed 2. Recommendations incorporated into DCP
2/12	Prepare management guidelines for <i>Posidonia australis</i> in Lake Macquarie, consistent with the types of information that Council provides on other threatened species	Development Control Plan	\$10,000	LMCC	NSW Fisheries CLD NSW Maritime	1. Guideline developed 2. Recommendations incorporated into DCP
2/13	Continue seagrass mapping and health monitoring, and investigate partnership opportunities with other organisations required to monitor seagrass	Partnerships; Consistent monitoring methodology	Existing staff resources to develop partnership arrangement.  Mapping and monitoring cost \$65,000 per annum	LMCC	NSW Fisheries Mine and electricity generation operators with seagrass monitoring responsibilities	1. Seagrass monitoring and mapping undertaken (as per NSW Fisheries methodology) on a regular basis 2. Funding partnerships established with private organisations (mine and electricity generation)

ID No.	Option	Focus	Cost, resources and funding opportunities	Lead Responsibilities	Support responsibilities	Performance Measures
2/14	Prioritise and undertake rehabilitation works in estuarine and floodplain wetland areas for protection and management.	Areas sensitive to climate change impacts	Existing staff resources	LMCC	OEH NSW Fisheries CLD	<ol style="list-style-type: none"> <li>1. Develop assessment criteria</li> <li>2. Identify priority sites for rehabilitation works</li> </ol>
2/15	Identify, prioritise and undertake rehabilitation of wetlands (all types of estuary wetlands) where protected buffer areas can be established to facilitate retreat.	Planning controls and identification of rehabilitation works sites	<p>\$60,000</p> <p>Successful grant application in 2013/2014 Estuary Management Program</p>	LMCC	OEH	<ol style="list-style-type: none"> <li>1. Report completed identifying priority wetlands</li> </ol>
2/16	Develop a foreshore development guideline that includes low impact methods for recreational structures and foreshore stabilisation treatments	Development Control Plan; Absolute waterfront private property	As per action 1/3	LMCC	CLD NSW Fisheries OEH	<ol style="list-style-type: none"> <li>1. Guideline developed</li> <li>2. Recommendations incorporated into DCP</li> </ol>
2/17	Continue education programs for construction industry and residential property owners to promote best practice stormwater management	Catchment-wide	Existing staff resources; \$15,000 for resource production	LMCC	EPA	<ol style="list-style-type: none"> <li>1. Development of capacity building resources for sensitive sub-catchments</li> </ol>
2/20	Retrofit existing stormwater quality improvement devices	Generation hotspots within urban sub-catchments	Grant funding dependent	LMCC		<ol style="list-style-type: none"> <li>1. Number of WSUD devices removing pollutants at or above design levels</li> </ol>
2/21	Install and maintain WSUD devices to reduce sediment and nutrient load	Urban sub-catchment generation hotspots	Grant funding dependent	LMCC		<ol style="list-style-type: none"> <li>1. Reduction of pollutant loads in sub-catchment hotspots and subsequent improvements in ecosystem health scores</li> </ol>

ID No.	Option	Focus	Cost, resources and funding opportunities	Lead Responsibilities	Support responsibilities	Performance Measures
2/38	Investigate the feasibility of a catchment based project to improve water quality and ecological condition in LT Creek and Fennel Bay	LT Creek	Seek funding via the OEH Estuary Management Program	LMCC	OEH	1. Investigate project potential and develop project brief if feasible
2/39	Advocate for a NSW Container Deposit System	Gross litter	Existing staff resources	LMCC		1. Continue advocacy for CDS as opportunities arise
3/1	Update the Mooring Management Plan for Lake Macquarie.	Mooring areas over seagrass beds	Seek funding via RMS Boating Infrastructure Partnership Program	NSW Maritime	LMCC CLD RMS	2. Mooring Management Plan updated and approved by CLD and LMCC
3/2	Establish an inter-council working group to provide consistent policy and strategy around access infrastructure for Lake Macquarie.	Lake-wide	Existing staff resources	LMCC WSC	CLD	1. Working group established and terms of reference developed
3/3	Continue to report on boat usage statistics for Lake Macquarie, including vessel size, numbers and locations of swing moorings, numbers of vessels berthed in marinas, and any incidents associated with mooring location, function or interaction with jetties.	Data collection	Existing resources	NSW Maritime		1. Annual Report
3/4	Introduce dinghy storage racks as a trial at selected high profile/high risk locations (e.g. Valentine, Marmong Point). Publicise and report on the trial.	Public foreshores adjoining mooring areas	\$180,000  Seek funding via RMS Boating Infrastructure Partnership Program	LMCC	NSW Maritime Transport NSW	1. Trial storage racks installed 2. Monitoring of trial sites and subsequent report 3. Public Consultation sessions

ID No.	Option	Focus	Cost, resources and funding opportunities	Lead Responsibilities	Support responsibilities	Performance Measures
3/5	Prepare a public wharf, jetty and boat ramp strategies for Lake Macquarie.	Long term recreational use	\$60,000 Seek funding via RMS Boating Infrastructure Partnership Program	LMCC	NSW Maritime Transport NSW	<ol style="list-style-type: none"> <li>Undertake recreational capacity survey</li> <li>Develop aquatic public infrastructure strategy</li> </ol>
3/36	Request Lake Macquarie participation in DPI trials to reduce fishing impacts on turtles	Recreational crab net use	Existing staff resources	LMCC	DPI Fisheries	<ol style="list-style-type: none"> <li>Formal approach to DPI Fisheries</li> </ol>
4/1	Develop an integrated coastal zone management implementation strategy and funding plan for the open coast and estuarine parts of the Lake Macquarie coastal zone.	Funding plan	Existing staff resources	LMCC	OEH	<ol style="list-style-type: none"> <li>Funding plan developed and reviewed by relevant Committees of Council</li> </ol>
4/2	Investigate and utilise all relevant and cost effective external funding avenues, to facilitate implementation.	Grant identification	Existing staff resources	LMCC	State and Federal Government agencies	<ol style="list-style-type: none"> <li>Identification of grant opportunities</li> </ol>
4/3	Review the membership of the Estuary and Coastline Management committee and reform as a Coastal Zone Panel, with representatives of key stakeholder groups for both the estuary and open coast.  Also review membership of the Aquatic Services Committee.	Consultation; Partnerships	Existing staff resources	LMCC		<ol style="list-style-type: none"> <li>Review Terms of Reference for Committees in light of priority actions for the CZMP</li> </ol>

ID No.	Option	Focus	Cost, resources and funding opportunities	Lead Responsibilities	Support responsibilities	Performance Measures
5/1	Allocate resources to carefully monitor opportunities under all grant programs and to ensure grant applications are best positioned to deliver funding for CZMP projects.	Grant funding	Existing staff resources	LMCC		1. Grant applications prepared in line with CZMP priority actions
5/2	Maintain close liaison with State and Commonwealth agencies about Lake Macquarie issues and initiatives, to lay groundwork for investment in innovative management, planning, monitoring and reporting processes.	Partnerships	Existing staff resources	LMCC	OEH EPA NSW Maritime NSW Fisheries Transport NSW	1. Agencies represented on the Estuary and Coastal Zone Management Committee
6/1	Continue adaptation conversations and planning with affected communities.	Urban areas most affected by sea level rise	Existing staff resources	LMCC	Utility providers such as Hunter Water, Ausgrid & Transgrid Transport NSW OEH	1. Adaptation Planning Workshops and ongoing consultation with affected communities
6/2	Regularly use electronic surveys and feedback opportunities on lake management issues, via Council's web site.	Community Consultation	Existing staff resources	LMCC		1. Annual lake survey 2. Public exhibition of relevant documents related to estuary management
6/3	Collaborate with University of Newcastle and other tertiary institutions to bring new research results into the community.	Community engagement; research opportunities	Existing staff resources	LMCC	University of Newcastle Tertiary Institutions	1. Continue research grant program 2. Continue tertiary education representation on the Estuary and Coastal Zone Management Committee

ID No.	Option	Focus	Cost, resources and funding opportunities	Lead Responsibilities	Support responsibilities	Performance Measures
6/4	Use local media to promote estuary management activities or works	Community engagement	Existing staff resources	LMCC	OEH NSW Maritime EPA	1. Quarterly media release
6/5	Conduct community forums based on collaborative engagement processes when decisions about major lake management issues are being made.	Community engagement and consultation	Existing staff resources	All issues	Government agencies relevant to the management issue	1. Development of a communication plan for CZMP implementation
7/1	Implement a comprehensive estuary health and community use monitoring program, consistent with the NSW State-wide MER strategy but also tailored to provide appropriate management information for LMCC and its community. Report results annually	Monitoring; Community engagement; audit	As part of Action 2/2	LMCC	EPA OEH NSW Fisheries	1. Lake Health Annual report
7/2	At intervals of no more than 10 years, review the implementation of the Estuary part of the CZMP, in conjunction with review and update of other components of the Lake Macquarie CZMP	Monitoring; Community engagement; audit	Existing staff resources	LMCC	All agencies having responsibilities under this plan	1. Review and report on status of implementation actions
7/3	Conduct an annual review audit of actions implemented from the Estuary part of the CZMP to inform progress and facilitate adjustments as necessary	Monitoring; Adaptive management	Existing staff resources	LMCC	All agencies having responsibilities under this plan	1. Audit completed and implementation plan adjusted accordingly

## 14.0 Implementation Schedule for Category B Actions

**Table 14.1** summarises category B action which would be implemented in years 5-10 of the plan, i.e. generally after the first progress review.

**Table 14.1 – Category B actions – for later implementation**

ID No.	Option	Focus	Cost, resources and funding opportunities	Lead Responsibilities	Support responsibilities
1/9	Establish consistent foreshore design requirements and management priorities with Wyong Shire Council	Development Control Plan; Foreshore stabilisation works undertaken by public authorities	Existing staff resources	LMCC	WSC
1/10	Conduct a climate change risk review of high risk tributary catchments	High risk tributary catchments	Seek grant funding	LMCC	OEH
1/11	Prepare policy statements to clarify requirements for filling of floodplain areas	Whole of catchment	Existing staff resources	LMCC	NSW Office of Water
2/18	Conduct an audit of privately owned/constructed foreshore structures and identify structures that are illegal or are having a significant impact on the health of the creek/foreshore area.	Privately owned foreshore properties	Seek funding	LMCC	
2/19	Regularly review water quality targets for runoff from new development	In conjunction with long-term monitoring results	Existing staff resources	LMCC	OEH
2/22	Investigate the use of stormwater levy funds to upgrade systems	Wyong City Council		WSC	
2/23	Initiate a targeted water quality improvement campaign with priority industry types	Industrial zones adjoining waterways	Seek funding	LMCC	NSW EPA
2/24	Conduct an audit of non-licensed premises that have potential to discharge polluted waters to Lake Macquarie	Industrial developments adjoining tributaries or the lake itself		LMCC	NSW EPA



ID No.	Option	Focus	Cost, resources and funding opportunities	Lead Responsibilities	Support responsibilities
2/25	Explore options for integrating lake water quality and hydrology data sets from different sources – industry, Council and community, to provide access to a comprehensive suite of data for the lake.	Partnerships; Consistent monitoring methodology	Existing staff resources	LMCC	OEH, NSW Fisheries, NSW EPA, Mining, Electricity, WSC
2/26	Support research on the impacts of cooling water discharges on the estuarine ecology of Lake Macquarie	Discharge intake, outlets and surrounds	Existing staff resources	LMCC	Electricity generators
2/27	Clarify Council's policy position on forced removal of illegal foreshore/creek bank structures.	Dora Creek, Shepherds Creek, residential areas most affected by sea level rise	Existing staff resources	LMCC	
2/28	Conduct community information days on foreshore and creek bank management – structures, planting and options for access.	Waterfront property owners	Existing staff resources	LMCC	
2/29	Initiate a trial replacement of existing swing moorings with environmentally friendly moorings.	Lake Macquarie Yacht Club and/or Boat Owners Association.		Local Land Services	LMCC, DPI Fisheries,
2/30	Prepare and distribute written information for the community that identifies areas of seagrass (by species), stressing the ecological and community use value of healthy seagrass.	Waterfront property owners, mooring lease holders	Seek funding	LMCC	DPI Fisheries, HLLS
2/31	Initiate research program into variations in seagrass dynamics and causes for observed seagrass losses.	Seagrass beds exhibiting high levels of spatial and temporal variation	Seek funding – OEH programs	LMCC	OEH

ID No.	Option	Focus	Cost, resources and funding opportunities	Lead Responsibilities	Support responsibilities
2/32	Investigate status and condition of remaining saltmarsh sites and opportunities for managing saltmarsh on private land.	Saltmarsh adjoining or within an urban / suburban context	Seek funding	LMCC	
2/33	Convert modified non-saline foreshore areas to saltmarsh (where feasible).	Non-saline foreshore areas on public land	Seek funding	LMCC	
2/34	Identify and promote nationally significant ecological values of Lake Macquarie, to enhance potential for access to Commonwealth funds for environmental management.	Catchment-wide	Existing staff resources	LMCC	OEH, NSW Fisheries, NSW Office of Water
2/35	In consultation with EPA, review the water quality management controls and processes at licensed premises.	EPA licensed premises		LMCC	NSW EPA
2/36	Support a partnership with power stations, OEH, EPA and DPI fisheries to determine and implement ongoing best practice management of discharge heat.	Partnerships; Best practice management	Existing staff resources	NSW Fisheries	LMCC, EPA, OEH, Electricity generators
3/7	Investigate the feasibility of an integrated foreshore Icon Park network, including upgrades required at foreshore reserves (facilities, interpretation, pathways).	Community engagement regarding natural and historical values	Existing staff resources	LMCC	Crown Lands, NPWS (OEH), Wyong Shire Council
3/8	Prepare a boating management plan for Lake Macquarie.	Balance of recreation and environmental values	Seek funding	NSW Transport	LMCC, Wyong Shire

ID No.	Option	Focus	Cost, resources and funding opportunities	Lead Responsibilities	Support responsibilities
3/9	Investigate and assess the appropriate long term balance between swing moorings and marina berths for keeled and motor recreation vessels.	Data collection and analysis	Seek funding	RMS	LMCC
3/10	Consult widely about issues associated with dinghy storage on the foreshore of reserves around Lake Macquarie.	Public foreshores adjoining mooring areas	Seek funding	LMCC	Yacht Clubs, RMS
3/11	Conduct an audit of dinghy storage on the foreshore of Lake Macquarie, considering locations, numbers of dinghies, ownership of dinghies (local or more remote), links to vessels moored in the bay; existing tethering processes; safety issues.	Public foreshores adjoining mooring areas	Seek funding	LMCC	
3/12	Implement the dinghy storage policy for Lake Macquarie.	Public foreshores adjoining mooring areas	Seek funding	LMCC	
3/13	Update the integrated foreshore management strategy for Lake Macquarie, highlighting strategic direction for public land around the lake.	Strategy	Existing staff resources	LMCC	Crown Lands
3/14	Support NPWS in efforts to manage invasive species (lantana, bitou, asparagus fern, etc.).	NPWS reserves and adjoining public land	Seek funding	LMCC	NPWS
3/15	Investigate options and priorities for transfer other (not SCA) sections of bushland foreshore to conservation management	Bushland foreshore parcels without conservation status	Existing staff resources	LMCC	

ID No.	Option	Focus	Cost, resources and funding opportunities	Lead Responsibilities	Support responsibilities
3/16	Investigate the likely cause of the apparent increase in the abundance of razor clams.	Waters adjoining public foreshores with high recreational use such as designated swimming areas	Seek funding	LMCC	NSW Fisheries
3/17	Provide sharps disposal bins located within foreshore reserve areas, accessible 24 hours daily.	High use public foreshores such as Speers Point Park	Seek funding	LMCC	
3/18	Education on the presence of sharks in the lake and their role in the ecology of the lake.	Community engagement	Seek funding	NSW Fisheries	LMCC
3/19	Targeted removal of razor clams from popular recreational areas (e.g. Belmont Baths).	Designated swimming areas	Seek funding	LMCC	NSW Fisheries
3/20	Beach and sandy foreshore cleaning to remove needles and syringes.	High recreational use public foreshores	Seek funding	LMCC	
3/21	Review Council's policy position on shark netting around public swimming areas	Policy review in light of updated incident data	Existing staff resources	LMCC	
5/3	Review the applicability of stormwater levies (Wyangong Council) for estuary management works (catchment runoff controls) that focus on water quality and estuary health	Funding	Existing staff resources	WSC	LMCC
6/6	Encourage and support citizen science participation, as well as access work by professional scientists.	Data collection; community engagement	Existing staff resources	LMCC	OEH NSW Fisheries
6/7	Applications for phones and other devices, which provide a guided trail around key ecological (or historical and cultural) places around the lake.	Community engagement	Seek funding	LMCC	OEH, HLLS

ID No.	Option	Focus	Cost, resources and funding opportunities	Lead Responsibilities	Support responsibilities
6/8	A formal lake shore walk, incorporating key messages from the CZMP	Community engagement	Seek funding	LMCC	Crown Lands, Wyong Shire Council, OEH (NPWS)
6/9	Continue Council's evening information sessions on topics about sustainable management of the coastal landscape.	Community engagement	Existing staff resources	LMCC	
6/10	Continue to offer summer programs about lake and beach ecology and processes.	Community engagement	Existing staff resources	LMCC	
6/11	Signage in popular reserves around the lake foreshore – stories about healthy lake processes, also linked to stories about historical and contemporary lake use.	Community engagement	Seek funding	LMCC	
6/12	Public art and designs for playgrounds and other equipment in reserves, to reflect the heritage and environmental values of the lake and its foreshore – with local focus – what's special about this place? How do we tell the story of our lives in this landscape?	Community engagement	Seek funding	LMCC	

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## Appendix A – Lake Waterway Flood Hazard Maps

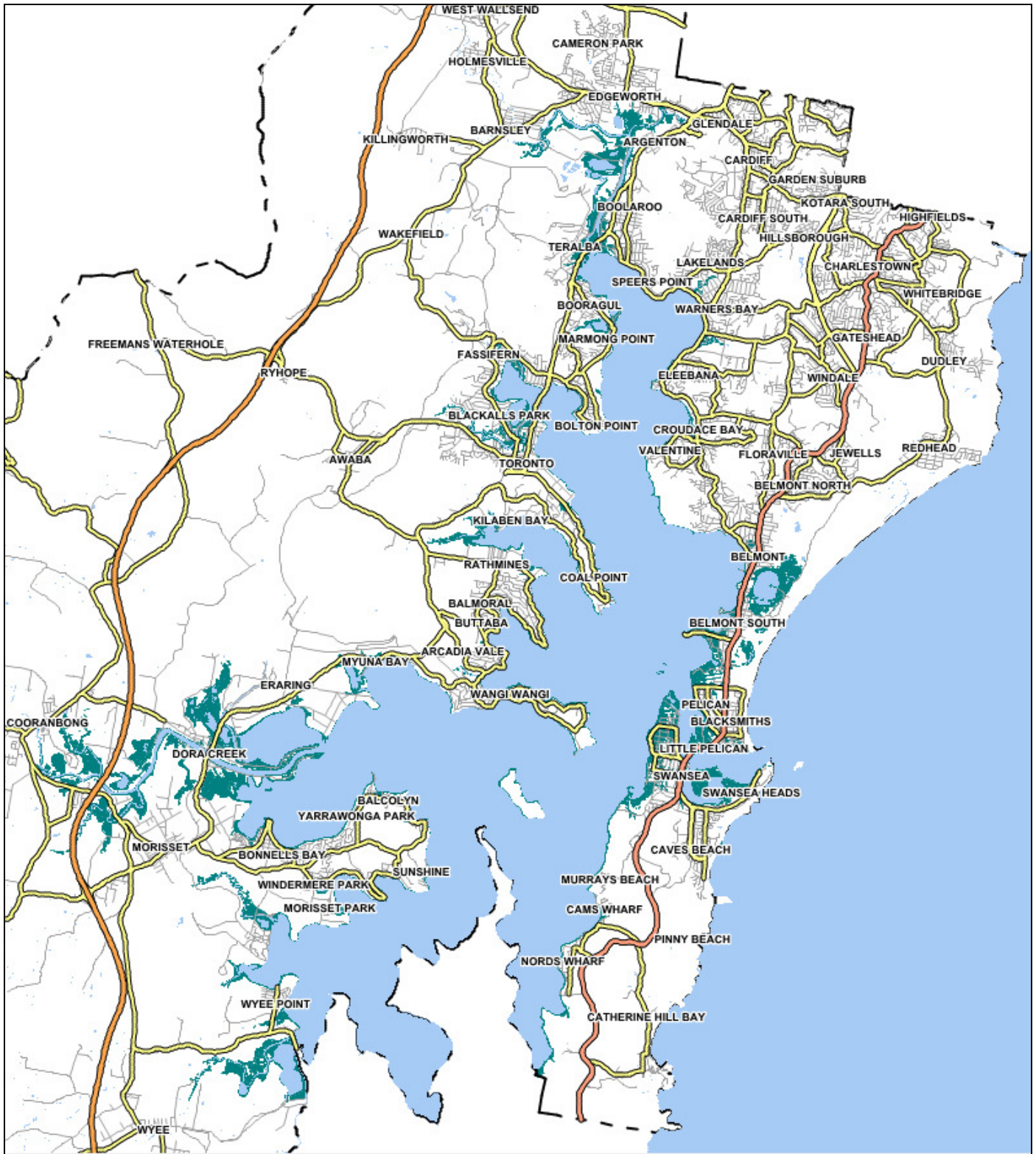


Figure 0.1- Elevations below 1.0m AHD. This land may be permanently inundated if average lake levels rise by 0.9metres. These levels are projected to be reached by approximately 2100.





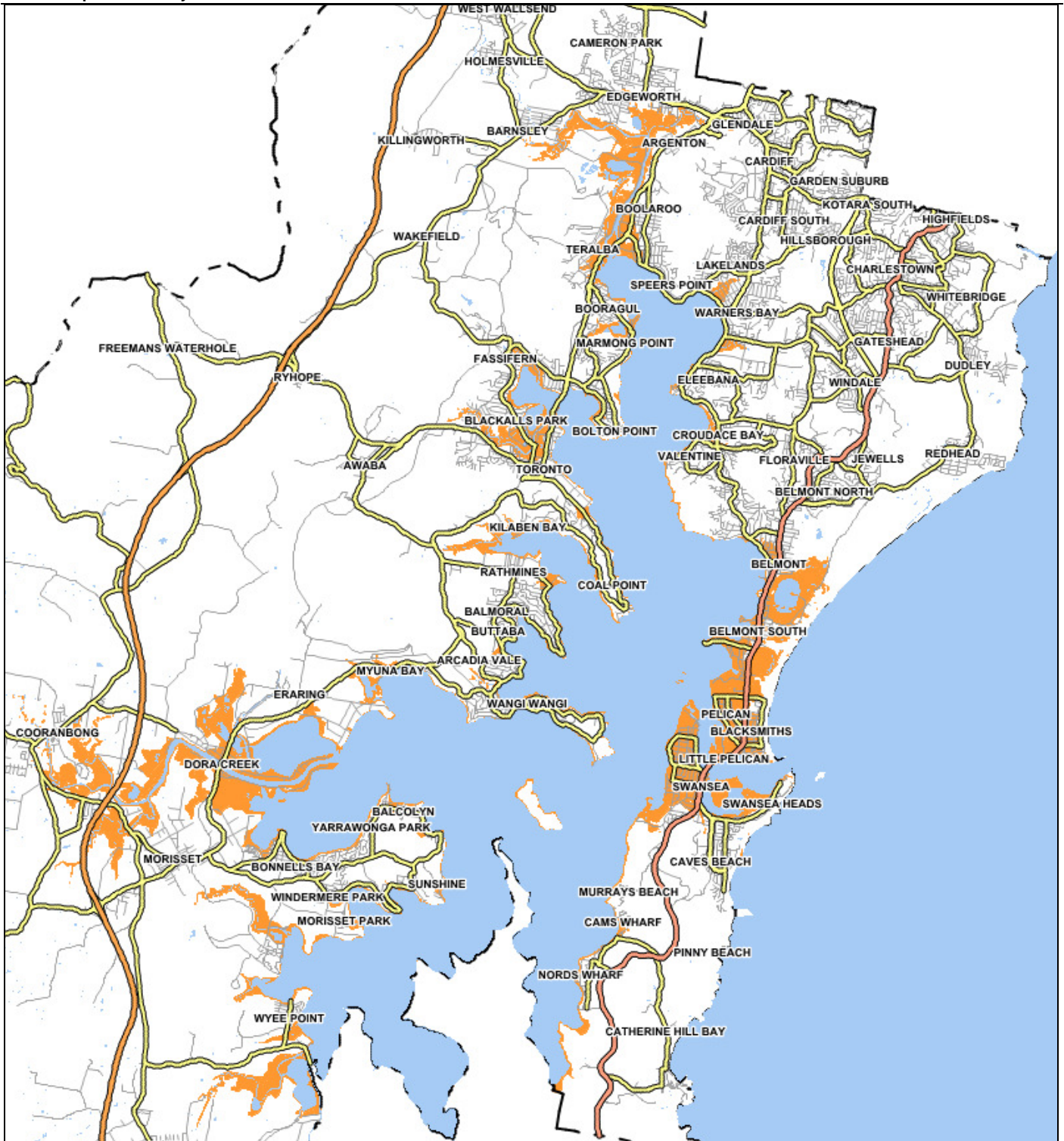


Figure 0.3 - Elevations below 1.86m AHD. This land may be flooded in a 1:100 year lake flood if average lake levels rise by 0.4metres. These levels are projected to be reached by approximately 2050.



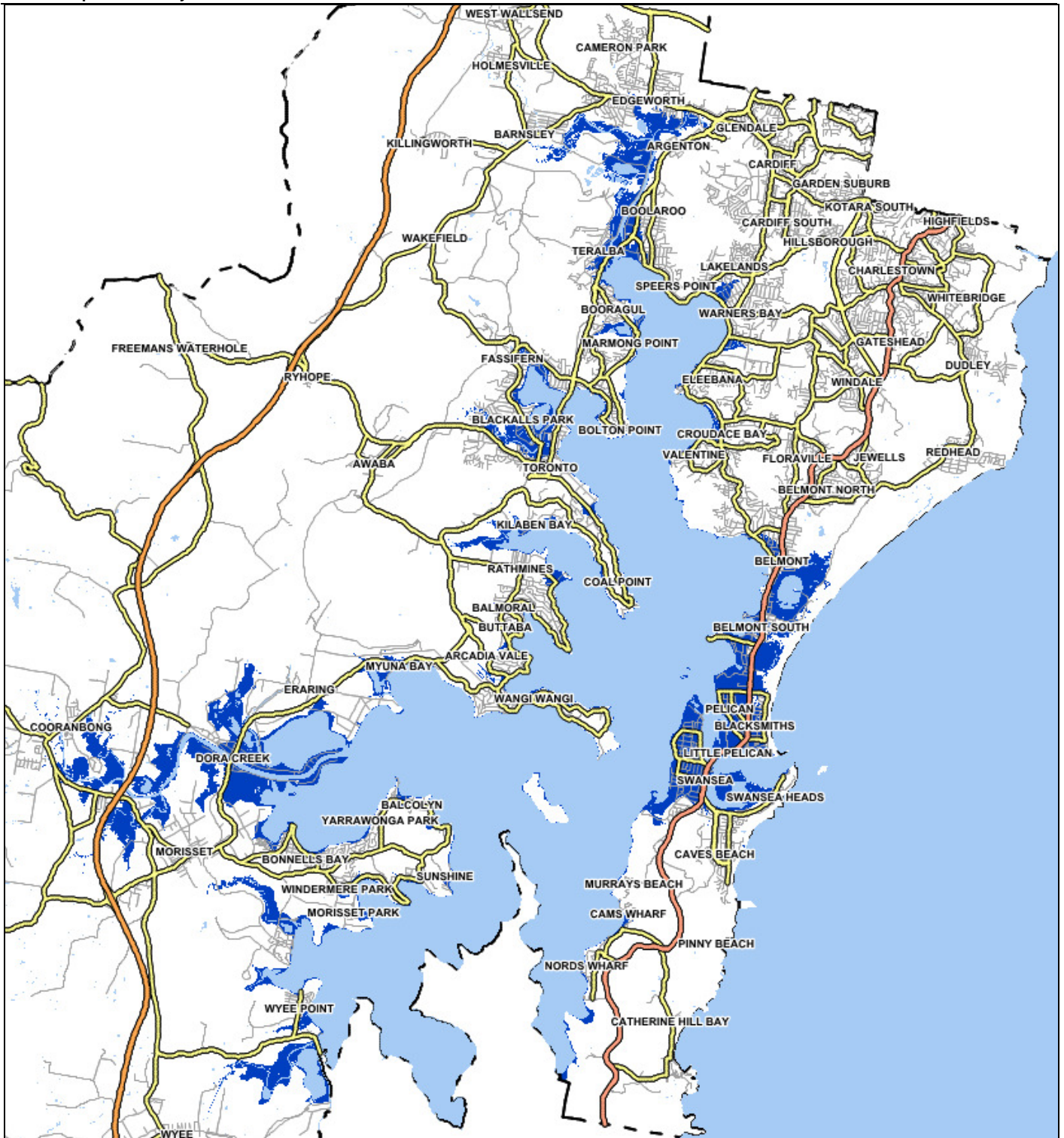


Figure 0.4 - Elevations below 2.32m AHD. This land may be flooded in a 1:100 year flood if average lake levels rise by 0.9metres. These levels are projected to be reached by approximately 2100.